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Butte County Department of Water and Resource Conservation

Butte County, California Groundwater Management Plan

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Appendix A Butte County Board of Supervisors Resolution of Intent to Prepare a Groundwater Management Plan

Appendix B Butte County Code Chapter 33A – Groundwater management (BMO Ordinance)

Appendix C Butte Basin Water Users Association 2003 Groundwater Status Report

Abbreviations

BBWUA – Butte Basin Water Users Association
BSAGWUA – Butte-Sutter Area Groundwater Users Association
BMO – Basin Management Objective
CBDA – California Bay-Delta Authority
CVP – Central Valley Project
CWC – California Water Code
Department – Butte County Department of Water and Resource Conservation
DWR – California Department of Water Resources
EC – Electrical Conductivity
EPA – Environmental Protection Agency
GMP – Butte County AB 3030 Groundwater Management Plan
gpd – gallons per day
gpm – gallons per minute
IWRP – Butte County Integrated Water Resource Plan
msl – mean sea level
ppm – parts per million
Reclamation – Bureau of Reclamation
SWP – State Water Project
SWRCB – State Water Resource Control Board
TAF – 1000 acre-feet
TDS – Total dissolved solids
TAC – Technical Advisory Committee
WAC – Water Advisory Committee
WHPA – wellhead protection area

Section 1
Introduction

1.1 Plan Authority and Administration

On August 26, 2003, the Butte County Board of Supervisors formally approved resolution 03-134 directing the Butte County Department of Water and Resource Conservation (Department) to proceed with the development of a countywide AB 3030 Groundwater Management Plan (GMP). The resolution is included as Appendix A. The County is an authorized groundwater management agency within the meaning of California Water Code (CWC) § 10753[1] (a) or (b). In order to avoid conflicts or inconsistencies with existing groundwater ordinances and groundwater management plans, the Department shall endeavor to coordinate this GMP with local agencies that have adopted rules and regulations to implement and enforce their own AB 3030 plans as required by CWC § 10753.9(a).

The Department has been participating in groundwater management activities for multiple years. The Department has focused on helping local users manage groundwater more effectively through several programs. In the last several years, the Department has increased groundwater level and quality monitoring, and has worked with other entities to collect and disseminate water quality and quantity data. Additionally, the Department assists other entities within the County with locally-driven groundwater management activities. The GMP documents the County's existing groundwater management programs, and explains potential future actions to increase the effectiveness of groundwater management, if current efforts do not meet the GMP objectives.

Section 1.2 discusses the GMP's objectives, and Section 1.3 outlines the area covered by the GMP. The overall plan development process, as required by the CWC, is described in detail in Section 1.4, and the public involvement process is described in Section 1.5

[1] CWC § 10753(a) Any local agency, whose service area includes a groundwater basin, or a portion of a groundwater basin, that is not subject to groundwater management pursuant to other provisions of law or a court order, judgment, or decree, may, by ordinance, or by resolution if the local agency is not authorized to act by ordinance, adopt and implement a groundwater management plan pursuant to this part within all or a portion of its service area.
(b) Notwithstanding subdivision (a), a local public agency, other than an agency defined in subdivision (g) of Section 10752, that provides flood control, groundwater management, or groundwater replenishment, or a local agency formed pursuant to this code for the principal purpose of providing water service that has not yet provided that service, may exercise the authority of this part within a groundwater basin that is located within its boundaries within areas that are either of the following:
(1) Not served by a local agency.
(2) Served by a local agency whose governing body, by a majority vote, declines to exercise the authority of this part and enters into an agreement with the local public agency pursuant to Section 10750.7 or 10750.8.

1.2 Plan Objectives

The GMP supports the long-term maintenance of high quality groundwater resources within the Plan Area for agricultural, environmental, rural domestic and urban needs. Specifically, the Butte County Groundwater Management Plan endeavors to:

- Minimize the long-term drawdown of groundwater levels;
- Protect groundwater quality;
- Prevent inelastic land surface subsidence from occurring as a result of groundwater pumping;
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality;
- Minimize the effect of groundwater pumping on surface water flows and quality; and
- Facilitate groundwater replenishment and cooperative management projects.

1.3 Area Covered by Plan

The Butte County GMP includes those areas overlying a groundwater basin or associated groundwater sub-basin within Butte County 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)). The Sacramento Valley Groundwater Basin resources within Butte County are located in the North Yuba, East Butte, West Butte, and Vina groundwater sub-basins. These sub-basins are shown on Figure 1-1.

The Butte County GMP Plan Area is shown on Figure 1-2. Areas managed under existing AB 3030 Groundwater Management Plans by a local agency (CWC § 10750.2(b)), and therefore excluded from inclusion in this GMP, include those areas within the borders of the Biggs-West Gridley Water District, Butte Water District, Richvale Irrigation District, and Western Canal Water District. Areas overlying the groundwater basin that are regulated by the Public Utilities Commission (CWC § 10750.7(a)), and therefore excluded from inclusion in this GMP, include those areas within the service area of California Water Service Company – Chico and California Water Service Company – Oroville. Additionally, the foothill and mountain areas of the County do not overlie groundwater basins as defined in Department of Water Resources (DWR) Bulletin 118-2003, and are therefore not included under this GMP.

Within Table 1-1, Inventory Units correspond to the above referenced groundwater sub-basins. Inventory Sub-units represent a geographical area that is a subset to an Inventory Unit. Inventory Sub-units generally represent organized water suppliers or

other independent water use areas that have common land use and water supply sources. Water resources within Inventory Units and Inventory Sub-units have been characterized in detail in the reports *Butte County Groundwater Inventory Analysis* (DWR, 2000) and *Butte County Water Inventory and Analysis* (CDM, 2001). These reports are available at the Butte County Department of Water and Resource Conservation office library for use by the public.

Table 1-1
Butte County AB 3030 GMP Included Areas

Inventory Units	Inventory Sub-Units	Areas Within Sub-Units	Included in Butte County GMP
East Butte	Biggs-West Gridley	Biggs-West Gridley Water District	
		City of Biggs	4
		City of Gridley	4
	Butte	Butte Water District	
		City of Biggs	4
		City of Gridley	4
	Butte Sink	All	4
	Cherokee	All	4
	Esquon	Durham Mutual Water District	4
		All Other Areas	4
	Pentz	All	4
	Richvale	Richvale Irrigation District	
	Thermalito	Thermalito Irrigation District	4
		All Other Areas	4
	Western Canal	Western Canal Water District	
North Yuba	North Yuba	California Water Service, Oroville	
		All Other Areas	4
Vina	Vina	California Water Service, Chico	
		All Other Areas	4
West Butte	Angel Slough	All	4
	Durham/ Dayton	California Water Service, Chico	
		Dayton Mutual Water District	4
		Durham Irrigation District	4
		All Other Areas	4
	Llano Seco	All	4
	M&T	M&T Ranch	4
	Western Canal	Western Canal Water District	

1.4 Plan Development Process

There are five main steps in the development of an AB 3030 groundwater management plan, defined under CWC § 10753.2 through 10753.6, as summarized below.

Step 1- Provide public notification of a hearing on whether or not to adopt a resolution of intention to draft a GMP and subsequently complete a hearing on whether or not to adopt a resolution of intention to draft a GMP. Following the hearing, draft a resolution of intention to draft a GMP.

Step 2 - Adopt a resolution of intention to draft a GMP and publish the resolution of intention in accordance with public notification (6066 gov code). Upon written request, provide copy of resolution of intention to interested persons. The Butte County Board of Supervisors adopted the resolution of intention to develop a GMP on August 26, 2003.

Step 3 - Prepare draft GMP within 2 years of resolution of intention adoption. Provide to the public a written statement describing the manner in which interested parties may participate in developing the GMP, as discussed in section 1.5 below. This may also include appointing a Technical Advisory Committee (TAC).

Step 4 - Provide public notification (6066 gov code) of a hearing on whether or not to adopt the GMP, followed by a hearing on whether or not to adopt the GMP.

Step 5 - If Protests are received for less than 50% of the assessed value of property in the county area the plan may be adopted within 35 days after completion of Step 4 above. If Protests are received for greater than 50% of the assessed value of the property in the county area, the plan will not be adopted.

1.5 Public Outreach and Education

Public outreach and education is a primary function of the Butte County Department of Water and Resource Conservation. The Department encourages two-way dialogue, characterized by information dissemination and requests for suggestions and feedback on Department activities. In addition to public outreach completed during development of the GMP as required under CWC § 10753.2 through 10753.6, the Department has regularly disseminated information on GMP development as part of its ongoing public outreach effort.

GMP-related information and draft documentation are available to the public on the Department's website (http://www.buttecounty.net/waterandresource/) and have been included in the Department's monthly newsletter, *Water Solutions*, that is distributed in hardcopy and via e-mail to all interested parties. The Department also provides regular updates on plan development to the Butte County Water

Commission and Board of Supervisors, with opportunity for the public to provide comment directly to Water Commission and Board of Supervisor members.

The Department has reported on GMP development during meetings with interested stakeholders. Stakeholder groups include the Butte Basin Water Users Association, Upper Ridge Coordinating Committee, Integrated Plan Steering Committee, and the Integrated Watershed Stakeholders Group. Individuals attending these meetings typically represent a wide range of organizations, including watershed groups, water agencies, independent groundwater users, and interest groups.

Future GMP public outreach and education will focus on GMP implementation activities. Following the Board of Supervisors' February 10, 2004 approval of a Basin Management Objective (BMO) ordinance, the Department is supporting local areas pursuing development of BMOs within their respective areas. Butte County Ordinance 3869, describing BMO development and implementation, is included as Appendix B. The Department has developed a Basin Management Objective Development Packet for use by local BMO representatives in each of the 16 areas identified in the approved ordinance. The packets are intended to provide information and guidance necessary to develop BMOs within each area.

1.6 Management Plan Components

The Butte County GMP includes the following required and recommended components:

- CWC § 10750 *et seq.* (seven mandatory components). Recent amendments to the CWC § 10750 *et seq.* require GMPs to include several components to be eligible for award of funding administered by DWR for the construction of groundwater projects or groundwater quality projects. These amendments to the CWC were included in Senate Bill 1938, effective January 1, 2003.

- CWC § 10750 *et seq.* (12 voluntary components). CWC § 10750 *et seq.* includes 12 specific technical issues that could be addressed in GMPs to manage the basin optimally and protect against adverse conditions.

- DWR Bulletin 118-223 components (seven recommended components).

Table 1-2 summarizes the required and recommended components of an AB 3030 plan pursuant to current guidance and the report section where each component is addressed.

1.7 Organization of AB 3030 Groundwater Management Plan

This GMP is organized into four sections:

- Section 1 – Introduction;
- Section 2 – Water Resources Setting;
- Section 3 – Plan implementation; and
- Section 4 – References.

Table 1-2
Butte County AB3030 GMP Components

Plan Component Description	Butte County Plan Section
CWC § 10750 *et seq.*, Mandatory Components	
1. Documentation of public involvement statement	1.5
2. Establish basin management objectives	3.2, 3.5.3, 3.6.1
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping.	3.4
4. Plan to involve other agencies located within groundwater basin.	3.7.2
5. Adoption of monitoring protocols by basin stakeholders.	3.4, 3.5.3
6. Map of groundwater basin showing area of agency subject to GMP, other local agency boundaries, and groundwater basin boundary as defined in DWR Bulletin 118.	Figure 1-1 Figure 1-2
7. For agencies not overlying groundwater basins, prepare GMP using appropriate geologic and hydrogeologic principles.	1.3
CWC § 10750 *et seq.*, Voluntary Components	
8. Control of saline intrusion.	3.4.2, 3.6.2
9. Identification and management of wellhead protection areas and recharge areas.	3.5.6
10. Regulation of the migration of contaminated groundwater.	3.5
11. Administration of well abandonment and well destruction program.	3.5.1
12. Mitigation of conditions of overdraft.	3.6.3
13. Replenishment of groundwater extracted by water producers.	3.6.3
14. Monitoring of groundwater levels and storage.	3.4.1
15. Facilitating conjunctive use operations.	3.6.2, 3.6.3
16. Identification of well construction policies.	3.5.1
17. Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	3.6.3
18. Development of relationships with state and federal regulatory agencies.	3.7.1
19. Review of land use plans and coordination with land use planning agencies to assess activities that create reasonable risk of groundwater contamination.	3.5.5
DWR Bulletin 118 Suggested Components	
20. Manage with Guidance of advisory committee.	3.6.1, 3.7.2
21. Describe area to be managed under GMP.	1.3
22. Create link between BMOs and goals and actions of GMP.	Section 3
23. Describe GMP monitoring program.	3.4
24. Describe integrated water management planning efforts.	3.8
25. Report on implementation of GMP.	3.9.1
26. Evaluate GMP periodically.	3.9.2

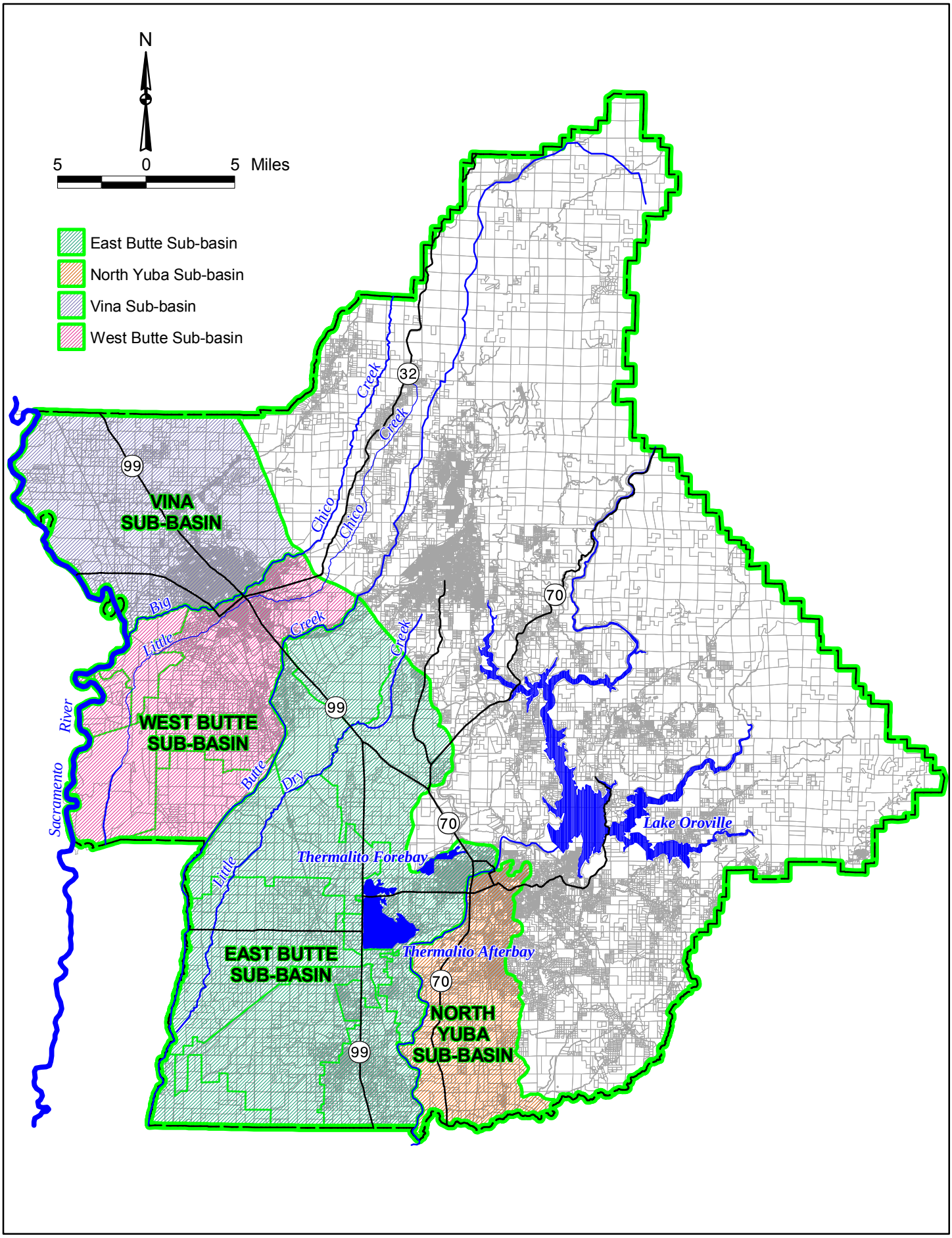


Figure 1-1
Sacramento Valley Groundwater Sub-basins in Butte County

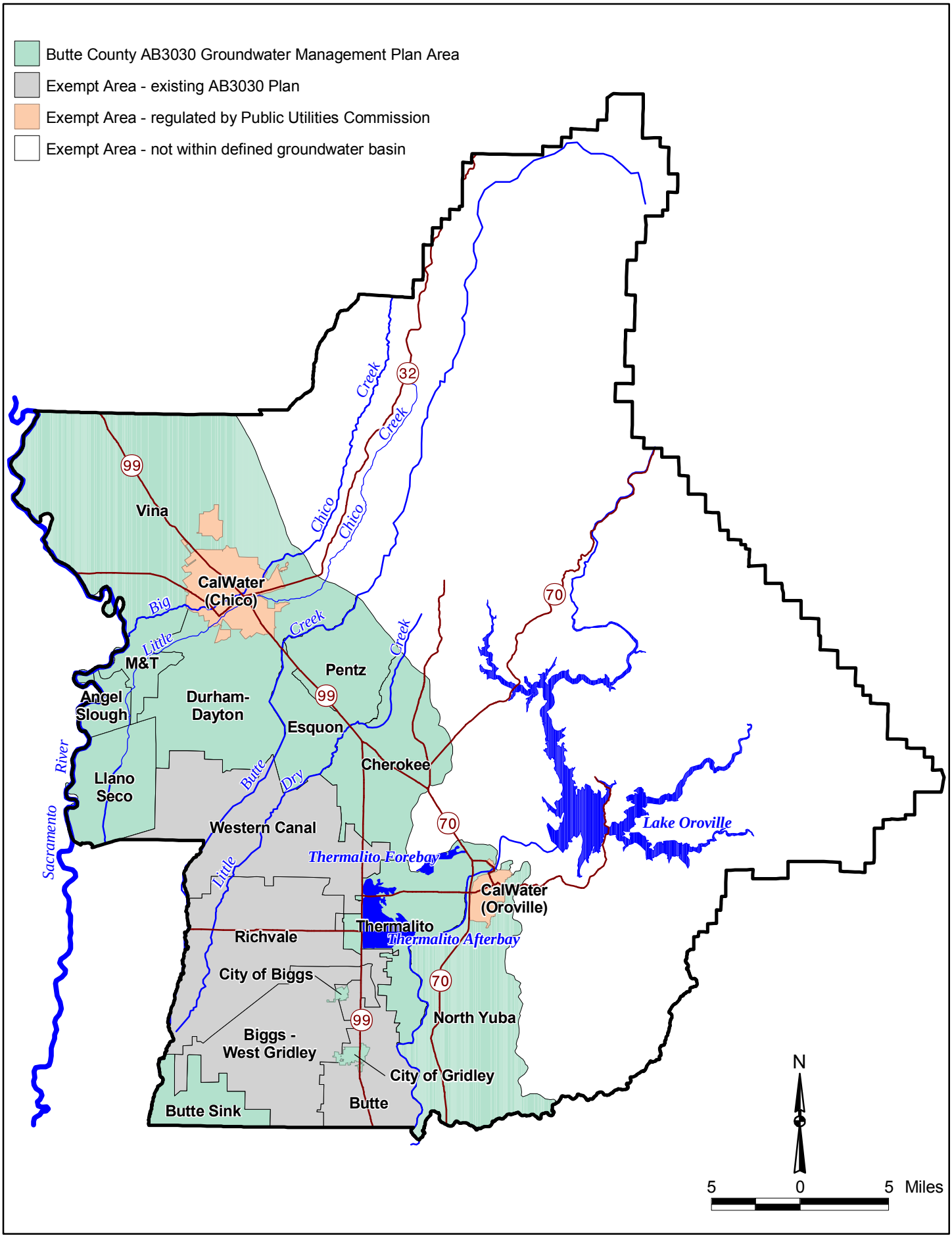


Figure 1-2
Butte County AB 3030 Plan Area

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. The 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 water suppliers or unorganized 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 within 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. Precipitation is strongly seasonal, with about half of the total annual precipitation generally occurring from November through mid-February. 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, 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 Honcutt Creek. Figure 2-2 illustrates the location of rivers, streams, water supply, and drainage features in the county.

Surface water bodies are believed to contribute to groundwater recharge as the water bodies traverse the outcrop locations of the county's freshwater-bearing geologic formations. Additionally, surface water managed for agricultural use contributes to groundwater recharge. Groundwater levels in upper aquifer of the Biggs-West Gridley sub-unit increase during the summer months in response to flood irrigation for rice production. 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 940,000 acre-feet in 2003 (Butte Basin Water Users Association, 2004).

2.5 Hydrogeology

The Sacramento Valley groundwater basin lies between the Coast Ranges 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 the Sacramento, Placer, Solano, Yolo, Yuba, Colusa, Tehama, Glenn and Butte Counties, and is the major source of groundwater in Butte County (DWR 2000).

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 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 of the Tuscan Formation occurs in these areas.

Figure 2-7
Tuscan Formation Recharge Areas

DWR Northern District is studying the confined nature of Tuscan Unit B. 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* (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. 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. Wells constructed in unconfined parts of the aquifer system tend to show less seasonal fluctuation in groundwater level than those in the lower, confined aquifer system because of the greater interconnection between shallow groundwater and surface-water systems.

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, 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).

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 in by a series of small arrows perpendicular to the groundwater elevation contours. 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 (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.

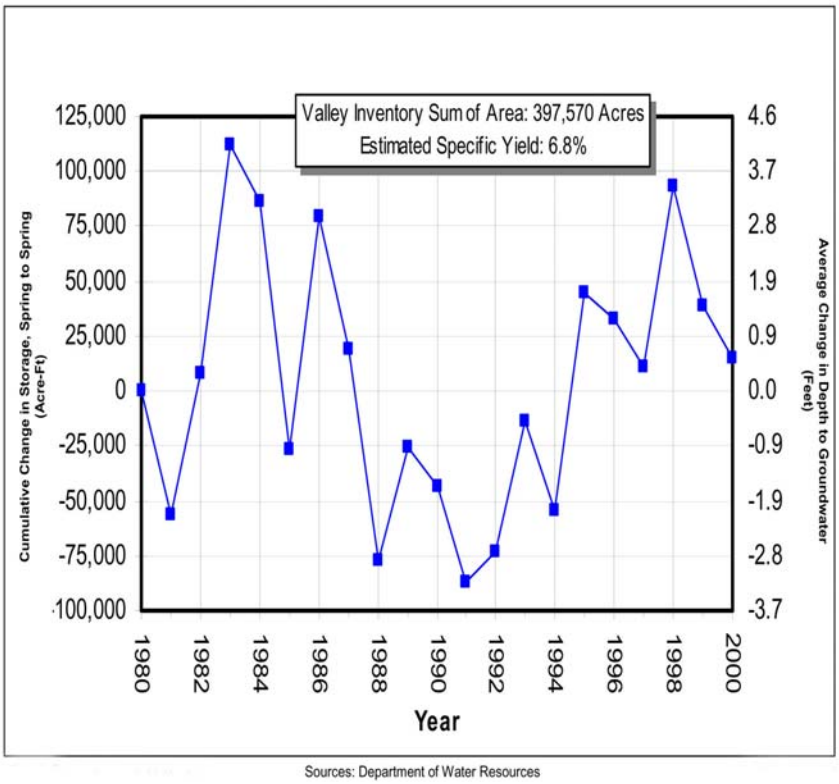


Figure 2-10
Changes in Groundwater Storage

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 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.

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 that is free of saline intrusion.

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

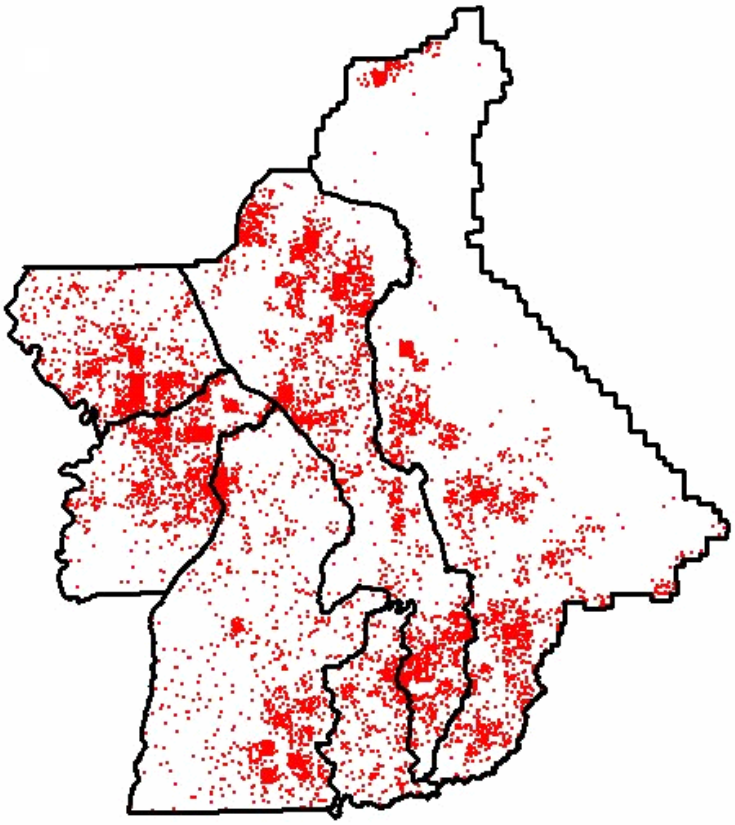
Inelastic land subsidence, for the purpose of the GMP, is the permanent lowering of the ground surface resulting from compaction of geologic materials caused by groundwater extraction. Permanent compaction is typically observed in fine-grained geologic materials. Land subsidence can damage infrastructure 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 in DWR's Well Completion Report database. The accuracy of



Source: DWR Northern District

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

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).

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							

Source: Department of Water Resources

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 in the valley area.
- The second largest demand component (15 percent) is conveyance losses, which represent 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:

- The 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 640 TAF in drought years, primarily due a reduction in surface water availability 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.

2.7.3 Water Demand and Supply Findings

The 2001 *Butte County Water Inventory and Analysis* report (CDM 2001) highlighted a number of findings with regard to the overall water supply conditions in the County:

- 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, not by total water supply.
- 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.

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 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

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.

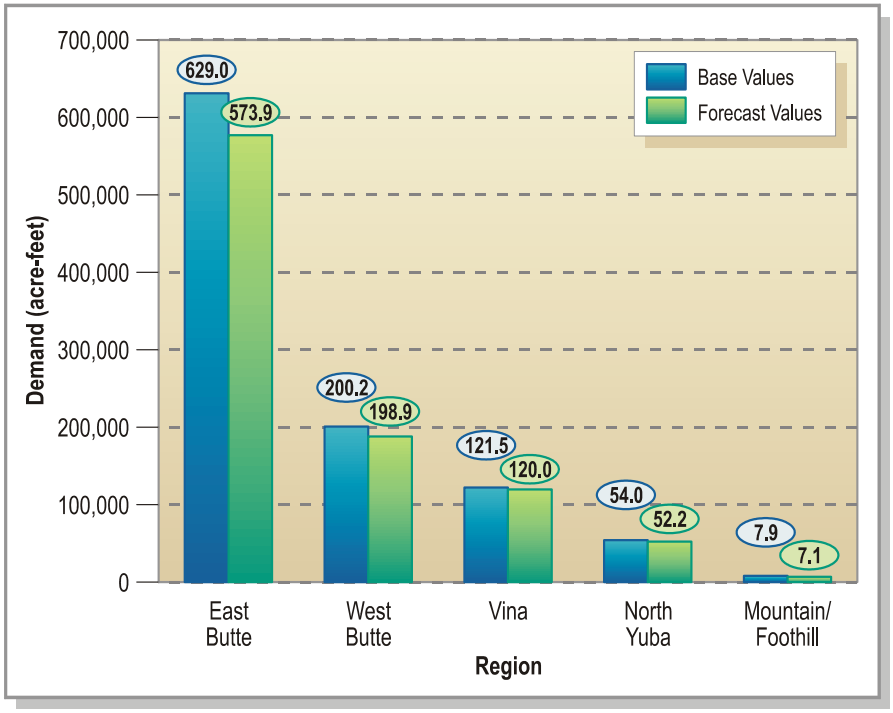


Figure 2-13
Comparison of Total Applied Water
Under Base and Combination (Average Year) Scenarios

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.

- 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	2,000 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

[1]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.

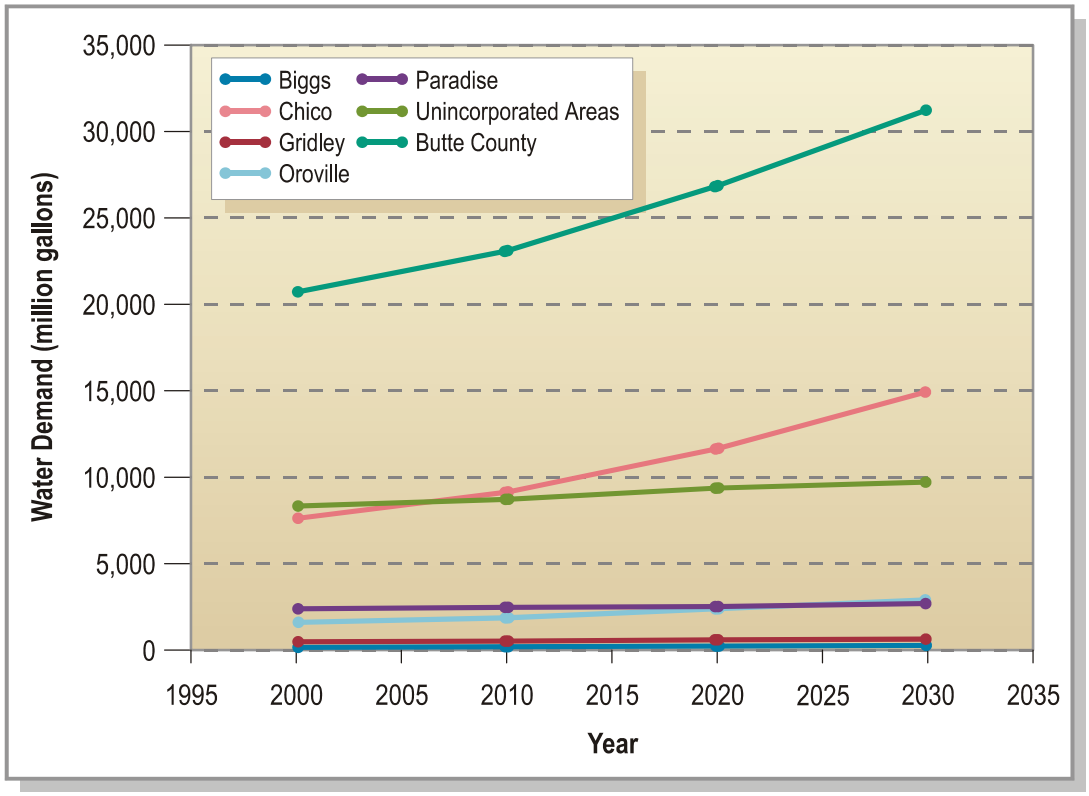


Figure 2-14
Urban Water Demand Forecast Results

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

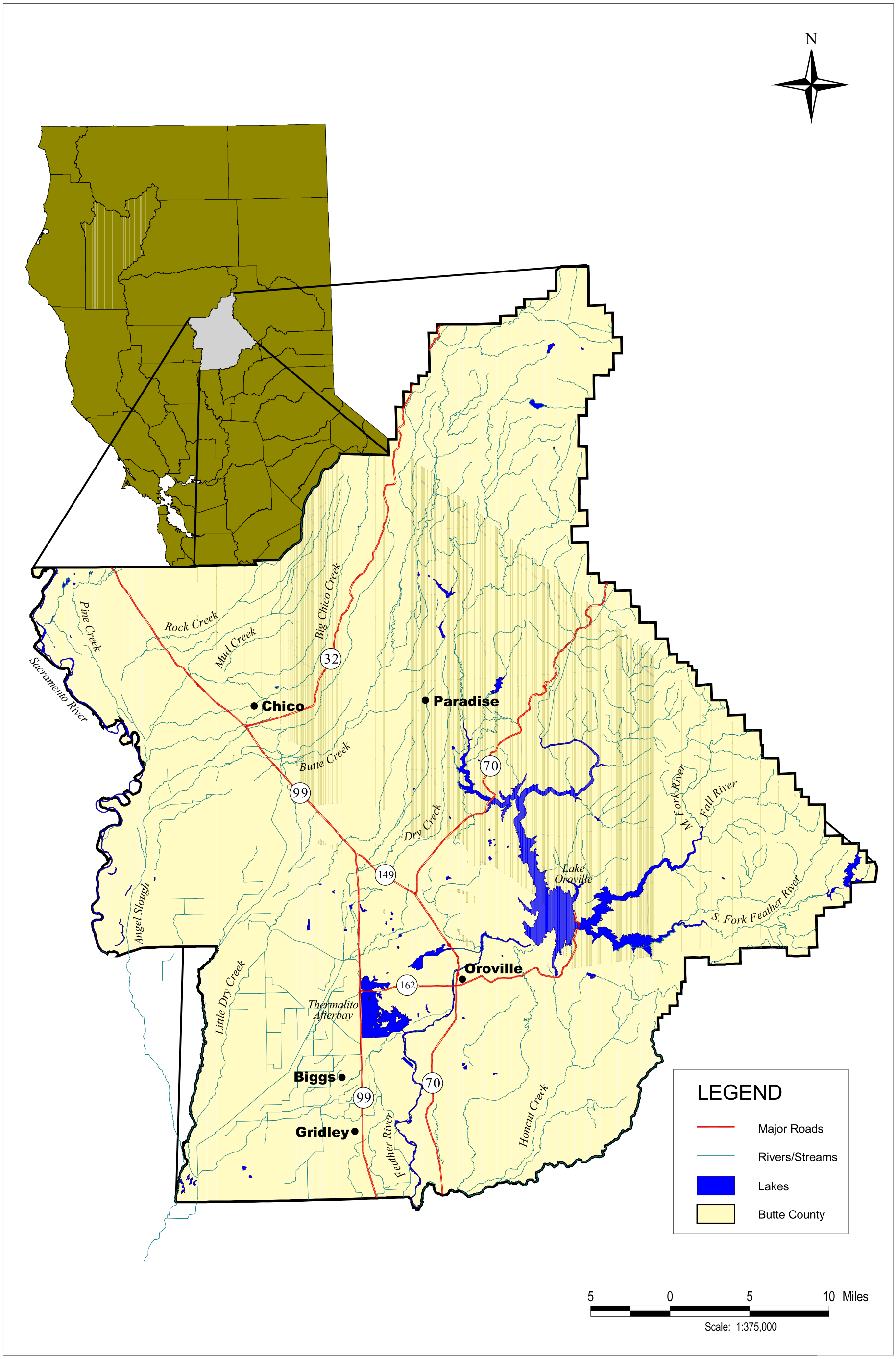
The demand for Paradise is projected to grow from 2,431.3 million gallons in 2000 to 2,701.2 million gallons in 2030, an increase of 11 percent.

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.

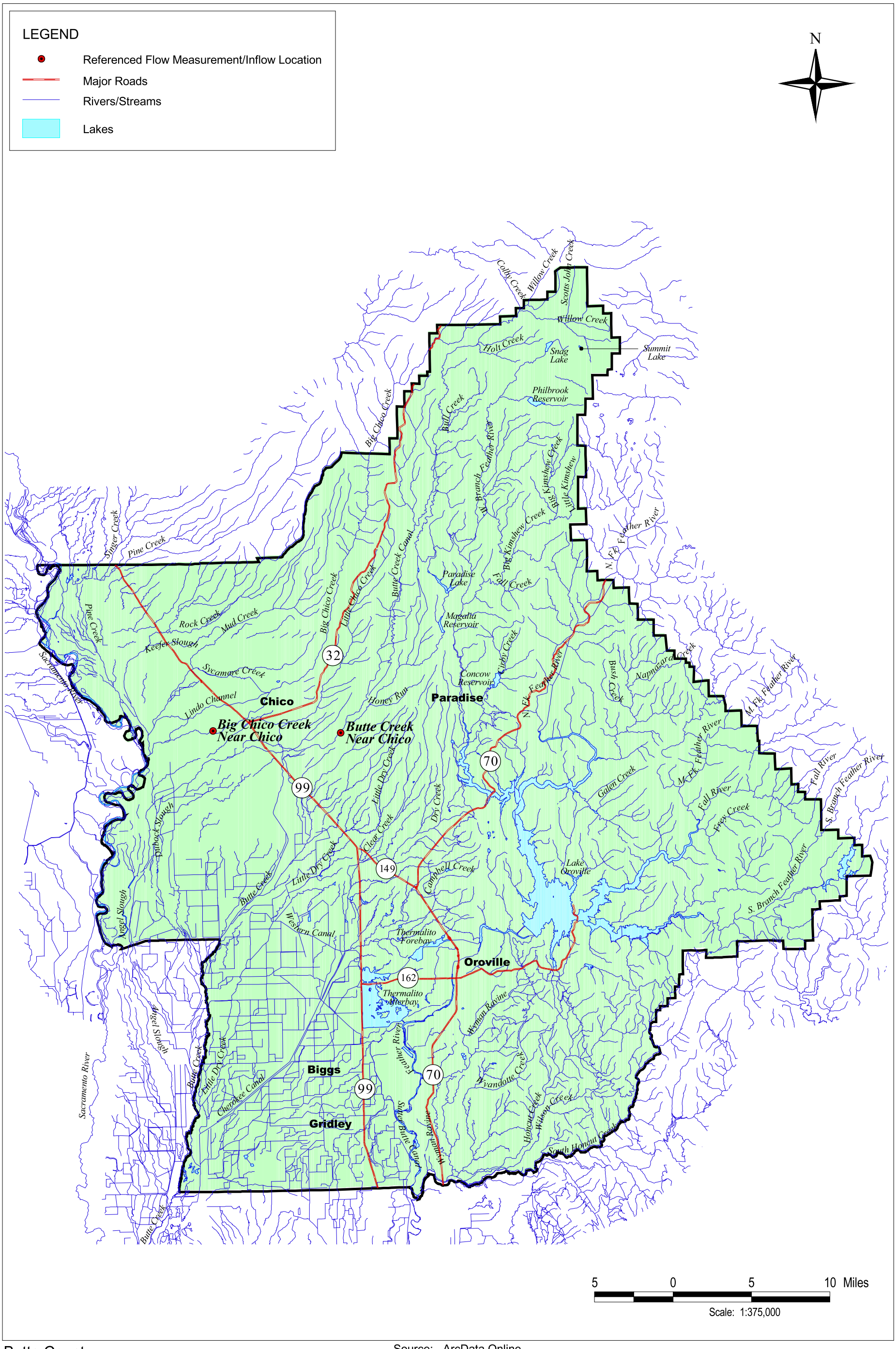


Source: Butte County Planning Department

Butte County
Department of Water & Resource Conservation

CDM Camp Dresser & McKee Inc.

Figure 2-1
Location Map



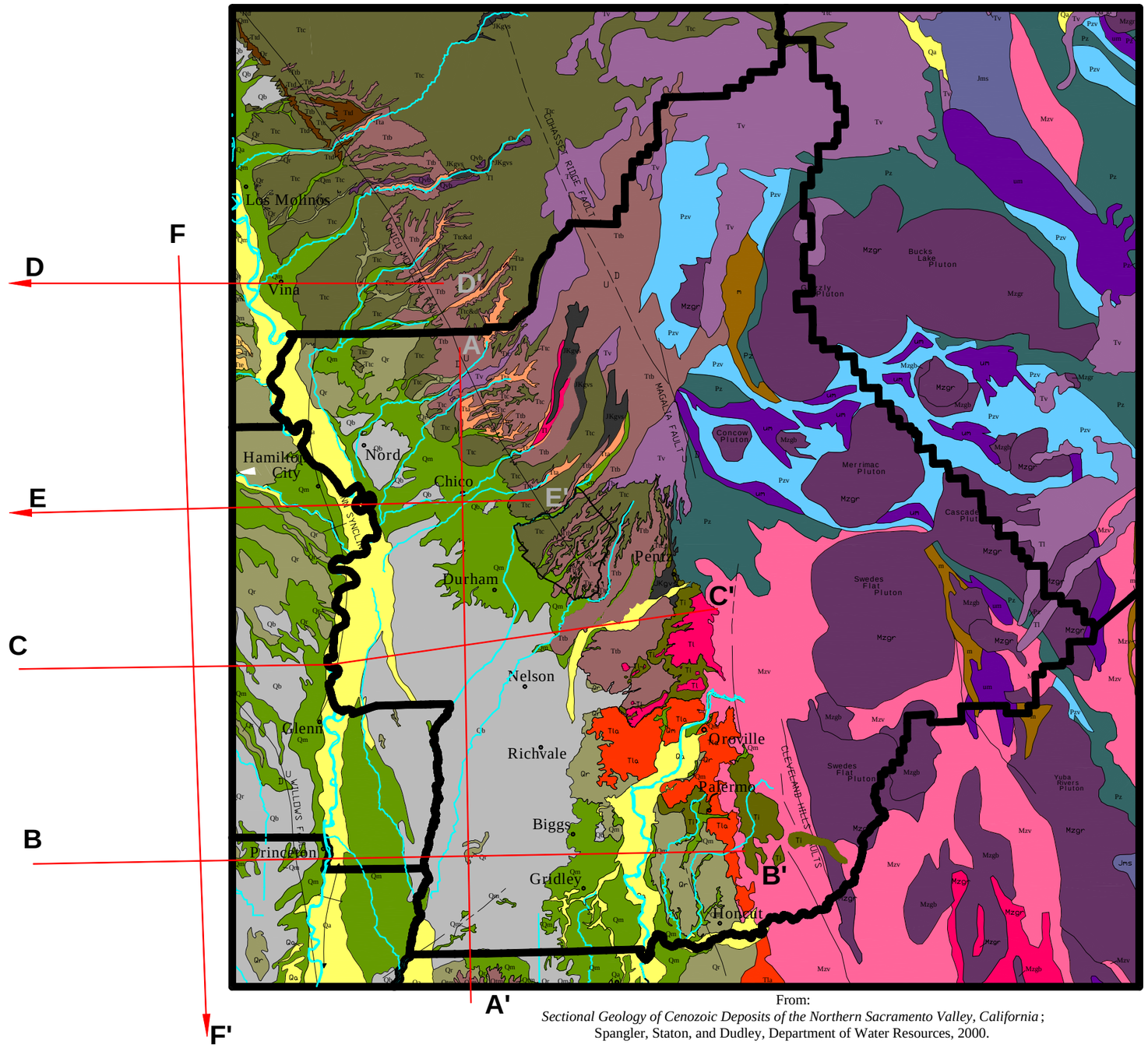
Source: ArcData Online

Butte County
Department of Water & Resource Conservation

Figure 2-2
Surface Water Features of Butte County

CDM Camp Dresser & McKee Inc.

GEOLOGIC MAP OF BUTTE COUNTY



Map Legend

Fault - dashed where location is approximate; U indicates upthrown side and D indicates downthrown side.

Thrust Fault - dashed where location is approximate; barbs are on the upthrown side.

Anticline

Syncline

Base of Fresh Water-Base of fresh water was determined from electric log resistivity and represents a specific conductance of less than 3,000 micromhos per centimeter.

D D'

Location of Geologic Cross-Sections: Letters correspond to geologic sections shown in Plates 4 and 5. Arrows indicate that cross-section extends beyond the shown area.

5 0 5 10

MILES

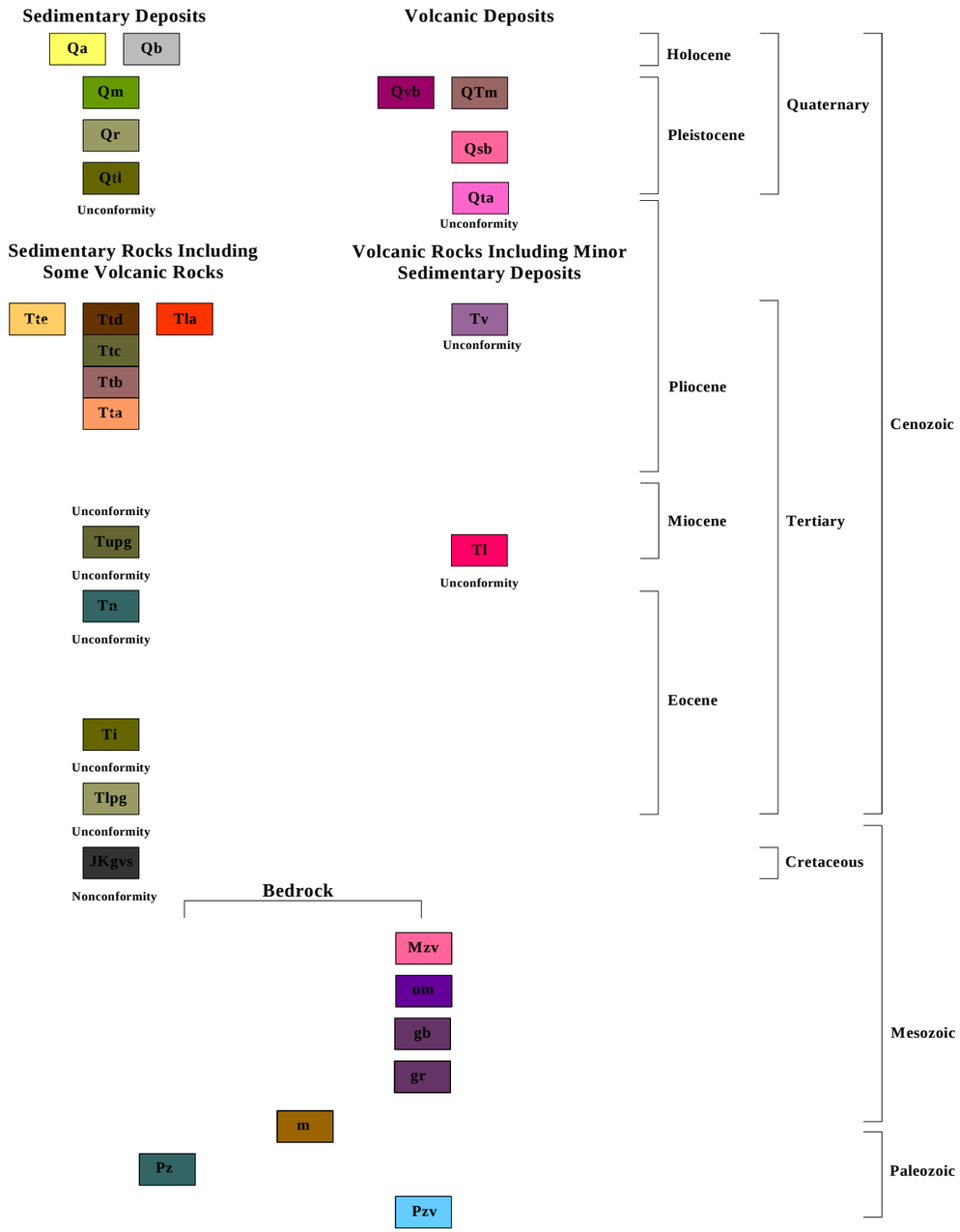
From:
Sectional Geology of Cenozoic Deposits of the Northern Sacramento Valley, California;
Spangler, Staton, and Dudley, Department of Water Resources, 2000.

CDM Camp Dresser & McKee Inc.

Source: Department of Water Resources

Figure 2-3
Geologic Map of Butte County

CORRELATION OF MAP UNITS



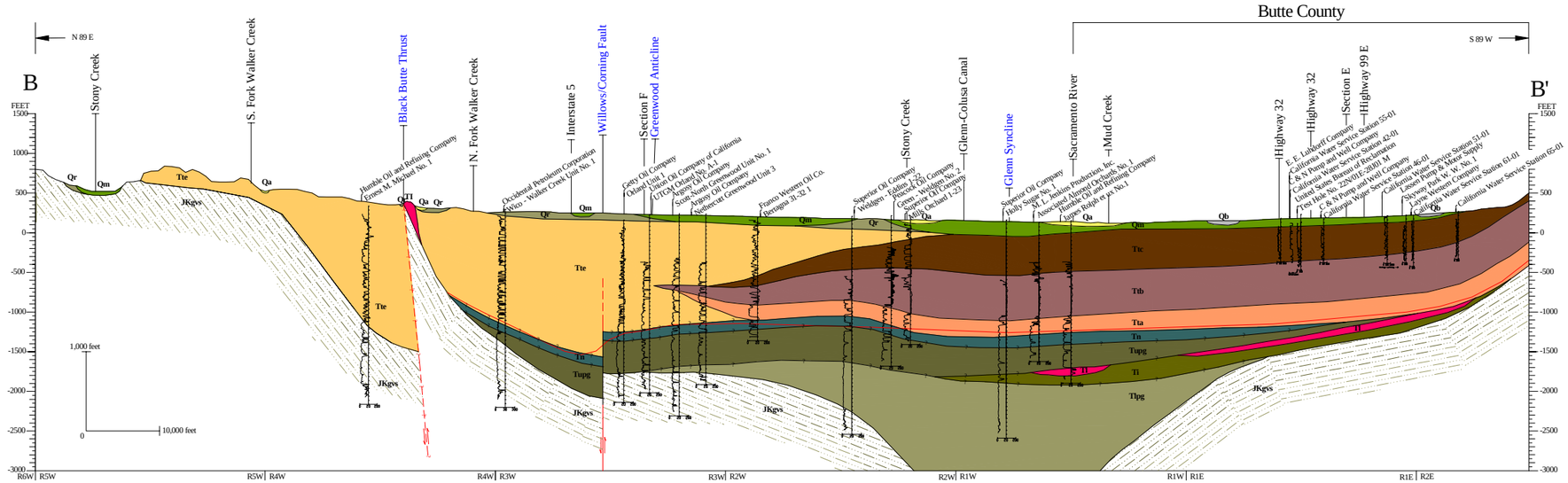
DESCRIPTION OF MAP UNITS

Qa	**Alluvium** (Holocene)-Includes surficial alluvium and stream channel deposits of unweathered gravel, sand and silt, maximum thickness 80 ft. *(adapted from Harwood and Helley, 1985)*.
Qb	**Basin deposits** (Holocene)-Fine-grained silt and clay derived from adjacent mountain ranges, maximum thickness up to 200 ft. *(adapted from Harwood and Helley, 1985)*.
Qm	**Modesto Formation**, undifferentiated (Pleistocene)-alluvial fan and terrace deposits consisting of unconsolidated weathered and unweathered gravel, sand, silt and clay, maximum thickness approximately 200 ft. *(adapted from Harwood & Helley, 1985).*
Qr	**Riverbank Formation**, undifferentiated (Pleistocene)-alluvial fan and terrace deposits consisting of unconsolidated to semi-consolidated gravel, sand and silt, maximum thickness approximately 200 ft. *(adapted from Harwood and Helley, 1985).*
Qtl	**Turlock Lake** (Pleistocene)-weathered and dissected arkosic gravels with minor amounts of resistant metamorphic rock fragments and quartz pebbles, sand and silt; maximum thickness approximately 100 ft. *(adapted from Harwood and Helley, 1985).*
Qvb	**Volcanic Basalts**, undifferentiated (Pleistocene)-younger basalt flows found primarily on the east side of the Sacramento Valley, includes minor exposures of andesite, maximum thickness 100 ft. *(adapted from Harwood and Helley, 1985).*
QTm	**Tuff Breccia** (Pliocene-Pleistocene)-tuff breccia forming outer ring surrounding the Sutter Buttes *(adapted from Harwood and Helley, 1985).*
Qsb	**Alluvium of the Sutter Buttes** (Pliocene-Pleistocene)-Volcanic fluvatile sediments, maximum thickness 980 ft.
Qta	**Volcanic Andesites**, undifferentiated (Pleistocene-Pliocene)-younger andesites forming the center of the Sutter Buttes *(adapted from Harwood and Helley, 1985).*
Tte	**Tehama Formation** (Pliocene)-includes Red Bluff Formation. Pale green, gray and tan sandstone and siltstone with lenses of pebble and cobble conglomerate, maximum thickness 2,000 ft *(adapted from Harwood and Helley, 1985)*.
Ttd	**Tuscan Unit D** (Pliocene)-Fragmental flow deposits characterized by monolithic masses containing gray hornblende and basaltic andesites and black pumice, maximum thickness 160 ft. *(adapted from Harwood and Helley, 1985)*
Ttc	**Tuscan Unit C** (Pliocene)-Volcanic lahars with some interbedded volcanic conglomerate and sandstone, maximum thickness 600 ft. *(adapted from Harwood and Helley, 1985; Staton (unpublished), 2000)*
Ttb	**Tuscan Unit B** (Pliocene)-Layered, interbedded lahars, volcanic conglomerate, volcanic sandstone and siltstone, maximum thickness 600 ft. *(adapted from Harwood and Helley, 1985; Staton (unpublished), 2000)*
Tta	**Tuscan Unit A** (Pliocene)-Interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone containing metamorphic rock fragments, maximum thickness 400 ft. *(adapted from Harwood and Helley, 1985; Staton (unpublished), 2000)*
Tla	**Laguna Formation** (Pliocene)-Interbedded alluvial gravel, sand and silt, maximum thickness 1,000 feet. *(adapted from Harwood and Helley, 1985; Olmsted and Davis, 1961; DWR Bulletin 118-6, 1978).*
Tv	**Basalts and andesites**, undifferentiated (Pliocene)-older basalts and andesites found on the northeastern portion of the Sacramento Valley and southwest of Winters, maximum thickness up to 230 ft. *(adapted from Harwood and Helley, 1985)*.
Tupg	**Upper Princeton Gorge** (Miocene-Eocene)-Non-marine sediments composed of sandstone with interbeds of mudstone and occasional conglomerate and conglomerate sandstone, maximum thickness 1,400 ft.
Tn	**Neroly Formation** (Miocene)-marine to non-marine sediments, blue-gray tuffaceous andesiticsandstone with interbeds of light grey tuff and tuffaceous shales and occasional conglomerate lenses, maximum thickness 500 ft.
Ti	**Lovejoy Basalt** (Miocene)-Black, dense, hard microcrystalline basalt, maximum thickness 65 feet. *(adapted from Harwood and Helley, 1985)*
Ti	**Ione Formation** (Eocene)-Marine to non-marine deltaic sediments, light colored, commonly white conglomerate, sandstone and siltstone, which is soft and easily eroded, maximum thickness 650 ft.
Tlpg	**Lower Princeton Gorge** (Eocene)-includes Capay Formation. Marine sandstone, conglomerate and interbedded silty shale, maximum thickness 2,400 ft. (*adapted from Redwine, 1972*)
JKgvs	**Great Valley Sequence** (Late Jurassic to Upper Cretaceous)-Marine clastic sedimentary rock consisting of siltstone, shale, sandstone and conglomerate, maximum thickness 15,000 ft.
Mzv	**Volcanic and Metavolcanic Rocks** (Mesozoic)-Undivided volcanic and metavolcanic rocks, andesite rhyolite flow rocks, greenstone, and volcanic breccia. (*adapted from Jennings, 1977*)
um	**Ultramafic Rocks** (Mesozoic)-Primarily composed of serpentine, with peridotite, gabbro, and diabase. (*adapted from Jennings, 1977*)
gb	**Gabbro** (Mesozoic)-Gabbro and dark diotric rocks. (*adapted from Jennings, 1977*)
gr	**Undifferenciated Granitic Plutons** (Paleozoic-Mesozoic)-Undivided granitic plutons and related rocks. (*adapted from Jennings, 1977*)
m	**Mixed Rocks** (pre-Cenozoic)-Undivided metasedimentary and metavolcanic rocks of greatly varying types. (*adapted from Jennings, 1977*)
Pz	**Paleozoic Metasedimentary Rocks** (Paleozoic)-Undivided metasedimentary rocks including slate, shale, sandstone, chert, conglomerate, limestone, dolomite, marble, phyllite,schist, hornfels, and quartzite. (*adapted from Jennings, 1977*)
Pzv	**Paleozoic Metavolcanic Rocks** (Paleozoic)-Undivided metavolcanic rocks, primarily flows, breccia, and tuff, including greenstone, diabase and pillow lavas. (*adapted from Jennings, 1977*)

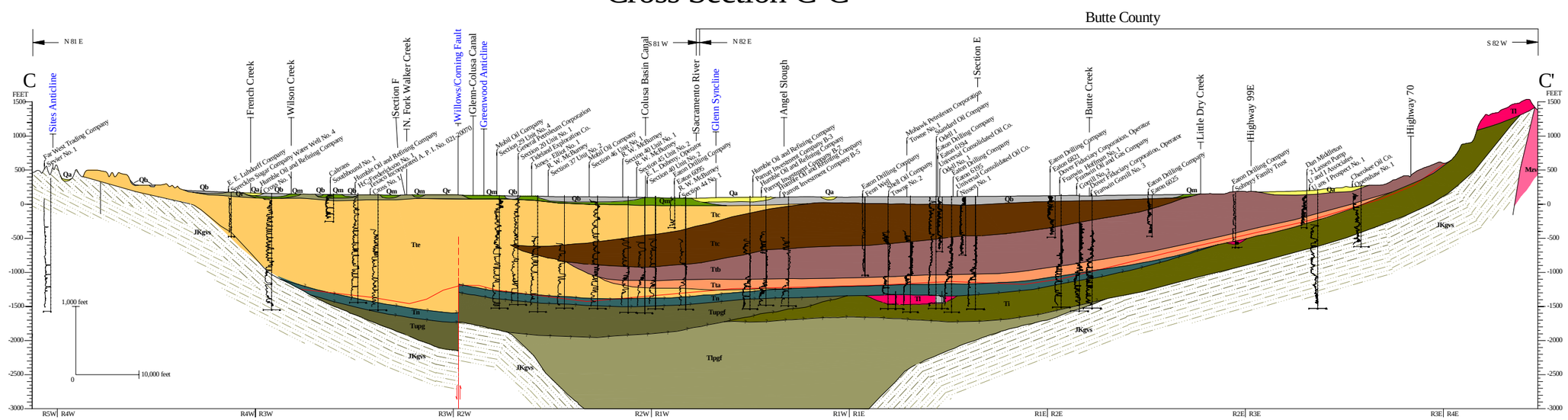
Source: Department of Water Resources

Figure 2-4
Geologic Legend

Cross Section B-B'



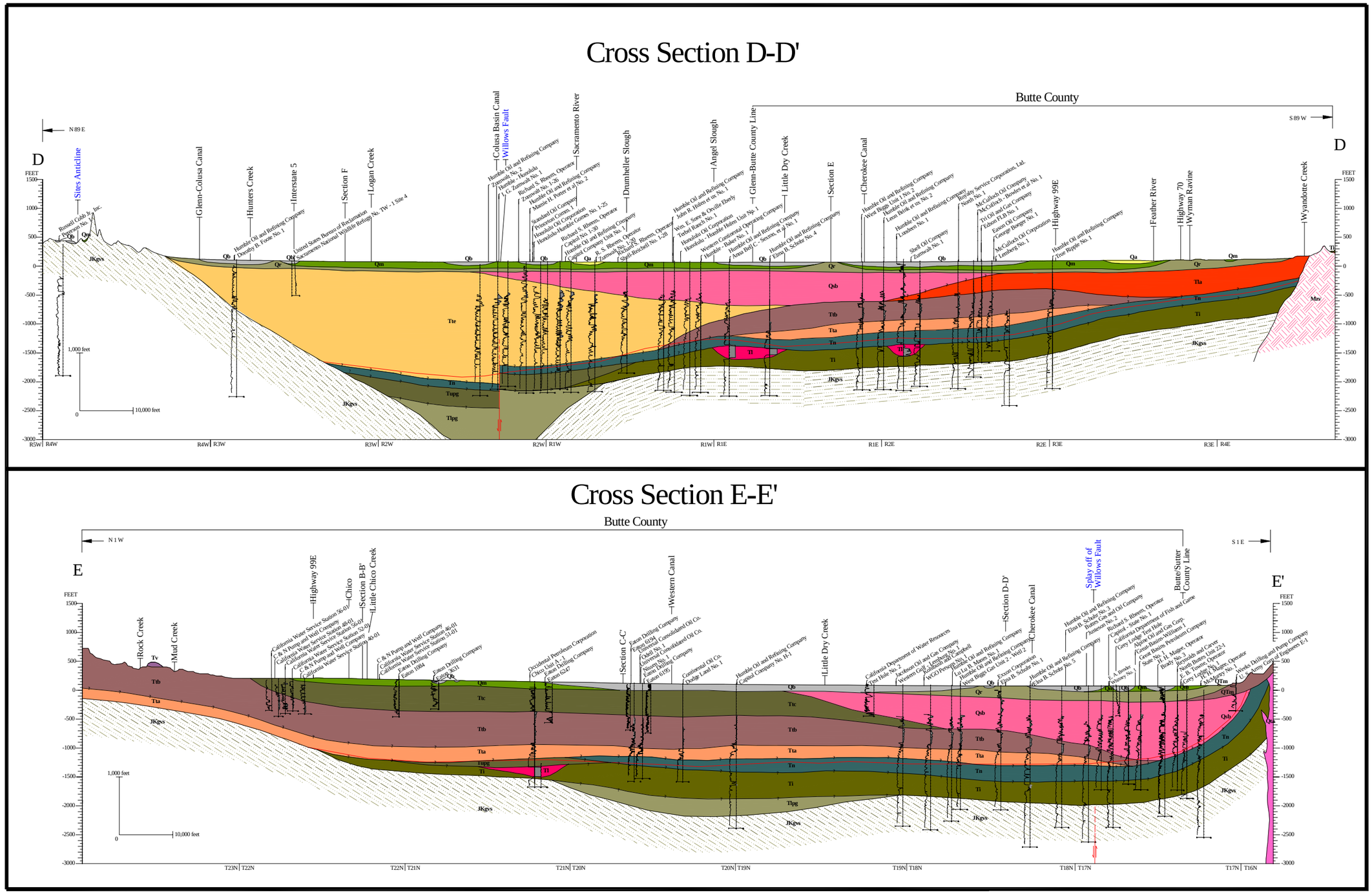
Cross Section C-C'



CDM Camp Dresser & McKee Inc.

Source: Department of Water Resources

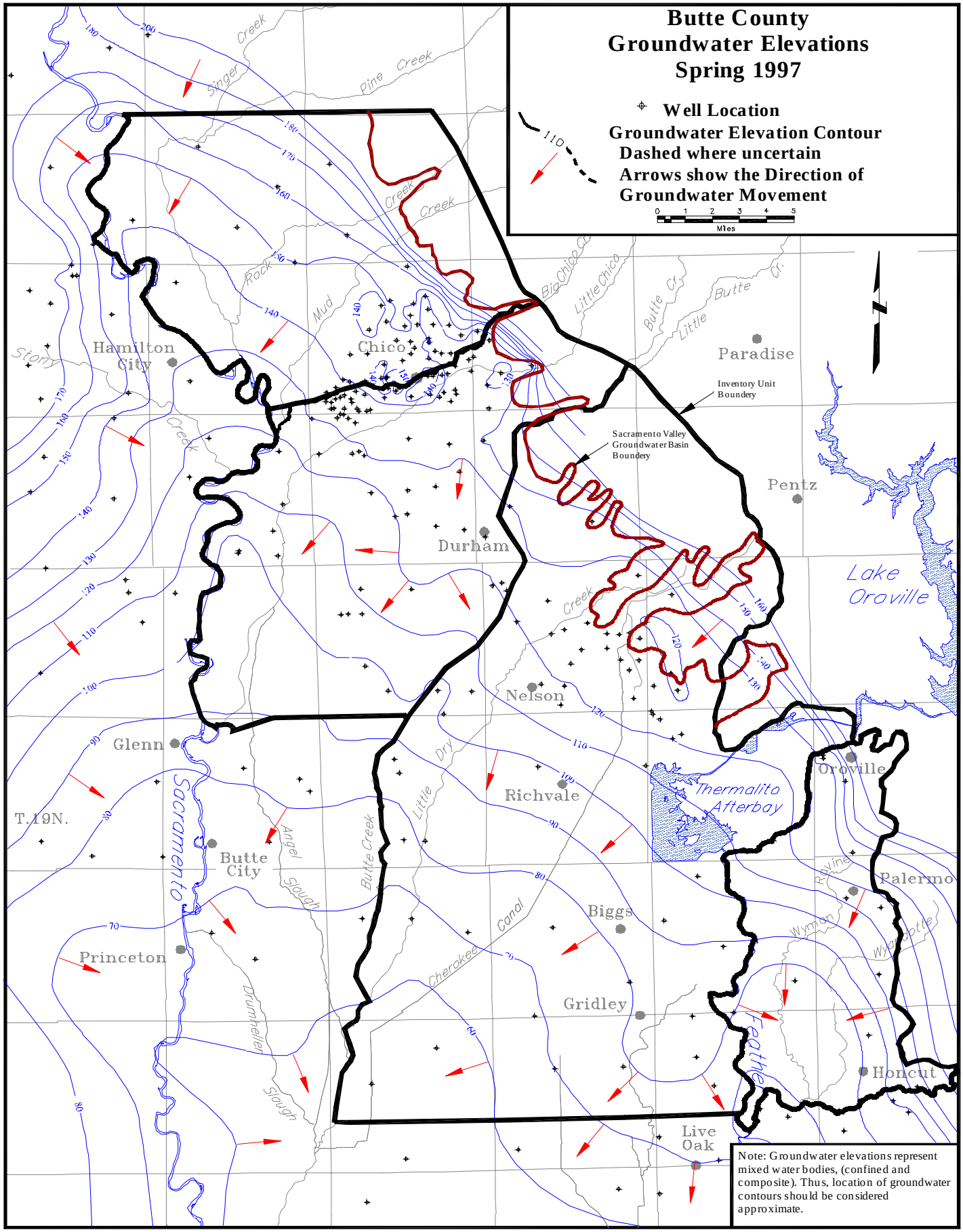
Figure 2-5
Butte County Geologic Map
Cross Section B-B' and C-C'



Source: Department of Water Resources

CDM Camp Dresser & McKee Inc.

Figure 2-6
Butte County Geologic Map
Cross Section D-D' and E-E'

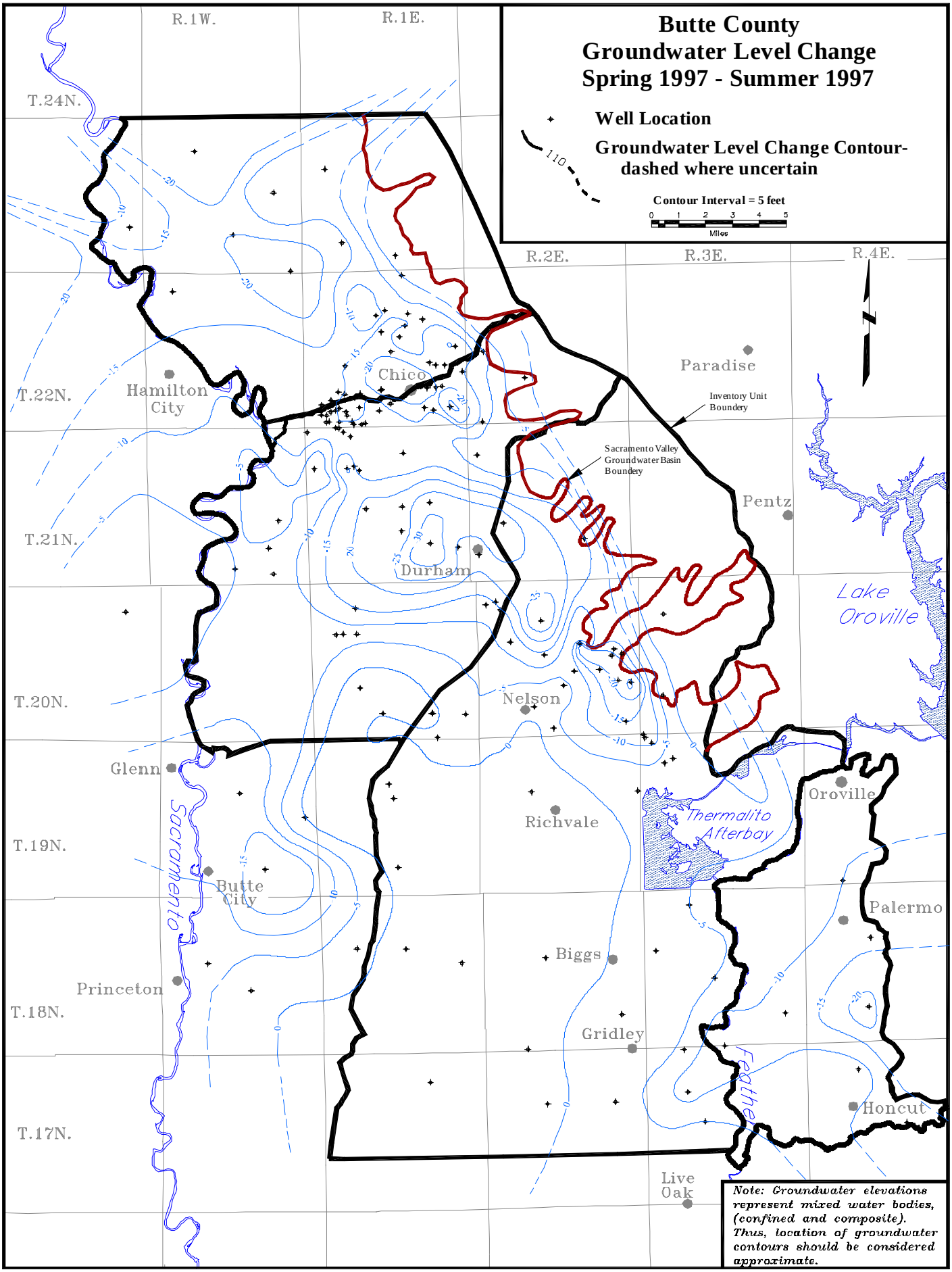


CDM Camp Dresser & McKee Inc.

Source: Department of Water Resources

Figure 2-8

Butte County Groundwater Elevations Spring 1997



CDM Camp Dresser & McKee Inc.

Source: Department of Water Resources

Figure 2-9

Butte County Groundwater Level Change Spring 1997 - Summer

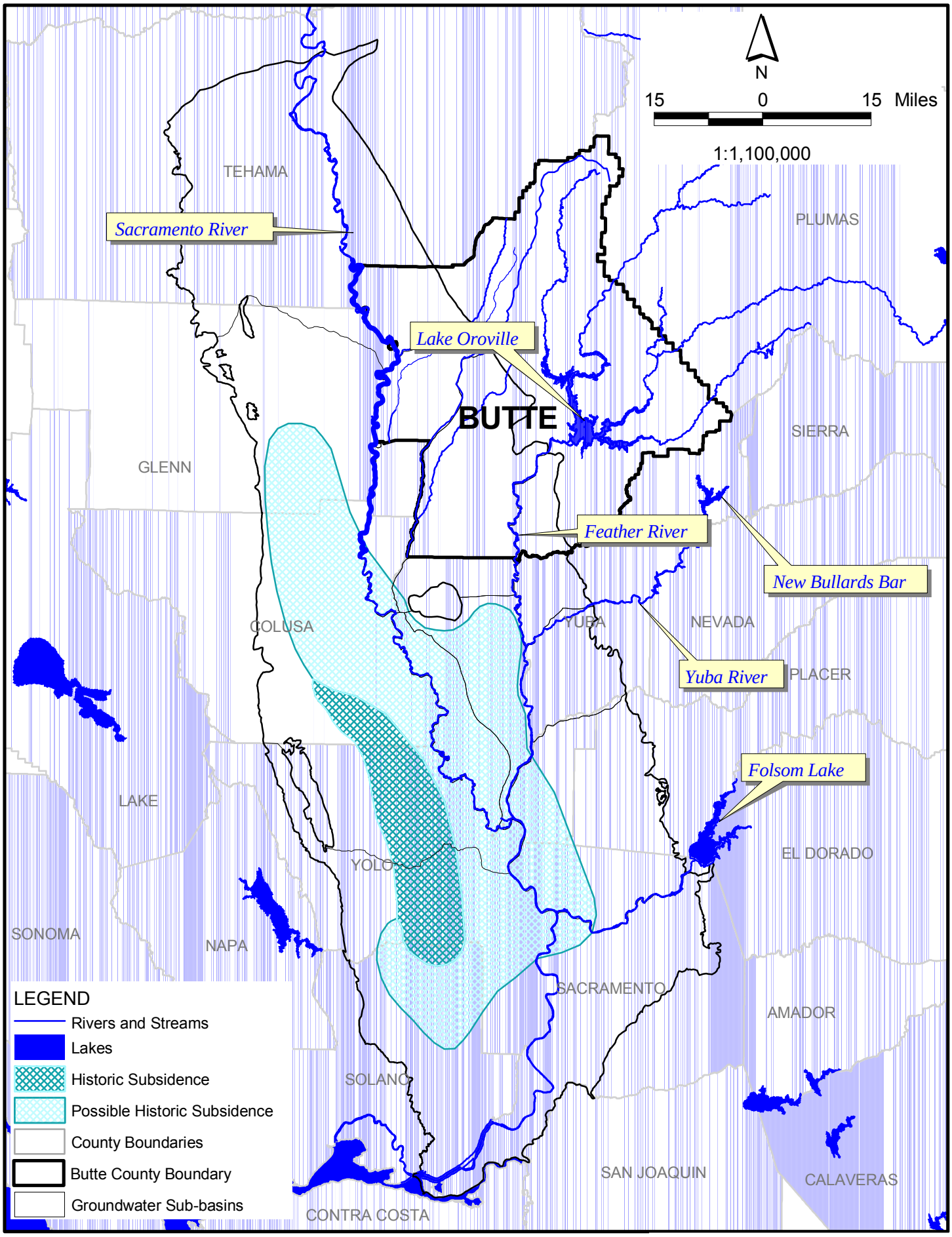


Figure 2-11
Regional Subsidence

Section 3
Plan Implementation

The Department is already performing many of the groundwater management activities associated with an AB 3030 Groundwater Management Plan. Through plan implementation, the Department is formalizing its groundwater management goal, management objectives, and plan components that elaborate on both current actions and planned future actions under the GMP.

3.1 Groundwater Management Goal

The goal of the Butte County GMP is to maintain or enhance groundwater quantity and quality, thereby providing a sustainable, high quality supply for agricultural, environmental, and urban use into the future that remains protective of resident's health, welfare, and safety.

3.2 Groundwater Management Objectives

Butte County began to establish groundwater management objectives in Chapter 33 of the Butte County Code, the Groundwater Conservation Ordinance. The purposes of Chapter 33 include:

> "The groundwater underlying Butte County is a significant water resource which must be reasonably and beneficially used and conserved for the benefit of the overlying land by avoiding extractions which harm the Butte Basin aquifer, causing exceedence of the safe yield or a condition of overdraft."

To accomplish the stated plan goal, the following management objectives are adopted under the Butte County GMP:

- Minimize the long-term drawdown of groundwater levels;
- Protect groundwater quality;
- Prevent inelastic land surface subsidence resulting from groundwater pumping;
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality;
- Minimize the effect of groundwater pumping on surface water flows and quality; and
- Facilitate groundwater replenishment and cooperative management projects.

The Butte County Board of Supervisors February 10, 2004 approval of a groundwater management ordinance, amending Chapter 33A of the Butte County Code, directs the Department to support the development and implementation of quantitative BMOs

within 16 defined sub-inventory units overlying the groundwater basin by February 2005. The above stated management objectives will guide development of the quantitative BMOs in Butte County. The Butte County Groundwater Management is included in Appendix B.

3.3 GMP Components

As discussed in section 1.6 and shown on Table 1-2, a number of mandatory, recommended, and voluntary components constitute the GMP content. These components have been grouped and are discussed, with proposed actions, under the following five headings:

- Groundwater Monitoring;
- Groundwater Resource Protection;
- Groundwater Sustainability;
- Stakeholder Involvement; and
- Integrated Water Resource Planning.

3.4 Groundwater Monitoring

The Department, in close cooperation with DWR Northern District, has developed and monitors an extensive monitoring network, as shown on Figure 3-1. Ongoing groundwater monitoring provides information needed to document current conditions, assess long-term trends, and to support development and implementation of BMOs associated with:

- Groundwater levels;
- Water quality; and
- Inelastic land subsidence.

3.4.1 Groundwater Elevation Monitoring

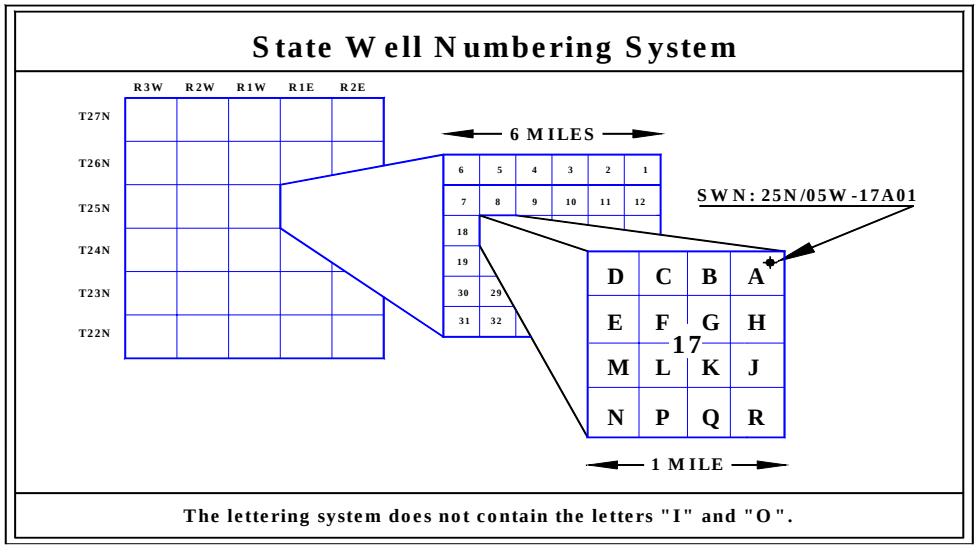
The Groundwater Conservation Ordinance (see Section 3.5.3) requires the Department, in cooperation with its Technical Advisory Committee, Butte Basin Water Users Association (BBWUA), DWR and the Regional Water Quality Control Board to develop and coordinate a countywide groundwater monitoring program. The program requires:

- Identification of specific monitoring wells.
- Measurement of groundwater levels in the monitoring wells at least four (4) times per year, during the months of March, July, August, and October.

- Each district and city within in the County is requested by the Department to submit copies of all its groundwater monitoring reports not later than December 1 of each year. Individuals are also encouraged to voluntarily provide any available groundwater data.

In 1997, the Department, in cooperation with DWR, began to expand the number of wells and frequency of groundwater level monitoring in the valley portion of Butte County. The current monitoring grid has 104 wells that the Department monitors for groundwater level. Approximately 29 of the 104 wells include water level sensors that continuously monitor and record water elevation. The remaining wells are monitored four times per year, in March, July, August, and October.

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,



Source: Department of Water Resources, Northern District

Figure 3-2
State Well Numbering System

range, section, and tract. Figure 3-2 illustrates the State Well Numbering System. An example could be a well designated 25N05W17A01M. The "25N" indicates the township, "05W" indicates the range, "17" indicates the section number, "A" indicates the tract portion of the section, "01" indicates that this is the first well installed in that area, and "M" stands for Mount Diablo Meridian (the baseline for the township and range system). Maps often represent this well information with just the section, tract portion of section and number; in this case, 17A01.

Recent monitoring results and a discussion of groundwater levels are included in the annual report submitted to the Butte County Water Commission by BBWUA entitled *2003 Groundwater Status Report*. The report is included in Appendix C. In general, the overall health of groundwater elevations is good. Groundwater level declines ranging

from 0.8 to 2.0 feet per year have been observed in many areas of the county. The report recommends close observation of groundwater level trends in areas with observed declines, but increased groundwater extraction is not believed to be the cause.

3.4.2 Groundwater Quality Monitoring

Groundwater quality monitoring is now required under the Groundwater Management ordinance as codified in Chapter 33A-9. At a minimum, groundwater samples will be collected once per year during peak groundwater use (July or August) and analyzed for temperature, pH, and electrical conductivity (EC).

The Department last conducted groundwater quality sampling throughout the Butte Basin during the week of July 28 through August 1, 2003. In cooperation with the DWR Northern District and the California State University, Chico, ten actively pumped wells throughout the basin were sampled for temperature, total dissolved solids (TDS), EC and pH. Figure 3-1 shows the sample locations and Table 3-1 presents the results of the water quality testing.

TDS measurements generally indicate the quantity of inorganic salts and small amounts of organic matter. The California state and Environmental Protection Agency (EPA) secondary drinking water standard for TDS is 500 milligrams per liter (mg/L), and the agricultural water quality goal for TDS is 450 mg/L. The secondary standards refer to the levels above which the constituent may be objectionable because of aesthetics or taste. All samples collected in 2003 indicated TDS levels meet both agricultural and drinking water standards.

The EPA's recommended preferable range for pH is from 6.5 and 8.5. All of the pH levels sampled for the basin are within this preferred range.

Table 3-1
Butte County 2003 Groundwater Quality Assessment

State Well Number	Approximate Location	Temperature ˚C	TDS (ppm)	EC (µS)	pH
18N02E35R01M	Gridley	18.5	184	370	7.5
19N04E06E02M	Oroville	17.9	82	164	6.5
20N01E15D01M	Western	18.1	123	248	8.1
20N02E09M02M	Esquon	19.9	213	425	7.5
20N02E15R01M	Western	18.2	172	344	6.6
20N02E24Q01M	Cherokee	21.9	115	232	7.5
21N01E15E02M	Dayton	19.9	175	348	7.2
21N03E26E01M	Butte Valley	26.4	93	186	6.9
22N01E15D02M	M&T	18.2	279	551	7.5
23N01E29L03M	North Chico	20.3	109	225	7.6

TDS – Total Dissolved Solids (parts per million)
EC – Electrical Conductivity (microseimens)

3.4.3 Inelastic Land Subsidence Monitoring

Four extensometers were installed between 1999 and 2003 by DWR in conjunction with the Department. Extensometer locations are shown on Figure 3-1. Two of the four wells are currently capped due to artesian flow. The Department does not currently monitor these two extensometers, but will monitor them after extending the well casing to a level above the well's static water level. Figures 3-3 and 3-4 present the extensometer records from the other two wells. Recent subsidence monitoring results are included in the BBWUA *2003 Groundwater Status Report*. The report is included in Appendix C. Extensometer measurements indicate subsidence is not occurring. Qualitative observation also indicates no subsidence of a significant magnitude.

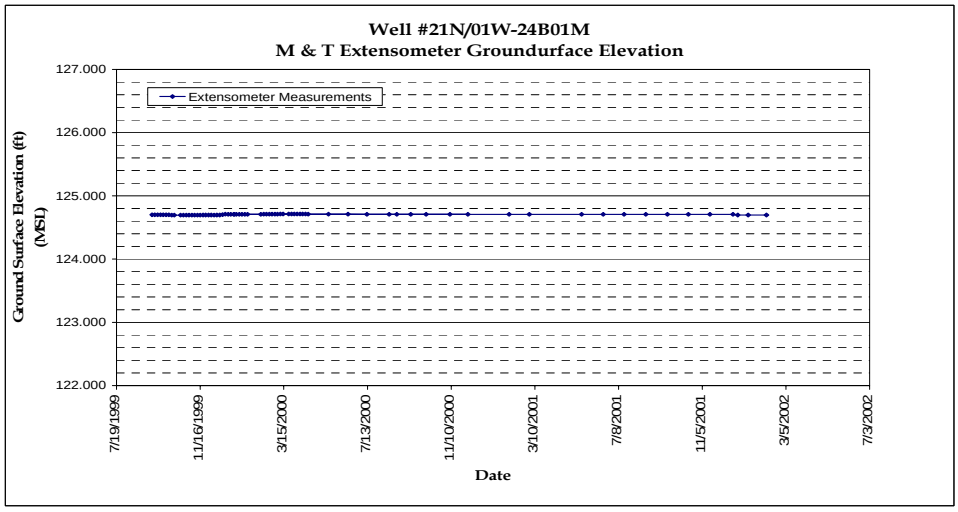
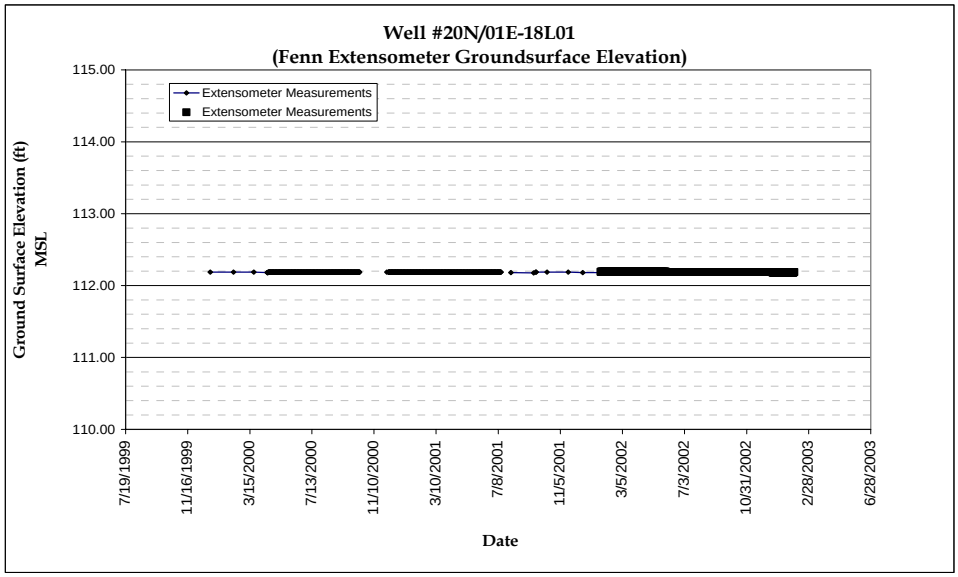


Figure 3-3
Extensometer 21N01W24B01M



Source: Department of Water Resources

Figure 3-4
Extensometer 20N01E18L01M

Groundwater Monitoring Actions: The Department will take the following actions:

- Support the development and implementation of BMOs in 16 sub-inventory areas overlying the groundwater basin.
- Work with local stakeholders and DWR to identify areas that may need additional groundwater level, groundwater quality, or subsidence monitoring based on identified data gaps or negative performance trends.
- Work with state and federal agencies to secure funding for expansion of the monitoring grid.
- Coordinate with DWR and local landowners to ensure that selected wells are maintained as part of a long-term monitoring program.

3.5 Groundwater Resource Protection

Butte County has enacted various ordinances specifically designed to promote the protection of groundwater resources, including:

- Groundwater well ordinances (5);
- Groundwater Management Program and Plan ordinance;
- Groundwater Management ordinance (BMO ordinance); and
- Groundwater Conservation ordinance.

Additional groundwater protection measures are provided under the Conservation Element of the County's General Plan. Wellhead and recharge protection measures may also be considered by the Department to facilitate groundwater protection. The following sections describe existing groundwater resource protection ordinances and measures.

3.5.1 Groundwater Well Ordinances

The California Water Code (13700 through 13806) requires proper construction of wells, and minimum standards for the construction of wells are specified in DWR Bulletins 74-81 and 74-90. These standards apply to all water wells, cathodic protection wells, and monitoring wells.

Chapter 23B of the Butte County General Ordinances enforces minimum standards for the construction of wells as specified in DWR Bulletins 74-81 and 74-90, except where superseded by state or federal law or modified by resolution of the Butte County Board of Supervisors, and also provides procedures for well spacing of new wells to reduce potential well interference problems.

The following is an overview of principal Butte County Ordinances related to groundwater well permitting, construction, and abandonment as contained in the Butte County Code.

- **Chapter 23B-3 Well Permitting**. This ordinance requires that any person, firm, association, organization, partnership, joint venture, business trust, corporation, company, federal, state or local agency, or special district formed under the laws of this state shall, within the unincorporated area of the County of Butte, obtain a written permit from the health officer to construct, repair, or deepen any public water supply well or individual well, or destroy any abandoned well. The permit application procedures are outlined in Chapter 23B-4.

- **Chapter 23B-5 Well Standards**. Standards for the construction, repair, reconstruction, deepening, abandonment and destruction of wells in Butte County are specified within Bulletin 74-81, Water Well Standards, State of California, except where superseded by state or federal law or modified by resolution of the Board of Supervisors.

- **Chapter 23B-5a Pumping capacity and parcel size**. The pumping capacity of the well's pump shall not be greater than fifty (50) gallons per minute per acre to reasonably serve the overlying land, including contiguous parcels of land under the same ownership as the land upon which the well is located. The total of the pumping capacities of the pumps for the new well and all existing wells (excepting wells which are exempt under section 23B-5c(1) and section 23B-5c(4)) within the applicable parcels shall not exceed fifty (50) gallons per minute per acre. The limitation on pumping capacity applies to all wells required to have a permit under this chapter and that are installed after July 25, 1996.

- **Chapter 23B-5b Well spacing requirements**. Butte County has established a well spacing ordinance. This ordinance requires that any well required to have a permit under Chapter 23B of the County Ordinances, and installed after July 25, 1996 be subject to the spacing requirements summarized in Table 3-2.

Table 3-2
Summary Butte County Well Spacing Requirements

Engineered Pumping Capacity (Gallons per minute)	Well Spacing Requirement (feet)
1000	450
2000	1,150
3000	1,700
4000	2,200
5000	2,600
Greater than 5000	Variance shall be required

- **Chapter 23B-13 Minimum well depth for domestic wells.** This chapter of the Ordinances requires that new individual well for domestic purposes be drilled to an adequate depth to ensure that it "will operate properly assuming a repeat of the groundwater conditions experienced during the period 1987 through 1994 in the area in which the new well is located."

3.5.2 Groundwater Management Program and Plan Ordinance

Chapter 24A of the General Ordinances of Butte County pertains to the coordination of groundwater management programs and plans adopted by various public agencies within the County.

The ordinance requires that the County help coordinate groundwater management programs and plans adopted within the County, and provide a minimum and uniform standard of groundwater protection within the County. To accomplish this, the ordinance states that the County should:

- Identify and implement, on a comprehensive and integrated basis, existing County ordinances and land use planning policies and their applicability and effect on groundwater management and regulation within the County.

- Protect the groundwater resources within the County through the management and regulation of groundwater pursuant to the County's police power and land use authority.

- Coordinate and cooperate with local water agencies, purveyors and groundwater users within the County.

- Participate in annual meetings to coordinate groundwater programs as required by CWC § 10755.3.

3.5.3 Groundwater Management Ordinance (BMO ordinance)

In January 2002, the Water Commission recommended to the Board of Supervisors to investigate the concept of utilizing BMOs as a potential method to manage the groundwater basin. The Board accepted this recommendation and directed the Department to proceed with the development of BMOs for the basin area of the County. The Department drafted and publicly circulated a draft ordinance for consideration by the Board. After significant public comment and ordinance revisions to address comment, the Board approved the ordinance on February 10, 2004.

The ordinance is based on several key guidelines, summarized below:

- The Board finds that the protection of the groundwater resource for beneficial use within the County is of major concern to the residents of the county for the protection of their health, welfare, and safety. The Board further declares that the

beneficial use and maintenance of groundwater and protection of recharge zones is of critical importance to the economy and environment of the County.

- The Board intends to ensure the continued sustainability of groundwater quantity and quality within the county.
- The Board intends to protect groundwater quality and prevent land subsidence.
- The County does not hereby intend to regulate, outside of Chapter 33, the use of groundwater; unless established BMOs are exceeded.
- It is essential for information gathering and management purposes that the County maintains a monitoring program addressing groundwater elevations, groundwater quality standards, and land subsidence criteria.
- In adopting this groundwater management ordinance, the County does not intend to limit other means of managing groundwater within the county authorized elsewhere in statute or ordinance, and intends to work cooperatively with local entities and the general public to further develop and implement joint groundwater management practices.

Table 3-3 provides an overview of a generalized BMO development and implementation process. The process for development and implementation of BMOs is discussed in Section 3.6.1.

Table 3-3
Generalized Approach to BMO Development[1]

Planning Phase	
	Develop Organizational Structure Establish Public Input Process Establish Management Areas
Implementation Phase	
	Obtain Statutory Authority Establish Advisory Committees Establish Monitoring Elements Establish Monitoring Program Develop Management Objectives
Management Phase	
	Collect Data Evaluate Data Reevaluate Monitoring Program Reevaluate Management Objectives Determine Need For Resolution
Resolution Phase	
	Technical Advisory Committee Investigation and Recommendation Water Advisory Committee (WAC) Strives For Mutually Agreeable Solution WAC Recommendation To Board Of Supervisors Board Of Supervisors Action

[1] From MO Presentation By Toccoy Dudley, DWR, Northern District

3.5.4 Groundwater Conservation Ordinance

Chapter 33 of the General Ordinances of Butte County pertains to the protection of groundwater resources from harm resulting from both the extraction of groundwater for use on lands outside the County and the substitution of groundwater for surface water transferred outside the County. The main components of the ordinance are described below:

- **Transfer Pumping Permits**: The ordinance bars the extraction of groundwater for use outside the County without first obtaining a permit. Permits are also required for groundwater pumping for use on land within the county in lieu of surface water, if the surface water which would have otherwise been used on the land is proposed to be transferred outside the County.

- **Monitoring**: As described in detail in Section 3.4.1, this ordinance requires that the Department, in coordination with BBWUA, DWR, and the Regional Water Quality Control Board "develop and coordinate a county-wide groundwater monitoring program".

- **Planning/Reporting**: A groundwater status report is to be developed based upon the data gathered and analyzed from the required monitoring program (see Section 3.9.1).

3.5.5 Conservation Element of General Plan

Butte County's General Plan, which sets out the County's adopted goals, objectives, policies and standards for various issues, includes a Conservation Element that emphasizes the importance of Butte County's natural resources, and outlines methods to protect these resources.

As part of the Department's Integrated Water Resource Plan development, the Department has provided technical information to the Butte County Department of Development Services to support an update of the water resource section of the General Plan's Conservation Element.

3.5.6 Wellhead and Recharge Area Protection Measures

To date, Butte County has not formally adopted wellhead or recharge area protection measures. The Department is currently in the process of completing its Integrated Water Resource Plan that includes a policy recommendation specific to protection of groundwater recharge areas through appropriate zoning and other management measures. The Butte County Water Commission and Board of Supervisors will consider implementation of policy recommendations for during the plan review and approval process.

Butte County has not pursed a wellhead protection plan, however, a federal program is in place to support development of such a plan if the Department deems it necessary. The purpose of the federal Wellhead Protection Program is to protect

groundwater sources of public drinking water supplies from contamination, thereby eliminating the need for costly treatment to meet drinking water standards. The program was established by the Safe Drinking Water Act Amendments of 1986 and is based on the concept that the development and application of land-use controls (usually applied at the local level in California) and other preventative measures can protect ground water.

A Wellhead Protection Area (WHPA), as defined by the 1986 Amendments, is "the surface and subsurface area surrounding a water well or wellfield supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." The WHPA may also be the recharge area that provides the water to a well or wellfield. Unlike surface watersheds that can be easily determined from topography, WHPAs can vary in size and shape depending on geology, pumping rates, and well construction.

Under the Act, states are required to develop an EPA-approved Wellhead Protection Program. To date, California has no formal state-mandated program, but instead relies on local agencies to plan and implement programs. For this reason, AB 3030 was enacted. A number of local governments, including Santa Clara Valley Water District, Descanso Community Water District, West San Bernardino County Water District, and Monterey County Water Management District, are in various stages of developing local ground water management programs that include WHPAs. Wellhead Protection Programs are not regulatory by nature, nor do they address specific sources. They are designed to focus on the management of the resource rather than control a limited set of activities or contamination sources.

Groundwater Resource Protection Actions: The Department will take the following actions:

- Support the development and implementation of BMOs in 16 sub-inventory areas overlying the groundwater basin.
- Participate in the review and provide recommendation for permit applications submitted under the Groundwater Conservation ordinance.
- Support the Butte County Department of Development Services during the policy update of the water resource section of the General Plan's Conservation Element.
- Pursue implementation of Integrated Water Resource Plan policies, programs, and projects approved by the Board of Supervisors, including recommendations addressing protection of groundwater recharge areas and development of a cooperative management program.
- Evaluate the need for a wellhead protection program in Butte County.

3.6 Groundwater Sustainability

The Department is currently engaged in various activities that promote groundwater sustainability. Specific actions currently being pursued or studied include:

- Development of quantitative Basin Management Objectives;
- Groundwater modeling; and
- Assessment of the potential for cooperative groundwater management between surface water and groundwater users.

3.6.1 Development of Quantitative Basin Management Objectives

Following the Board of Supervisors' February 10, 2004 approval of a Basin Management Objective (BMO) ordinance, the Department is supporting local areas with development of BMOs within their respective areas. The ordinance states, "The Board intends to ensure the continued sustainability of groundwater quantity and quality within the county." Butte County Ordinance 3869, describing BMO development and implementation, is included as Appendix B.

Water Advisory Committee (WAC) members appointed by the Board of Supervisors will support BMO development and implementation. The Department has developed a BMO Development Packet for use by local BMO representatives in each of the 16 areas identified in the approved ordinance. The packets are intended to provide information and guidance necessary to develop BMOs within each area.

Local representatives will be responsible for the development, implementation, monitoring and reporting of groundwater levels, groundwater quality, and inelastic land subsidence within their local area. The Technical Advisory Committee will investigate reported noncompliance. Efforts will be made to resolve noncompliance issues at the local level. If noncompliance issues cannot be resolved at the local level, the Water Advisory Committee may recommend a plan to the Water Commission to modify, reduce or terminate groundwater extraction in the impacted/impacting area.

3.6.2 Groundwater Modeling

Groundwater models can be effectively used to assess how proposed groundwater management actions, changes in cultural practices, or changes in hydrologic conditions may affect groundwater sustainability.

In 1994, BBWUA developed a groundwater flow model of the "Butte Groundwater Basin" following the late 1980s through early 1990s drought. The model provides BBWUA with a tool to improve groundwater management within the basin. The model was last updated it in 2002. The Department has entered into an agreement with BBWUA whereby the Department is responsible for model updates and maintenance.

In support of the Department's Integrated Water Resource Plan project, the Department is currently completing a review and update of the Butte Basin Groundwater Model. As part of the model update, the Department is incorporating DWR Northern District's improved interpretation of the basin stratigraphy and hydrogeologic properties. An improved representation of these model properties will allow the Department to more accurately evaluate current and future water management options. The Department is also considering which model code will have the greatest utility during participation in regional groundwater studies and programs.

Once the groundwater model has been reviewed, updated and re-calibrated, it can be used to:

- Evaluate water transfer applications under chapter 33;
- Study short-, medium-, and long-term drought impacts to groundwater;
- Evaluate recharge benefits and impacts;
- Support updates of water inventory and analysis and annual groundwater status reports; and
- Support development of quantitative management objectives (see Section 3.6.1).

3.6.3 Construction and Operation of Groundwater Management Facilities

Ensuring the long-term sustainable use of the groundwater resources within the Plan area may require the planning and construction of projects that:

- Evaluate the need and potential for enhanced groundwater recharge;
- Enhance groundwater recharge;
- Facilitate cooperative management projects through improvements to recharge, extraction, and distribution infrastructure; and
- Protect groundwater quality, or remediate contaminated sites.

The Steering Committee supporting the development of the Integrated Water Resource Plan is currently considering policies, programs, and projects associated with the construction and operation of groundwater management facilities.

Groundwater Sustainability Actions: The Department will take the following actions:

- Provide technical support associated with development of BMOs in Butte County.

- Assist in coordination and management activities of the Water Advisory Committee.
- Complete an update of the BBWUA groundwater model and support maintenance of the model into the future.
- Utilize the groundwater flow model to simulate proposed changes in groundwater management practices that may impact groundwater sustainability.
- As directed by the Board, support the coordinated management of groundwater and surface water.
- Pursue funding from state agencies, federal agencies, and partnerships for groundwater sustainability activities.

3.7 Stakeholder Involvement

Public outreach and education is a primary function of the Butte County Department of Water and Resource Conservation. The Department encourages two-way dialogue, characterized by information dissemination and requests for suggestions and feedback on Department activities. The Department has regularly disseminated information on GMP development as part of its ongoing public outreach effort. GMP-related information and draft documentation are available to the public on the Department's website (http://www.buttecounty.net/waterandresource/) and have been included in the Department's monthly newsletter, *Water Solutions*, that is distributed in hardcopy and via e-mail to all interested parties.

The Department also regularly engages in cooperative efforts with state and federal agencies. Additionally, the Department actively encourages the involvement of advisory committees and related stakeholders. The following sections describe the Department's involvement with these water resource stakeholders.

3.7.1 Interagency and District Cooperation

Effective groundwater management requires coordination and cooperation between numerous local, state, and federal agencies. The Department will continue to work proactively with key state and federal regulatory agencies, as well as the local districts and County departments, such as:

Local Districts with AB 3030 Groundwater Management Plans. The Department works closely with local water districts, including those with existing AB 3030 Groundwater Management Plans. Water districts with existing AB 3030 groundwater management plans are represented on the Butte County Water Commission where they provide coordination between Department activities and groundwater management activities of the local water districts. Also, through his role as Chairman of the Butte Basin Water Users Association, the Department's Director, Ed Craddock,

facilitates communication and cooperation between the Department and members of BBWUA.

In Butte County, the following agencies have AB 3030 plans:

- Biggs-West Gridley Water District,
- Butte Water District,
- Richvale Irrigation District, and
- Western Canal Water District.

- **State Water Resources Control Board (SWRCB).** The SWRCB is the lead state water agency responsible for maintaining water quality standards and providing the framework and direction for groundwater protection efforts. The Department has established a working relationship with the SWRCB, which currently funds a number of watershed coordination programs within the County.

- **California Department of Water Resources.** DWR plays in important role in supporting both surface water and groundwater management. The Department and the DWR Northern District have worked cooperatively on a number of important programs, including the Butte County Groundwater and Surface Water Inventory Analysis. DWR also continues to support water level and extensometer monitoring in Butte County. Additionally, DWR is actively studying the Butte groundwater basin to achieve an improved understanding of the rate and direction of groundwater movement. DWR is also assessing groundwater recharge locations and rates within the county. These studies will provide information that could lead to improved groundwater management in the county.

- **Bureau of Reclamation (Reclamation).** The Department is working closely with Reclamation to develop projects to enhance both surface and groundwater management within the County. Reclamation plans to fund the review and update of the Butte County groundwater model.

- **California Bay-Delta Authority.** The Department has an inter-jurisdictional personnel exchange agreement with the California Bay-Delta Authority (CBDA), where a Department staff member is serving as CBDA's Sacramento Valley regional representative. The agreement enhances the Department's interaction with CALFED member agencies and provides a means for the Department to actively communicate the county's position on CBDA programs and activities that have the potential to affect Butte County.

3.7.2 Advisory Committees and Stakeholders

There are a number of important advisory committees and stakeholder groups that play an active role in managing the water resources of Butte County.

- **Butte County Water Commission.** The Butte County Water Commission was appointed by the Board of Supervisors to advise and provide technical information on water management issues affecting the County. The Water Commission is composed of one member representing each board district (nominated by the county supervisor elected to represent that district) and four members at large of whom two are landowners of property served by water districts and two are landowners served by private wells.

- **Water Commission Technical Advisory Committee.** The Water Commission in turn has nominated a seven person Technical Advisory Committee. The Technical Advisory Committee consists of individuals with backgrounds and/or education in water management and hydrology.

- **BMO Water Advisory Committee.** WAC members appointed by the Board of Supervisors will support BMO development and implementation. The WAC will be comprised of area-specific members, with one member appointed from each defined sub-inventory unit, and one each from the Foothill and Mountain inventory units. Additional at-large members will include representatives from the incorporated communities, the agricultural community, the environmental community, and one from each organized watershed group in the county.

- **Butte Basin Water Users Association.** BBWUA is one of the largest water management associations in the County, and was formed in response to a number of events affecting water users in the County, including the 1987-1992 drought. The main function of the association is to inform members of current and potential changes in local, state, and federal water policy that could affect water supplies. Current members of the BBWUA include:

  - Biggs-West Gridley Water District
  - Richvale Irrigation District
  - County of Butte
  - California Water Service Company
  - Western Canal Water District
  - Butte-Sutter Basin Area Groundwater Users Corporation
  - City of Biggs
  - City of Gridley
  - Durham Mutual Water Company

- **Butte-Sutter Area Groundwater Users Corporation.** Fred Montgomery formed the Butte-Sutter Area Groundwater Users Corporation (BSAGUC) in the early 1990s to represent independent groundwater producers' interests. BSAGUC is an initial member of BBWUA. The BSAGUC holds periodic meetings of its members to discuss groundwater management issues. As an example, the group provided comments on the recently enacted BMO ordinance in the county. The Department regularly solicits comment from BSAGUC on groundwater-related issues.

Stakeholder Involvement Actions: The Department will take the following actions:

- Continue to work cooperatively with DWR headquarters and DWR Northern District on groundwater management activities.
- Continue to work cooperatively with the Bureau of Reclamation on groundwater management activities.
- Continue to work cooperatively with the California Bay-Delta Authority on programs and policies that support groundwater management efforts in Butte County.
- The Department will be responsive to the needs and requests of the Water Commission, TAC, WAC, and BBWUA.
- The Department will continue to support locally-driven stakeholder groups.
- Consider Discussions to jointly develop a countywide coordinated AB3030 GMP that would incorporate areas with existing AB3030 plans.

3.8 Integrated Water Resource Planning

The Department is developing an Integrated Water Resources Plan to provide direction for the long-term enhancement and conservation of the County's resources. The Integrated Plan's stated purpose is "to improve water management in the County and to maintain agricultural viability, meet urban and environmental needs, ensure a future groundwater supply to overlying users, enhance the economy, and protect the citizens and natural resources of Butte County."

The Department initiated an 8-month planning process to develop the Integrated Plan. The Department formed a Steering Committee of local stakeholders

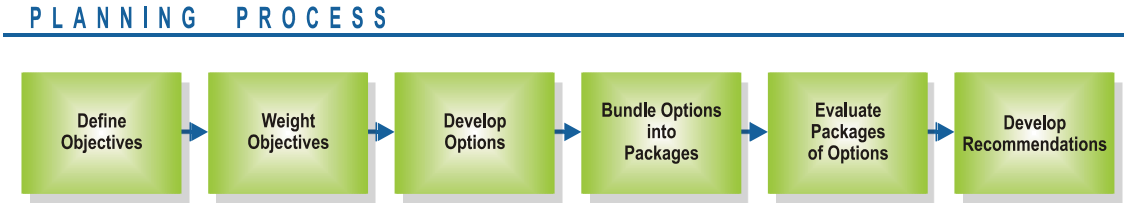


Figure 3-5
IWRP Planning Process

representing agricultural, urban, and environmental interests to participate in development of the Integrated Plan. Figure 3-5 depicts the planning process.

The Committee met six times during the planning process. First, the Committee developed plan objectives, which were grouped into four categories: local control, water supply, economy, and natural resources. Figure 3-6 presents the Plan's objectives. The Committee then developed options to meet the objectives. The options address environmental needs within the County, water conservation opportunities, water supply needs on the Ridge, conjunctive management programs, policy issues, and future management of the SWP allocation. The Committee evaluated each option and created a package of options to be considered for implementation.

The final product of the Integrated Plan is a set of policy recommendations for consideration by the Board of Supervisors. The policy recommendations have the Integrated Plan's objectives as their foundation and incorporate the options as a series implementation steps for each policy. The policy recommendations build off the County's existing water management efforts and if approved, will shape future Butte County water management.

Integrated Water Resource Planning Actions: The Department will take the following actions:

- Assist in the development of plan recommendations for consideration by members of the public, the Water Commission, and the Board of Supervisors.
- Implement plan policies, programs, and projects approved by the Board of Supervisors.
- Pursue funding sources for implementation of plan policies, programs, and projects.

3.9 GMP Implementation, Reporting and Updating

Implementation of the BMO ordinance will result in development of compliance reports associated with water level elevation, water quality, and inelastic land subsidence. The Department is currently receiving annual reports associated with groundwater level and land subsidence monitoring from BBWUA. GMP updates will be considered each five years or as needed on a more frequent basis. The following sections discuss plan implementation, reporting and updating in additional detail.

3.9.1 GMP Implementation

Plan section 3.3 identifies the five GMP component groups. Individual plan components are described in sections 3.4 through 3.8. Plan implementation actions are identified at the conclusion of each section. Additionally, this section concludes with actions associated with GMP implementation, reporting, and updating. Figure 3-4 summarizes implementation actions and the associated implementation schedule.

3.9.2 GMP Implementation Report

Currently, separate groundwater-related reporting is required by BBWUA under the Groundwater Conservation Ordinance (see Section 3.5.4) and by BMO sub-area representatives (see Section 3.6.1). Information contained in these reports is used to:

- Develop groundwater depth or elevation contour maps, which can be used to develop an understanding of the overall groundwater flow patterns in a basin;
- Develop groundwater hydrographs (charts of depth /elevation of groundwater versus time), which can be used to illustrate historic trends or changes in groundwater levels over time;
- Assess the change of groundwater in storage; and
- Measure changes in land surface elevation because of groundwater withdrawals.

Specific to the Groundwater Conservation Ordinance, BBWUA must submit a report summarizing the previous year's monitoring activities to the Department by February of each year. The report must include an analysis of the amount of groundwater pumping that can occur during the water year within each sub-basin without exceeding the safe yield of each sub-basin. Additionally, the Department requests each district and city within the county to submit copies of groundwater monitoring reports to the Department not later than December 1 of each year. The Department also encourages individuals to voluntarily provide any available groundwater data.

Specific to the BMO ordinance, representatives from each of the 16 individual BMO areas are required to submit results associated with groundwater level, groundwater quality, and land subsidence monitoring to the Department within 30 days of collection.

3.9.3 GMP Update

The Department's increasing knowledge of subsurface conditions and management techniques will likely result in the need for periodic plan updates. As further studies of basin geology and groundwater behavior provide new information, the Department must consider if this new information should result in a change in groundwater management. Additionally, as the Department works with different management techniques, it will likely realize more effective ways to accomplish the objectives within this Plan.

The Department will continually consider improvements to the groundwater management techniques. The Department will work to incorporate these improvements as they develop. In addition, the Department will formalize changes to this AB 3030 plan once every five years, if changes need to be made.

GMP Implementation, Reporting and Updating Actions: The Department will take the following actions:

- Pursue funding for a web-based BMO Information Center to house BMO development, implementation, and reporting information.
- Consider opportunities to consolidate reporting of groundwater level, groundwater quality, and inelastic land subsidence information as currently required of BBWUA and BMO participants.
- Work cooperatively with local stakeholders, county government, and local advisory committees to assess needed GMP updates.
- Sponsor an annual meeting of local districts with AB3030 GMPs to discuss the status of individual plans and opportunities for development of a countywide coordinated AB 3030 GMP.

Table 3-4. Summary of GMP Actions

	Description of Action	Implementation Schedule
I.	**Groundwater Monitoring**	
1	Support the development and implementation of BMOs in 16 sub-inventory areas overlying the groundwater basin.	Spring 2004 – Spring 2005
2	Work with local stakeholders and DWR to identify areas that may need additional groundwater level, groundwater quality, or subsidence monitoring based on identified data gaps or negative performance trends.	Annual
3	Work with state and federal agencies to secure funding for expansion of the monitoring grid.	Annual
4	Coordinate with DWR and local landowners to ensure that selected wells are maintained as part of a long-term monitoring program.	Annual
II.	**Groundwater Resource Protection**	
1	Support the development and implementation of BMOs in 16 sub-inventory areas overlying the groundwater basin.	Spring 2004 - Spring 2005
2	Participate in the review and provide recommendation for permit applications submitted under the Groundwater Conservation ordinance.	Ongoing
3	Support the Butte County Department of Development Services during the policy update of the water resource section of the General Plan's Conservation Element.	Through Completion
4	Pursue implementation of Integrated Water Resource Plan policies, programs, and projects approved by the Board of Supervisors, including recommendations addressing protection of groundwater recharge areas and development of a cooperative management program.	2004 – 2005
5	Evaluate the need for a wellhead protection program in Butte County.	Fall 2004

Table 3-4. Summary of GMP Actions (continued)

	Description of Action	Implementation Schedule
III.	**Groundwater Sustainability**	
1	Provide technical support associated with development of BMOs in Butte County.	Spring 2004 - Spring 2005
2	Assist in coordination and management activities of the Water Advisory Committee.	Annual
3	Complete an update of the BBWUA groundwater model.	Spring 2004 - Spring 2005
4	Support maintenance of the BBWUA groundwater model.	Annual
5	Utilize the groundwater flow model to simulate proposed changes in groundwater management practices that may impact groundwater sustainability.	Annual
6	As directed by the Board, support the coordinated management of groundwater and surface water.	As Needed
7	Pursue funding from state agencies, federal agencies, and partnerships for groundwater sustainability activities.	Annual
IV.	**Stakeholder Involvement**	
1	Continue to work cooperatively with DWR headquarters and DWR Northern District on groundwater management activities.	Annual
2	Continue to work cooperatively with the Bureau of Reclamation and the USACE on groundwater management activities.	Annual
3	Continue to work cooperatively with the California Bay-Delta Authority on programs and policies that support groundwater management efforts in Butte County.	Annual
4	The Department will be responsive to the needs and requests of the Water Commission, TAC, WAC, BSAGWUC, and BBWUA.	Ongoing
5	The Department will continue to support locally-driven stakeholder groups.	Ongoing
6	Consider discussions to jointly develop a countywide coordinated AB 3030 GMP that would incorporate areas with existing AB 3030 plans.	2004 - 2005
V.	**Integrated Water Resources Planning**	
1	Assist in the development of plan recommendations for consideration by members of the public, the Water Commission, and the Board of Supervisors.	Spring 2004
2	Implement plan policies, programs, and projects approved by the Board of Supervisors.	Annual
3	Pursue funding sources for implementation of plan policies, programs, and projects.	Annual
VI.	**GMP Implementation, Reporting and Updating**	
1	Pursue funding for a web-based BMO Information Center to house BMO development, implementation, and reporting information.	Spring 2004
2	Consider opportunities to consolidate reporting of groundwater level, groundwater quality, and inelastic land subsidence information as currently required of BBWUA and BMO participants.	Spring 2005
3	Work cooperatively with local stakeholders, county government, and local advisory committees to assess needed GMP updates.	Annual
4	Sponsor an annual meeting of local districts with AB3030 GMPs to discuss the status of individual plans and opportunities for development of a countywide coordinated AB 3030 GMP.	Annual

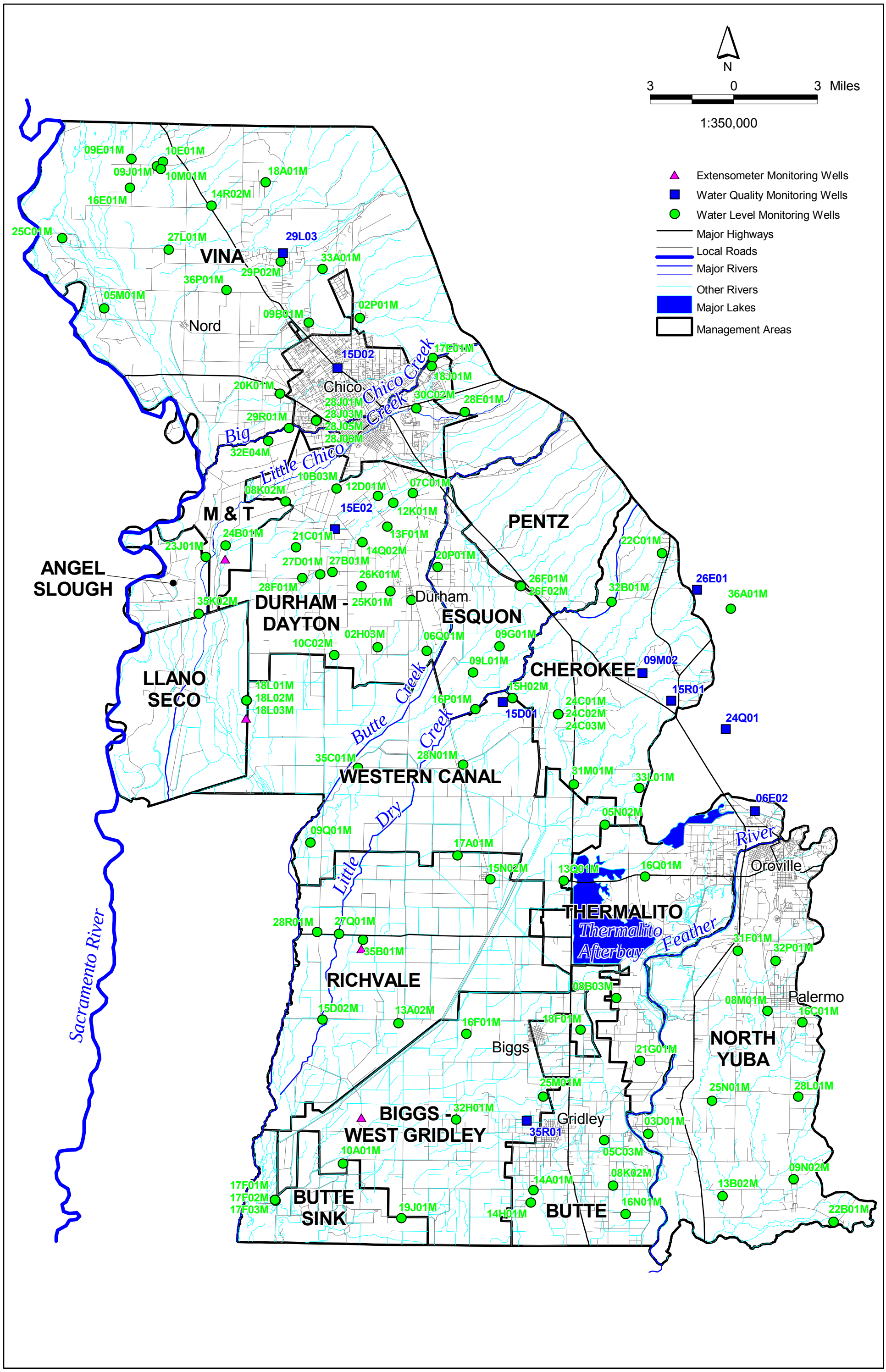


Figure 3-1
Butte County Groundwater Monitoring Grid

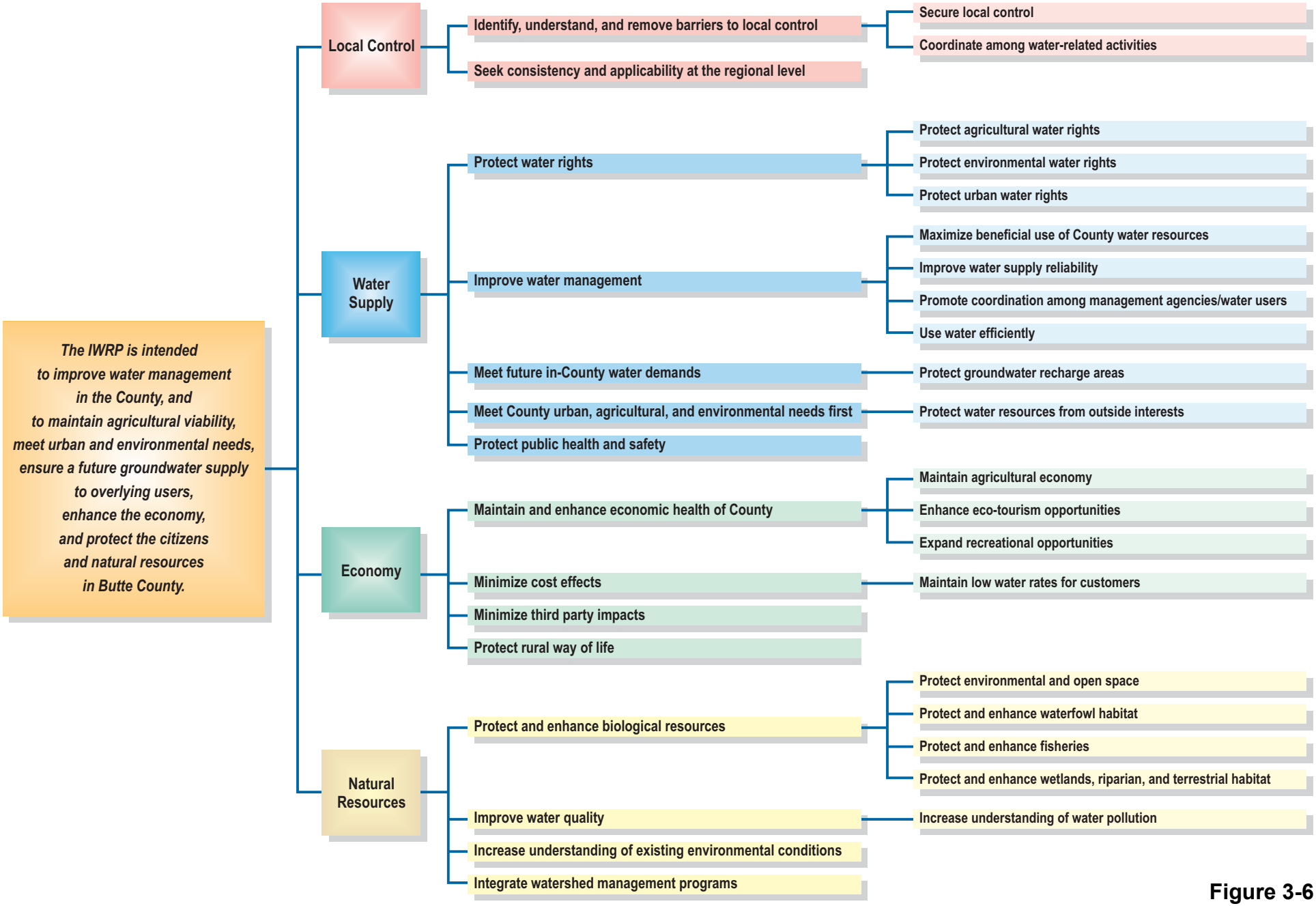


Figure 3-6
IWRP Planning Objectives

Rev. 3-17-04

Section 4
References

Butte Basin Water Users Association. 2004. *Groundwater Status Report.* Report prepared for the Butte County Water Commission.

California Department of water Resources. 2003. *California's Groundwater, Bulletin 118 Update 2003.*

California Department of Water Resources, Northern District. 2000. *Draft Butte County Groundwater Inventory Analysis*. Department of Planning and Local Assistance.

California Department of Water Resources, Northern District. 1991. Western Canal groundwater test program, Memorandum Report.

Camp Dresser and McKee Inc. 2001 *Butte County Water Inventory and Analysis.* Sacramento, California. Report prepared for Butte County, California.

Camp Dresser and McKee Inc. 2003. *Butte County Urban water Demand Forecast.* Report prepared for Butte County, California.

Camp Dresser and McKee Inc. 2003. *Butte County Agricultural Water Demand Forecast.* Report prepared for Butte County, California.

Helley, E.J., and Harwood, D.S. 1985. *Geologic map of the late Cenozoic deposits of the Sacramento Valley and northern Sierran foothills, California*. U.S. Geological Survey Miscellaneous Field Studies Map MF-1790, Scale 1:62,500, 5 sheets.

Newlin, Vickie. 28 July 2003. (Butte County Department of Water and Resource Conservation). Email message with J. Ayres of Camp Dresser and McKee Inc., Sacramento, CA.

Olmsted, F.H., and Davis, G.H. 1961. *Geologic features and ground-water storage capacity of the Sacramento Valley, California*. U.S. Geological Survey Water Supply Paper 1497, 241p.

Slade, R.C., and Associates, LLC. 2000. *Hydrogeologic evaluation and well siting feasibility study, Paradise Irrigation District, Butte County, California*. Unpublished draft report.