

Appendix A

Summary Hydrogeology of Butte County

DWR prepared the *Butte County Groundwater Inventory Analysis* in support of this report. Pieces of DWR's report are excerpted in this appendix and the full text is available from DWR, Northern District.

Summary Topography, Geology and Hydrogeology of Butte County

The following is a discussion of the geologic units and their hydrogeologic properties found within the Sacramento Valley, Foothill and Mountain Regions of Butte County.

SACRAMENTO VALLEY REGION

Topography

The Sacramento Valley Region of Butte County lies within the Sacramento Valley groundwater basin, as shown in Figure 3-1. Upland portions of the Sacramento Valley Region range in elevation from 300 to 400 feet above mean sea level (msl). This upland topography consists of low hills, dissected uplands, and alluvial fans of moderate relief. The land surface slopes downward toward the axis of the valley where the elevation is generally about 70 to 90 feet above msl, with ground surface elevation decreasing southward toward the Sutter Buttes.

The Butte Basin lies south of Chico and west of the Feather River and is characterized by an expansive, flat topography. Prior to flood control on the Feather and Sacramento Rivers, it was subject to extensive seasonal flooding. Slow-moving floodwater deposited the fine clay that now comprises rich agricultural soil.

South of the Butte County line, the Sutter Buttes comprise a small-scale volcanic mountain range intruded the valley sediments during the early Pleistocene period (1.2 million years ago). The intrusion buckled the valley sediments upward forming a barrier to groundwater flow. The Sutter Buttes block the general north-to-south trend of groundwater migration, forcing groundwater to the surface. The upward movement results in a shallow groundwater table and the formation of wetlands along the west side of the Sutter Buttes.

In an effort to better display and support understanding of the groundwater resources of the Sacramento Valley groundwater basin, the Department of Water Resources developed a series of maps illustrating the surface and subsurface geology. The surface geology of the Butte County portion of these maps is shown in Figure 3-1, and in the four geologic cross-sections shown in Figures 3-2, 3-3 and 3-4. The cross-sections also illustrate the subsurface geology, base of fresh water, geologic structure and stratigraphic sequence beneath the Sacramento Valley portion of Butte County.

Surface and Subsurface Geology

The regional structure of the Sacramento Valley groundwater basin consists of an asymmetrical trough tilting to the southwest, with a steeply dipping western limb and a gently dipping eastern limb (Page, 1986). Older granitic and metamorphic rocks underlie the valley forming the basement bedrock on which younger marine and continentally derived sediments and volcanic rock have been deposited. Along the valley axis, and west of the present day Sacramento River, basement rock is at considerable depth, ranging from 12,000 to 19,000 feet below ground surface. Immediately overlying the basement bedrock is a thick sequence of sandstone, shale and conglomerate rocks of marine origin, ranging from Jurassic to Eocene in age. Within the Butte County portion of the Sacramento Valley, these sediments are saline or brackish, and serve as the base of fresh groundwater.

The oldest of the Jurassic to Eocene marine sediments is known as the Great Valley Sequence, which is Jurassic to Cretaceous in age. Water contained within the Great Valley Sequence is primarily saline. The Lower Princeton Gorge fill of Eocene age consists of a mixture of marine sediments and continental material derived from the walls of an eroded sub-marine canyon that was carved into the Great Valley sediments (Redwine, 1972). Groundwater contained within these sediments is almost exclusively saline.

In most locations, the Lower Princeton Gorge fill is unconformably overlain by the Eocene Ione Formation or the Miocene Upper Princeton Gorge fill, as shown in the *Butte County Groundwater Inventory Analysis*. Groundwater within the Ione Formation is primarily saline. The Ione Formation is present both in the surface and subsurface of the Sacramento Valley region. In Butte County, surface exposure of the Ione Formation is limited to areas protected by the overlying Lovejoy Basalt.

Following deposition of the Ione Formation, several volcanic eruptions in the Cascade Range produced a series of basalt flows that spread across the valley sediments during the Miocene Period. These flows comprise the hard, black, microcrystalline Lovejoy Basalt. Groundwater, primarily saline or brackish, is transmitted and stored within the secondary porosity created by the fracturing and jointing of the basalt. The Lovejoy Basalt can be seen as the caprock for Table Mountain on cross-section C-C' in Figure 3-4.

The Miocene age Upper Princeton Gorge fill is widespread throughout the Sacramento Valley, but present only in the subsurface. This formation consists primarily of sandstone with interbedded layers of conglomerate. Water contained within the Upper Princeton Gorge fill is primarily saline to brackish. The Upper Princeton Gorge fill is overlain by the Neroly Formation in nearly all locations. The Neroly Formation is overlain by Tuscan Formation on the east side of the valley, the Tehama Formation on the west side of the valley and the Laguna Formation in the southeast portion of the valley. Also of Miocene age, the Neroly Formation is the

youngest formation in the northern Sacramento Valley that is not exposed at the surface.

Overlying the Neroly Formation are the Pliocene age Tuscan, Tehama and Laguna Formations, which are the major fresh groundwater bearing units in the northern Sacramento Valley. Only the Tuscan and the Laguna Formations are exposed at the surface in Butte County. Surface exposures of the Tehama Formation can be seen along the western side of the Sacramento Valley. Dipping eastward, the Tehama Formation interfingers with the Tuscan Formation in the subsurface along the central north-south axis of the valley.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccias, tuffaceous sandstone, and volcanic ash layers. Mudflows originated in the vicinity of present-day Lassen Peak and most likely filled ancient stream channels as they flowed toward the valley. Upon reaching the valley the mudflows fanned out across the valley floor. Some larger lahars may have continued to flow southward in the valley along drainage channels in the sediment.

West-flowing rivers and streams draining the Sierra Nevada Mountains deposited the Laguna Formation. These rivers and streams spilled over their banks and spread out across the broad flood plains of the valley depositing eroded material from the Sierra Nevada Mountains. The only exposures within Butte County occur southwest of Oroville. More recent alluvial fan and terrace deposits overlie the Laguna Formation in the valley portion of Butte County.

The surface geology of the Sacramento Valley portion of Butte County is comprised primarily of alluvial deposits whose source area is the eroded material derived from surrounding mountain ranges. These sediments were deposited as alluvial fan, terrace, and basin deposits by a network of streams and rivers flowing into the Sacramento Valley. Along the front of the foothills, alluvial fan and terrace deposits of the Riverbank and Modesto Formations mark the edge of the valley sedimentary units.

The Pleistocene Riverbank Formation represents the oldest of the alluvial fan and terrace deposits. The thickness of the Riverbank Formation varies from less than one foot to over two hundred feet depending upon location (Helley and Harwood, 1985). The Riverbank Formation primarily overlies the Laguna Formation in the southern portion of Butte County and the Tuscan Formation in the northern portion of the county. Overlying the Riverbank Formation in many locations is the Modesto Formation. The terrace deposits of the Modesto Formation are exposed in many of the presently active stream-cut canyons along the foothills.

Overlying the alluvial fans of the Riverbank and Modesto Formations are the fine silts and clays of the basin deposits of Holocene age. Basin deposits are seen primarily in the western and southern Butte County portion of the valley region, forming the

highly productive agricultural soils characteristic of these areas. The thickness of the basin deposits varies generally from less than ten feet along the margins of the exposure to more than one hundred feet in the center of the valley. Basin deposits provide limited quantities of groundwater to shallow wells due to the fine-grained nature of the sediments.

Holocene age Alluvium is the youngest of the geologic units present within the Sacramento Valley Region.

Alluvial deposits primarily overlie the Modesto Formation and basin deposits, except where the alluvium is composed of mine tailings. Due to the limited extent and thickness, Alluvium is not considered to be a significant water-bearing unit.

Deformational structures within the Sacramento Valley Region of Butte County include several faults and folds. Offset on the Chico Monocline Fault formed a monoclinial flexure, the Chico Monocline, that forms the eastern boundary of the Sacramento Valley Region north of Durham. North of Chico, the Chico Monocline deforms the Tuscan Formation and acts as an eastward aquifer boundary (DWR Bulletin 118-6, 1978). South of Chico, beds have a gentler slope of approximately 2 to 5 degrees and evidence of the monocline disappears north of Oroville.

North of the Sutter Buttes, a minor splay fault associated with the Willows Fault system is present at depth and displaces only Jurassic-Cretaceous age sediments (see Figure 3-1). In the western portion of Butte County, the Glenn Syncline has produced some minor downward flexure of the deeper sedimentary units, as seen in cross-section C-C' in Figure 3-4.

Fresh Groundwater Bearing Units

On a regional scale, the base of post-Eocene continental deposits is commonly considered the approximate base of fresh groundwater in the Sacramento Valley (Page, 1974). Locally, the base of fresh groundwater varies depending upon local subsurface geology and geologic formational structure.

The approximate base of fresh groundwater is shown in the geologic cross-sections in Figures 3-3 and 3-4. It was determined through examination of electrical resistivity logs, which were derived from criteria established by C.F. Berkstresser, Jr., in *Base of Fresh Ground Water in the Sacramento-San Joaquin Delta California*; United States Geological Survey, prepared in cooperation with the California Department of Water Resources, 1973. This report determined that the base of freshwater is water with a specific conductance of less than 3,000 micromhos per centimeter; water with a specific conductance that exceeds 3,000 micromhos per centimeter is considered to be saline.

In the Sacramento Valley Region of Butte County, fresh groundwater-bearing units include the Tuscan, Laguna, Riverbank and Modesto Formations. Groundwater in

these formations largely exists within the primary porosity associated with the spaces between the individual sand and gravel deposits, and within the secondary porosity associated with fractures and jointing of the more competent volcanic rocks.

Tuscan Formation

Age and Composition. The Tuscan Formation is described as four separate but lithologically similar units, Units A through D, which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood, 1985). Stratigraphic position and general lithologic character distinguish each unit. Unit A consists of the oldest deposits of the Tuscan Formation. Units B and C overlie Unit A in most locations in Butte County. Unit D is the youngest unit and is exposed only in localized areas northeast of Red Bluff. Groundwater in the Sacramento Valley portion of Butte County is contained primarily within the two lower units of the Tuscan Formation, Units A and B.

Unit A (Tta) is the oldest water-bearing unit of the Tuscan Formation. This unit is characterized by the presence of metamorphic clasts within the interbedded lahars, volcanic conglomerate, volcanic sandstone and siltstone. Unit A contains the Nomlaki Tuff, a dacitic pumice tuff, at its base or within the basal portion of the unit. The presence of the Nomlaki Tuff within the basal sections of the Tuscan, Tehama, and Laguna Formations indicates simultaneous deposition of these units.

Unit A is distinguished from the other units by the presence of metamorphic clasts within the lahars and conglomerates. Exposures of Unit A are shown on the geologic map and underlying Butte County on all four cross sections of the Sacramento Valley. Unit B overlies Unit A in most locations.

Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. These evenly layered, moderately thin beds form the characteristic look of the Tuscan Formation seen in the foothills of Butte County. Extending eastward into the subsurface, the sediments of Unit B form a very productive water-bearing system. In most locations, Unit C overlies Unit B. Unit B can be seen on the geologic map and underlying Butte County on all four cross sections of the Sacramento Valley.

Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the foothills, these lahars are well cemented and form the cap-rock for the ridges in Butte County. Evidence of wood fragments found in Unit C suggests fast-moving, massive mudflows at the time of deposition. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B. Unit C is the youngest unit of the Tuscan Formation that is present in Butte County and can be seen on the geologic map and all four cross sections of the Sacramento Valley. Unit C is overlain in some locations by Unit D.

Unit D is the youngest depositional unit and is characterized by large masses of grey hornblende andesite. Exposures of Unit D are found in limited extent northeast of Red Bluff. No exposures of Unit D are mapped at the surface or in the subsurface within Butte County.

The Tuscan Formation is overlain by Holocene and Pleistocene alluvial sediments, which include the Modesto and Riverbank Formations, and younger stream channel and basin deposits. In most places, the Tuscan Formation unconformably overlies either Upper Cretaceous marine sedimentary rocks or the basement complex with angular unconformity (Olmsted and Davis, 1961). In other areas the Tuscan Formation rests unconformably on the Neroly Formation, the Ione Formation and/or the Lovejoy Basalt.

The volcanic sediments of the Tuscan Formation interfinger with the non-marine and non-volcanic sediments of the Tehama Formation in the subsurface (Lydon, 1969). This contact is considered to occur at depth in the vicinity west of the Sacramento River. As mentioned previously, the presence of the Nomlaki Tuff at the base of the Tuscan, Tehama, and Laguna Formations suggests simultaneous deposition and an age correlation of these units.

Depositional Environment and Source Area. The Tuscan was deposited as a series of volcanic lahars over a period of about one million years (Lydon, 1969). The source area of the lahars were eroded volcanoes historically located northwest and south of Lassen Peak. Mudflows most likely followed ancient stream channels and valleys while travelling in a southwestward direction. The flows then fanned out upon reaching the valley floor, causing deposition to vary in thickness and in topographic elevation. As areas of the well-cemented volcanic lahars were eroded and redeposited, aquifer material on the valley floor resulted in a heterogeneous, and in some areas, unconsolidated mass of sediments.

Extent and Thickness. The Tuscan Formation extends from east of Redding to west of Oroville, and from the base of the Cascade/Sierra Nevada Mountain Range into the subsurface about 5 miles west of the Sacramento River (Page, 1986). Maximum thickness of the formation ranges from about 1,700 feet in the east, and thins to approximately 300 feet at the westward extent (Lydon, 1968). Unit C and Unit B have a mapped thickness of about 600 feet each and Unit A averages around 250 feet thick, for a total approximate thickness of about 1,450 feet in Butte County.

Water-bearing Properties. Groundwater in the Sacramento Valley Region is contained primarily within the pore spaces of the reworked sand and gravel layers. Much of the groundwater in the Tuscan Formation is confined under pressure by layers of impermeable clays, lahars or tuff breccia.

Groundwater encountered within Unit A is associated with primary porosity of the conglomerate and sandstone layers, and also with secondary porosity associated with

the fractured tuff breccia. Within Unit B, the interbedded, permeable layers of reworked sand and gravel act as a conduit for groundwater movement, transmitting water into the aquifer from recharge areas in the Cascade foothills. The permeable layers of the Unit B sediments compose the main aquifer material for groundwater storage in the valley. The fine-grained, consolidated lahars of Unit C form thick, low permeability confining layers for groundwater contained in the more permeable sediments of Unit B.

Volcanic sands of the Tuscan Formation yield high amounts of water to wells in many areas of the eastern Sacramento Valley. California Water Service wells in the Chico area have specific yields that range between 900 and 3,000 gallons per minute (gpm) (DWR Bulletin 118-6, 1978). Three wells at the Chico Airport produce between 900 and 950 gpm with specific capacities between 26 and 45 gpm per foot of drawdown (Olmsted and Davis, 1961).

Well yields and specific capacities for the Sacramento Valley Region were also calculated on data obtained from utility pump tests. Results from 2,662 pump tests on 944 wells revealed an average well yield ranges from a low of 976 gpm in the North Yuba Inventory Unit, to a high of 1,395 gpm in the Vina Inventory Unit. The average specific capacity calculated from 974 pump tests on 433 wells was 78 gpm per foot for the entire Sacramento Valley region. 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.

Aquifer performance tests have been performed in several areas of Butte County. These tests were used to evaluate the water-bearing characteristics of the Tuscan Formation. 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 in this study provided a range of 45.7 to 104.7 gpm per foot of drawdown (DWR Memorandum Report, 1991).

A similar test was performed on a well located in the East Butte Inventory Unit. The extraction well utilized for this test was designed and constructed to draw water only from the lower-confined portion of the Tuscan Formation. Aquifer transmissivity was calculated to be approximately 75,000 gpd per foot. Storativity was estimated between .0001 and .00001. The specific capacity of the extraction well was measured at 23 gpm per foot of drawdown (DWR Memorandum Report, 1996).

Laguna Formation

Age and Composition. The Pliocene age Laguna Formation (Tla) is composed of continental deposits containing predominantly fine-grained, poorly bedded, and compacted sediments. These deposits are composed of a heterogeneous mixture of interbedded alluvial fine sand, silt and clay of granitic and metamorphic origin with

minor conglomerate lenses (Olmsted and Davis, 1961). Clay is more predominant in the fine-grained sediments south of Oroville. The sand is arkosic and contains abundant weathered feldspar, biotite, and angular quartz clasts. The Arroyo Seco gravels are considered to be part of the Laguna Formation by some sources. Near Oroville, the gravel deposits are of granitic or metamorphic composition and are contained within a silty to sandy matrix.

Depositional Environment and Source Area. West-flowing rivers and streams draining the Sierra Nevada Mountains deposited the Laguna Formation. Uplift of the Sierra Nevada Mountains during their formation increased erosion of the metamorphic and plutonic rocks. Rivers and streams carried this eroded material to the valley floor where they overtopped their banks and spread out across the broad flood plains of the valley, depositing eroded material into broad alluvial fans.

Extent and Thickness. Exposure of the Laguna Formation is discontinuous and extends from Oroville southward to Lodi. The only exposures within Butte County occur southwest of Oroville. The thickness of the Laguna Formation is difficult to determine because the base of the unit is rarely exposed. Estimates of the maximum thickness range from 180 feet (Helley and Harwood, 1985) to 1,000 feet (Olmsted and Davis, 1961). The position and thickness of the Laguna Formation can be seen in cross section D-D' in Figure 3-4.

Water-bearing Properties. 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 capacities 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

Age and Composition. The Riverbank Formation was deposited between 450,000 and 130,000 years ago forming wide alluvial fans and terrace deposits. Stream terrace deposits of the Riverbank Formation appear topographically above younger, Modesto age terrace deposits. Due to post-depositional weathering of the Riverbank Formation, deposits exhibit a reddish color. Topographic location and the weathered red color distinguish the Riverbank from more recent alluvial fan and terrace deposits (Helley and Harwood, 1985).

Depositional Environment and Source Area. The Riverbank Formation consists of gravel, sand, and silt eroded from the surrounding Coastal, Klamath, Cascade and

Sierra Nevada Mountain Ranges and deposited in the Sacramento Valley. The source area determines the mineral constituents of the deposits. Near Sacramento, the deposits are primarily arkosic; however, mafic content of igneous rock fragments increases northward.

Extent and Thickness. Exposures of the Riverbank Formation within Butte County are observed primarily west of Oroville and southward. Thickness of the Riverbank Formation ranges from less than one foot to over 200 feet depending on location. More recent deposition of the Modesto Formation and basin deposits has produced the limited surface exposure of this formation. It is indicated in Figure 3-3.

Water-bearing Properties. The thickness of the Riverbank Formation can be a limiting factor to the water-bearing capabilities of the formation. The Riverbank Formation is moderately to highly permeable and yields moderate quantities of water to domestic and shallow irrigation wells. It also provides water to deeper irrigation wells that have multiple zones of perforation. Well yields are higher in areas where concentrations of gravel and sand are present. Groundwater occurs generally under unconfined conditions.

Modesto Formation

Age and Composition. Radiocarbon dating indicates that the Modesto Formation is Pleistocene in age, with the upper and lower members dated at 14,000 and 42,000 years old, respectively (Marchand and Allwardt, 1981). The Modesto Formation consists of tan and light grey gravelly sand, silt and clay. Where it overlies the Tuscan Formation, the clasts within the Modesto are distinctly red, brown, or black. The upper member shows no indication of weathering while the lower member shows slight weathering (Helley and Harwood, 1985).

Depositional Environment and Source Area. The Modesto Formation consists of gravel, sand, and silt eroded from the surrounding Coastal, Klamath, Cascade and Sierra Nevada Mountain Ranges and deposited in the Sacramento Valley. The Modesto forms coalescing alluvial fans and stream bank terraces. Exposures of the Modesto Formation are present along most of the major streams and rivers within Butte County.

Extent and Thickness. The Modesto Formation is widespread throughout the Sacramento Valley, occurring from Redding south into the San Joaquin Valley. The most notable occurrences are found along the Sacramento and Feather Rivers. Similar to the Riverbank, the Modesto Formation ranges in thickness from less than ten feet in many of the terraces and along the margins of the valley to nearly two hundred feet across the valley floor (Helley and Harwood, 1985).

Water-bearing Properties. Like the Riverbank Formation, the thickness of the Modesto Formation limits the water-bearing capabilities of the formation. These deposits provide water to domestic and shallow irrigation wells as well as to deeper

wells with multiple zones of perforations. In locations where gravel and sand predominate, groundwater yields are moderate. Lesser yields are found in areas with high silt and clay content. Groundwater occurs generally under unconfined conditions.

Movement of Groundwater

Groundwater movement in the Sacramento Valley Region was evaluated utilizing groundwater elevation contours developed for Butte County. The contours shown in the *Butte County Groundwater Inventory Analysis* were developed using March 1997 groundwater level data collected by DWR and local cooperators. The flow arrows indicate the general direction of groundwater movement.

The directional flow arrows illustrate that regional groundwater movement in Butte County is southwestward from the foothills towards the Sacramento River. This indicates that the Sacramento River drains groundwater from the northern and central portions of the county. Some localized contour anomalies along the boundary between the West and East Butte Inventory Units can be attributed to the draining of groundwater toward Butte Creek. The general southwest flow pattern within Butte County is disrupted in the Chico Urban Area by municipal groundwater extraction. This disruption is indicated in the *Butte County Groundwater Inventory Analysis* by small-scale localized groundwater depressions and mounds. A larger scale groundwater depression is depicted in the southwest portion of the North Yuba Inventory Unit.

Another notable anomaly is located in the southwest portion of Butte County. In this area, groundwater converges under the Butte Sink and Biggs-West Gridley Inventory Units. Groundwater from the East Butte Inventory Unit flows southwestward while groundwater from the Sacramento River flows southeast and eastward. Deformation of the valley sediments by the Sutter Buttes and the buried Colusa Dome, located west of the Sutter Buttes, cause this anomalous flow pattern.

Outside of Butte County, a change occurs in the groundwater flow along the Sacramento River near Princeton. North of this location the groundwater flows toward the Sacramento River where it drains groundwater from the Northern Sacramento Valley. South of Princeton, groundwater flows away from the river acting to recharge the groundwater system.

FOOTHILL REGION

Topography

The Foothill Region of Butte County lies between the Sacramento Valley Region and the Mountain Region. It ranges in elevation from 50 feet above msl at the base of the Campbell Hills on the margin of the Sacramento Valley, to 1,250 feet msl north of Stirling City where it merges into the Mountain Region.

The Foothill Region is a recharge area for the Butte County portion of the Sacramento Valley groundwater basin aquifer. Groundwater recharge occurs in the form of precipitation and deep percolation of runoff from nearby creeks, streams and reservoirs.

Surface and Subsurface Geology

The Foothill Region occupies the transitional geologic zone between Tertiary sediments in the west part of Butte County and Mesozoic-Paleozoic rocks in the east part of the county (see Figure 3-1 and, for more detail, the *Butte County Groundwater Inventory Analysis*). Mesozoic rocks encompass the Jurassic and Cretaceous age rock ranging in age from 245 to 65 mybp. Older Paleozoic rocks range in age from 544 to 245 mybp. The Jurassic and Cretaceous sedimentary rocks outcrop in the northern Foothill Region.

Paleozoic rocks consist of metavolcanic and metasedimentary geologic units. These units, exposed mainly in the eastern and southern margins of the Foothill Region, were deposited during periods of volcanic activity and subsequently metamorphosed due to tectonic compression and contact metamorphism. Metavolcanic rocks (Pzv) consist primarily of breccia and tuff, with lesser amounts of greenstone, diabase and pillow lavas. Metasedimentary rocks (Pz) are composed of slate, shale, sandstone, chert, conglomerate, limestone, dolomite, marble, phyllite, schist, hornfels and quartzite. Groundwater found in these areas is associated mainly with secondary porosity.

Resting unconformably on top of the Paleozoic deposits are rocks of the Late Mesozoic Era. Late Mesozoic rocks were deposited in a marine forearc-basin setting. After deposition, tectonic stress caused the eastern limb of the Sacramento Valley trough to be uplifted, raising Great Valley sediments (JKgvs) to their present elevation above the valley floor. These older sediments are seen in outcrop above Little Chico, Big Chico and Butte Creek drainages (see the *Butte County Groundwater Inventory Analysis*).

Unconformably overlying Late Mesozoic marine deposits are a series of Tertiary age continental deposits. The major geologic unit exposed in the northern and western part of the Foothill Region is the Tuscan Formation, composed of Units A, B and C (Tta, Ttb, Ttc). The Tuscan Formation was deposited as a series of mudflows originating from ancient, eroded volcanoes of the Cascade Range. Other Tertiary units in the Foothill Region consist of older, undifferentiated andesites and basalts of the Tertiary Volcanics (Tv), basalt deposits of the Lovejoy Formation (Tl) and marine to non-marine sandstone and siltstone deposits of the Ione Formation (Ti). Although the continentally derived Laguna Formation (Tla) is marginally exposed in the southern portion of the Foothill Region, the majority of this unit falls within the Sacramento Valley portion of Butte County, as seen in the *Butte County Groundwater Inventory Analysis*.

Quaternary deposits situated on the western margin of the Foothill Region consist of the Modesto Formation and alluvium (see Figure 3-1). These sediments were deposited along the streams and creeks draining the Foothill Region, creating stream terraces and alluvial fans. The Modesto Formation (Qm) consists of unconsolidated, unweathered to slightly weathered gravel, sand, silt and clay, with thickness ranging from 1 to 200 feet.

The major geologic structure in the Foothill Region is the Foothill Fault system. The Foothill Fault system includes the Cohasset Ridge Fault, the Magalia Fault and a mapped, but as yet unnamed fault, located south of the Magalia and shown in Figure 3-1. These faults are included in a system of northwest trending, steeply east-dipping to vertical faults that have experienced up to 100 feet of movement in the past 2.4 million years (Helley and Harwood, 1985).

Another major structural feature in the Foothill Region is the Chico Monocline. The Chico Monocline is a northwest-trending southwest-facing flexure that roughly follows the northwestern boundary of the Foothill Region, extending from Chico to Red Bluff. North of Chico, the Chico Monocline deforms the Tuscan Formation and has a dip of up to 25 degrees where it acts as an eastward aquifer boundary (DWR Bulletin 118-6, 1978). South of Chico, beds have a gentler slope of approximately 2 to 5 degrees and evidence of the monocline disappears.

Fresh Groundwater Bearing Units

The Tuscan Formation is the major source of groundwater in the Foothill Region. Groundwater occurs in the fractures and joints of the volcanic mudflows, as well as in the weathered horizons between buried mudflows (Slade, 2000).

Lesser amounts of groundwater are found in the Modesto Formation, which is a localized source of groundwater and supplies moderate amounts of water to shallow wells.

Tuscan Formation

Age and Composition. The Pliocene Tuscan Formation is composed of tuff breccia, lapilli, tuff, and volcanic conglomerate, sand and silt (Lydon, 1969). The Tuscan Formation is described as four separate but lithologically similar units, Units A through D, which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood, 1985). In the Foothill Region, only Units A through C are exposed at the surface.

Unit A (Tta) is the oldest water-bearing unit of the Tuscan Formation and consists of fragmented metamorphic rocks found within the interbedded lahars, volcanic conglomerate, sandstone and siltstone. Unit B (Ttb) is defined along the Chico Monocline as a series of interbedded lahars, volcanic conglomerate, sandstone and siltstone. It is characterized on resistivity curves by its distinctive and consistently

high deflections seen in cross-section on Figure 3-4. Unit B is differentiated from Unit A by its lack of metamorphic content.

Unit C (Ttc) consists of lahars with some interbedded volcanic conglomerate and sandstone. Evidence of wood fragments found in Unit C suggests fast-moving, massive mudflows at the time of deposition. Unit C is exposed as the cap-rock on the hills east of Chico and acts as a confining layer in the subsurface for Unit B. Unit C is differentiated from Unit B by its fine-grained, more consolidated nature, whereas Unit B consists of coarser-grained sediments, providing it with a higher groundwater storage capacity. In the Foothill region of Butte County, Unit D, the youngest unit of the Tuscan Formation, is not present.

Depositional Environment and Source Area. The Tuscan was deposited as a series of mudflows, or lahars, over a period of about one million years (Lydon, 1969). The source area of the lahars were eroded volcanoes historically located northwest and south of Lassen Peak. Mudflows most likely followed ancient stream channels and valleys while travelling in a southwestward direction. The flows then fanned out upon reaching the valley floor, causing deposition to vary in thickness and in topographic elevation. As areas of the well-cemented volcanic lahars were eroded and redeposited, aquifer material on the valley floor resulted in a heterogeneous, and in some areas, unconsolidated mass of sediments.

Extent and Thickness. The Tuscan Formation extends from east of Redding to west of Oroville, and from the Cascade/Sierra Nevada Mountain Range into the subsurface about 5 miles west of the Sacramento River (Page, 1986). Maximum thickness of the formation ranges from about 1,700 feet in the east, and thins to approximately 300 feet at the westward extent (Lydon, 1968). Unit C and Unit B have a mapped thickness of about 600 feet each and Unit A averages around 250 feet thick, for a total approximate thickness of about 1,450 feet.

Water-bearing Properties. The Tuscan Formation exposed in the Foothill Region acts as a recharge area for the aquifer system in the Sacramento Valley. In addition, the Tuscan Formation is the primary source of fresh groundwater to wells in the northern and western areas of the Foothill Region. Groundwater intercepted in wells in this region is generally of an unconfined nature, with groundwater levels reflecting rainfall patterns. Most groundwater in the formation is confined under pressure by layers of impermeable clays and tuff-breccia (DWR Bulletin 118-6, 1978). On average, specific yields for the Tuscan Formation range from 900 gpm to 3,000 gpm (DWR Bulletin 118-6, 1978). However, in the foothill region specific yields are much lower.

Based on work done by Slade and Associates LLC, transmissivity values in the Tuscan Formation are approximately 10,000 gallons per day per foot. in Paradise Irrigation District D Tank Well, located on Clark Road in Paradise. However, in the Lime Saddle area, Slade and Associates LLC have determined that transmissivity values in the confined portion of the Tuscan Formation are an extremely low 1,100 gpd per foot.

A third study, also conducted by Slade and Associates LLC, was based on the results of PG&E pumping tests in the Magalia area. These results presented transmissivity rates ranging from 10,000 gpd per foot to approximately 20,000 gpd per foot.

Modesto Formation

Age and Composition. Radiocarbon dating indicates that the Modesto Formation is Pleistocene in age, with the upper and lower members dated at 14,000 and 42,000 years old, respectively (Marchand and Allwardt, 1981). It consists of tan and light grey gravelly sand, silt and clay; where it overlies the Tuscan Formation clasts are distinctly red, brown or black (Helley and Harwood, 1985). Both members contain unconsolidated sediments, however the upper member is unweathered, whereas the lower member is slightly weathered.

Depositional Environment and Source Area. The Modesto Formation was deposited under fluvial conditions as a series of coalescing alluvial fans by streams that still exist today (Helley and Harwood, 1985). The lower member forms terraces that are topographically higher than the upper member. The source area for the Modesto Formation is the Cascade and Sierra Nevada Mountain Ranges.

Extent and Thickness. The Modesto Formation is widespread throughout the Sacramento Valley, occurring from Redding south into the San Joaquin Valley. The most notable occurrences are found along the Sacramento and Feather Rivers. The Modesto Formation is exposed along the upper reaches of Butte Creek in the northern part of the Foothill Region. Thickness of the unit ranges up to 200 feet in the basin, and thinning toward the foothills (Marchand and Allwardt, 1981, DWR, 1999).

Water-bearing Properties. Shallow domestic wells can draw moderate amounts of groundwater from these terrace deposits. Alluvial deposits (Qa) range in size from boulders to sand and silt and have high infiltration rates (DWR, 1978). These deposits are thin at higher elevations, thickening downstream to a maximum thickness of 80 feet, providing low to moderate amounts of groundwater. In areas where silt and clay predominate, permeability of the Modesto Formation is variable and well yields are limited. In locations where gravel and sand predominate, groundwater yields to domestic wells are higher. In the Foothill Region, the Modesto Formation is thin to moderate in thickness and yields only moderate amounts of water to wells. Groundwater in the Modesto Formation occurs under unconfined conditions.

The eastern Mesozoic-Paleozoic deposits exhibit very little, if any, primary porosity. However, due to secondary porosity, small amounts of water can be found within the fractures and joints of these dense, hard rocks.

Tertiary sediments (65 to 1.8 mybp) are exposed in the northern and western zones of the region tend to contain fresh groundwater mainly through primary porosity. Surficial Quaternary sediments found along a few of the drainages in the Foothill Region supply modest amounts of groundwater to shallow domestic wells.

Groundwater in the outcropping Late Mesozoic sedimentary rocks is usually brackish and does not contribute to the region's potable groundwater supply.

Movement of Groundwater

Although there is no data to determine the direction and /or velocity of groundwater movement, groundwater generally follows the contour of the topographic surface. In the Foothill Region, this can be interpreted as groundwater flowing from high to low elevations, following drainages towards the center of the valley, where it tends to track the course and direction of the Sacramento River.

The Magalia fault may act as a barrier to groundwater movement (Slade, 2000).

MOUNTAIN REGION

The Mountain Region is the easternmost region in Butte County. There are no appreciable geologic units supplying groundwater to the mountain area. Elevation ranges from around 230 feet at the southernmost boundary of Butte County near the confluence of Honcutt and Wilson Creeks, to 2,180 feet in the northeastern part of the county at Humboldt Peak.

Surface and Subsurface Geology

Mesozoic and Paleozoic age plutonic, volcanic and metamorphic rocks make up the majority of the surface and subsurface geology of the Mountain Region. Mesozoic rocks encompass the Jurassic and Cretaceous age rock ranging in age from 245 to 65 mybp. Older Paleozoic rocks range in age from 544 to 245 mybp.

Primary porosity is virtually non-existent in these rocks due to the amount of cementation, consolidation, crystallization or metamorphism that has occurred (Slade, 2000). Other geologic formations consist of Tertiary volcanic sediments exposed in the northern part of the Mountain Region. Of these units, only the Tuscan Formation, located in a small northwestern segment of the Mountain Region, is considered to act as a groundwater-bearing unit. There are no significant surficial alluvial deposits in this region.

Plutonic, volcanic and metamorphic rocks of Mesozoic and Paleozoic age are found throughout the Mountain Region. Paleozoic rocks consisting of metasedimentary (Pz) and metavolcanic (Pzv) rocks were deposited during periods of volcanic activity and then metamorphosed due to tectonic compression and contact metamorphism. Metasedimentary rocks consist of slate, shale, sandstone, chert, conglomerate, limestone, dolomite, marble, phyllite, schist, hornfels and quartzite. Metavolcanic sediments are composed primarily of breccia and tuff, and also include greenstone, diabase and pillow lava.

Granitic plutonic rocks (Mzgr) were emplaced during the Mesozoic Era, as were gabbro and dioritic rocks (Mzgb). Ultramafic rocks (um) composed of serpentine,

peridotite, gabbro and diabase are exposed primarily in the central and southern portions of the Mountain Region. Mixed rocks (m) are composed of undifferentiated metasedimentary and metavolcanic rocks. The plutonic rock demarcates the boundary between the Sierra Nevada Mountain Range and the Cascade Mountain Range to the north, and generally coincides with the divide of the Feather River drainage.

Tertiary sediments (65 to 1.8 mybp) are exposed in the northern, southeastern and southwestern portions of the Mountain Region. The major geologic unit of any importance for the occurrence of groundwater is the Tuscan Formation Unit B (Ttb). This unit was deposited as a series of mudflows originating from ancient, eroded volcanoes of the Cascade Range. It is exposed only in the northwestern portion of the region. Additional Tertiary units include the Tertiary Volcanics (Tv) and the Ione Formation (Ti). The Tertiary Volcanics are exposed in the north and southeastern areas and are composed of older, undifferentiated andesites and basalts. The Ione Formation is composed of sandstone and siltstone and was deposited in a marine to non-marine environment. A small exposure of the Ione Formation is exposed in the southwestern portion of the Mountain Region.

Fresh Groundwater Bearing Units

Groundwater found in the Mesozoic and Paleozoic rocks is very limited and associated mainly with secondary porosity.

The limited amount of groundwater encountered in the Mesozoic rocks environment is derived primarily through secondary porosity associated with fractured and jointed rock.

Although groundwater is encountered in the Ione Formation, the quality is poor due to its brackish nature. In general, the limited amount of fresh groundwater encountered in the Tertiary sediments is associated with secondary porosity.

Although the Tuscan Formation is the main groundwater-bearing unit for the Foothill and Sacramento Valley Regions, in the Mountain Region it is tightly cemented and consolidated, and it too supplies only limited amounts of water. Where groundwater does occur, it is limited to the fractures and joints within the volcanic mudflows and breccias.

Tuscan Formation

Age and Composition. The Pliocene Tuscan Formation is composed of tuff breccia, lapilli, tuff, and volcanic conglomerate, sand and silt (Lydon, 1969). The Tuscan Formation is described as four separate but lithologically similar units, Units A through D, which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood, 1985). Unit B (Ttb) is the only unit exposed in the Mountain Region and is described as a series of interbedded lahars, volcanic conglomerate,

sandstone and siltstone. It is characterized on resistivity curves by its distinctive and consistently high deflections seen in cross-section on Figure 3-3.

Water-bearing Properties. In the Mountain Region, groundwater is related largely to secondary porosity and is not available in appreciable amounts. Where groundwater does occur, it is found in the fractures and joints of the volcanic mudflows and breccias.

Movement of Groundwater

Although there is no data to determine the direction and /or velocity of groundwater movement, groundwater generally follows the contour of the topographic surface. In the Mountain Region, this can be interpreted as groundwater flowing from high to low elevations, following drainages towards the center of the valley where it tends to track the course and direction of the Sacramento River.

Appendix B

Water Rights

Table B-1
Major Appropriative Right-Holders In Butte County

Source	Owner Name	Type of Use	Type of Right	Approx. Max. Acre-Feet
R.D.Main drain	Calthie Walton	Irrig.	Direct Diversion	5,880
Hamlin Slough	Rancho Esquon Partners	Irrig.	Direct Diversion	4,416
Hamlin Slough	Rancho Esquon Partners	Irrig.	Direct Diversion	5,106
Philbrook Creek	PG&E	Storage	Power	5,060
Cottonwood Creek	PG&E	Irrig.	Direct Diversion	1,350
West Branch Feather River	PG&E	Power	Storage	1,196
West Branch Feather River	PG&E	Power	Direct Diversion	91,250
Butte Creek	PG&E	Power	Direct Diversion	69,350
Butte Creek	PG&E	Power	Direct Diversion	131,400
West Branch Feather River	PG&E	Power	Direct Diversion	54,750
Inskip Creek	PG&E	Power	Direct Diversion	2,700
Butte Creek	PG&E	Power	Direct Diversion	365
Butte Creek	PG&E	Power	Direct Diversion	365
Butte Creek	PG&E	Power	Direct Diversion	180
Kelsey Creek	PG&E	Power	Direct Diversion	1,460
Stevens Creek	PG&E	Power	Direct Diversion	1,460
Butte Creek	PG&E	Power	Direct Diversion	365
Butte Creek	PG&E	Power	Direct Diversion	365
Clear Creek	PG&E	Power	Direct Diversion	29,200
Butte Creek	PG&E	Power	Direct Diversion	120
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	540
West Branch Feather River	PG&E	Power	Direct Diversion	1,460
West Branch Feather River	PG&E	Power	Direct Diversion	1,905
Long Ravine	PG&E	Power	Direct Diversion	94,900
Little West Branch	PG&E	Power	Direct Diversion	2,700
Cunningham Ravine	PG&E	Power	Direct Diversion	3,650
West Branch Feather River	PG&E	Power	Direct Diversion	1,460
West Branch Feather River	PG&E	Power	Direct Diversion	2,190
Helltown Ravine	PG&E	Power	Direct Diversion	131,400
Butte Creek	PG&E	Power	Direct Diversion	365
North Canyon Creek	PG&E	Power	Direct Diversion	1,825
Little Butte Creek	PG&E	Power	Direct Diversion	4,200
North Fork Feather River	PG&E	Power	Direct Diversion	1,536,650
North Fork Feather River	PG&E	Power	Direct Diversion	584,000
North Fork Feather River	PG&E	Power	Direct Diversion	365,250
Butte Creek	PG&E	Power	Direct Diversion	730
Hamlin Slough	Gorrill Land Co.	Irrig.	Direct Diversion	4,500
Hamlin Slough	Gorrill Land Co.	Irrig.	Direct Diversion	8,029
Little Dry Creek	Gorrill Land Co.	Irrig.	Direct Diversion	6,000
District 100 Main Drain	Lucky Ten Ranch	Irrig.	Direct Diversion	1,688
RD100 Main Drain	Charles Sheppard	Irrig.	Direct Diversion	2,673

**Table B-1
Major Appropriative Right-Holders In Butte County**

Source	Owner Name	Type of Use	Type of Right	Approx. Max. Acre-Feet
RD833 Lateral A	Garaventa Family Trust	Irrig.	Direct Diversion	4,800
District 100 Main Drain	Edgar Meyer	Irrig.	Direct Diversion	3,300
West Branch Butte Creek	Vaughn Franklin	Mining	Direct Diversion	1,825
RD833 Lateral A-N	Cherokee Farms Inc.	Irrig.	Direct Diversion	750
RD833 Lateral A	Cherokee Farms Inc.	Irrig.	Direct Diversion	330
RD833 Lateral A	Paul Minasian	Irrig.	Direct Diversion	1,008
RD833 Lateral A	Paul Minasian	Irrig.	Direct Diversion	2,562
RD833 Lateral E	Rudd Farming Inc.	Irrig.	Direct Diversion	990
RD833 Lateral E	Rudd Farming Inc.	Irrig.	Direct Diversion	4,140
RD833 Main Drain	Birdie Vanderford Trust B	Irrig.	Direct Diversion	3,400
Hamilton Slough	Lund Parker Ranches	Irrig.	Direct Diversion	2,880
Hamilton Slough	Walter Owen	Irrig.	Direct Diversion	1,260
Slate Creek	Yuba Co.Water Dist.	Storage	Power	34,200
Rock Creek	Emerald C Kiwi Fruit Corp	Irrig.	Direct Diversion	571
Rock Creek	Emerald C Kiwi Fruit Corp	Irrig.	Direct Diversion	1,170
Rock Creek	Emerald C Kiwi Fruit Corp	Irrig.	Direct Diversion	1,170
Butte Creek	McPherrin Land Co.	Irrig.	Direct Diversion	6,300
Butte Creek	McPherrin Land Co.	Irrig.	Direct Diversion	1,500
Dry Creek	Casey Sohnrey	Irrig.	Direct Diversion	2,520
Butte Creek	Nevis Industries Inc.	Irrig.	Direct Diversion	3,440
Durham Slough	Nevis Industries Inc.	Irrig.	Direct Diversion	840
Odell Drain	Nevis Industries Inc.	Irrig.	Direct Diversion	3,780
Ditchh 100	Robert Loring	Irrig.	Direct Diversion	41,400
Cottonwood Creek	Bar-X Goose Ranch	Irrig.	Direct Diversion	2,520
Cottonwood Creek	George Chaffin	Irrig.	Storage	450
Flag Canyon Creek	George Chaffin	Irrig.	Direct Diversion	720
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	840
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	180
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	1,440
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	1,440
Butte Creek	Butte Sink Waterfowl Association	Irrig.	Direct Diversion	75,000
South Honcut Creek	Big Land Development Corp.	Irrig.	Direct Diversion	2,700
Pine Creek	Metropolitan Life Insurance Co.	Irrig.	Direct Diversion	8,400
Sacramento River	Metropolitan Life Insurance Co.	Irrig.	Direct Diversion	17,688
Gold Run	Table Mountain I.D.	Irrig.	Direct Diversion	2,700
Butte Creek	Energy Growth Group	Irrig.	Direct Diversion	182,500
East Branch Mud Creek	Mud Creek Hydro Partners	Power	Direct Diversion	7,300
East Branch Mud Creek	Mud Creek Hydro Partners	Power	Direct Diversion	7,560
Camp Creek	Solar Research Corp	Power	Direct Diversion	21,900
RD100 Main Drain	Charles Sheppard	Recreation	Direct Diversion	2,040
Cherokee Canal Cottonwood Creek	Cherrywood Farms	Irrig.	Direct Diversion	5,400
Berry Creek	Berry Creek Water Users Inc.	Irrig.	Direct Diversion	3,650
Little Butte Creek	Lucian Vandegrift	Irrig/ Other	Direct Diversion	2,920
Little Butte Creek	Lucian Vandegrift	Storage	Direct Diversion	70

**Table B-2
Water Rights in DWR Butte Creek Watermaster Service Area**

Diversion Number	Water Right Owner	Import (a) (cfs)	Priority			Priority								SWRCB
			1 st (cfs)	2 nd (cfs)	3 rd (cfs)	1 st (b) (cfs)	2 nd (c) (cfs)	3 rd (d) (cfs)	4 th (e) (cfs)	5 th (f) (cfs)	6 th (g) (cfs)	7 th (h) (cfs)	8 th (l) (cfs)	Appropriative (j) (cfs)
Butte Creek			(Schedule 7, Decree 18917)			(Paragraphs 80 through 87, Decree 18917. Note: Inferior to Schedule 7)								
50	M&T Chico Ranch, Inc.	53.333									25.000	2.500		
	Parrot Ranch Company	53.333									25.000			
	Dayton Mutual Water Co.	3.334	16.000											
	Parrot & M&T		0.170											
	John McAmis		0.120											
	John Drake		0.100											
	Tom Kniffin		0.050											
	Raynor Gimbal		0.115											
	Frank Solinsky		0.155											
	D.B Hall		0.180											
	Tim Hutzler		0.040											
	J.W. Holt		0.040											
	Robert Shepherd		0.040											
	Terry Arthur		0.040											
	Barbara Allen		0.250											
	Patrick Conroy		0.880											
	M. Leen		0.820											
53	(pump) U.S. Dept. of Agriculture		2.000											
	J.R. Kennedy		1.850											2.96 (k)
54	Hester Patrick		3.150											5.04 (k)
55	J.E. Camenzind		0.780											0.59 (l)
	A. Kent Garrett		0.540											0.40 (l)
	Michael Brown		0.430											0.32 (l)
	Kenneth Houser		0.490											0.37 (l)
	Clifford Johnsen		0.870											0.65 (l)
56	Durham Mutual Water Co.		44.700											
	Butte Creek Country Club		2.000											
	Carolyn Geiger		0.480											
	Dixon Family Trust		0.390											
	Norman Domon		0.670											

Table B-2 Water Rights in DWR Butte Creek Watermaster Service Area														
Diversion Number	Water Right Owner	Import (a) (cfs)	Priority			Priority								SWRCB
			1 st (cfs)	2 nd (cfs)	3 rd (cfs)	1 st (b) (cfs)	2 nd (c) (cfs)	3 rd (d) (cfs)	4 th (e) (cfs)	5 th (f) (cfs)	6 th (g) (cfs)	7 th (h) (cfs)	8 th (l) (cfs)	Appropriative (j) (cfs)
Butte Creek			(Schedule 7, Decree 18917)			(Paragraphs 80 through 87, Decree 18917. Note: Inferior to Schedule 7)								
	Kevin Lemos		0.010											
	Stephen Vomoga		1.447											
	P.J. Konyn		0.020											
	Doris Picchi		0.020											
	Ranko Bebich		0.446											
	Deborah Humphreys		0.447											
	Durham House Preservation		0.260											
	(pump) Sam G. Lewis		2.000											
57	(pump) William H. Coats		3.890											
58	(pump) M. Wakenfield		0.430											
	(pump) Norman Domon		0.180											
58A	C.M. Hansen											2.500		
60	Rancho Esquon Partners		0.390	6.000	0.750		13.250	8.000						66.00 (m)
60A	(pump) M.J. Keeney		0.660											
61	(w) Gorrill R Ranch				1.000	14.000			15.000					25.80 (n)
	Western Canal												33.330	
62	Elma J. Ryon				0.570					4.290				
	Skinner Brothers				0.120					0.650				
	Eldo McAllister				0.310					4.560				
Hamlin Slough			(Paragraphs 71 through 76, Decree 18917)											
64,65	Rancho Esquon Partners		3.82 (p)											
64,65	Rancho Esquon Partners		4.58 (q)		3.22 (s)									
64,65	Rancho Esquon Partners		3.60 (r)		1.38 (t)									
66	(w) Gorrill R Ranch			15.00 (u)	6.70 (v)									

Table B-2
Water Rights in DWR Butte Creek Watermaster Service Area

Notes:

- (a) This water is imported from the West Branch Feather River to Butte Creek by PG&E via Toadtown Canal, De Sabla Power Plant, and Centerville Power Plant. The imported water is measured by a 10-foot parshall flume designated by PG&E as BW-12. Five percent is subtracted from the water measured at the parshall flume as conveyance loss between the flume and diversion 50. See paragraph 37.
- (b) July 1 to September 30. Total decreed diversions from Butte Creek and Hamlin Slough not to exceed 21.7 cfs. See paragraph 80.
- (c) April 1 to September 30. See paragraph 81. April 1 to September 30. See paragraph 81.
- (d) April 1 to June 15. See paragraph 82.
- (e) 15.00 cfs from April 1 to June 30 and 6.70 cfs from July 1 to September 30. Total decreed diversions from Butte Creek and Hamlin Slough not to exceed 21.7 cfs. See paragraph 83.
- (f) April 1 to September 30. See paragraph 84.
- (g) 25.00 cfs from April 1 to October 15 and 5.00 cfs from October 16 to March 31. See paragraph 85.
- (h) Entire year. See paragraph 86.
- (i) April 1 to June 15. See paragraph 87.
- (j) All SWRCB Appropriative water rights are inferior to the adjudicated water rights defined in Decree 18917 and 60 cfs for fish flows. See license Nos. 11046 and 11044 for details.
- (k) Application No. 22534, License No. 10432 March 1 to June 15.
- (l) Application No. 22564, License No. 10433 March 1 to June 15.
- (m) Application No. 22039, License No. 11046 April 1 to June 15.
- (n) Application No. 22321, License No. 11044 April 1 to June 15.
- (p) 0.82 cfs for the entire year plus 3.00 cfs from May 1 to October 1. See paragraph 71.
- (q) 1.00 cfs for the entire year plus 3.58 cfs from May 1 to October 1. See paragraph 71.
- (r) 0.60 cfs for the entire year plus 3.00 cfs from May 1 to October 1. See paragraph 72.
- (s) April 1 to September 15. See paragraph 74.
- (t) April 1 to September 15. See paragraph 75.
- (u) 1.00 cfs for the entire year plus 14.00 cfs from April 15 to June 30. See paragraph 73.
- (v) 6.70 cfs from April 1 to June 30 and 21.70 cfs from July 1 to September 15. See paragraph 76.
- (w) Total decreed diversions from Butte Creek and Hamlin Slough not to exceed 21.7 cfs. See paragraphs 73, 80, and 83.