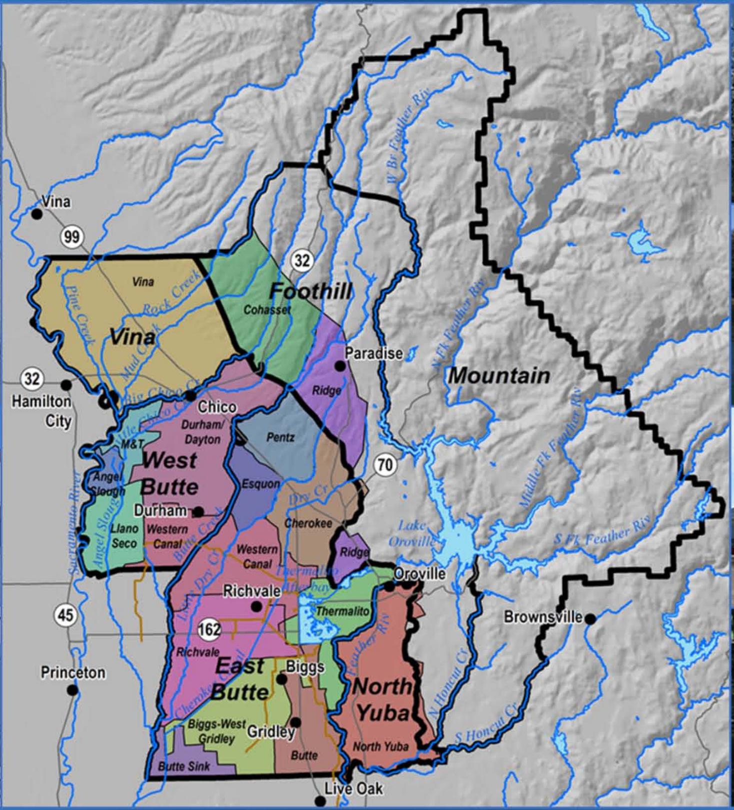
ButteCounty
CALIFORNIA

Water Inventory and Analysis

June 2016










Butte County
WATER & RESOURCE CONSERVATION

Department of Water and Resource Conservation

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FINAL REPORT

Butte County
Water Inventory and Analysis

June 2016

Butte County Department of Water and Resource Conservation

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Acronyms and Abbreviations

ac	Acre
af	Acre-Foot
AN	Above Normal (Hydrologic Year Type)
A_W	Applied Water
BBGM	Butte Basin Groundwater Model
BCDWRC	Butte County Department of Water and Resource Conservation
BIS	Basic Irrigation Scheduling
BMO	Basin Management Objective
BN	Below Normal (Hydrologic Year Type)
BWD	Butte Water District
BWGWD	Biggs-West Gridley Water District
C	Critical (Hydrologic Year Type)
CalWater	California Water Service Company
CAT	Climate Action Team
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CDM	Camp Dresser Mckee
CIMIS	California Irrigation Management Information System
CUF	Consumptive Use Fraction
D	Deep Percolation
D	Dry (Hydrologic Year Type)
DWR	Department of Water Resources
ET	Evapotranspiration
ETa	Actual Evapotranspiration
ETaw	Evapotranspiration of Applied Water
ETo	Reference Evapotranspiration
EToF	Crop Coefficient
ETp	Potential Evapotranspiration
ETpr	Evapotranspiration of Precipitation
FNF	Full Natural Flow
FRRAWMP	Feather River Regional Agricultural Water Management Plan
G	Generic Water Source
GCM	Global Climate Model
GSP	Groundwater Sustainability Plan
HCI	Hydrologic Consultants, Inc.
IDC	IWFM Demand Calculator

IU	Inventory Unit
IWFM	Integrated Water Flow Model
M&I	Municipal and Industrial
M&T	M&T Chico Ranch
maf	Million Acre-Feet
MSR	Municipal Service Review
NCDC	National Climatic Data Center
NCWA	Northern California Water Association
NRCS	Natural Resources Conservation Service
NRO	DWR Northern Region Office
NSVIRWMP	Northern Sacramento Valley Integrated Regional Water Management Plan
P	Precipitation
PG&E	Pacific Gas and Electric Company
PID	Paradise Irrigation District
PRISM	Parameter-elevation Relationships on Independent Slopes Model
R_f	Return Flow
RID	Richvale Irrigation District
R_p	Runoff of Precipitation
SB88	Senate Bill 88
SCS	Soil Conservation Service
SEBAL	Surface Energy Balance Algorithm for Land
SEWD	Sutter Extension Water District
SFWPA	South Feather Water and Power Agency
SGMA	Sustainable Groundwater Management Act
SIU	Subinventory Unit
SNA	SEBAL North America
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
taf	Thousand Acre-Feet
TSMF	Target Soil Mositure Fraction
TWSD	Thermailto Water and Sewer District
U	Reuse
UCCE	University of California Cooperative Extension
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UWMP	Urban Water Management Plan

W	Wet (Hydrologic Year Type)
WCWD	Western Canal Water District
WDL	Water Data Library
WI&A	Water Inventory and Analysis Report
WY	Water Year
WYA	West Yost Associates
WYI	Water Year Index

Appendices

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Executive Summary

"You can't manage what you don't measure." That old adage sums up the purpose of the *2016 Water Inventory and Analysis Report.* The Butte County Board of Supervisors and the Butte County Water Commission recognize that water resource management is essential to the long-term economic and environmental health of the County. They also understand that the management and protection of water resources is contingent upon having adequate scientific information and analytical tools to assess current and future conditions. The foundation of water resource management must be built on data, research and analysis. For over two decades, the Board of Supervisors supported the development of a robust suite of water resource data[1] that accounted for baseline demand, water resource availability, and analysis of changed circumstances. These materials provided the foundation for water resource management in Butte County. First produced in 2001, the Butte County *Water Inventory and Analysis Report* (WI&A) provided an important set of water demand analyses. In 2008 a report was prepared to evaluate changes from the 2001 WI&A (Craddock 2008). As part of the *2005 Butte County Integrated Water Resources Plan* (CDM 2005), agricultural and urban water demand forecast reports were prepared, allowing Butte County to assess future water demand and the availability to identify economic and ecologic consequences (e.g., groundwater overdraft, land subsidence, water supply shortages). However, existing baseline and forecast information are outdated and are insufficient for future planning purposes.

In 2013 the Butte County Board of Supervisors began the Water Resource Management and Protection Project. The Project, through a number of phases, will strengthen Butte County's water resource management capabilities by developing comprehensive water resource analyses and analytical tools. The *2016 Water Inventory and Analysis Report* and the update of the Butte Basin Groundwater Model (BBGM) were the first phase of the Project. The *2016 Water Inventory and Analysis Report* not only updates the analysis of the County's water supply and demand, but it fundamentally changes the County's analytical approach to help sustain water resources for future generations.

Although the *2016 Water Inventory and Analysis Report* builds upon the *2001 Water Inventory and Analysis Report*, a number of important distinctions represent a paradigm shift in Butte County's analytical approach. While the 2001 report provided a detailed snapshot of normal and drought hydrologic conditions and the analysis method provided valuable information that served the needs of that time, future planning and analysis require a more robust approach. One of the important changes is the integration of the BBGM as a platform for developing and analyzing data for the *2016 Water Inventory and Analysis Report* and future analyses. The BBGM is a mathematical model that covers the extent of the Vina, West Butte, East Butte, and North Yuba subbasins, otherwise referred to as the Butte Basin. The BBGM is a physically

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[1] Water Inventory and Analysis (CDM 2001), Urban and Agricultural Water Demand Forecast (CDM 2004a, 2004b), Butte County Groundwater Inventory (DWR 2005), Butte Basin Groundwater Model (HCI 1996, CDM 2008a)

based, hydrologic model that accounts for various sources and uses of water continuously over time. It can examine water supply and demand scenarios with outcomes that lie beyond the realm of historical experience. The BBGM can produce outputs that describe impacts from different scenarios (e.g., increased demands, climate change, and droughts) compared to current (up to 2014) water supply and demand conditions. To maximize the capabilities of the BBGM, the code and data inputs had to be updated. The update of the BBGM was undertaken concurrently with the development of the *2016 Water Inventory and Analysis* report.

The *2016 Water Inventory and Analysis* project includes development of potential future demand and climate change scenarios to support development of projections of future water budgets and identification of associated water management challenges. Although predicting the future is an exercise subject to substantial uncertainty, reasonable assumptions can be made about potential future conditions for planning purposes to better understand how the system may respond to potential changes. For example, land use plans have set targets for development for the next couple of decades. As a result, future water demand can be based on these plans. Changes in cropping patterns and associated irrigation practices can have a substantial effect on total water demands, as well as the portion of demand met by surface water versus groundwater. Estimating potential shifts in cropping patterns allows for the evaluation of resultant changes in water demands. Another important future consideration is the impact of short and long term drought periods on available water supplies. Lastly, climate change may alter groundwater recharge and water supply reliability.

The integration of the BBGM with the *2016 Water Inventory and Analysis Report* positions the Department with the long term ability to conduct water resource analyses as the need arises. An early benefit of this approach was realized through the *Assessment of Butte County Drought Impacts, 2012-2015* Technical Memorandum (Davids Engineering 2016). The assessment evaluated drought impacts on the basin through analysis derived from the IWFM Demand Calculator and supported by recent development of water budgets as part of the *Feather River Regional Agricultural Water Management Plan* (FRRAWMP) (NCWA 2014). The assessment sought to answer two broad questions – (1) can a reasonable basin-wide estimate of increased demand on the basin as a result of the drought be provided, and (2) how do previous analyses compare to the current 2012-2015 drought? The drought analysis demonstrated the analytical capabilities to provide answers to compelling water management questions. The obligation of the Sustainable Groundwater Management Act (SGMA) of 2014 to conduct water balance (or "water budget") analyses necessitates having the capacity to perform novel analytical assessments. The completion of the *2016 Water Inventory and Analysis Report* and the updated BBGM prepares the County to meet these obligations.

2016 Water Inventory and Analysis Highlights

The *2016 Water Inventory and Analysis* (WI&A) considers conditions in six inventory units (IUs): Vina, West Butte, East Butte, North Yuba, Foothill, and Mountain. These IUs are further divided into subinventory units (SIUs) as shown in Figure ES.1. The Vina, West Butte, East Butte, and

North Yuba IUs correspond to the portions of Sacramento Valley groundwater subbasins within Butte County as defined by the California Department of Water Resources (DWR) in Bulletin 118 (2003).

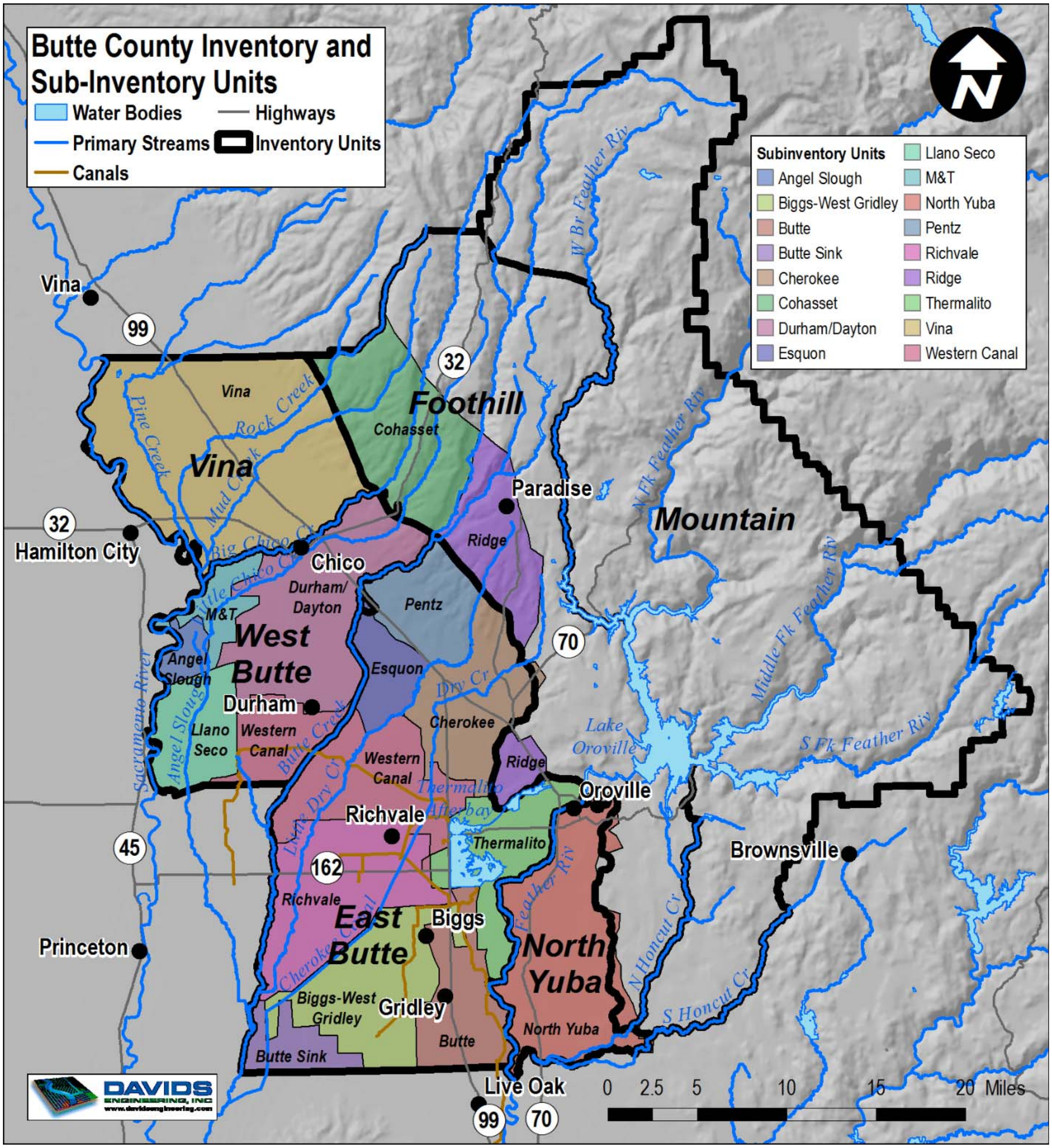

Figure ES.1. Butte County Water Inventory and Analysis Inventory Units and Subinventory Units.

The WI&A water budgets highlight the nexus of land use and water resources. Specifically, recent trends in land use within Butte County are discussed, along with historical surface water diversions and groundwater pumping. Then, water budgets quantifying inflows of water to and outflows from the land surface are presented, followed by a description of potential demand and climate change scenarios to support future analysis using the BBGM. Finally, conclusions and recommendations/next steps from the WI&A are summarized.

Land Use

Butte County covers approximately 1,677 square miles (1.073 million acres). The valley floor area[2] represents approximately 452,000 acres (ac) and includes approximately 234,000 ac of irrigated agriculture, 141,000 ac of non-irrigated lands, 47,000 ac of developed lands, and 30,000 ac of wetlands. Non-irrigated land includes native grasses, shrubland, forest, barren land, and riparian vegetation. The Foothill and Mountain IUs are primarily non-irrigated rangeland and forest with some development, particularly in the Paradise area and other rural communities, and represent approximately 216,000 acres and 407,000 acres, respectively. Land use based on a detailed survey conducted by the DWR Northern Region Office (NRO) in 2011 is shown in Figure ES.2.

Trends in general land use on the valley floor include relatively steady irrigated agricultural acreage[3] since the mid-1990's and a decrease in non-irrigated land[4] of approximately 11,000 acres since the mid-1990's (Figure ES.3). These decreases are balanced by an increase in developed land[5] over this period, as well as a lesser increase in wetlands[6].

Primary crops grown are rice and orchards, with rice representing an average of approximately 103,000 acres and orchards representing an average of approximately 93,000 acres (Figure ES.4). Almonds (38,000 acres), walnuts (34,000 acres), and prunes (11,000 acres) are the primary orchard crops, with decreases in almond and prune acreage over time offset by increases in walnuts and, to a lesser extent, other trees and vines (e.g., olives, peaches and nectarines, kiwis, pistachios, pears, and cherries) (Figure ES.5). Other than orchards and rice, crops include pasture and alfalfa (13,000 acres), grain (4,000 acres), and miscellaneous field and annual crops (5,000 acres) (Figure ES.6). Acreages for grain and other crops have decreased substantially over time, while pasture and alfalfa acreage has increased. On average, 16,500 acres were idle annually.

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[2] Defined as the Vina, West Butte, East Butte, and North Yuba IUs.

[3] Irrigated agriculture includes irrigated land in annual and perennial crops, including land temporarily idled in some years for agronomic or other reasons.

[4] Non-irrigated land includes native grasses, shrubland, forest, barren land, and riparian vegetation.

[5] Developed land includes urban, rural residential, and semi-agricultural areas (farmsteads, feedlots, etc.).

[6] Wetlands consist of seasonal, semi-permanent, and permanent wetlands. Additionally, Thermalito Afterbay within the East Butte Inventory Unit is classified as wetlands for purposes of this report and represents approximately 4,000 acres.

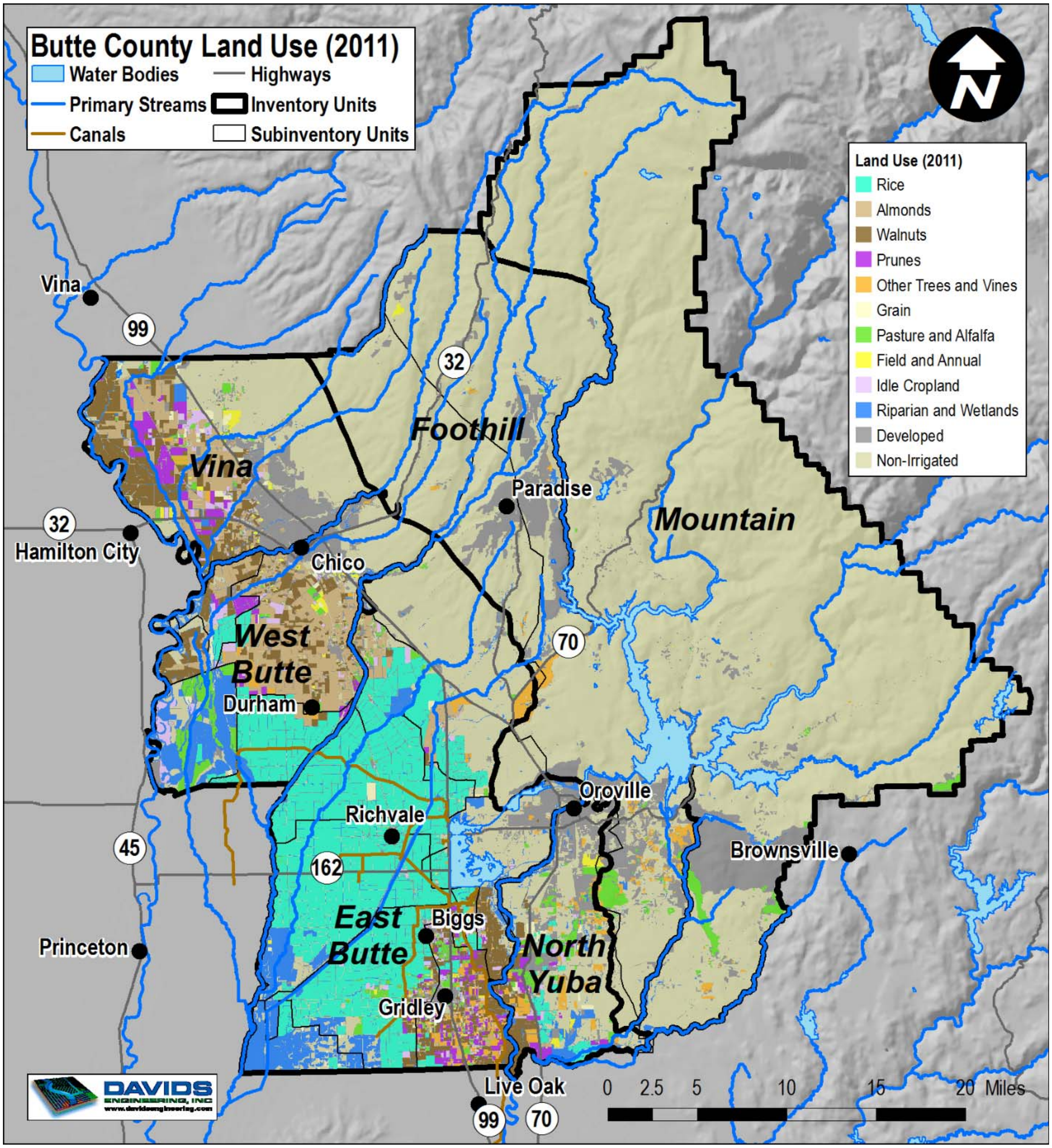

Figure ES.2. Butte County Land Use, 2011 (Source: DWR).

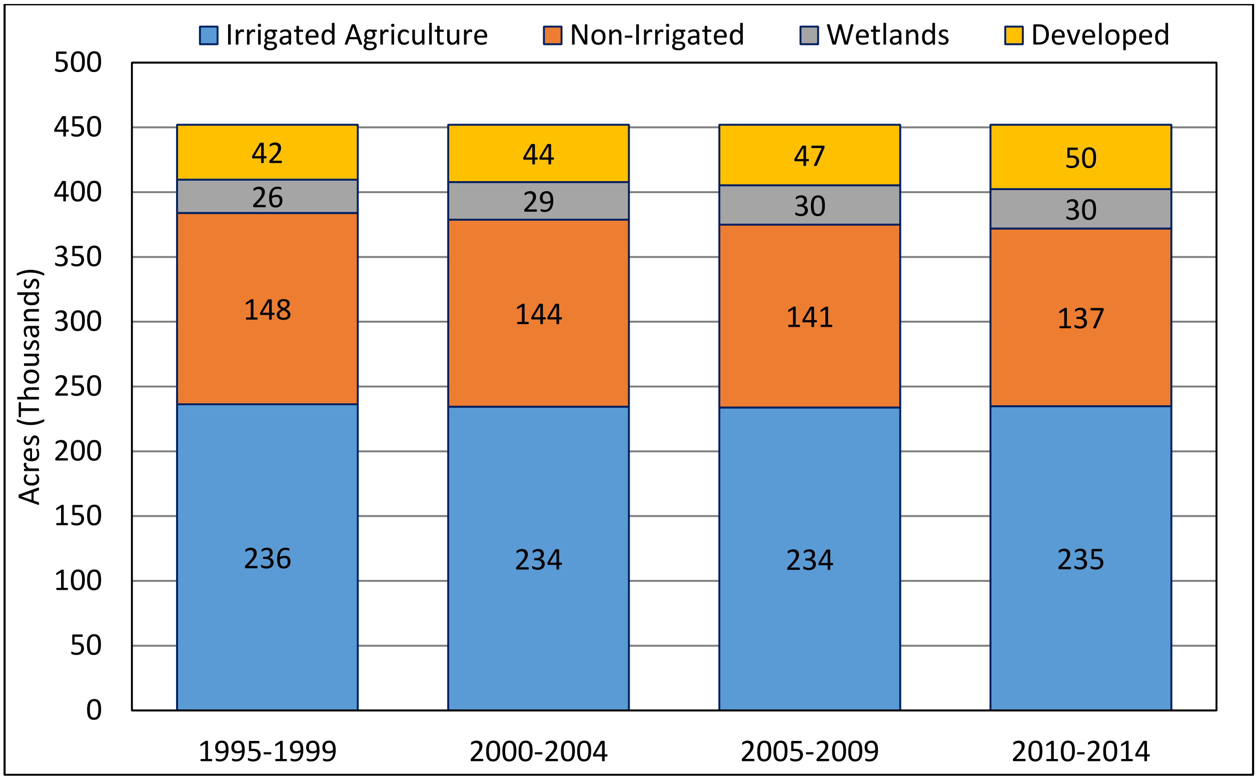

Figure ES.3. Butte County Valley Floor General Land Use, 1995-2014.

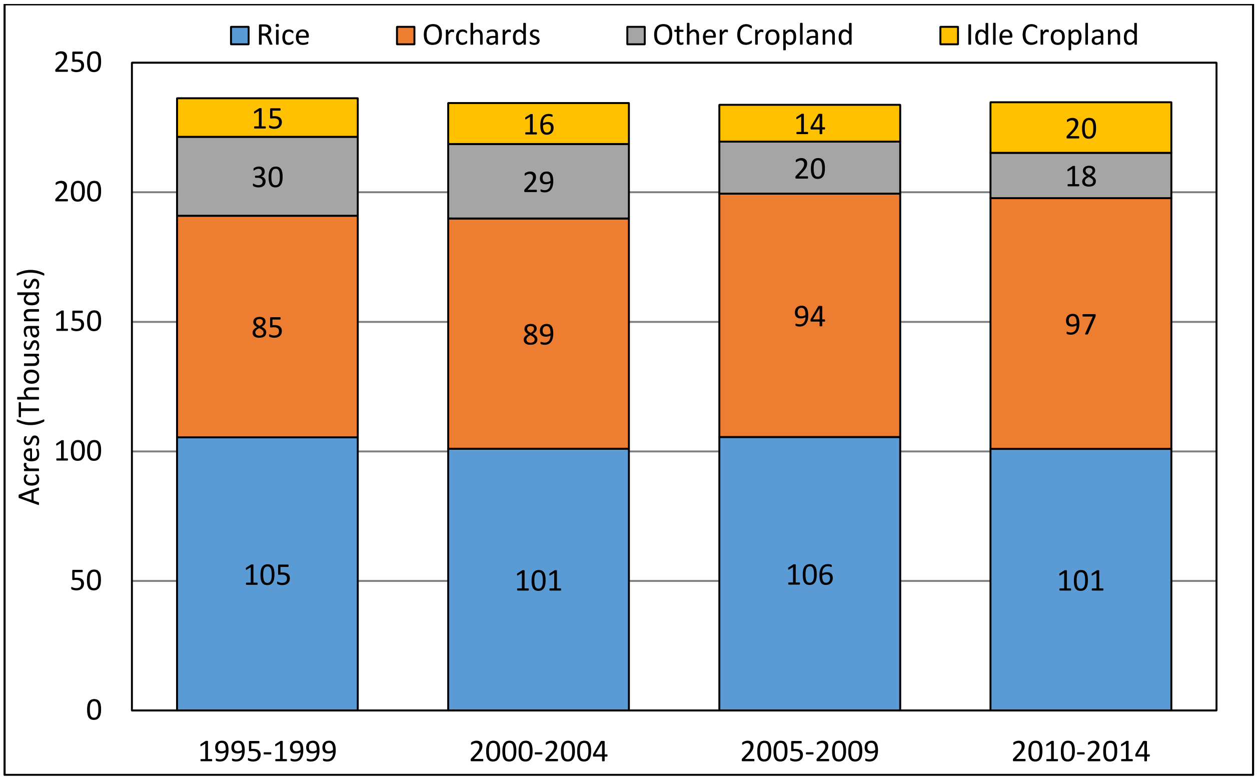

Figure ES.4. Butte County Valley Floor Irrigated Agricultural Land Use, 1995-2014.

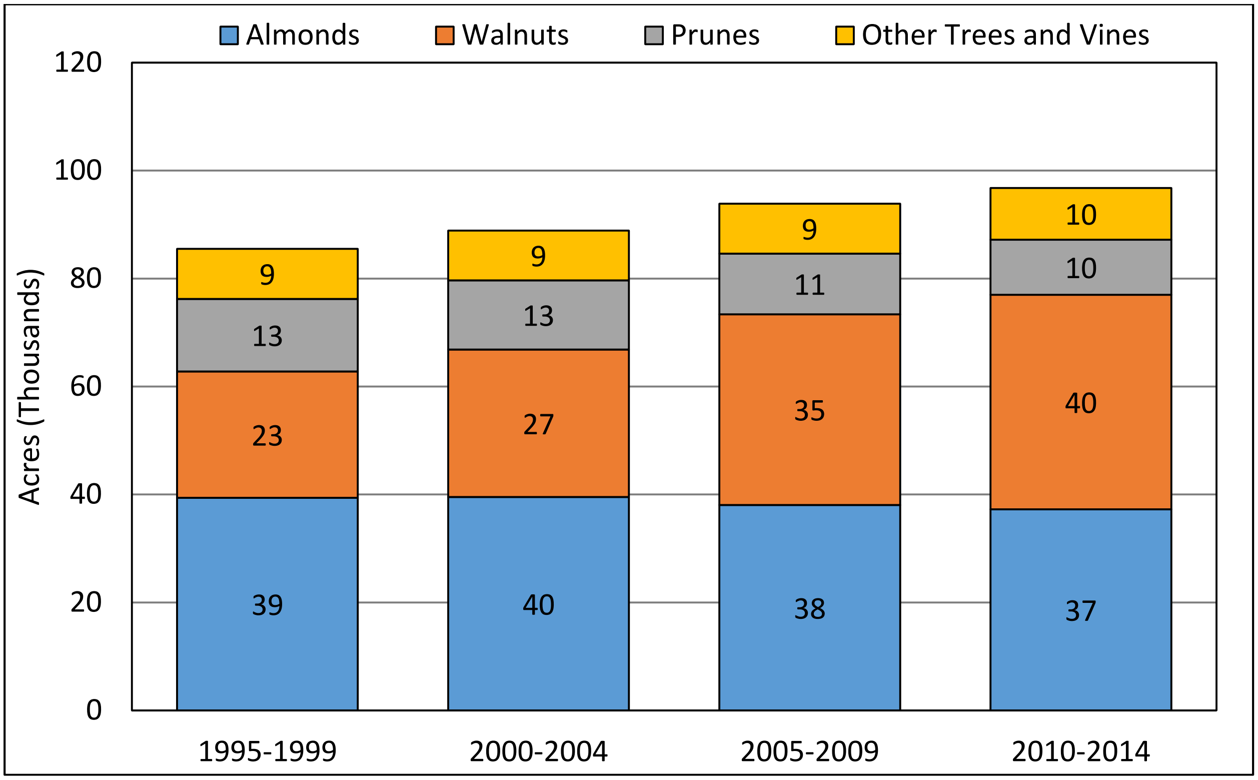

Figure ES.5. Butte County Valley Floor Orchard Land Use, 1995-2014.

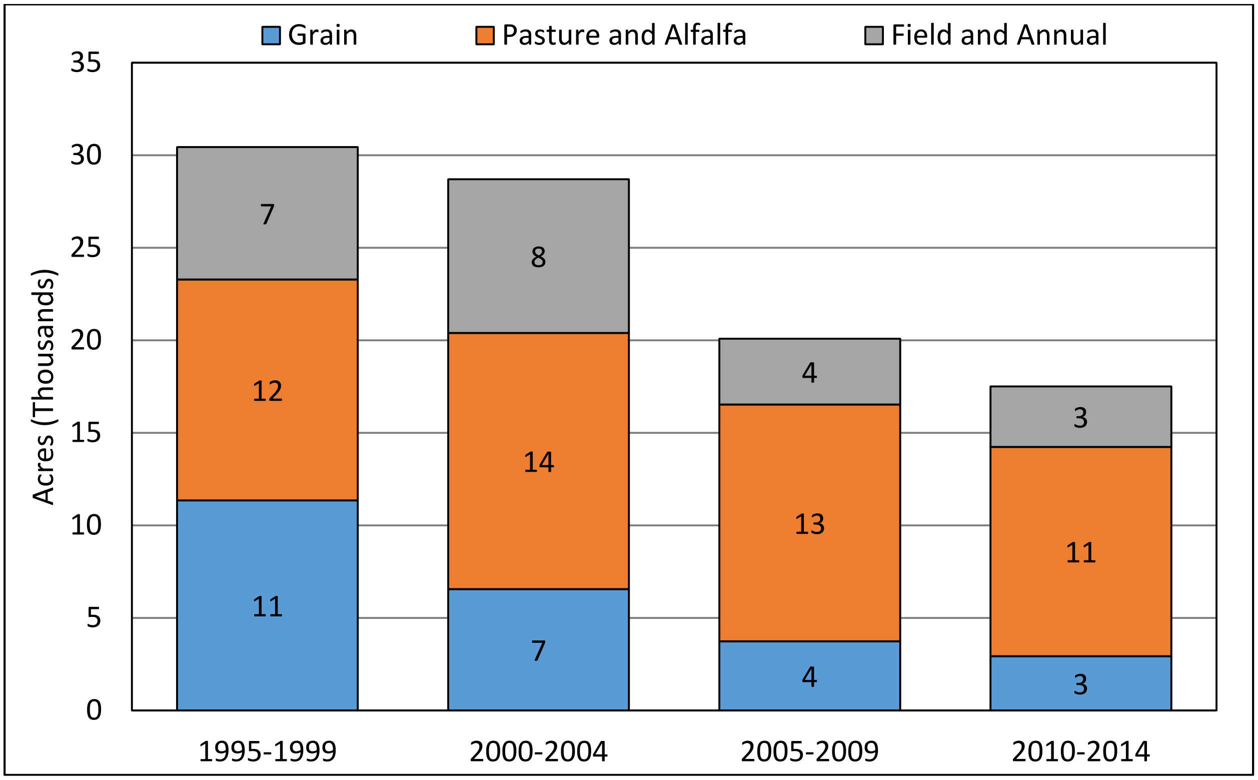

Figure ES.6. Butte County Valley Floor Other Crop Land Use, 1995-2014.

Surface Water Diversions

Primary surface streams relied on to provide water supplies in Butte County include the Feather River and Butte Creek. Water is also diverted from the Sacramento River and other, minor sources[7]. The vast majority of these diversions occur within the valley floor IUs, although Paradise Irrigation District also diverts water for domestic and M&I use within its service area.

Estimated annual diversions for water years[8] 2000 to 2014 are presented in Figure ES.7. Total surface water diversions during this period ranged from 742,600 af to 906,800 af with an average of 827,900 af. Feather River diversions ranged from 629,900 af to 778,600 af during this period with an average of 696,600 af. Butte Creek diversions ranged from 24,400 af to 71,600 af with an average of 54,700 af. Sacramento River diversions ranged from 2,400 af to 18,300 af with an average of 8,400 af. Other diversions ranged from 49,400 af to 58,800 af with an average of 54,600 af.

The primary destination of diverted surface water in Butte County is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure ES.8. Deliveries ranged from 635,300 af to 777,100 af with an average of 709,200 af. Losses to seepage, spillage, and evaporation averaged 55,200 af, 58,800 af, and 4,700 af, respectively.

Diversions are subject to limitations based on diversion agreement terms (e.g. settlement contracts between the Department of Water Resources and Western Canal Water District and the Joint Districts) and regulatory actions of the State Water Resources Control Board (SWRCB). SWRCB regulatory actions to curtail diversions may apply to senior pre-1914 and riparian water rights in periods of drought, as occurred in 2015.

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[7] Other sources include miscellaneous riparian diversions and surface water supplies. These include diversions from the Feather River watershed other than the Feather River Settlement Contractors (e.g., South Feather Water and Power) and the Cherokee Canal.

[8] A water year refers to the period from October to September each year, with the beginning month of October selected based on the typical beginning of the winter rainy season. For example, the 2000 water year includes the period from October 1999 to September 2000.

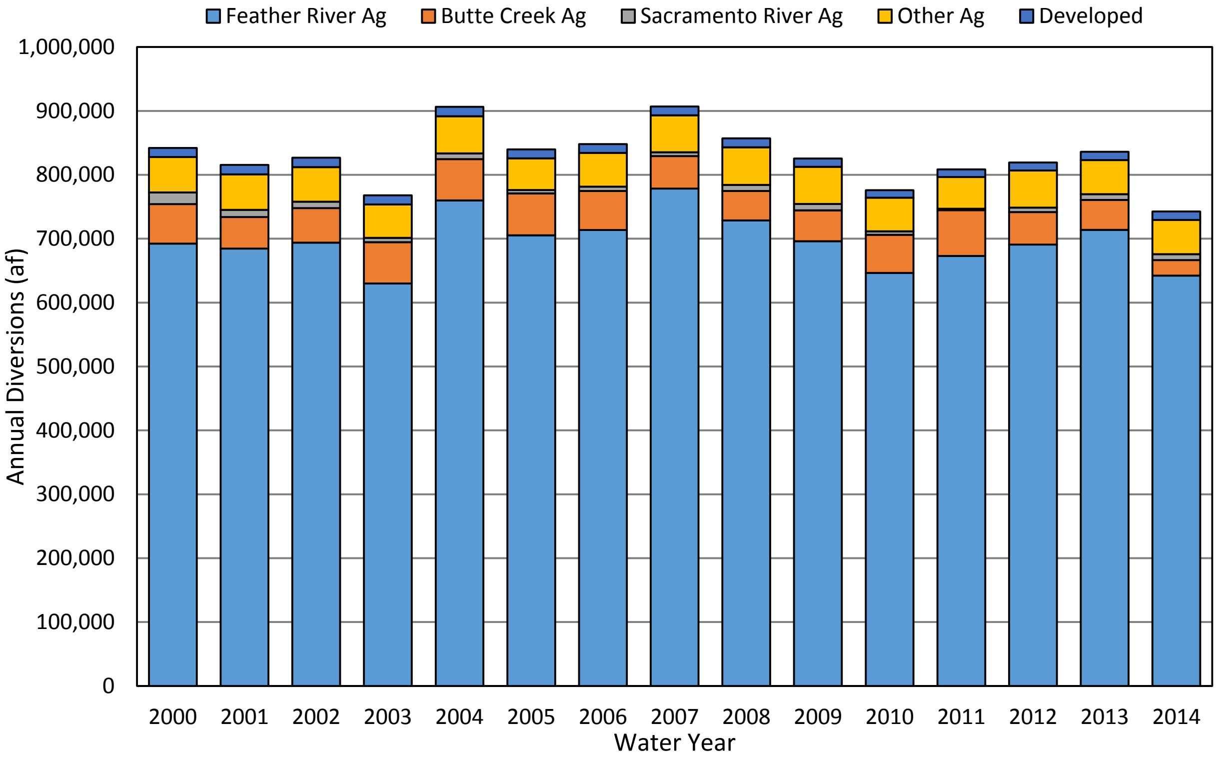

Figure ES.7. Butte County Estimated Surface Water Diversions by Source, 2000-2014.

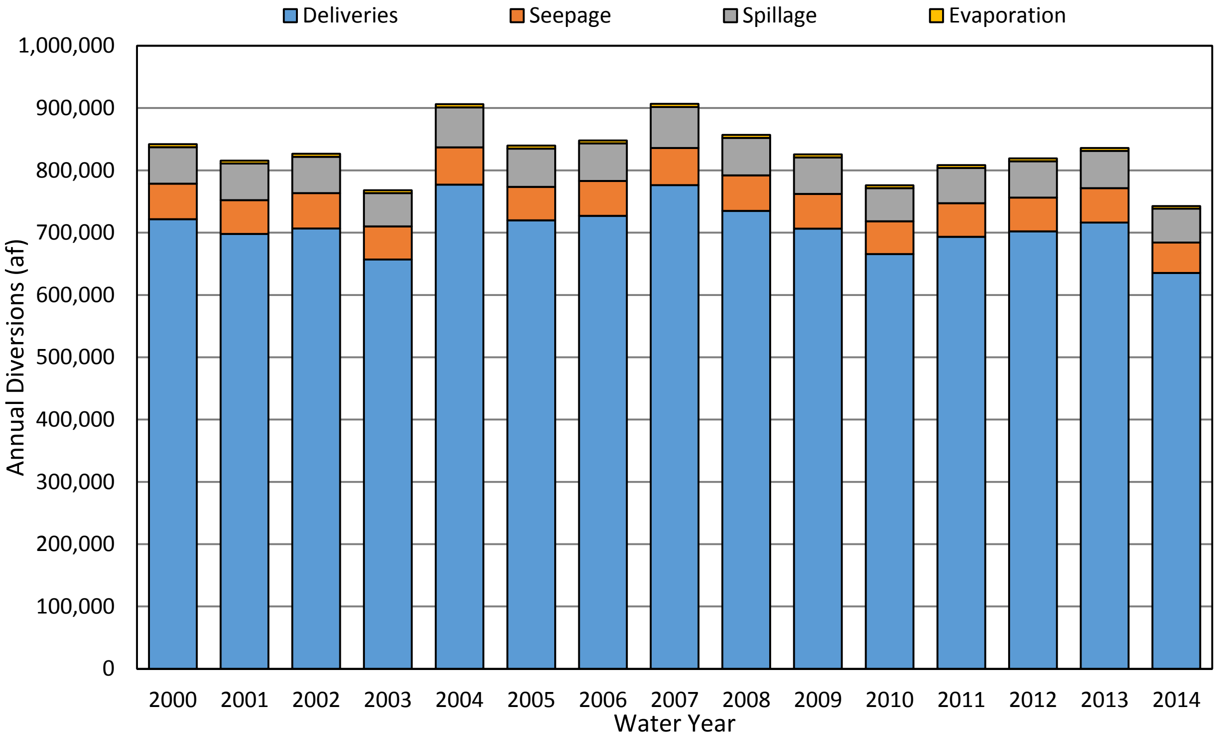

Figure ES.8. Butte County Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

Groundwater Pumping

Groundwater provides a source of supply to meet irrigation, domestic, M&I, environmental, and stockwater demands. Estimated pumping within the valley floor IUs for water years 2000 to 2014 is presented in Figure ES.9. In the figure, symbols for each year are color-coded based on the Sacramento Valley Water Year Index (WYI), a key indicator of seasonal variability in interannual hydrology. The WYI is used to classify individual water years as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), or Critical (C) with respect to surface water runoff in the Sacramento River Basin. Total estimated groundwater pumping during this period ranged from 316 thousand acre-feet (taf) in the wet year of 2011 to 489 taf in the critically dry year of 2008. Average pumping during this period is estimated to be 411 taf annually.

As indicated in the figure, pumping varies substantially from year to year and is highly correlated to the WYI, with increased pumping in dry and critical years to meet increased irrigation demands and decreased pumping in wet and above normal years. Although linear regression suggests some increase in pumping over time, the correlation between pumping and time is weak ($R^2 = 0.05$), and the apparent increase between 2011 and 2014 is likely due to drought. Pumping in the County increases substantially in years during which Feather River supplies in the East Butte and West Butte IUs are curtailed. For example, in the curtailment year of 2015, it is estimated that groundwater pumping in the Feather River Settlement Contractor service areas within Butte County increased by approximately 130 taf in response to curtailment of approximately 50 percent of surface water supplies (Davids Engineering 2016).

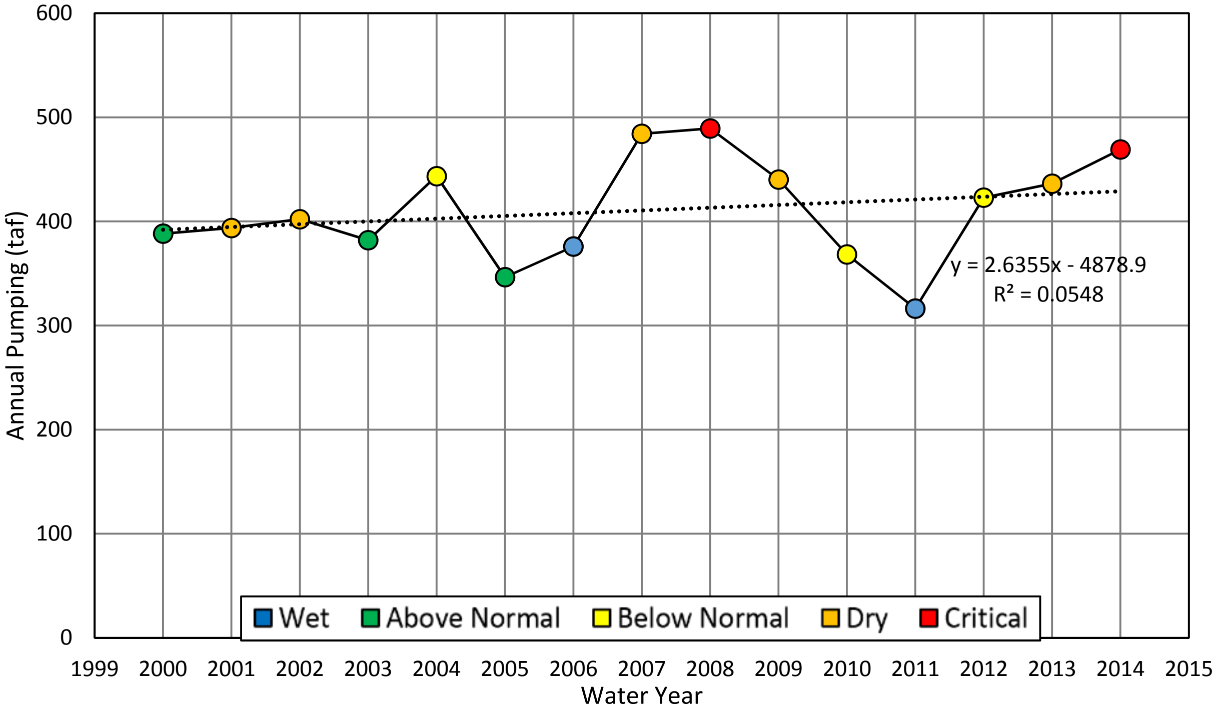

Figure ES.9. Butte County Valley Floor Estimated Groundwater Pumping and Water Year Type, 2000-2014.

Water Budget

Presented in this report are water budget results for the land surface[9]. A water budget is just like a checking account: The inflows (deposits) minus the outflows (withdrawals) must add up to the total change in storage (account balance) of water within the defined region over time. Water budgets can be defined for different subsets of the system. As shown in Figure ES.10, the inflows include precipitation (P), applied water (A_W) (i.e. irrigation), and reuse (U), and the outflows include evapotranspiration (ET), runoff (R_p), return flow (R_f), and deep percolation (D). By developing annual water budgets, we can see how each of these components changes over time as water supplies and demands change.

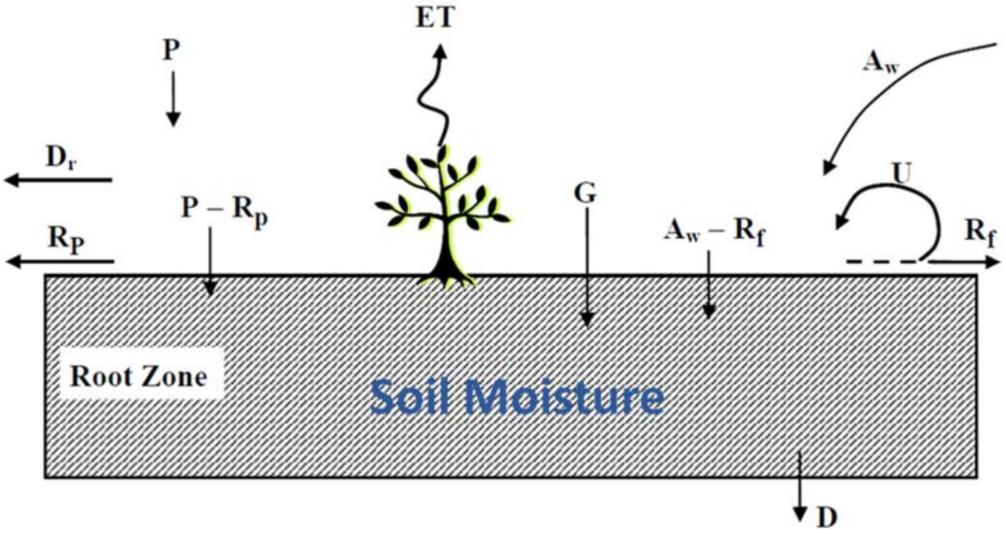

Figure ES.10. Representation of Root Zone Flow Processes by IDC (DWR 2015) (P = Precipitation, ET = Evapotranspiration, A_w = Applied Water, U = Reuse, R_f = Irrigation Return Flow, D_r = Outflow from Rice and Wetland Pond Drainage, R_p = Runoff of Precipitation, D = Deep Percolation, and G = Generic Water Source (e.g. Fog)) (Source: DWR).

County-wide, approximately 95 percent of developed water use[10] is for irrigated agriculture and managed wetlands, with the remaining 5 percent for developed lands. Almost all irrigated agriculture and managed wetlands water use and the majority of developed water use occurs on the valley floor, although both surface water and groundwater supplies are critical to the population of the Foothill and Mountain IUs.

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[9] The land surface water budgets include irrigated agricultural lands, developed lands, non-irrigated lands, and wetlands. The budgets do not include waterways such as streams, canals, and drains.

[10] Developed water use refers to the use of surface water diversion and groundwater pumping to meet agricultural, urban, managed wetlands, or other demands.

Developed water supplies for the valley floor IUs include surface water diversions and groundwater pumping. Primary demands in valley floor IUs are irrigation demands to meet crop ET requirements, managed wetlands, and developed lands.

Land surface inflows on the Butte County Valley Floor (Vina, West Butte, East Butte, and North Yuba IUs) average approximately 2.040 million acre-feet (maf) annually and include precipitation (914 taf), applied surface water (715 taf), and groundwater pumping (411 taf) (Figure ES.11, Figure ES.12, and Table ES.1). Precipitation varied from 562 taf in 2007 to 1.314 maf in 2011. Groundwater pumping varied from 316 taf in 2011 to 489 taf in 2008. Applied surface water varied from 641 taf in 2014 to 782 taf in 2007. Annual flows are provided in Table ES.1, along with the water year type as discussed in Section 4.2.

As indicated in Figure ES.12, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

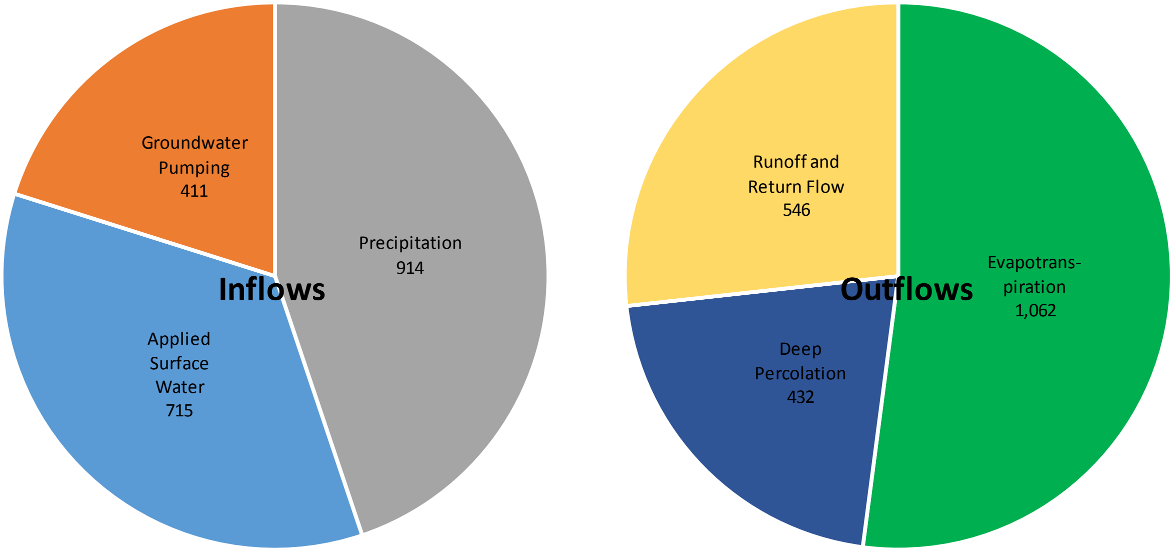

Figure ES.11. Butte County Valley Floor Overall Average Annual Inflows and Outflows, 2000-2014.

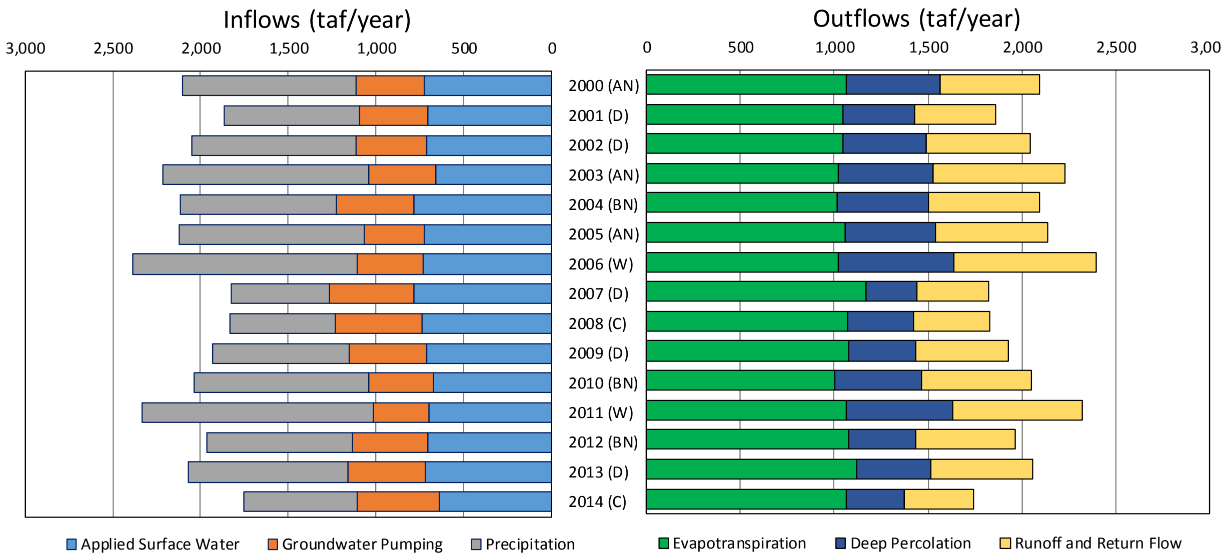

Figure ES.12. Butte County Valley Floor Overall Water Year Inflows and Outflows, 2000-2014.

Table ES.1. Butte County Valley Floor Overall Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	984	728	388	1,066	496	531	-5
2001 (D)	768	703	394	1,047	382	431	-3
2002 (D)	934	711	402	1,048	445	550	-8
2003 (AN)	1,172	662	382	1,022	504	707	23
2004 (BN)	891	782	443	1,015	486	596	-27
2005 (AN)	1,052	724	346	1,058	480	601	23
2006 (W)	1,275	732	376	1,023	613	760	6
2007 (D)	562	782	484	1,167	272	382	3
2008 (C)	605	740	489	1,073	348	407	-19
2009 (D)	775	713	440	1,074	363	492	7
2010 (BN)	998	672	368	1,005	458	591	17
2011 (W)	1,314	699	316	1,063	570	692	-1
2012 (BN)	835	709	423	1,080	356	530	-7
2013 (D)	908	722	436	1,118	398	545	21
2014 (C)	643	641	469	1,067	307	369	-24
Minimum	562	641	316	1,005	272	369	-27
Maximum	1,314	782	489	1,167	613	760	23
Average	914	715	411	1,062	432	546	0
Averages by Hydrologic Year Type							
Wet (W)	1,295	715	346	1,043	591	726	2
Above Normal (AN)	1,069	705	372	1,049	493	613	14
Below Normal (BN)	908	721	412	1,033	433	572	-6
Dry (D)	789	726	431	1,091	372	480	4
Critical (C)	624	691	479	1,070	328	388	-22

Future Demand and Climate Change Scenarios

As part of the WI&A, agricultural and urban demand scenarios and climate change scenarios have been developed to support analysis of potential future supplies and demands using the BBGM (Davids Engineering 2013, 2015). Demand and climate change scenarios have been developed to allow for evaluation of potential future conditions and to better understand the sensitivity of water supplies and demands in Butte County to changes in agricultural and urban water use and changes in underlying hydrology (precipitation and stream flows) that may result from climate change. The scenarios are not intended to be predictions of most likely future conditions, but rather to support sensitivity analysis and provide greater understanding of Butte County's water resources to support planning.

Demand Scenario

A scenario representing potential agricultural demands has been developed that considers changes in cropping and evapotranspiration, expansion of the irrigated area, changes in irrigation water source (conversion from surface water to groundwater in some areas), and changes in irrigation technology and management.

The demand scenario assumes the following changes:

- Field, truck, and pasture crops will continue to shift to higher value crops.
- Crop evapotranspiration rates for non-rice crops will increase by approximately 10 percent.
- Rice ground will convert to orchards where shallow groundwater levels suggest limited risk of "drowning" due to high water table and flood risk. The greatest potential for these changes is believed to be along the east side of Butte Creek in the Esquon and Western Canal SIUs.
- Irrigation will expand through new orchard plantings on class 3, 4, or 5 lands[11], primarily in the East Butte SIU between Thermalito Afterbay and the Feather River and in the North Yuba SIU south of Oroville and north of Honcut Creek.
- Orchards within the Butte SIU, rice ground converted to orchards, and areas of irrigation expansion within the East Butte and North Yuba IUs will rely on groundwater for irrigation.
- Irrigation efficiency for orchards will increase by approximately five percent.

In addition to these changes in irrigation demands, the demand scenario will update urban demand estimates based on updated urban water management plans that are expected to be available later in 2016.

Climate Change Scenario

To evaluate potential impacts of climate change, two climate change scenarios have been selected from the Governor's 2008 Climate Action Team (CAT) recommended scenarios for evaluating water management in California. The CAT identified 12 scenarios as part of its evaluation that can be used to project future temperature; precipitation timing and amounts; snowfall, snowmelt, and runoff, etc. By mid-century, the scenarios generally agree in an increase in average air temperature. Results are more mixed regarding changes in

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[11] As defined by Agriculture Handbook No. 210, issued by the USDA Soil Conservation Service (SCS 1961). Also described in Davids Engineering technical memorandum on *Agricultural and Urban Demand Scenarios and Climate Change Scenarios for BBGM Update* (2015)

precipitation, but on average a slight reduction in precipitation is suggested. The two scenarios selected are as follows:

- Central tendency (“consensus” among scenarios)[12]
- Hotter-Drier (more extreme heating and drying)[13]

Based on the scenarios selected, magnitudes of historical precipitation, streamflows, and diversions are adjusted to develop BBGM inputs. One set of inputs will be developed for each scenario.

Conclusions

The *2016 Water Inventory and Analysis Report* not only updates the analysis of the County’s water supply and demand, but it fundamentally changes the County’s analytical approach to help sustain water resources for future generations. One of the important changes is the integration of the BBGM as a platform for developing and analyzing data for the *2016 Water Inventory and Analysis Report* and future analyses. The integration of the BBGM with the *2016 Water Inventory and Analysis Report* positions the Department with the long term ability to conduct water resource analyses as the need arises. An early benefit of this approach was realized through the *Assessment of Butte County Drought Impacts, 2012-2015* Technical Memorandum (Davids Engineering 2016). The obligation of the Sustainable Groundwater Management Act (SGMA) of 2014 to conduct water balance analyses necessitates having the capacity to perform novel analytical assessments. The completion of the *2016 Water Inventory and Analysis Report* and the updated BBGM prepares the County to meet these obligations.

Land use in the Butte County valley floor area has been relatively steady in recent years, with little change in irrigated agricultural lands and a modest decrease in non-irrigated lands. This decrease is offset by increases in developed lands and wetlands. Shifting of crops has occurred, including some increase in orchards (particularly walnuts) and a decrease in other, non-rice crops. There is the potential for marginal expansion of irrigation in some areas, particularly in the East Butte IU between Thermalito Afterbay and the Feather River and in the North Yuba IU between Oroville and Honcut Creek. Potential impacts of additional crop shifting and irrigation expansion will be evaluated using the BBGM and demand scenarios developed as part of the WI&A (as described in Section 6).

The primary climate variable affecting water conditions in the County is inter-annual differences in precipitation and snowfall. Variability from year to year impacts both the availability of surface water to meet demands and the amount of pumping required to meet crop irrigation requirements. In the future, temperatures are likely to increase as a result of climate change, resulting in less snowpack in the Feather River watershed and earlier runoff.

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[12] NCAR CCSM3, b1 emission scenario (http://www-pcmdi.llnl.gov/ipcc/model_documentation/CCSM3.htm).
[13] MIROC3.2, a2 emission scenario (http://www-pcmdi.llnl.gov/ipcc/model_documentation/MIROC3.2_medres.htm).

These changes will make existing surface water supplies less reliable, increasing the need to rely on groundwater to meet demands. Climate change scenarios developed as part of the WI&A will allow for evaluation of the potential impacts of climate change using the BBGM.

Groundwater level declines have been observed in some areas of the County over recent years and are likely driven mainly by drought conditions leading to reduced deep percolation (potential recharge) and increased groundwater pumping. Pumping estimates developed as part of the WI&A suggest that these groundwater level declines may be related more to reduced recharge, rather than increased pumping, though the frequent occurrence of dry and critically dry years in the past decade have resulted in increased pumping. Pumping appears to be influenced more by inter-annual precipitation than to other factors such as increasing crop acreage or crop shifting over time.

Water budgets developed as part of the WI&A provide valuable information describing land surface processes to support evaluation of the sustainability of available water supplies. The scale at which supplies and demands are quantified is critical to supporting effective water management. Subinventory water budgets underlying the IU water budgets presented in the WI&A (Appendix C) allow for direct engagement with local stakeholders and closer examination of current and historical conditions and trends, while also helping to identify data gaps that need to be addressed to better manage for sustainability in the future.

Recommendations and Next Steps

Recommendations and suggested next steps have been identified as part of developing the *2016 Water Inventory and Analysis Report* (WI&A) and include the following:

- While many of the large diversions are continuously monitored and recorded, limited information is available for others. Work with local stakeholders to better document surface water diversions, including investigation of riparian diversions in some SIUs and additional information describing water supplies for managed wetlands. Diversion estimates developed as part of the WI&A provide a good basis to support discussion with diverters.
- Groundwater pumping for irrigation has generally been estimated based on estimates of crop irrigation requirements in areas known to rely on groundwater. Look for opportunities to verify and refine groundwater pumping estimates by obtaining pumping data from cooperative landowners.
- Deep percolation in some areas may return to the surface layer through accretion in drains and natural waterways or may be consumed by phreatophytic vegetation. Further investigate the ultimate fate of deep percolation from agricultural lands. Through modelling of specific waterways and shallow groundwater, the BBGM will support this investigation.
- The relative proportion of non-consumed water returning as deep percolation or surface runoff for the WI&A does not explicitly account for percolation from stormwater

retention ponds or releases from wastewater treatment plants to local waterways. Refine water budgets for developed lands to verify and refine estimates of non-consumed water.

- Further evaluate water budgets from the WI&A and developed for the groundwater system using the BBGM for historical and current drought periods to better understand factors contributing to recent historic low water levels in some areas.
- Identify and evaluate additional options to adapt to drought, future demands, and climate change.
- Continue public outreach regarding the WI&A and SIU water budgets to educate and inform the public regarding water resources in the County and to gather additional insights to support future water management efforts.
- Continue the process of updating and calibrating the BBGM through further refinement of input datasets and calibration of aquifer parameters to simulate historical water levels and streamflows.
- To retain local groundwater management authority, Butte County should continue to implement the Sustainable Groundwater Management Act (SGMA), including utilizing the WI&A and BBGM information to support development of Groundwater Sustainability Plans (GSPs). One of the key principles of SGMA is that groundwater is best managed at the local level. Developing a water budget and utilizing a groundwater model are requirements of groundwater sustainability plans. The WI&A provides a foundation for meeting these requirements.

1. Introduction to the 2016 Water Inventory and Analysis Report

1.1 Background

California's water resources are highly variable geographically, seasonally, and annually. Managing these resources in the face of increasing and competing demands has become increasingly difficult. Difficult decisions can be made easier with more and better data and analysis. The *2001 Water Inventory and Analysis Report* concluded that long-term trends in groundwater storage indicate that the groundwater basin is not in a state of decline. More than fifteen years have passed and circumstances have changed. For example, many groundwater dependent portions of the basin have shown a steady decline in groundwater elevations. Another indication of changing circumstances is that a significant number of monitoring wells have reached new historic low groundwater elevations. Some of the wells have periods of record going back fifty years. The generally dry hydrologic period, including the current historic drought, is likely driving the unprecedented decline in groundwater elevations. However, there are likely other factors involved, so qualitative presumptions cannot be the basis for groundwater management. The system is more complex and the stakes are too high. Water management decisions should be informed by comprehensive water analyses that account for the range of variables including the increased demand and the impact of climate change (warmer and dryer conditions).

The *2016 Water Inventory and Analysis Report* represents an important step forward in developing tools for water resource management. The *2016 Water Inventory and Analysis Report* utilizes the BBGM as a platform for analyzing data for current conditions and future analyses. The BBGM is a mathematical model that covers the extent of the Vina, West Butte, East Butte and North Yuba subbasins, otherwise referred to as the Butte Basin. The BBGM is a complete, physically based, hydrologic model, accounting for various sources and uses of water continuously over time. This allows for an examination of water supply and demand scenarios with outcomes that lie beyond the realm of historical experience, such as could result from land use changes, population changes, climate change, and/or prolonged drought periods. To maximize the benefits of the BBGM, the code and data inputs had to be updated. The BBGM was coded in the Integrated Water Flow Model (IWFM) version 2.4.1. The Department updated the BBGM to IWFM-2015 using version 4.1 of the IWFM Demand Calculator (IDC). IDC 4.1 provides improved characterization of ponded land uses (i.e., rice and wetlands) and stream diversion data. The previous version of the BBGM simulated historical conditions (precipitation, stream flow, land use, water deliveries and pumping, groundwater levels and stream-groundwater interaction) for 1970-1999. The time series inputs for the BBGM were updated to produce estimates of water supplies and demands throughout the model domain over the full simulation period (1970 through 2014). The outputs from the updated BBGM will be used to explore impacts from different scenarios (e.g., increased demand projections, climate change, droughts) compared to current water supply and demand conditions. The results of the *2016 Water Inventory and Analysis Report* and upcoming analyses of changed conditions will provide the framework to support local dialogue on sustainable groundwater management.

1.2 Purpose and Scope

The purpose of the *2016 Water Resource Inventory and Analysis Report* is to present an overview of current county water supply and demand conditions. Urban, agricultural, and environmental water needs are estimated, reflecting conditions through water year 2014. The *2016 Water Inventory and Analysis Report* utilizes recent census data, land use data, Urban Water Management Plans and adopted General Plans to reflect the latest population, crop acreage and production, crop water requirement, environmental water use, water quality, and habitat quality data. The *2016 Water Inventory and Analysis Report* establishes a baseline for agricultural, urban, and environmental water availability and use in each of the subbasins of Butte County. The *2016 Water Inventory and Analysis Report* serves an important role by:

1. Integrating the Butte Basin Groundwater Model as a useful and productive tool.
2. Identifying how water demands have changed over the past fifteen years in different areas and the drivers of change.
3. Preparing water budgets for each sub-inventory unit to inform the local conversation regarding resource use and sustainability.
4. Assessing what the future may hold and how best to prepare by developing forecasts for future urban and agricultural water demands and developing climate change hydrology scenarios for future groundwater model runs and associated analyses.

The *2016 Water Inventory and Analysis Report* continues the approach of dividing Butte County into sub-inventory units. The subinventory units were employed in the *2001 Water Inventory and Analysis Report* and are represented in the BBGM. The subinventory units were developed on the basis of groundwater subbasins and common water sources. The principal Bulletin 118 groundwater subbasins within the County have been designated as inventory units. These include Vina, West Butte, East Butte, and North Yuba. In addition, the Foothill, and Mountain inventory units encompass the non-valley portions of the County. Each inventory unit has been further divided into subinventory units. Twenty subinventory units are included within the County, representing water suppliers or unorganized areas with common water sources and uses (Figure 1.1).

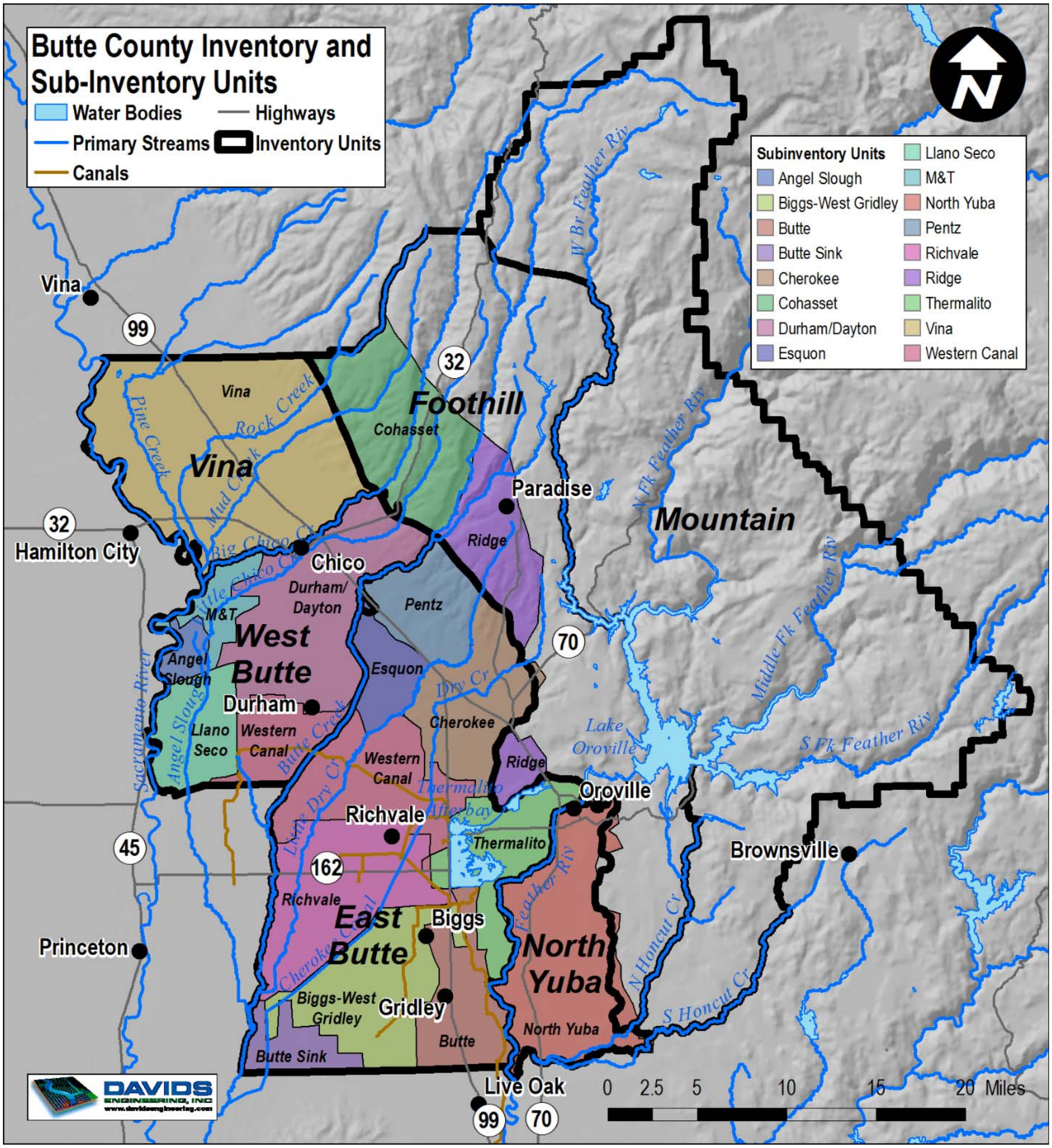

Figure 1.1. Butte County Water Inventory and Analysis Inventory Units and Subinventory Units.

The *2016 Water Inventory and Analysis Report* benefits from the detailed water balance analyses developed as part of the Feather River Regional Agricultural Water Management Plan (FRRAWMP) (NCWA 2014). The FRRAWMP study area extends from the Sacramento River and Sutter Bypass in the west to the Feather River in the east and from Western Canal Water District in the north to the Freemont Weir in the south. An objective of the *2016 Water Inventory and Analysis Report* is to ensure consistency between these efforts to ensure that the most current understanding of the surface and groundwater hydrology of the Butte Basin is incorporated into the County's water management planning.

1.3 Relationship to the Sustainable Groundwater Management Act (SGMA)

The Sustainable Groundwater Management Act (SGMA) went into effect in January 2015. One of the key principles of SGMA is that each groundwater basin has unique characteristics and challenges; therefore, groundwater is best managed at the local level, and local agencies should have the tools they need to sustainably manage their resources. Another principle is when local agencies cannot or will not manage their groundwater sustainably, the State will intervene. To avoid state intervention, groundwater sustainability agencies must be formed by June, 2017 and implement groundwater sustainability plans that will bring the basin into sustainability in 20 years. Local public agencies with water management, water supply or land use authority are eligible to be a groundwater sustainability agency. The components of groundwater sustainability plans (GSPs) are subject to regulations adopted by the Department of Water Resources. A water budget with potential use of a groundwater model is a required component of a GSP. The initiation of the *2016 Water Inventory and Analysis Report* predated the enactment of SGMA. The *2016 Water Inventory and Analysis Report* and SGMA share a similar goal of basing local sustainable groundwater management decisions on a set of analytical analyses. The utilization of the BBGM to develop water budget scenarios will likely meet SGMA requirements. However, the GSP regulations establish that specific input and projection parameters (e.g., precipitation, ET, hydrology, climate change, land use, etc.) be based on standards set by DWR. The regulations allow local agencies to use other data provided that they can demonstrate that the data are of sufficient quality. It is possible that the data and forecast parameters in the *2016 Water Inventory and Analysis Report* and subsequent analyses may not match the standards set by DWR for GSPs. Some of the data may be acceptable to DWR for GSP compliance while others may not. The result may be that some of the data used in the *2016 Water Inventory and Analysis Report* may be modified for the GSP(s) scheduled for submission in 2022.

1.4 Acknowledgments

The *2016 Water Inventory and Analysis Report* was prepared under the leadership and ingenuity of Dr. Christina Buck, Department of Water and Resource Conservation, and the team from Davids Engineering led by Grant Davids and Byron Clark and supported by Ken Loy and Mandy Ott of West-Yost Associates. Davids Engineering developed the time series data for the BBGM and produced an analysis of drought impacts. The Department was responsible for operating the model and providing model results to Davids Engineering for analysis and presentation in the Water Inventory and Analysis report. Davids Engineering conducted the special analysis of drought impacts. The *2016 Water Inventory and Analysis Report* benefited from the input of a Project Advisory Committee. The advisory committee was comprised of members of the Butte County Water Commission, Technical Advisory Committee (TAC) and County staff. The members of the Advisory Committee included Paul Gosselin (Water and Resource Conservation), Vickie Newlin (Water and Resource Conservation), Dan Breedon (Development Services), George Barber (Water Commission), David Skinner (Water Commission), Joe Connell (TAC), Pete Bonacich (TAC), and Richard Price (TAC). Finally, the *2016 Water Inventory and Analysis Report* was made possible by the policy leadership and financial support of the Butte County Board of Supervisors. Through the leadership of the Board of Supervisors, Butte County will be positioned to sustainably manage water resources for the foreseeable future.

Information provided by the Feather River Regional Agricultural Water Management Plan was also critical to the report. We appreciate the partnership with Western Canal Water District, Richvale Irrigation District, Butte Water District and the Biggs-West Gridley Water District. The report benefited from collaboration with California Water Service Chico, California Water Service Oroville, M&T Ranch, Rancho Esquon, and other water managers. Finally, public presentations before the Butte County Water Commission and at other meetings provided meaningful input.

1.5 Contents of the Water Resource Inventory and Analysis Report

The *2016 Water Inventory and Analysis Report* is structured to be generally consistent with the previous version of the *Water Inventory and Analysis Report*. One major difference is that the section on Water Suppliers and Managers was moved to Appendix A. The *2016 Water Inventory and Analysis Report* includes the following Sections:

- Section 1. Introduction to the 2016 Water Inventory and Analysis Report
- Section 2. Inventory and Analysis Methodology
- Section 3. Land Use and Cropping Patterns
- Section 4. Climate and Hydrology
    - 4.1 Climate
    - 4.2 Surface Water Hydrology
    - 4.3 Groundwater Hydrology
- Section 5. Historical Water Demands and Supplies
- Section 6. Future Water Demands and Supplies
- Section 7. Conclusions and Recommendations
- Section 8. References

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2. Inventory and Analysis Methodology

The Department of Water Resources (DWR) develops and maintains the Integrated Water Flow Model (IWFM). IWFM is a surface-subsurface hydrologic model that couples the integrated hydrologic modeling approach with a root zone component that uses the irrigation-scheduling-type approach. The stand-alone root zone modeling tool is named the IWFM Demand Calculator (IDC) which solves the soil moisture balance in the root zone to compute agricultural and urban water demands (DWR 2015). Inputs developed for the Butte Basin Groundwater Model (BBGM) and Water Inventory & Analysis (WI&A) update serve as inputs for the IWFM and IDC versions of the BBGM. Water Budgets presented in Section 5 of this report are derived from IDC results and other developed inputs as described in the following sections.

2.1 Summary of a Water Budget

The irrigation scheduling approach of IDC simulates the ways water moves into, through, and out of the root zone. Overall, just like a checking account, the inflows minus the outflows must add up to the total change in storage of water within the defined region. Water budgets can be defined for different subsets of the system. Presented in this report are water budget results for the land surface system. As shown in Figure 2.1, the inflows include precipitation (P), applied water (A_W) (i.e. irrigation), and reuse (U), and the outflows include evapotranspiration (ET), runoff (R_p), return flow (R_f), and deep percolation (D). By developing annual water budgets, we can see how each of these components changes over time as water supplies and demands change.

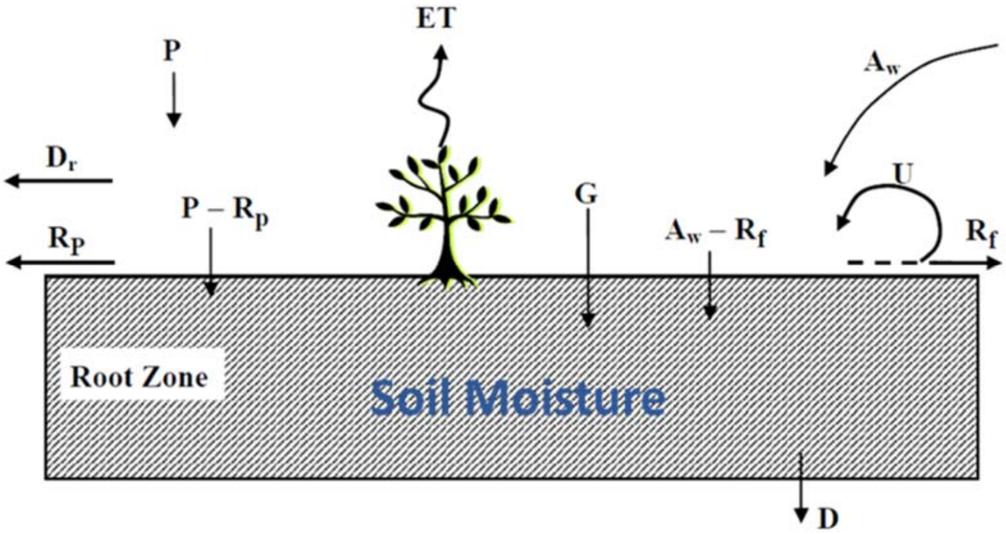

Figure 2.1. Representation of Root Zone Flow Processes by IDC (DWR 2015) (P = Precipitation, ET = Evapotranspiration, A_w = Applied Water, U = Reuse, R_f = Irrigation Return Flow, D_r = Outflow from Rice and Wetland Pond Drainage, R_p = Runoff of Precipitation, D = Deep Percolation, and G = Generic Water Source (e.g. Fog)).

To develop a water budget, both an understanding of how the system works and datasets for each of the variables are needed. Most variables are not constant and change seasonally, annually, and over a long period of time. Some of the changes are temporary (e.g. drought years), but others may be longer term or permanent (e.g. land use).

Relatively direct measurements are available for some datasets (e.g. precipitation), but for other datasets it is necessary to develop reasonable estimates based on available information. Applied water, or irrigation water demand, is calculated by the IDC component of the BBGM based on climate conditions, soil parameters, crop evapotranspiration, and irrigation practices. The source of applied water can be surface water deliveries (which are specified based on measured or estimated data) or groundwater pumping. Groundwater pumping for agricultural water use is not metered or directly measured systematically in Butte County. As a result, pumping is estimated by estimating required agricultural water demands to irrigate a particular crop. Since some of the demand may be met by delivered or recovered surface water, any remaining water requirement is assumed to be met by groundwater pumping.

Deep percolation is also calculated by IDC and represents water that moves through and drains out of the root zone. This process is driven by the characteristics of the soil as represented by specified soil parameters in IDC, particularly saturated hydraulic conductivity. This water may continue to move downward through the unsaturated zone into the aquifer system or in cases where there is a shallow or perched water table, it could move laterally into a stream channel or canal and become surface runoff or it could be utilized by phreatophytic vegetation and transpired.

Similarly, runoff is calculated by IDC and results from the intensity of precipitation events and applied water and the characteristics of the land surface as represented by NRCS curve numbers. Curve numbers are assigned based on soil properties and land use.

Methods for developing data inputs for precipitation, evapotranspiration, and other components of the system are described in Section 2.3.

2.2 Butte Basin Groundwater Model

Development of the original Butte Basin Groundwater Model (BBGM) began in 1992 by HCI under the direction and funding of the Butte Basin Water Users Association (HCI 1996). The original version used a modeling code called FEMFLOW3D and simulated historical conditions from 1970 to 1991. The model was then extended to simulate historical conditions through 1999 through a series of updates. During 2003-2008, CDM conducted a significant update to the model, changing the modeling code to IWFM v.2.4.1, revising the hydrostratigraphy from three layers to nine layers based on DWR Northern Region Office (DWR NRO) geologic cross sections, and expanding the model domain into the foothill area to directly incorporate potential recharge areas. The model was recalibrated and used to run a base case and 50% surface water curtailment scenario (CDM 2008b). This version of the BBGM is referred to as the 2008 CDM version.

The update of the BBGM for the WI&A (BBGM-2016) uses the same model domain, grid, subregions, and stream network as the 2008 CDM version (CDM 2008a) (Figure 2.2). The BBGM-2016 version runs using model code IWFM-2015 and version 2015.0.36 of the IWFM Demand Calculator (IDC) using v. 4.0 of the root zone component (DWR 2015). It maintains a daily time step with some daily input (i.e. precipitation, stream inflow), some monthly input data (i.e. surface water diversions) and some annual input data (i.e. land use). The BBGM-2016 model time period is 1970-2014.

Although model structure is the same in many ways as the 2008 CDM version, major differences include additional crop types to better represent ponded crops (i.e. rice and wetlands), recalibrated soil parameters, and elemental land use. A major change in the rootzone v.4.0 code is representation of land use on the elemental scale rather than the subregion scale and direct representation of flooding fields for ponded crops (i.e. rice and wetlands). These changes to the BBGM are described in more detail below.

2.2.1 Modeled Crops and Land Uses

Crops that require flooding are referred to as ‘ponded crops’ in IWFM. These include rice and managed wetlands. Rice is divided into two crop types in the BBGM. One that represents acreage with winter flooding for rice straw decomposition and the other without winter flooding for decomposition. To represent the shift in practice from rice straw burning to winter flooding for decomposition between 1991 and 2001 as a result of the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991, land use acreage for these crop types are shifted linearly over time from 1991 to 2001, with approximately 12 percent of rice being flooded in the winter prior to 1991 and 53 percent of rice flooded in the winter in 2001 and later years.

In Butte County, the distribution of ponded crop acreage is largely driven by and constrained by soil characteristics and the drainage properties of the soil. Thus, rice and managed wetlands acreage tend to historically be geographically stationary. In the BBGM, elements corresponding to this ponded crop acreage are identified as ‘ponded crop elements’ and as a result are assigned different soil properties than ‘nonponded elements’ with similar soil types (described in further detail in the following section). This however results in rice and wetland acreage that inevitably occurs in nonponded elements on the margins of the ponded crop element zones. This acreage is input to the BBGM as nonponded acreage for rice and managed wetlands. Acreage for all other crop types including truck crops, orchard crops, and annual crops are considered nonponded crop acreage. Native crop types, native and riparian, is specified land use acreage that does not receive applied water. Urban areas are represented by an urban crop type. Ponded and nonponded elements are shown in Figure 2.3.

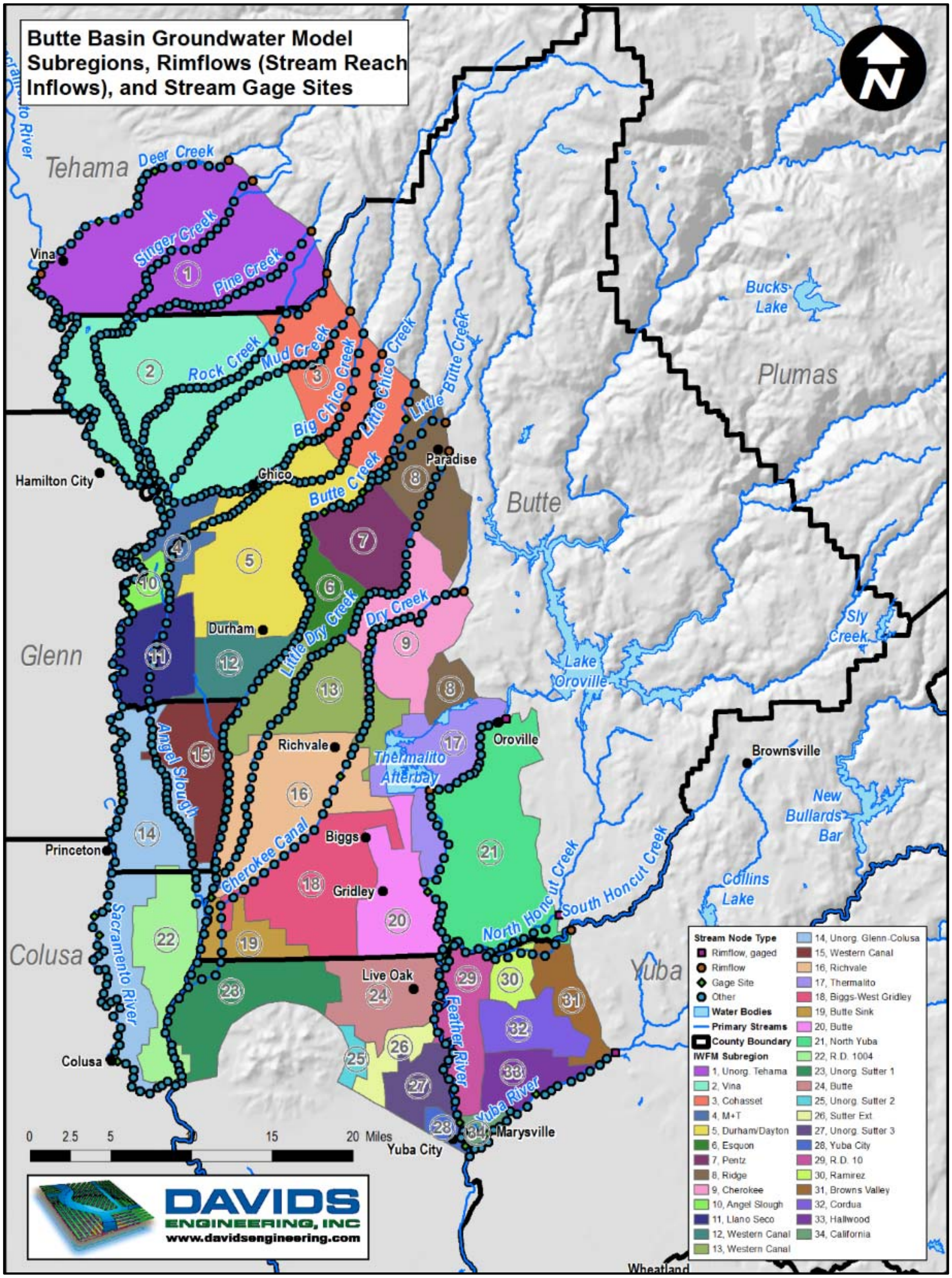

Figure 2.2. Butte Basin Groundwater Model Domain, Subregions, and Stream Network[1].

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[1] The model grid is shown later in Figure 2.3.

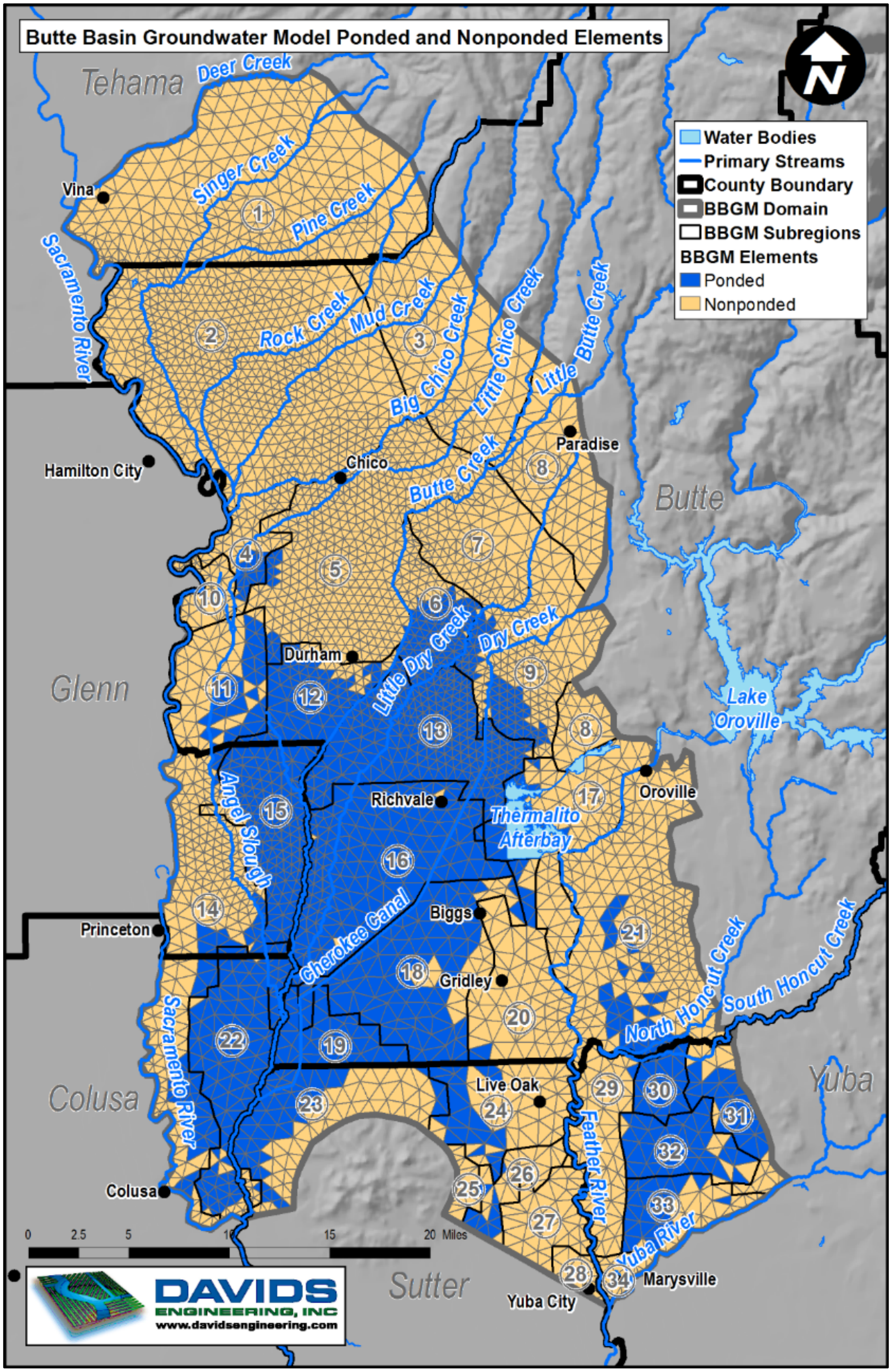

Figure 2.3. Butte Basin Groundwater Model Ponded and Nonponded Grid Elements.

For each ponded crop, a daily time series of ponding depth (in inches) is developed to represent the pattern of flood up and drainage associated with planting and harvest or wetlands management. The timing of ponding for rice is based on the timing of diversions from the Afterbay that provide the surface water source for the water district areas. For wetlands, the timing of ponding is based on refuge water management plans (CDFW 2011, USFWS 2011).

Due to laser leveling practices of rice fields that began in the 1980s and became the dominant management practice by 1995 (Mutters 2015), less water was needed to flood a more uniform field. To capture the effect of this management practice on water use, ponding depth inputs were increased going back to 1970 by a factor of two and then ramped down linearly from 1980-1995 to the current values. Current ponding depths range from 0 to about 5.5 inches and vary in time.

A schematic showing modelled crops and other land uses by category is provided in Figure 2.4.

2.2.2 Root Zone and Land Surface Parameters

Root zone and land surface parameters are assigned to each element in the BBGM. Root zone parameters describing the soil characteristics include total porosity, field capacity, wilting point, pore size distribution index, and saturated hydraulic conductivity. Campbell's equation is used to represent the moisture content in the root zone as a function of the hydraulic conductivity. Each model element is assigned a soil group based on soil texture (e.g. silty clay, sandy loam, clay loam, etc.) as specified by the NRCS soil survey. Then each soil group has a set of corresponding soil parameters. These were calibrated based on the time required to drain from saturation to field capacity[2] and the gravimetric drainage rate once field capacity is reached, which should be near zero. For elements specified as ponded elements, the saturated hydraulic conductivity is significantly reduced to avoid unreasonably high applied water estimates due to high deep percolation rates. Reduced hydraulic conductivity in these areas reflects reduced percolation resulting from heavy, clay soils; plow pan; cemented layers; and perched shallow groundwater.

A map showing soil texture class by element is included as Figure 2.5. Saturated hydraulic conductivity, reflecting soil texture class and ponded/nonponded element assignment is included as Figure 2.6.

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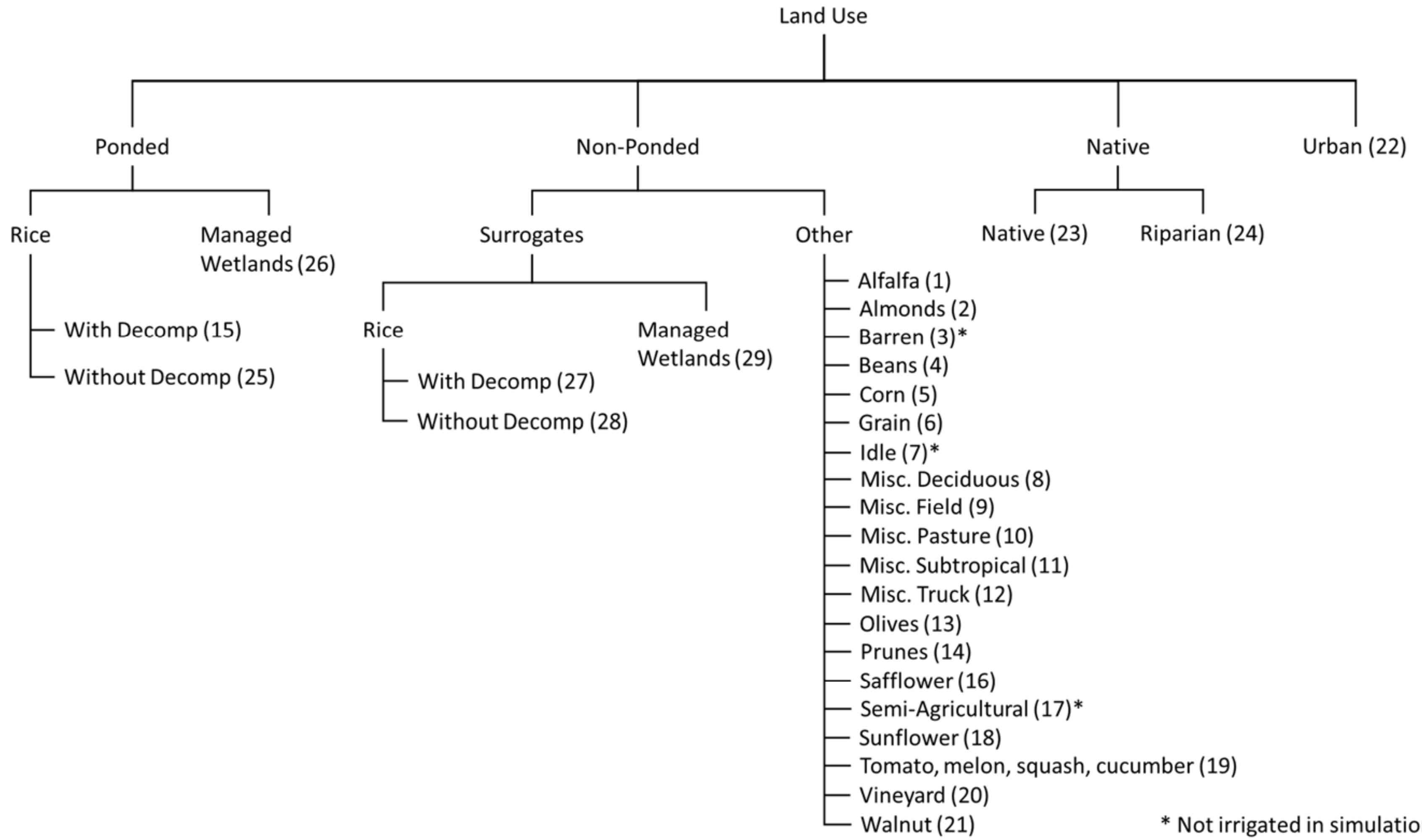
[2] Lighter textured soils such as sands and loams are expected to drain more quickly than silts and clays.



* Not irrigated in simulation

Figure 2.4. Butte Basin Groundwater Model Modelled Crops and Other Land Uses.

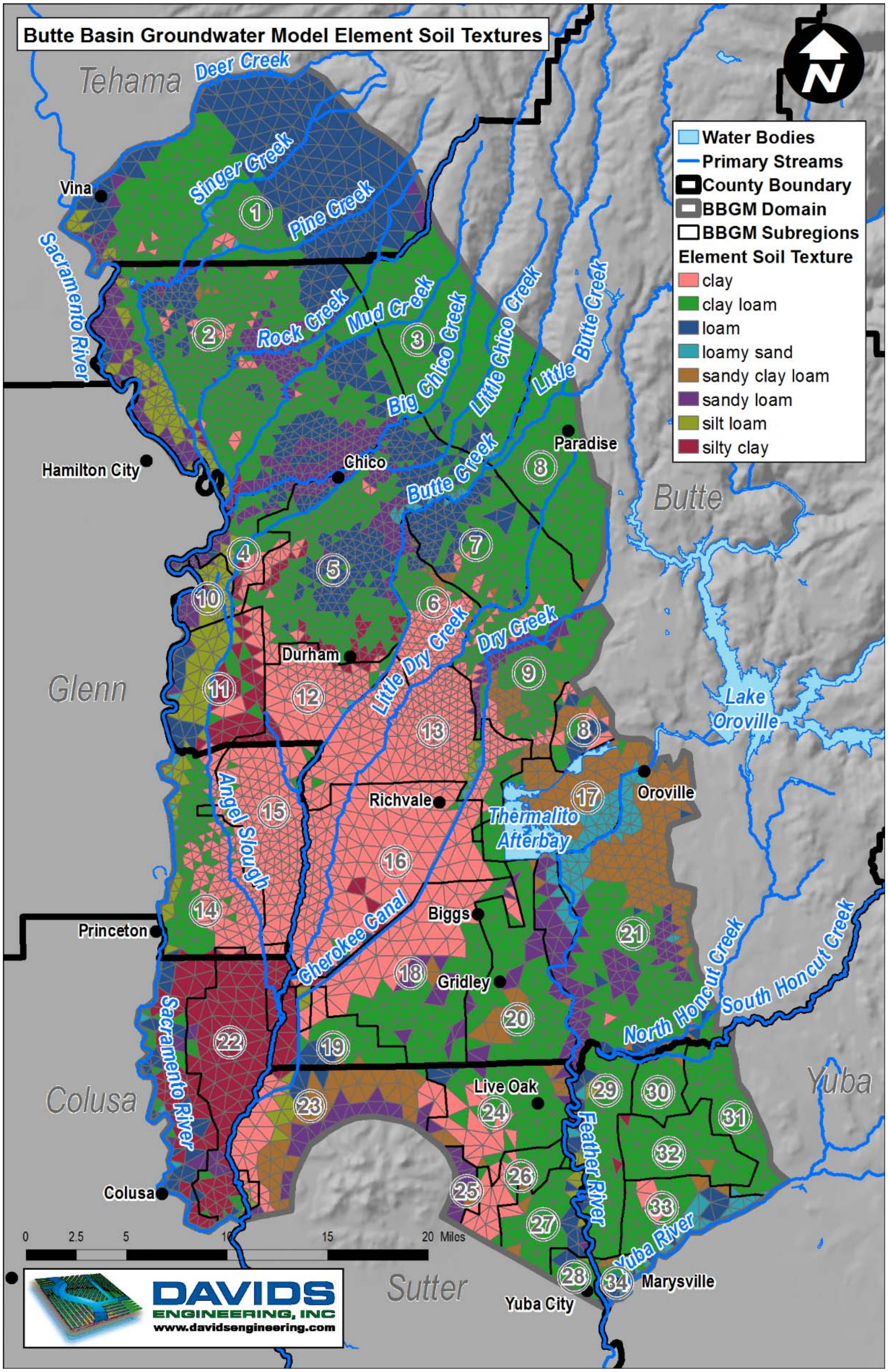


Figure 2.5. Butte Basin Groundwater Model Element Soil Textures.

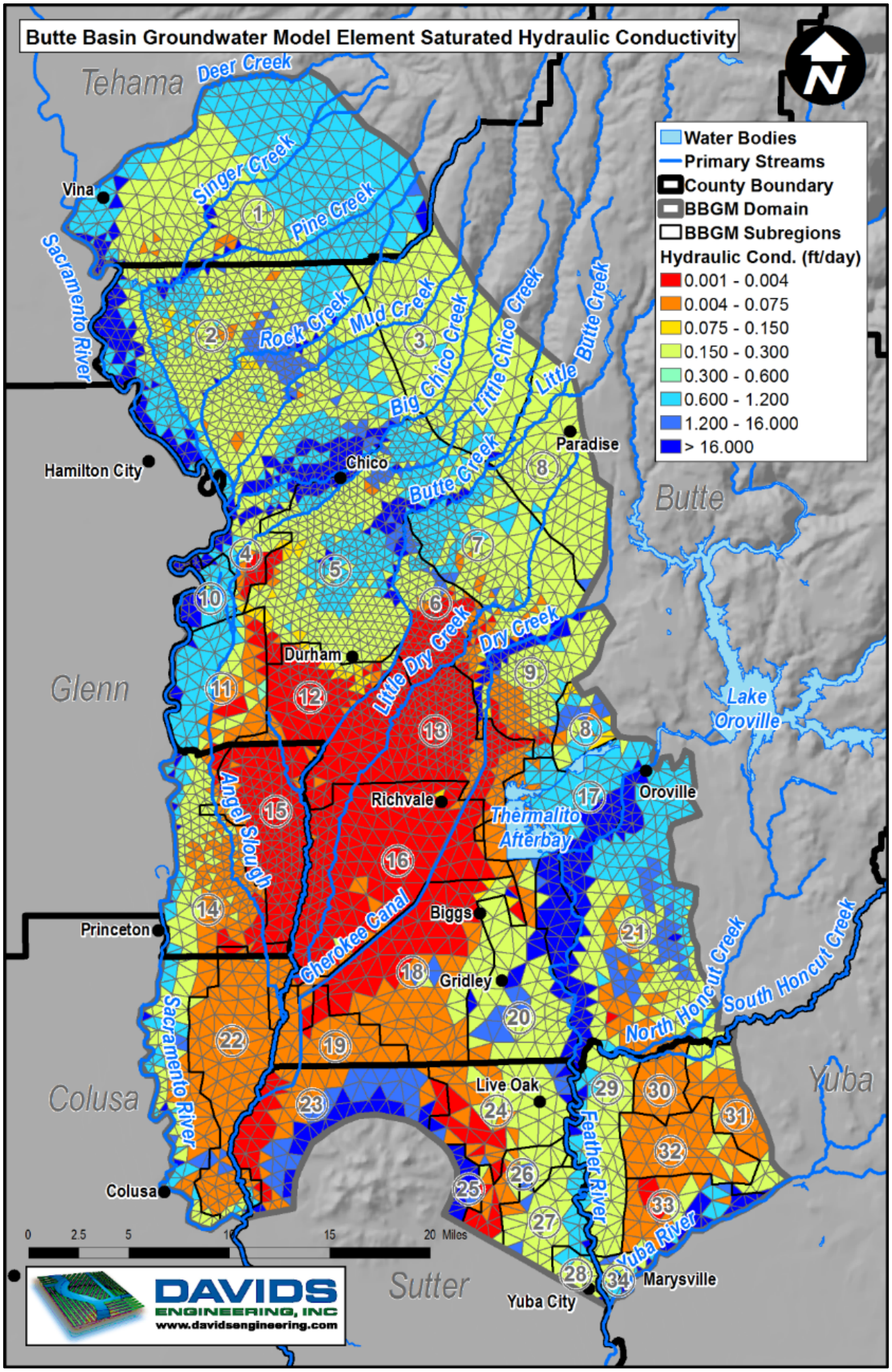


Figure 2.6. Butte Basin Groundwater Model Element Saturated Hydraulic Conductivity.

2.3 Water Inventory Methodology

This section describes methodologies for the update of the Water Inventory and Analysis Report (WI&A) and the Butte Basin Groundwater Model (BBGM) to update water supply and demand conditions through 2014. Discussion and methodologies are provided for the following datasets used in the update:

- Precipitation
- Streamflows
- Diversions and Pumping
- Land Use
- Reference Evapotranspiration (ETo), Crop Coefficients, and Actual Evapotranspiration (ETa)
- Irrigation Efficiency
- Land Surface Water Budgets

Update of the WI&A has been supported by detailed water balance analyses conducted as part of development of the Feather River Regional Agricultural Water Management Plan (FRRAWMP) (NCWA 2014). The FRRAWMP study area extends from the Sacramento River and Sutter Bypass in the west to the Feather River in the east and from Western Canal Water District in the north to Freemont Weir in the south, covering the southern portion of Butte County in the East Butte and West Butte inventory units (and subbasins). In particular, the FRRAWMP includes detailed water budgets for the Biggs-West Gridley, Butte, Richvale, and Western Canal subinventory units. An objective of the coordination of these efforts is to ensure that the most current understanding of surface water and groundwater hydrology and conditions within the County is incorporated into the WI&A.

2.3.1 Precipitation

Existing BBGM input data files of precipitation for the five weather stations represented in the model (Chico University Farm, Colusa 2 SSW, Marysville, Oroville, and Paradise) as described by CDM (2008a) were compared to raw precipitation data compiled by BCDWRC. The data were downloaded from the National Climatic Data Center (NCDC)[3]. The station locations are shown in Figure 2.7. The figure indicates the zone represented by each station, along with precipitation adjustment factors applied to estimate precipitation for each element based on long term spatial distribution of precipitation as described by CDM (2008a).

Review and update of the existing BBGM datasets included filling of gaps in both the raw data and the existing BBGM input files to ensure a complete record of precipitation for each station. Gaps for a given station were filled based on correlation to neighboring stations. Extreme daily

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[3] Available at www.ncdc.noaa.gov.

precipitation totals were screened for and corrected where appropriate based on correlations to other nearby stations.

2.3.2 Streamflows

Seventeen streams are represented in the Butte Basin Groundwater Model and therefore require development of time series of inflow where these streams enter the model domain (referred to as "rimflows" or rim inflows). Major streamflows into and on the borders of the County are estimated based on U.S. Geological Survey (USGS) and California Data Exchange Center (CDEC) stream gages. These include Deer Creek, Big Chico Creek, the Upper Feather River, the Yuba River, and the Sacramento River. The majority of remaining stream inflows are estimated based on a multiplier applied to the "Big Chico Creek near Chico" gaged streamflow. A summary of the data source for each stream inflow is included in the Rimflows section of the technical memorandum *Recommended Methodologies for Update of Butte County Water Inventory and Analysis and Butte Basin Groundwater Model* (Davids Engineering 2013). This method is the same approach used in previous versions of the BBGM.

In addition to providing a summary of streamflows for major gages, an inventory of historical and existing stream gages in the County has been developed and is provided in Appendix B. BBGM rimflow locations and associated stream gages were shown previously in Figure 2.2.

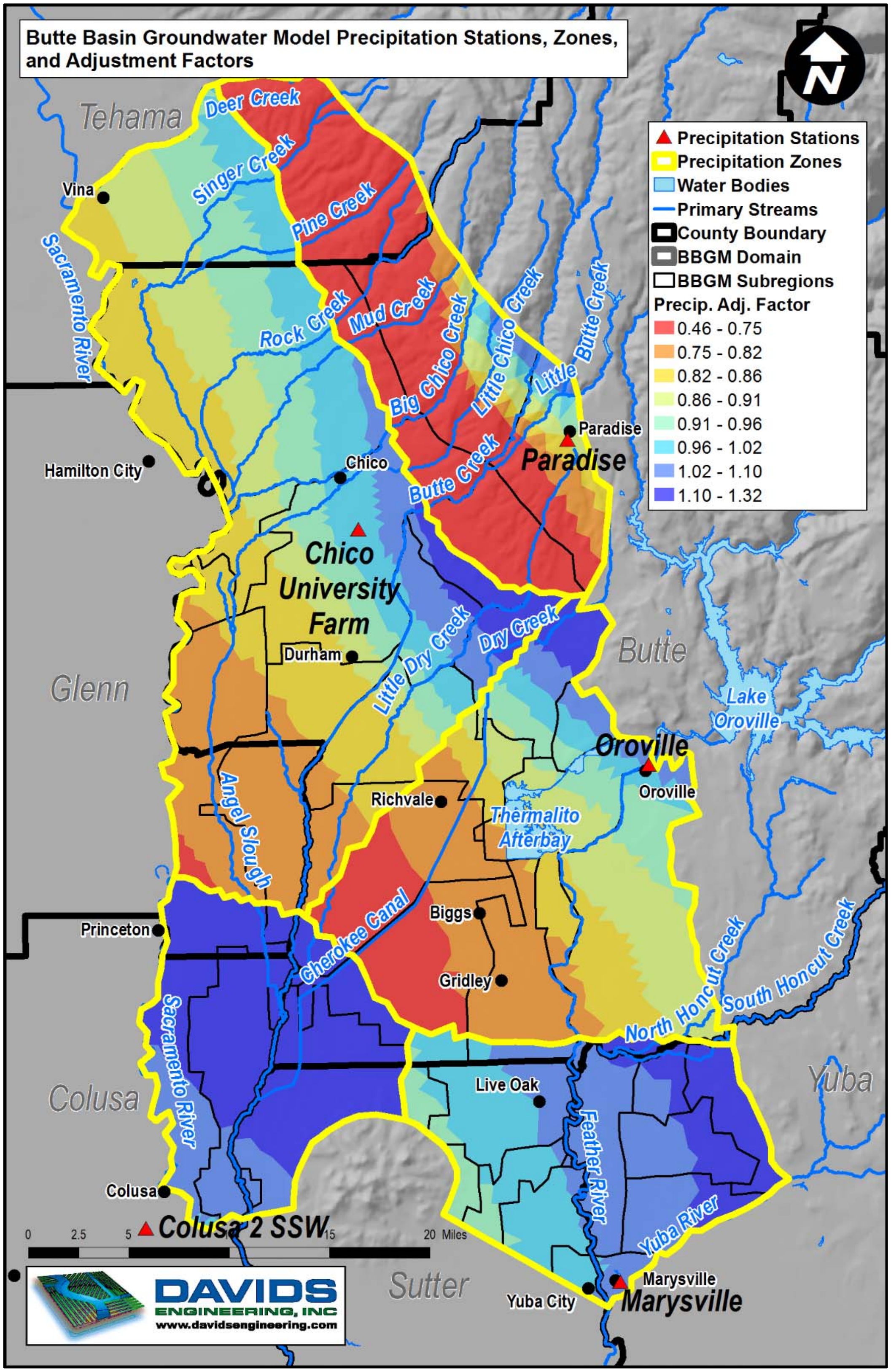

Figure 2.7. Butte Basin Groundwater Model Precipitation Stations, Zones, and Elemental Precipitation Adjustment Factors.

2.3.3 Diversions and Pumping

Diversions

Diversions are estimated based on a combination of available diversion records from water districts, watermaster field schedules, and estimated diversions based on independent estimates of agricultural water demand[4]. The primary surface water users in Butte County divert from Thermalito Afterbay, Butte Creek, and the Sacramento River, and diversion records have been compiled through 2014. Once monthly diversions are estimated, surface water deliveries are calculated as historical diversions minus estimated conveyance losses to spillage, seepage, and evaporation. In the BBGM, diversions occurring from streams represented within the model domain are removed at a specific stream node. Other diversions originating from streams or water bodies for which streamflow is not explicitly modelled are specified to originate outside of the model domain. In either case, diversions for use within the model domain are assigned to the subregion or subregions where the water is used.

Surface water diversions for municipalities, such as Paradise (supplied by Paradise Irrigation District) and Oroville (supplied by California Water Service Company (CalWater)), Thermalito Water and Sewer District (TWSD), and South Feather Water and Power Agency (SFWPA) have been obtained from the water suppliers or estimated based on available Urban Water Management Plans (UWMPs) as part of the BBGM update (West-Yost Associates 2016). For cases in which only annual diversion records are available, representative monthly urban demand patterns have been used to estimate monthly diversions.

Pumping

Groundwater pumping has been estimated for individual subinventory units and aggregated to provide estimates of total pumping for the inventory unit as a whole. Irrigation pumping has been estimated based on cropping, soils, weather conditions, and estimated irrigation efficiencies, similar to surface water diversions for areas known to use surface water but without available diversion records, as described previously. For water suppliers diverting water from Thermalito Afterbay for irrigation (Biggs-West Gridley Water District, Butte Water District, Richvale Irrigation District, and Western Canal Water District) and Gray Lodge Wildlife Area (within the Butte Sink subinventory unit), pumping estimates were developed as part of the Feather River Regional Agricultural Water Management Plan (FRRAWMP) based on estimated areas relying on groundwater within each supplier service area (NCWA 2014). For other areas of the County, the estimates were developed using IDC as part of the BBGM update as the amount of applied water required to meet irrigation or other demands, after accounting for any available surface water deliveries.

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[4] As described by HCI (1996), water user areas were developed based on a combination of water source and general land use type (rice, non-rice crops, native vegetation, native riparian) as determined from DWR land use surveys and based on water supplier service areas. For each water user area with a surface water supply but no available diversion records, diversions were estimated based on cropping, soils, weather conditions, and estimated irrigation efficiencies using IDC.

Urban pumping has been estimated based on reported and estimated pumping volumes developed for the BBGM update based on UWMPs, Municipal Service Reviews (MSRs), and the Northern Sacramento Valley Integrated Regional Water Management Plan (NSVIRWMP) (West-Yost Associates 2016). For the City of Chico, monthly pumping volumes were provided for the period of analysis by CalWater. For the City of Oroville, monthly pumping volumes were provided for the period of analysis by CalWater and estimated for TWSD based on the District's UWMP. For the City of Biggs, pumping was estimated based on the City's MSR. For the Durham area, pumping was estimated based on Durham Irrigation District's MSR. For the City of Gridley, pumping was estimated based on the NSVIRWMP. For the Town of Paradise, pumping was based on Paradise Irrigation District's UWMP. For cases in which only annual pumping estimates are available, representative monthly urban demand patterns have been used to estimate monthly pumping. A summary of total pumping per inventory unit is included in Section 4.3.3 under Groundwater Pumping.

Rural residential groundwater pumping has been estimated based on U.S. Census Bureau population estimates and per capita water usage rates for Butte County based on available supplier data described above. Using census data for 2000, the population of areas not within urban water supplier service areas was determined and adjusted over time based on annual County-wide estimates of population. Then, rural residential pumping for each area was estimated assuming demands of approximately 260 gallons per person per day. Estimates of rural residential pumping are summarized in Table 4.3 and in water budgets presented in Section 5.

2.3.4 Land Use

Land use has been estimated annually for each subinventory unit (and groundwater model element) as part of the BBGM update. Data sources for the land use analysis include DWR land use surveys for 1994, 1999, 2004, and 2011 and annual agricultural commissioner crop reports for the full period of analysis. Land use data for the WI&A update were developed as follows:

- Compile available DWR land use surveys and agricultural commissioner crop reports, and assign reported acreages to crop and other land use types represented in the BBGM.
- Intersect the BBGM model elements with the DWR land use surveys in GIS to establish land use within each element at the time of each land use survey.
- For each land use and DWR survey, determine an adjustment factor to be applied to the commissioner crop survey to correct for differences in acreage. Estimate an adjustment factor to be applied to each land use over time by interpolating between land use survey years.
- For each element and land use survey, determine the fraction of total acreage by land use existing within the element. Estimate the fraction to be applied to each element and land use over time by interpolating between land use survey years.

- Apply a special adjustment in years of fallowing based water transfers. In such years, the rice acreage for elements within each participating water district is adjusted based on the estimated amount of land fallowed.
- Aggregate land use for BBGM model elements to subinventory units and inventory units for reporting in the WI&A update.

The approach used to quantify historical land use is generally consistent with the process applied by DWR for the California Water Plan. By utilizing agricultural commissioner crop reports to estimate annual changes in cropping, the approach inherently accounts for economic and other factors that affect annual cropping decisions. Water district-specific accounting for fallowing-based transfers allows for explicit accounting in the BBGM and WI&A update.

Another source of available cropping data is the annual reports of the Joint Districts (BWGWD, RID, BWD, and SEWD). These reports provide annual acreages by general crop type for each of the districts; however, the cropping information is provided at a coarser level of detail than the crop types represented in the BBGM. Additionally, cropping data developed by Western Canal Water District (WCWD) are available. These sources of cropping data were used to validate the cropping information from the DWR crop surveys and agricultural commissioner crop reports.

2.3.5 Reference Evapotranspiration, Crop Coefficients, Actual Evapotranspiration, and Evapotranspiration of Applied Water

Evapotranspiration (ET) by crops and other vegetation represent a primary outflow of water from inventory and subinventory units within the County. For the WI&A and BBGM, ET is estimated for each land use type by multiplying reference evapotranspiration (ETo) by a crop (or water use) coefficient (EToF) as described by Allen et al. (1998). In order to accurately account for ET as part of the water budgets developed for the WI&A, crop coefficients based on actual ET (ETa), as compared to potential ET (ETp) are used. Then, for irrigated crops total ET is partitioned into ET derived from precipitation (ETpr) and ET derived from applied water (ETaw). By dividing ETaw by estimated irrigation efficiencies, estimates of pumping and in some cases surface water diversions are developed.

Reference Evapotranspiration (ETo)

Reference evapotranspiration was estimated based on the California Irrigation Management Information System (CIMIS) agronomic weather station at Durham (Station 12). The Durham station is the only CIMIS station located in Butte County and has a long period of record (established in October 1982). Quality control procedures were applied based on the methodology of Allen et al. (2005). For purposes of the BBGM, ETo prior to 1982 is estimated based on correlation to air temperature using the Hargreaves-Semani equation.

Crop Coefficients (EToF)

Crop coefficients representing actual ET were developed based on available results of a Surface Energy Balance Algorithm for Land (SEBAL) analysis of the Sacramento Valley for 2009 (Bastiaanssen et al. 2005, SNA 2012). Crop coefficients were calculated for each land use class represented in the BBGM and WI&A update based on actual ET from SEBAL and reference ET from the Durham CIMIS station. For 2009, detailed land use datasets from DWR for Glenn and Colusa counties developed for that year were relied upon to support the analysis.

The SEBAL datasets correspond to the irrigation season from approximately March through September. Crop coefficients during the winter period were estimated using the Basic Irrigation Scheduling (BIS) tool developed by Dr. Richard Snyder at U.C. Davis in cooperation with DWR based on reference ET and precipitation patterns observed during the 2000-2014 update period (Snyder et al. 2007).

A sample SEBAL image depicting actual ET for July 26, 2009 is shown in Figure 2.8. As indicated, data is available for the majority of the County, with the northern edge of the satellite image at approximately Chico.

For almonds and walnuts, crop coefficients during the growing season derived from the 2009 SEBAL data were reduced for prior years based on discussions with University of California Cooperative Extension (UCCE) specialists (Connell and Fulton 2015). Specifically, whereas historical ET for a mature healthy almond orchard was considered to be approximately 42 inches annually in the Sacramento Valley, changes in growing practices since the mid 1990’s including tree spacing, pruning practices, fertilization, and irrigation have resulted in estimated ET rates of approximately 48 inches in recent years. As a result of this trend, crop coefficients were reduced linearly from 2010 back to 1995 by approximately one percent per year.

Actual Evapotranspiration (ETa)

Actual evapotranspiration was calculated on a daily basis by multiplying ETo from the Durham CIMIS station by the EToF corresponding to each day and land use type. ETo, crop coefficients, and resulting calculated ETa are shown for 2013 for rice and almonds in Figures 2.9 and 2.10, respectively.

Evapotranspiration of Applied Water (ETaw)

ETaw was calculated on a daily basis for each land use type using the IWFM Demand Calculator (IDC) (DWR 2015). For each day, IDC simulates root zone water balance processes, including precipitation, irrigation, infiltration, runoff, deep percolation, evapotranspiration, and stored soil moisture. Relative amounts of stored soil moisture derived from precipitation and applied irrigation water are tracked over time, and ETa is divided into ETaw and ETpr based on the relative amount of precipitation and applied water each day. For the water budget analysis, daily ETa and ETaw are then aggregated for each inventory and subinventory unit over time.

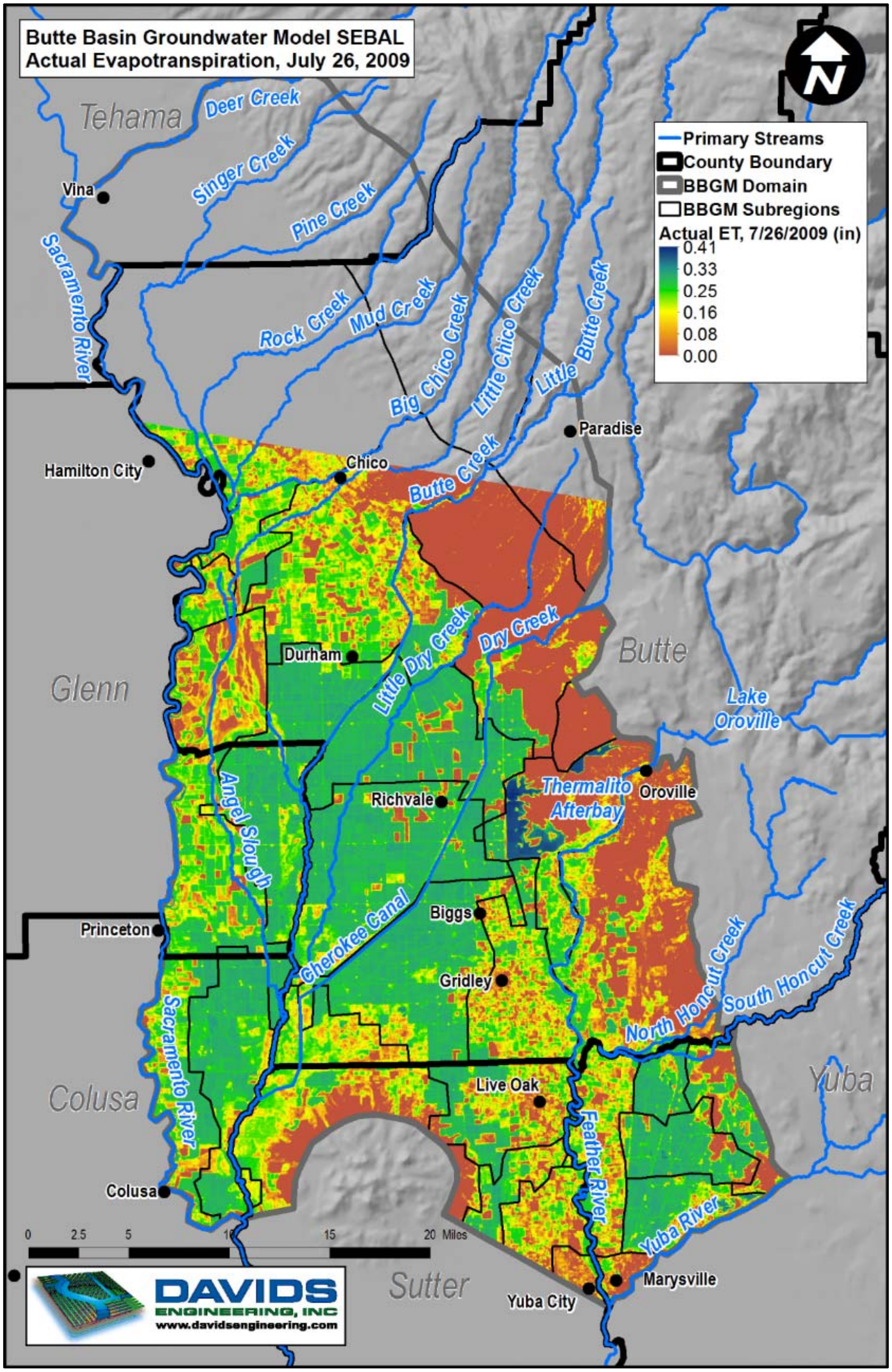

Figure 2.8. Butte Basin Groundwater Model SEBAL Actual Evapotranspiration, July 26, 2009.

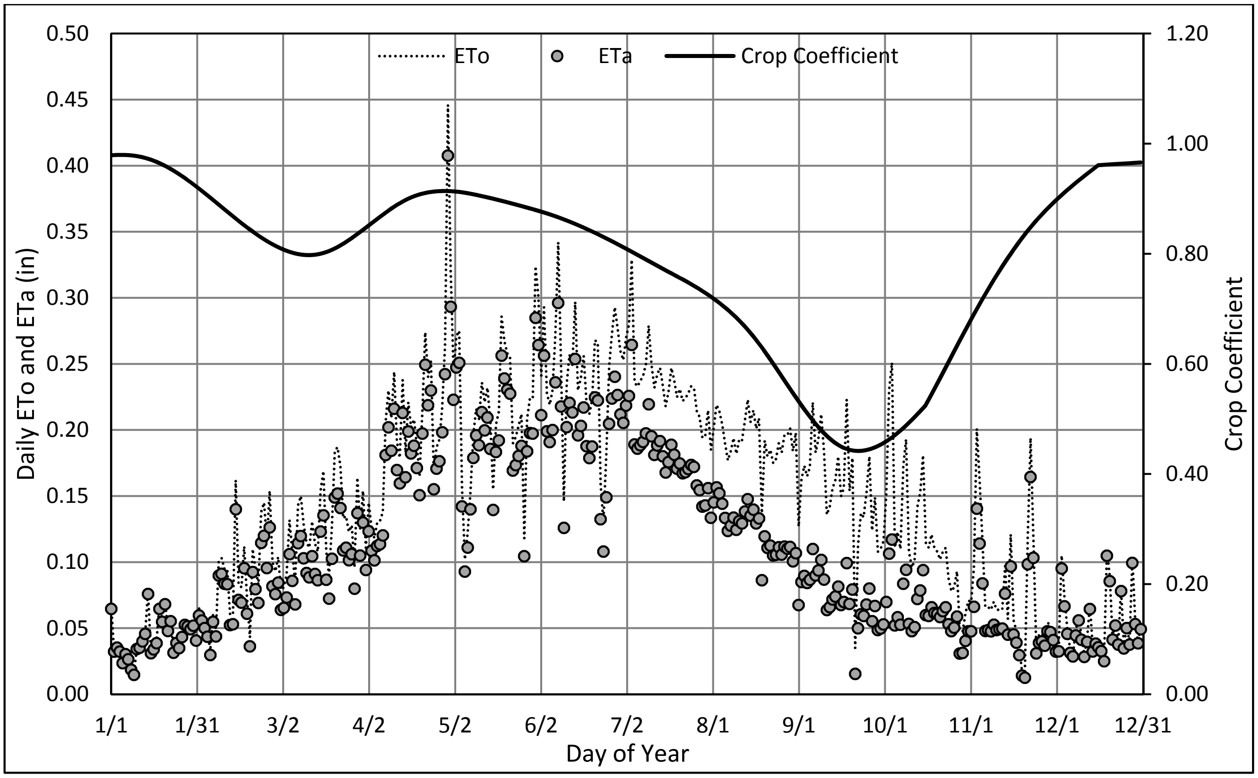

Figure 2.9. Daily Reference ET (ETo), Crop Coefficient (EToF), and Actual ET (ETa) for Almonds, 2013.

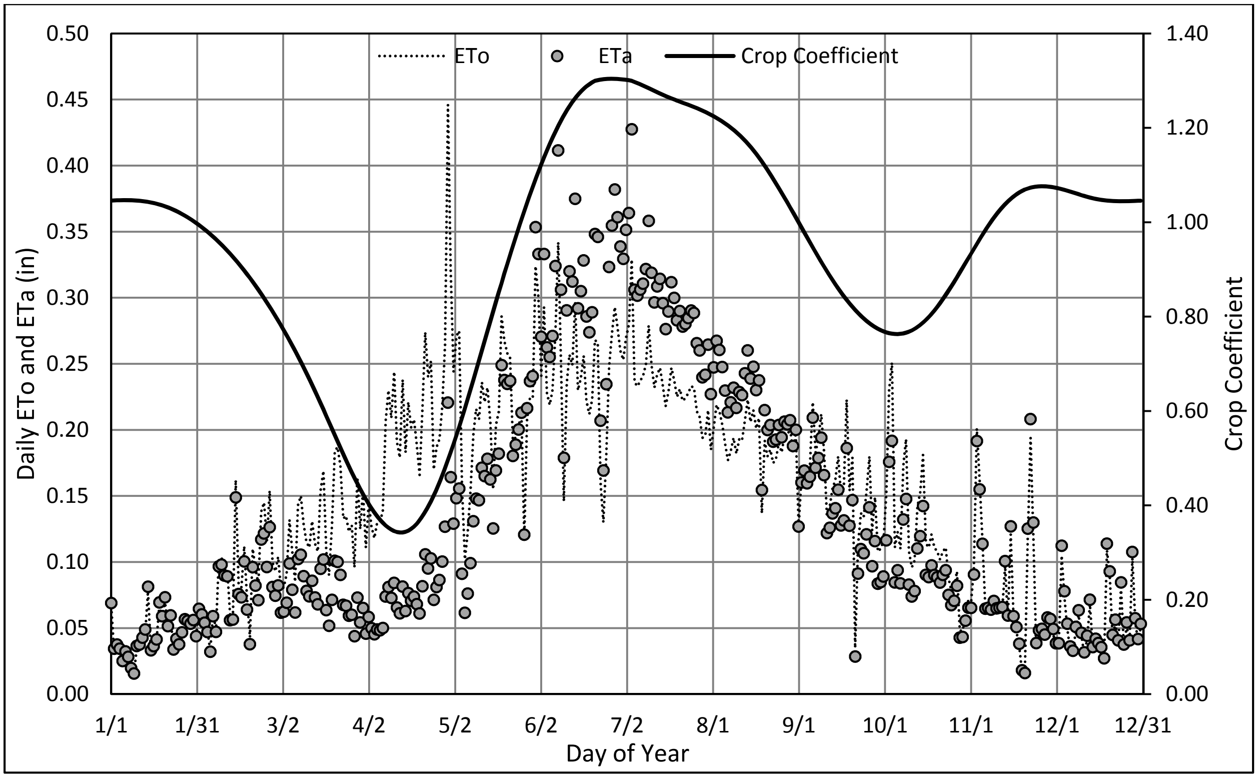

Figure 2.10. Daily Reference ET (ETo), Crop Coefficient (EToF), and Actual ET (ETa) for Rice with Winter Decomp. Water, 2013.

2.3.6 Irrigation Efficiency

Irrigation efficiencies for non-ponded crops (orchards, pasture and hay, and field and annual crops) are parameterized indirectly in IDC by specifying the amount of water to be applied during irrigation events as a fraction of the field capacity of the soil (DWR 2015). Estimated irrigation efficiencies were developed for orchards and other non-ponded crops based on several sources, including discussion with UCCE farm advisors (Connell and Fulton 2015), the project advisory committee, distribution uniformity evaluations conducted by the Tehama County Resource Conservation District (Greer 2013), Canessa et al. (2011), CalFed (2006), and detailed water balances developed as part of the FRRAWMP (NCWA 2014).

Increases in irrigation efficiency for orchards have been observed by UCCE farm advisors over past decades. For purposes of the BBGM and WI&A, irrigation efficiency is expressed as a consumptive use fraction (CUF), calculated as the ratio of ETaw to applied irrigation water on an annual basis. To represent increases in the CUF over time, the target soil moisture fraction (TSMF) was gradually decreased in the BBGM between 1970 and 2010, resulting in an increase in CUF for orchards from around 0.74 in the 1970s to around 0.83 since 2010. Average CUF values by crop are summarized in Table 2.1. These values vary somewhat for a given crop from year to year and based on soil characteristics.

Table 2.1. Average Butte County Consumptive Use Fraction (CUF) Values by Crop, 2000-2014.

Crop Category	Crop	CUF
Rice	with Winter Water	0.51
	without Winter Water	0.59
	Average	0.54
Orchards	Almonds	0.80
	Walnuts	0.79
	Prunes	0.80
	Other	0.65
	Average	0.78
Other Crops	Grain	0.66
	Pasture	0.67
	Other	0.67
	Average	0.67

2.3.7 Land Surface Water Budgets

Land surface water budgets were developed for each valley floor inventory and subinventory unit for the WI&A update period based on the methodology described above and IDC results from the BBGM. They are described in Section 5 and Appendix C. Within each inventory and subinventory unit, an aggregate budget for the area is provided, as well as budgets by general land use types. Specifically, budgets are provided for irrigated agriculture and wetlands, developed lands, and non-irrigated lands.

Inflows include precipitation, applied surface water (as applicable), and groundwater pumping (as applicable). Outflows include evapotranspiration, surface water runoff and return flows, and deep percolation. Average annual inflows and outflows are presented on a water year basis[5] for the 2000-2014 update period, as well as providing averages for the overall period and by hydrologic water year type.

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[5] A water year refers to the period from October to September each year, with the beginning month of October selected based on the typical beginning of the winter rainy season. For example, the 2000 water year includes the period from October 1999 to September 2000.

3. Land Use and Cropping Patterns

This section summarizes historical and current land use and cropping patterns within Butte County. First, County-wide land use is described, with an emphasis on the valley floor area, followed by detailed land use for individual valley floor inventory units (IUs). Land use in the County over the past two decades has been evaluated based on land use surveys prepared by DWR for 1994, 1999, 2004, and 2011. For the valley floor IUs, DWR surveys and annual Butte County agricultural commissioner crop reports are used to develop annual estimates of land use. As a result, land use for the County as a whole is reported for each DWR survey, while land use for individual valley floor IUs is reported based on annual estimates. Five-year averages of general land use are reported for the IUs from 1995 to 2014, along with annual values for 2000 to 2014 for more specific irrigated agricultural land uses.

Detailed land use for the Ridge and Mountain inventory units is not reported separately as these areas are dominated by non-irrigated land and include limited irrigated agriculture or developed lands, with the exception of the Paradise area, which falls in the Ridge inventory unit.

3.1 Butte County

Butte County covers approximately 1,677 square miles (1.073 million acres). The valley floor represents approximately 452,000 acres (ac) and includes approximately 234,000 ac of irrigated agriculture, 141,000 ac of non-irrigated lands, 47,000 ac of developed lands, and 30,000 ac of wetlands. The Foothill and Mountain IUs are primarily non-irrigated rangeland and forest with some development, particularly in the Paradise area and other rural communities, and represent approximately 216,000 acres and 407,000 acres, respectively. Land use based on a detailed survey conducted by the DWR Northern Region Office (NRO) in 2011 is shown in Figure 3.1.

Changes in general land use on the valley floor include relatively steady irrigated agricultural acreage[1] since the mid-1990’s and a decrease in non-irrigated land[2] of approximately 11,000 acres since the mid-1990’s (Figure 3.2). These decreases are balanced by an increase in developed land[3] over this period, as well as a lesser increase in wetlands[4].

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[1] Irrigated agriculture includes irrigated land in annual and perennial crops, including land temporarily idled in some years for agronomic or other reasons.

[2] Non-irrigated land includes native grasses, shrubland, forest, barren land, and riparian vegetation.

[3] Developed land includes urban, rural residential, and semi-agricultural areas (farmsteads, feedlots, etc.).

[4] Wetlands consist of seasonal, semi-permanent, and permanent wetlands. Additionally, Thermalito Afterbay within the East Butte Inventory Unit is classified as wetlands for purposes of this report and represents approximately 4,000 acres

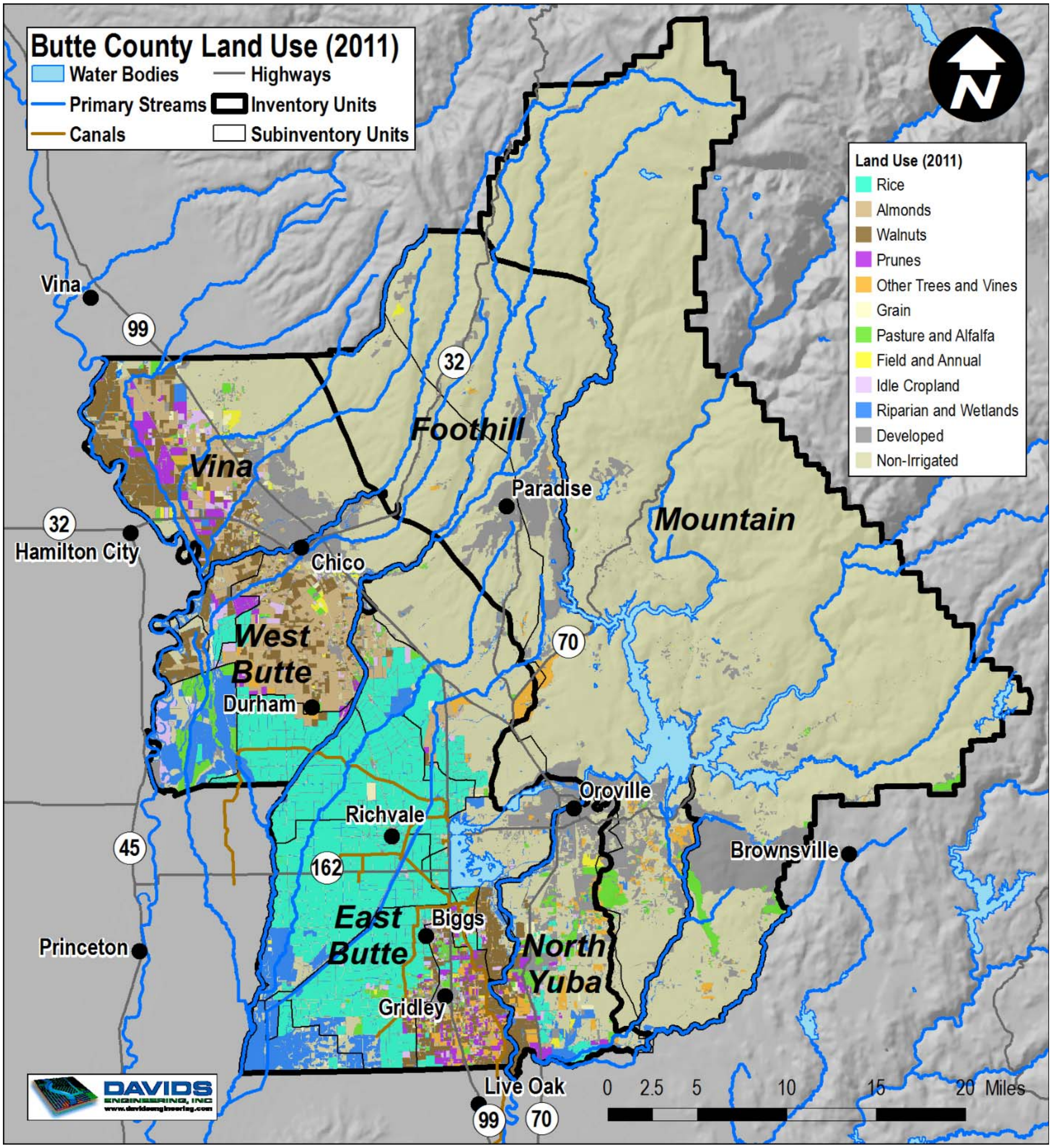

Figure 3.1. Butte County Land Use, 2011 (Source: DWR).

Primary crops grown are rice and orchards, with rice representing an average of approximately 103,000 acres and orchards representing an average of approximately 93,000 acres (Figure 3.3). Almonds (38,000 acres), walnuts (34,000 acres), and prunes (11,000 acres) are the primary orchard crops, with decreases in almond and prune acreage over time offset by increases in walnuts and, to a lesser extent, other trees and vines (e.g., olives, peaches and nectarines, kiwis, pistachios, pears, and cherries) (Figure 3.4). Other than orchards and rice, crops include pasture and alfalfa (13,000 acres), grain (4,000 acres), and miscellaneous field and annual crops (5,000 acres) (Figure 3.5). Acreages for grain and other crops have decreased substantially over time, while pasture and alfalfa acreage has increased. On average, 16,500 acres were idle annually.

Idle ground refers to agricultural cropland land temporarily idled in some years for agronomic and economic reasons (depressed commodity prices, grading, tillage, soil amendments and fumigation, irrigation system conversion, etc.) or for temporary water transfers based on reduced consumptive use[5]. Rice is the primary crop that has been historically idled to temporarily generate water for transfer in the County. Between 2000 and 2014 it is estimated that approximately 16,500 ac were idle annually, on average, with average idling in the seven transfer years (2001, 2003, 2008, 2009, 2010, 2012, and 2014) of 25,000 ac and average idling in the remaining eight non-transfer years of 8,200 ac. Additional information describing participation in temporary water transfers by individual water suppliers within the County is included in the Feather River Regional Agricultural Water Management Plan (FRRAWMP) (NCWA 2014). During idling for transfer, growers may also improve their fields through grading or other agronomic activities.

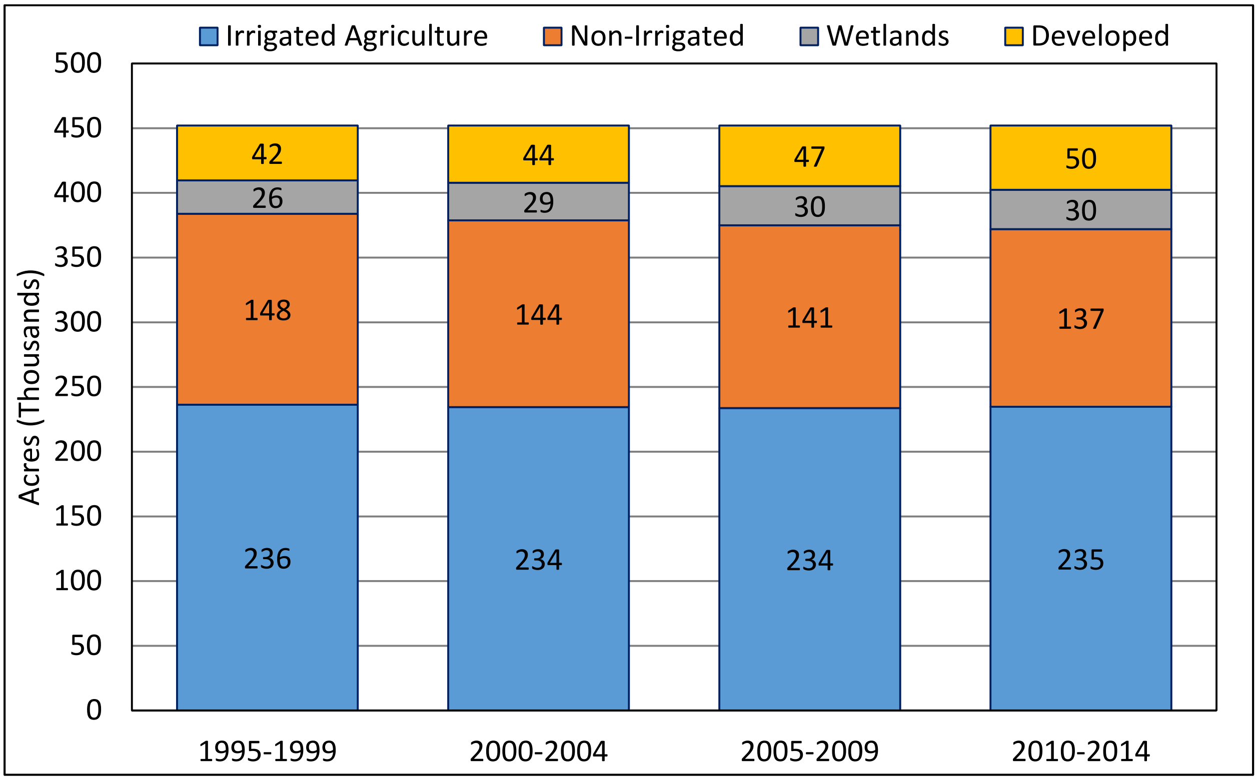

Figure 3.2. Butte County Valley Floor General Land Use, 1995-2014.

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[5] Additional information describing temporary water transfers in California based on crop idling is available from DWR at http://www.water.ca.gov/watertransfers/. In particular, the "Water Transfer White Paper" describes current State and Federal policies regarding temporary water transfers.

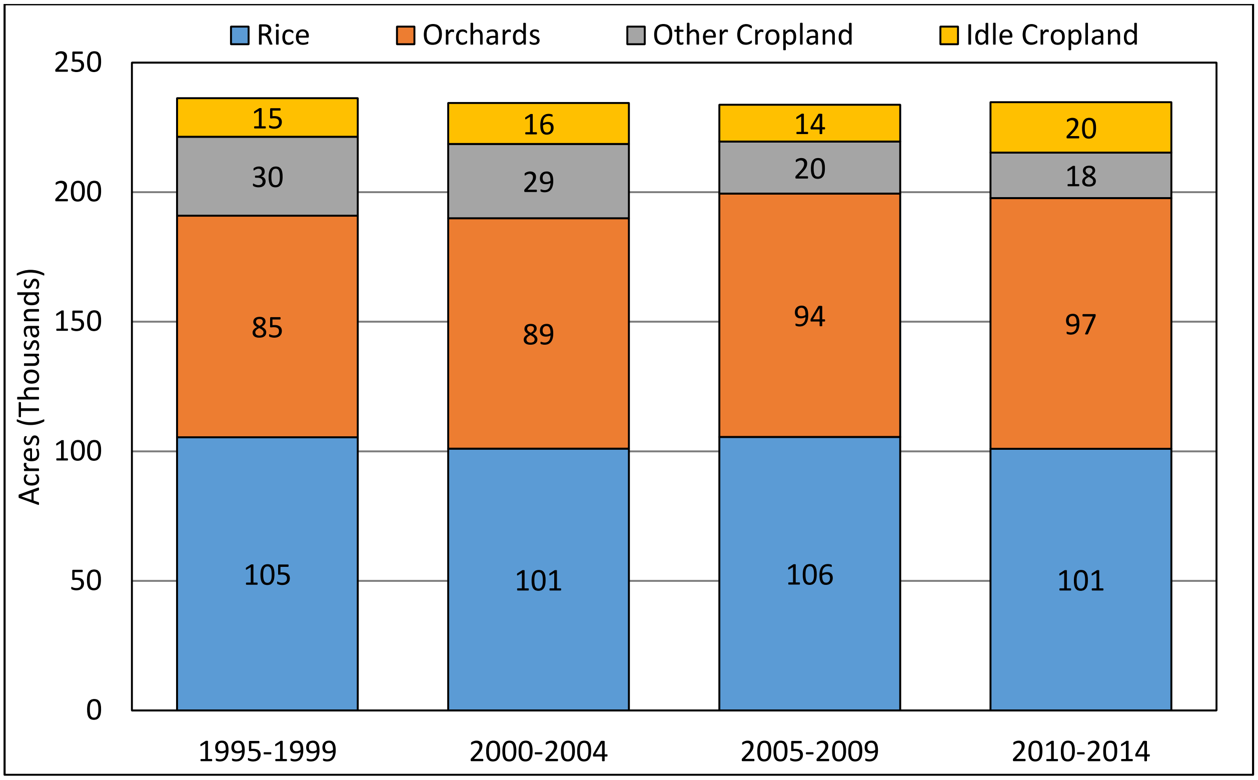

Figure 3.3. Butte County Valley Floor Irrigated Agricultural Land Use, 1995-2014.

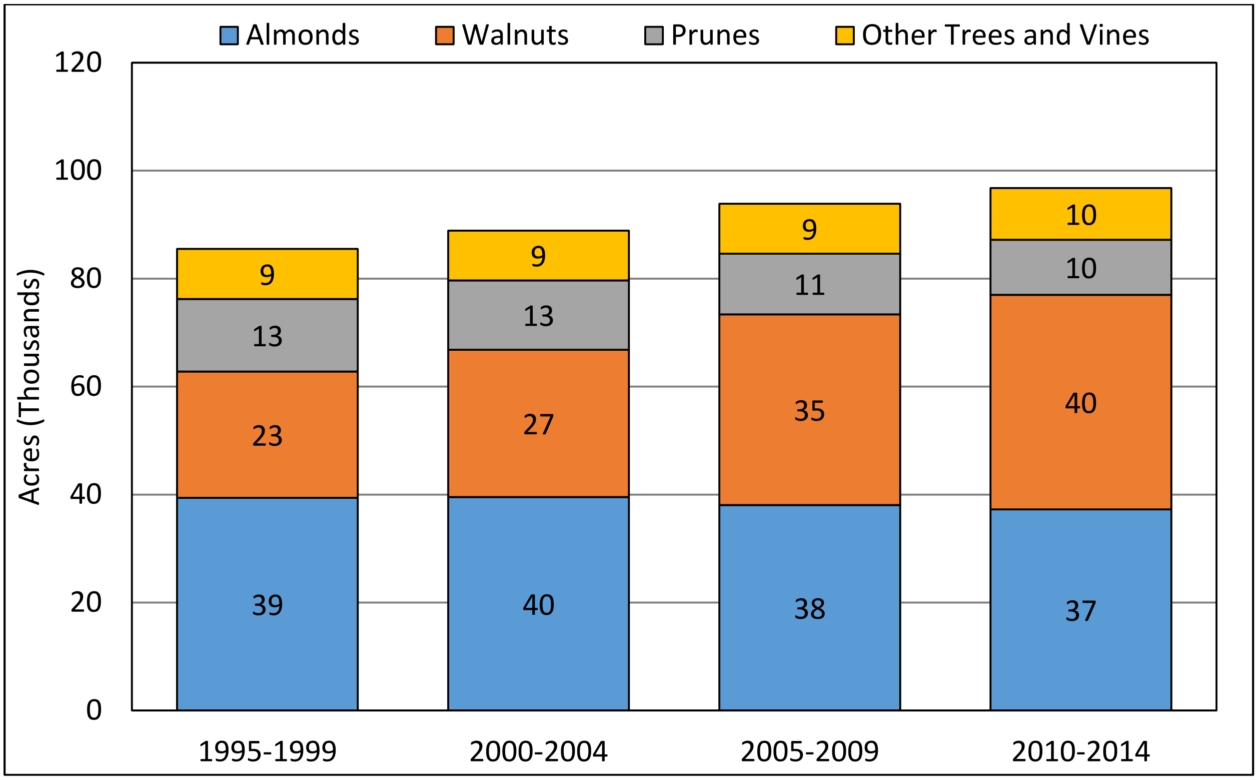

Figure 3.4. Butte County Valley Floor Orchard Land Use, 1995-2014.

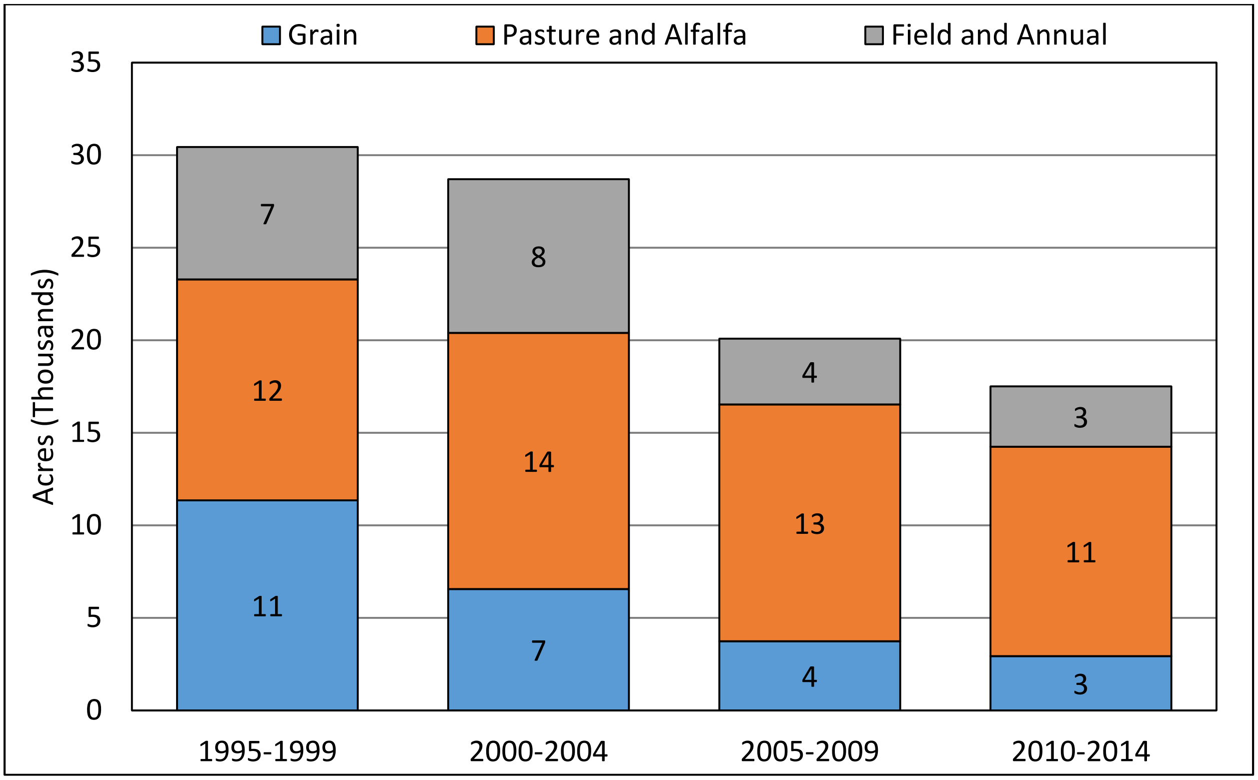

Figure 3.5. Butte County Valley Floor Other Crop Land Use, 1995-2014.

3.2 Vina Inventory Unit

The Vina IU includes portions of Butte County within the Vina Bulletin 118 Groundwater Subbasin. The only subinventory unit (SIU) in this IU is Vina. The Vina IU covers approximately 88,000 ac and includes approximately 37,500 ac of irrigated agriculture, 36,600 ac non-irrigated lands, 13,500 ac of developed lands, and 400 ac of wetlands (Figure 3.6). Non-irrigated lands have decreased from approximately 39,000 acres in the late 1990's to approximately 35,000 acres in the early 2010's. This reduction is offset by increases in both irrigated agriculture and developed lands.

Primary crops grown are orchards, representing an average of 31,300 ac annually. Other crops have averaged 3,600 ac over the 15-year period from 2000 to 2014. Walnuts (13,900 ac), almonds (12,800 ac), and prunes (4,100 ac) are primary orchard crops, with other orchards making up 500 ac annually. Other crops include pasture and alfalfa (1,300 ac), grain (1,000 ac), and miscellaneous field and annual crops (1,300 ac). On average, 2,600 acres were idle annually between 2000 and 2014. Idling for temporary water transfers has not occurred in the Vina IU.

Changes in cropping between 2000 and 2014 include a modest increase in walnuts offset partially by decreases in almonds and other, non-rice crops. Annual acreages by crop are shown graphically in Figures 3.7, 3.8, and 3.9 and are provided in Table 3.1. Annual acreages for other land uses are provided in Table 3.2.

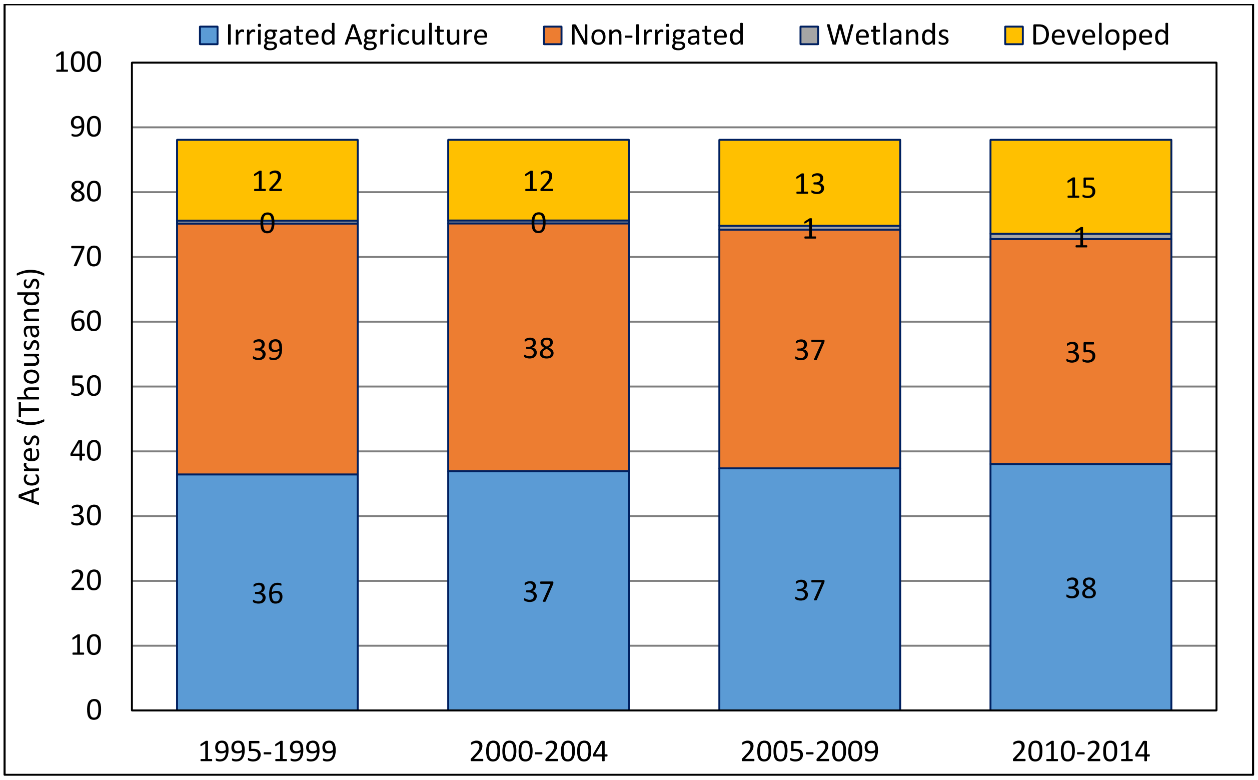

Figure 3.6. Vina General Land Use, 1995-2014.

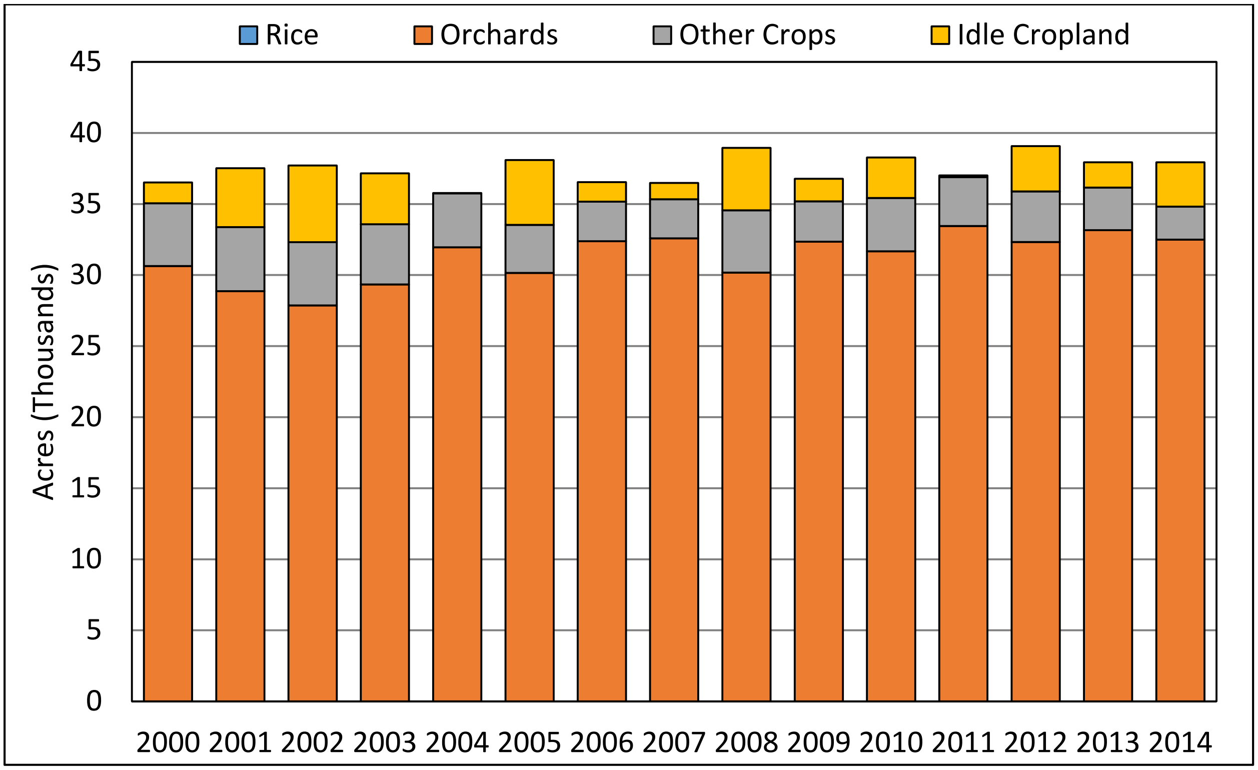

Figure 3.7. Vina Irrigated Agricultural Land Use, 2000-2014.

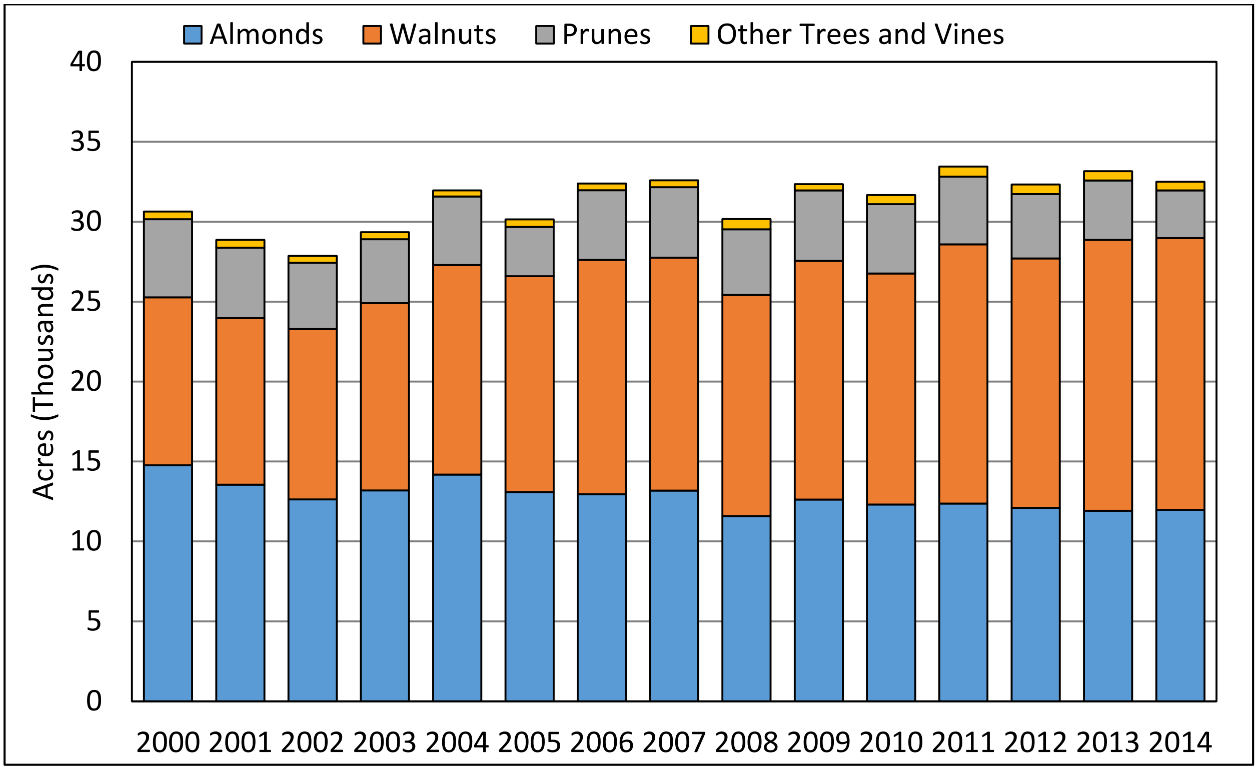

Figure 3.8. Vina Orchard Land Use, 2000-2014.

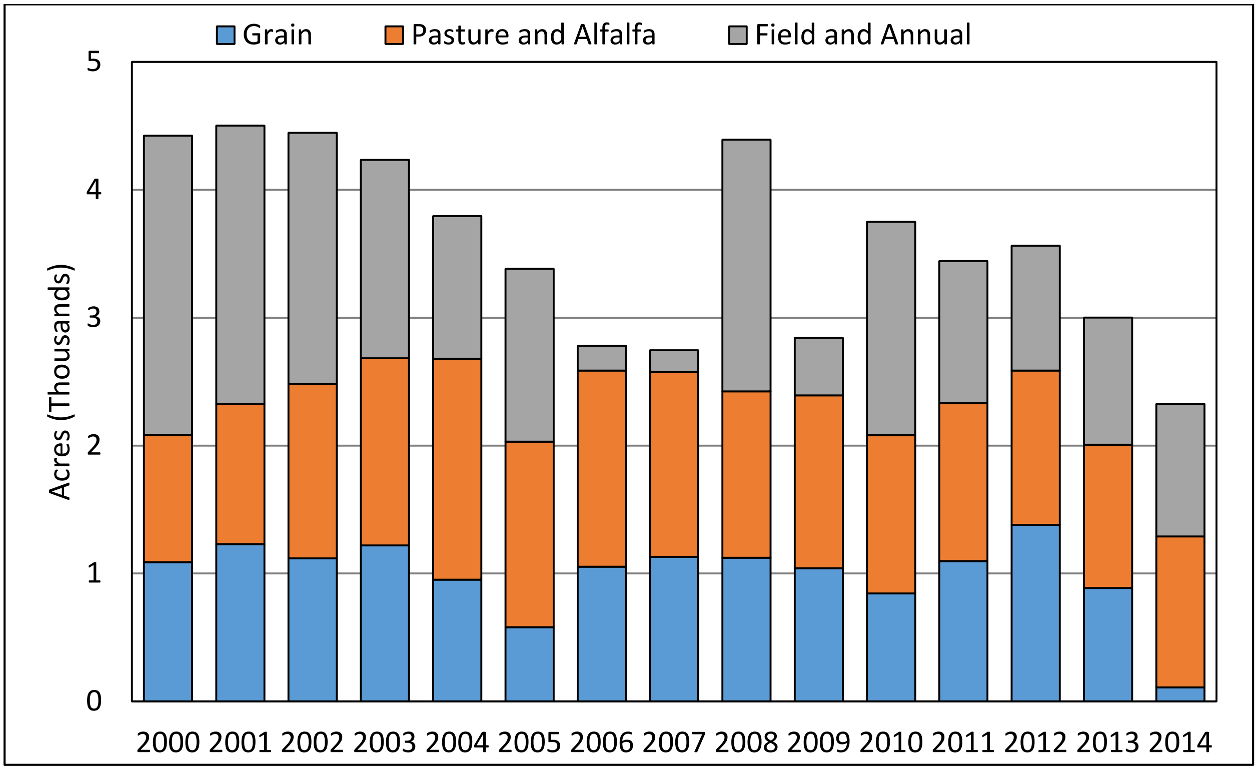

Figure 3.9. Vina Other Crop Land Use, 2000-2014.

Table 3.1. Vina Irrigated Agricultural Land Use, 2000-2014.

Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	0	14,763	10,505	4,890	478	1,089	997	2,338	1,462	35,058	36,520
2001	0	13,552	10,417	4,402	498	1,229	1,097	2,176	4,150	33,370	37,520
2002	0	12,628	10,652	4,152	433	1,118	1,363	1,965	5,401	32,310	37,711
2003	0	13,192	11,720	3,992	438	1,219	1,464	1,551	3,586	33,576	37,162
2004	0	14,178	13,116	4,283	380	952	1,727	1,116	17	35,752	35,769
2005	0	13,088	13,504	3,084	475	580	1,451	1,351	4,568	33,532	38,100
2006	0	12,952	14,664	4,349	423	1,053	1,534	193	1,379	35,167	36,546
2007	0	13,184	14,564	4,407	433	1,131	1,445	170	1,153	35,335	36,488
2008	0	11,587	13,832	4,102	649	1,123	1,301	1,968	4,392	34,562	38,954
2009	0	12,615	14,935	4,410	391	1,040	1,353	450	1,587	35,194	36,781
2010	0	12,304	14,460	4,332	576	843	1,238	1,667	2,856	35,422	38,278
2011	0	12,370	16,213	4,236	632	1,096	1,236	1,111	123	36,893	37,016
2012	0	12,100	15,604	4,027	597	1,379	1,208	976	3,185	35,892	39,077
2013	0	11,917	16,945	3,715	582	887	1,121	993	1,776	36,159	37,936
2014	0	11,976	16,997	2,986	537	109	1,181	1,035	3,114	34,821	37,935
Min	0	11,587	10,417	2,986	380	109	997	170	17	32,310	35,769
Max	0	14,763	16,997	4,890	649	1,379	1,727	2,338	5,401	36,893	39,077
Average	0	12,827	13,875	4,091	501	990	1,314	1,271	2,583	34,870	37,453

Table 3.2. Vina Other Land Use, 2000-2014.

Year	Wetlands	Developed	Non-Irrigated	Total
2000	472	12,706	38,389	51,567
2001	446	12,201	37,920	50,567
2002	444	12,141	37,791	50,376
2003	441	12,430	38,055	50,926
2004	454	12,819	39,044	52,318
2005	473	12,333	37,181	49,988
2006	547	13,230	37,765	51,541
2007	606	13,571	37,423	51,599
2008	633	13,144	35,357	49,133
2009	720	14,139	36,447	51,307
2010	757	14,046	35,007	49,810
2011	852	14,856	35,363	51,072
2012	806	14,298	33,907	49,011
2013	818	14,712	34,622	50,152
2014	815	14,689	34,649	50,152
Min	441	12,141	33,907	49,011
Max	852	14,856	39,044	52,318
Average	619	13,421	36,595	50,635

3.3 West Butte Inventory Unit

The West Butte IU includes portions of Butte County within the West Butte Bulletin 118 Groundwater Subbasin. SIUs included are Angel Slough, Durham/Dayton, Llano Seco, M&T, and Western Canal[6]. The West Butte IU covers approximately 94,000 ac and includes approximately 56,000 ac of irrigated agriculture, 22,000 ac of non-irrigated lands, 9,000 ac of developed lands, and 7,000 ac of wetlands (Figure 3.10). Irrigated agriculture has decreased from approximately 62,000 ac in the late 1990's to approximately 56,000 ac in the early 2010's. Other land uses have increased over this period.

Primary crops grown are orchards and rice, with orchards representing an average of 33,000 ac and rice representing an average of 14,000 ac for the 15-year period from 2000 to 2014. Almonds (22,000 ac), walnuts (8,000 ac), and prunes (2,000 ac) are the primary orchard crops. Other than orchards and rice, crops include pasture and alfalfa (4,600 ac), grain (1,200 ac), and miscellaneous field and annual crops (2,100 ac). Between 2000 and 2014 it is estimated that approximately 4,000 ac were idle annually, on average, with average idling in the seven transfer years (2001, 2003, 2008, 2009, 2010, 2012, and 2014) of 5,300 ac and average idling in the remaining eight non-transfer years of 2,900 ac. Additional information describing participation in temporary water transfers by individual water suppliers within the County is included in the FRRAWMP (NCWA 2014). As discussed previously in Section 3.1, idling occurs in all years due to agronomic and economic decisions by individual growers with increased idling in some years due to temporary water transfers.

Changes in cropping between 2000 and 2014 include a decrease in grain and field and annual crops and an increase in walnuts. Annual acreages by crop are shown graphically in Figures 3.11, 3.12, and 3.13 and are provided in Table 3.3. Annual acreages for other land uses are provided in Table 3.4.

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[6] The portion of Western Canal Water District west of Butte Creek in Butte County.

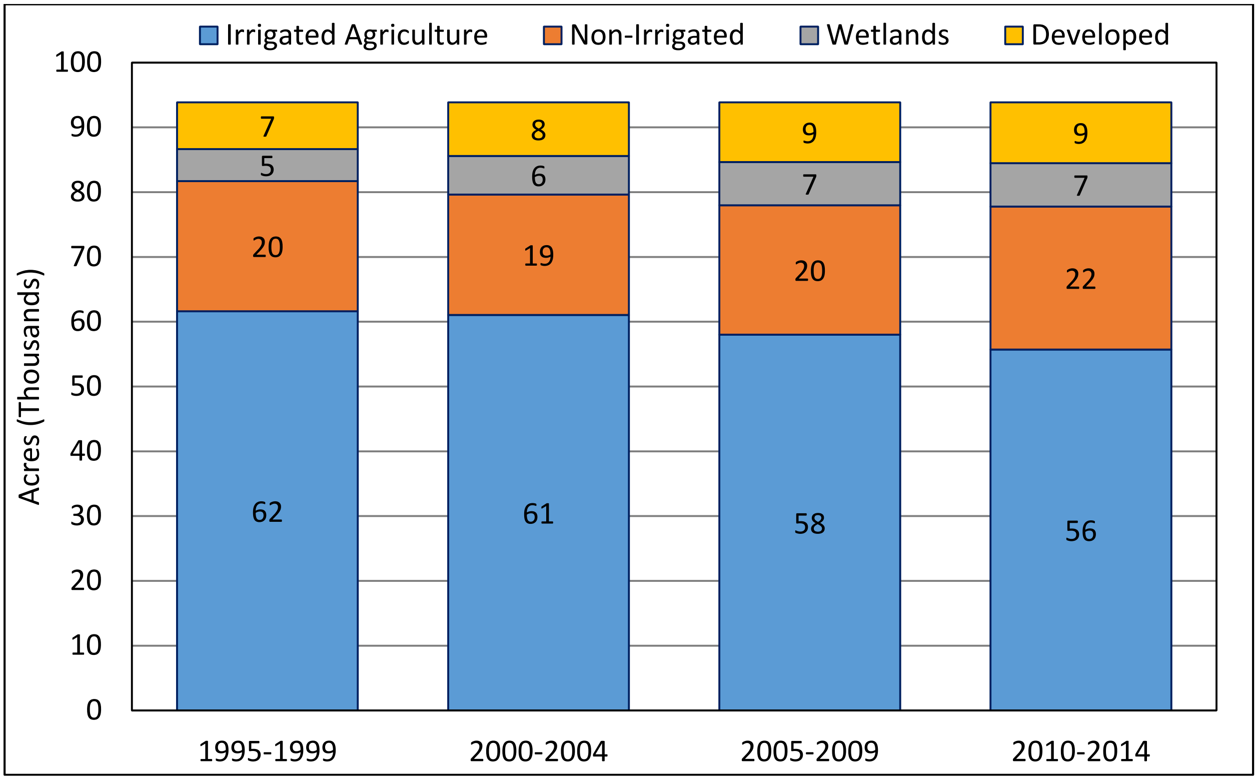

Figure 3.10. West Butte General Land Use, 1995-2014.

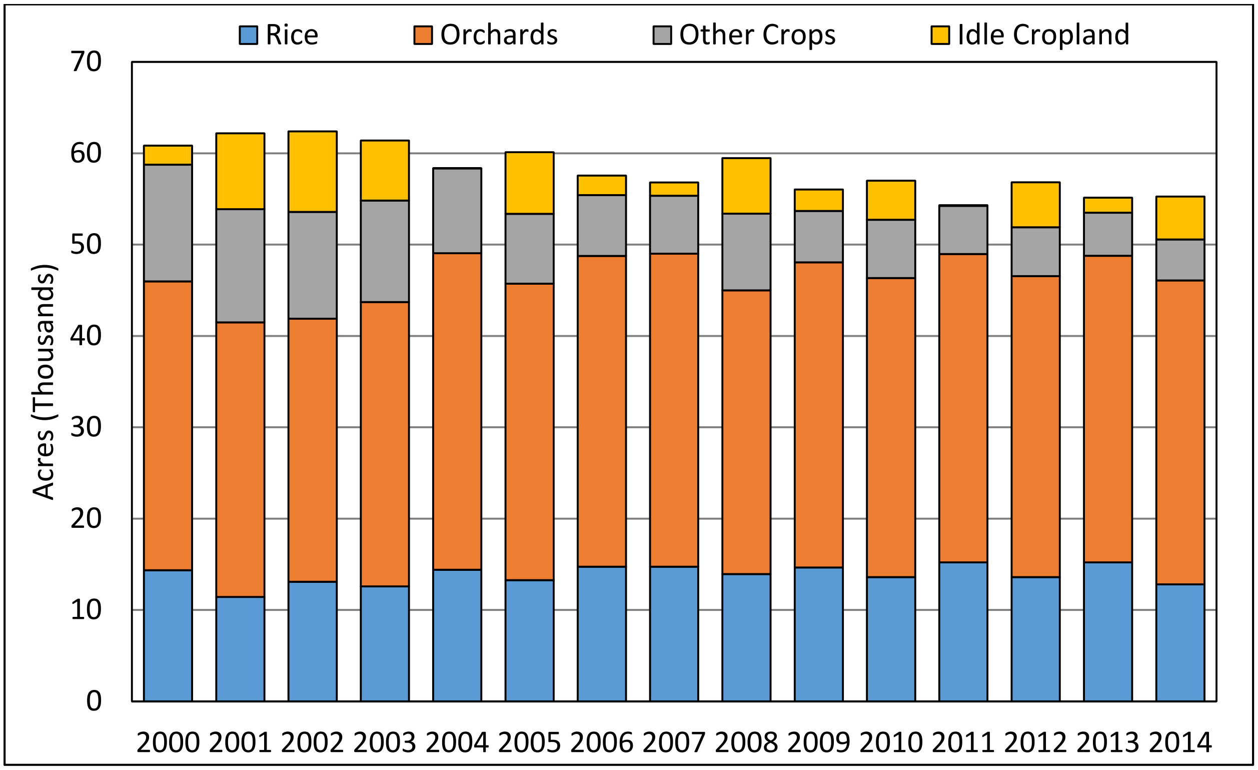

Figure 3.11. West Butte Irrigated Agricultural Land Use, 2000-2014.

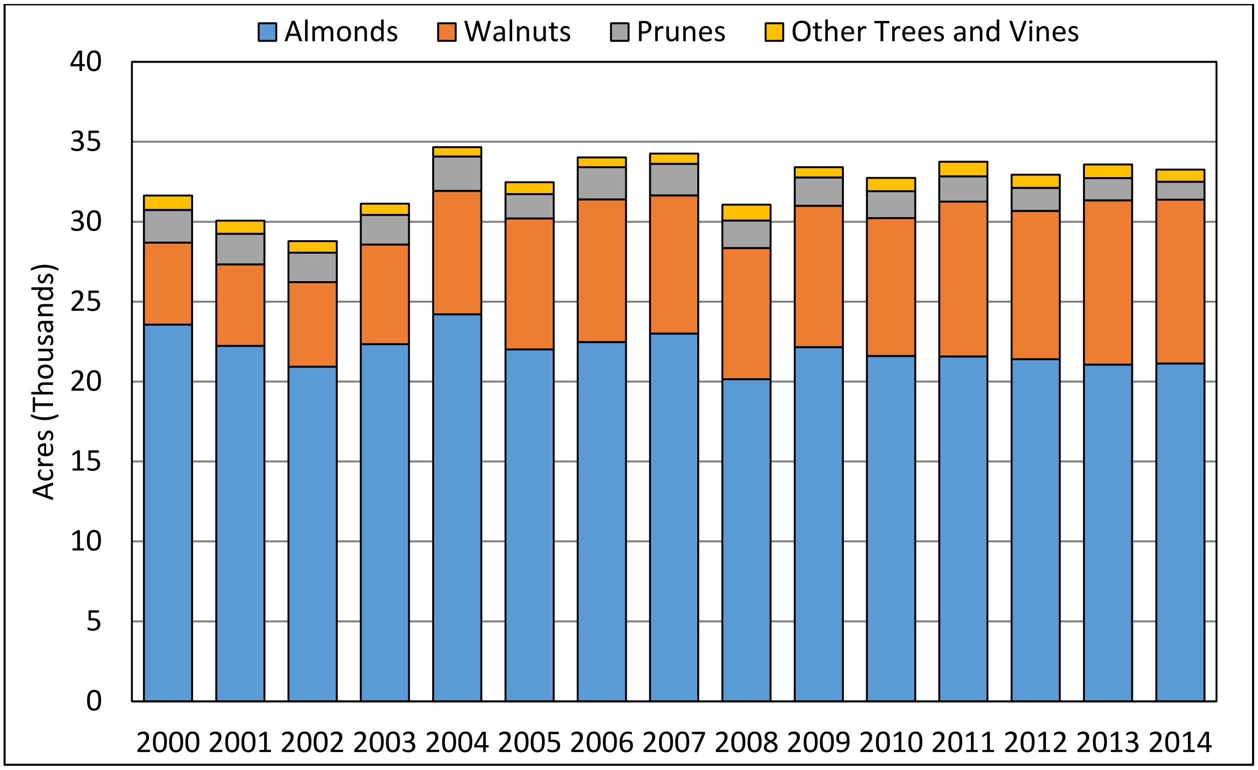

Figure 3.12. West Butte Orchard Land Use, 2000-2014.

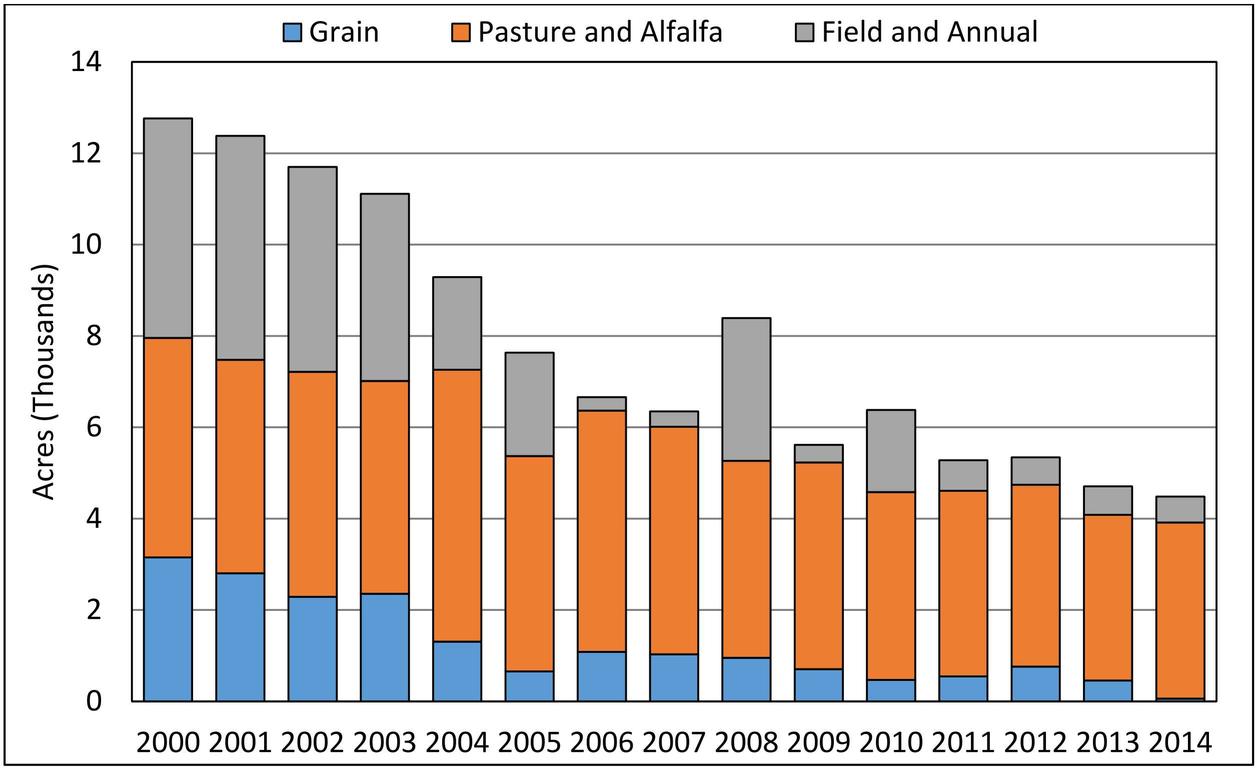

Figure 3.13. West Butte Other Crop Land Use, 2000-2014.

Table 3.3. West Butte Irrigated Agricultural Land Use, 2000-2014.

Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	14,347	23,570	5,124	2,042	899	3,151	4,808	4,806	2,089	58,747	60,836
2001	11,427	22,238	5,093	1,912	821	2,805	4,671	4,904	8,311	53,871	62,182
2002	13,099	20,927	5,297	1,843	720	2,288	4,927	4,488	8,812	53,588	62,400
2003	12,588	22,343	6,226	1,853	707	2,357	4,659	4,097	6,568	54,829	61,397
2004	14,403	24,208	7,720	2,157	574	1,309	5,952	2,030	16	58,353	58,368
2005	13,271	22,017	8,194	1,521	734	656	4,715	2,265	6,748	53,373	60,120
2006	14,733	22,477	8,919	2,018	612	1,085	5,282	293	2,141	55,418	57,558
2007	14,740	23,007	8,646	1,965	648	1,030	4,982	337	1,449	55,355	56,805
2008	13,930	20,154	8,199	1,718	998	955	4,311	3,127	6,087	53,391	59,478
2009	14,661	22,153	8,842	1,780	632	706	4,524	387	2,345	53,684	56,029
2010	13,593	21,601	8,627	1,677	838	469	4,114	1,799	4,285	52,718	57,003
2011	15,212	21,572	9,690	1,577	914	547	4,063	669	81	54,245	54,325
2012	13,602	21,401	9,277	1,442	825	760	3,982	602	4,933	51,891	56,824
2013	15,207	21,059	10,283	1,391	847	455	3,631	623	1,653	53,495	55,148
2014	12,810	21,131	10,251	1,119	763	58	3,859	569	4,697	50,559	55,256
Min	11,427	20,154	5,093	1,119	574	58	3,631	293	16	50,559	54,325
Max	15,212	24,208	10,283	2,157	998	3,151	5,952	4,904	8,812	58,747	62,400
Average	13,842	21,990	8,026	1,734	769	1,242	4,565	2,066	4,014	54,234	58,249

Table 3.4. West Butte Other Land Use, 2000-2014.

Year	Wetlands	Developed	Non-Irrigated	Total
2000	5,553	7,752	19,723	33,027
2001	5,526	7,686	18,469	31,681
2002	5,648	7,986	17,829	31,463
2003	6,166	8,492	17,808	32,466
2004	6,842	9,445	19,208	35,495
2005	6,629	8,875	18,239	33,743
2006	6,781	9,470	20,054	36,305
2007	6,816	9,554	20,688	37,058
2008	6,332	8,774	19,279	34,385
2009	6,728	9,454	21,653	37,834
2010	6,503	9,143	21,214	36,860
2011	6,899	9,617	23,023	39,538
2012	6,397	9,117	21,525	37,039
2013	6,835	9,513	22,367	38,715
2014	6,852	9,517	22,238	38,607
Min	5,526	7,686	17,808	31,463
Max	6,899	9,617	23,023	39,538
Average	6,434	8,960	20,221	35,614

3.4 East Butte Inventory Unit

The East Butte IU includes portions of Butte County within the East Butte Bulletin 118 Groundwater Subbasin. SIUs included are Biggs-West Gridley, Butte[7], Butte Sink, Cherokee, Esquon, Pentz, Richvale, Thermalito, and Western Canal[8]. The East Butte IU covers approximately 219,000 acres and includes approximately 125,000 ac of irrigated agriculture, 58,000 ac of non-irrigated lands, 28,000 ac of wetlands[9], and 15,000 ac of developed lands (Figure 3.14). Irrigated agriculture has increased from approximately 122,000 acres in the late 1990's to approximately 125,000 acres in the early 2010's. Other land uses have decreased over this period.

Primary crops grown are rice and orchards, with rice representing an average of 86,000 ac and orchards representing an average of 22,000 ac for the 15-year period from 2000 to 2014. Walnuts (9,600 ac), prunes (4,100 ac), and almonds (3,400 ac) are the primary orchard crops. Other than orchards and rice, crops include pasture and alfalfa (3,600 ac), grain (1,300 ac), and miscellaneous field and annual crops (1,300 ac). Between 2000 and 2014 it is estimated that approximately 9,000 ac were idle annually, on average, with average idling in the seven transfer years (2001, 2003, 2008, 2009, 2010, 2012, and 2014) of 16,300 ac and average idling in the remaining eight non-transfer years of 2,700 ac. Additional information describing participation in temporary water transfers by individual water suppliers within the County is included in the FRRAWMP (NCWA 2014). As discussed previously in Section 3.1, idling occurs in all years due to agronomic and economic decisions by individual growers with increased idling in some years due to temporary water transfers.

Changes in cropping between 2000 and 2014 include a decrease in prunes, grain, and field and annual crops and an increase in walnuts. Annual acreages by crop are shown graphically in Figures 3.15, 3.16, and 3.17 and are provided in Table 3.5. Annual acreages for other land uses are provided in Table 3.6.

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[7] The portion of Butte Water District in Butte County.

[8] The portion of Western Canal Water District east of Butte Creek in Butte County.

[9] Within the East Butte Inventory Unit, Thermalito Afterbay is classified as wetlands for purposes of this report and represents approximately 4,000 acres.

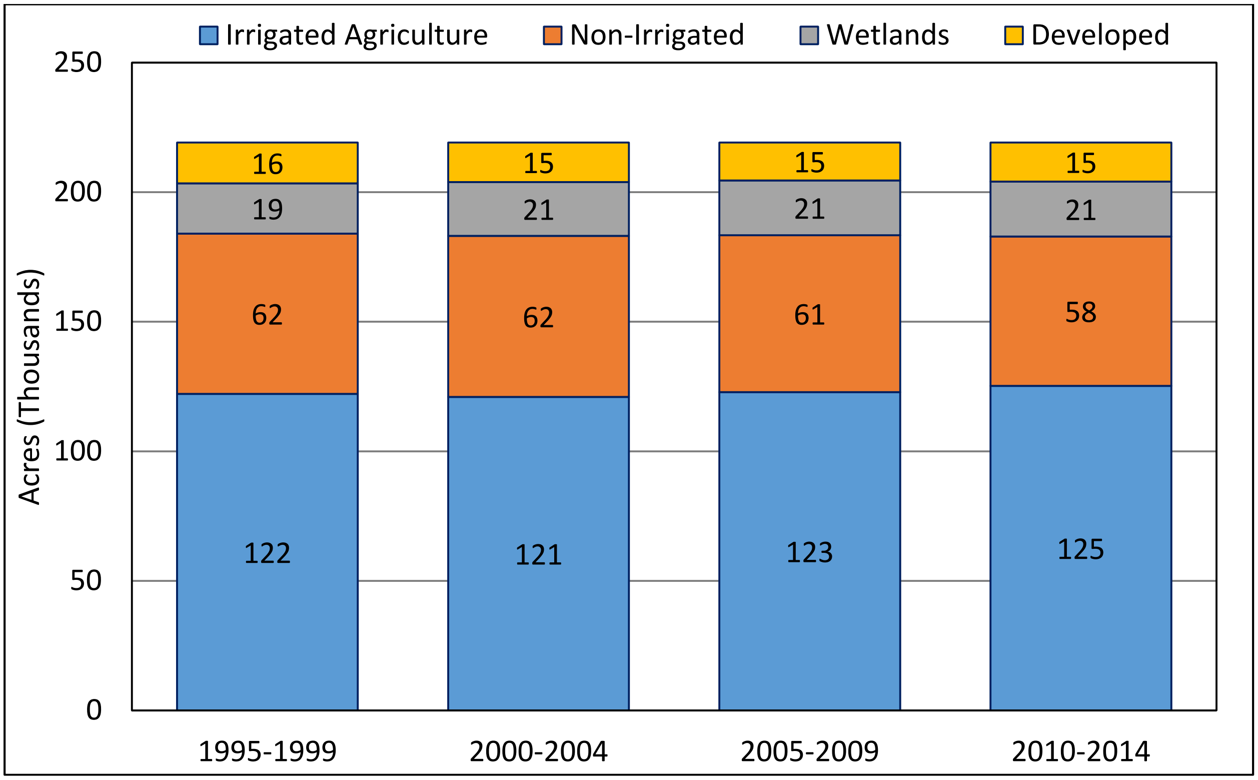

Figure 3.14. East Butte General Land Use, 1995-2014.

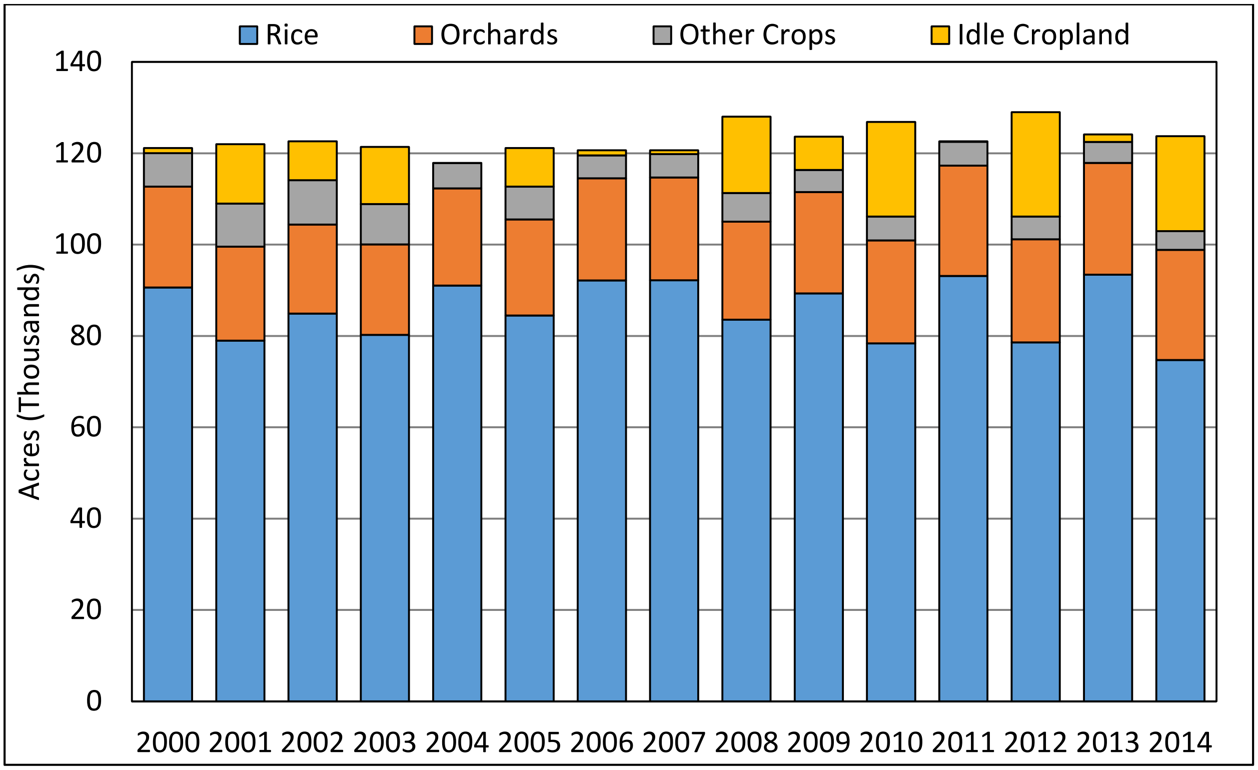

Figure 3.15. East Butte Irrigated Agricultural Land Use, 2000-2014.

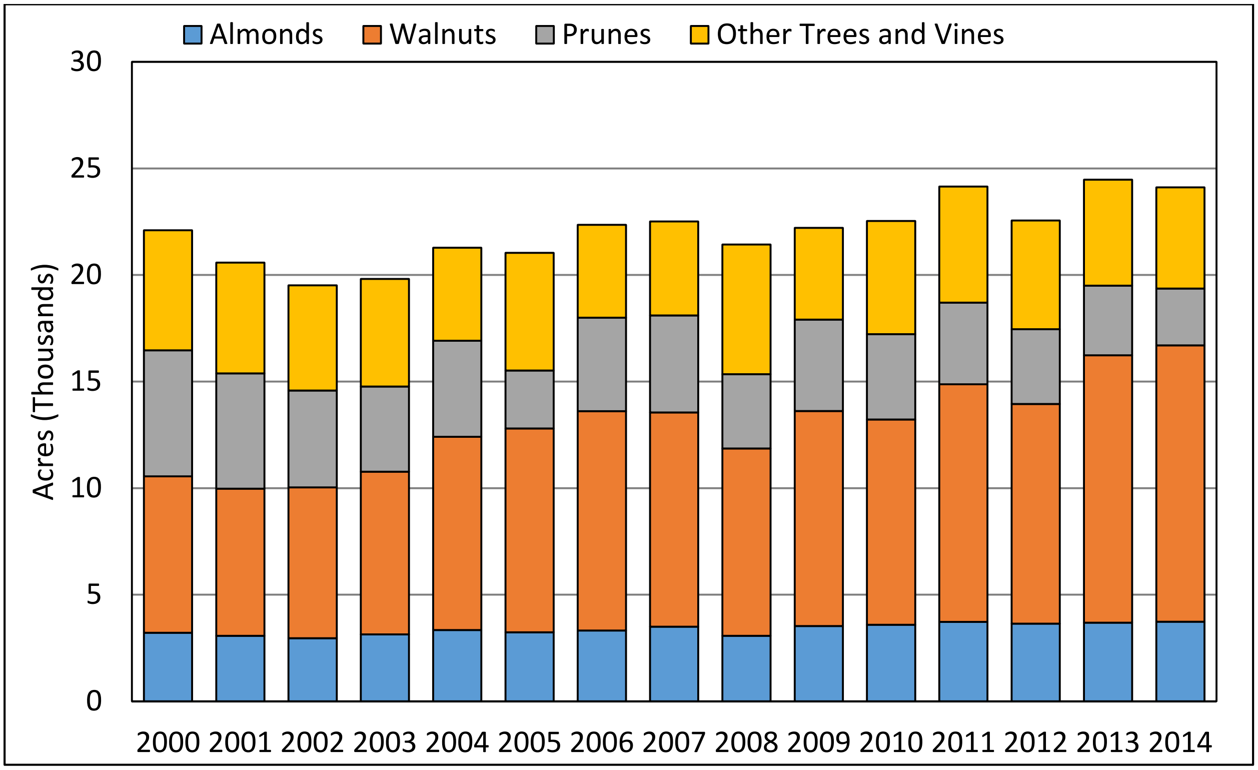

Figure 3.16. East Butte Orchard Land Use, 2000-2014.

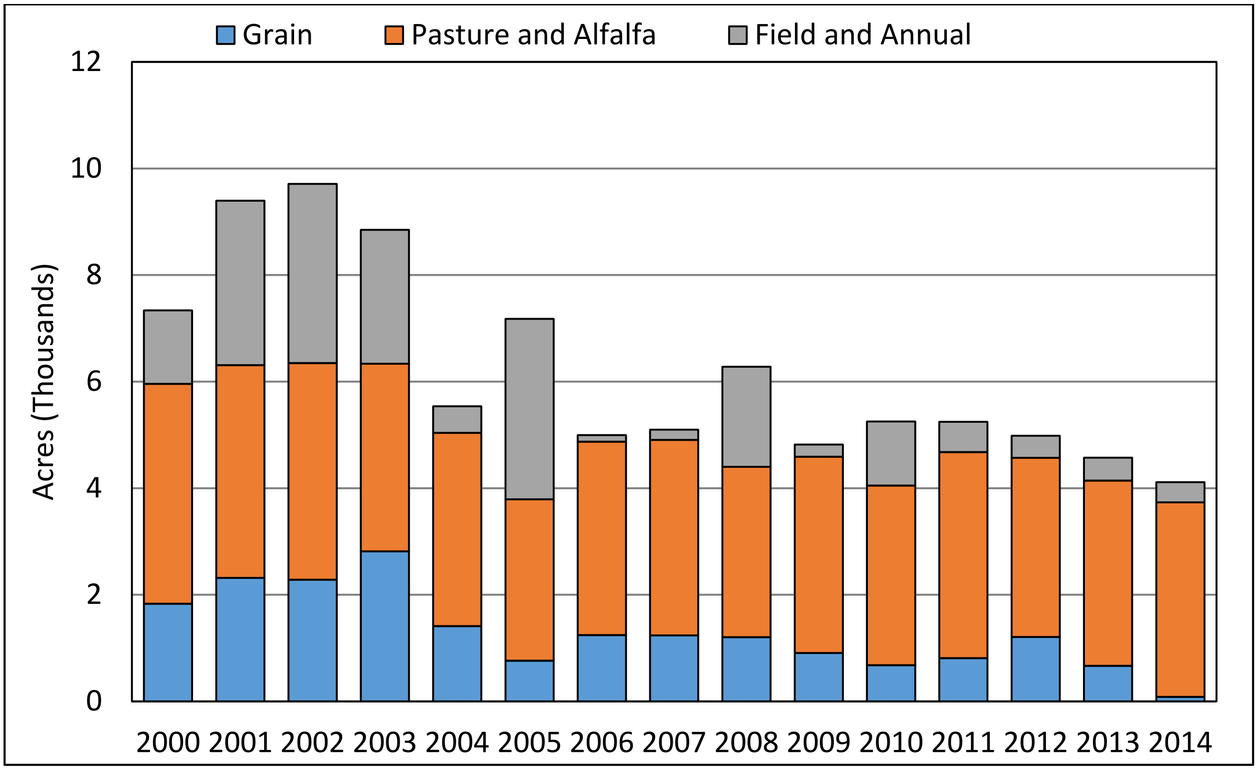

Figure 3.17. East Butte Other Crop Land Use, 2000-2014.

Table 3.5. East Butte Irrigated Agricultural Land Use, 2000-2014.

Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	90,600	3,214	7,340	5,914	5,628	1,831	4,127	1,379	1,104	120,034	121,138
2001	78,994	3,072	6,899	5,413	5,193	2,316	3,995	3,086	13,020	108,968	121,988
2002	84,893	2,958	7,076	4,544	4,935	2,284	4,065	3,362	8,512	114,117	122,629
2003	80,231	3,142	7,632	3,993	5,047	2,817	3,520	2,511	12,489	108,892	121,381
2004	91,030	3,341	9,068	4,508	4,360	1,412	3,626	500	12	117,845	117,858
2005	84,469	3,240	9,560	2,717	5,524	762	3,029	3,389	8,447	112,688	121,135
2006	92,169	3,317	10,295	4,389	4,357	1,243	3,632	121	1,153	119,522	120,675
2007	92,200	3,499	10,050	4,550	4,410	1,239	3,666	193	861	119,808	120,669
2008	83,587	3,072	8,791	3,486	6,083	1,205	3,196	1,880	16,712	111,299	128,011
2009	89,308	3,528	10,092	4,290	4,300	906	3,685	229	7,315	116,338	123,653
2010	78,377	3,590	9,626	4,007	5,311	679	3,372	1,202	20,706	106,163	126,869
2011	93,141	3,728	11,144	3,829	5,446	812	3,866	567	84	122,532	122,615
2012	78,605	3,644	10,300	3,508	5,102	1,207	3,364	415	22,851	106,146	128,996
2013	93,419	3,685	12,549	3,269	4,970	668	3,477	429	1,653	122,466	124,120
2014	74,746	3,733	12,967	2,663	4,748	84	3,652	378	20,781	102,971	123,752
Min	74,746	2,958	6,899	2,663	4,300	84	3,029	121	12	102,971	117,858
Max	93,419	3,733	12,967	5,914	6,083	2,817	4,127	3,389	22,851	122,532	128,996
Average	85,718	3,384	9,559	4,072	5,027	1,298	3,618	1,309	9,047	113,986	123,033

Table 3.6. East Butte Other Land Use, 2000-2014.

Year	Wetlands	Developed	Non-Irrigated	Total
2000	20,771	16,035	61,232	98,039
2001	20,246	15,311	61,632	97,188
2002	20,059	14,914	61,575	96,548
2003	21,006	14,612	62,177	97,795
2004	21,745	15,595	63,979	101,319
2005	21,241	14,509	62,291	98,041
2006	21,464	15,027	62,011	98,502
2007	21,586	15,335	61,587	98,508
2008	20,063	13,557	57,545	91,165
2009	21,253	14,862	59,409	95,524
2010	20,585	14,392	57,331	92,308
2011	21,833	15,762	58,966	96,561
2012	20,175	14,282	55,723	90,180
2013	21,648	15,469	57,940	95,057
2014	21,748	15,574	58,101	95,424
Min	20,059	13,557	55,723	90,180
Max	21,833	16,035	63,979	101,319
Average	21,028	15,016	60,100	96,144

3.5 North Yuba Inventory Unit

The North Yuba IU includes portions of Butte County within the North Yuba Bulletin 118 Groundwater Subbasin. The only SIU in this IU is North Yuba. The North Yuba IU covers approximately 51,000 acres and includes approximately 24,000 ac of non-irrigated lands, 16,000 ac of irrigated agriculture, 10,000 ac of developed lands, and 2,000 ac of wetlands (Figure 3.18). Non-irrigated lands have decreased from approximately 27,000 acres in the late 1990's to approximately 23,000 acres in the early 2010's. This reduction is offset primarily by an increase in developed lands.

Primary crops grown are orchards, representing an average of 7,300 ac annually. Other, non-rice crops have averaged 4,400 ac, and rice has averaged 3,000 ac annually over the 15-year period from 2000 to 2014. Walnuts (2,700 ac) and prunes (1,500 ac) are primary orchard crops, with other orchards (e.g., olives, peaches, pears, and cherries) making up 3,100 ac annually. Other crops include pasture and alfalfa (3,200 ac), grain (900 ac), and miscellaneous field and annual crops (400 ac). On average, 900 acres were idle annually between 2000 and 2014. Idling for temporary water transfers has not occurred in the North Yuba IU.

Changes in cropping between 2000 and 2014 include a modest increase in walnuts offset by a decrease in prunes, as well as a slight decrease in other, non-rice crops. Annual acreages by crop are shown graphically in Figures 3.19, 3.20, and 3.21 and are provided in Table 3.7. Annual acreages for other land uses are provided in Table 3.8.

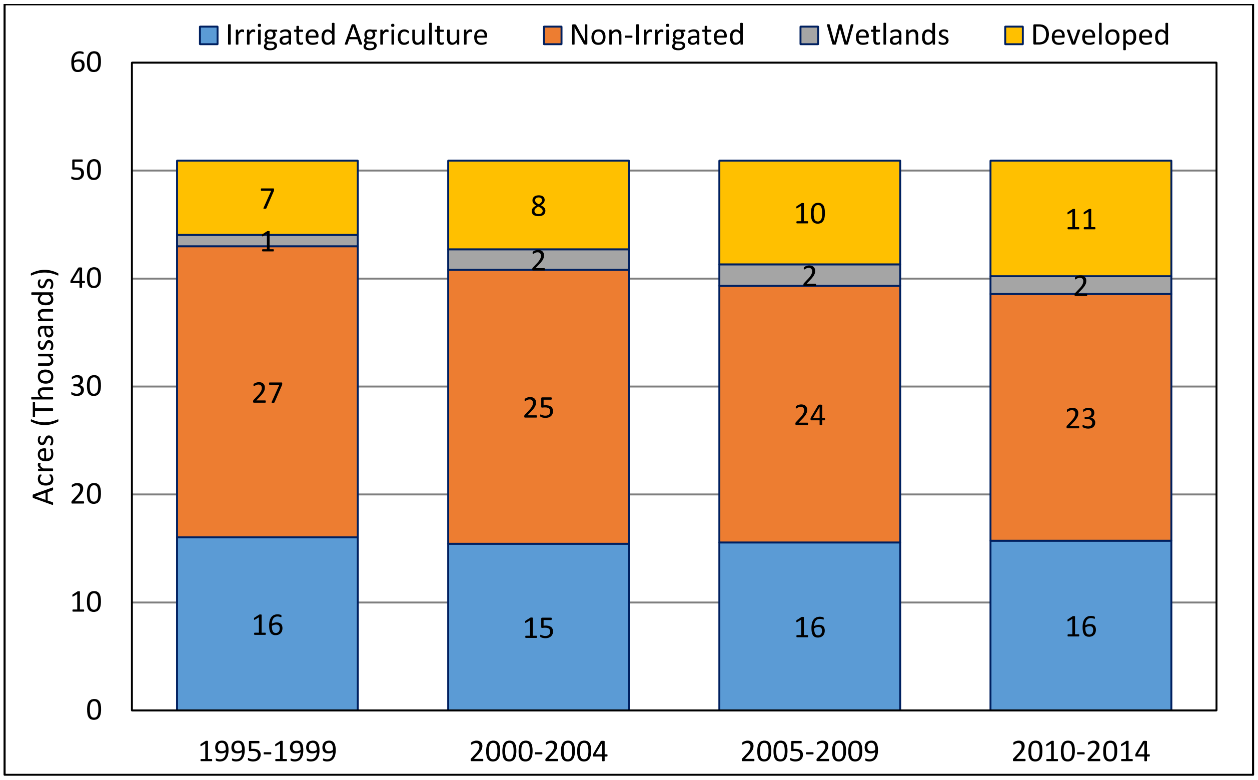

Figure 3.18. North Yuba General Land Use, 1995-2014.

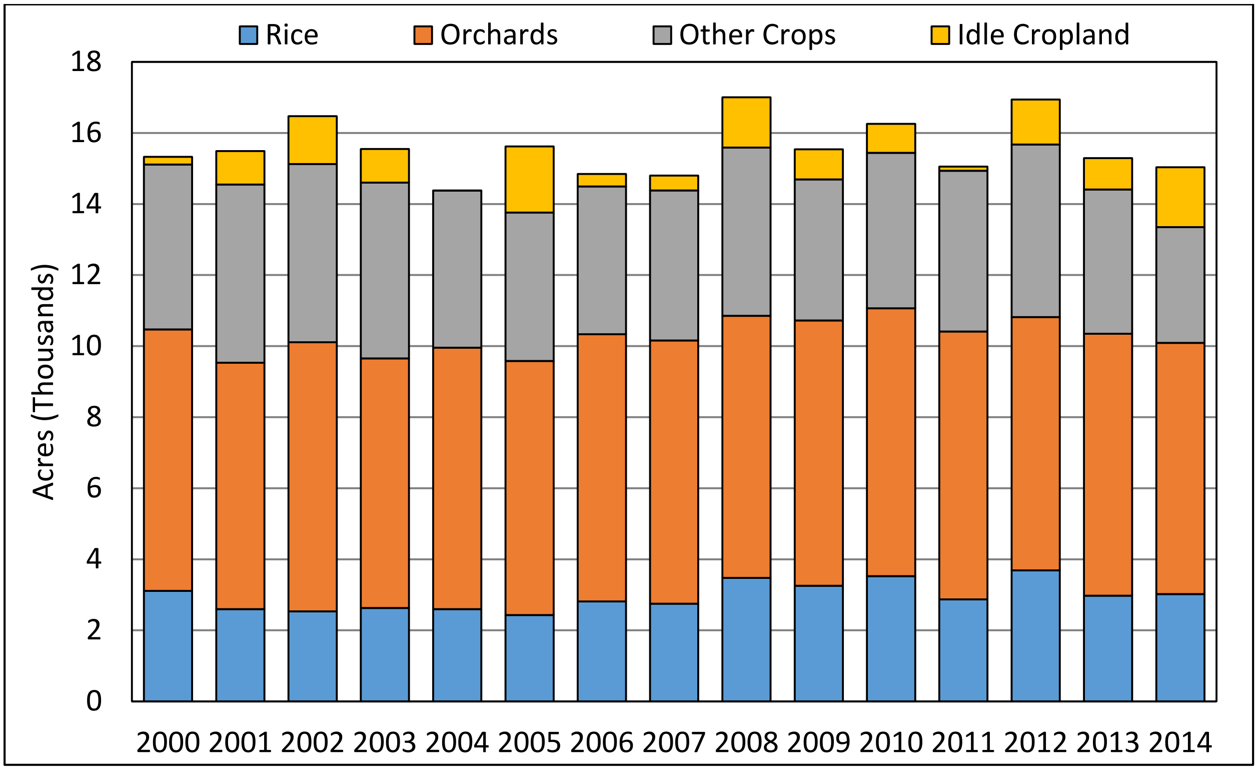

Figure 3.19. North Yuba Irrigated Agricultural Land Use, 2000-2014.

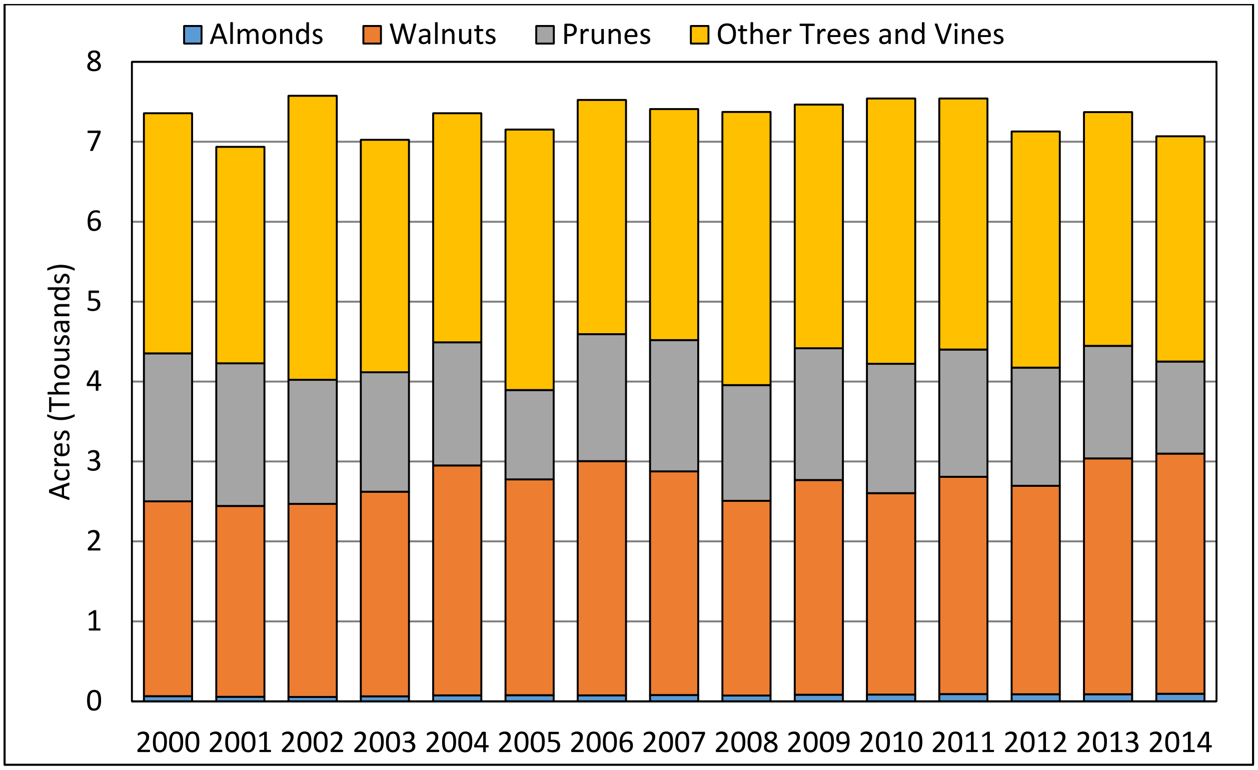

Figure 3.20. North Yuba Orchard Land Use, 2000-2014.

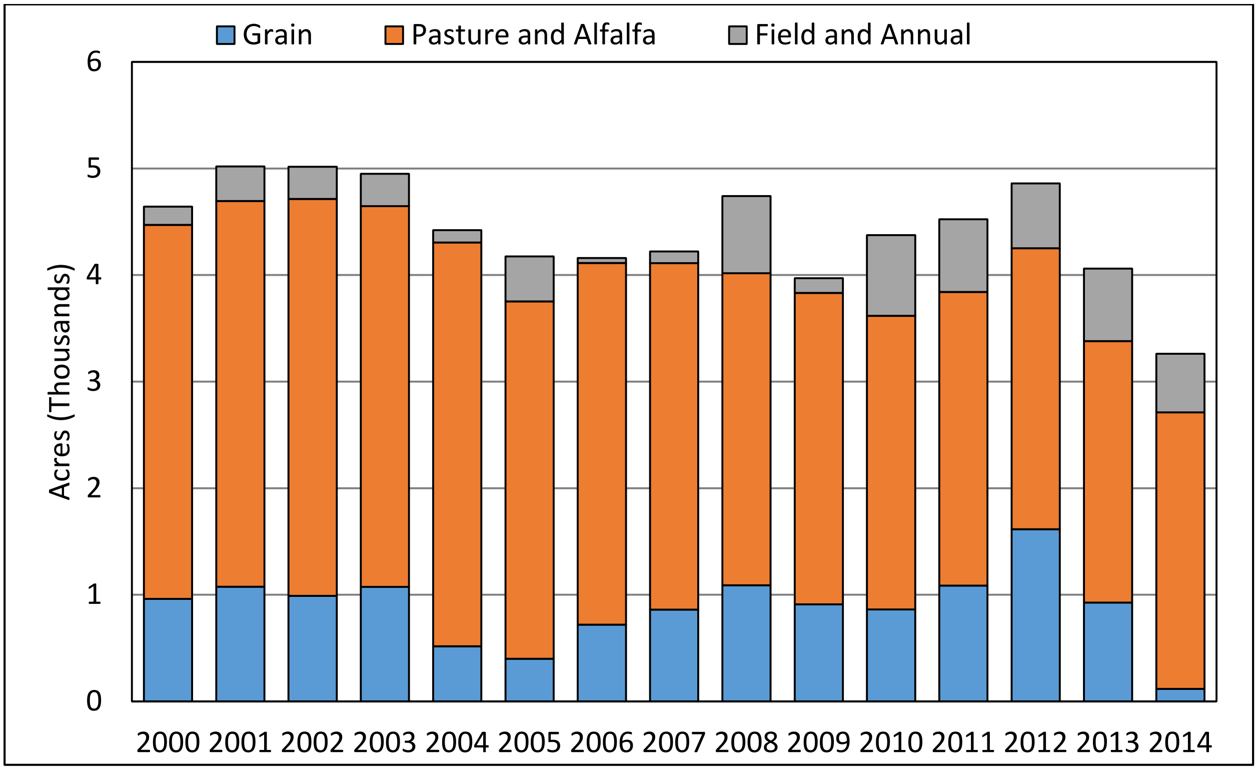

Figure 3.21. North Yuba Other Crop Land Use, 2000-2014.

Table 3.7. North Yuba Irrigated Agricultural Land Use, 2000-2014.

Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	3,112	64	2,438	1,851	3,004	961	3,510	171	219	15,111	15,331
2001	2,595	56	2,388	1,785	2,707	1,075	3,619	325	939	14,551	15,490
2002	2,534	54	2,415	1,553	3,553	990	3,725	301	1,351	15,125	16,475
2003	2,629	62	2,560	1,495	2,907	1,074	3,573	303	946	14,603	15,549
2004	2,596	74	2,876	1,540	2,868	517	3,789	117	5	14,376	14,381
2005	2,430	77	2,698	1,119	3,258	399	3,354	422	1,862	13,758	15,620
2006	2,813	74	2,930	1,590	2,930	720	3,393	47	352	14,496	14,848
2007	2,750	77	2,800	1,643	2,890	861	3,252	109	420	14,381	14,801
2008	3,477	72	2,435	1,448	3,419	1,089	2,929	723	1,412	15,592	17,003
2009	3,256	82	2,687	1,648	3,049	910	2,922	138	848	14,691	15,540
2010	3,525	85	2,519	1,619	3,319	863	2,755	756	818	15,440	16,258
2011	2,870	90	2,717	1,594	3,141	1,086	2,756	682	116	14,936	15,051
2012	3,687	87	2,610	1,478	2,955	1,614	2,638	609	1,264	15,677	16,941
2013	2,976	88	2,952	1,407	2,925	927	2,454	680	885	14,407	15,293
2014	3,022	93	3,006	1,151	2,819	117	2,595	549	1,685	13,352	15,036
Min	2,430	54	2,388	1,119	2,707	117	2,454	47	5	13,352	14,381
Max	3,687	93	3,006	1,851	3,553	1,614	3,789	756	1,862	15,677	17,003
Average	2,951	76	2,669	1,528	3,050	880	3,151	396	875	14,700	15,574

Table 3.8. North Yuba Other Land Use, 2000-2014.

Year	Wetlands	Developed	Non-Irrigated	Total
2000	1,542	7,680	26,367	35,589
2001	1,700	7,775	25,956	35,431
2002	1,842	7,887	24,715	34,445
2003	2,076	8,562	24,733	35,371
2004	2,359	9,120	25,060	36,539
2005	2,168	8,957	24,176	35,300
2006	2,144	9,557	24,371	36,072
2007	2,059	9,838	24,222	36,119
2008	1,758	9,518	22,641	33,917
2009	1,837	10,150	23,393	35,380
2010	1,663	10,234	22,764	34,662
2011	1,677	10,892	23,299	35,869
2012	1,551	10,333	22,095	33,979
2013	1,670	10,958	23,000	35,627
2014	1,685	11,089	23,110	35,884
Min	1,542	7,680	22,095	33,917
Max	2,359	11,089	26,367	36,539
Average	1,849	9,503	23,993	35,346

4. Climate and Hydrology

Many aspects of the physical setting of Butte County play a role in the hydrologic cycle within the County. Topography within the County significantly impacts precipitation patterns. Temperature variations influence whether precipitation falls as rain or snow, which in turn impacts the timing of surface water runoff. Temperature and other factors also influence the evaporative demand of the atmosphere and corresponding irrigation requirements for crops. Both surface water and extracted groundwater are used to meet the water demands. System components impacting water resources in the County described in this section include climate, surface water hydrology, and groundwater hydrology.

4.1 Climate

Butte County has a Mediterranean climate with cool, wet winters and hot, dry summers. Unlike many locations in California, rainfall and winter snowpack in the Sierra Nevada provide significant surface water flows and groundwater recharge as water drains through the County.

Climate variation within the County occurs primarily due to changes in elevation. Precipitation is least on the valley floor and greatest in the Foothill Inventory Unit (IU) and Mountain IU areas as elevation increases. Conversely, temperatures are warmest on the valley floor and coolest in the mountains. Similarly, reference evapotranspiration (ETo), a measure of evaporative demand, is greatest on the valley floor and least in the mountains. This variability in climate is discussed in greater detail in the following sections.

4.1.1 Precipitation

Average annual precipitation generally increases from west to east across Butte County, associated with increasing elevation. Moisture-laden weather patterns from the Pacific Ocean travel west to east across California and Butte County during the winter months. Air cools as it moves east and it is lifted over the Sierra Nevada through the process of orographic cooling. This process results in condensation of moisture and precipitation. Precipitation from orographic cooling is evidenced by the spatial distribution of average annual rainfall for Butte County from 1981 to 2010 shown in Figure 4.1[1].

Precipitation is strongly seasonal, occurring generally between October and March or April, with about two thirds of the total annual precipitation generally occurring between November and February. Average monthly precipitation totals for valley floor IUs (Vina, West Butte, East Butte, and North Yuba), the Foothill IU, the Mountain IU, and the County as a whole for the

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[1] Source: PRISM Climate Group, Oregon State University (prism.oregonstate.edu).

period 1981-2010 are shown in Figure 4.2. Water year[2] annual precipitation totals for 1981 to 2015 for the Chico University Farm and Paradise weather stations[3] are shown in Figure 4.3.

Inter-annual precipitation varies widely. For Chico University Farm, water year precipitation between 1981 and 2015 averaged 27.0 inches but varied between 13.2 inches in 2007 and 48.0 inches in 1998. For Paradise, water year precipitation between 1981 and 2015 averaged 55.8 inches but varied between 34.8 inches in 2014 and 102.3 inches in 1995.

4.1.2 Temperature

Converse to precipitation, average temperature decreases from west to east across Butte County, associated with increasing elevation. The spatial distribution of average annual temperature within Butte County from 1981 to 2010 is shown in Figure 4.4[4].

Monthly County-wide average temperature varies from approximately 45 F in January and December to 77 F in July based on PRISM estimates for the 1981 to 2010 period. Average monthly temperature is similar among valley floor IUs and decreases slightly for the Foothill IU (Figure 4.5). Temperatures are least for the Mountain IU.

Although there is substantial seasonal variability in temperature, there is not a large difference between the valley floor and mountain areas. For example, the difference in annual average air temperature between the valley floor IUs and the Mountain IU is only 6 F.

4.1.3 Reference Evapotranspiration

Similar to temperature, reference evapotranspiration (ETo) decreases from west to east across Butte County, associated with increasing elevation. The spatial distribution of annual ETo within Butte County for 2014 is shown in Figure 4.6[5]. ETo is relatively similar on the valley floor.

Monthly average ETo for the California Irrigation Management Information System (CIMIS) weather station at Durham (Station 12) varied from 1.2 inches in December to 7.3 inches in July for the 1981 to 2015 period (Figure 4.7). About three quarters of annual ETo generally occurs between April and September. Annual ETo tends to be greatest in warm, dry years and least in cool, wet years. For Durham, water year ETo between 1981 and 2015 averaged 50.1 inches but varied between 43.4 inches in 1998 and 54.1 inches in 2007 (Figure 4.8).

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[2] A water year refers to the period from October to September each year, with the beginning month of October selected based on the typical beginning of the winter rainy season. For example, the 2000 water year includes the period from October 1999 to September 2000.

[3] Source: National Climatic Data Center (NCDC) stations 041715 and 046685 (www.ncdc.noaa.gov).

[4] Source: PRISM Climate Group, Oregon State University (prism.oregonstate.edu).

[5] Source: California Irrigation Management Information System (cimis.water.ca.gov). Derived from SpatialCIMIS ETo raster data. Long-term average raster data are not currently available, though the spatial distribution of relative ETo is expected to be similar across years.

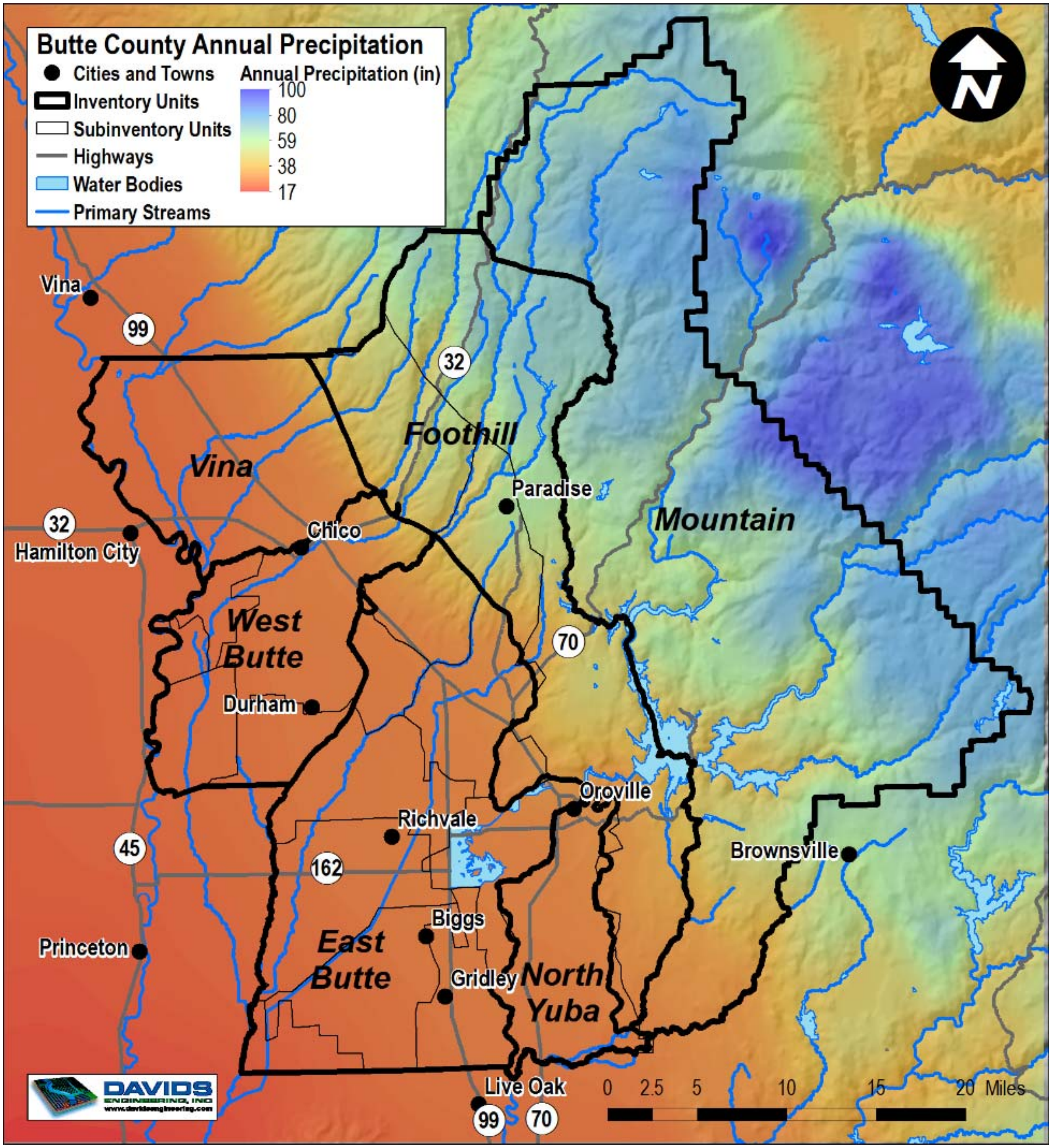

Figure 4.1. Butte County Average Annual Precipitation, 1981-2010 (Source: PRISM Climate Group).

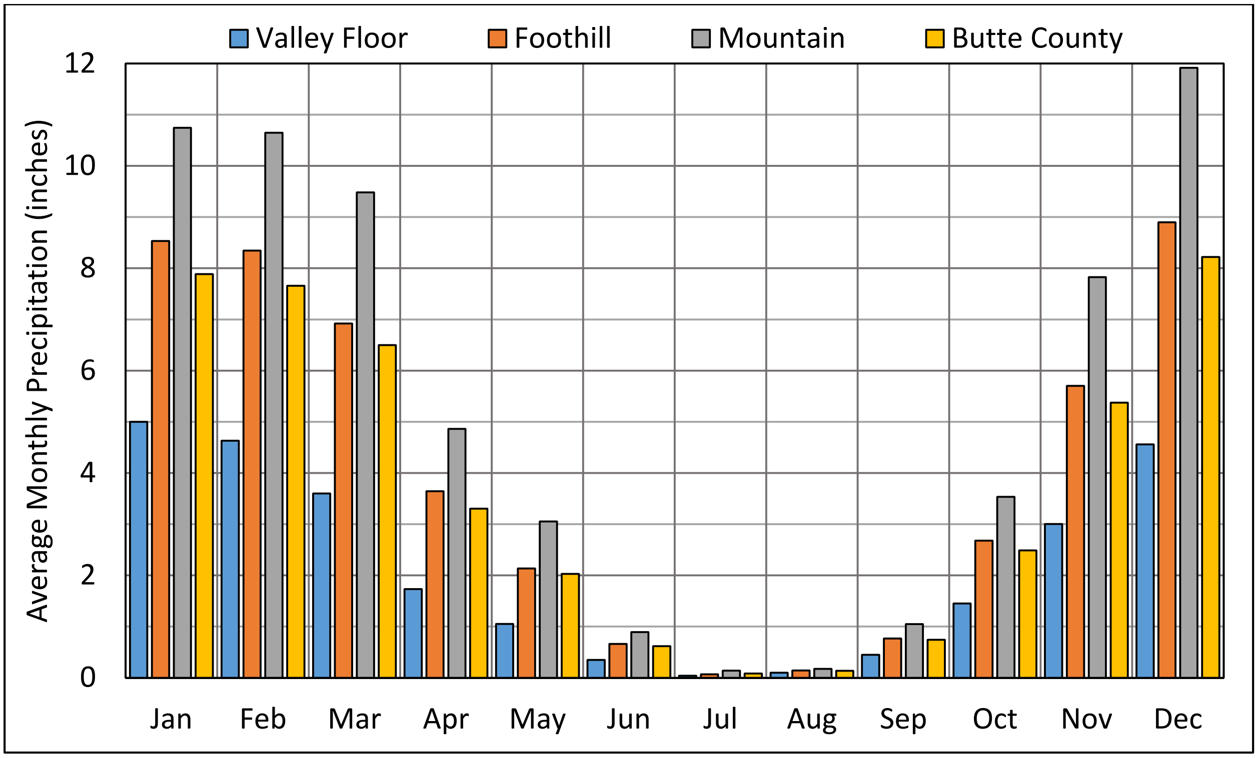

Figure 4.2. Average Monthly Precipitation for Valley-Floor, Foothill, and Mountain Inventory Units and Butte County, 1981-2010 (Source: PRISM Climate Group).

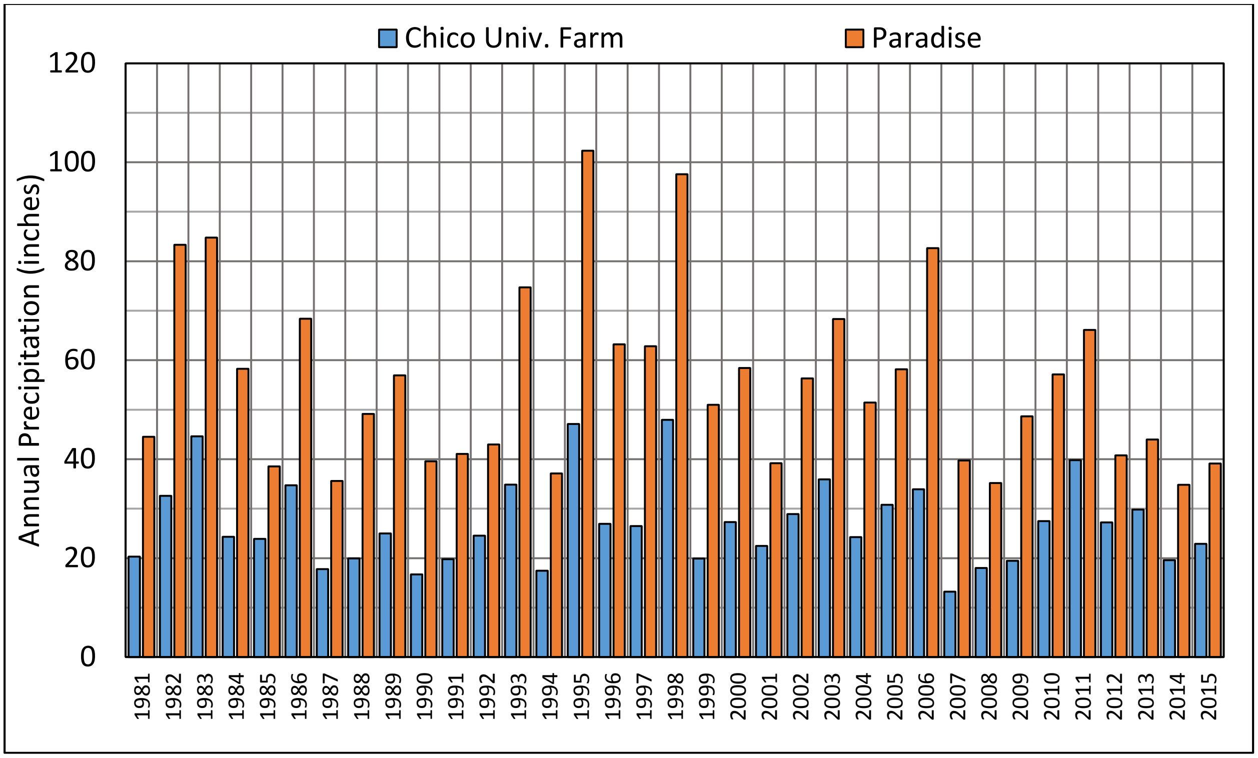

Figure 4.3. Water Year Precipitation for Chico University Farm (NCDC 041715) and Paradise (NCDC 046685), 1981-2015.

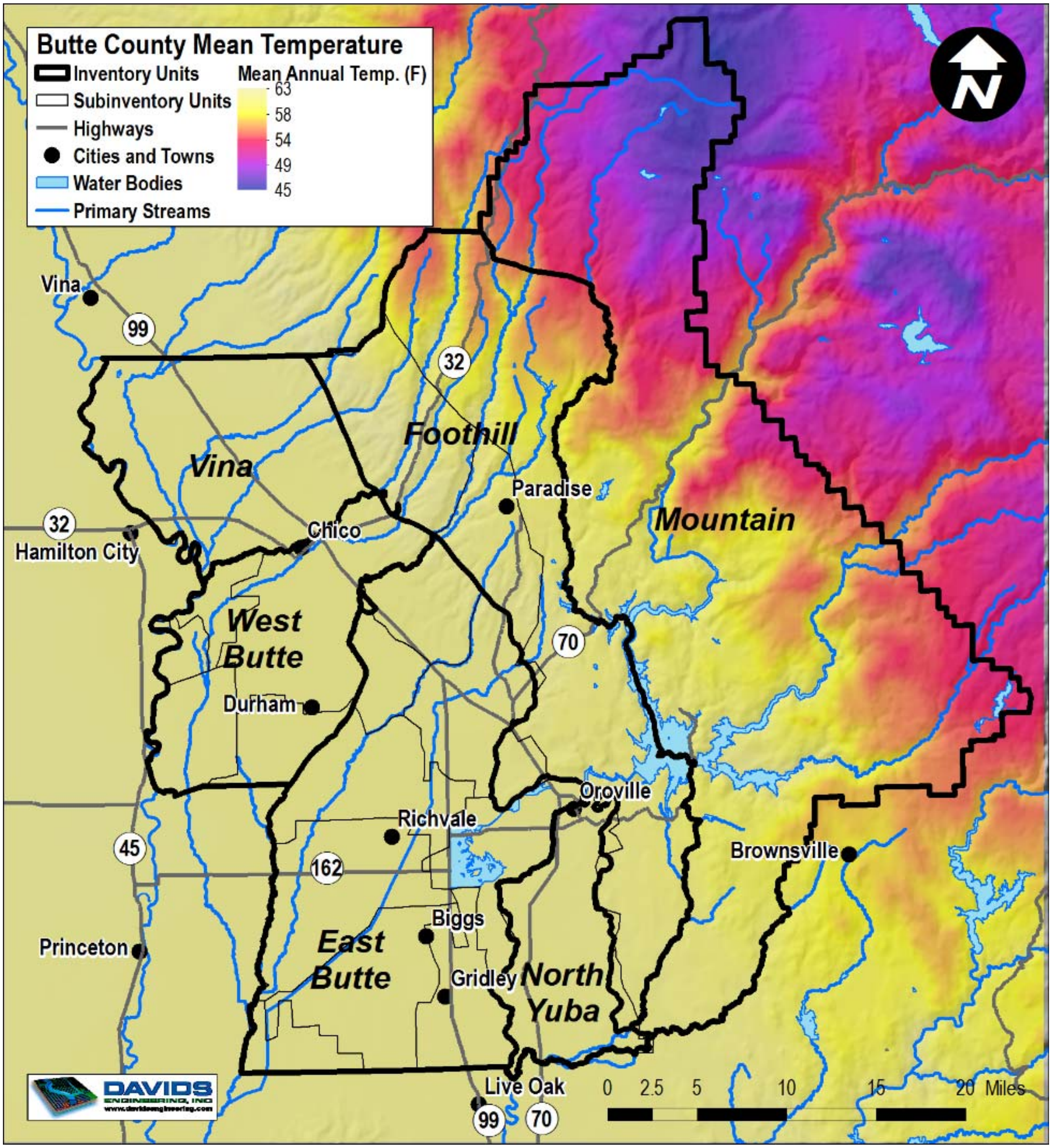

Figure 4.4. Butte County Average Annual Temperature, 1981-2010 (Source: PRISM Climate Group).

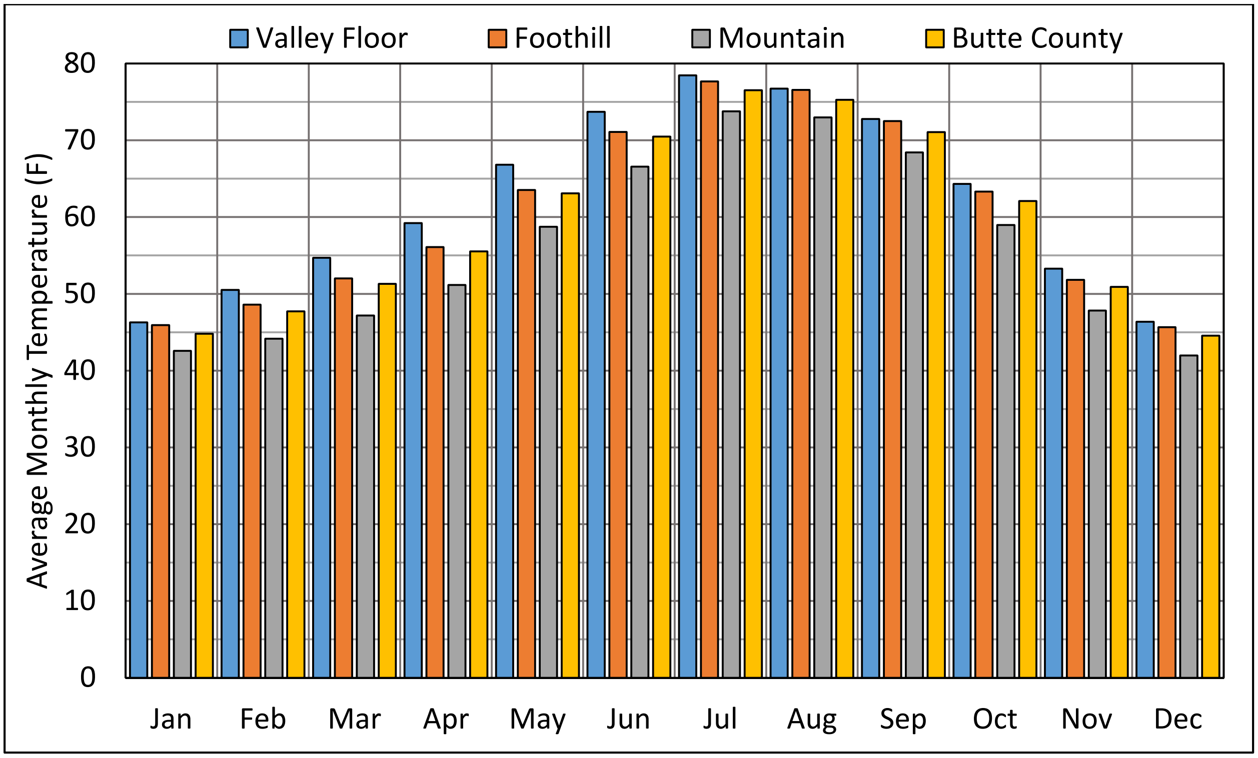

Figure 4.5. Average Monthly Temperature for Valley-Floor, Foothill, and Mountain Inventory Units and Butte County, 1981-2010 (Source: PRISM Climate Group).

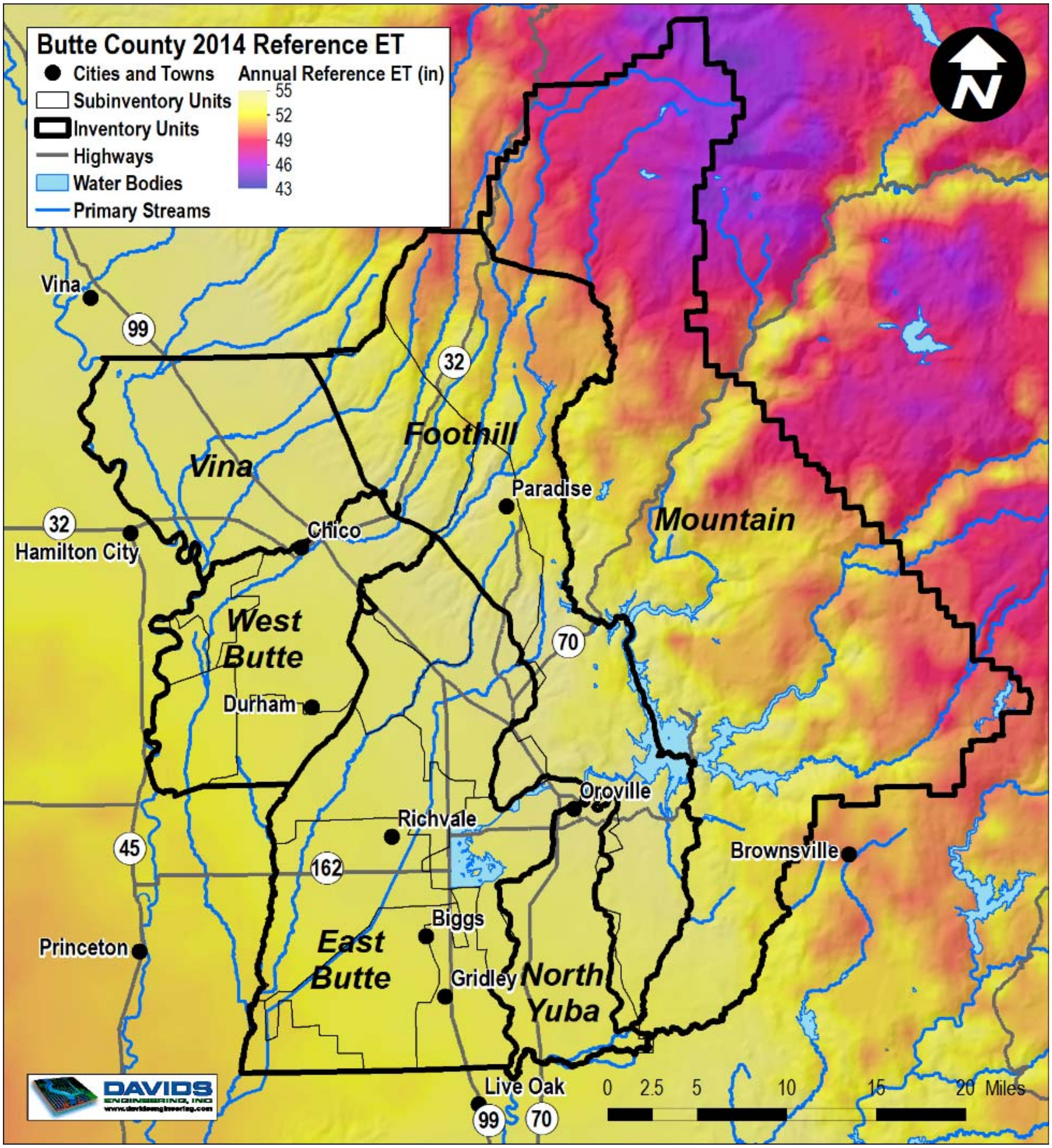

Figure 4.6. Butte County Annual Reference Evapotranspiration, 2014 (Source: CIMIS).

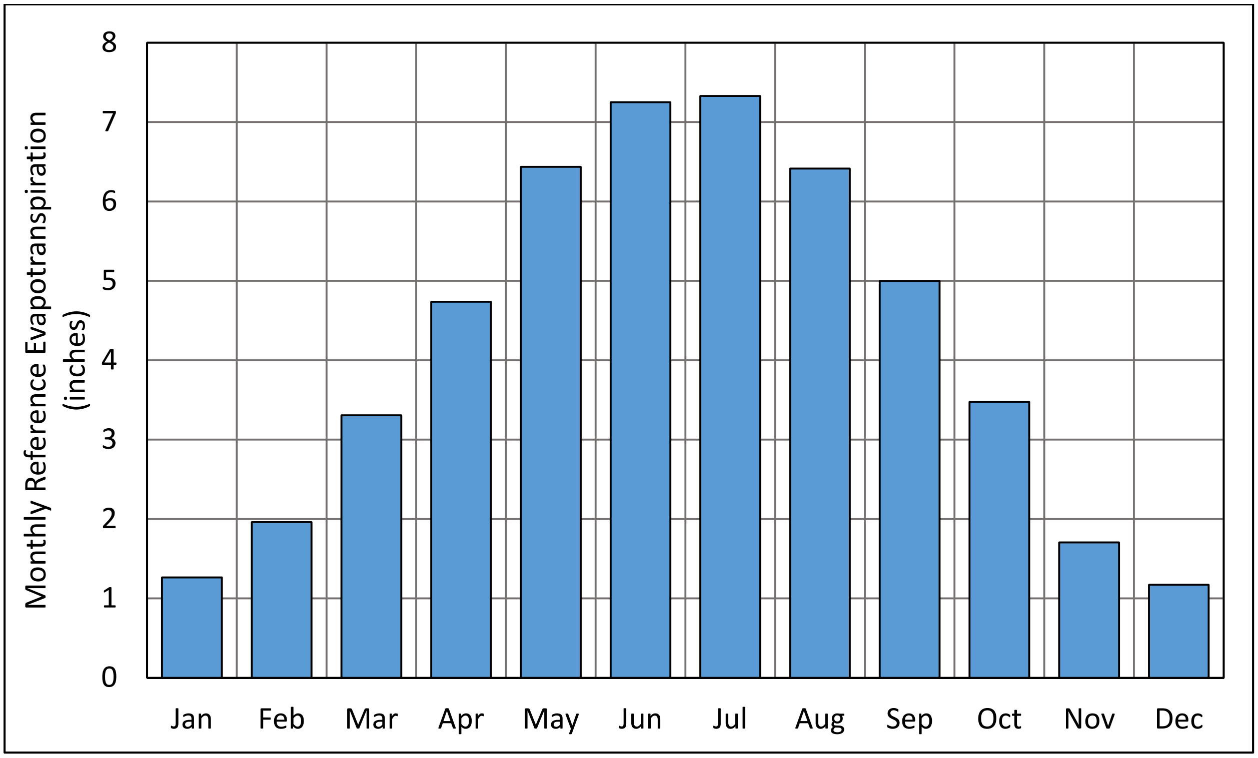

Figure 4.7. Average Monthly Reference Evapotranspiration for Durham CIMIS (Station 12), 1981-2015.

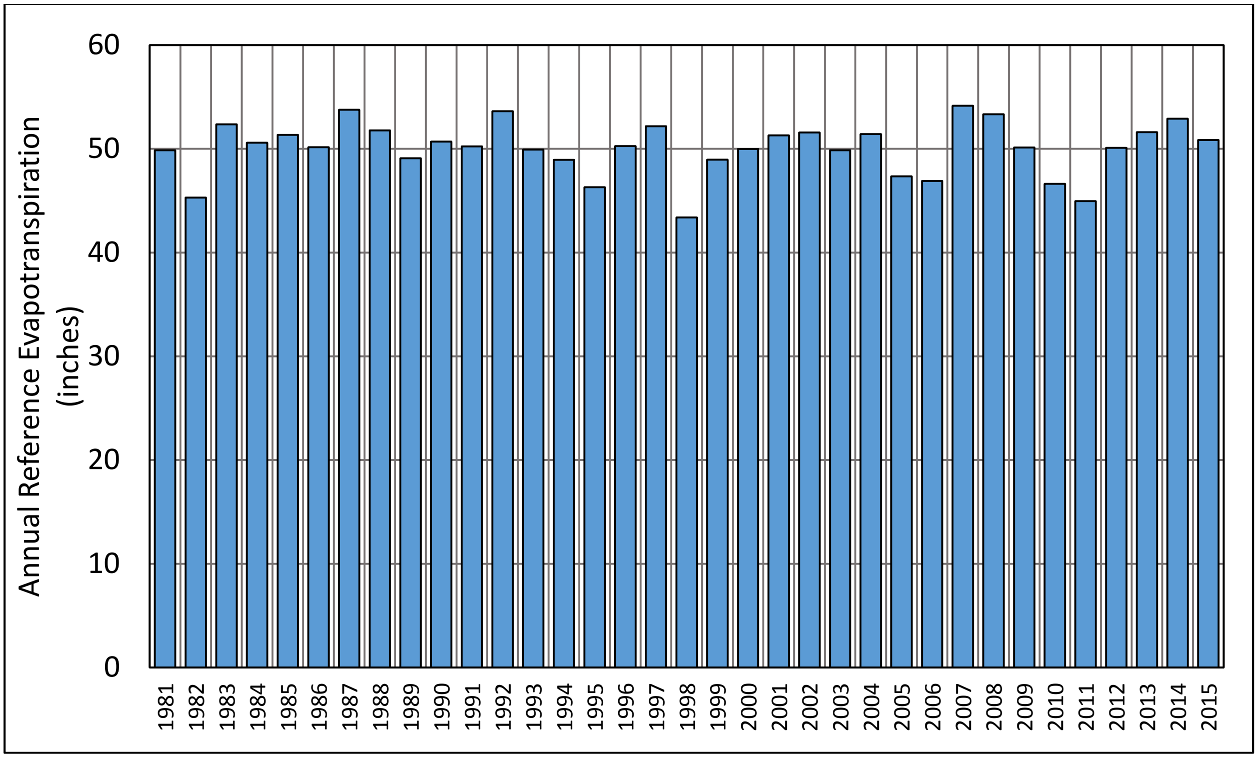

Figure 4.8. Water Year Reference Evapotranspiration for Durham CIMIS (Station 12), 1981-2015.

4.2 Surface Water Hydrology

This section provides an overview of the surface water hydrology of Butte County, including discussion of surface water sources and channels, other measured flows, surface water storage, and diversions.

4.2.1 Overview

Surface water hydrology of the Sacramento Valley and Butte County is characterized by large variability in inter-annual precipitation and runoff resulting in both drought and flooding, sometimes in the same year. In contrast, relative differences in seasonal runoff are more predictable, with rainfall runoff occurring during the winter or snowfall forming snowpack in higher elevations that runs off as it melts in the spring and early summer.

A key indicator of seasonal variability in inter-annual hydrology is the Sacramento Valley Water Year Index (WYI), which is used to classify individual water years as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), or Critical (C) with respect to surface water runoff in the Sacramento River Basin. Key rivers contributing to runoff from the basin are the Sacramento River itself, the Feather River, the Yuba River, and the American River. The WYI for each year is weighted 70 percent based on unimpaired runoff from the Basin for the current year and 30 percent based on unimpaired runoff from the prior year (expressed in millions of acre-feet (maf)). Unimpaired runoff represents the amount of runoff that would occur in the basin absent any diversions, storage, or inter-basin imports and exports.

The Sacramento Valley WYI for the 45-year period from 1971 to 2015 is shown in Figure 4.9, along with corresponding water year type classifications. During this period, the WYI ranged from 3.1 maf in 1977 to 15.3 maf in 1983[6], representing a five-fold difference occurring only 6 years apart. The average WYI over this period is 7.9 maf. Historical and recent drought periods are evident in the figure. Of note is that only one above normal or wet year has occurred since 2007, and only four above normal or wet years have occurred since 2001.

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[6] These years also represent the historical minimum and maximum WYIs for the 115-year period of record from 1901 to 2015.

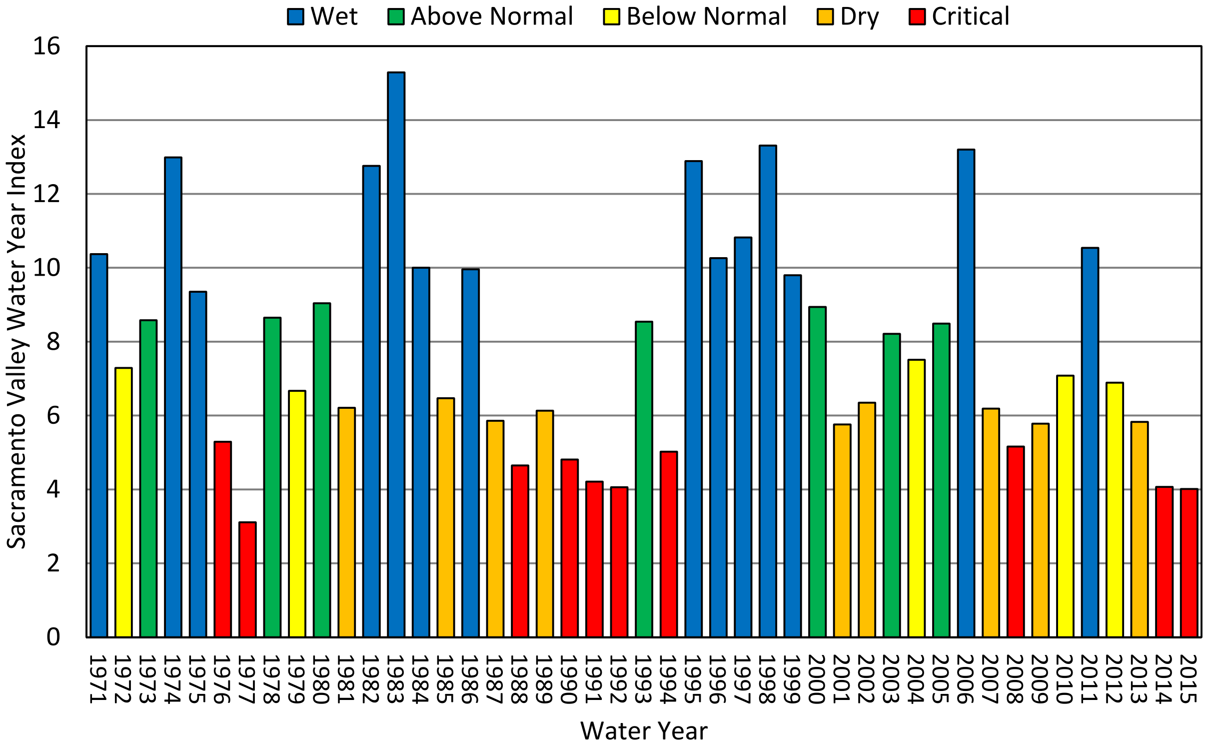

Figure 4.9. Sacramento Valley Water Year Index.

4.2.2 Surface Water Sources and Channels

Figure 4.10 shows the principal entry points to Butte County for surface water and the major channels, natural and modified, by which it flows through the County. The principal waterways originating outside the County are:

- The Sacramento River
- The Feather River. The North, Middle and South Forks originate outside the County and, together with the West Branch, supply water to Lake Oroville with a portion of flow routed through the Thermalito Forebay and Afterbay facilities to generate hydropower and deliver irrigation water supply, with the remaining water returning to the Feather River.
- Big Chico Creek
- Butte Creek
- Pine Creek

Runoff and groundwater flows within the County contribute to the flows in the above waterways and also to those arising within the County. These waterways represent the major streams and water supply and drainage features in the County and include:

- Natural Waterways
  - The West Branch of the Feather River. The West Branch joins the forks originating outside the County and supplies water to Lake Oroville and then to

Thermalito Forebay and Afterbay. Diversions are additionally made by PG&E to Butte Creek, as described below.
    - Little Chico Creek
    - Rock Creek
    - Dry Creek
    - Little Dry Creek
    - Clear Creek
    - Angel Slough
    - Wyandotte Creek
    - Honcut Creek
- Supply Canals
    - Western Main Canal
    - Western Lateral 374
    - Richvale Main Canal
    - Sutter Butte Canal
    - Minderman Canal
    - Biggs-West Gridley Main Canal
- Flood Control Channels
    - Cherokee Canal
    - Lindo Channel (Sandy Gulch)
    - Sycamore Bypass Channel

Water is distributed from Thermalito Afterbay to canals serving multiple users including Western Canal Water District and the Joint Districts. The Joint Districts include Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District[7], and Sutter Extension Water District[8].

Water from the West Branch of the Feather River is diverted to the Toadtown Canal for power generation and cold water for fish by PG&E. The Butte Canal carries Toadtown Canal and Butte Creek water to the De Sabla power plant forebay. Hydropower is also generated at several other locations. Operations at all of these sites affect the timing of water releases. At Oroville-Thermalito, Toadtown, and De Sabla-Centerville, water for power generation is transferred from the Feather River watershed to the Butte Creek watershed.

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[7] A portion of Butte Water District's service area falls within Sutter County.

[8] All of Sutter Extension Water District's service area falls within Sutter County.

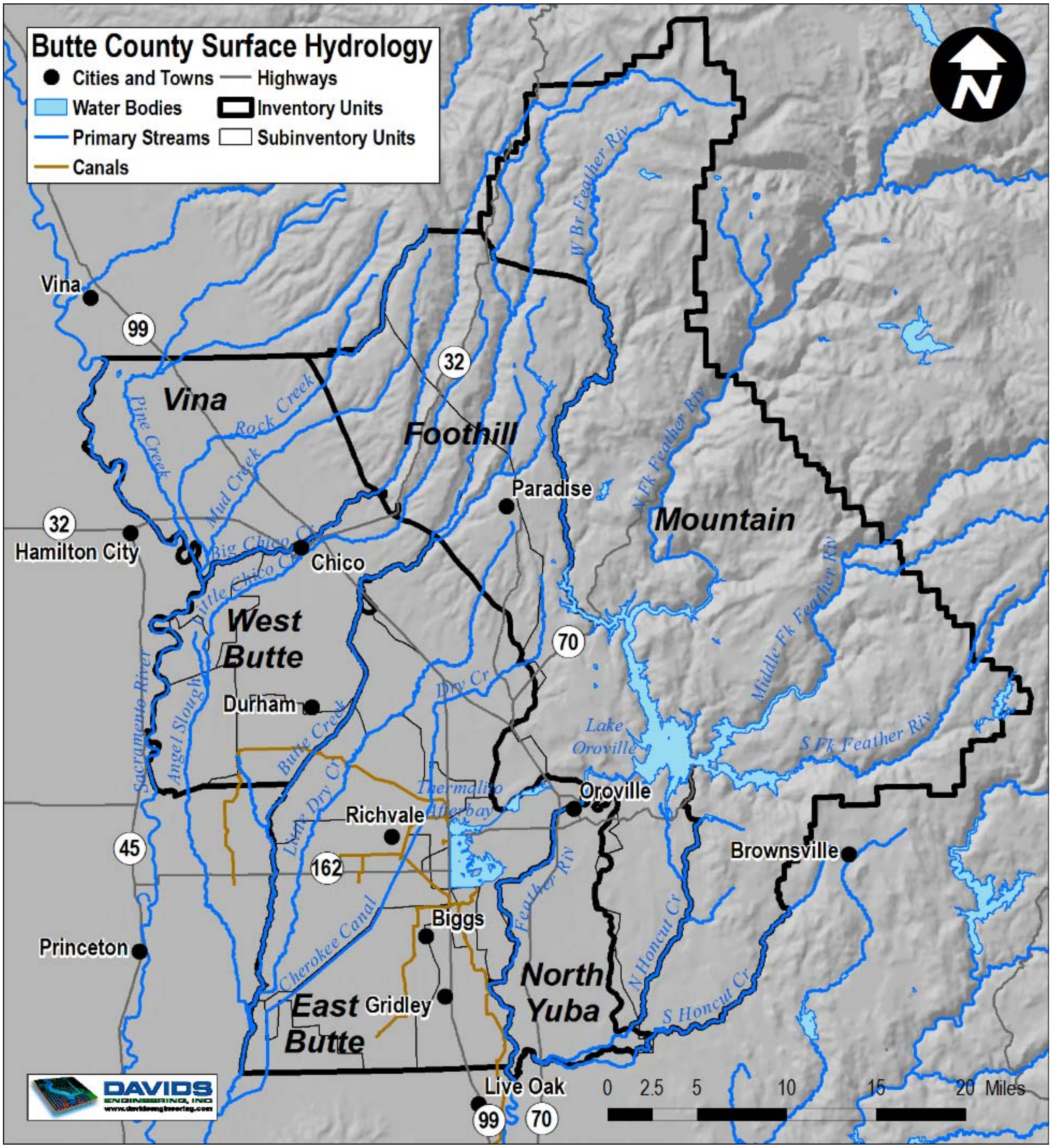

Figure 4.10. Butte County Surface Hydrology.

Historical flows for several surface water channels in Butte County have been estimated as part of the WI&A update and to update datasets for the BBGM. Flows correspond to locations where stream gages currently exist or were historically present, or locations where surface channels enter the valley floor alluvium. Flows summarized below include the following:

- Sacramento River at Vina Bridge[9]
- Feather River at Oroville Full Natural (Unimpaired) Flow[10]
- Butte Creek near Chico[11]
- Big Chico Creek near Chico[12]

As indicated in Figure 4.11, average monthly flows for the Sacramento River are greatest between January and March, reflecting runoff from precipitation on the valley floor, planned reservoir releases, and reservoir spillage in some years. Flows are sustained through July or August and even into November as water is released from storage in Lake Shasta. In contrast, unimpaired Feather River flows and flows from Butte Creek and Big Chico Creek are greatest between approximately February and May as a result of runoff from snowmelt. These flows decrease greatly between May and July once the snow has melted.

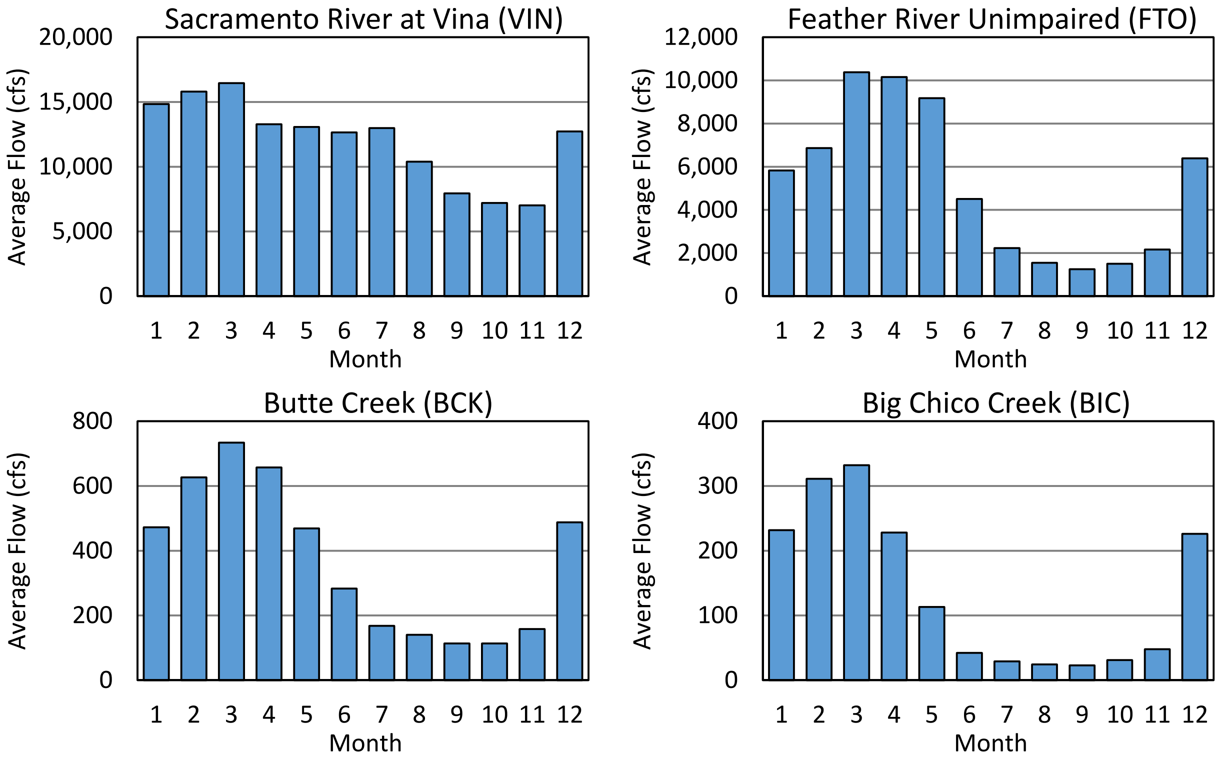

Figure 4.11. Average Monthly Flow by Surface Water Channel, 2000-2014.

Annual runoff varies greatly among streams and from year to year (Figure 4.12). During the 2000 to 2014 period, maximum annual runoff occurred in 2006 for all four streams reported herein, and minimum annual runoff occurred during 2014.

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[9] Source: California Data Exchange Center (CDEC) station VIN (cdec.water.ca.gov).
[10] Source: CDEC station FTO (cdec.water.ca.gov).
[11] Source: CDEC station BCK (cdec.water.ca.gov).
[12] Source: CDEC station BIC (cdec.water.ca.gov).

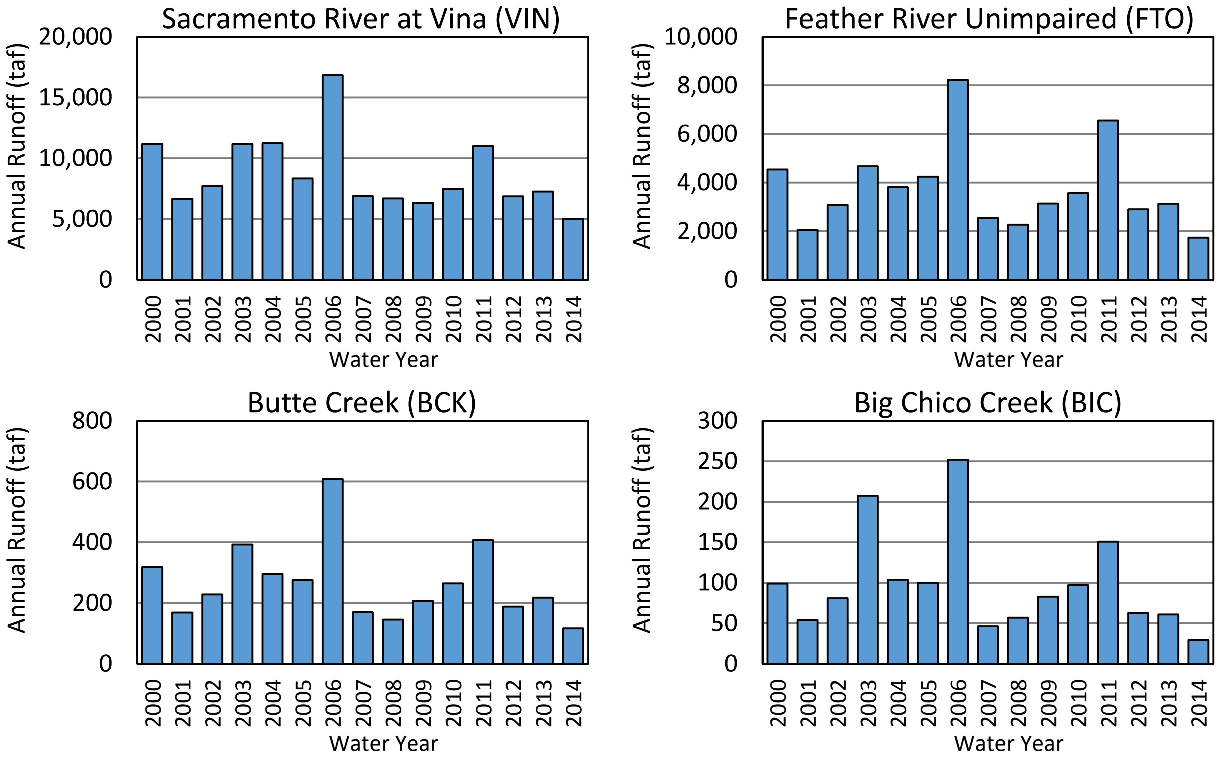
Sacramento River at Vina (VIN)
Feather River Unimpaired (FTO)
Butte Creek (BCK)
Big Chico Creek (BIC)

Figure 4.12. Annual Runoff by Surface Water Channel, 2000-2014.

4.2.3 Other Measured Flows

Other measured flows in Butte County include numerous historical and existing stream gages. Data for these gages are available through the California Data Exchange Center (CDEC), from the U.S. Geological Survey (USGS), and through the DWR Water Data Library (WDL). In many cases, data for a particular gage is available from more than one source. For example, several USGS gages are also reported through CDEC. In addition to these public data sources, local water suppliers maintain additional flow monitoring sites to track diversions and flows within canal systems to support system operations. Due to the passage of Senate Bill 88 (SB88), additional real time monitoring of diversions will be conducted in coming years, including the availability of diversion information for large diversions being made publicly available by 2020.

A list of past and current locations in Butte County providing surface water flow and/or storage information is provided in Appendix B. The sites listed include those identified as being located in Butte County by CDEC and USGS. The list includes 34 CDEC sites and 89 USGS sites.

4.2.4 Surface Water Storage

Numerous water storage reservoirs exist within the County. DWR Bulletin 17 provides information on 24 dams in Butte County that fall under the jurisdiction of DWR's Division of Dam Safety (DWR, Bulletin 17, 2000). Table 4.1 lists dams within Butte County under the jurisdiction of the Division of Dam Safety, including information on the dam name, owner, year completed, stream dammed and storage capacity.

Table 4.1. Butte County Dams under Jurisdiction of the Division of Dam Safety.

Reservoir Name	Owner	Year Completed	Stream Impounded	Storage Capacity (acre-feet)
Al Chaffin	George Chaffin	1957	Cottonwood Creek Tributary	450
California Park	California Park Homeowners Association	1986	Dead Horse Slough	335
Cannon Ranch	Spring Valley Minerals	1870	Oregon Gulch Tributary	176
Concow	Thermalito Table Mountain Irrigation District	1925	Concow Creek	8,600
Desabla Forebay	Pacific Gas and Electric Company	1903	Middle Butte Creek	280
Feather River Hatchery	Department of Water Resources	1964	Feather River	580
Forbestown Division	South Feather Water and Power Agency	1962	South Fork Feather River	358
Grizzly Creek	Mr. & Mrs. Ronald T. Dreisbach	1964	Grizzly Creek	76
Kunkle	Pacific Gas and Electric Company	1907	West Branch Feather River Tributary	253
Lake Madrone	Lake Madrone Water District	1931	Berry Creek	200
Lake Wyandotte	South Feather Water and Power Agency	1924	North Honcut Creek	1,300
Lost Creek	South Feather Water and Power Agency	1924	Lost Creek	5,680
Magalia	Paradise Irrigation District	1918	Little Butte Creek	2,900[13]
Miners Ranch	South Feather Water and Power Agency	1962	North Honcut Creek Tributary	912
Oroville	Department of Water Resources	1968	Feather River	3,537,577
Paradise	Paradise Irrigation District	1957	Little Butte Creek	11,500
Philbrook	Pacific Gas and Electric Company	1926	Philbrook Creek	5,180
Poe	Pacific Gas and Electric Company	1959	North Fork Feather River	1,150
Ponderosa Division	South Feather Water and Power Agency	1962	South Fork Feather River	4,750
Round Valley	Pacific Gas and Electric Company	1877	West Branch Feather River	1,147
Sly Creek	South Feather Water and Power Agency	1961	Lost Creek	65,050
Thermalito Afterbay	Department of Water Resources	1967	Feather River Tributary	57,041
Thermalito Division	Department of Water Resources	1967	Feather River	13,328
Thermalito Forebay	Department of Water Resources	1967	Cottonwood Creek Tributary	11,768

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[13] Storage capacity of 2,900 af based on DWR Bulletin 17. According to Paradise Irrigation District, actual storage is currently limited to 800 af.

4.2.5 Irrigation Water Source

Areas with access to surface water for irrigation include the southern portion of the West Butte IU and the majority of the East Butte IU. Other areas with surface water supplies also exist within the County as shown in Figure 4.13. The figure shows the water source for irrigation based on DWR's 2011 land and water use survey for Butte County. In addition to areas with access to surface water for irrigation, areas reliant on groundwater or a mix of groundwater and surface water are also shown.

4.2.6 Diversions

Surface water diversions to meet demands for irrigated agriculture, wetlands, and developed lands are summarized in this section. Primary surface streams providing water supplies in Butte County include the Feather River and Butte Creek. Water is also diverted from the Sacramento River and other, minor sources[14]. The vast majority of these diversions occur within the valley floor IUs, although Paradise Irrigation District also diverts water for domestic and M&I use within its service area. Recent historical diversions are summarized for the County as a whole and for each valley floor IU.

Diversions are subject to limitations based on diversion agreement terms (e.g. settlement contracts between DWR and Western Canal Water District and the Joint Districts) and regulatory actions of the State Water Resources Control Board (SWRCB). SWRCB regulatory actions to curtail diversions may apply to senior pre-1914 and riparian water rights in periods of drought.

Butte County

Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.14. Total surface water diversions during this period ranged from 742,600 af to 906,800 af with an average of 827,900 af. Feather River diversions ranged from 629,900 af to 778,600 af during this period with an average of 696,600 af. Butte Creek diversions ranged from 24,400 af to 71,600 af with an average of 54,700 af. Sacramento River diversions ranged from 2,400 af to 18,300 af with an average of 8,400 af. Other diversions ranged from 49,400 af to 58,800 af with an average of 54,600 af.

The primary destination of diverted surface water in Butte County is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.15. Deliveries ranged from 635,300 af to 777,100 af with an average of 709,200 af. Losses to seepage, spillage, and evaporation averaged 55,200 af, 58,800 af, and 4,700 af, respectively.

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[14] Other sources include miscellaneous riparian diversions and surface water supplies. These include diversions from the Feather River watershed other than the Feather River Settlement Contractors (e.g., South Feather Water and Power) and the Cherokee Canal.

Annual diversions were substantially less in 2015 than during the 2000-2014 period due to curtailments of Feather River, Butte Creek, and Sacramento River supplies. Estimated diversions during 2015, considered provisional at the time of preparation of this report, are included in Appendix D.

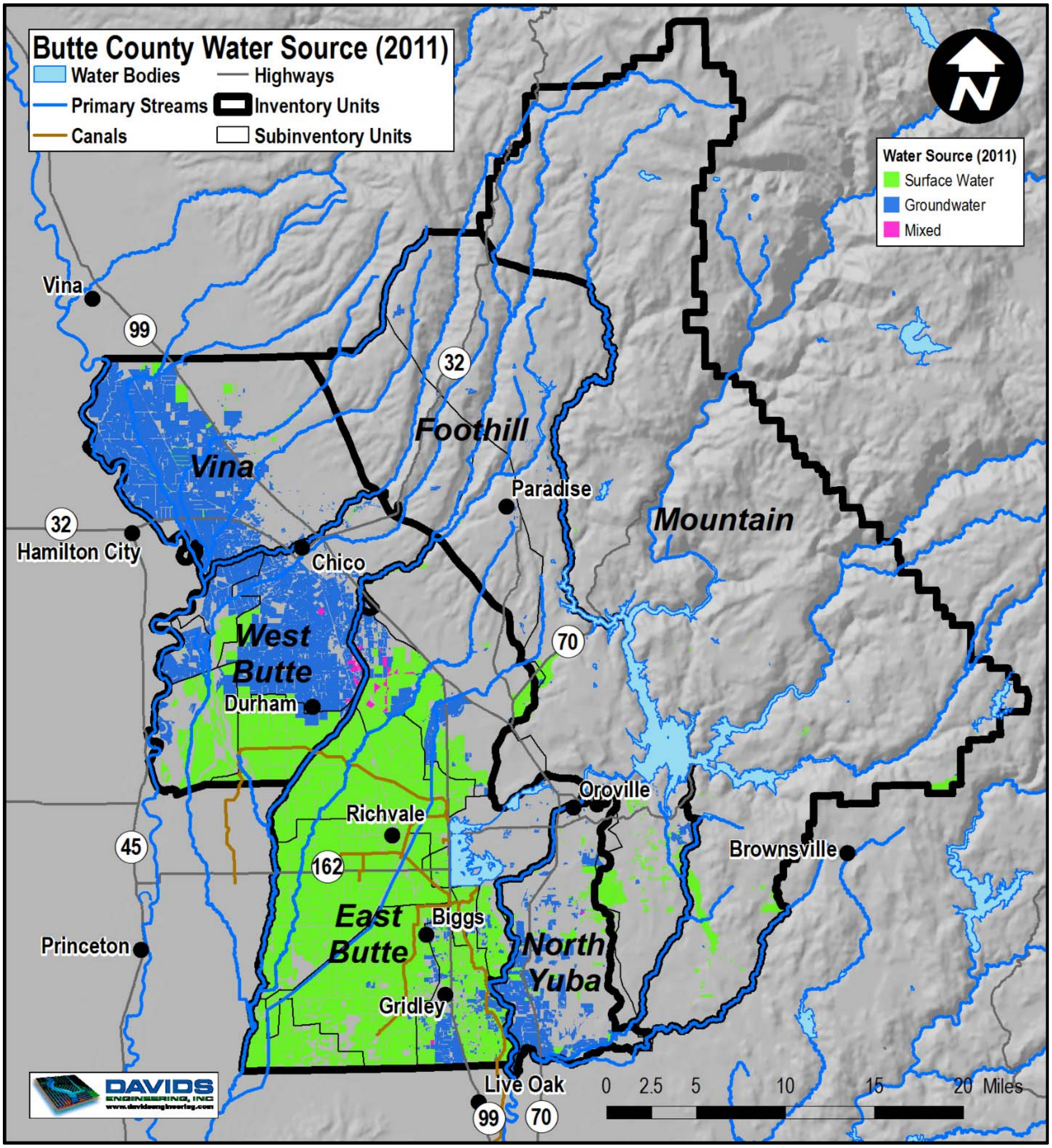

Figure 4.13. Butte County Irrigation Water Source, 2011 (Source: DWR).

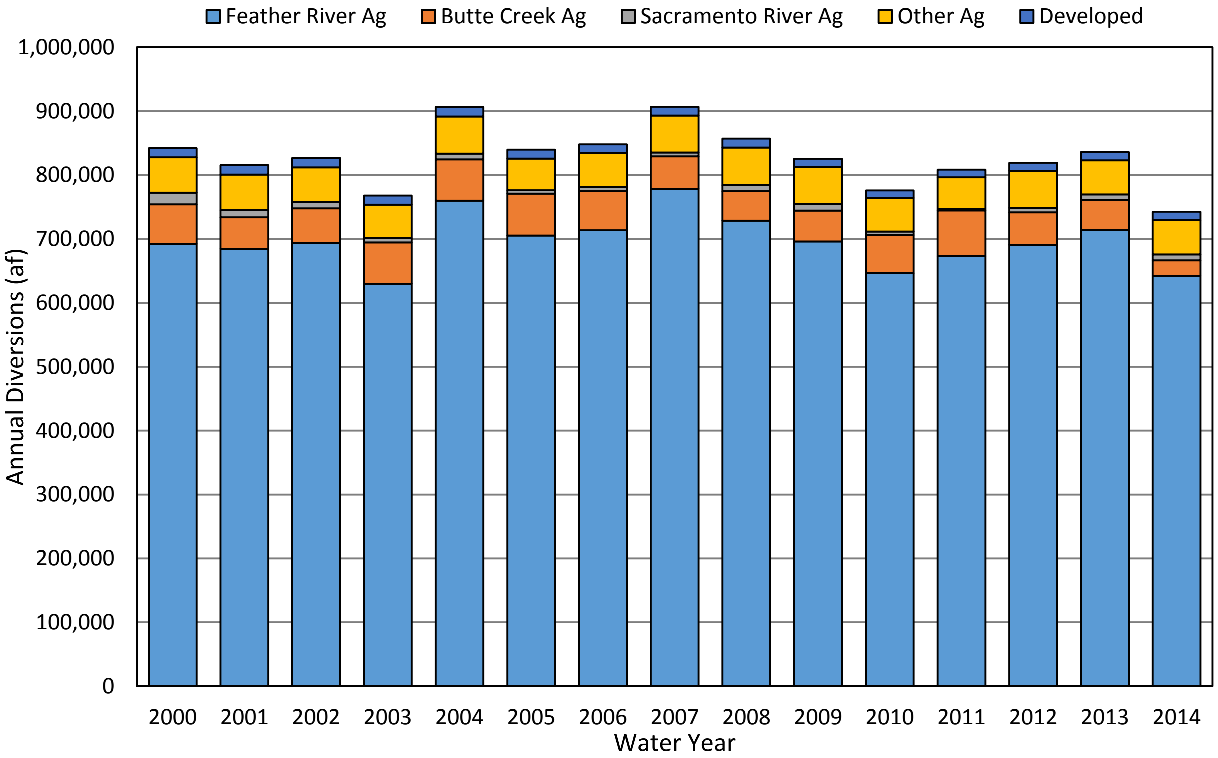

Figure 4.14. Butte County Estimated Surface Water Diversions by Source, 2000-2014.

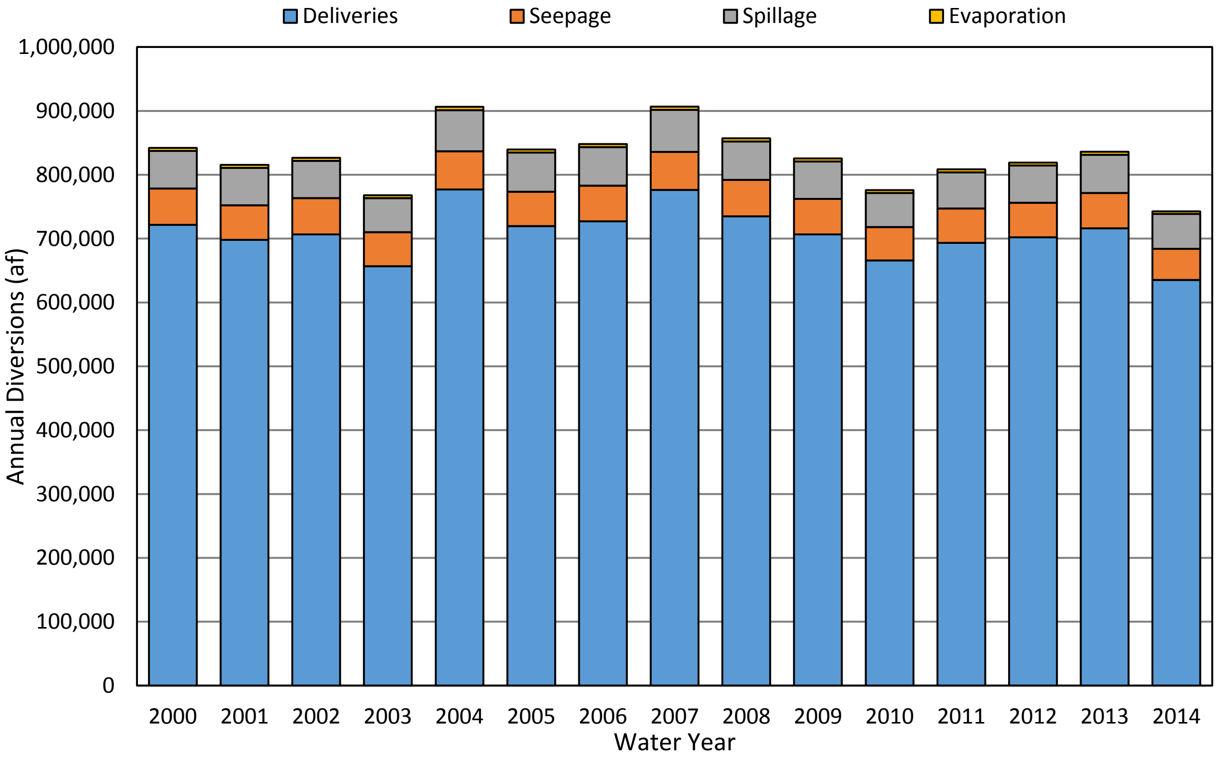

Figure 4.15. Butte County Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

Vina Inventory Unit

Surface water diversions to meet demands within the Vina IU are limited to minor riparian diversions for irrigation. There are no surface water diversions for domestic or municipal and industrial (M&I) use in Vina. Estimated annual diversions for water years 2000 to 2014 from the Sacramento River are presented in Figure 4.16. Total surface water diversions during this period ranged from 9,400 af to 12,400 af with an average of 11,000 af.

The primary destination of diverted surface water in the Vina IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.17. Deliveries ranged from 6,700 af to 8,900 af with an average of 7,900 af. Losses to seepage, spillage, and evaporation averaged 2,000 af, 800 af, and 300 af, respectively.

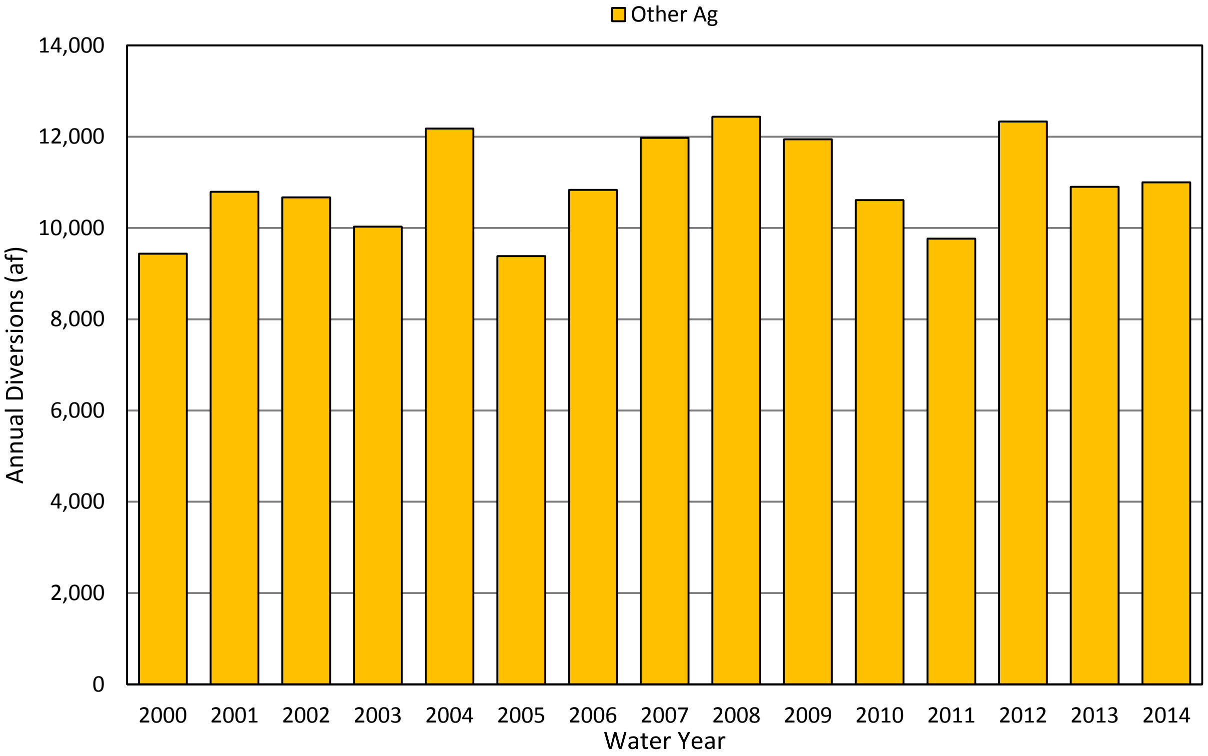

Figure 4.16. Vina Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

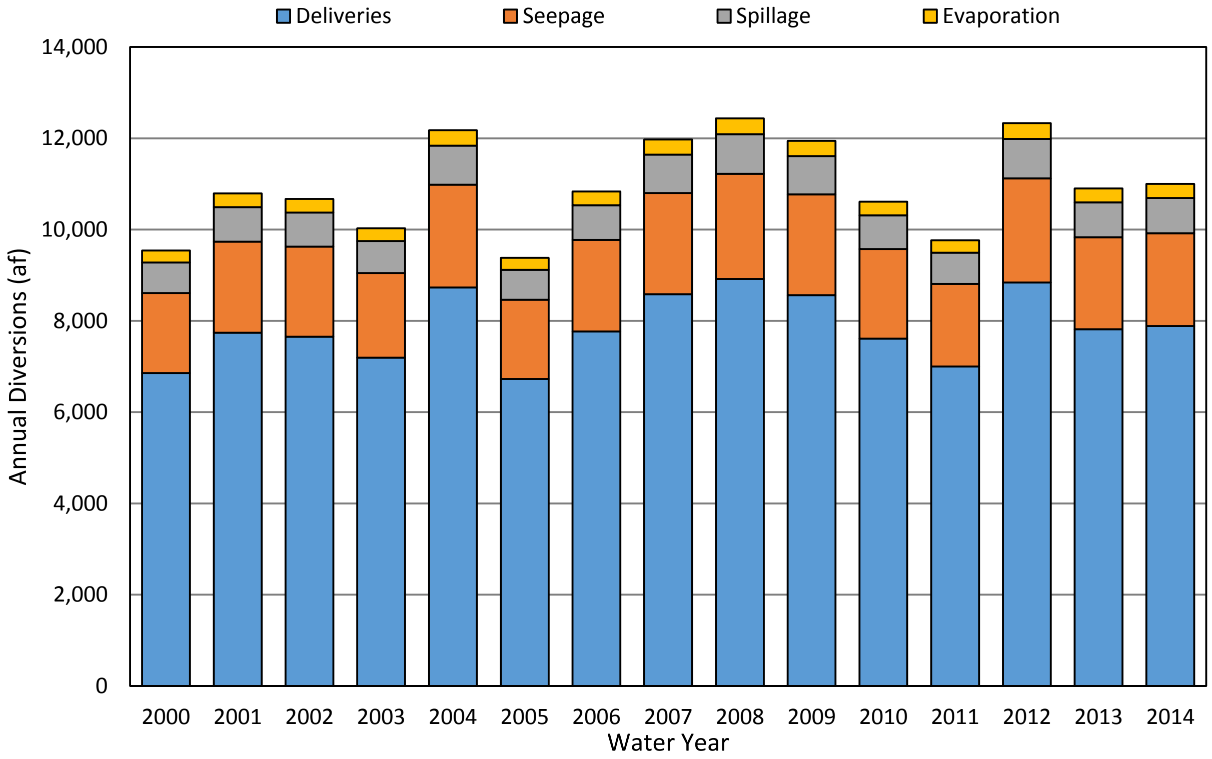

Figure 4.17. Vina Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

West Butte Inventory Unit

Surface water diversions to meet demands within the West Butte IU include diversions from the Feather River by Western Canal Water District; from Butte Creek by Dayton Mutual Water Company, Durham Mutual Water Company, Llano Seco Rancho, and M&T Chico Ranch; and from the Sacramento River by Llano Seco Rancho, M&T Chico Ranch, and riparian diverters in the Angel Slough SIU. M&T also has water rights to a small amount of water from Little Chico Creek. There are no surface water diversions for domestic or municipal and industrial (M&I) use in West Butte.

Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.18. Total surface water diversions during this period ranged from 92,500 af to 124,800 af with an average of 108,400 af. Feather River diversions ranged from 54,900 af to 70,700 af during this period with an average of 65,300 af. Butte Creek diversions ranged from 16,400 af to 41,800 af with an average of 34,700 af. Sacramento River diversions ranged from 2,400 af to 18,200 af with an average of 8,400 af.

The primary destination of diverted surface water in the West Butte IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.19. Deliveries ranged from 81,000 af to 101,300 af with an average of 94,400 af.

Losses to seepage, spillage, and evaporation averaged 8,300 af, 4,800 af, and 900 af, respectively.

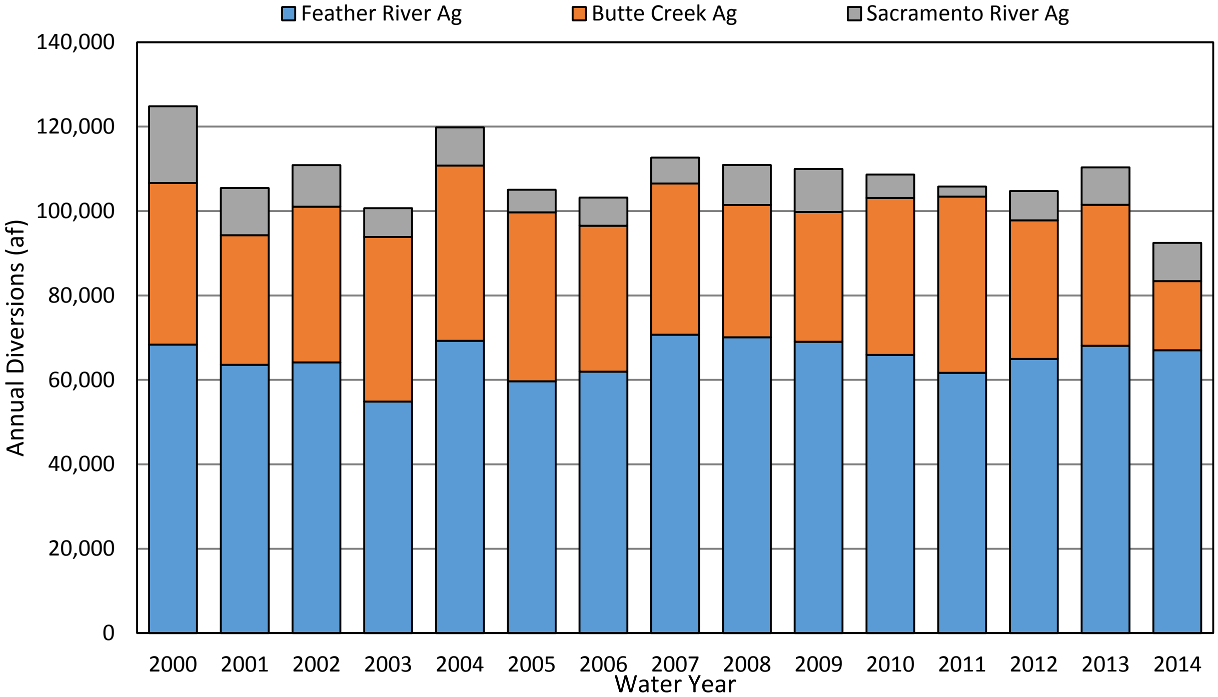

Figure 4.18. West Butte Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

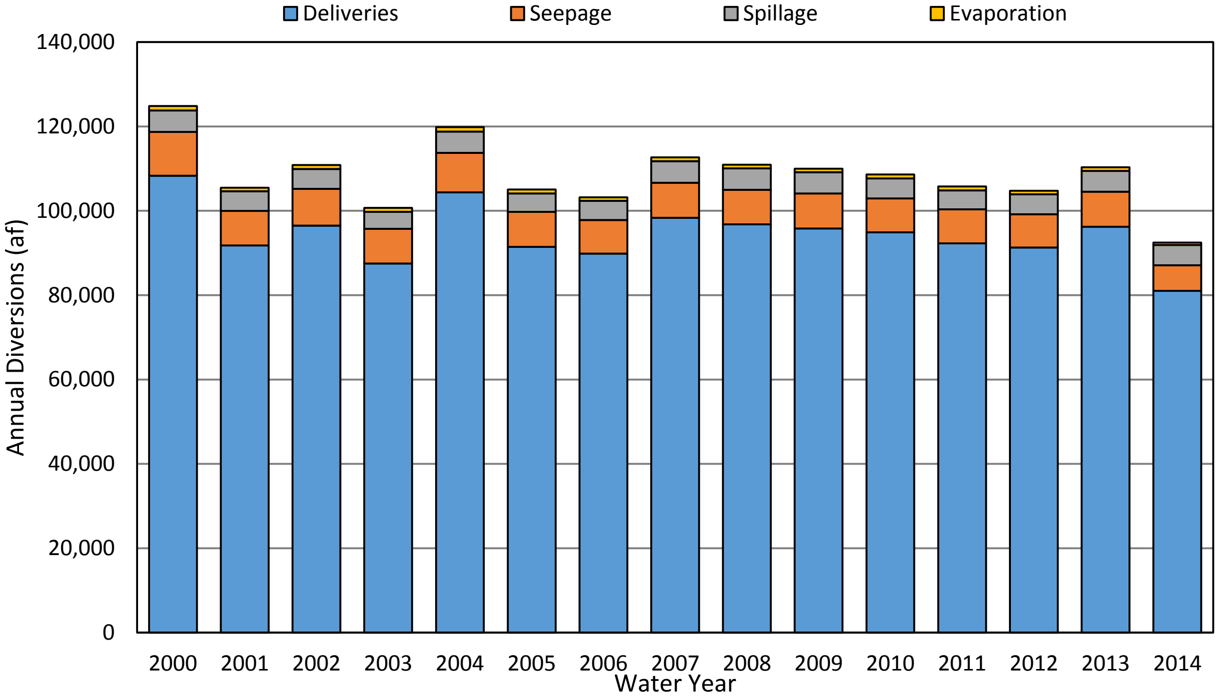

Figure 4.19. West Butte Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

East Butte Inventory Unit

Surface water diversions to meet demands within the East Butte IU include diversions from the Feather River by Western Canal Water District, Richvale Irrigation District, Biggs-West Gridley Water District, and Butte Water District; from Butte Creek by Durham Mutual Water Company, Rancho Esquon, and Western Canal Water District; and other diversions in the Cherokee, Thermalito, and Butte Sink subinventory units. In addition to diversions for irrigation and wetlands, these other diversions include water diverted by Thermalito Water and Sewer District for domestic and M&I use.

Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.20. Total surface water diversions during this period ranged from 617,000 af to 758,500 af with an average of 686,200 af. Feather River diversions ranged from 575,100 af to 707,900 af during this period with an average of 631,300 af. Butte Creek diversions ranged from 8,000 af to 29,800 af with an average of 20,000 af. Other diversions ranged from 30,100 af to 35,500 af with an average of 32,700 af.

The primary destination of diverted surface water in the East Butte IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.21. Deliveries ranged from 527,300 af to 649,100 af with an average of 587,700 af. Losses to seepage, spillage, and evaporation averaged 42,800 af, 52,500 af, and 3,200 af, respectively.

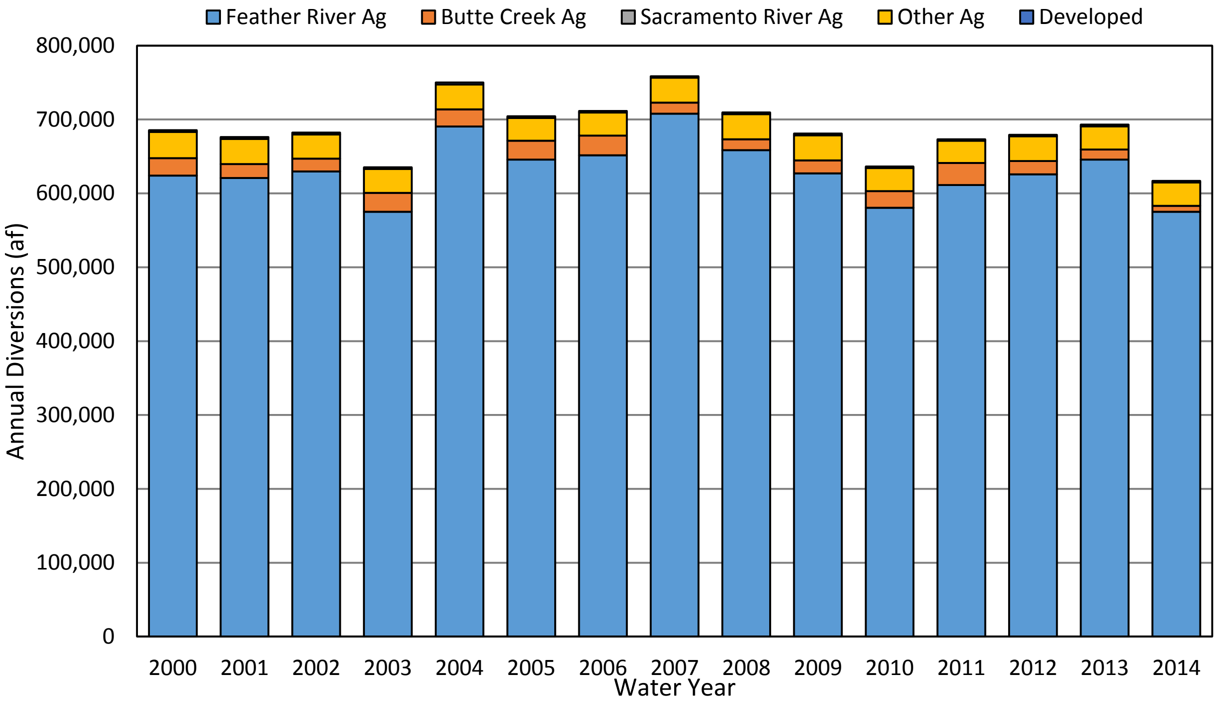

Figure 4.20. East Butte Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

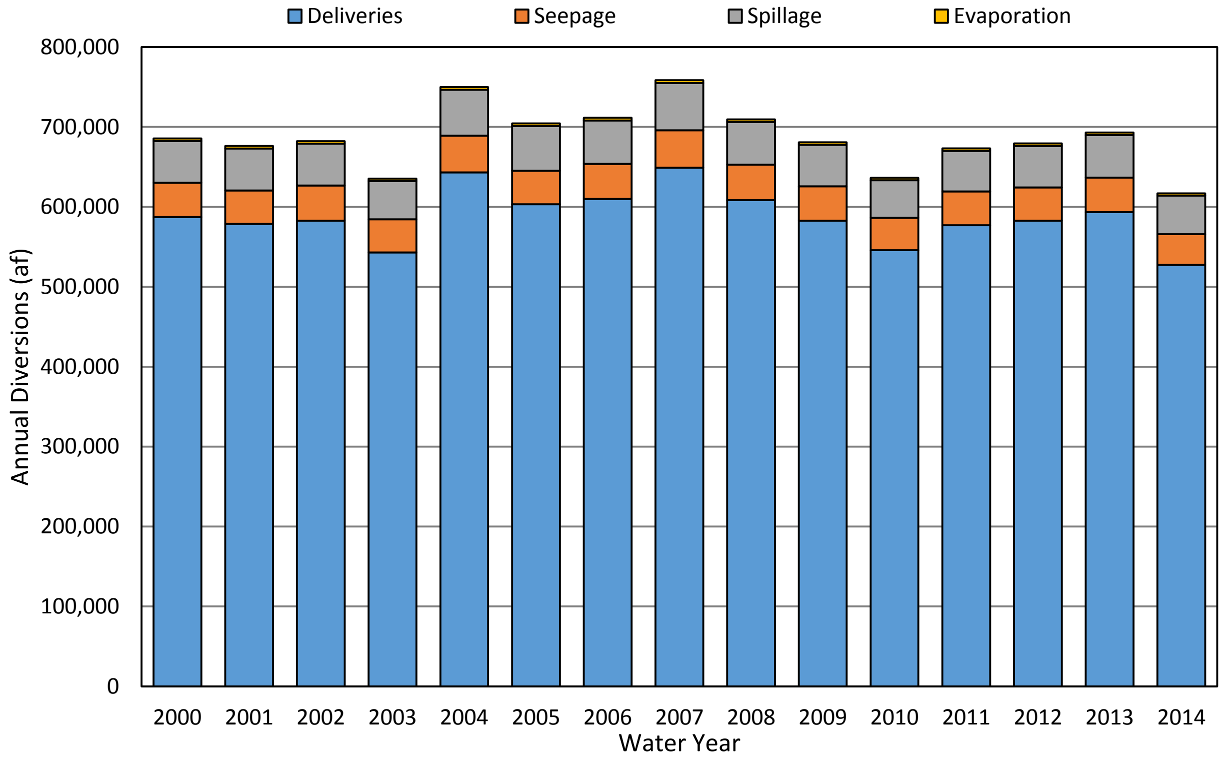

Figure 4.21. East Butte Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

North Yuba Inventory Unit

Surface water diversions to meet demands within the North Yuba IU include diversions by South Feather Water and Power Agency and CalWater Oroville. Diversions by South Feather are for irrigation and domestic and M&I use, while diversions by CalWater are exclusively for domestic and M&I use. Estimated annual diversions for water years 2000 to 2014 are presented in Figure 4.22. Total surface water diversions during this period ranged from 13,300 af to 16,200 af with an average of 14,900 af.

The primary destination of diverted surface water in the North Yuba IU is irrigation deliveries; however, some water is lost through conveyance to seepage, spillage, and evaporation. Estimated annual deliveries and conveyance losses between 2000 and 2014 are presented in Figure 4.23. Deliveries ranged from 10,600 af to 12,700 af with an average of 11,700 af. Losses to seepage, spillage, and evaporation averaged 2,000 af, 800 af, and 300 af, respectively.

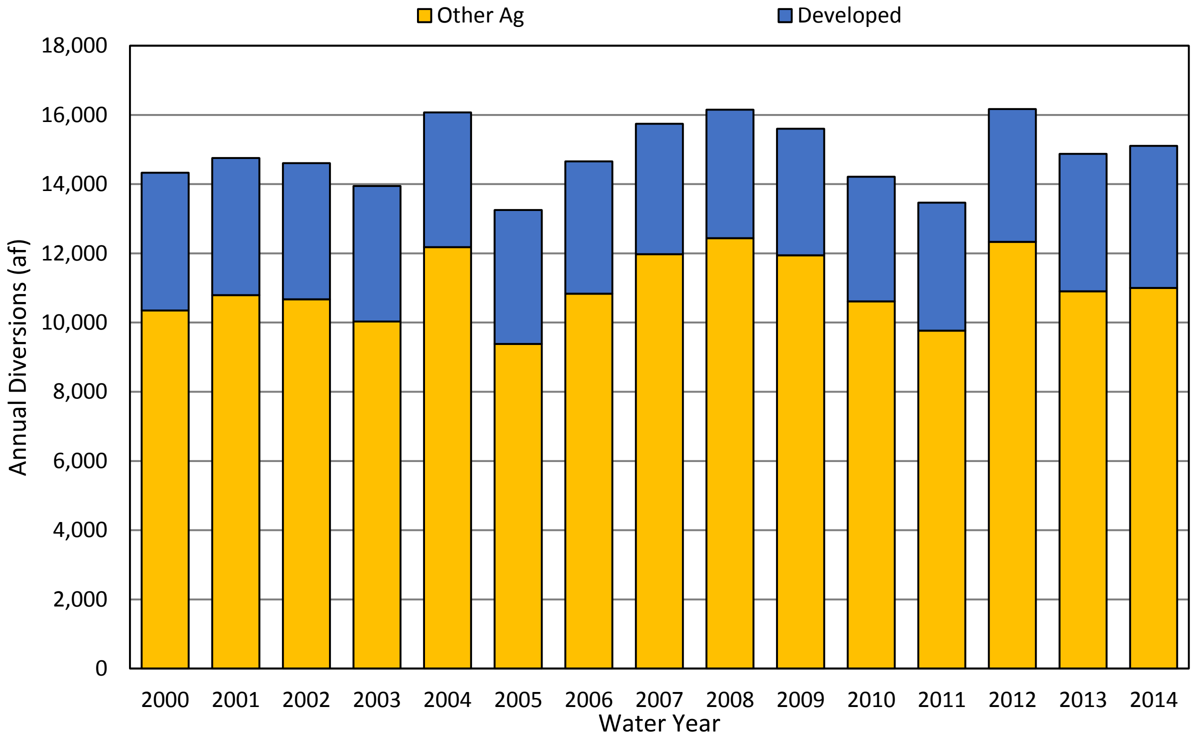

Figure 4.22. North Yuba Inventory Unit Estimated Surface Water Diversions by Source, 2000-2014.

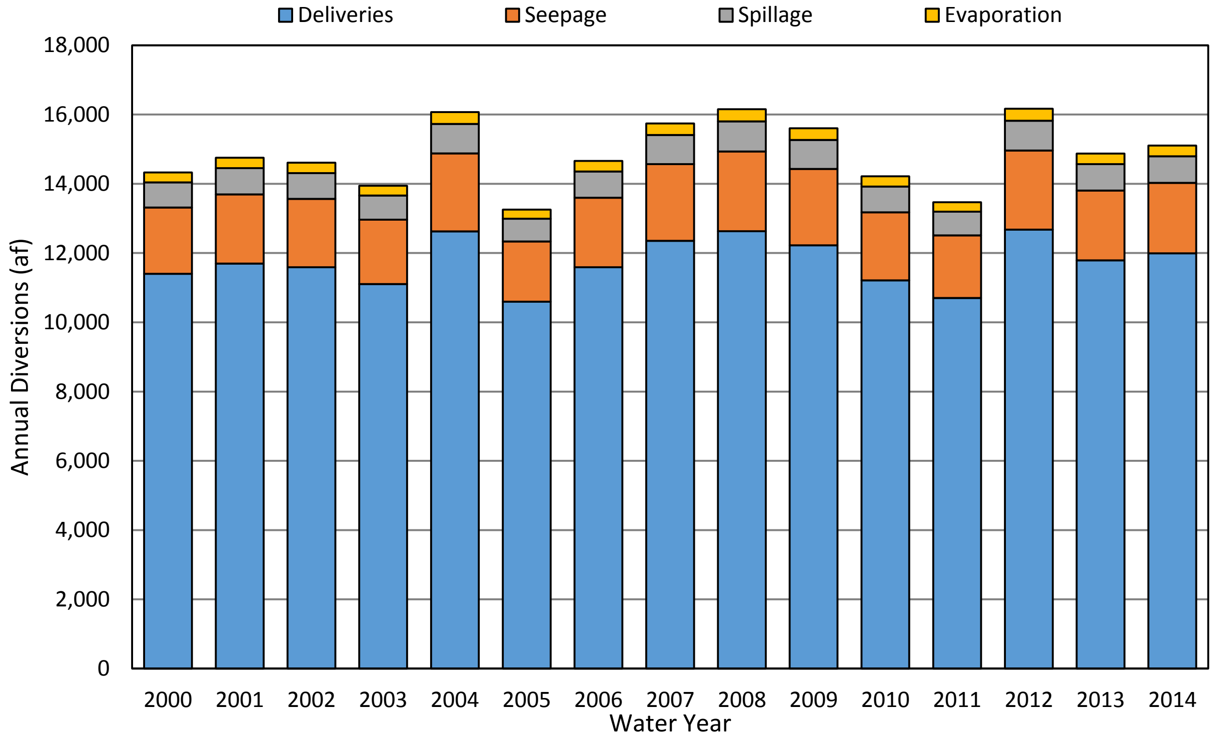

Figure 4.23. North Yuba Inventory Unit Estimated Surface Water Deliveries and Conveyance Losses, 2000-2014.

4.3 Groundwater Hydrology

This section provides a brief background on the hydrogeology of the County and the differences between the Valley and Foothill and Mountain aquifer systems. It then describes the groundwater conditions in the Butte County portions of Sacramento Valley groundwater subbasins (Vina, West Butte, East Butte and North Yuba inventory units) based on available groundwater level monitoring data and estimates of groundwater pumping. Finally, the distribution and number of wells in each inventory unit is provided and discussed.

Current groundwater level conditions are documented each year in the Annual Groundwater Status Report, available on the Department's webpage (www.buttecounty.net/waterresourceconservation/GroundwaterStatusReports).

4.3.1 Hydrogeology

Other reports have detailed the hydrogeology of the Sacramento Valley and the formations making up the aquifer systems in Butte County. These reports by the Department of Water Resources include the *Geology of the Northern Sacramento Valley, 2014 (DWR 2014)*, the *Butte County Groundwater Inventory Analysis, 2005 (DWR 2005)*, and the Butte County *Lower Tuscan Aquifer Monitoring, Recharge, and Data Management Project final report, 2013 (Brown and Caldwell 2013)*. Included below is a brief overview of the local hydrogeology.

Butte County hydrogeology is generally characterized by two different types of groundwater systems. In the Foothill and Mountain inventory units (IUs), fractured rock aquifers provide variable amounts of water primarily to domestic wells. In fractured rock, water fills the space between cracks and fractures in the rock and therefore the degree of fracturing and the extent to which those fractures are connected highly influences potential well production. Conditions are highly variable, and water levels or production of a well in one location does not necessarily provide information on what conditions may be in another well, even if it is nearby. Therefore, groundwater level monitoring is not conducted in the fractured rock areas of the county.

In the Foothill region, groundwater occurs in the fractures and joints of the Tuscan Formation volcanic mudflows, as well as in the weathered horizons between buried mudflows. 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. The Tuscan Formation is also found in the Mountain Region but it is tightly cemented and consolidated and supplies only limited amounts of water. Where groundwater does occur, it is limited to the fractures and joints within the volcanic mudflows and breccias (DWR 2005).

Wells in fractured rock in the Foothill and Mountain regions are at greatest risk of producing less water or "going dry" from year to year and especially during drought and dry periods. During the drought period beginning in 2012, the County received a number of reports of wells in the Cohasset, Forest Ranch, and other foothill areas having problems or no longer supplying water for domestic use. Wells that historically experienced water supply reliability problems in the fall from year to year, began having problems earlier in the year in the spring or summer.

The majority of Butte County's groundwater resources come from the Sacramento Valley Region where spaces between gravel, sand, and clay particles of various formations store and transmit water in the aquifer systems. Principal hydrogeologic units of the Sacramento Valley groundwater basin consist of Pliocene sedimentary deposits, such as the Tuscan, Laguna, and Tehama formations, and Quaternary terrace deposits, such as the Riverbank and Modesto formations. Aquifer systems composed of Tuscan, Laguna, and Tehama formations are the source of water for deep irrigation and municipal wells, while the Riverbank and Modesto formations yield water to the shallower domestic wells (DWR 2005).

A notable feature within West and East Butte inventory units is the Butte Basin. This area lies south of Chico and west of the Feather River. Characterized by an expansive, flat topography, the Butte Basin was, prior to flood control on the Feather and Sacramento rivers, an area of extensive seasonal flooding. This slow-moving floodwater deposited the fine clay that now provides the rich agricultural soil used primarily for rice production (DWR 2005). In this area, groundwater mounds up on the north side of the Sutter Buttes before it flows westward around the Buttes and between the buried Colusa dome and southward (DWR, 2014).

The 2014 and 2005 DWR reports (DWR 2014 and DWR 2005) provide more details on Sacramento Valley geology and individual geologic formations and structure. DWR has developed geologic cross sections of the region which are included in the 2014 DWR report along with maps of surficial geology. Other research by Dr. Todd Greene at California State University, Chico is exploring and mapping the hydrostratigraphy of the Lower Tuscan and Tehama Aquifer (Greene and Hoover 2014). Better understanding the hydrogeology, aquifer dynamics, and recharge paths of the aquifer systems in Butte County and the Northern Sacramento Valley region is an area of active research by Butte County, DWR, and others.

4.3.2 Valley Floor Groundwater Conditions

This section describes the general directions of groundwater flow in the County and trends in groundwater levels and groundwater pumping in each inventory unit. The purpose of this section is to provide an overview of groundwater conditions to provide context for the water budgets provided in Section 5.

Groundwater levels are monitored through a cooperative agreement between DWR and Butte County and provide the basis for the groundwater contour map, change in groundwater level map, and hydrographs from specific wells included in this section.

Groundwater Movement

The overall pattern of groundwater movement in Butte County during spring is southwesterly toward the Sacramento River. The direction of groundwater movement is illustrated in Figure 4.24 by a series of small arrows perpendicular to the groundwater elevation contours. These contours are created from water level measurements collected from wells during the spring of 2012. Water level measurements are filtered based on well construction information (when available) and are intended to approximate groundwater elevations in the unconfined to uppermost semi-confined portions of the aquifer.

Locally, the movement of groundwater varies. Isolated areas of groundwater depression are located in the City of Chico resulting from year-round pumping of groundwater for municipal use. South of Chico in the vicinity of Durham, where agricultural pumping is greatest, a cone of depression has formed causing water to move toward that area. South of there, the southwesterly pattern of movement resumes with a generally uniform gradient through the southwestern portion of the county where surface water is mainly used for irrigation and groundwater levels tend to be stable. Another small depression is located in the southeast portion of the basin.

An interesting flow pattern is also present in the southwestern corner of the East Butte Inventory Unit. The valley sediments deformed by the intrusion of the Sutter Buttes and the buried Colusa Dome, west of the Sutter Buttes, partially control groundwater flow in this area. 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, shallow gradient (indicated by contours that are farther apart), and the formation of wetlands along the west side of the Sutter Buttes.

Direction of movement can vary from year to year. During drought years when groundwater use increases, areas of groundwater depression can be exacerbated.

Groundwater Level Change

Groundwater level change maps produced by DWR Northern Region Office (NRO) provide a snapshot of how groundwater conditions have changed over time. Figure 4.25 shows the difference between measured water levels in the spring of 2004 and the spring of 2015 for the main pumping zone of the aquifer system, wells 100-450 feet deep. This maps shows the areas of greatest decline to be in the Vina and West Butte inventory units, where groundwater demand to meet urban and agricultural demands is greatest. In contrast, it highlights the relatively stable groundwater conditions in the southern portion of the County mostly corresponding to surface water irrigated agriculture.

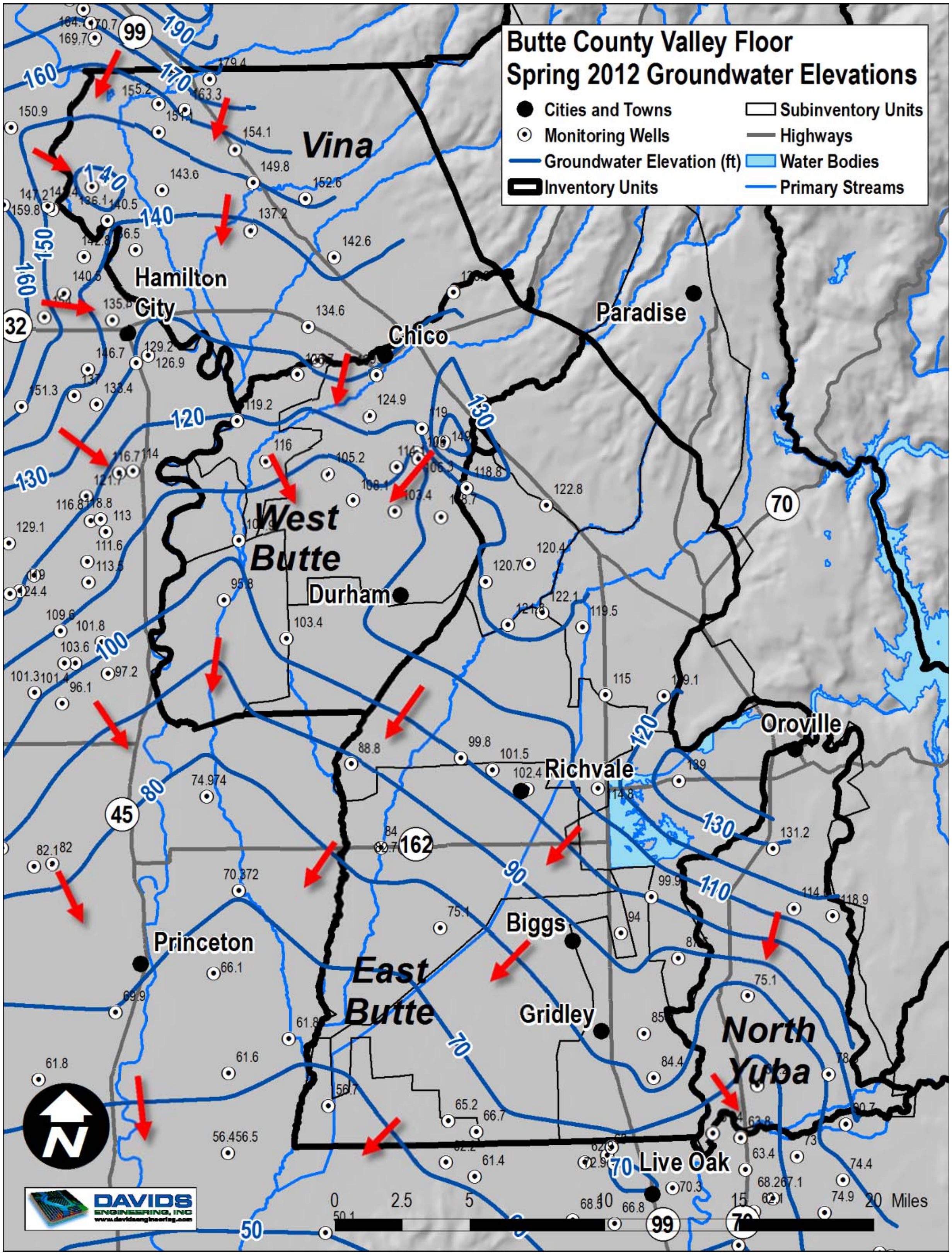

Figure 4.24. Spring 2012 Groundwater Elevations, with Flow Direction Indicated by Red Arrows (Source: DWR Groundwater Information Center).

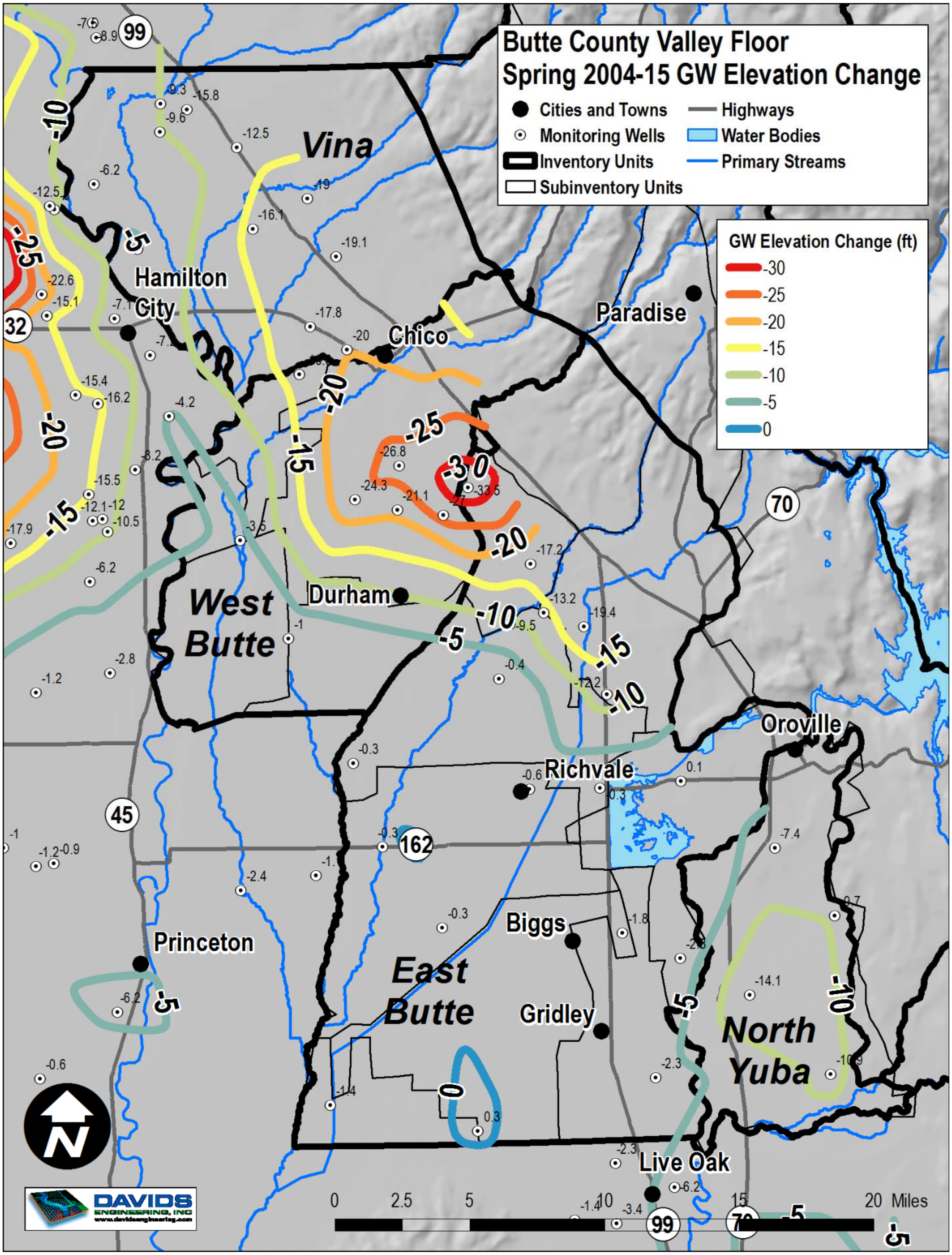

Figure 4.25. Groundwater Elevation Change, Spring 2004 to 2015 for Wells 100-450 feet Deep.

Groundwater Levels

Within the Butte County portion of the Sacramento Valley groundwater basin, groundwater level monitoring is conducted by a cooperative effort between Butte County and DWR NRO. Water levels are monitored in a network of approximately 140 wells in March, July, August, and October. The number of wells and type are summarized for these wells in Table 4.2, and the well locations are shown in Figure 4.26. A list of individual monitoring wells is provided in Appendix B.

Due to recent drought conditions, water levels were measured monthly from March through October in 2014, 2015, and 2016. A number of these wells are multi-completion dedicated monitoring wells and the rest are agricultural or domestic wells. These data provides information on groundwater storage conditions and water level trends dating back to the late 1940s in some cases and are available online from the state's Water Data Library (http://www.water.ca.gov/waterdatalibrary/). In addition, California Water Service Chico and Oroville districts provide spring and fall groundwater level data for a selection of their wells for inclusion in annual County reporting (see Appendix G of the County's Groundwater Status Report).

Groundwater level conditions are described in each Inventory Unit in the following sections.

Table 4.2. Number of Butte County Monitoring Wells by Inventory Unit and Well Type.

	Monitoring Well Count					
Inventory Unit	**Irrigation**	**Observation**	**Residential**	**Stockwatering**	**Other**	**Total**
Vina	9	15	6	0	0	30
West Butte	20	17	4	1	0	42
East Butte	14	30	12	0	4	60
North Yuba	5	0	2	0	1	8
Totals	48	62	24	1	5	140

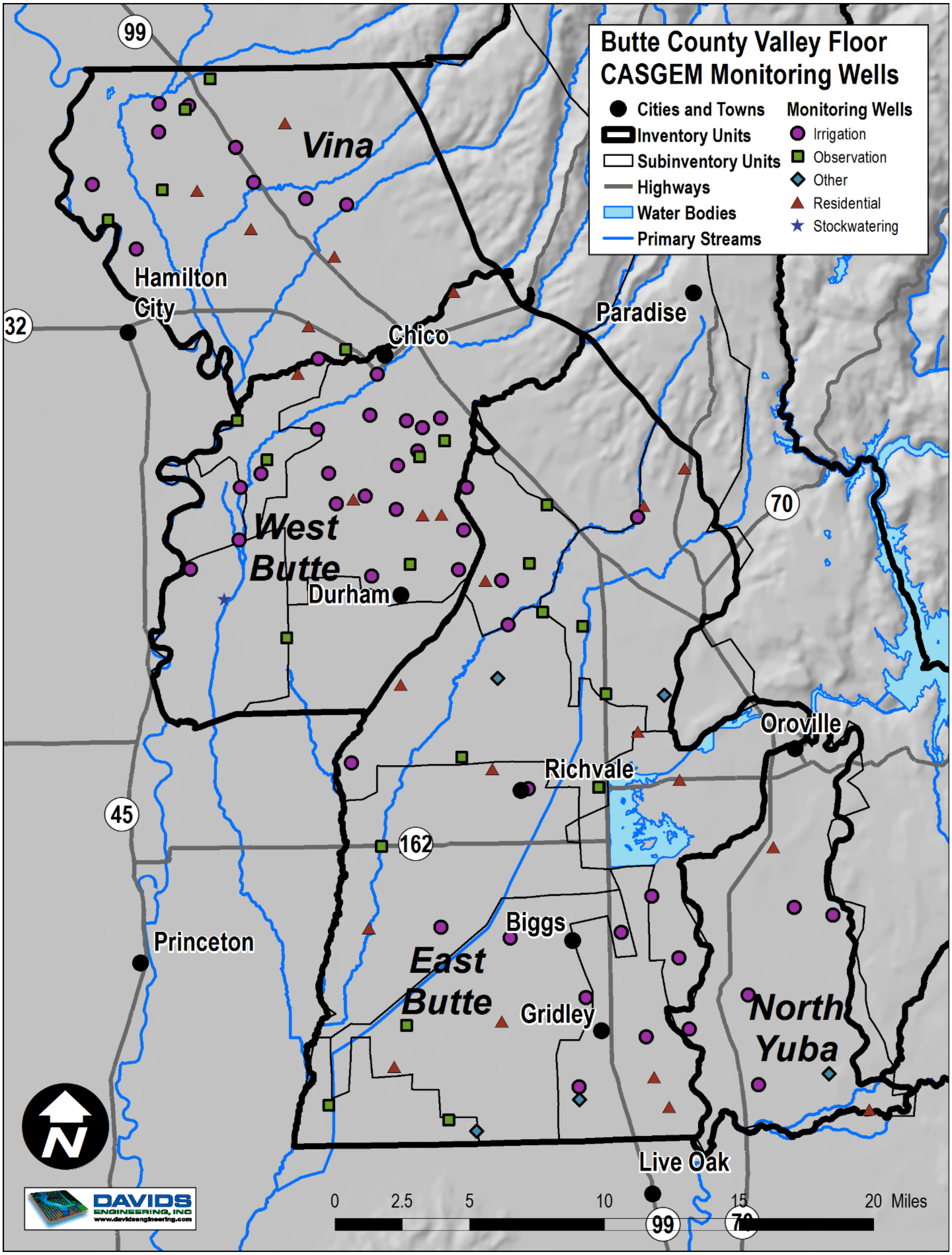

Figure 4.26. Butte County Monitoring Wells.

Vina Inventory Unit

The Vina Subbasin (5-21.57) covers about 75,000 acres in the northern portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by Tehama County to the north, Big Chico Creek to the south, the Sacramento River to the west, and the foothills to the east. The Vina aquifer system includes stream channel and alluvial fan deposits, and deposits of the Modesto and Tuscan formations.

The Vina inventory unit has a network of about 30 monitoring wells. A number of these wells are multi-completion dedicated monitoring wells and the rest are agricultural or household wells. This data provides information on groundwater storage conditions and water level trends dating back to the late 1950s in some cases. In addition, the CalWater Service area covers a portion of the inventory unit and Cal Water-Chico provides spring and fall groundwater level data for seven of their wells for inclusion in annual County reporting.

Groundwater serves as the sole source of agricultural irrigation water for the vast majority of the Vina inventory unit, as shown in the map of irrigation water source from DWR land use surveys (Figure 4.13). Groundwater levels have been declining on the order of 1-2 feet per year for the past 10 years, with the exception of a couple of wet years that occurred during that time (namely 2006 and 2011). This has resulted in declines in groundwater levels in the primary pumping zone (100-450 feet below ground surface) of up to 15-20 feet (Figure 4.25). Declines are greatest in the Chico area and toward the eastern side of the inventory unit. A significant portion of these water level declines has occurred over the past four years of severe drought, about 7-16 feet. Groundwater levels are closer to the ground surface in the western part of the inventory unit near the Sacramento River.

A number of monitoring wells with long periods of record are reaching new historical lows. These wells tend to be shallow (<200 feet) domestic wells, however irrigation wells have reportedly experienced reduced pressure, production, or water supply reliability problems in recent years as well. Figure 4.27 shows groundwater levels from a shallow domestic well near the center of the inventory unit, 23N01W36P001M. The hydrograph shows trends in groundwater levels since 1959 with declines during previous drought periods and recently declining spring levels on the order of 16 feet from 2004 to 2015.

Hydrographs for all BMO wells in the Vina inventory unit can be viewed in the BMO reports for Vina and the Chico Urban Area found in Appendix G of the Groundwater Status Report.

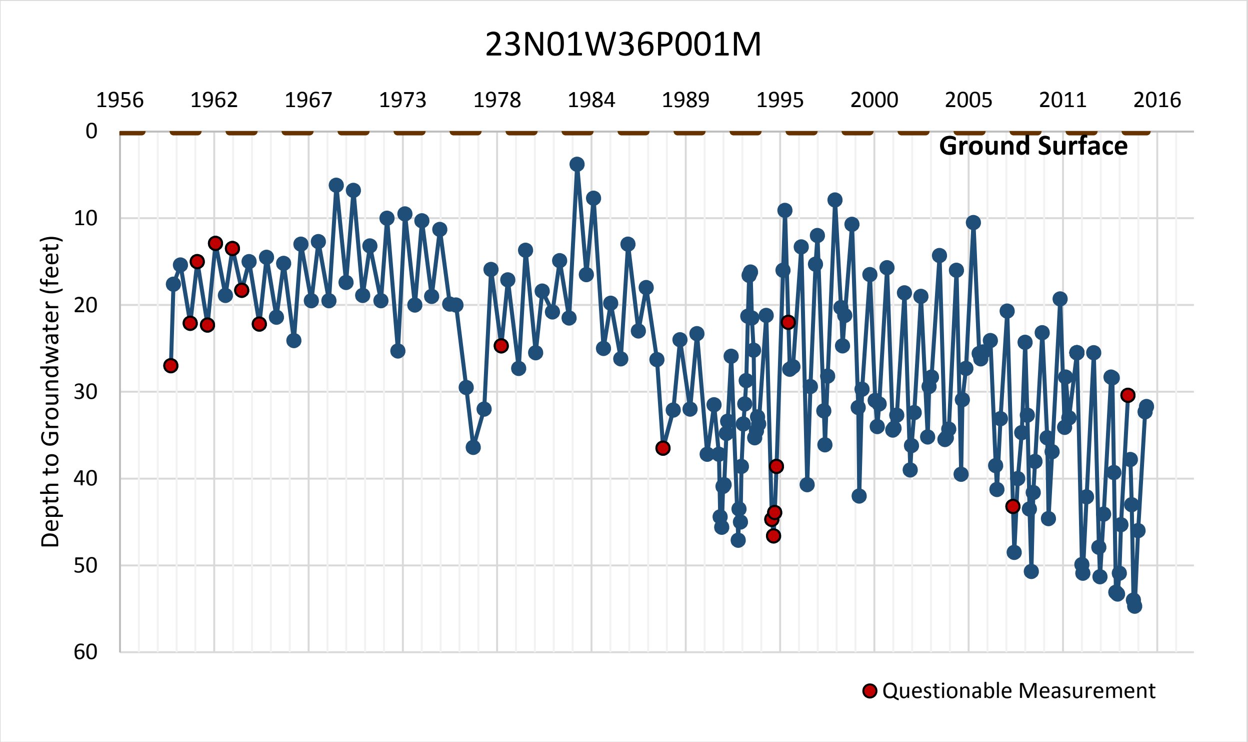

Figure 4.27. Monitoring Well 23N01W36P001M Hydrograph.

West Butte Inventory Unit

The West Butte Subbasin (5-21.58) covers about 86,500 acres in the north-central portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by Big Chico Creek to the north, Butte Creek to the south, the Sacramento River to the west and the foothills to the east. The West Butte aquifer system includes stream channel deposits, basin deposits, Sutter Buttes alluvium, and deposits of the Modesto, Riverbank, Tuscan and Tehama formations (DWR 2005).

The West Butte inventory unit has 42 wells monitored by the County and DWR. In addition, Cal Water-Chico is partially located in the northern portion of the inventory unit and also provides groundwater level data for seven of their production wells.

In groundwater dependent areas of this inventory unit, groundwater levels have larger variations within an irrigation season and between years than in surface water irrigated areas where groundwater levels are relatively stable. Groundwater serves as the sole source of agricultural irrigation water for a large area of the West Butte inventory unit, as shown in the map of irrigation water source from DWR land use surveys (Figure 4.13). The greatest groundwater level declines in the County have occurred in the Durham area south of Chico. Groundwater levels declined on the order of a couple of feet per year for the past 10 years, except in a couple of wet years that occurred during this time (namely 2006 and 2011). This has resulted in declines in groundwater levels in the primary pumping zone (100-450 feet below ground surface) of up to 33.5 feet from 2004 to 2015 (Figure 4.25). A significant portion of these water level declines occurred over the past four years of severe drought, about 8-15 feet.

A number of monitoring wells with long periods of record are reaching new historical lows. These wells tend to be shallow (<200 feet) domestic or irrigation wells. Wells in this inventory unit have reportedly experienced reduced pressure, production and water supply reliability problems in recent years. This results in lowering pumps within the well, construction of new wells, or deepening existing wells. Figure 4.28 shows groundwater levels from a shallow domestic well near the center of the groundwater dependent area, 21N01E27D001M. The hydrograph shows trends in groundwater levels since 1946 with declines during previous drought periods, recovery during extended wet periods, and recently declining spring levels on the order of 24 feet from 2004 to 2015. Shallow domestic wells surrounded by groundwater dependent irrigated agriculture are especially vulnerable to going dry as water levels drop during the irrigation season.

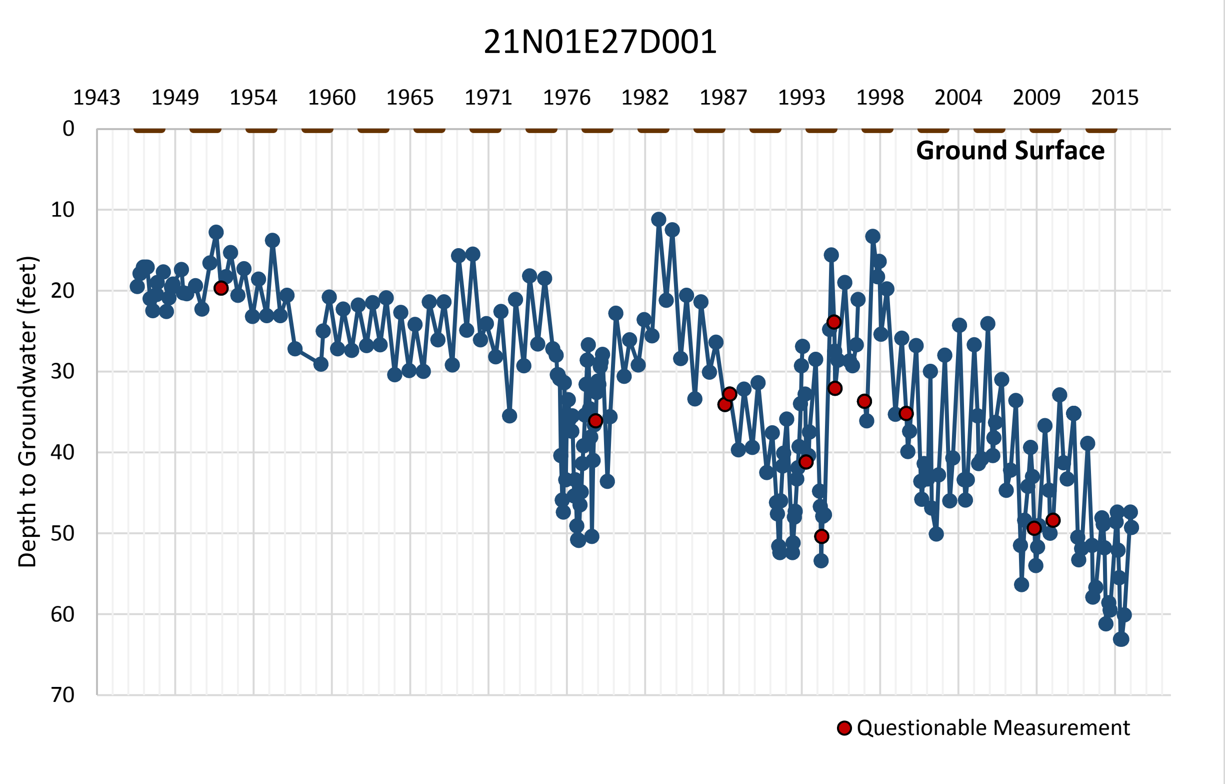

Figure 4.28. Monitoring Well 21N01E27D001M Hydrograph.

Adjacent to these groundwater dependent agricultural areas (i.e. Durham-Dayton) are surface water irrigated lands primarily growing rice (i.e. Western Canal). With rare use of groundwater, these areas have more stable groundwater level conditions and shallower groundwater. Spring levels have remained relatively the same from 2004 to 2015 in the primary pumping zone (100-450 foot deep wells), with declines on the order of only 0.3 to 1.5 feet (Figure 4.25). Figure 4.29 shows groundwater levels in a dedicated multi-completion monitoring well, 20N01E18L003M, on 7 Mile Lane that shows conditions in the shallow portion of the aquifer system (screening interval 100-110 feet). Water levels are within eight feet of the ground surface and vary only a few feet within the year and very little from year to year. In recent years, orchards have replaced rice acreage on the margins of these surface water irrigated areas. Often, a water source change from surface water to groundwater is associated with this land use change. Groundwater levels have begun to respond with greater seasonal variation and moderate declines from one year to the next in recent years in these areas.

Hydrographs for all BMO wells in the West Butte inventory unit can be viewed in the BMO reports for the Chico Urban Area, Durham Dayton, M&T, Angel Slough, Llano Seco, and Western Canal subregions found in Appendix G of the Groundwater Status Report.

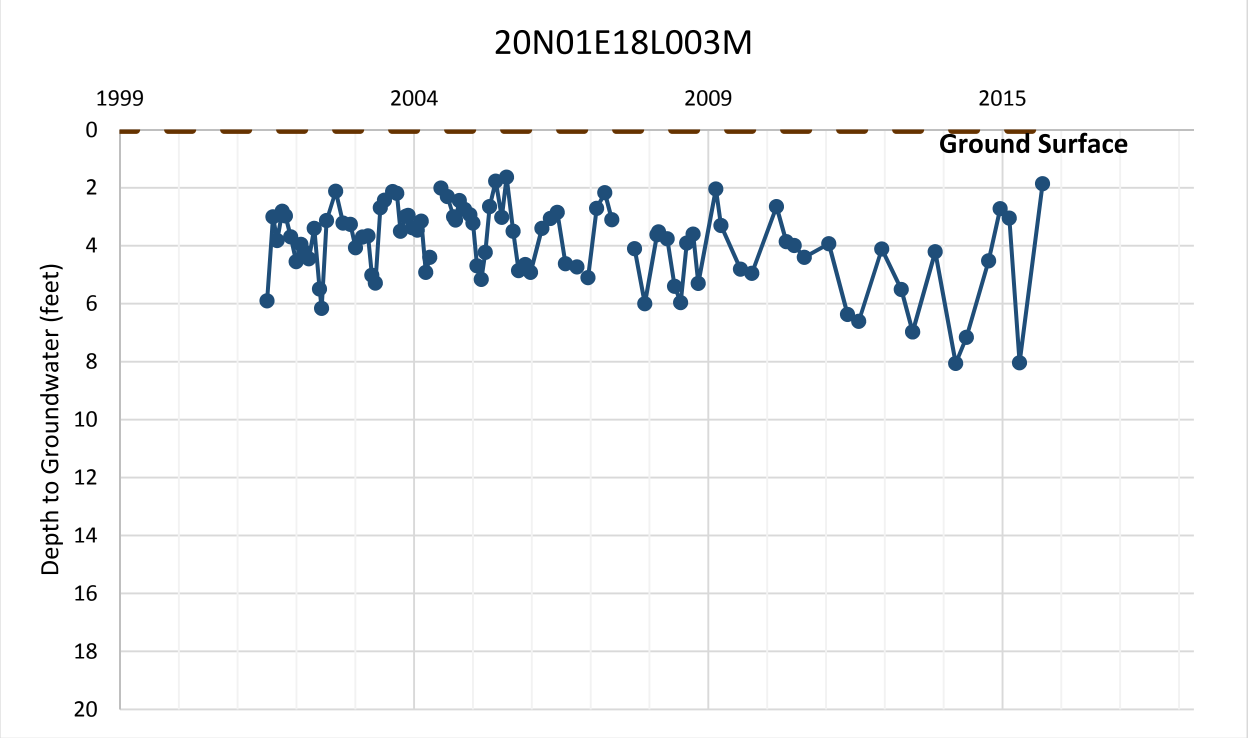

Figure 4.29. Monitoring Well 20N01E18L003M Hydrograph.

East Butte Inventory Unit

The East Butte Subbasin (5-21.59) covers about 188,700 acres in the south-central valley portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by Butte Creek to the north and west, the Butte County line to the south, foothills to the northeast, and the Feather River to the southeast. The East Butte aquifer system includes stream channel deposits, basin deposits, Sutter Buttes alluvium, and deposits of the Modesto, Riverbank, Tuscan and Laguna formations.

Groundwater levels are monitored in a network of over 60 wells in the East Butte inventory unit. This data provides information on groundwater storage conditions and water level trends dating back to the 1940s in some cases. In the groundwater dependent areas in the northeast portion of the East Butte inventory unit (Figure 4.13), groundwater levels have declined on the order of 1-2 feet per year for the past 10 years, with the exception of a couple of wet years that occurred during that time (namely 2006 and 2011). This has resulted in declines in groundwater levels in the primary pumping zone (100-450 feet below ground surface) of up to 15-20 feet in the East Butte inventory unit and up to 30-35 feet in the adjacent West Butte inventory unit since 2004 (Figure 4.25). A significant portion of these water level declines has occurred over the past four years of severe drought, about 7-14 feet.

Figure 4.30 shows groundwater levels from a dedicated monitoring well, 20N02E24C001M, in the Cherokee Strip area of the East Butte inventory unit. This area is groundwater dependent and primarily produces orchard crops. The hydrograph shows trends in groundwater levels since 2000 with declining spring levels on the order of 19 feet from 2004 to 2015.

Adjacent to these groundwater dependent agricultural areas are surface water irrigated lands primarily growing rice. With rare use of groundwater, these areas have stable groundwater level conditions. Depth to water is shallow (typically less than 5-10 feet) and spring 2015 groundwater levels are within three feet of their 2004 spring levels (Figure 4.25). Figure 4.31 shows a hydrograph for monitoring well 18N02E16F001M located near the center of the inventory unit in the Biggs-West Gridley irrigation district. Groundwater levels in this shallow irrigation well vary only a couple of feet within the year and are generally within 10 feet of the ground surface. Although groundwater is rarely pumped for irrigation in most of the water district areas, groundwater serves as an important water supply buffer in times of drought as experienced in 2015 when the surface water districts within the County received water supply cutbacks for the first time in 23 years.

Areas with long term declining groundwater levels in Butte County are areas solely dependent on groundwater for irrigation. In Butte Water District, located within the southeastern portion of the East Butte inventory unit, growers in recent years have shifted to wells for water supply when they shift from annual crops to orchard crops or from flood irrigation to pressurized systems. This shift to groundwater increases demand on the basin and reduces recharge from applied surface water. This land and water source shift has also occurred on the margins of Western Canal Water District. Although water levels within the Butte Water District area have not declined drastically yet, should the area slowly shift to groundwater dependence, it will likely develop cones of depression like other areas of the county that are solely dependent on groundwater. Maintaining use of surface water for irrigation in portions of the inventory unit where it is available and delivery infrastructure already exists is an important step in achieving sustainable groundwater management as required by the Sustainable Groundwater Management Act.

Hydrographs for all BMO wells in the East Butte inventory unit can be viewed in the BMO reports for the Pentz, Esquon, Cherokee, Western Canal, Thermalito, Richvale, Biggs-West

Gridley, Butte Sink, and Butte subregions found in Appendix G of the Groundwater Status Report.

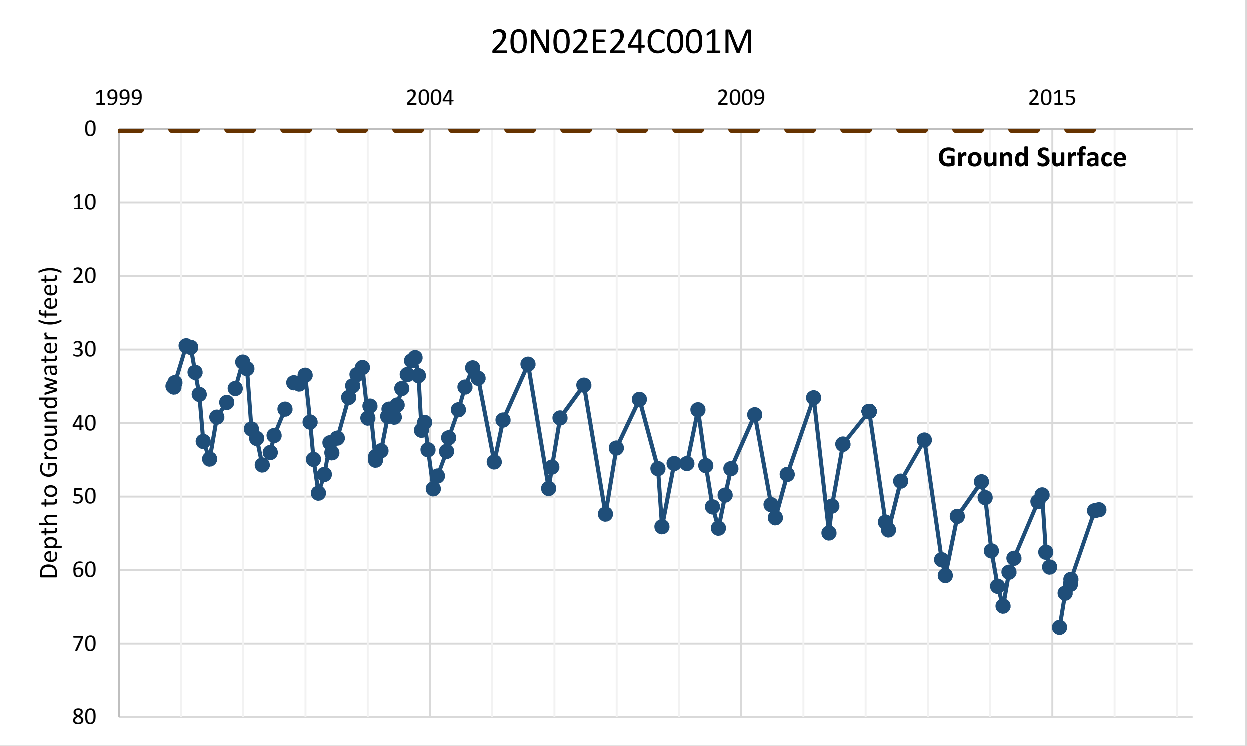

Figure 4.30. Monitoring Well 20N02E24C001M Hydrograph.

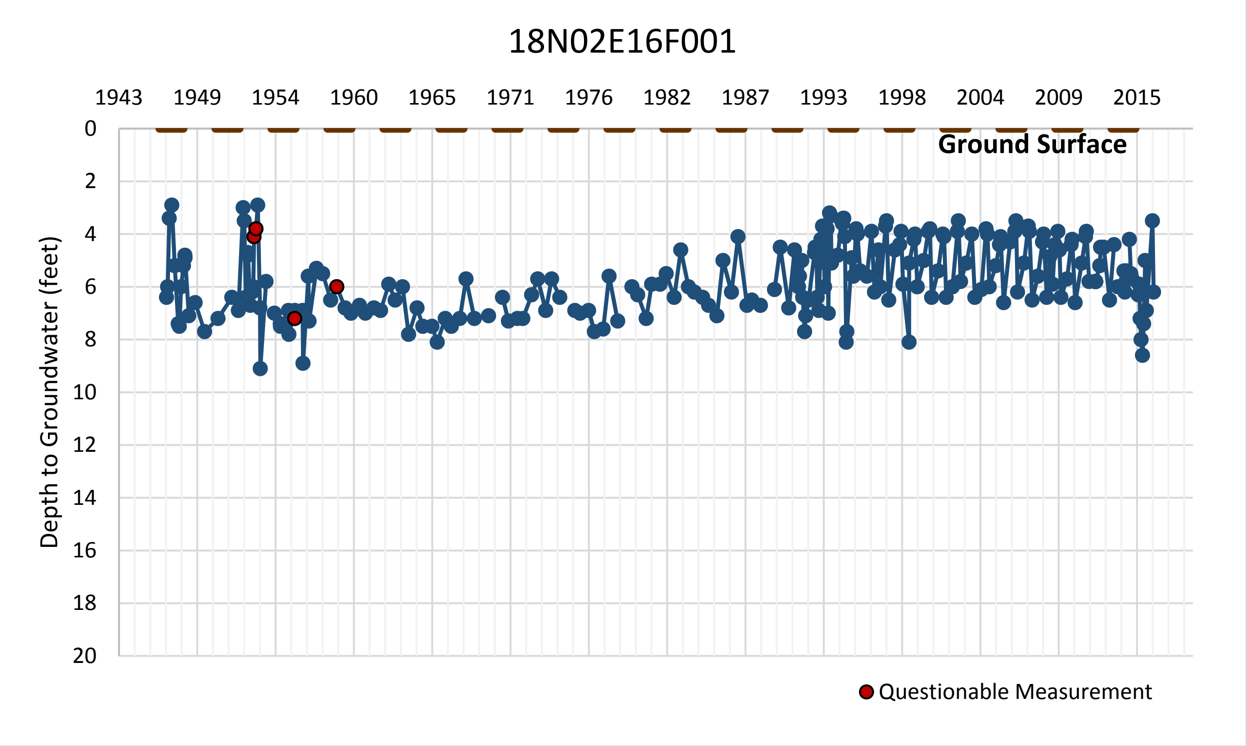

Figure 4.31. Monitoring Well 18N02E16F001M Hydrograph.

North Yuba Inventory Unit

The North Yuba Subbasin (5-21.60) covers about 47,500 acres in the southeastern portion of Butte County in the Sacramento Valley Groundwater Basin. It is bordered by the Feather River to the north and west, Yuba County to the south, and foothills to the east. The North Yuba aquifer system includes recent valley sedimentary deposits, floodplain and alluvium deposits, and deposits of the Victor, Laguna, and Mehrten formations. The primary source of agricultural water in the North Yuba Inventory Unit is groundwater. Groundwater is also used as a municipal water source for portions of Oroville.

Groundwater levels are monitored in a network of about 8 wells in the North Yuba inventory unit. These wells are agricultural or domestic wells. This data provides information on groundwater storage conditions and water level trends dating back to the late 1940s in some cases. In addition, CalWater - Oroville provides spring and fall groundwater level data for three of their wells for inclusion in annual County reporting.

In groundwater dependent areas, groundwater levels have larger variations within an irrigation season and between years than in surface water irrigated areas where groundwater levels are relatively stable. Along the Feather River, surface water generally provides water for irrigation. Further east, groundwater serves as the sole source of agricultural irrigation water for a large area of the North Yuba inventory unit, as shown in the map of irrigation water source from DWR land use surveys (Figure 4.13). The limited network of monitoring wells show that water levels are relatively stable in some places, are affected by Feather River flows near the river, and have experienced declines during dry and critical years in other places. Groundwater levels in the four wells monitoring the main pumping zone (100-450 feet below ground surface) in this inventory unit fell 7 to 14 feet from 2004 to 2015 (Figure 4.25). A significant portion of these water level declines occurred over the past four years of severe drought, about 5-8 feet.

Figure 4.32 shows groundwater levels from an irrigation well of intermediate depth (200-600 feet) near the county border on the east side of the inventory unit, 17N04E09N002M. The hydrograph shows trends in groundwater levels since 2001 with slight declines during previous drought years and declining spring levels on the order of 10 feet from 2004 to 2015.

Hydrographs for all BMO wells in the North Yuba inventory unit can be viewed in the BMO report for the North Yuba subregion found in Appendix G of the Groundwater Status Report.

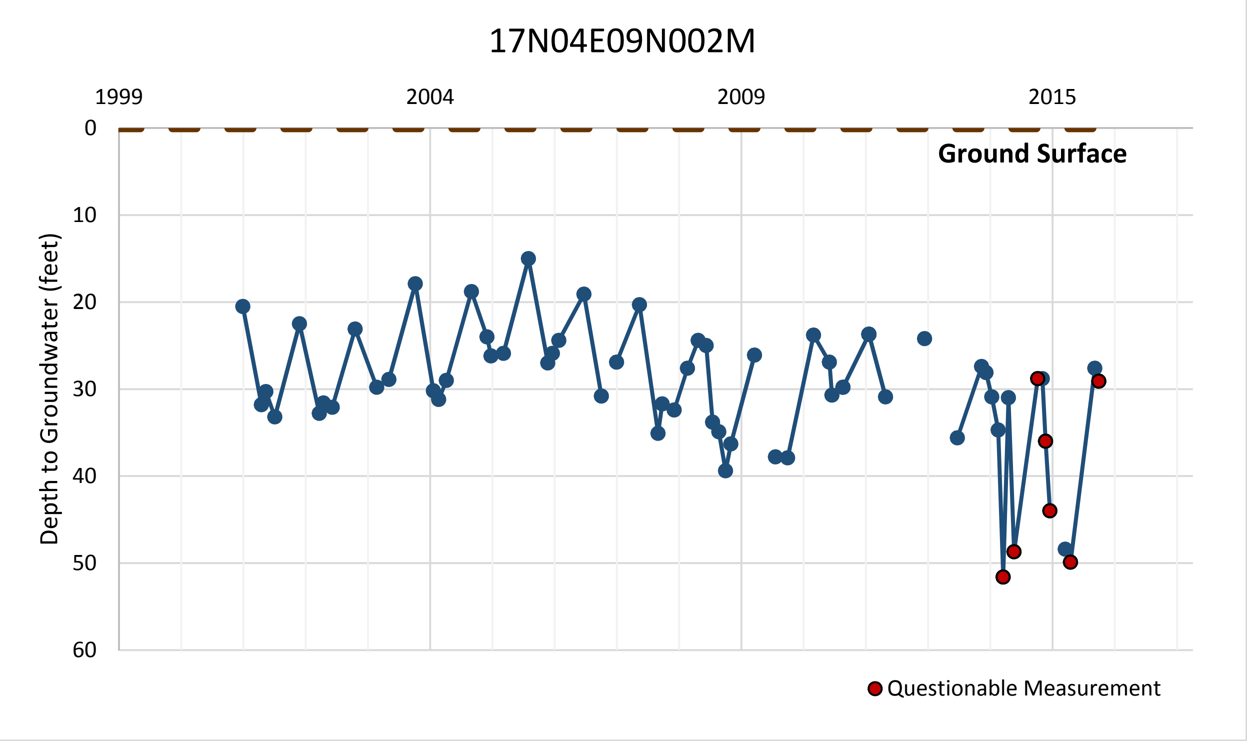

Figure 4.32. Monitoring Well 17N04E09N002M Hydrograph.

4.3.3 Groundwater Pumping

Groundwater provides a source of supply to meet irrigation, domestic, M&I, environmental, and stockwater demands. Estimated pumping within the valley floor IUs for water years 2000 to 2014 is presented in Figure 4.33. In the figure, symbols for each year are color-coded based on the Sacramento Valley Water Year Index (WYI), a key indicator of seasonal variability in inter-annual hydrology. The WYI is used to classify individual water years as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), or Critical (C) with respect to surface water runoff in the Sacramento River Basin. Total estimated groundwater pumping during this period ranged from 316 thousand acre-feet (taf) in the wet year of 2011 to 489 taf in the critically dry year of 2008. Average pumping during this period is estimated to be 411 taf annually.

As indicated in the figure, pumping varies substantially from year to year and is highly correlated to the WYI, with increased pumping in dry and critical years to meet increased irrigation demands and decreased pumping in wet and above normal years. Although linear regression suggests some increase in pumping over time, the correlation between pumping and time is weak ($R^2 = 0.05$), and the apparent increase between 2011 and 2014 is likely due to drought.

Pumping in the County increases substantially in years during which Feather River supplies in the East Butte and West Butte IUs are curtailed. For example, in the curtailment year of 2015, it is estimated that groundwater pumping in the Feather River Settlement Contractor service areas within Butte County increased by approximately 130 taf in response to curtailment of approximately 50 percent of surface water supplies (Davids Engineering 2016, included as Appendix D).

Table 4.3 summarizes estimated average annual groundwater pumping for the four IUs and the Valley Floor portion of Butte County as a whole by water demand type: irrigated agriculture and wetlands, Municipal/Industrial (M&I), and rural residential.

Table 4.3. Average Annual Groundwater Pumping (taf), 2000-2014.

Inventory Unit	Irrigated Agriculture and Wetlands	M&I	Rural Residential	Total
Vina	88.3	19.6	0.8	108.7
West Butte	115.8	8.9	1.2	125.9
East Butte	119.5	2.9	2.1	124.5
North Yuba	50.7	0.1	0.8	51.5
Valley Floor	374.3	31.4	4.8	410.6

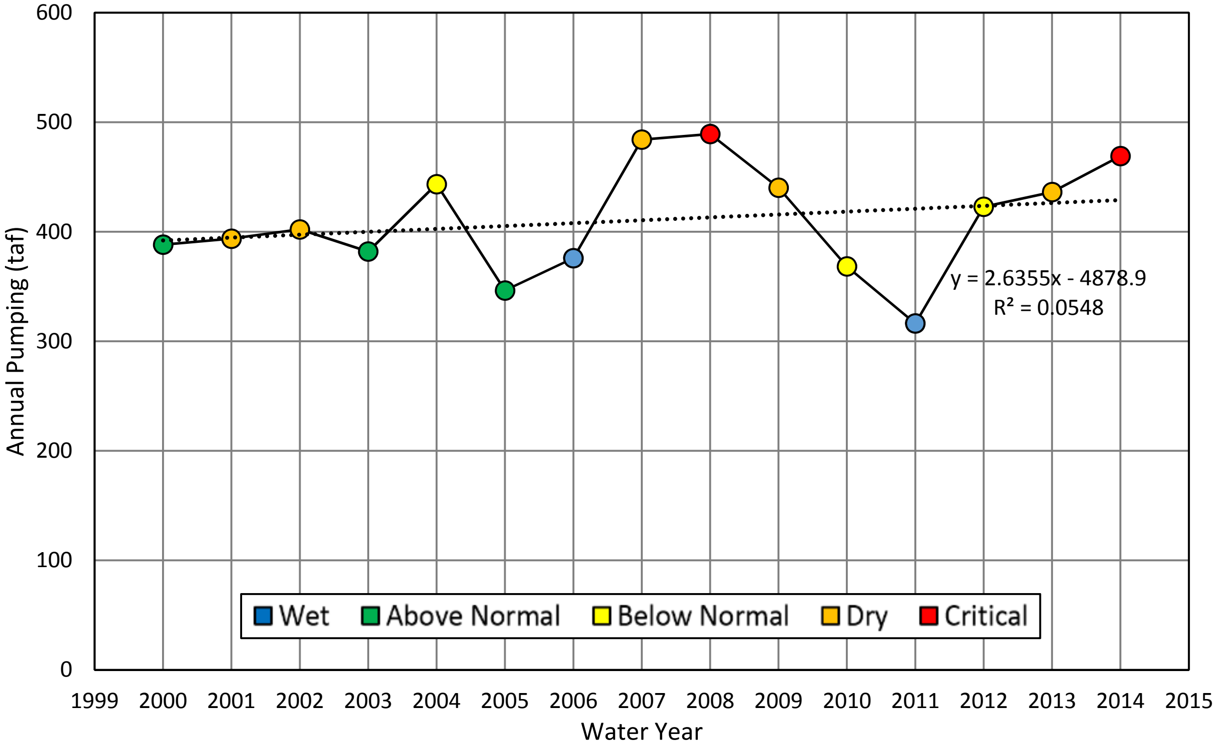

Figure 4.33. Butte County Valley Floor Estimated Groundwater Pumping and Water Year Type, 2000-2014.

Vina Inventory Unit

In the Vina IU, the majority of demands are met using groundwater. Vina includes irrigated agriculture, wetlands, portions of the Chico urban area, and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within the Vina IU for water years 2000 to 2014 is presented in Figure 4.34. Total estimated groundwater pumping during this period ranged from 82 thousand acre-feet (taf) in the wet year of 2011 to 128 taf in the critically dry year of 2008. Average pumping during this period is estimated to be 109 taf annually. The linear regression suggests no significant trend in pumping over time (correlation between pumping and time is weak, $R^2 = 0.0002$), and the apparent increase between 2011 and 2014 is likely due to drought. Variations in pumping appear to be mainly driven by variability in annual precipitation.

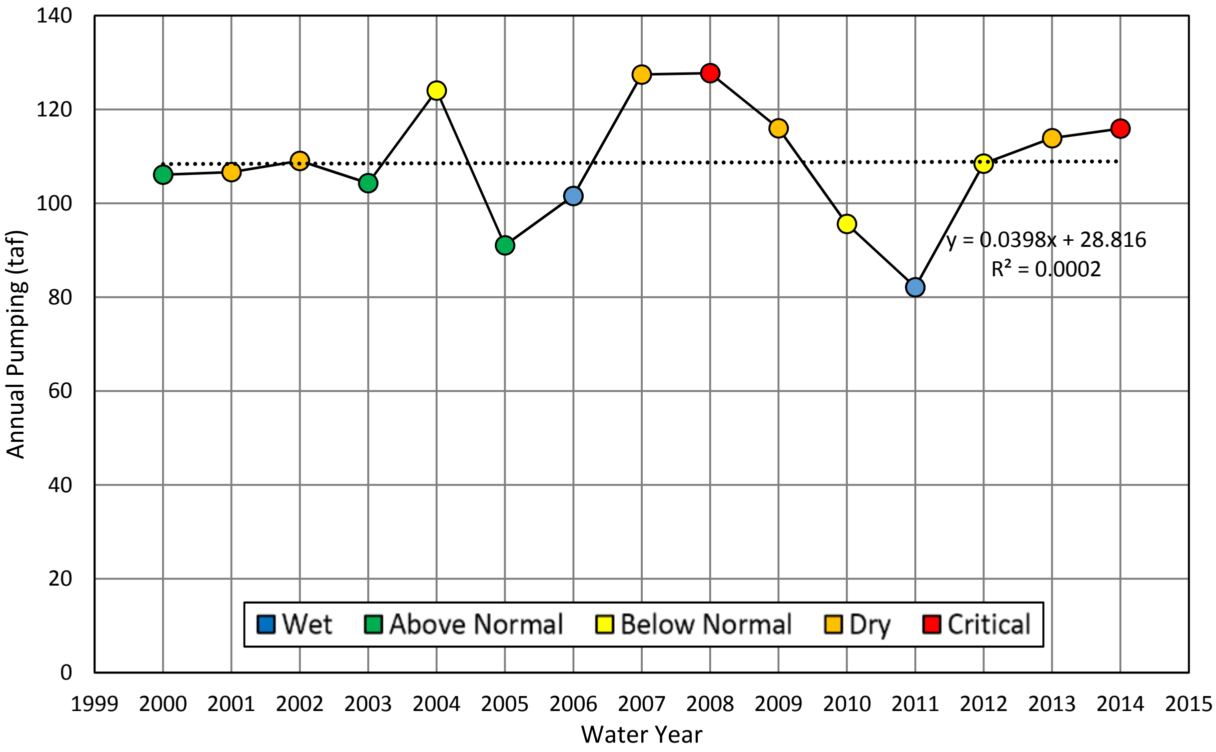

Figure 4.34. Vina Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

West Butte Inventory Unit

In the West Butte IU, the majority of demands are met using groundwater. West Butte includes irrigated agriculture and wetlands, portions of the Chico urban area, Durham, and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within the West Butte IU for water years 2000 to 2014 is presented in Figure 4.35. Total estimated groundwater pumping during this period ranged from 88 thousand acre-feet (taf) in the wet year of 2011 to 156 taf in the dry year of 2007. Average pumping during this period is estimated to be 126 taf annually. Although linear regression suggests some increase in pumping over time, the correlation between pumping and time is weak (R^2 = 0.01), and the apparent increase between 2011 and 2014 is likely due to drought. Variations in pumping appear to be mainly driven by variability in annual precipitation.

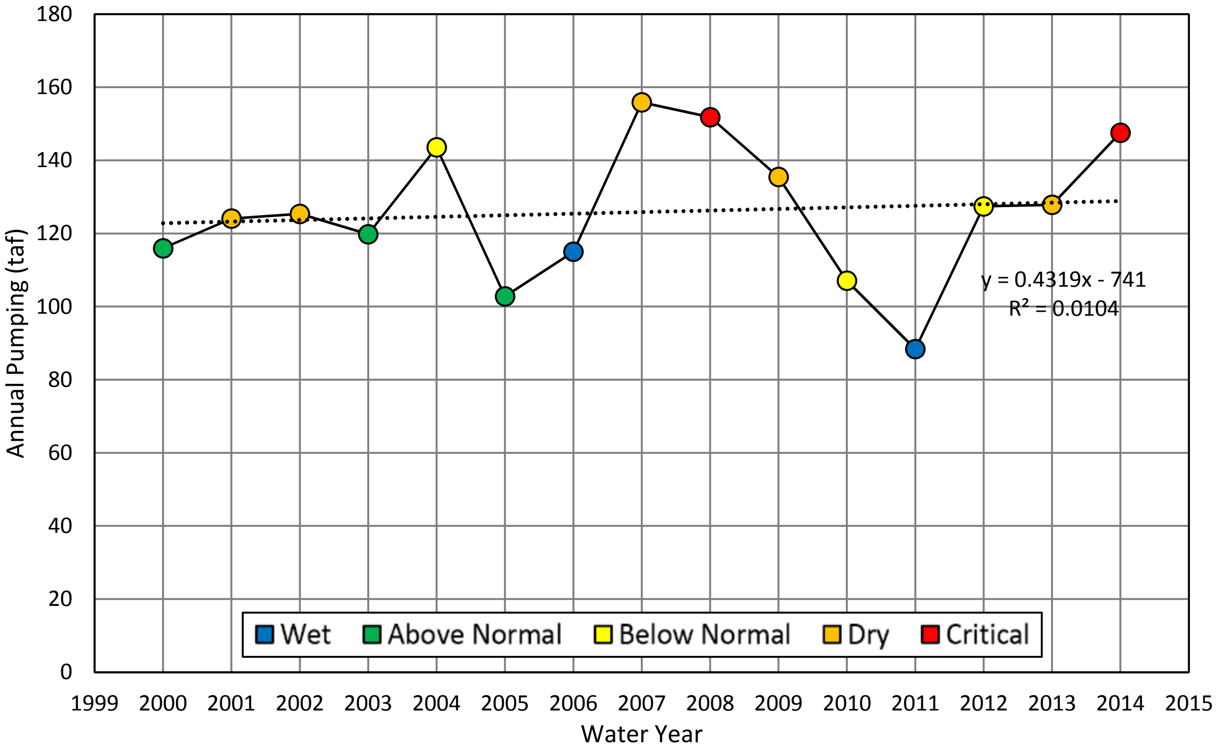

Figure 4.35. West Butte Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

East Butte Inventory Unit

In the East Butte IU, the majority of demands are met using surface water with groundwater mainly serving orchard irrigation needs and providing a source of drought water supply during cutback years to the Feather River Settlement Contractors (as in 2015). East Butte includes irrigated agriculture and wetlands, the Oroville, Gridley and Biggs urban areas and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within the East Butte IU for water years 2000 to 2014 is presented in Figure 4.36. Total estimated groundwater pumping during this period ranged from 105 thousand acre-feet (taf) in the wet year of 2011 to 152 taf in the critically dry year of 2014. Average pumping during this period is estimated to be 124 taf annually. Linear regression suggests some increase in pumping over time, with a moderate correlation between pumping and time (R^2 = 0.38). The apparent increase between 2011 and 2014 is likely primarily due to drought.

Variations in pumping appear to be mainly driven by variability in annual precipitation, although additional examination of other potential factors such as changes in crops grown, overall irrigated acreage, or conversion from surface water to groundwater may be other factors.

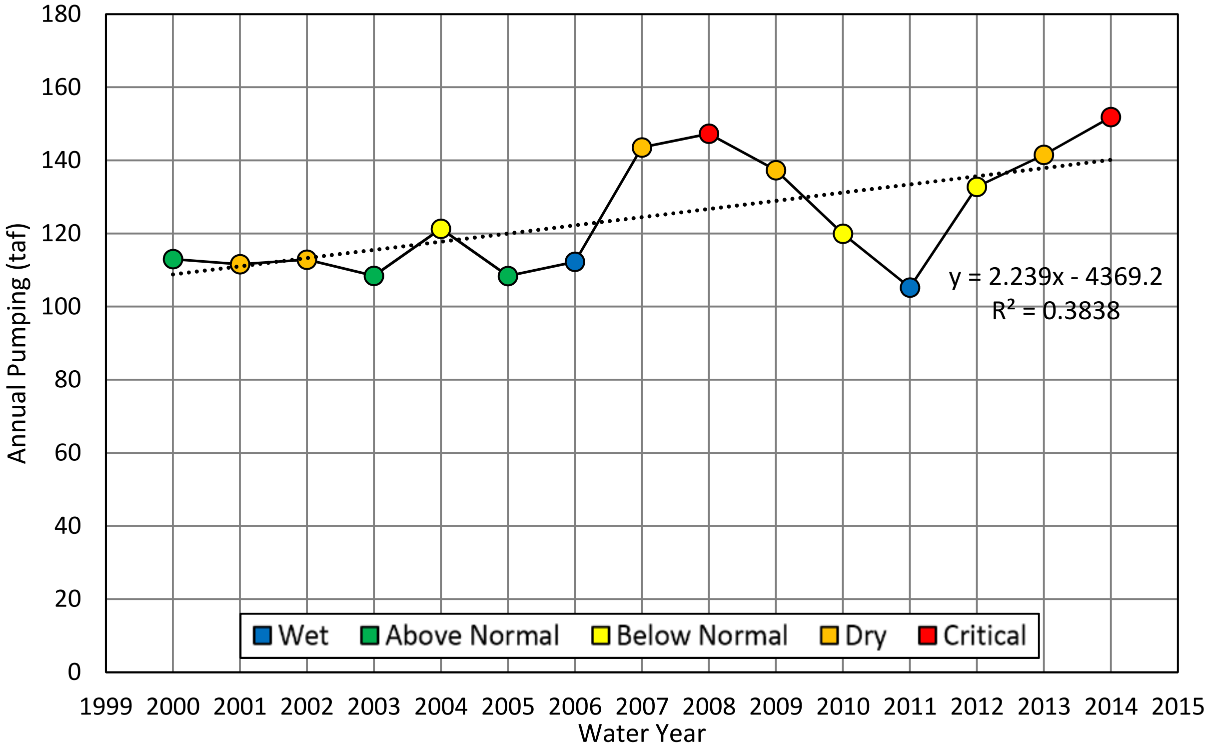

Figure 4.36. East Butte Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

North Yuba Inventory Unit

In the North Yuba IU, the majority of demands are met by groundwater. North Yuba includes irrigated agriculture and wetlands, and rural residential land use dependent on private domestic wells for indoor and outdoor water use. Estimated pumping within this IU for water years 2000 to 2014 is presented in Figure 4.37. Total estimated groundwater pumping during this period ranged from 41 thousand acre-feet (taf) in the wet year of 2011 to 62 taf in the critically dry year of 2008. Average pumping during this period is estimated to be 52 taf annually. Although linear regression suggests some decrease in pumping over time, the correlation between pumping and time is weak ($R^2 = 0.004$). Variations in pumping appear to be largely influenced by variability in annual precipitation.

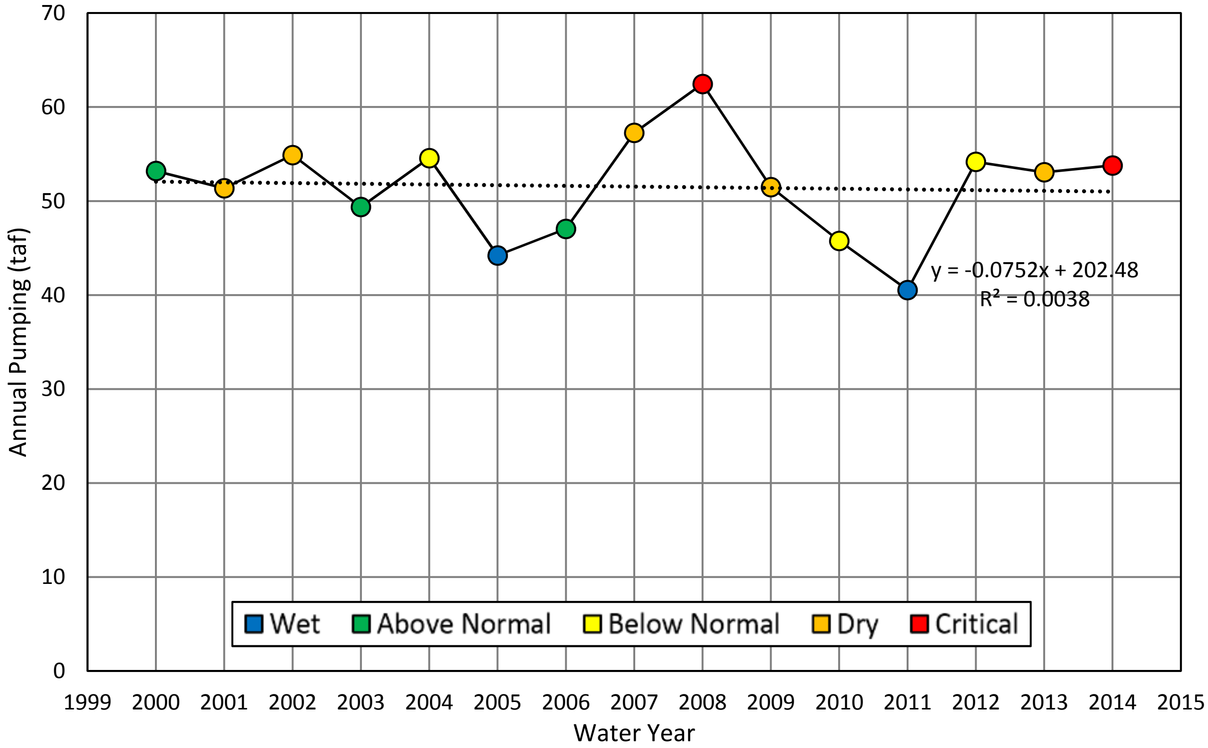

Figure 4.37. North Yuba Inventory Estimated Groundwater Pumping and Water Year Type, 2000-2014.

4.3.4 Groundwater Development

Well Counts, Distribution, and Development over Time

Based on well completion reports on file with DWR NRO describing wells constructed between 1900 and August 2015, there are over 17,000 wells in Butte County. The wells are classified by type as domestic, irrigation, municipal and industrial (M&I), monitoring, and other. Figure 4.38 indicates the densities of domestic, irrigation, M&I, and monitoring wells within the County. Table 4.5 summarizes the number of wells by type, inventory unit, and subinventory unit within the County.

Domestic wells are widely distributed through most portions of the County, including the Foothill Inventory Unit and the southern portion of the Mountain Inventory Unit. Irrigation wells are distributed across the valley floor inventory units, with the greatest concentrations in the Vina and West Butte inventory units, corresponding to areas of reliance on groundwater for irrigation. M&I and dedicated monitoring wells are most concentrated in populated areas such as the cities of Chico and Oroville.

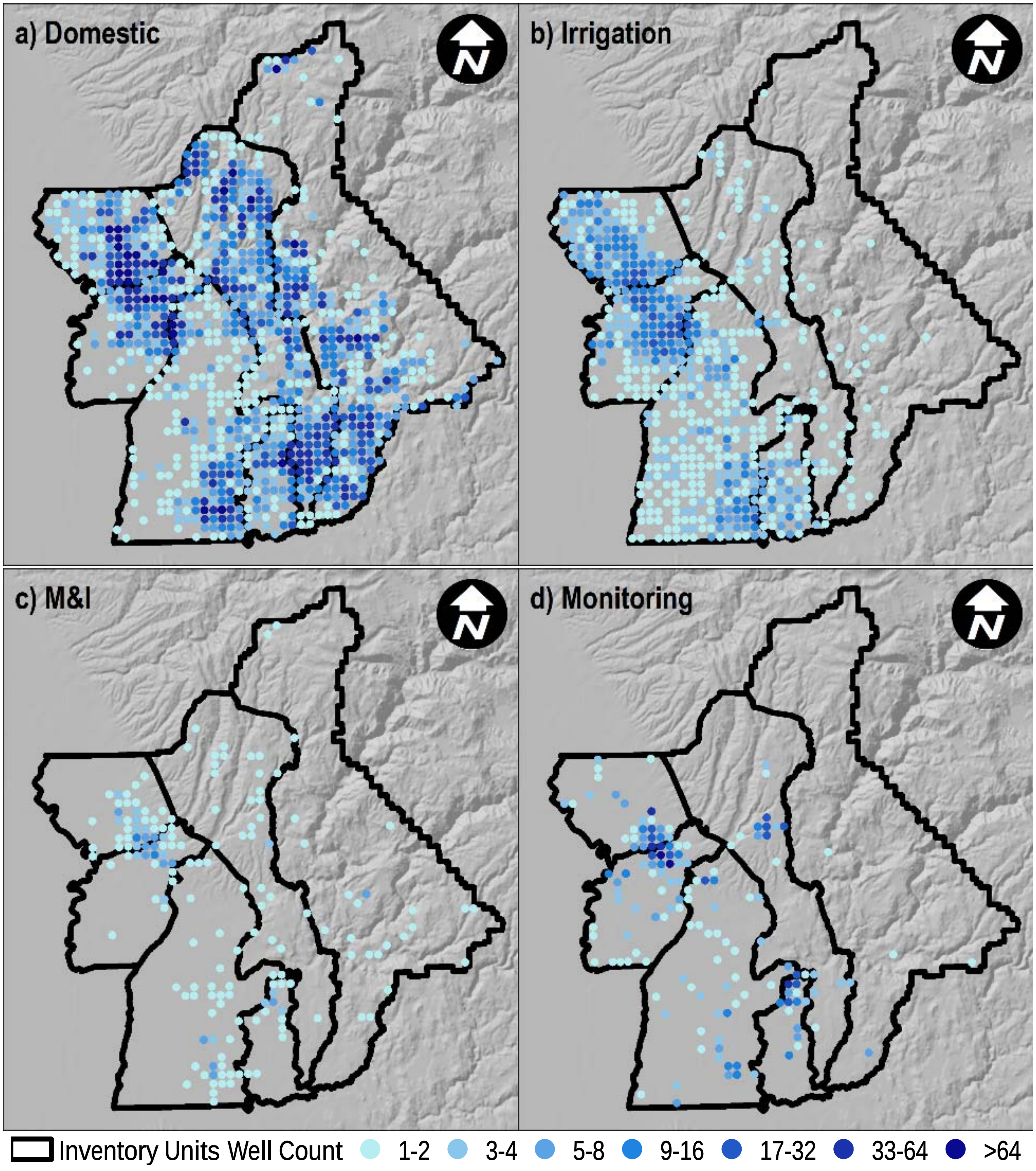

Figure 4.38. Distribution of Wells in Butte County by Type.

Table 4.4 and Figure 4.38 were prepared based on information in the Well Completion Report database on file at DWR. The accuracy of the well-location information varies according to the source of the particular data. Although most locations are correct to within one-half mile, some well completion report data may be in error by up to several miles.

Based on well completion data from DWR for the period 2000 to 2014, well construction has varied over time (Figure 4.39). Domestic well construction increased from 2000 to 2004 and then declined until 2013, when construction increased from approximately 70 to 150 wells per year (average of 164 wells per year between 2000 and 2014). Irrigation well construction has been relatively steady over time, averaging approximately 15 wells per year, with increases to 30 or more wells per year in 2007 and 2014, potentially due to drought or long term water level declines in some areas. M&I well construction varied between 1 and 5 wells per year (average of 3 wells per year) during the 2000 to 2014 period, with monitoring well construction varying over time but averaging 32 wells per year.

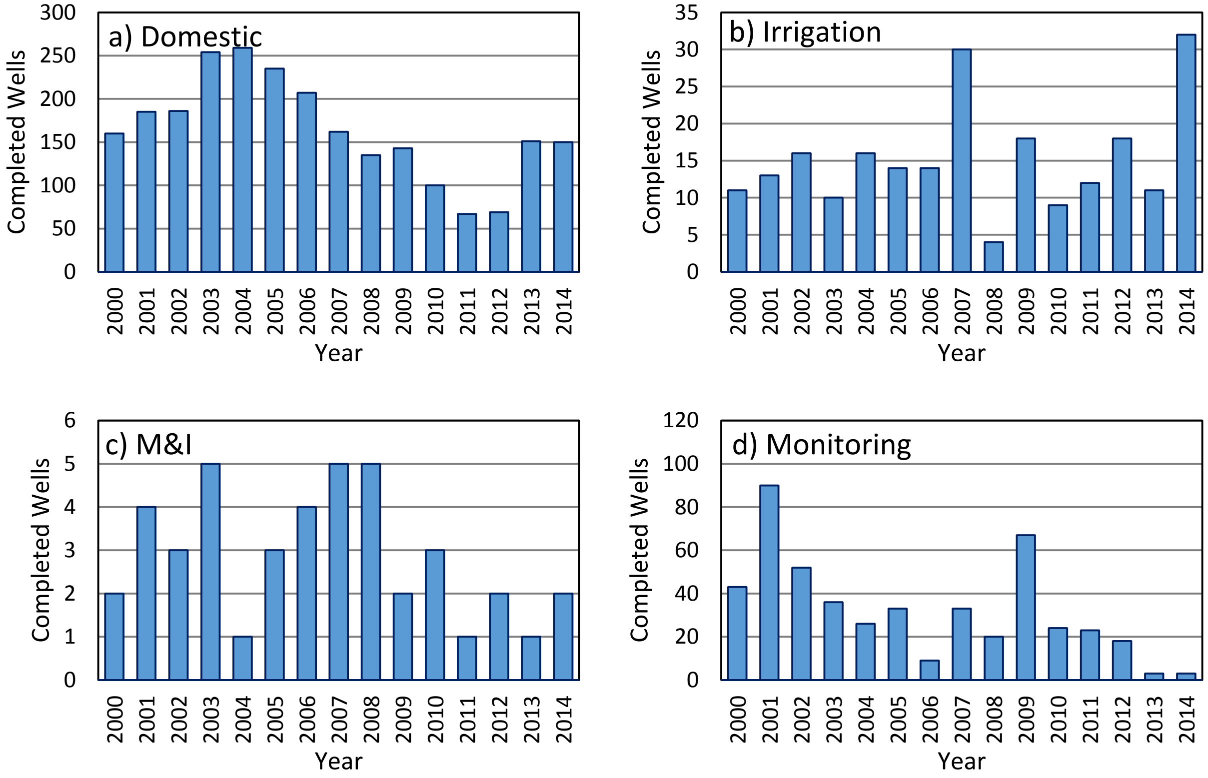

Figure 4.39. Butte County Annual Well Construction.

Well Depths

Well depth and well use data were collected from Well Completion Reports filed with DWR. A total of approximately 15,000 well records having depth data were evaluated and classified into three well-type categories: domestic, irrigation, and M&I. The minimum, maximum, and average well depths listed by well type and by inventory unit and subinventory unit are presented in Table 4.5.

Table 4.4. Number of Wells by Inventory Unit and Subinventory Unit.

Inventory Unit	Subinventory Unit	Well Count					
		Domestic	Irrigation	M&I	Monitoring	Other	Total
East Butte	Biggs-West Gridley	208	93	8	21	24	354
	Butte	693	211	30	48	49	1,031
	Butte Sink	3	14	0	6	2	25
	Cherokee	110	79	4	8	17	218
	Esquon	339	122	4	10	36	511
	Pentz	81	23	3	38	11	156
	Richvale	96	88	4	13	15	216
	Thermalito	223	82	17	48	113	483
	Western Canal	46	84	4	10	13	157
	Total	1,799	796	74	202	280	3,151
Foothill	Cohasset	269	4	3	0	7	283
	Ridge	426	19	3	42	29	519
	Other	2,742	63	31	88	96	3,020
	Total	3,437	86	37	130	132	3,822
Mountain	Mountain	2,885	33	30	12	62	3,022
North Yuba	North Yuba	587	189	25	143	93	1,037
Vina	Vina	2,297	651	83	211	266	3,508
West Butte	Angel Slough	9	44	0	0	2	55
	Durham/Dayton	1,404	608	68	390	262	2,732
	Llano Seco	1	17	0	6	8	32
	M&T	29	54	1	30	15	129
	Western Canal	28	28	1	6	3	66
	Total	1,471	751	70	432	290	3,014
County Total		12,476	2,506	319	1,130	1,123	17,554

Table 4.5. Well Depths by Inventory Unit and Subinventory Unit.

Inventory Unit	Subinventory Unit	Well Completion Depth (Feet)														
		Irrigation					Domestic					Municipal and Industrial				
		Count	Min.	Max.	Mean	Median	Count	Min.	Max.	Mean	Median	Count	Min.	Max.	Mean	Median
East Butte	Biggs-West Gridley	93	60	750	243	203	208	32	323	99	91	8	55	381	163	115
	Butte	211	35	983	165	140	693	19	399	86	80	30	35	430	199	200
	Butte Sink	14	193	616	391	400	3	110	200	140	110	0	NA	NA	NA	NA
	Cherokee	79	84	871	426	468	110	26	630	178	153	4	110	475	286	279
	Esquon	122	62	883	376	334	339	25	320	131	121	4	93	460	266	255
	Pentz	23	93	535	300	275	81	43	705	201	155	3	97	735	479	605
	Richvale	88	80	692	289	260	96	40	310	113	105	4	137	180	164	169
	Thermalito	82	36	463	185	148	223	30	700	120	100	17	55	275	128	104
	Western Canal	84	109	880	511	540	46	50	500	157	133	4	87	215	166	181
	Total	796	35	983	292	274	1,799	19	705	114	102	74	35	735	195	190
Foothill	Cohasset	4	117	600	439	520	269	25	960	314	215	3	300	857	617	695
	Ridge	19	69	875	228	126	426	18	1,030	345	265	3	132	600	334	270
	Other	63	30	875	291	200	2,742	19	1,060	266	200	31	37	930	447	430
	Total	86	30	875	284	199	3,437	18	1,060	279	209	37	37	930	452	439
Mountain	Mountain	33	45	600	291	300	2,885	11	1,010	240	200	30	100	970	279	240
North Yuba	North Yuba	189	28	656	294	278	587	25	990	140	120	25	64	600	195	185
Vina	Vina	651	40	1,050	327	248	2,297	14	940	149	140	83	33	830	454	525
West Butte	Angel Slough	44	60	367	211	213	9	35	125	88	100	0	NA	NA	NA	NA
	Durham/Dayton	608	60	750	356	337	1,404	15	800	146	130	68	36	924	396	399
	Llano Seco	17	175	905	411	390	1	56	56	56	56	0	NA	NA	NA	NA
	M&T	54	52	920	444	460	29	54	640	161	140	1	710	710	710	710
	Western Canal	28	109	880	516	555	28	67	540	165	100	1	420	420	420	420
	Total	751	52	920	361	347	1,471	15	800	147	129	70	36	924	401	404
County Total		2,506	28	1,050	320	270	12,476	11	1,060	200	146	319	33	970	345	275

5. Historical Water Demands and Supplies

5.1 Overview

This section describes historical water demands and supplies in Butte County in the context of land surface water budgets quantifying flows into and out of irrigated, non-irrigated, and developed lands over time. Land surface water budgets, as described previously in Section 2 of this report (see Figure 2.1), are presented for the period 2000 to 2014 and illustrate the reliance on surface water, groundwater, and precipitation to meet consumptive and non-consumptive demands, while also providing estimates of the relative quantities of water consumed through evapotranspiration (ET) or returning to the system as deep percolation or surface runoff.

Variability in precipitation and available surface water supplies from year to year illustrate conditions in wet vs. dry years. In extreme dry years, curtailment of approximately 50 percent of Feather River supplies from Lake Oroville (the primary surface water supply in the County) can occur; however such conditions did not occur during the 2000 to 2014 period. Curtailment did occur in 2015, and the impacts on demands and supplies are described in a technical memorandum prepared for the Department by Davids Engineering and entitled *Assessment of Butte County Drought Impacts, 2012-2015* (2016). The assessment is included as Appendix D of this report. Results of the assessment are summarized as follows:

> *Dry years and drought correspond to below normal precipitation and resulting reduction in available water supplies to support agricultural, urban, and environmental water demands. All else equal, reduced precipitation in Butte County and the watersheds it relies upon results in decreased surface water supplies, increased irrigation demands, and decreased groundwater recharge, although these impacts do not occur in direct proportion to decreased precipitation. Impacts on surface water supplies depend upon dynamics in the timing and amount of precipitation received as snowfall, melting and runoff of accumulated snowfall, reservoir storage and operations, and water rights considerations. Similarly, irrigation demands are influenced primarily by the timing and amount of precipitation occurring on the valley floor, along with reference evapotranspiration as influenced by solar radiation, temperature, wind speed, humidity, and other factors. Net recharge of the underlying groundwater system is influenced by a combination of these factors.*
>
> *The recent 2012 to 2015 drought period is marked by a reduction in precipitation and surface water supplies, including important spring runoff from snowmelt. Reduced precipitation on the valley floor has led to increased irrigation demands, particularly for non-rice crops, which are more dependent on precipitation to meet irrigation water demands, particularly during the late winter/early spring. The reduction in surface water supplies has led to increased demand for groundwater to meet crop irrigation requirements. This is particularly true for 2015, when Butte Creek water supplies were*

> *curtailed and Feather River settlement contractor supplies were curtailed for the first time since 1992.*
>
> *Over this same period, groundwater recharge from precipitation in the form of deep percolation of precipitation on irrigated and non-irrigated lands has decreased. The combination of the drought impacts of reduced supplies and reduced recharge from precipitation is that net recharge of the groundwater system has declined during the 2012 to 2015 period, as compared to the 2001 to 2007 baseline period. Additional information describing seepage from and accretions to streams, canals, and drains is needed to fully quantify impacts of drought on groundwater recharge; however observations can be made regarding the impact of drought on net recharge from the irrigated and non-irrigated land surfaces in the County.*

County-wide, approximately 95 percent of developed water use[1] is for irrigated agriculture and managed wetlands, with the remaining 5 percent for developed lands. Almost all irrigated agriculture and managed wetlands water use and the majority of developed water use occurs on the valley floor, although both surface water and groundwater supplies are critical to the population of the Foothill and Mountain IUs.

Developed water supplies for the valley floor IUs include surface water diversions and groundwater pumping. Surface water supplies and diversions are described in Section 4.2, along with the amount of diversions delivered to meet irrigation or other demands. Well development and groundwater pumping in the County is discussed in Section 4.3. Primary demands in valley floor IUs are irrigation demands to meet crop ET requirements, managed wetlands, and developed lands. Estimation of ET, deep percolation, and runoff and return flows for irrigation is discussed in Section 2. Estimation of demands for developed (urban, residential, and M&I) lands is additionally described in Section 2.

A brief discussion of water supplies and demands in the Foothill and Mountain IUs is provided in the following section. Then, more detailed water budgets are presented for the valley floor IUs in the remaining sections, including overall water budgets and individual budgets for irrigated agriculture and wetlands, developed lands, and native lands. A more detailed evaluation of supplies and demands for the Foothill and Mountain IUs could be included as part of a future analysis to complement the evaluations for each valley floor IU.

5.2 Foothill and Mountain Inventory Units

Water supplies in the Foothill and Mountain IUs include surface water diversions by Paradise Irrigation District (PID) and groundwater pumping from fractured rock aquifers as described in Section 4.3. In the Foothill IU, surface water deliveries by PID have totaled approximately 7,500 af annually, on average between 2000 and 2014. Remaining water supplies in the Foothill IU

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[1] Developed water use refers to the use of surface water diversion and groundwater pumping to meet agricultural, urban, managed wetlands, or other demands.

include pumping of an estimated 2,800 af annually by Del Oro Water Company and 6,700 af annually by others based on population and per capita water use estimates. Less than 30 af annually is pumped by Paradise I.D. (WYA 2016). Estimated private domestic pumping in the Mountain IU is 1,900 af annually based on population and per capita water use estimates. As described previously in Section 4.3, there are approximately 3,440 domestic wells and 40 M&I wells in the Foothill IU and 2,890 domestic wells and 30 M&I wells in the Mountain IU. Additionally, there are estimated to be approximately 90 irrigation wells in the Foothill IU and 30 irrigation wells in the Mountain IU.

Primary demands in the Foothill and Mountain IUs are for domestic and M&I use. A more detailed evaluation of water demands in the Foothill and Mountain IUs could be performed in the future to better quantify consumptive and non-consumptive uses of water.

5.3 Butte County Valley Floor

5.3.1 Overall Water Budget

Land surface inflows on the Butte County Valley Floor (Vina, West Butte, East Butte, and North Yuba IUs) average approximately 2.040 million acre-feet (maf) annually and include precipitation (914 taf), applied surface water (715 taf), and groundwater pumping (411 taf) (Figure 5.1, Figure 5.2, and Table 5.1). Precipitation varied from 562 taf in 2007 to 1.314 maf in 2011. Groundwater pumping varied from 316 taf in 2011 to 489 taf in 2008. Applied surface water varied from 641 taf in 2014 to 782 taf in 2007. Annual flows are provided in Table 5.1, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.2, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation. For each water year, the water year type is indicated for each year in parentheses as described in Section 4.2[2].

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[2] W – Wet, AN – Above Normal, BN – Below Normal, D – Dry, C – Critical.

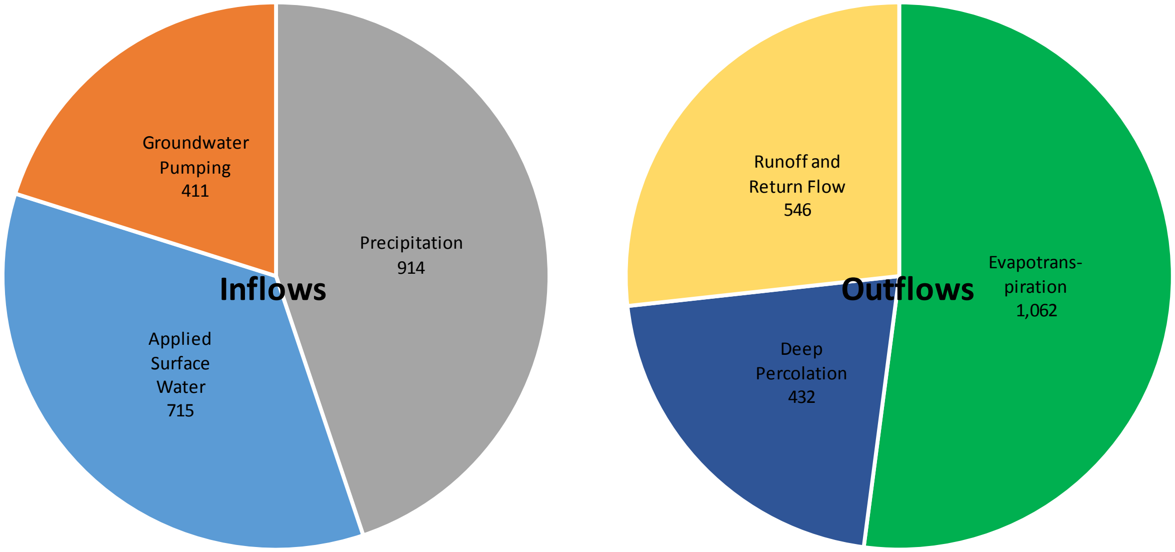

Figure 5.1. Butte County Valley Floor Overall Average Annual Inflows and Outflows, 2000-2014.

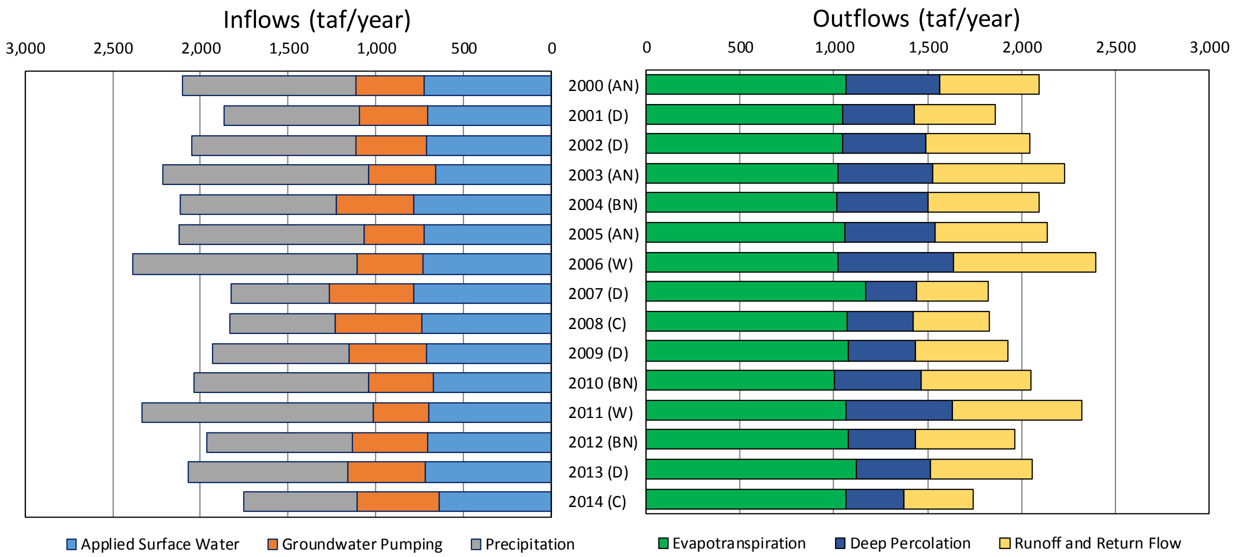

Figure 5.2. Butte County Valley Floor Overall Water Year Inflows and Outflows, 2000-2014.

Table 5.1. Butte County Valley Floor Overall Water Year Inflows, Outflows, and Change in Storage[3], 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	984	728	388	1,066	496	531	-5
2001 (D)	768	703	394	1,047	382	431	-3
2002 (D)	934	711	402	1,048	445	550	-8
2003 (AN)	1,172	662	382	1,022	504	707	23
2004 (BN)	891	782	443	1,015	486	596	-27
2005 (AN)	1,052	724	346	1,058	480	601	23
2006 (W)	1,275	732	376	1,023	613	760	6
2007 (D)	562	782	484	1,167	272	382	3
2008 (C)	605	740	489	1,073	348	407	-19
2009 (D)	775	713	440	1,074	363	492	7
2010 (BN)	998	672	368	1,005	458	591	17
2011 (W)	1,314	699	316	1,063	570	692	-1
2012 (BN)	835	709	423	1,080	356	530	-7
2013 (D)	908	722	436	1,118	398	545	21
2014 (C)	643	641	469	1,067	307	369	-24
Minimum	562	641	316	1,005	272	369	-27
Maximum	1,314	782	489	1,167	613	760	23
Average	914	715	411	1,062	432	546	0
Averages by Hydrologic Year Type							
Wet (W)	1,295	715	346	1,043	591	726	2
Above Normal (AN)	1,069	705	372	1,049	493	613	14
Below Normal (BN)	908	721	412	1,033	433	572	-6
Dry (D)	789	726	431	1,091	372	480	4
Critical (C)	624	691	479	1,070	328	388	-22

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[3] For the land surface water budgets presented in the WI&A, Change in Storage refers to changes in water stored in the root zone at the Earth's surface, rather than changes in storage in the underlying groundwater system. On an annual basis, changes in root zone soil moisture storage are expected to be near zero, as compared to changes in the amount of water stored in the groundwater system, which may be appreciable.

5.3.2 Irrigated Agriculture and Wetlands Water Budget

Inflows to irrigated agriculture and wetlands on the Butte County Valley Floor average approximately 1.59 maf annually and include precipitation (504 taf), groundwater pumping (374 taf), and applied surface water (709 taf) (Figure 5.3, Figure 5.4, and Table 5.2). Precipitation varied from 295 taf in 2007 to 741 taf in 2011. Groundwater pumping varied from 282 taf in 2011 to 450 taf in 2007. Applied surface water varied from 635 taf in 2014 to 776 taf in 2004 and 2007. Annual flows are provided in Table 5.2, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.4, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

5.3.3 Developed Lands Water Budget

Inflows to developed lands on the Butte County Valley Floor average approximately 140 taf annually and include precipitation (98 taf), groundwater pumping (36 taf), and applied surface water (6 taf) (Figure 5.5, Figure 5.6, and Table 5.3). Precipitation varied from 61 taf in 2007 to 148 taf in 2011. Groundwater pumping has been relatively consistent over time, varying from approximately 32 taf to 39 taf annually, with an average estimated pumping of 31 taf by water suppliers and 5 taf by rural residential pumpers. Annual flows are provided in Table 5.3, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.6, groundwater pumping was relatively steady from year to year between 2000 and 2014. Pumping for developed lands remains relatively steady due to insensitivity of indoor water demands to precipitation and less sensitivity of outdoor water use (irrigation) to precipitation than for irrigated agriculture. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

Some runoff and return flow from developed lands returns to the groundwater system through septic systems and stormwater retention while other runoff and return flow enters local waterways. Additional analysis is needed to refine estimates of the relative proportion of non-consumed water use on developed lands that returns to the surface water systems rather than returning to the groundwater system.

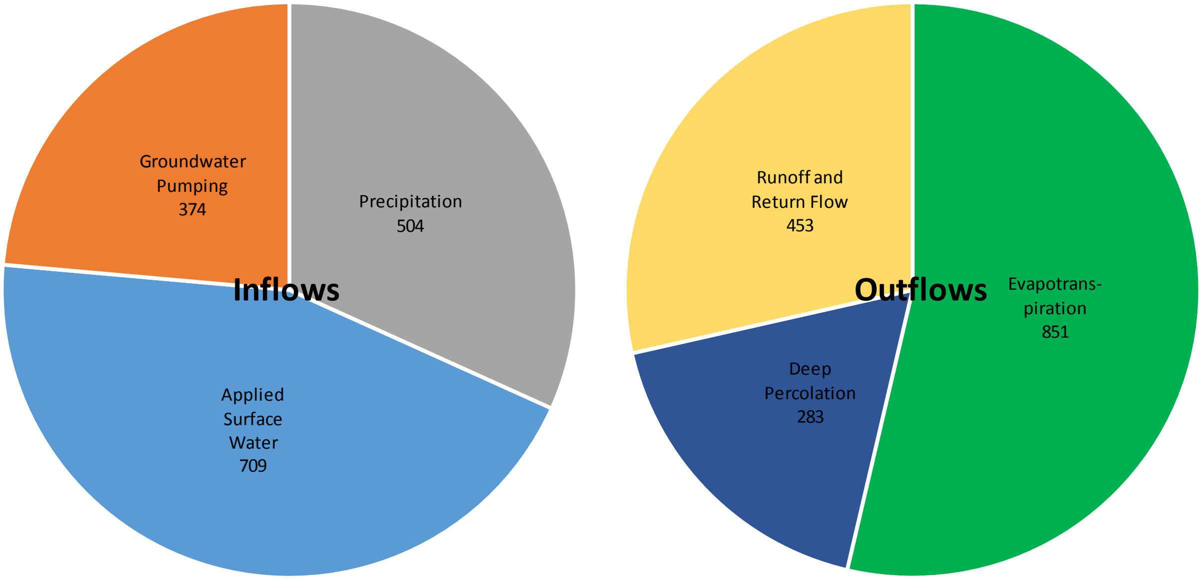

Figure 5.3. Butte County Valley Floor Irrigated Agriculture and Wetlands Average Annual Inflows and Outflows, 2000-2014.

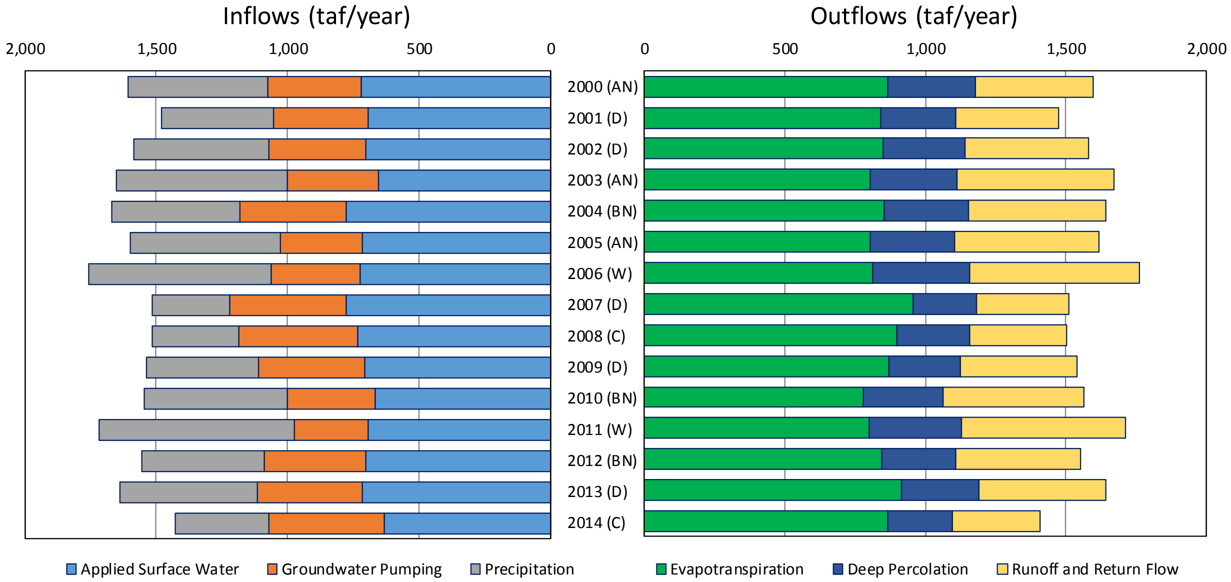

Figure 5.4. Butte County Valley Floor Irrigated Agriculture and Wetlands Water Year Inflows and Outflows, 2000-2014.

Table 5.2. Butte County Valley Floor Irrigated Agriculture and Wetlands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
Water Year	**Precipitation**	**Surface Water**	**Groundwater**	**Evapotranspiration**	**Deep Percolation**	**Runoff and Return Flow**	
2000 (AN)	530	721	354	865	315	420	-6
2001 (D)	423	697	359	843	264	368	-4
2002 (D)	517	705	366	851	289	441	-6
2003 (AN)	651	655	346	806	306	561	20
2004 (BN)	489	776	404	852	303	489	-24
2005 (AN)	570	718	310	804	299	515	20
2006 (W)	692	726	337	812	346	606	9
2007 (D)	295	776	445	955	227	330	-4
2008 (C)	331	734	450	901	258	345	-11
2009 (D)	429	707	403	870	255	416	2
2010 (BN)	548	666	334	781	281	503	16
2011 (W)	741	693	282	799	329	585	-3
2012 (BN)	465	703	388	848	259	446	-3
2013 (D)	523	716	401	914	276	454	4
2014 (C)	354	635	437	864	234	312	-16
Minimum	295	635	282	781	227	312	-24
Maximum	741	776	450	955	346	606	20
Average	504	709	374	851	283	453	0
Averages by Hydrologic Year Type							
Wet (W)	717	710	310	806	338	595	3
Above Normal (AN)	584	698	337	825	306	499	11
Below Normal (BN)	501	715	375	827	281	479	-4
Dry (D)	437	720	395	887	262	402	-1
Critical (C)	343	684	443	883	246	329	-13

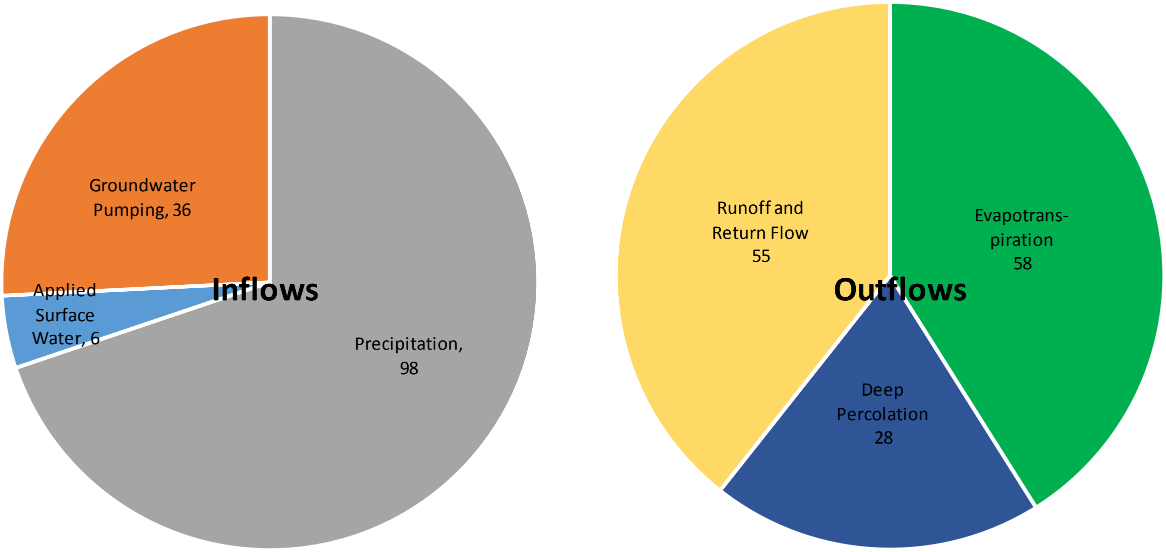

Figure 5.5. Butte County Valley Floor Developed Lands Average Annual Inflows and Outflows, 2000-2014.

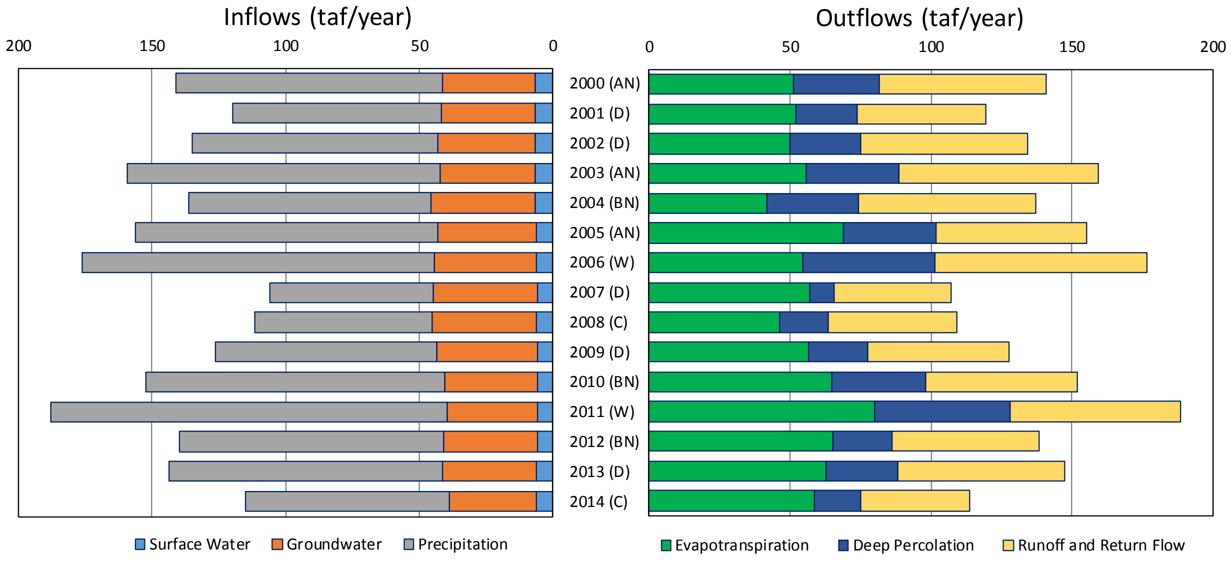

Figure 5.6. Butte County Valley Floor Developed Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.3. Butte County Valley Floor Developed Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	100	7	35	51	30	59	0
2001 (D)	78	7	35	52	22	46	0
2002 (D)	92	6	36	50	25	59	0
2003 (AN)	117	6	36	56	33	71	0
2004 (BN)	91	7	39	42	33	63	1
2005 (AN)	113	6	37	69	33	53	-1
2006 (W)	132	6	38	55	47	75	0
2007 (D)	61	6	39	57	9	42	1
2008 (C)	66	6	39	46	17	46	-2
2009 (D)	83	6	38	56	21	50	1
2010 (BN)	112	6	35	65	33	54	0
2011 (W)	148	6	34	80	48	60	1
2012 (BN)	99	6	35	65	21	53	-1
2013 (D)	102	6	35	63	25	59	4
2014 (C)	76	6	32	59	16	39	-1
Minimum	61	6	32	42	9	39	-2
Maximum	148	7	39	80	48	75	4
Average	98	6	36	58	28	55	0
Averages by Hydrologic Year Type							
Wet (W)	140	6	36	67	48	68	1
Above Normal (AN)	110	6	36	59	32	61	0
Below Normal (BN)	100	6	36	57	29	56	0
Dry (D)	83	6	37	56	20	51	1
Critical (C)	71	6	36	52	17	42	-2

5.3.4 Non-Irrigated Lands Water Budget

Inflows to non-irrigated lands on the Butte County Valley Floor average approximately 313 taf annually and include precipitation (Figure 5.7, Figure 5.8, and Table 5.4). Precipitation varied from 207 taf in 2007 to 451 taf in 2006. Annual flows are provided in Table 5.4, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.8, ET, deep percolation, and runoff vary over time largely in proportion to precipitation.

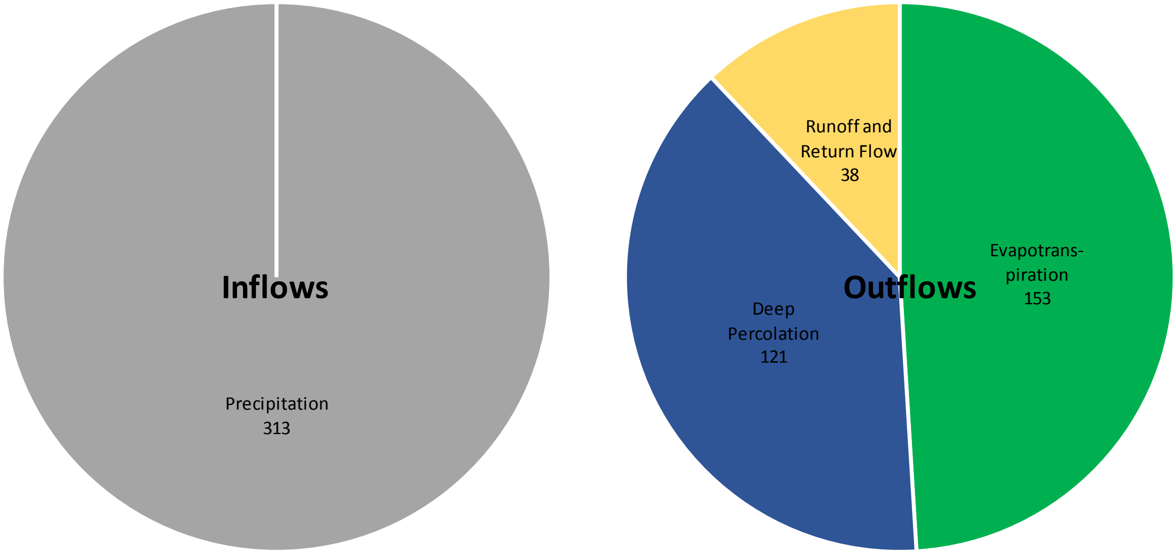

Figure 5.7. Butte County Valley Floor Non-Irrigated Lands Average Annual Inflows and Outflows, 2000-2014.

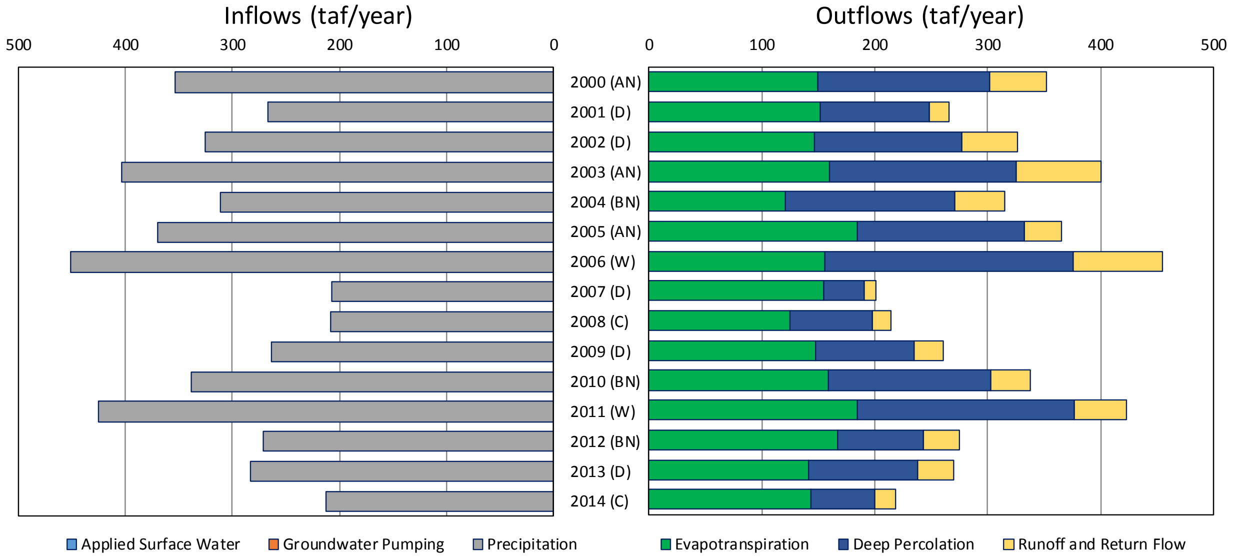

Figure 5.8. Butte County Valley Floor Non-Irrigated Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.4. Butte County Valley Floor Non-Irrigated Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	354	0	0	150	151	51	1
2001 (D)	266	0	0	152	96	17	1
2002 (D)	325	0	0	147	131	50	-1
2003 (AN)	404	0	0	160	165	75	3
2004 (BN)	311	0	0	121	150	44	-4
2005 (AN)	369	0	0	185	148	33	4
2006 (W)	451	0	0	156	220	79	-4
2007 (D)	207	0	0	155	36	10	6
2008 (C)	208	0	0	126	73	16	-7
2009 (D)	264	0	0	148	87	26	3
2010 (BN)	338	0	0	159	144	35	0
2011 (W)	425	0	0	185	192	46	2
2012 (BN)	271	0	0	167	76	32	-3
2013 (D)	283	0	0	141	97	31	13
2014 (C)	212	0	0	144	57	18	-7
Minimum	207	0	0	121	36	10	-7
Maximum	451	0	0	185	220	79	13
Average	313	0	0	153	121	38	1
Averages by Hydrologic Year Type							
Wet (W)	438	0	0	170	206	63	-1
Above Normal (AN)	376	0	0	165	155	53	3
Below Normal (BN)	307	0	0	149	123	37	-2
Dry (D)	269	0	0	149	89	27	4
Critical (C)	210	0	0	135	65	17	-7

5.4 Vina Inventory Unit

5.4.1 Overall Water Budget

Land surface inflows in Vina average approximately 297 thousand acre-feet (taf) annually and include precipitation (180 taf), groundwater pumping (109 taf), and applied surface water (8 taf) (Figure 5.9, Figure 5.10, and Table 5.5). Precipitation varied from 95 taf in 2007 to 265 taf in 2011. Groundwater pumping varied from 82 taf in 2011 to 128 taf in 2008. Applied surface water varied between 7 taf and 9 taf during this period. Annual flows are provided in Table 5.5, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.10, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

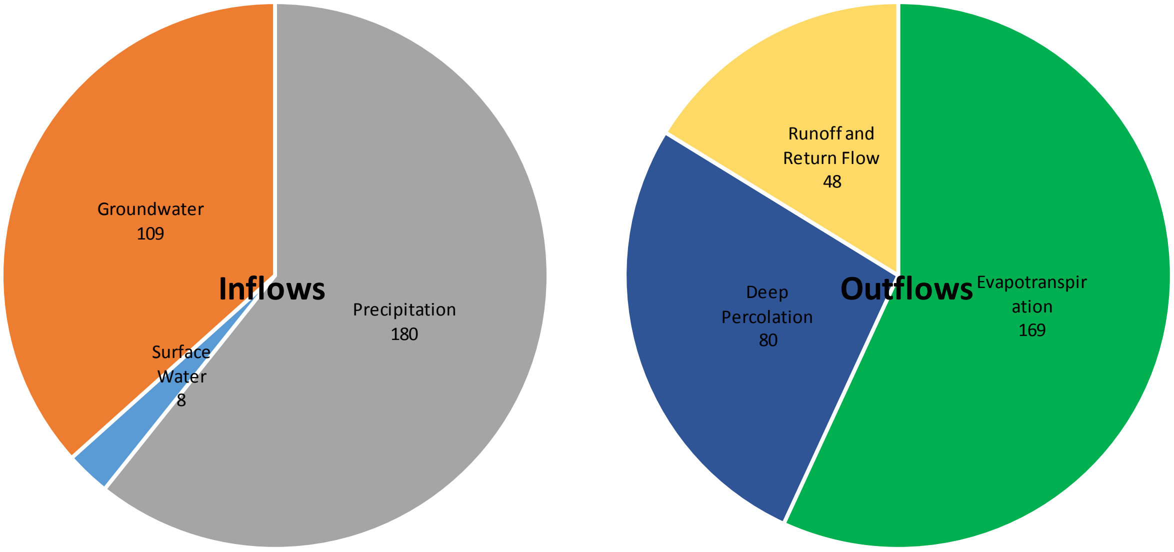

Figure 5.9. Vina Overall Average Annual Inflows and Outflows, 2000-2014.

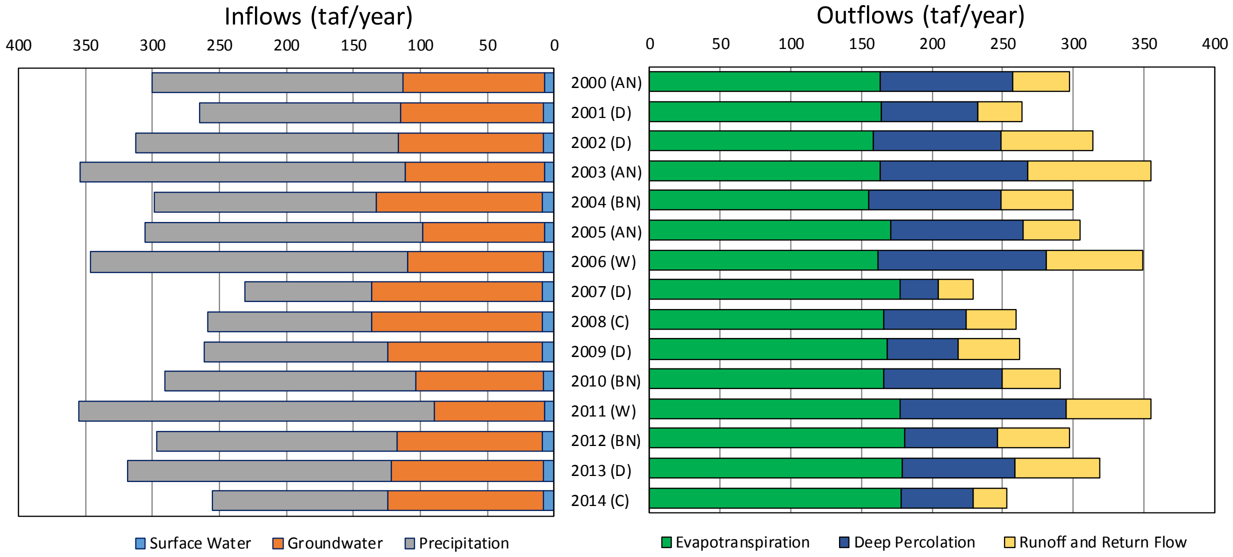

Figure 5.10. Vina Overall Water Year Inflows and Outflows, 2000-2014.

Table 5.5. Vina Overall Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	187	7	106	163	94	40	-2
2001 (D)	150	8	107	164	68	31	0
2002 (D)	196	8	109	158	91	65	-1
2003 (AN)	243	7	104	163	105	87	2
2004 (BN)	166	9	124	155	94	51	-1
2005 (AN)	208	7	91	171	93	40	2
2006 (W)	237	8	102	162	119	68	2
2007 (D)	95	9	127	177	27	24	-2
2008 (C)	122	9	128	166	59	35	-1
2009 (D)	136	9	116	169	50	43	2
2010 (BN)	188	8	96	166	84	41	1
2011 (W)	265	7	82	177	118	60	2
2012 (BN)	180	9	108	181	65	51	-1
2013 (D)	197	8	114	179	79	60	8
2014 (C)	131	8	116	179	50	24	-7
Minimum	95	7	82	155	27	24	-7
Maximum	265	9	128	181	119	87	8
Average	180	8	109	169	80	48	0
Averages by Hydrologic Year Type							
Wet (W)	251	7	92	169	119	64	2
Above Normal (AN)	213	7	100	166	97	56	0
Below Normal (BN)	178	8	109	167	81	48	0
Dry (D)	155	8	115	169	63	45	2
Critical (C)	127	8	122	172	55	30	-4

5.4.2 Irrigated Agriculture and Wetlands Water Budget

Inflows to irrigated agriculture and wetlands in Vina average approximately 170 taf annually and include precipitation (74 taf), groundwater pumping (88 taf), and applied surface water (8 taf) (Figure 5.11, Figure 5.12, and Table 5.6). Precipitation varied from 36 taf in 2007 to 113 taf in 2011. Groundwater pumping varied from 64 taf in 2011 to 106 taf in 2008. Applied surface water varied from 7 taf to 9 taf between 2000 and 2014. Annual flows are provided in Table 5.6, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.12, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

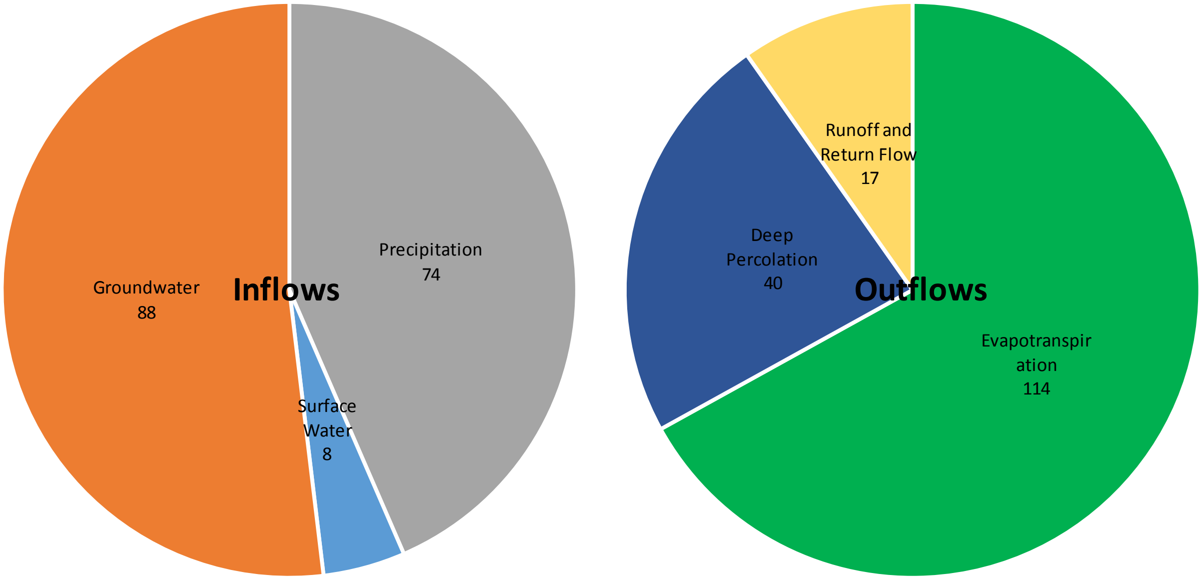

Figure 5.11. Vina Irrigated Agriculture and Wetlands Average Annual Inflows and Outflows, 2000-2014.

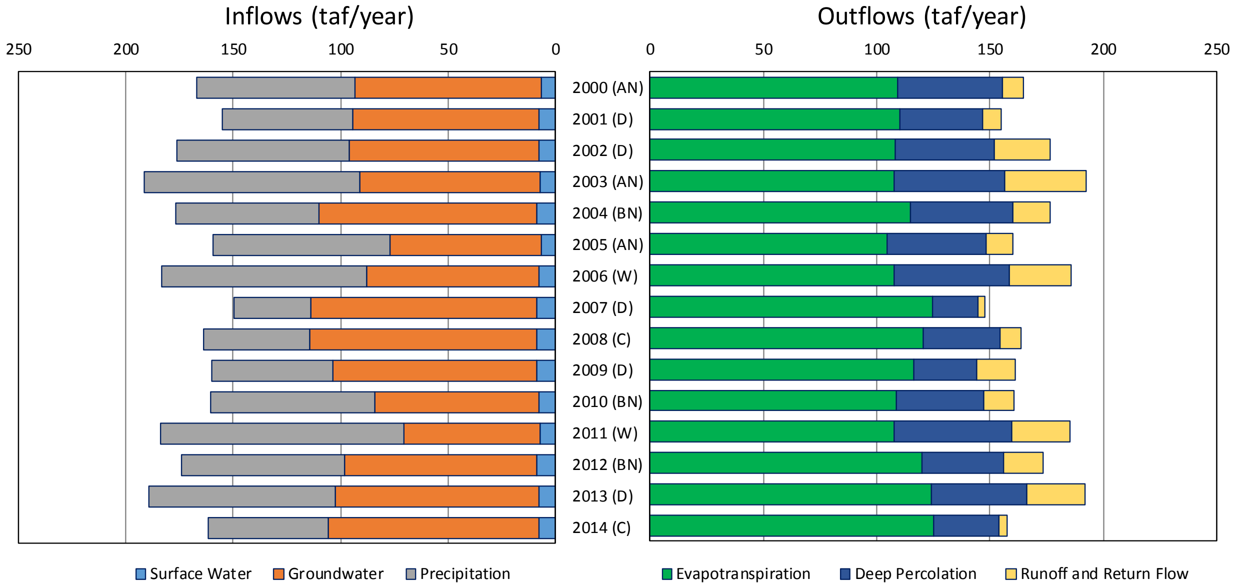

Figure 5.12. Vina Irrigated Agriculture and Wetlands Water Year Inflows and Outflows, 2000-2014.

Table 5.6. Vina Irrigated Agriculture and Wetlands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	74	7	86	109	46	9	-2
2001 (D)	61	8	87	110	36	8	-1
2002 (D)	80	8	88	108	44	25	0
2003 (AN)	100	7	84	108	49	36	1
2004 (BN)	67	9	101	115	45	17	0
2005 (AN)	83	7	70	105	43	12	0
2006 (W)	96	8	80	108	51	27	2
2007 (D)	36	9	105	125	20	3	-2
2008 (C)	49	9	106	121	34	9	0
2009 (D)	57	9	95	116	28	17	1
2010 (BN)	76	8	76	109	39	14	1
2011 (W)	113	7	64	108	52	25	1
2012 (BN)	76	9	89	120	36	18	-1
2013 (D)	87	8	95	124	42	26	3
2014 (C)	56	8	98	125	29	3	-4
Minimum	36	7	64	105	20	3	-4
Maximum	113	9	106	125	52	36	3
Average	74	8	88	114	40	17	0
Averages by Hydrologic Year Type							
Wet (W)	104	7	72	108	51	26	2
Above Normal (AN)	86	7	80	107	46	19	0
Below Normal (BN)	73	8	89	115	40	16	0
Dry (D)	64	8	94	117	34	16	0
Critical (C)	52	8	102	123	31	6	-2

5.4.3 Developed Lands Water Budget

The Vina IU includes the City of Chico north of Big Chico Creek and the communities of Vina and Nord. Inflows to developed lands in Vina average approximately 48 taf annually and include precipitation (28 taf) and groundwater pumping (20 taf) (Figure 5.13, Figure 5.14, and Table 5.7). Precipitation varied from 14 taf in 2007 to 45 taf in 2011. Groundwater pumping has been relatively consistent over time, pumping varying from approximately 18 taf to 23 taf annually with an average estimated pumping of 20 taf by water suppliers and 1 taf by rural residential pumpers. No surface water is delivered to meet demands for developed lands in Vina. Annual flows are provided in Table 5.7, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.14, groundwater pumping was relatively steady from year to year between 2000 and 2014. Pumping for developed lands remains relatively steady due to insensitivity of indoor water demands to precipitation and less sensitivity of outdoor water use (irrigation) to precipitation than for irrigated agriculture. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

Some runoff and return flow from developed lands returns to the groundwater system through septic systems and stormwater retention while other runoff and return flow enters local waterways. Additional analysis is needed to refine estimates of the relative proportion of non-consumed water use on developed lands that returns to the surface water systems rather than returning to the groundwater system.

5.4.4 Non-Irrigated Lands Water Budget

Inflows to non-irrigated lands in Vina average approximately 78 taf annually and include precipitation (Figure 5.15, Figure 5.16, and Table 5.8). Precipitation varied from 45 taf in 2007 to 108 taf in 2003. Annual flows are provided in Table 5.8, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.16, ET, deep percolation, and runoff vary over time largely in proportion to precipitation.

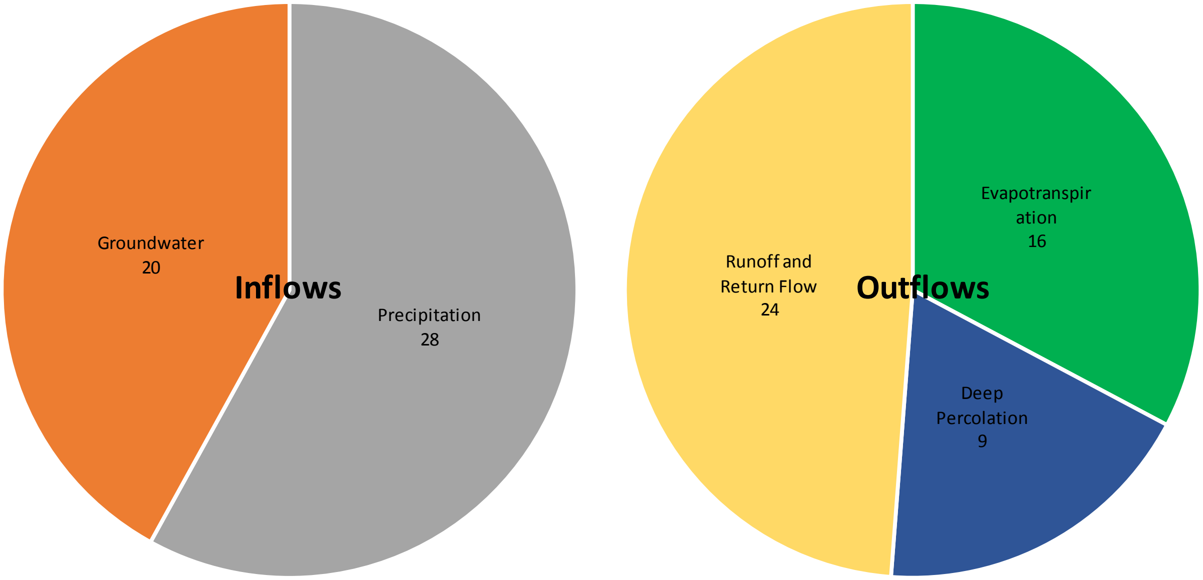

Figure 5.13. Vina Developed Lands Average Annual Inflows and Outflows, 2000-2014.

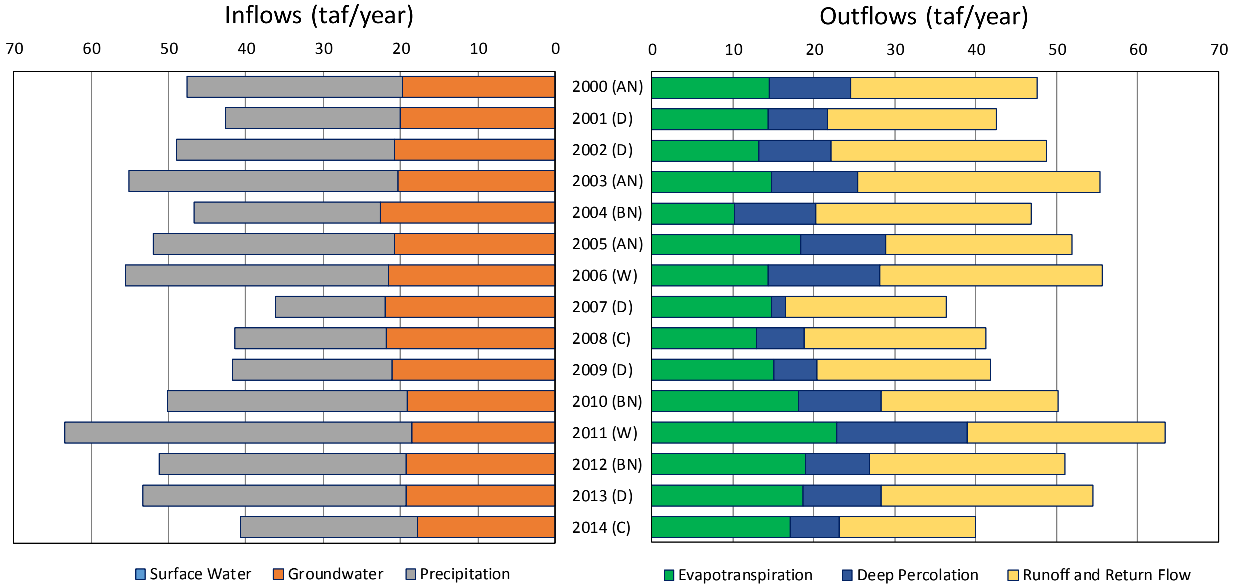

Figure 5.14. Vina Developed Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.7. Vina Developed Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	**Precipi-tation**	**Surface Water**	**Ground-water**	**Evapotrans-piration**	**Deep Percolation**	**Runoff and Return Flow**	**Change in Storage (taf)**
2000 (AN)	28	0	20	14	10	23	0
2001 (D)	23	0	20	14	7	21	0
2002 (D)	28	0	21	13	9	27	0
2003 (AN)	35	0	20	15	11	30	0
2004 (BN)	24	0	23	10	10	26	0
2005 (AN)	31	0	21	18	10	23	0
2006 (W)	34	0	22	14	14	28	0
2007 (D)	14	0	22	15	2	20	0
2008 (C)	19	0	22	13	6	22	0
2009 (D)	21	0	21	15	5	21	0
2010 (BN)	31	0	19	18	10	22	0
2011 (W)	45	0	18	23	16	24	0
2012 (BN)	32	0	19	19	8	24	0
2013 (D)	34	0	19	19	10	26	1
2014 (C)	23	0	18	17	6	17	-1
Minimum	14	0	18	10	2	17	-1
Maximum	45	0	23	23	16	30	1
Average	28	0	20	16	9	24	0
Averages by Hydrologic Year Type							
Wet (W)	39	0	20	19	15	26	0
Above Normal (AN)	31	0	20	16	10	25	0
Below Normal (BN)	29	0	20	16	9	24	0
Dry (D)	24	0	21	15	7	23	0
Critical (C)	21	0	20	15	6	20	0

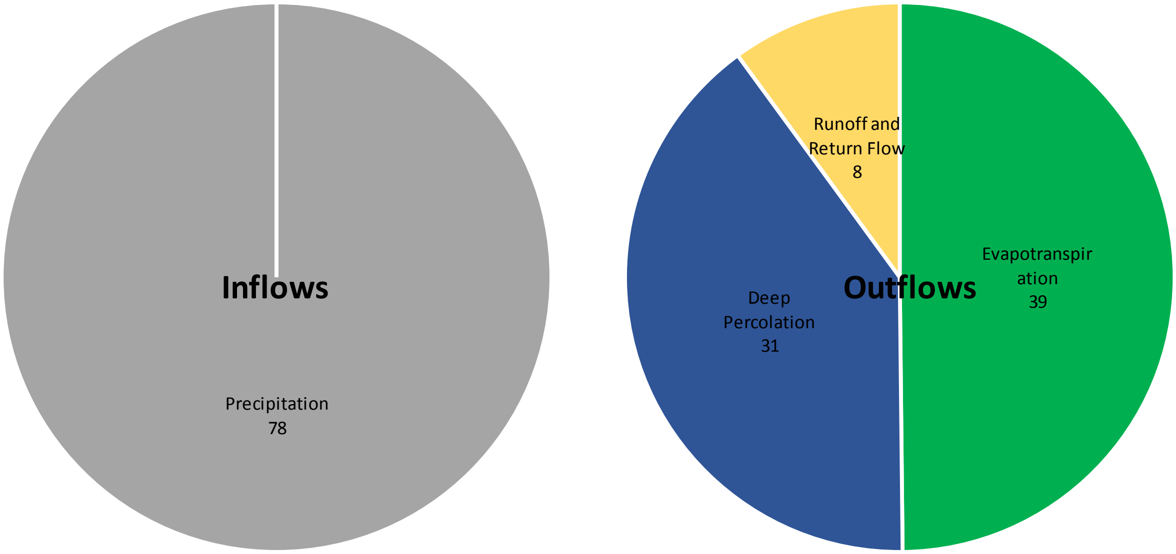

Figure 5.15. Vina Non-Irrigated Lands Average Annual Inflows and Outflows, 2000-2014.

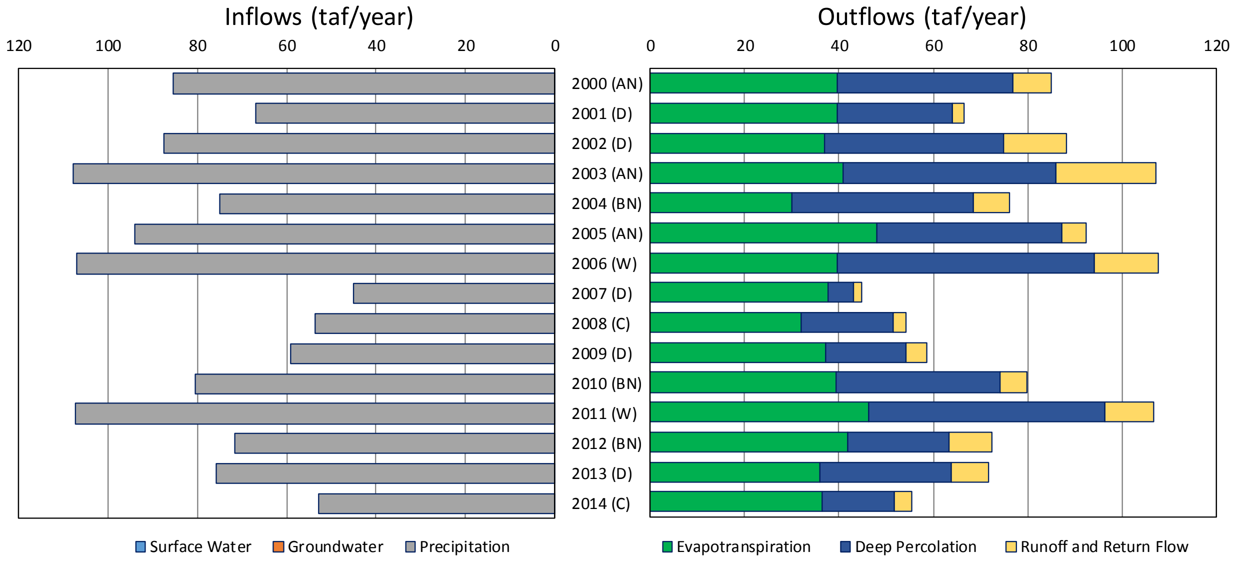

Figure 5.16. Vina Non-Irrigated Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.8. Vina Non-Irrigated Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	85	0	0	40	37	8	0
2001 (D)	67	0	0	40	25	2	0
2002 (D)	87	0	0	37	38	13	-1
2003 (AN)	108	0	0	41	45	21	1
2004 (BN)	75	0	0	30	38	8	-1
2005 (AN)	94	0	0	48	39	5	1
2006 (W)	107	0	0	40	54	14	-1
2007 (D)	45	0	0	38	5	2	0
2008 (C)	54	0	0	32	19	3	0
2009 (D)	59	0	0	37	17	4	0
2010 (BN)	80	0	0	39	35	6	1
2011 (W)	107	0	0	46	50	10	0
2012 (BN)	72	0	0	42	22	9	-1
2013 (D)	76	0	0	36	28	8	4
2014 (C)	53	0	0	36	15	4	-3
Minimum	45	0	0	30	5	2	-3
Maximum	108	0	0	48	54	21	4
Average	78	0	0	39	31	8	0
Averages by Hydrologic Year Type							
Wet (W)	107	0	0	43	52	12	0
Above Normal (AN)	96	0	0	43	41	12	1
Below Normal (BN)	76	0	0	37	32	7	0
Dry (D)	67	0	0	37	23	6	1
Critical (C)	53	0	0	34	17	3	-2

5.5 West Butte Inventory Unit

5.5.1 Overall Water Budget

Land surface inflows in West Butte average approximately 408 thousand acre-feet (taf) annually and include precipitation (188 taf), groundwater pumping (126 taf), and applied surface water (94 taf) (Figure 5.17, Figure 5.18, and Table 5.9). Precipitation varied from 98 taf in 2007 to 277 taf in 2011. Groundwater pumping varied from 88 taf in 2011 to 156 taf in 2007. Applied surface water varied from 81 taf in 2014 to 108 taf in 2000. Annual flows are provided in Table 5.9, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.18, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

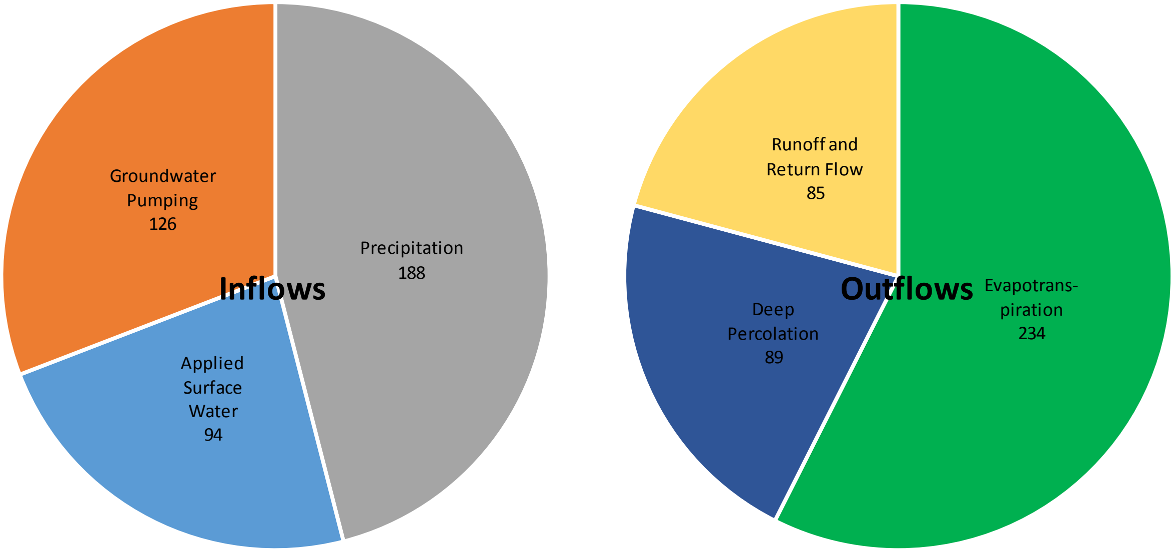

Figure 5.17. West Butte Overall Average Annual Inflows and Outflows, 2000-2014.

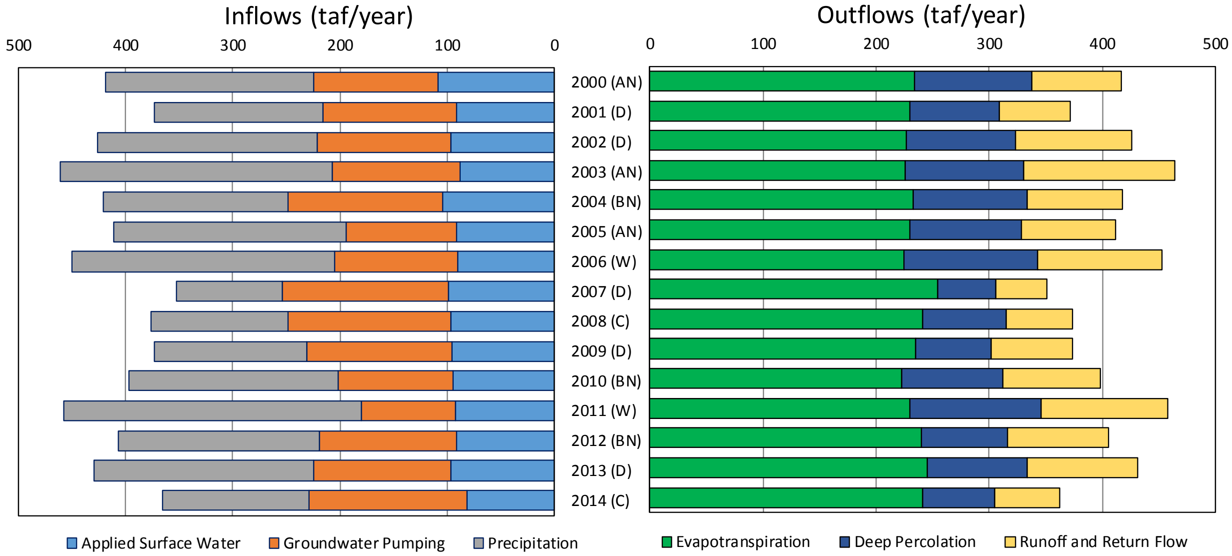

Figure 5.18. West Butte Overall Water Year Inflows and Outflows, 2000-2014.

Table 5.9. West Butte Overall Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	195	108	116	234	104	79	-2
2001 (D)	157	92	124	230	79	62	-1
2002 (D)	204	96	125	227	96	103	-1
2003 (AN)	253	88	120	225	106	134	4
2004 (BN)	173	104	144	233	101	84	-5
2005 (AN)	217	91	103	230	98	84	3
2006 (W)	246	90	115	224	118	110	0
2007 (D)	98	98	156	255	52	45	-2
2008 (C)	127	97	152	241	74	59	-3
2009 (D)	141	96	135	236	66	72	0
2010 (BN)	195	95	107	222	90	87	2
2011 (W)	277	92	88	230	116	113	-1
2012 (BN)	188	91	127	240	76	90	-1
2013 (D)	206	96	128	245	88	98	6
2014 (C)	137	81	148	241	64	57	-7
Minimum	98	81	88	222	52	45	-7
Maximum	277	108	156	255	118	134	6
Average	188	94	126	234	89	85	0
Averages by Hydrologic Year Type							
Wet (W)	261	91	102	227	117	111	-1
Above Normal (AN)	222	96	113	230	103	99	2
Below Normal (BN)	185	97	126	232	89	87	-1
Dry (D)	161	96	134	238	76	76	1
Critical (C)	132	89	150	241	69	58	-5

5.5.2 Irrigated Agriculture and Wetlands Water Budget

Inflows to irrigated agriculture and wetlands in West Butte average approximately 336 taf annually and include precipitation (126 taf), groundwater pumping (116 taf), and applied surface water (94 taf) (Figure 5.19, Figure 5.20, and Table 5.10). Precipitation varied from 62 taf in 2007 to 184 taf in 2011. Conversely, groundwater pumping varied from 79 taf in 2011 to

149 taf in 2007. Applied surface water varied from 81 taf in 2014 to 108 taf in 2000. Annual flows are provided in Table 5.10, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.20, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

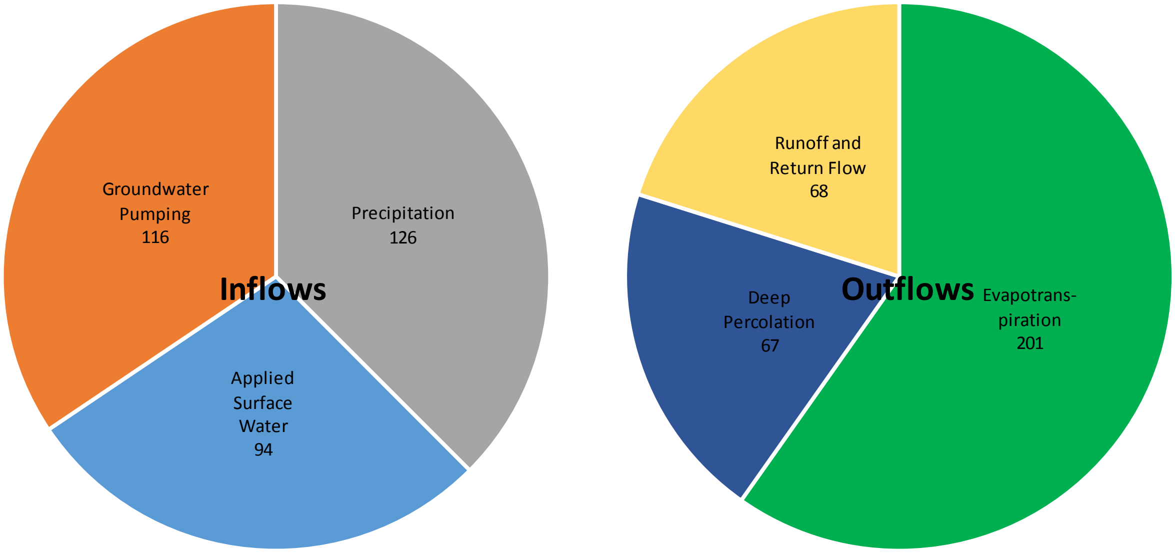

Figure 5.19. West Butte Irrigated Agriculture and Wetlands Average Annual Inflows and Outflows, 2000-2014.

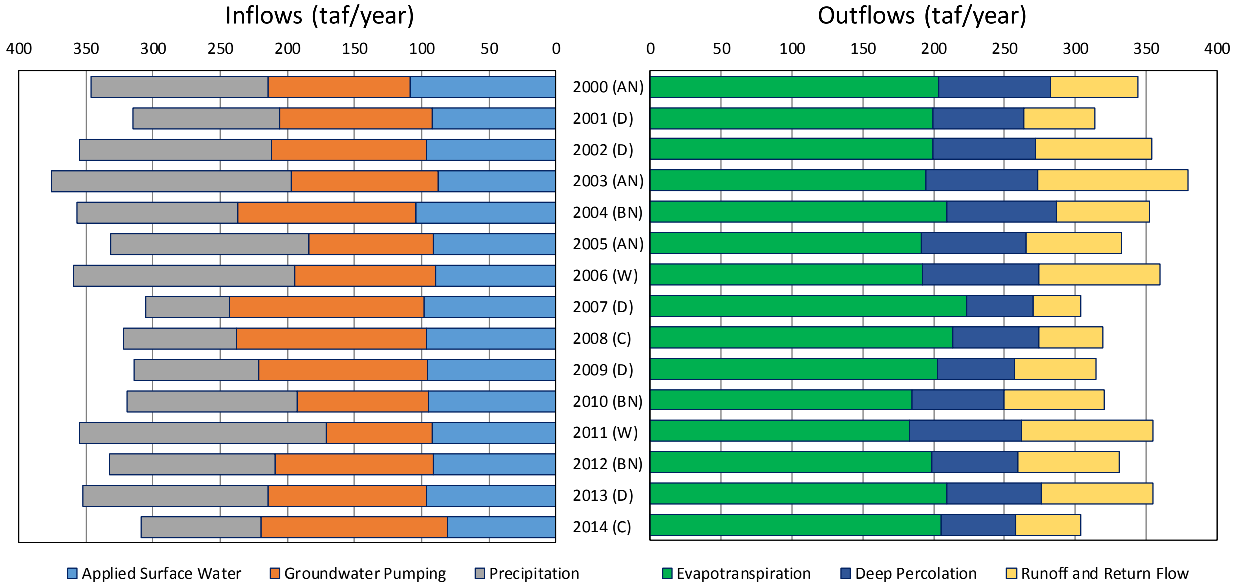

Figure 5.20. West Butte Irrigated Agriculture and Wetlands Water Year Inflows and Outflows, 2000-2014.

Table 5.10. West Butte Irrigated Agriculture and Wetlands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	132	108	106	204	79	61	-2
2001 (D)	109	92	114	200	64	50	-1
2002 (D)	143	96	115	200	72	82	-1
2003 (AN)	178	88	110	195	78	106	4
2004 (BN)	119	104	133	210	77	66	-4
2005 (AN)	147	91	93	192	74	68	2
2006 (W)	165	90	104	192	82	85	1
2007 (D)	62	98	145	223	46	34	-2
2008 (C)	84	97	141	213	61	45	-2
2009 (D)	94	96	125	203	54	58	0
2010 (BN)	127	95	97	185	64	71	2
2011 (W)	184	92	79	183	79	93	0
2012 (BN)	123	91	118	199	61	71	-1
2013 (D)	137	96	118	209	67	79	3
2014 (C)	89	81	139	205	53	46	-5
Minimum	62	81	79	183	46	34	-5
Maximum	184	108	145	223	82	106	4
Average	126	94	116	201	67	68	0
Averages by Hydrologic Year Type							
Wet (W)	174	91	92	188	81	89	0
Above Normal (AN)	152	96	103	197	77	78	1
Below Normal (BN)	123	97	116	198	67	70	-1
Dry (D)	109	96	124	207	61	60	0
Critical (C)	86	89	140	209	57	46	-3

5.5.3 Developed Lands Water Budget

The West Butte IU includes the City of Chico south of Big Chico Creek and the community of Durham. Inflows to developed lands in West Butte average approximately 29 taf annually and include precipitation (19 taf) and groundwater pumping (10 taf) (Figure 5.21, Figure 5.22, and Table 5.11). Precipitation varied from 10 taf in 2007 to 29 taf in 2011. Groundwater pumping has been relatively consistent over time, varying from approximately 9 taf to 11 taf annually with an average estimated pumping of 9 taf by water suppliers and 1 taf by rural residential pumpers. No surface water is delivered to meet demands for developed lands in West Butte. Annual flows are provided in Table 5.11, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.22, groundwater pumping was relatively steady from year to year between 2000 and 2014. Pumping for developed lands remains relatively steady due to insensitivity of indoor water demands to precipitation and less sensitivity of outdoor water use (irrigation) to precipitation than for irrigated agriculture. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

Some runoff and return flow from developed lands returns to the groundwater system through septic systems and stormwater retention while other runoff and return flow enters local waterways. Additional analysis is needed to refine estimates of the relative proportion of non-consumed water use on developed lands that returns to the surface water systems rather than returning to the groundwater system.

5.5.4 Non-Irrigated Lands Water Budget

Inflows to non-irrigated lands in West Butte average approximately 43 taf annually and include precipitation (Figure 5.23, Figure 5.24, and Table 5.12). Precipitation varied from 26 taf in 2007 to 64 taf in 2011. Annual flows are provided in Table 5.12, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.24, ET, deep percolation, and runoff vary over time largely in proportion to precipitation.

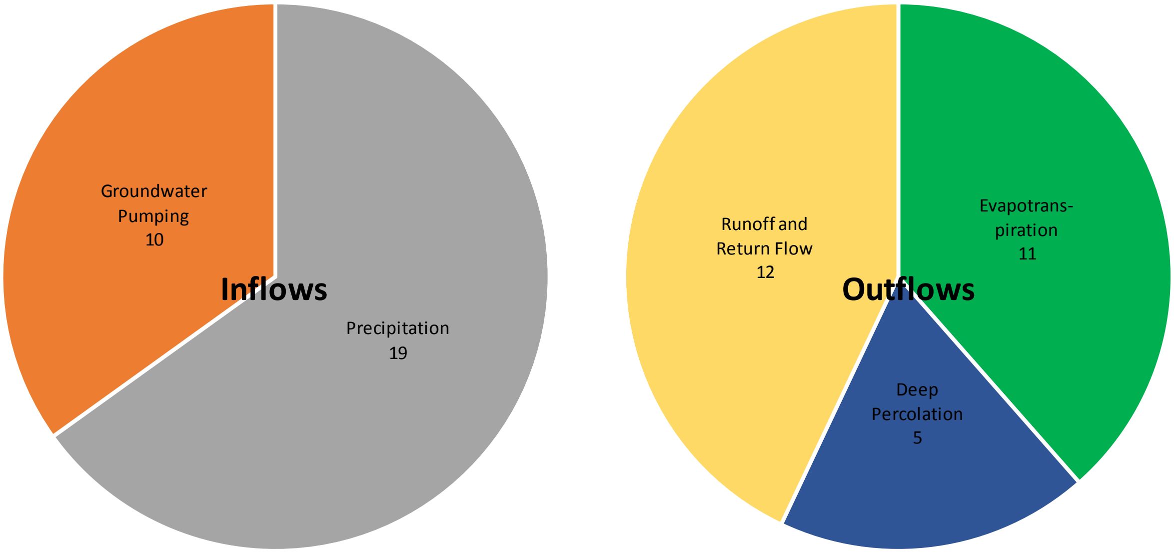

Figure 5.21. West Butte Developed Lands Average Annual Inflows and Outflows, 2000-2014.

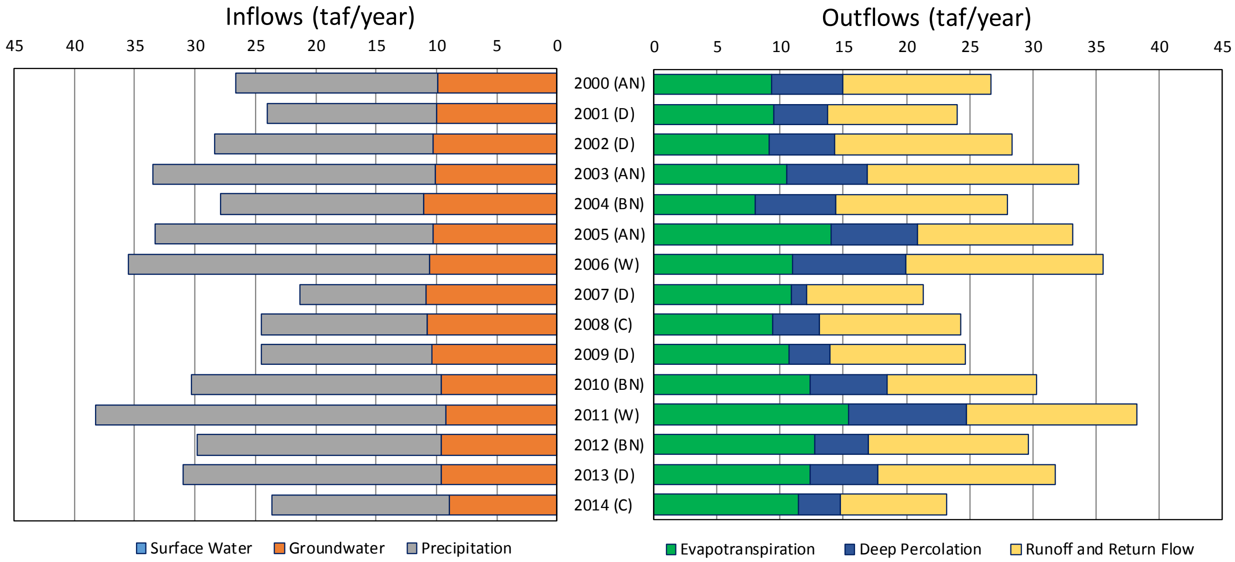

Figure 5.22. West Butte Developed Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.11. West Butte Developed Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	17	0	10	9	6	12	0
2001 (D)	14	0	10	10	4	10	0
2002 (D)	18	0	10	9	5	14	0
2003 (AN)	23	0	10	10	6	17	0
2004 (BN)	17	0	11	8	6	14	0
2005 (AN)	23	0	10	14	7	12	0
2006 (W)	25	0	11	11	9	16	0
2007 (D)	10	0	11	11	1	9	0
2008 (C)	14	0	11	9	4	11	0
2009 (D)	14	0	10	11	3	11	0
2010 (BN)	21	0	10	12	6	12	0
2011 (W)	29	0	9	15	9	14	0
2012 (BN)	20	0	10	13	4	13	0
2013 (D)	21	0	10	12	5	14	1
2014 (C)	15	0	9	11	3	8	0
Minimum	10	0	9	8	1	8	0
Maximum	29	0	11	15	9	17	1
Average	19	0	10	11	5	12	0
Averages by Hydrologic Year Type							
Wet (W)	27	0	10	13	9	15	0
Above Normal (AN)	21	0	10	11	6	14	0
Below Normal (BN)	19	0	10	11	6	13	0
Dry (D)	16	0	10	11	4	12	0
Critical (C)	14	0	10	10	3	10	0

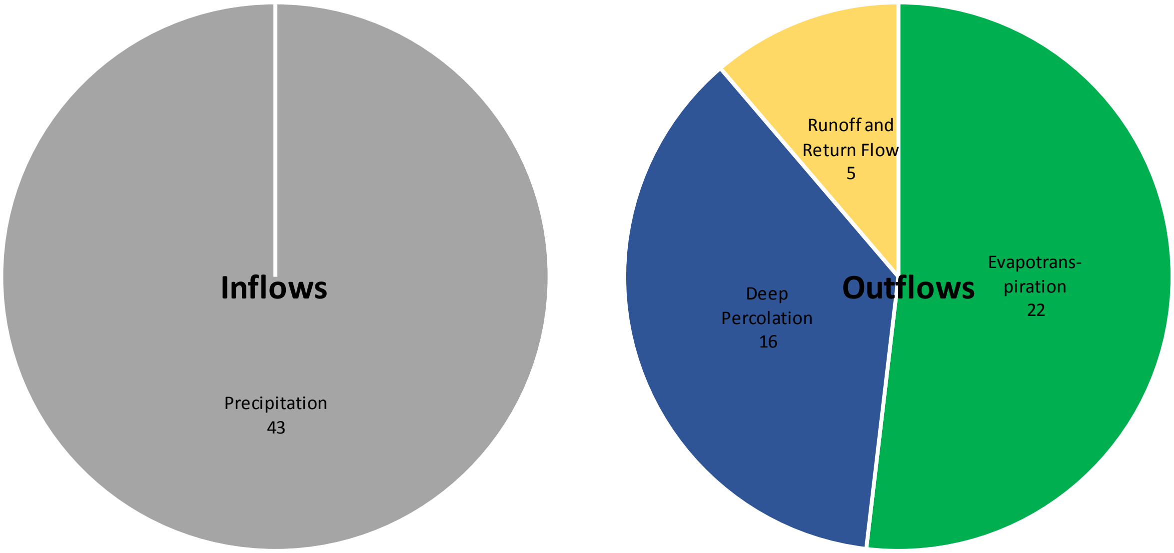

Figure 5.23. West Butte Non-Irrigated Lands Average Annual Inflows and Outflows, 2000-2014.

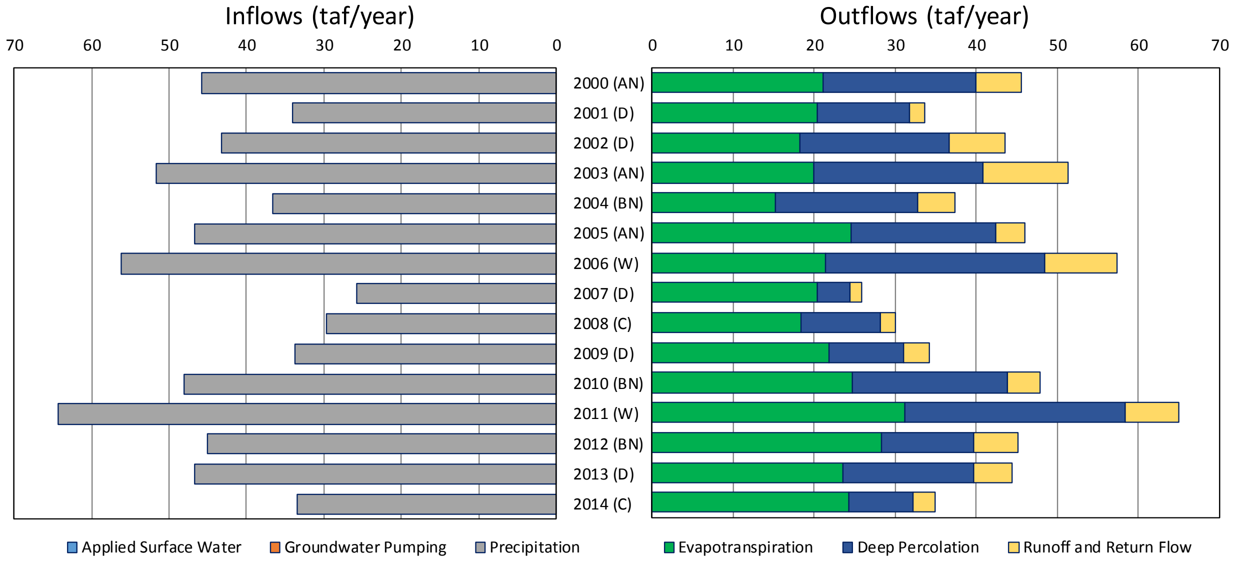

Figure 5.24. West Butte Non-Irrigated Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.12. West Butte Non-Irrigated Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	46	0	0	21	19	6	0
2001 (D)	34	0	0	20	11	2	0
2002 (D)	43	0	0	18	18	7	0
2003 (AN)	52	0	0	20	21	11	0
2004 (BN)	37	0	0	15	18	5	-1
2005 (AN)	47	0	0	25	18	4	1
2006 (W)	56	0	0	21	27	9	-1
2007 (D)	26	0	0	20	4	2	0
2008 (C)	30	0	0	18	10	2	0
2009 (D)	34	0	0	22	9	3	0
2010 (BN)	48	0	0	25	19	4	0
2011 (W)	64	0	0	31	27	6	-1
2012 (BN)	45	0	0	28	11	5	0
2013 (D)	47	0	0	23	16	5	2
2014 (C)	33	0	0	24	8	3	-1
Minimum	26	0	0	15	4	2	-1
Maximum	64	0	0	31	27	11	2
Average	43	0	0	22	16	5	0
Averages by Hydrologic Year Type							
Wet (W)	60	0	0	26	27	8	-1
Above Normal (AN)	48	0	0	22	19	7	0
Below Normal (BN)	43	0	0	23	16	5	0
Dry (D)	37	0	0	21	12	4	0
Critical (C)	32	0	0	21	9	2	-1

5.6 East Butte Inventory Unit

5.6.1 Overall Water Budget

Land surface inflows in East Butte average approximately 1.17 million acre-feet (maf) annually and include applied surface water (601 taf), precipitation (441 taf), and groundwater pumping (124 taf) (Figure 5.25, Figure 5.26, and Table 5.13). Precipitation varied from 291 taf in 2008 to 636 taf in 2006. Groundwater pumping varied from 105 taf in 2011 to 152 taf in 2014. Applied surface water varied from 540 taf in 2014 to 663 taf in 2007. Annual flows are provided in Table 5.13, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.26, applied surface water was relatively steady from year to year between 2000 and 2014. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

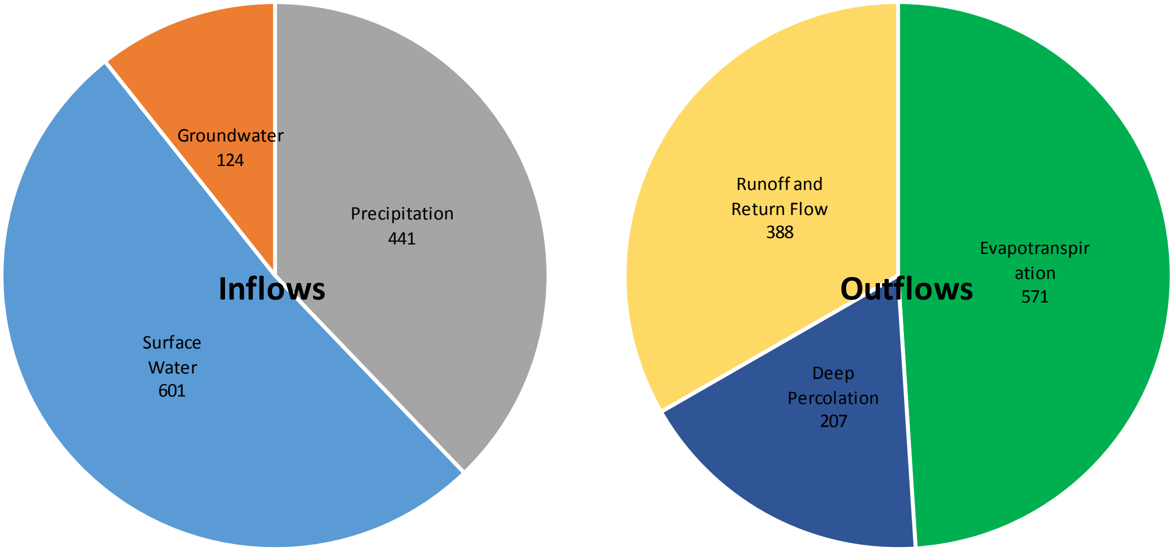

Figure 5.25. East Butte Overall Average Annual Inflows and Outflows, 2000-2014.

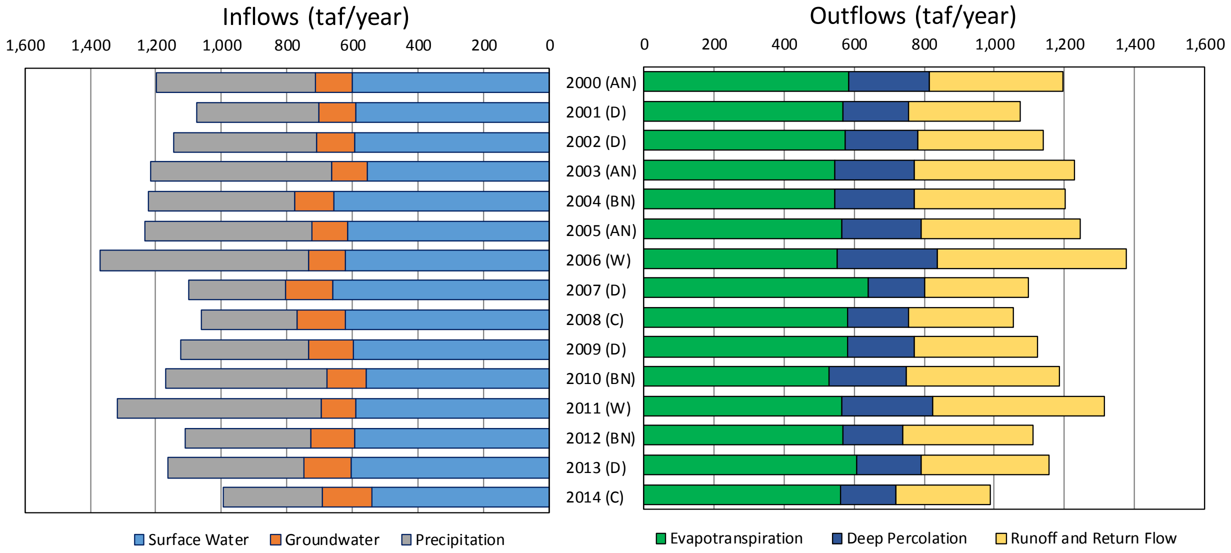

Figure 5.26. East Butte Overall Water Year Inflows and Outflows, 2000-2014.

Table 5.13. East Butte Overall Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	483	601	113	585	230	381	-1
2001 (D)	372	592	112	567	187	319	-2
2002 (D)	437	596	113	576	205	359	-8
2003 (AN)	550	556	108	544	226	458	16
2004 (BN)	443	657	121	546	224	433	-21
2005 (AN)	508	616	108	565	228	453	18
2006 (W)	636	622	112	552	285	540	5
2007 (D)	292	663	144	641	159	296	4
2008 (C)	291	622	147	581	175	298	-13
2009 (D)	391	596	137	581	191	352	4
2010 (BN)	493	558	120	528	221	437	14
2011 (W)	624	589	105	565	258	490	-2
2012 (BN)	381	596	133	566	172	371	-5
2013 (D)	414	606	142	607	184	366	5
2014 (C)	302	540	152	561	157	272	-9
Minimum	291	540	105	528	157	272	-21
Maximum	636	663	152	641	285	540	18
Average	441	601	124	571	207	388	0
Averages by Hydrologic Year Type							
Wet (W)	630	606	109	559	272	515	1
Above Normal (AN)	514	591	110	565	228	431	11
Below Normal (BN)	439	604	125	547	205	414	-4
Dry (D)	381	611	129	594	185	338	1
Critical (C)	297	581	150	571	166	285	-11

5.6.2 Irrigated Agriculture and Wetlands Water Budget

Inflows to irrigated agriculture and wetlands in East Butte average approximately 987 taf annually and include precipitation (269 taf), applied surface water (598 taf), and groundwater pumping (120 taf) (Figure 5.27, Figure 5.28, and Table 5.14). Precipitation varied from 172 taf in 2007 to 394 taf in 2011. Groundwater pumping varied from 100 taf in 2011 to 147 taf in

2014. Applied surface water varied from 538 taf in 2014 to 661 taf in 2007. Annual flows are provided in Table 5.14, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.28, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. Variations result from varying cropped acreage, including idling-based water transfers and differences in annual precipitation timing and amounts and corresponding impacts on crop water requirements. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

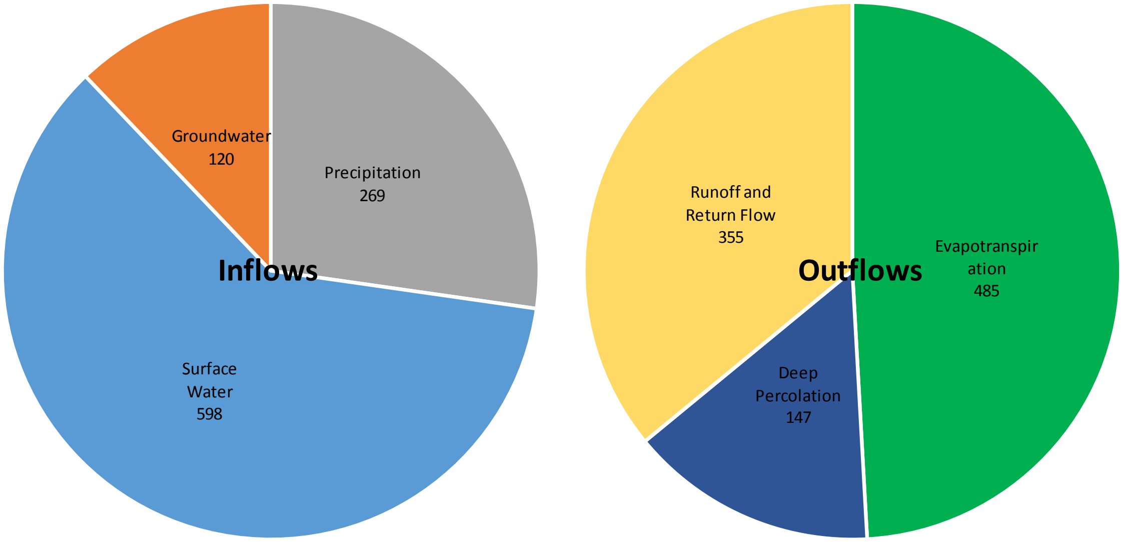

Figure 5.27. East Butte Irrigated Agriculture and Wetlands Average Annual Inflows and Outflows, 2000-2014.

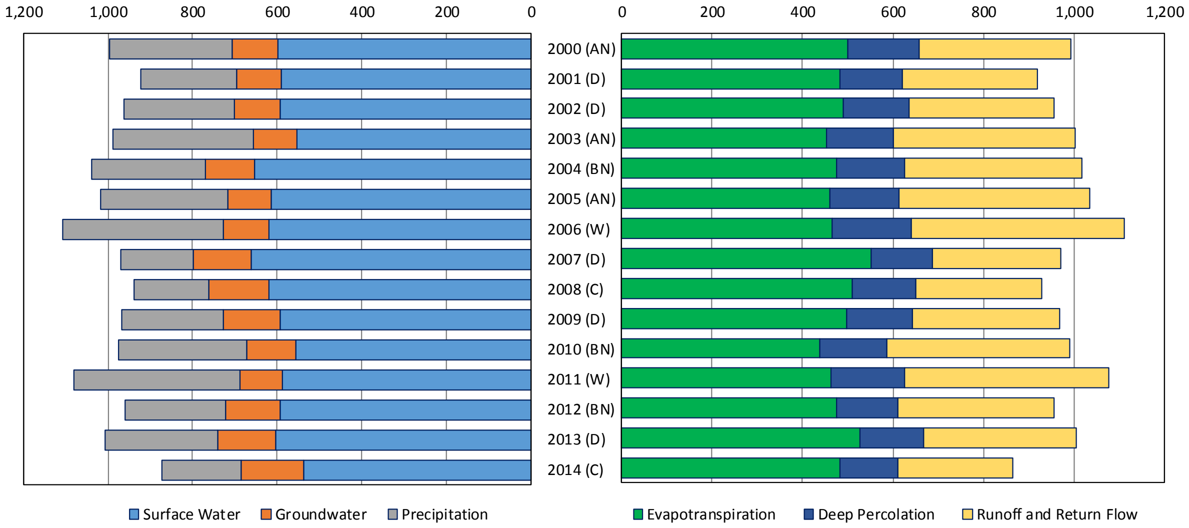

Figure 5.28. East Butte Irrigated Agriculture and Wetlands Water Year Inflows and Outflows, 2000-2014.

Table 5.14. East Butte Irrigated Agriculture and Wetlands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	288	599	109	501	158	335	-2
2001 (D)	225	589	107	482	139	299	-2
2002 (D)	261	593	108	491	144	320	-7
2003 (AN)	330	553	104	452	148	402	15
2004 (BN)	267	654	117	476	150	392	-20
2005 (AN)	302	613	104	460	154	421	17
2006 (W)	380	620	107	465	175	472	6
2007 (D)	172	661	138	551	138	283	0
2008 (C)	177	620	142	511	139	280	-9
2009 (D)	241	594	132	498	145	326	1
2010 (BN)	305	556	115	438	148	403	14
2011 (W)	394	587	100	462	164	451	-4
2012 (BN)	238	594	127	475	136	346	-2
2013 (D)	267	604	136	527	141	338	-1
2014 (C)	187	538	147	483	129	253	-7
Minimum	172	538	100	438	129	253	-20
Maximum	394	661	147	551	175	472	17
Average	269	598	120	485	147	355	0
Averages by Hydrologic Year Type							
Wet (W)	387	604	103	463	170	462	1
Above Normal (AN)	306	588	105	471	153	386	10
Below Normal (BN)	270	601	120	463	145	380	-3
Dry (D)	233	608	124	510	141	313	-2
Critical (C)	182	579	144	497	134	267	-8

5.6.3 Developed Lands Water Budget

The East Butte IU includes the City of Oroville north and west of the Feather River, the cities of Gridley and Biggs, and the communities of Richvale and Thermalito. Inflows to developed lands in East Butte average approximately 38 taf annually and include precipitation (31 taf), groundwater pumping (5 taf), and applied surface water (2 taf) (Figure 5.29, Figure 5.30, and Table 5.15). Precipitation varied from 20 taf in 2008 to 43 taf in 2011. Groundwater pumping has been relatively consistent over time, varying from approximately 4 taf to 6 taf annually with an average estimated pumping of 3 taf by water suppliers and 2 taf by rural residential pumpers. Approximately 2 taf of surface water is delivered to meet demands for developed lands in East Butte. Annual flows are provided in Table 5.15, along with the water year type as discussed in Section 4.2.

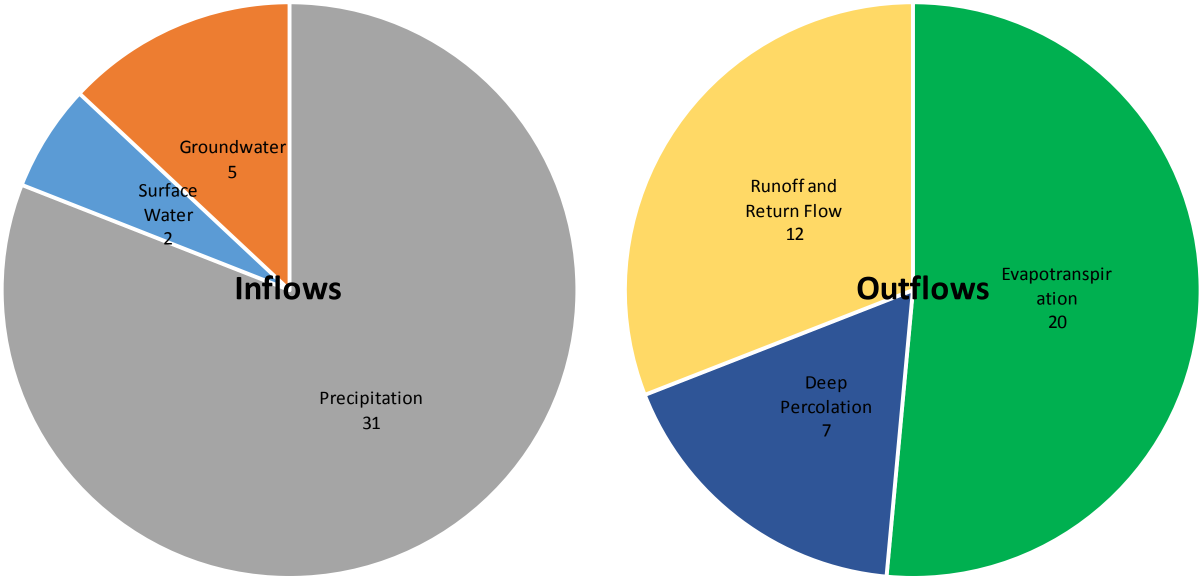

Figure 5.29. East Butte Developed Lands Average Annual Inflows and Outflows, 2000-2014.

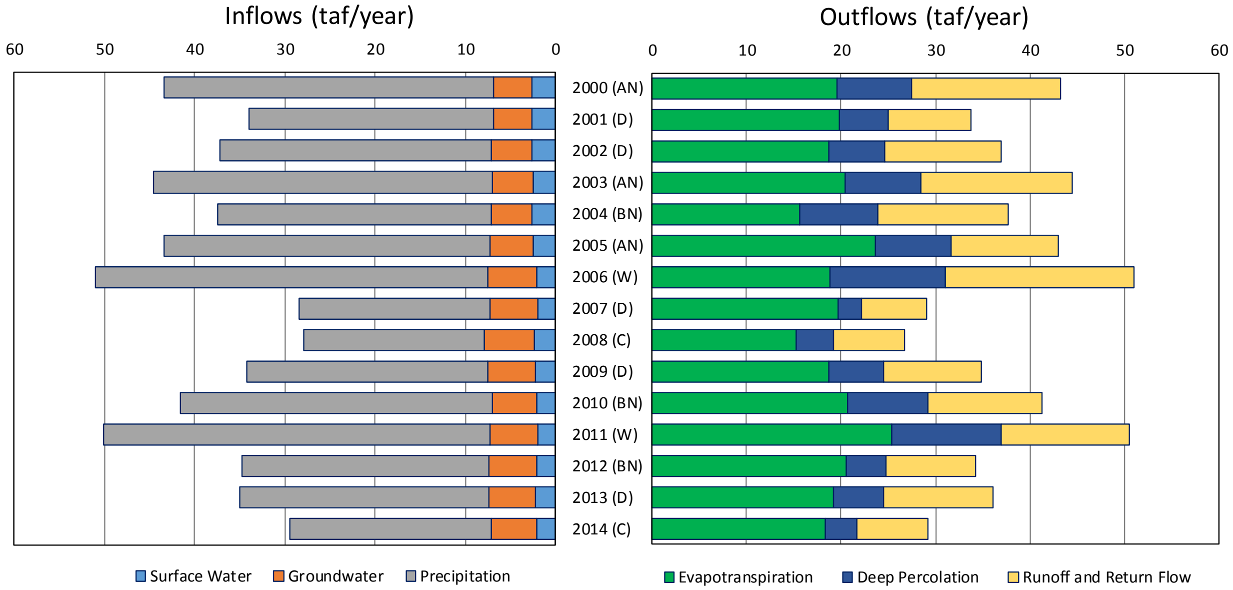

Figure 5.30. East Butte Developed Lands Water Year Inflows and Outflows, 2000-2014.

As indicated in Figure 5.30, groundwater pumping was relatively steady from year to year between 2000 and 2014. Pumping for developed lands remains relatively steady due to insensitivity of indoor water demands to precipitation and less sensitivity of outdoor water use (irrigation) to precipitation than for irrigated agriculture. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

Table 5.15. East Butte Developed Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	36	3	4	20	8	16	0
2001 (D)	27	3	4	20	5	9	0
2002 (D)	30	3	5	19	6	12	0
2003 (AN)	38	3	4	20	8	16	0
2004 (BN)	30	3	5	16	8	14	0
2005 (AN)	36	2	5	24	8	11	0
2006 (W)	43	2	5	19	12	20	0
2007 (D)	21	2	5	20	2	7	1
2008 (C)	20	2	6	15	4	8	-1
2009 (D)	27	2	5	19	6	10	1
2010 (BN)	34	2	5	21	8	12	0
2011 (W)	43	2	5	25	12	13	0
2012 (BN)	27	2	5	21	4	9	-1
2013 (D)	28	2	5	19	5	12	1
2014 (C)	22	2	5	18	3	8	0
Minimum	20	2	4	15	2	7	-1
Maximum	43	3	6	25	12	20	1
Average	31	2	5	20	7	12	0
Averages by Hydrologic Year Type							
Wet (W)	43	2	5	22	12	17	0
Above Normal (AN)	37	3	5	21	8	14	0
Below Normal (BN)	31	2	5	19	7	12	0
Dry (D)	26	2	5	19	5	10	0
Critical (C)	21	2	5	17	4	8	-1

Some runoff and return flow from developed lands returns to the groundwater system through septic systems and stormwater retention while other runoff and return flow enters local waterways. Additional analysis is needed to refine estimates of the relative proportion of non-consumed water use on developed lands that returns to the surface water systems rather than returning to the groundwater system.

5.6.4 Non-Irrigated Lands Water Budget

Inflows to non-irrigated lands in East Butte average approximately 141 taf annually and include precipitation (Figure 5.31, Figure 5.32, and Table 5.16). Precipitation varied from 93 taf in 2014 to 213 taf in 2006. Annual flows are provided in Table 5.16, along with the water year type as discussed in Section 4.2. As indicated in Figure 5.32, ET, deep percolation, and runoff vary over time largely in proportion to precipitation.

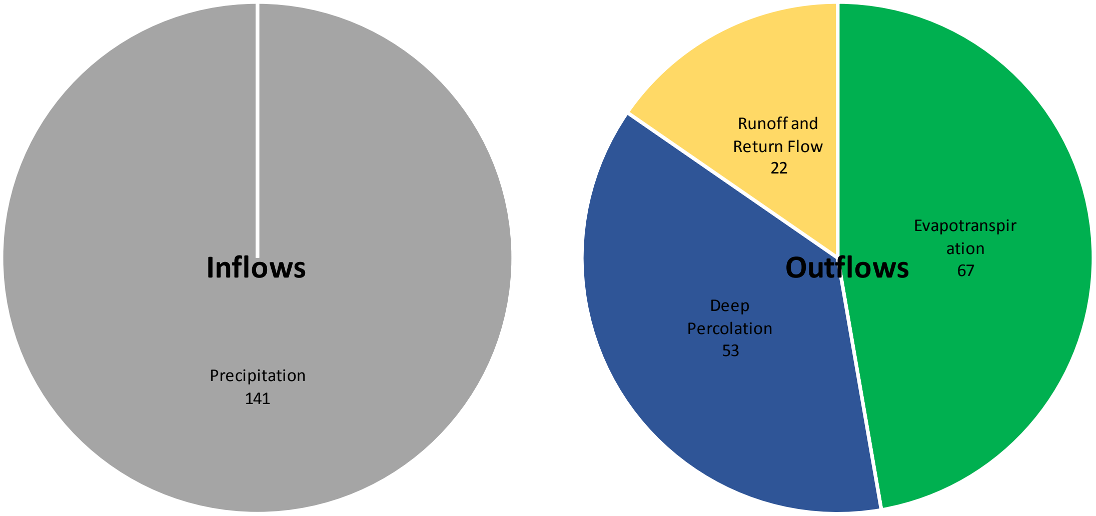

Figure 5.31. East Butte Non-Irrigated Lands Average Annual Inflows and Outflows, 2000-2014.

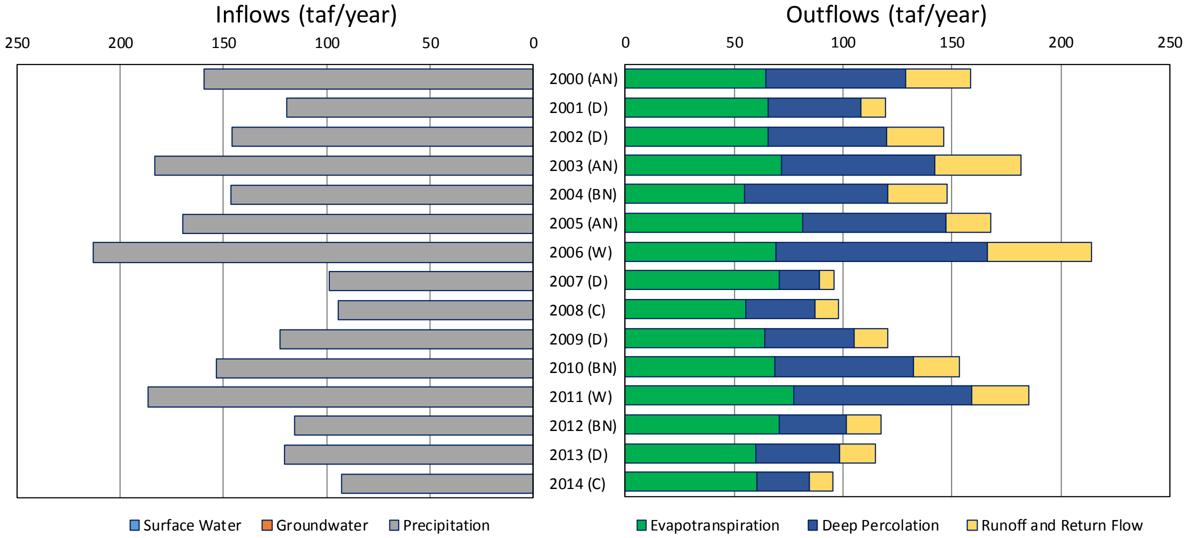

Figure 5.32. East Butte Non-Irrigated Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.16. East Butte Non-Irrigated Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf) Precipi-tation	Surface Water	Ground-water	Outflows (taf) Evapotrans-piration	Deep Percolation	Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	159	0	0	64	64	30	0
2001 (D)	119	0	0	66	42	11	0
2002 (D)	146	0	0	66	54	27	-1
2003 (AN)	183	0	0	72	70	40	2
2004 (BN)	146	0	0	55	66	27	-1
2005 (AN)	170	0	0	82	66	21	2
2006 (W)	213	0	0	69	98	48	-1
2007 (D)	99	0	0	71	19	6	3
2008 (C)	94	0	0	56	32	10	-4
2009 (D)	123	0	0	64	41	16	2
2010 (BN)	154	0	0	69	64	22	0
2011 (W)	187	0	0	77	82	26	1
2012 (BN)	115	0	0	70	31	16	-2
2013 (D)	120	0	0	60	38	16	5
2014 (C)	93	0	0	60	24	11	-3
Minimum	93	0	0	55	19	6	-4
Maximum	213	0	0	82	98	48	5
Average	141	0	0	67	53	22	0
Averages by Hydrologic Year Type							
Wet (W)	200	0	0	73	90	37	0
Above Normal (AN)	171	0	0	73	67	30	1
Below Normal (BN)	138	0	0	65	54	21	-1
Dry (D)	121	0	0	65	39	15	2
Critical (C)	94	0	0	58	28	11	-3

5.7 North Yuba Inventory Unit

5.7.1 Overall Water Budget

Land surface inflows in North Yuba average approximately 169 thousand acre-feet (taf) annually and include precipitation (106 taf), groundwater pumping (52 taf), and applied surface water (12 taf) (Figure 5.33, Figure 5.34, and Table 5.17). Precipitation varied from 64 taf in 2008 to 157 taf in 2006. Groundwater pumping varied from 41 taf in 2011 to 62 taf in 2008.

Applied surface water has been relatively steady over time, varying from 11 taf to 13 taf and averaging 12 taf. Annual flows are provided in Table 5.17, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.34, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

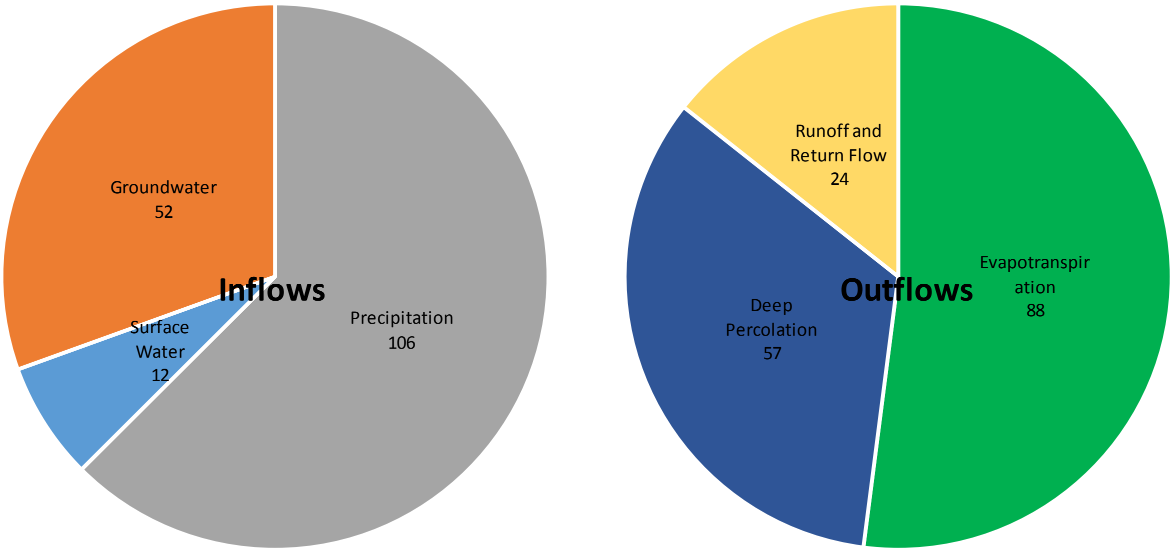

Figure 5.33. North Yuba Overall Average Annual Inflows and Outflows, 2000-2014.

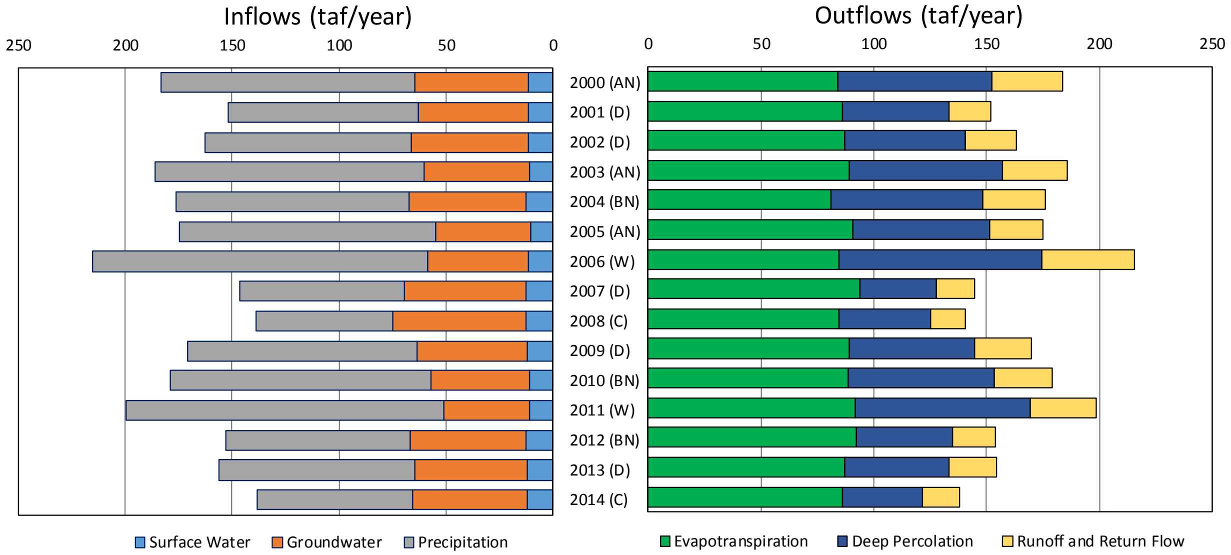

Figure 5.34. North Yuba Overall Water Year Inflows and Outflows, 2000-2014.

Table 5.17. North Yuba Overall Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	119	11	53	84	68	31	1
2001 (D)	89	12	51	86	47	18	0
2002 (D)	96	12	55	87	53	23	1
2003 (AN)	125	11	49	89	68	29	1
2004 (BN)	109	13	55	81	67	28	-1
2005 (AN)	120	11	44	91	61	24	1
2006 (W)	157	12	47	85	90	41	-1
2007 (D)	77	12	57	94	34	17	3
2008 (C)	64	13	62	84	41	16	-3
2009 (D)	107	12	51	89	55	25	1
2010 (BN)	122	11	46	89	65	26	0
2011 (W)	148	11	41	92	78	29	0
2012 (BN)	86	13	54	92	43	19	0
2013 (D)	91	12	53	87	46	21	1
2014 (C)	73	12	54	86	36	16	-1
Minimum	64	11	41	81	34	16	-3
Maximum	157	13	62	94	90	41	3
Average	106	12	52	88	57	24	0
Averages by Hydrologic Year Type							
Wet (W)	153	11	44	88	84	35	0
Above Normal (AN)	121	11	49	88	66	28	1
Below Normal (BN)	106	12	51	87	58	24	0
Dry (D)	92	12	54	89	47	21	1
Critical (C)	68	12	58	85	38	16	-2

5.7.2 Irrigated Agriculture and Wetlands Water Budget

Inflows to irrigated agriculture and wetlands in North Yuba average approximately 93 taf annually and include precipitation (35 taf), groundwater pumping (51 taf), and applied surface water (8 taf) (Figure 5.35, Figure 5.36, and Table 5.18). Precipitation varied from 21 taf in 2008 to 53 taf in 2006. Groundwater pumping varied from 40 taf in 2011 to 61 taf in 2008. Applied surface water has been relatively steady over time, varying from 7 taf to 9 taf and averaging 8 taf. Annual flows are provided in Table 5.18, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.36, applied surface water was relatively steady from year to year between 2000 and 2014, with greater variability in groundwater pumping. In general, pumping increases in dry years due to increased irrigation requirements resulting from decreased precipitation. With respect to outflows, total ET is relatively steady over time, with variability in deep percolation and surface water runoff varying largely in proportion to annual precipitation.

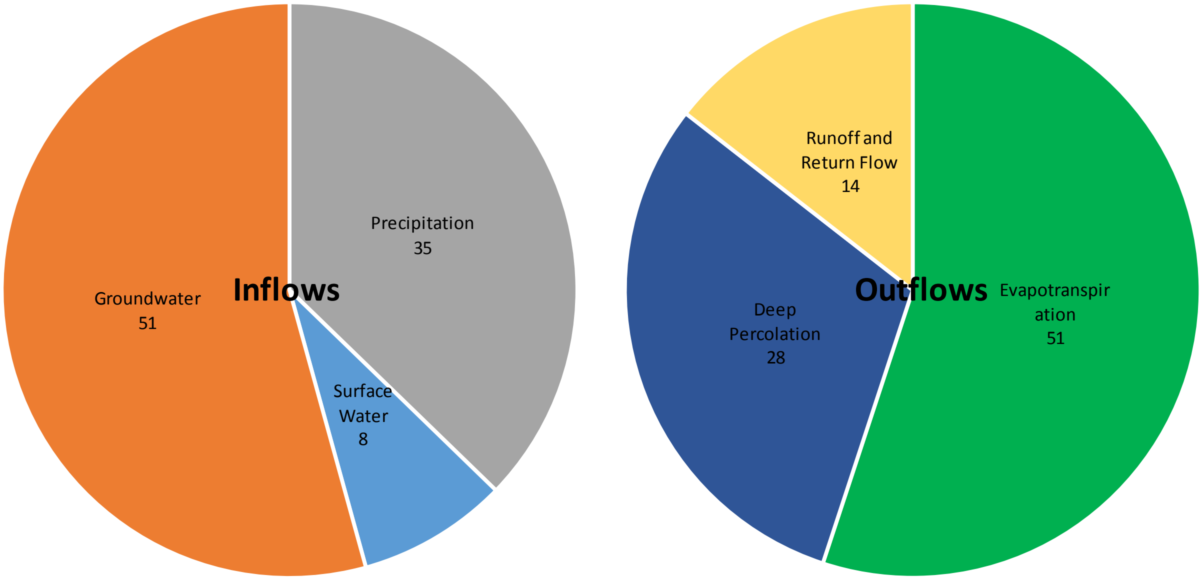

Figure 5.35. North Yuba Irrigated Agriculture and Wetlands Average Annual Inflows and Outflows, 2000-2014.

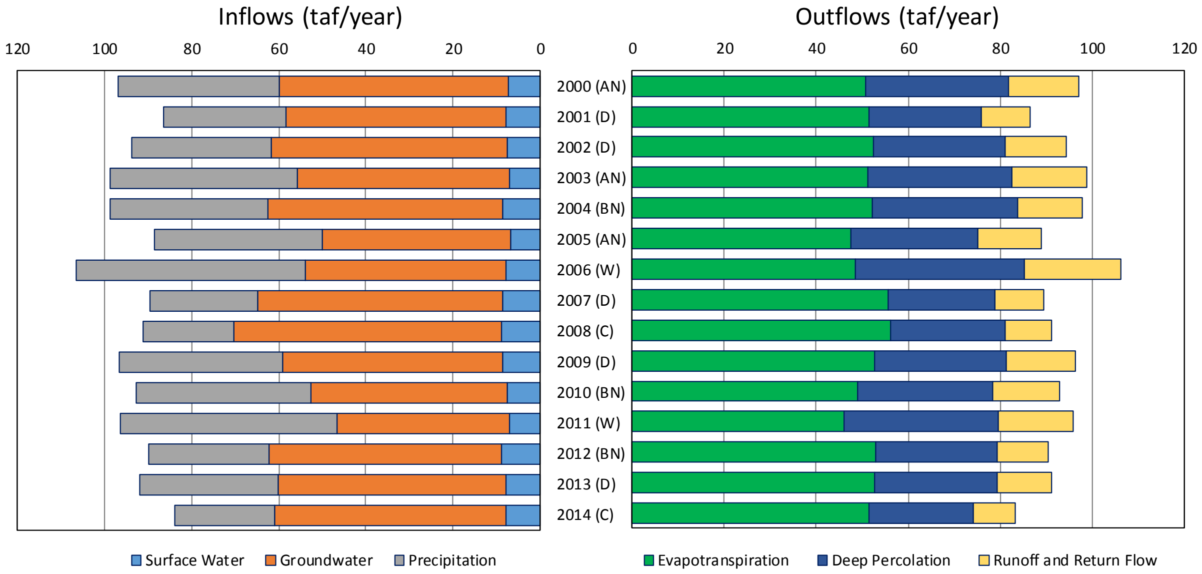

Figure 5.36. North Yuba Irrigated Agriculture and Wetlands Water Year Inflows and Outflows, 2000-2014.

Table 5.18. North Yuba Irrigated Agriculture and Wetlands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	**Precipi-tation**	**Surface Water**	**Ground-water**	**Evapotrans-piration**	**Deep Percolation**	**Runoff and Return Flow**	**Change in Storage (taf)**
2000 (AN)	37	7	52	51	31	15	0
2001 (D)	28	8	51	52	24	11	0
2002 (D)	32	8	54	53	29	13	1
2003 (AN)	43	7	49	51	31	16	0
2004 (BN)	36	9	54	52	31	14	-1
2005 (AN)	38	7	43	47	28	14	0
2006 (W)	53	8	46	48	37	21	0
2007 (D)	25	9	56	56	23	11	0
2008 (C)	21	9	61	56	25	10	0
2009 (D)	37	9	51	53	29	15	0
2010 (BN)	40	8	45	49	29	15	0
2011 (W)	50	7	40	46	34	16	-1
2012 (BN)	28	9	53	53	26	11	0
2013 (D)	32	8	52	53	26	12	-1
2014 (C)	23	8	53	52	23	9	-1
Minimum	21	7	40	46	23	9	-1
Maximum	53	9	61	56	37	21	1
Average	35	8	51	51	28	14	0
Averages by Hydrologic Year Type							
Wet (W)	51	7	43	47	35	19	0
Above Normal (AN)	39	7	48	50	30	15	0
Below Normal (BN)	35	8	51	51	29	13	0
Dry (D)	31	8	53	53	26	12	0
Critical (C)	22	8	57	54	24	10	0

5.7.3 Developed Lands Water Budget

The North Yuba IU includes the City of Oroville south and east of the Feather River and the communities of Palermo and Honcut. Inflows to developed lands in North Yuba average approximately 25 taf annually and include precipitation (20 taf), applied surface water (4 taf), and groundwater pumping (1 taf) (Figure 5.37, Figure 5.38, and Table 5.19). Precipitation varied from 13 taf in 2008 to 32 taf in 2011. Surface water deliveries and groundwater pumping have been relatively consistent over time, averaging 4 taf and 1 taf, respectively. Approximately 100 af of groundwater is pumped by water suppliers annually, with 800 af pumped by rural residents. Annual flows are provided in Table 5.19, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.38, applied surface water and groundwater pumping were relatively steady from year to year between 2000 and 2014. Applied surface water and pumping for developed lands remain relatively steady due to insensitivity of indoor water demands to precipitation and less sensitivity of outdoor water use (irrigation) to precipitation than for irrigated agriculture. With respect to outflows, total ET is greatest in wet years and least in dry years, with variability in deep percolation and surface water runoff also varying largely in proportion to annual precipitation.

Some runoff and return flow from developed lands returns to the groundwater system through septic systems and stormwater retention while other runoff and return flow enters local waterways. Additional analysis is needed to refine estimates of the relative proportion of non-consumed water use on developed lands that returns to the surface water systems rather than returning to the groundwater system.

5.7.4 Non-Irrigated Lands Water Budget

Inflows to non-irrigated lands in North Yuba average approximately 51 taf annually and include precipitation (Figure 5.39, Figure 5.40, and Table 5.20). Precipitation varied from 30 taf in 2008 to 75 taf in 2006. Annual flows are provided in Table 5.20, along with the water year type as discussed in Section 4.2.

As indicated in Figure 5.40, ET, deep percolation, and runoff vary over time largely in proportion to precipitation.

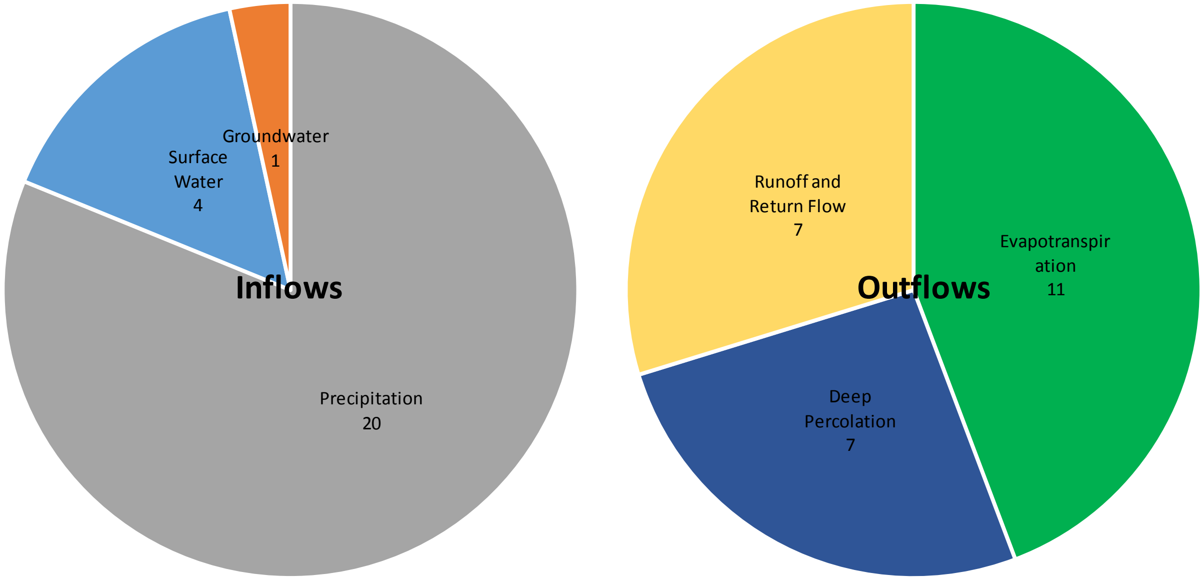

Figure 5.37. North Yuba Developed Lands Average Annual Inflows and Outflows, 2000-2014.

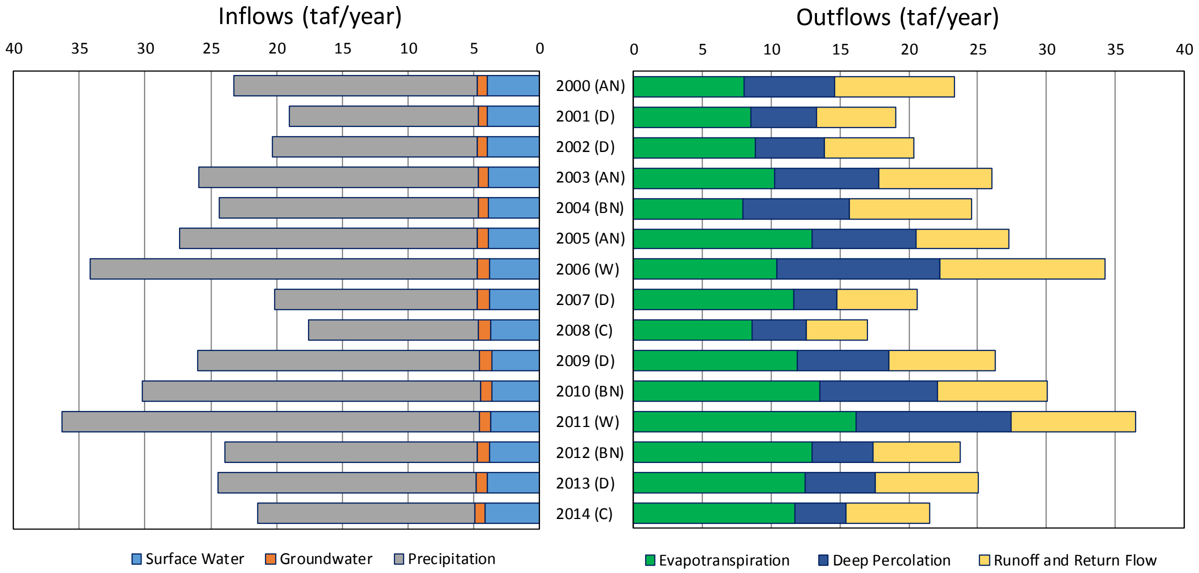

Figure 5.38. North Yuba Developed Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.19. North Yuba Developed Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipitation	Surface Water	Groundwater	Evapotranspiration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	19	4	1	8	7	9	0
2001 (D)	14	4	1	9	5	6	0
2002 (D)	16	4	1	9	5	6	0
2003 (AN)	21	4	1	10	8	8	0
2004 (BN)	20	4	1	8	8	9	0
2005 (AN)	23	4	1	13	8	7	0
2006 (W)	29	4	1	10	12	12	0
2007 (D)	15	4	1	12	3	6	1
2008 (C)	13	4	1	9	4	5	-1
2009 (D)	21	4	1	12	7	8	0
2010 (BN)	26	4	1	14	9	8	0
2011 (W)	32	4	1	16	11	9	0
2012 (BN)	19	4	1	13	4	6	0
2013 (D)	20	4	1	13	5	7	1
2014 (C)	17	4	1	12	4	6	0
Minimum	13	4	1	8	3	5	-1
Maximum	32	4	1	16	12	12	1
Average	20	4	1	11	7	7	0
Averages by Hydrologic Year Type							
Wet (W)	31	4	1	13	12	11	0
Above Normal (AN)	21	4	1	10	7	8	0
Below Normal (BN)	22	4	1	11	7	8	0
Dry (D)	17	4	1	11	5	7	0
Critical (C)	15	4	1	10	4	5	0

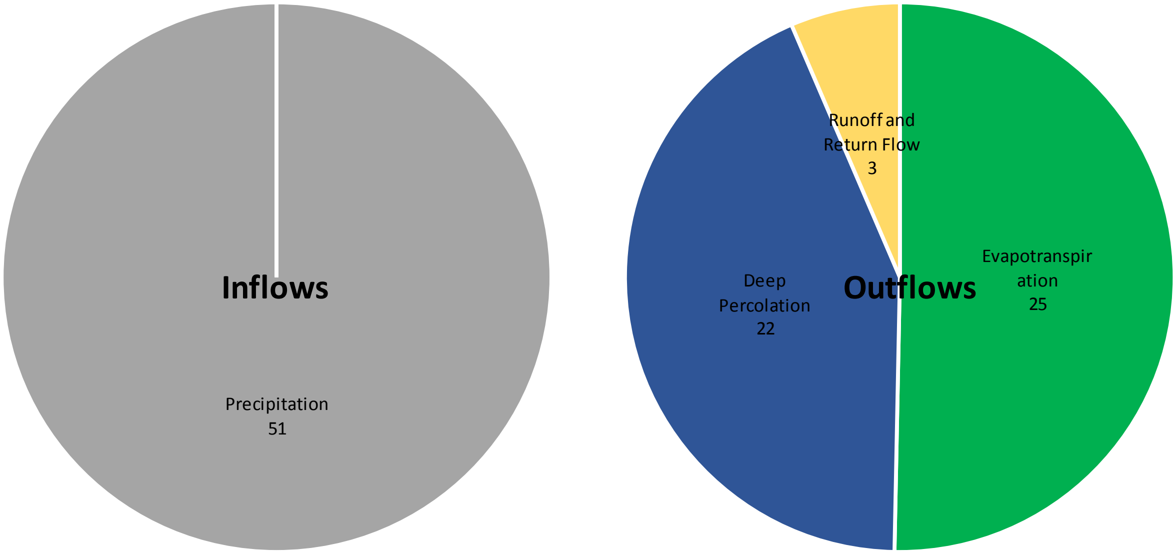

Figure 5.39. North Yuba Non-Irrigated Lands Average Annual Inflows and Outflows, 2000-2014.

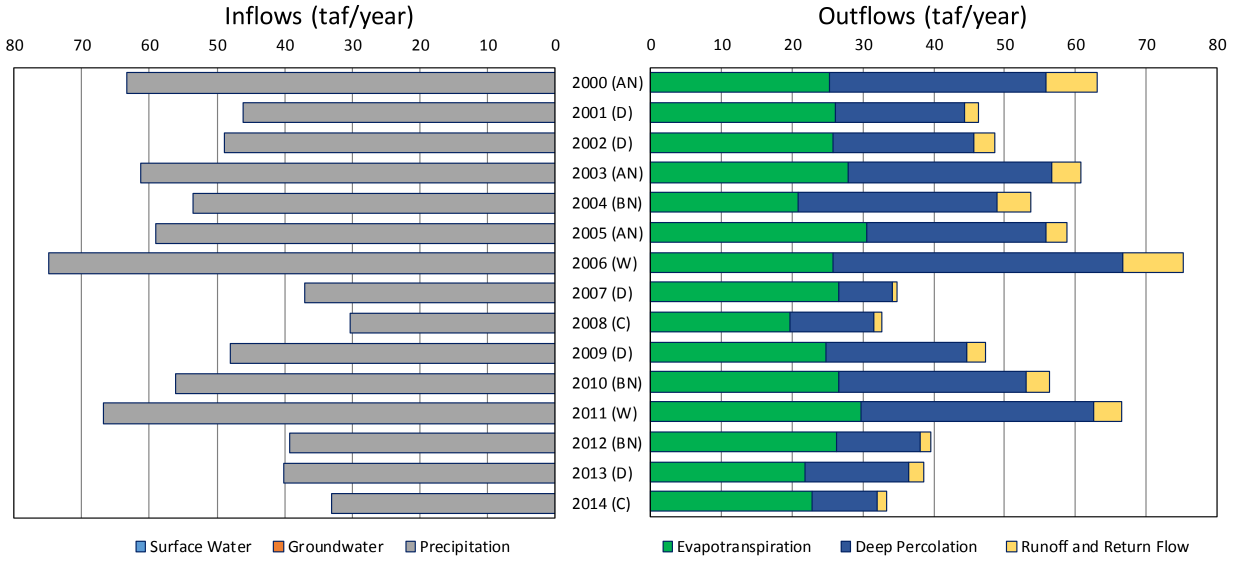

Figure 5.40. North Yuba Non-Irrigated Lands Water Year Inflows and Outflows, 2000-2014.

Table 5.20. North Yuba Non-Irrigated Lands Water Year Inflows, Outflows, and Change in Storage, 2000-2014.

	Inflows (taf)			Outflows (taf)			
Water Year	**Precipi-tation**	**Surface Water**	**Ground-water**	**Evapotrans-piration**	**Deep Percolation**	**Runoff and Return Flow**	**Change in Storage (taf)**
2000 (AN)	63	0	0	25	31	7	0
2001 (D)	46	0	0	26	18	2	0
2002 (D)	49	0	0	26	20	3	0
2003 (AN)	61	0	0	28	29	4	1
2004 (BN)	53	0	0	21	28	5	0
2005 (AN)	59	0	0	31	25	3	0
2006 (W)	75	0	0	26	41	8	0
2007 (D)	37	0	0	27	8	1	2
2008 (C)	30	0	0	20	12	1	-2
2009 (D)	48	0	0	25	20	3	1
2010 (BN)	56	0	0	27	27	3	0
2011 (W)	67	0	0	30	33	4	0
2012 (BN)	39	0	0	26	12	2	0
2013 (D)	40	0	0	22	15	2	1
2014 (C)	33	0	0	23	9	1	0
Minimum	30	0	0	20	8	1	-2
Maximum	75	0	0	31	41	8	2
Average	51	0	0	25	22	3	0
Averages by Hydrologic Year Type							
Wet (W)	71	0	0	28	37	6	0
Above Normal (AN)	61	0	0	28	28	5	0
Below Normal (BN)	50	0	0	25	22	3	0
Dry (D)	44	0	0	25	16	2	1
Critical (C)	32	0	0	21	11	1	-1

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6. Future Water Demands and Supplies

As part of the WI&A, agricultural and urban demand scenarios and climate change scenarios have been developed to support analysis of potential future supplies and demands using the BBGM (Davids Engineering 2013, 2015). Demand and climate change scenarios have been developed to allow for evaluation of potential future conditions and to better understand the sensitivity of water supplies and demands in Butte County to changes in agricultural and urban water use and changes in underlying hydrology (precipitation and stream flows) that may result from climate change. The scenarios are not intended to be predictions of likely future conditions, but rather to support sensitivity analysis and provide greater understanding of Butte County's water resources to support planning.

6.1 Agricultural and Urban Demand Scenario

6.1.1. Background and Discussion

In recent years, there has been a relatively sustained reduction in field, truck, and pasture crops in the County. These crops have been replaced by orchards, primarily walnuts, which tend to have greater evapotranspiration than other, non-rice crops. Analysis of mid-summer Landsat satellite imagery suggests that vegetation density has increased over time. Rice ground in some areas has experienced a shift to orchards in recent years and may continue to some extent in the future.

As older orchards are replaced and new advances in farming occur, evapotranspiration (ET) may further increase along with crop yields. Between around 1990 and 2015, it is estimated based on Landsat that growing season ET for non-rice crops increased in aggregate by approximately 10 percent.

Review of the irrigated footprint in Butte County in recent years and soils data from the Natural Resources Conservation Service suggests that the potential for expansion of the irrigated area is somewhat limited. Two potential areas of expansion have been identified. These are the portion of the East Butte Subbasin between Thermalito Afterbay and the Feather River and the North Yuba Subbasin in Butte County (south of Oroville and North of Honcut Creek).

Transition from surface water to groundwater has been observed in some areas of the County in recent years. In particular, orchards within Butte Water District have converted to groundwater at a relatively steady rate in recent years due to a combination of factors. Additionally, lands converting from rice to orchards may have a tendency to utilize groundwater for irrigation. Lands of irrigation expansion discussed above will also likely rely on groundwater for irrigation.

Improvements in irrigation technology (application uniformity) and management (irrigation scheduling) have occurred over time, leading to increases in irrigation efficiency (defined herein as the fraction of applied water beneficially consumed by the crop as ET). Current estimates of the Consumptive Use Fraction (ET of applied water divided by applied water), equivalent herein to irrigation efficiency, in aggregate within Butte County are estimated to be approximately 0.79 on average for orchard crops.

Primary urban water suppliers in Butte County include CalWater Chico, CalWater Oroville, and the cities of Gridley and Biggs. These suppliers are currently in the process of developing mid-century demand projections as part of Urban Water Management Plan (UWMP) updates to be adopted in 2016.

6.1.2. Demand Scenario Assumptions

A scenario representing potential agricultural demands has been developed that considers changes in cropping and evapotranspiration, expansion of the irrigated area, changes in irrigation water source (conversion from surface water to groundwater in some areas), and changes in irrigation technology and management.

The demand scenario assumes the following changes:

- Field, truck, and pasture crops will continue to shift to higher value crops. Current land use will be updated for the agricultural demand scenario to shift remaining field, truck, and pasture crops to higher value crops. Walnuts, will be used as a surrogate for higher value crops. Current acreages in almonds and other orchard crops will not be changed. As of 2015, there are an estimated 109,000 ac of non-rice crops in the County, of which approximately 14,000 acres are field, truck, or pasture crops.
- Crop evapotranspiration rates for non-rice crops will increase by approximately 10 percent. As part of the agricultural demand scenario, ET rates for non-rice crops will be increased by an additional 10 percent between April and September. Winter ET rates will not be increased because ET during the winter is driven primarily by evaporation of precipitation rather than by crop transpiration.
    - For almonds and prunes, annual ETa will increase from 36.7 to 39.3 inches annually, on average.
    - For walnuts, annual ETa will increase from 40.5 to 43.6 inches annually, on average.
- Rice ground will convert to orchards where shallow groundwater levels suggest limited risk of "drowning" due to high water table and flood risk. The greatest potential for these changes is believed to be along the east side of Butte Creek in the Esquon and Western Canal SIUs. Land use for selected rice ground will be converted to orchards as part of the agricultural demand scenario. Walnuts will be used as a surrogate for all orchard crops. Rice ground along the eastern side of Butte Creek in the Esquon and Western Canal subregions will be considered. For any given field, the potential to shift to orchards will be evaluated based on parcel size (e.g., at least 20 acres) and based on historical spring depths to shallow groundwater following wet winters. The observed historical groundwater depths (available from DWR) will allow for a qualitative

assessment of the risk of "drowning" of orchards due to elevated shallow groundwater and potential flooding.

- Irrigation will expand through new orchard plantings on class 3, 4, or 5 lands[1], primarily in the East Butte SIU between Thermalito Afterbay and the Feather River and in the North Yuba SIU south of Oroville and north of Honcut Creek. In order to evaluate potential impacts of expansion of irrigation in the East Butte and North Yuba SIUs, selected class 3, 4, or 5 lands that are not currently irrigated will be assumed to transition to orchards (with walnuts as a surrogate for all orchard crops). Individual parcels will be selected based on a minimum parcel size (e.g., at least 20 acres).
- Orchards within the Butte SIU, rice ground converted to orchards, and areas of irrigation expansion within the East Butte and North Yuba IUs will rely on groundwater for irrigation. To evaluate potential impacts of increased reliance on groundwater for irrigation, the following areas will be assumed to rely on groundwater as part of the agricultural demand scenario:
  - Orchards within Butte Water District
  - Rice ground converted to orchards, as described above
  - Areas of irrigation expansion within the East Butte and North Yuba subbasins, as described above
- Irrigation efficiency for orchards will increase by approximately five percent. As part of the agricultural demands scenario, it is assumed that an additional 5 percent increase in irrigation efficiency will occur.
- Urban demand estimates will be modified based on updated urban water management plans that are expected to be available later in 2016. Historical pumping estimates will be modified so that demand volumes match the most recent UWMP projections for each supplier.

6.2 Climate Change Scenario

6.1.3. Background and Discussion

Evaluation of the potential impacts and effects of climate change on water management in Butte County will support evaluation of the following and other questions:

- Warmer air temperatures may lead to more winter precipitation, more rain, and less snow. What effect does this have on basin hydrology in general and on groundwater conditions in particular?
- What is the vulnerability of the system to potential climate change impacts?

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[1] As defined by Agriculture Handbook No. 210, issued by the USDA Soil Conservation Service (SCS 1961). Also described in Davids Engineering technical memorandum on *Agricultural and Urban Demand Scenarios and Climate Change Scenarios for BBGM Update* (2015)

- What would be the effects of a prolonged drought? For example, what if we had not experienced several wet years after the 1990s drought?

Potential impacts of climate change are estimated based on projected changes in greenhouse gasses under different emission scenarios. These scenarios are driven by assumptions related to population growth, economic activity, societal attitudes and behavior, and technological advancement. Based on the emission scenarios, global climate models (GCMs) are developed by climate scientists to project changes in climate such as temperature and precipitation. There are a large number of GCMs and emission scenarios available.

In California, the Governor's Climate Action Team selected six GCMs and two emission scenarios, resulting in 12 climate change scenarios and recommended them for the 2009 California Water Plan update. To demonstrate the range in variability in future conditions among scenarios, projections of temperature and precipitation from the studies are shown in Figures 6.1 and 6.2, respectively. As indicated, the scenarios project increases in temperature. Results vary substantially among GCMs in the timing and degree of temperature increase; however, temperature increases under the high emission scenario (A2) tend to be greater than the lower emission scenario (B1). With respect to precipitation, the results are somewhat more mixed, with a general projection of decreasing annual precipitation as the century progresses.

Increased temperature and reduced precipitation are expected to result in reduced winter snowpack and increased runoff earlier in the year, which will reduce available surface water supplies and increase reliance on groundwater. Additionally, applied water demands will increase as less precipitation is available to support crop growth. A more in-depth discussion of climate change and groundwater in California has been developed by Fisher et al. (2013) and is available at the California Water Blog (http://californiawaterblog.com/2013/10/09/groundwater-and-climate-change-in-california/).

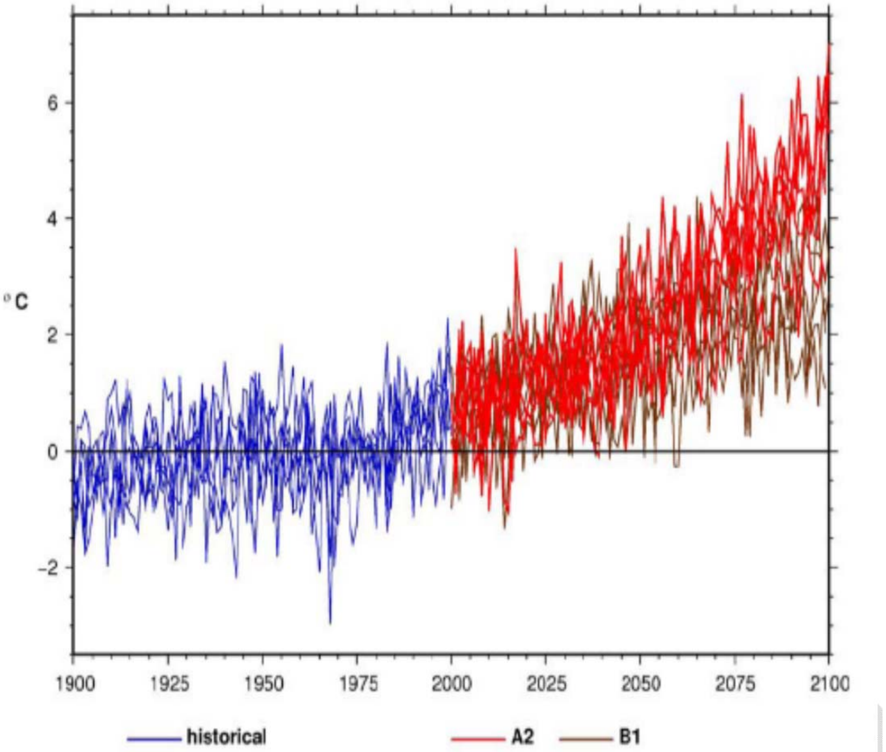

Figure 6.1. Projections of Mean Temperature Increase for Sacramento Area from 12 CAT Scenarios (Cayan et al., 2008).

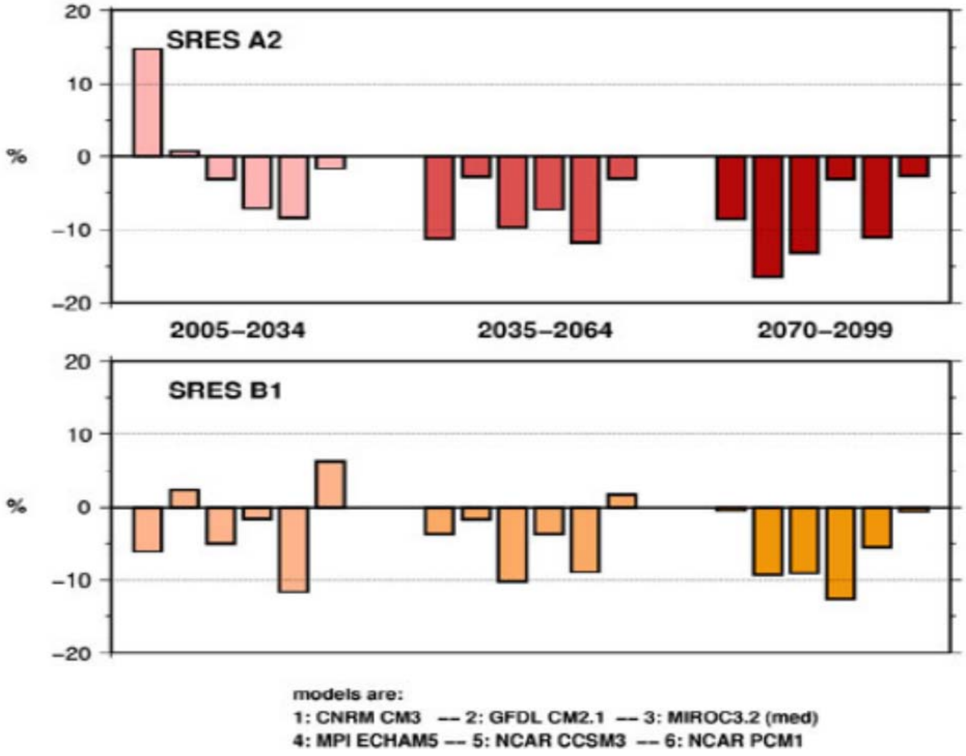

Figure 6.2. Projected Changes in Precipitation Relative to 1961-1990 Average for Northern California from 12 CAT Scenarios (Cayan et al., 2008).

6.1.4. Selected Climate Change Scenarios

To evaluate potential impacts of climate change, two climate change scenarios have been selected from the Governor's 2008 Climate Action Team (CAT) recommended scenarios for evaluating water management in California using an ensemble based approach. The CAT identified 12 scenarios as part of its evaluation that can be used to project future temperature; precipitation timing and amounts; snowfall, snowmelt, and runoff, etc. By mid-century (2035-2065), the scenarios generally agree in an increase in average air temperature, as shown in Figure 6.3. In the figure, scenarios are divided into four quadrants corresponding to (1) hotter, drier; (2) hotter, wetter; (3) warmer, drier; and (4) warmer, wetter based on average results. Results are more mixed regarding changes in precipitation, but on average a slight reduction in precipitation is suggested. The two scenarios selected and highlighted in Figure 6.3 are as follows:

- Central tendency ("consensus" among scenarios)[2]. This scenario predicts (1) a 2.4 F increase in mean annual temperature, (2) a 2 percent decrease in valley floor precipitation, (3) a 2 percent decrease in Feather River water year full natural flow, and (4) a 27 percent decrease in Feather River April to July runoff by mid-century.
- Hotter-Drier (more extreme heating and drying)[3]. This scenario predicts (1) a 3.2 F increase in mean annual temperature, (2) an 11 percent decrease in valley floor precipitation, (3) a 19 percent decrease in Feather River water year full natural flow, and (4) a 46 percent decrease in Feather River April to July runoff by mid-century.

For comparison, the climate change scenario selected for the 2011 State Water Project (SWP) Delivery Reliability Report (DWR 2011) is shown. This scenario predicts (1) a 2.4 F increase in mean annual temperature, (2) a 3 percent increase in valley floor precipitation, (3) a 3 percent increase in Feather River water year full natural flow, and (4) a 25 percent decrease in Feather River April to July runoff by mid-century.

Based on the scenarios selected, magnitudes of historical precipitation, streamflows, and diversions are in the process of being adjusted using a perturbation ratio approach to develop BBGM inputs. One set of inputs will be developed for each scenario.

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[2] NCAR CCSM3, b1 emission scenario (http://www-pcmdi.llnl.gov/ipcc/model_documentation/CCSM3.htm).

[3] MIROC3.2, a2 emission scenario (http://www-pcmdi.llnl.gov/ipcc/model_documentation/MIROC3.2_medres.htm).

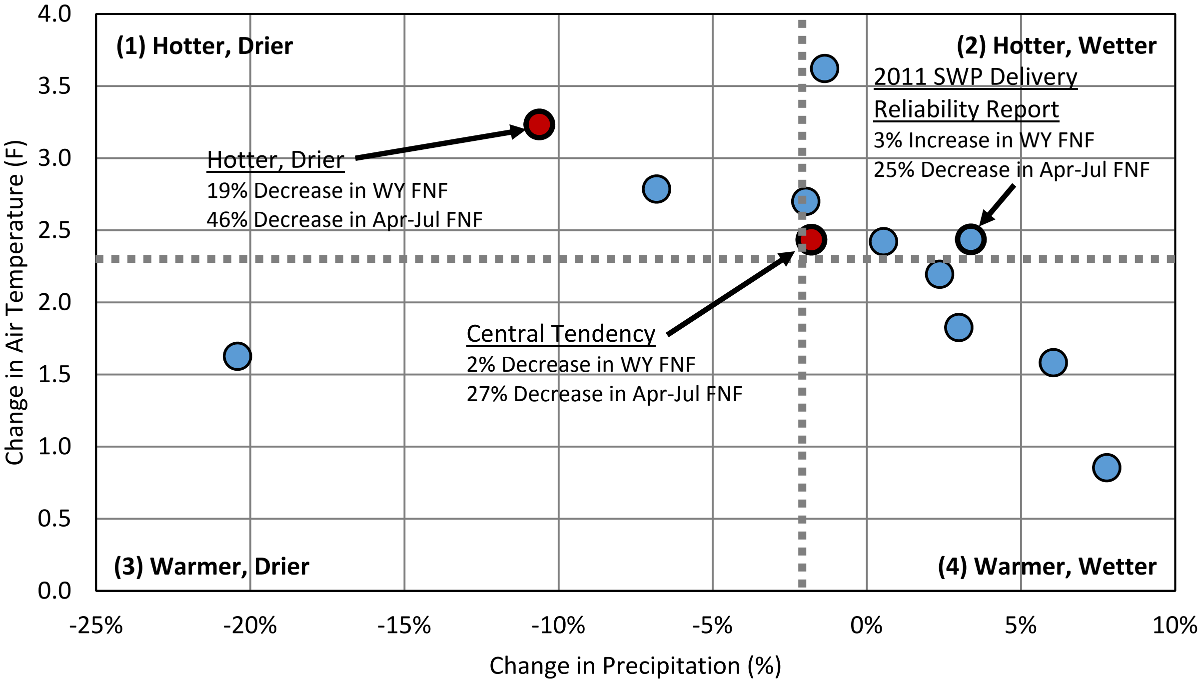

Figure 6.3. Comparison of Mid-Century (2035-2065) Changes in Butte Basin Mean Annual Precipitation and Air Temperature for 2008 CAT Scenarios. Corresponding Changes in Feather River Water Year Full Natural Flow (WY FNF) and April to July FNF Shown for Selected Scenarios.

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7. Conclusions and Recommendations

7.1 Conclusions

The *2016 Water Inventory and Analysis Report* not only updates the analysis of the County's water supply and demand, but it fundamentally changes the County's analytical approach to help sustain water resources for future generations. One of the important changes is the integration of the Butte Basin Groundwater Model (BBGM) as a platform for developing and analyzing data for the *2016 Water Inventory and Analysis Report* and future analyses. The integration of the BBGM with the *2016 Water Inventory and Analysis Report* positions the Department with the long term ability to conduct water resource analyses as the need arises. An early benefit of this approach was realized through the *Assessment of Butte County Drought Impacts, 2012-2015* Technical Memorandum (Davids Engineering 2016, included as Appendix D). The obligation of the Sustainable Groundwater Management Act (SGMA) of 2014 to conduct water balance analyses necessitates having the capacity to perform novel analytical assessments. The completion of the *2016 Water Inventory and Analysis Report* and the updated BBGM prepares the County to meet these obligations.

Land use in the Butte County valley floor area has been relatively steady in recent years, with little change in irrigated agricultural lands and a modest decrease in non-irrigated lands. This decrease is offset by increases in developed lands and wetlands. Shifting of crops has occurred, including some increase in orchards (particularly walnuts) and a decrease in other, non-rice crops. There is the potential for marginal expansion of irrigation in some areas, particularly in the East Butte IU between Thermalito Afterbay and the Feather River and in the North Yuba IU between Oroville and Honcut Creek. Potential impacts of additional crop shifting and irrigation expansion will be evaluated using the BBGM and demand scenarios developed as part of the WI&A (as described in Section 6).

The primary climate variable affecting water conditions in the County is interannual differences in precipitation and snowfall. Variability from year to year impacts both the availability of surface water to meet demands and the amount of pumping required to meet crop irrigation requirements. In the future, temperatures are likely to increase as a result of climate change, resulting in less snowpack in the Feather River watershed and earlier runoff. These changes will make existing surface water supplies less reliable, increasing the need to rely on groundwater to meet demands. Climate change scenarios developed as part of the WI&A will allow for evaluation of the potential impacts of climate change using the BBGM (as described in Section 6).

Groundwater level declines have been observed in some areas of the County over recent years and are likely driven mainly by drought conditions leading to reduced deep percolation (potential recharge) and increased groundwater pumping. Pumping estimates developed as part of the WI&A suggest that these groundwater level declines may be related more to reduced recharge, rather than increased pumping, though the frequent occurrence of dry and critically dry years in the past decade has resulted in increased pumping. Pumping appears to be influenced more by interannual precipitation than to other factors such as increasing crop acreage or crop shifting over time.

Surface layer water budgets developed as part of the WI&A provide valuable information describing land surface processes to support evaluation of the sustainability of available water supplies. The scale at which supplies and demands are quantified is critical to supporting effective water management. Subinventory water budgets underlying the IU water budgets presented in the WI&A (Appendix C) allow for direct engagement with local stakeholders and closer examination of current and historical conditions and trends, while also helping to identify data gaps that need to be addressed to better manage for sustainability in the future. Ultimately, in the context of developing GSPs as part of implementing SGMA, water budgets will need to be expanded to include the underlying groundwater system. Development of these budgets will be supported by the WI&A and BBGM.

7.2 Recommendations and Next Steps

Recommendations and suggested next steps have been identified as part of developing the WI&A and include the following:

- While many of the large diversions are continuously monitored and recorded, limited information is available for others. Work with local stakeholders to better document surface water diversions, including investigation of riparian diversions in some SIUs and additional information describing water supplies for managed wetlands. Diversion estimates developed as part of the WI&A provide a good basis to support discussion with diverters.
- Groundwater pumping for irrigation has generally been estimated based on estimates of crop irrigation requirements in areas known to rely on groundwater. Look for opportunities to verify and refine groundwater pumping estimates by obtaining pumping data from cooperative landowners.
- Deep percolation in some areas may return to the surface layer through accretion in drains and natural waterways or may be consumed by phreatophytic vegetation. Further investigate the ultimate fate of deep percolation from agricultural lands. Through modelling of specific waterways and shallow groundwater, the BBGM will support this investigation.
- The relative proportion of non-consumed water returning as deep percolation or surface runoff for the WI&A does not explicitly account for percolation from stormwater retention ponds or releases from wastewater treatment plants to local waterways. Refine water budgets for developed lands to verify and refine estimates of non-consumed water.

- Further evaluate water budgets from the WI&A and developed for the groundwater system using the BBGM for historical and current drought periods to better understand factors contributing to recent historic low water levels in some areas.
- Identify and evaluate additional options to adapt to drought, future demands, and climate change.
- Continue public outreach regarding the WI&A and SIU water budgets to educate and inform the public regarding water resources in the County and to gather additional insights to support future water management efforts.
- Continue the process of updating and calibrating the BBGM through further refinement of input datasets and calibration of aquifer parameters to simulate historical water levels and streamflows.
- To retain local groundwater management authority, Butte County should continue to implement the Sustainable Groundwater Management Act (SGMA), including utilizing the WI&A and BBGM information to support development of Groundwater Sustainability Plans (GSPs). One of the key principles of SGMA is that groundwater is best managed at the local level. Developing a water budget and utilizing a groundwater model are requirements of groundwater sustainability plans. The WI&A provides a foundation for meeting these requirements.

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A. Butte County Water Suppliers and Managers

A.1. Overview

Butte County residents, agriculture, and businesses receive water from both surface water and groundwater sources. Surface water deliveries are dictated by an extensive water rights law doctrine that establishes uses of water and priority of different users. California does not have a similarly defined system of groundwater rights, although there are statutes that regulate uses of groundwater. The implementation of the Sustainable Groundwater Management Act of 2014 will be the cornerstone of groundwater management.

A.2. Surface Water Rights

Water has always been an important commodity in California, and a complex system of water rights has developed. Water resources were first significantly used during the Gold Rush of 1848, and competition for water resources intensified with the growth of agriculture and industry.

The highest priority rights are “riparian rights,” which are attached to properties that border natural waterways. Water from riparian rights can be used only on the property adjacent to the waterway, and riparian right-holders cannot transfer their water. Originally, riparian water rights secured water with no limits placed on its use. However, a later court case changed this position and established that water users with riparian rights must be held to a standard of “reasonable use.”

The second type of water rights are appropriative rights, which can be secured by properties not immediately adjacent to waterways. This water rights system was initiated by miners, who would post a notice to divert water and that posting would secure the water right. Appropriative water rights were recognized legally in 1855, and are prioritized according to a “first in time, first in right” hierarchy. Appropriative water rights are dependent on the water being put to beneficial use. If the water is not used for a period of 5 years, the water rights can expire.

The two types of water rights systems created conflicts between water users, so the Water Commission Act of 1913 was passed to allow more rational control of water rights. The Act declared that water is a property of the state and established a permit process to control water rights. The State Water Resources Control Board (SWRCB) was established to govern the permit process. The Water Commission Act became the basis for appropriating water, but it does not apply to groundwater, riparian rights or appropriative rights established prior to 1914 (“Pre-1914” rights).

Water use must be “reasonable and beneficial.” Beneficial uses include irrigation, domestic, municipal and industrial, hydroelectric power, recreational uses, protection and enhancement of fish, wildlife habitat, fire protection, frost protection, stock watering, and aesthetic enjoyment.

In years of water shortage, appropriative right-holders must reduce their water use according to inverse priority. Priority is established by the year that the rights were secured, so the most recent right-holders are the most junior and will be subject to cutbacks first during shortages. Appropriative right-holders will continue to be cut back in inverse priority until the shortage is corrected. If the shortage is so severe that a shortfall remains after all appropriative right-holders have stopped using water, then the riparian right-holders must share the remaining reduction.

The many natural waterways in Butte County allow riparian rights for landowners bordering these waterways. The major individual appropriative water right holders in Butte County searched through the State Water Resources Control Board's eWRIMS database at: http://www.swrcb.ca.gov/waterrights/water_issues/programs/ewrims. The major water right holders are defined as those holders having right(s) that provide quantities of water equal to or greater than 1,000 acre-feet.

Adjudicated rights are those assigned by a court judgment that divides the water of a natural waterway between all of the parties within the drainage area. There are two adjudications of water rights in Butte County. One adjudication is known as the Pine Creek adjudication (No. 7814) and involves lands located in the northwestern corner of Butte County and a portion of Tehama County. The major adjudication within Butte County is known as the Butte Creek adjudication (No. 18917).

A.3. The State Water Project

In 1960, California voters approved the Burns-Porter Act, a $1.75 billion bond issue to finance development of the State Water Project (SWP). Designed and implemented by the DWR, the SWP's main purpose was management of water resources in northern California, the San Francisco Bay area, the San Joaquin Valley, the Central Coast, and southern California. Today, the SWP management goals include supply (maximizing diversion, storage, and redistribution of surplus water from wet periods), flood control, power generation, recreation, fish and wildlife protection and habitat enhancement, and water quality improvement. The SWP manages 29 water storage facilities, 18 pumping plants, five hydroelectric power plants, four pumping-generating plants, and 660 miles of canals and pipelines. The SWP has contracts for 4.2 million acre-feet of water, but not all of this water has been developed. Approximately 70 percent of SWP deliveries go to urban users, and 30 percent to agricultural uses. The SWP is the largest state-built, multipurpose water project in the United States.

When the SWP was first under consideration, residents of northern California were concerned that the project would impact their water rights. The state addressed these concerns by including an "area-of-origin" statute, which protects water within areas that the water originates.

The SWP has entered into several contracts within Butte County. Water right settlement agreements were executed with the Joint Water District Boards (555,000 acre-feet) and Western Canal Water District (295,000 acre-feet) to settle protests over the construction of State Water Project facilities at Oroville. Under these agreements, the DWR provides the districts with a water supply from Lake Oroville in exchange for the districts exercising their individual water rights.

The County has an allocation of 27,500 acre feet from the State Water Project for in-county water demand. The County currently contracts with Del Oro Water Company and California Water Service Company in Oroville. Until 2008, the state allowed the County to only pay for the amount of water used. However beginning in 2008, the state required that the County pay the annual cost of the entire allocation. In 2008, the Department of Water and Resource Conservation secured a two-year sale of surplus Table A allocation that provided the County with revenue to cover the cost for almost four years. The unprecedented sale avoided an immediate fiscal crisis and allowed time for the County to explore a long term strategy. The long term strategy was set in motion in 2011. The County entered into a ten year agreement with the Palmdale Water District and Westside Water Districts to lease a portion of the County’s Table A allocation not needed for in-county uses. The lease agreements provide financial stability to the management of Table A while retaining the option for meeting future in-county demands.

A.4. Central Valley Project

In the 1930s, as an attempt to protect the Central Valley from water shortages and flooding, the state formulated the Central Valley Project (CVP). However, due to its coincidence with the depression era, the state was unable to finance the project. Despite the shortfall, Federal funding and authorization was provided in 1935 for the U.S. Bureau of Reclamation (USBR) to begin work on the project. The CVP includes 18 reservoirs (with four additional reservoirs jointly owned with the SWP), the largest of which is Lake Shasta on the Sacramento River. The CVP delivers approximately seven million acre-feet (MAF) of water per year, with 6.2 MAF to agricultural uses, 0.5 MAF to urban uses, and 0.3 MAF to wildlife refuge use (DWR Bulletin 160-98).

USBR entered into water rights settlement contracts with various water right holders along the Sacramento River in 1964. The purpose of entering into those contracts was to provide for partial repayment of the construction costs of Shasta Dam, which recognized the benefits they received from that facility and provided agreement with those having water rights for diversions from the Sacramento River (the contracts are for a period of 40 years and are subject to renewal in 2004). USBR also determined deficiencies of those water rights in the critical summer months and provided in contracts for delivery of CVP water during those summer months. One water right holder in Butte County included in this program is M&T, Incorporated. Under its contract with USBR, the total amount of water rights agreed upon is 16,980 acre-feet and a Project water supply of 976 acre-feet for a total of 17,956 acre-feet. The Gray Lodge

Wildlife Area is in the southern portion of Butte County, and a portion of its water supply is served by the CVP.

A.5. East Butte Inventory Unit

The East Butte Inventory Unit includes approximately 219,000 acres in the southern part of the County. It is bordered by Butte Creek to the north and west, the Butte County line to the south, the foothills to the northeast and the Feather River to the southwest. East Butte contains the cities of Biggs and Gridley, and a portion of the city of Oroville. The primary crop types in the region are rice and orchards. The Gray Lodge Wildlife Area is in the southwestern corner of the unit. The cities of Biggs and Gridley use groundwater, but the remainder of the unit primarily utilizes surface-water supplies.

A.5.1. Biggs-West Gridley Subinventory Unit

Biggs-West Gridley is located in the southwest corner of the East Butte Subbasin. The majority of the subinventory unit is composed of Biggs-West Gridley Water District, an agricultural water supplier that provides surface water from the Feather River. The subinventory unit also contains a small part of Gray Lodge Wildlife Area, roughly 2600 acres, which is within the boundaries of the Biggs-West Gridley Water District.

Biggs-West Gridley Water District

Biggs-West Gridley Water District was formed in 1942, and has grown to occupy approximately 34,785 acres. Of Biggs-West Gridley's total area, 31,300 acres are irrigated for agriculture and managed wetland uses. The district's primary crop is rice, with approximately 20,897 acres dedicated to the crop in 2016. Biggs-West Gridley also provides water to the Gray Lodge Wildlife Area, of which 2,600 acres are within their service area. In addition to providing water to the portion of the refuge within their service area, they provide water to an additional 5,900 acres of the refuge as part of an agreement with the USBR to meet CVPIA requirements. There are three other areas south of Gray Lodge (outside of Butte County, but within the District's service area) to which Biggs-West Gridley provides a total of 800 acre-feet of water. Biggs-West Gridley does not make additional deliveries to these areas, but the areas recapture drainage water to use for irrigation purposes.

Biggs-West Gridley joined together with Butte Water District, Richvale Irrigation District, and Sutter Extension Water District to coordinate the acquisition, maintenance and operation of a water supply and distribution facility. Sutter Extension is entirely within Sutter County, and parts of Butte Water District and Biggs-West Gridley are within Sutter County, while Richvale is entirely within Butte County. These districts cooperated to purchase water rights and a canal system from the Sutter Butte Canal Company. The four districts and the Sutter Butte Canal Company entered into an agreement dated July 12, 1956, covering the maintenance and operation of the canal system. This agreement was amended by: (a) an agreement and conveyance dated September 21, 1966, entered into by the District; and (b) an agreement and conveyance dated April 11, 1969, entered into at Biggs and Richvale and consented to by Butte and Sutter. The districts then entered into four additional agreements affecting their operation, diversion facilities, main canal, and available water. These included: (a) an agreement dated July 6, 1964, entered into by the DWR; (b) an agreement on diversion of water from the Feather River, dated May 27, 1969, entered into by the DWR; (c) a water sale and exchange agreement entered into by PG&E and the districts on or about May 27, 1969; and (d) a consent agreement, dated May 27, 1969, entered into by PG&E and the districts. The four districts created the Joint Water District in 1968 with powers to control, maintain, and operate the joint water distribution facilities of each district, and required the continued maintenance of rainfall, snowfall, weather, evaporation, hydrographic, engineering, and other data and records available and continuously accumulated relating to Feather River water flows, water diversion rights and the use of water within the districts. The Joint Water District's settlement agreement with DWR preserves the Joint Water Board's pre-1914 water rights to the Feather River, allows DWR to divert water from the Feather River for the State Water Project at Lake Oroville, and requires DWR to supply water from the Lake Oroville via Thermalito Afterbay at no charge. The settlement agreement supplies are subject to reductions in water-short years of up to 50% in any one year and not to exceed a total of 100% in any 7 year period.

Some landowners within the District have backup wells to make up for water lost during droughts, or to provide all water during droughts so that the remaining surface water can be marketed. However, the District itself has no production wells. Biggs-West Gridley has up to 3,000 acres of "second status" lands that were brought into the District after 1979. During years when the DWR reduces water deliveries, the second status lands are the first to have their water deliveries reduced. Biggs-West Gridley has a past history of being chronically water short. They have an entitlement of 160,958 acre-feet as an upper limit for their District, but they have been as much as 5 TAF short. In these years, they have bought added supply from other districts within the Joint Board. They also have numerous recapture systems throughout the district that provides approximately 25 TAF and could serve as an additional drought management tool. There are no surface storage facilities within the District. Biggs-West Gridley has a system of canals to distribute water throughout their service area, and they estimate that the system has approximately 1% losses per mile, which include seepage, evapotranspiration, and associated losses. They are 17 miles long, which results in a 17% loss as canals traverse the district. The conveyance system in Biggs-West Gridley is currently handling 700 cfs of diversions during the summer, but it was not designed for this flow. In 2014, USBR commenced construction to enlarge BWGD's conveyance system to meet additional flow requirements associated with delivering new water (CVPIA water) to the Gray Lodge Wildlife Area. USBR's construction is planned over multiple years, and will increase the District's capacity to a flow of 850 cfs.

In 2014 Biggs-West Gridley began the implementation of a Customer Delivery Measurement System to comply with the Water Conservation Act of 2009 (SBX7-7) on their 360 outlets to growers. At 2014 dollars, implementation of the measurement system was estimated to be approximately $1,360,202, and to be a multi-year project. Biggs-West Gridley in December of 2015 updated their Agricultural Water Management Plan in accordance with the requirements of the Water Conservation Act of 2009 and Executive Order B-29-15, as issued on April 1, 2015. Additionally, in 2015 Biggs-West Gridley filed with DWR as a Groundwater Sustainability Agency for a portion of the East Butte Groundwater Basin under the Sustainable Groundwater Act of 2014.

Gray Lodge Wildlife Area

Portions of Gray Lodge Wildlife Area are located within the Biggs-West Gridley inventory sub-unit. The refuge is described as part of the Butte Sink subinventory unit because the majority of the refuge is located in that area.

A.5.2. Butte Subinventory Unit

The Butte Subinventory Unit is located in the southeast portion of the East Butte Subbasin. The Butte Subinventory Unit includes Butte Water District, which provides Feather River water for agricultural uses, and the cities of Biggs and Gridley.

Butte Water District

In the spring of 1952, the Sutter Butte Canal Company implemented a 30 percent rate increase. The landowners in the Gridley and Biggs area were concerned about the rising cost of water, and this additional increase provided a strong motivation to take action. The Butte Water District (Butte) was formed in 1953 with plans to acquire 11 percent of the Sutter Butte Canal Company's original water right on the Feather River as well as some of its canals. The District was formed primarily to provide irrigation water for farms in the Gridley and East Biggs area. Butte Water District is slightly more than 18,000 acres in size at present. Butte's surface water is diverted from the Thermalito Afterbay through the Sutter Butte Canal.

Almost all of Butte's acreage is irrigated for agricultural use. The District borders the Feather River, so it has mostly permanent crops such as orchards (10,000 are permanent, which represents 55% of its total irrigated acres). Because it borders the river, Butte has predominantly sandier soils, such as Gridley Loam to Columbia Loam. Farmers grow peaches, prunes, walnuts, almonds, kiwis, melons, rice, small grains, pasture, and alfalfa. At present there are no anticipated changes in crop mix, but city growth has begun to penetrate into agricultural areas.

Butte provides surface water, but many individual farmers have groundwater wells for backup. Surface water is often cheaper than groundwater because customers pay only for the operations and maintenance of the conveyance system that delivers the water, and not for the water itself. The use of surface water instead of groundwater is dependent on the irrigation method. If a farmer is using micro-jet irrigation, it works better with groundwater because it does not require filtration and has adequate pressure for distribution. Farmers sometimes prefer this method because they can easily inject fertilizers, and it is less labor-intensive. However, surface water is much cheaper for rice irrigation.

Butte Water District is a member of the Joint Water Districts, as discussed in the above description under the Biggs-West Gridley Water District. Butte Water District is allotted a portion of 133,000 acre-feet/year out of the total Joint Water District entitlement, and they currently use 70-80% of this total.

City of Biggs

The City of Biggs operates a public freshwater system providing clean water to residents and businesses for drinking, households, and irrigation. Three groundwater wells are operated by certified operators in the City's Public Works Department. Each well is closely monitored and controlled by high-tech state-of-the-art control systems. Water is delivered through the City through a subterranean network of interconnected pipes, over half of which were upgraded and replaced in 2007. Certified operators maintain the system daily and take weekly samples to testing labs. Very little treatment is required for Biggs' water, as the local groundwater sources are excellent in quantity and quality. The city consistently serves high quality water to its residents and provides an annual water quality assessment report. The city recently completed a major water system upgrade including replacement of approximately 30,000 lineal feet of waterline mains; complete refurbishment of two wells; abandonment of the old elevated water tank; and installation of automated telemetry controls, automated emergency generator back-up, a 10,000 gallon hydropneumatic tank, new fire hydrants, and water meters. This project helped the operations costs of the public works department by reducing maintenance caused by leaks within the old system. Additionally, the new upgrade improved service reliability and boosted water pressures city wide from the former 38 psi to approximately 55 psi. The fire department has significantly greater ability to extract water from the system to fight fires. The city has a current adopted Water Master Plan.

City of Gridley

The City of Gridley (Gridley) began to provide water to its residents through the Public Works Department around 1949. There are approximately 960 acres within the city limits. In 2013, the population of Gridley was approximately 6,561 people. Domestic water is provided within city limits primarily by the city’s water system, with the exception of private wells at the Butte County Fairgrounds and the Signature Fruit cannery (south of downtown). City water is provided from wells located throughout the city ranging in depth from 240 to 450 feet. The water is treated with chlorine at each well site prior to delivery to customers. Wells are equipped with backup generators. The city’s system, has a pumping capacity of 6,280 gallons of water per minute (gpm). The City’s distribution system consists of almost 40 miles of pipes that carry water from groundwater wells to Gridley’s homes and businesses.

The U.S. Environmental Protection Agency (EPA) is responsible for enforcing drinking water quality standards, although much of this authority is delegated to the states. The Safe Drinking Water Act (SDWA) is the main federal law that ensures the quality of Americans' drinking water. EPA drinking water standards are developed as a Maximum Contaminant Level (MCL) for each chemical or microbe. The MCL is the concentration that is not anticipated to produce adverse health effects after a lifetime of exposure, based upon toxicity data and risk assessment principles. The California Department of Health Services (DHS) implements the SDWA in California. DHS requires public water systems to perform routine monitoring for regulated contaminants that may be present in their drinking water supply. A water system with a contaminant exceeding an MCL must notify the public and remove the source from service or initiate a process and schedule to install treatment for removing the contaminant.

A.5.3. Butte Sink Subinventory Unit

Butte Sink is located in the southwest corner of Butte County and receives much of the runoff from the remainder of the county. The Gray Lodge Wildlife Area is located within Butte Sink. Part of the Butte Sink still remains comparatively unchanged from its original condition, although water developments have reduced the amount of flooding. Water for wetlands in the Butte Sink is derived from flood waters, Butte Creek, Sacramento River, and agricultural return flows from rice fields. Within the Butte Basin, 67 organized hunting clubs are now maintained over 52,000 acres of habitat including over 22,000 acres of flooded lands.

Gray Lodge Wildlife Area

In 1931 the DFG purchased the 2,540-acre Gray Lodge Gun Club to establish the first Sacramento Valley wildlife refuge. In 1971, an additional 5,860-acres were purchased, which increased the refuge area to 8,400 acres. The Refuge is located adjacent to the Butte Sink, which is an overflow area of Butte Creek and the Sacramento River. The Refuge’s 8,000 acre-feet of firm water supplies are from the Biggs-West Gridley Water District. In addition, Biggs-West Gridley has allocated 12,000 acre-feet of water per year to the Refuge. However, only 8,000 acre-feet are available during the irrigation season from April to November. The Refuge also diverts water from the Reclamation Districts 833 and 2054 Drains, which convey agricultural return flows. The return flows are available only during the summer and early fall when the rice fields are drained. The Reclamation Districts relinquish any right to the water that leaves their boundaries during the period of time that the rice fields are being drained. This water then becomes abandoned, and DFG has filed water rights permits on this abandoned water. Based upon existing data, water quality appears to be adequate for refuge management.

In October 1992, the United States Congress passed Public Law 102-575, known as the Central Valley Project Improvement Act. Part of that legislation made the Secretary of the Interior (Secretary) responsible for providing firm water supplies of suitable quality to maintain and improve wetland habitat areas on units of the National Wildlife Refuge System in the Central Valley of California, including Gray Lodge Wildlife Area. The Secretary is to provide up to current average annual water deliveries, known as level 2, and optimum management water supplies, known as level 4. The amount of water the Secretary is responsible for is that quantity of water less any other water supplies that are available from existing water rights, long-term contracts, and groundwater to the refuges. The refuge has a fairly extensive groundwater well network that provides over four thousand acre-feet per year.

Since the Secretary is responsible, it becomes an obligation of USBR, the operator of the CVP. The USBR does not have facilities to directly serve water to Gray Lodge and must rely on the State Water Project to provide the water from Thermalito Afterbay. The USBR will then enter into a long-term contract with the DWR that will provide replacement for the water delivered from Thermalito Afterbay by making Central Valley Project water available in the Sacramento-San Joaquin Delta. Additional water potentially may be obtained from Thermalito Afterbay and conveyed through Biggs-West Gridley facilities, the Cherokee Canal, or Western Canal Water Users Association (WCWUA) facilities. The Cherokee Canal, an old mining drainage channel, is operated by Richvale Irrigation District, a member of the Joint Water District. Water from the Cherokee Canal could be diverted to BWGWD for delivery to the Refuge. The WCWUA facilities divert water from Thermalito Afterbay and are operated year-round to deliver water to hunting clubs in the Butte Sink.

A.5.4. Cherokee Subinventory Unit

Cherokee Sub-Inventory Unit covers an area of approximately 14,700 acres. Cherokee Sub-Inventory Unit (SIU) is bordered on the north and east by the foothill area. To the northwest are the Pentz and Esquon Sub-Inventory Units (SIU), to the southwest lies the Western Canal SIU, and due south is the Thermalito SIU. The majority of water volume pumped from groundwater in the Cherokee SIU is for farmland irrigation. Domestic water supply usage from the aquifer is of smaller volume but equally critical. There are presently few other sources of water for domestic use in the Cherokee SIU. All residents are totally dependent on water from the aquifer system except for few who use water from natural springs near the eastern perimeter of the Cherokee SIU. Rural housing is quickly developing and increasing in numbers in Butte Valley and will increase demands for groundwater in the Cherokee SIU.

A.5.5. Esquon Subinventory Unit

The Esquon Subinventory Unit is in the northern portion of the East Butte Subbasin. Esquon contains the Durham Mutual Water Company, an agricultural water supplier. Rancho Esquon (Adams-Esquon Ranch), a large, privately owned agricultural facility, is also in the Esquon Subinventory Unit. The majority of land use within Esquon is agricultural, with crops including rice, almonds, corn, pasture, and others.

Rancho Esquon

Rancho Esquon is a major landowner within the Esquon Subinventory Unit. Rancho Esquon is also part of the Butte Creek adjudication, and has water rights to divert water from Adams-Esquon Dam. They have rights (of varying priority) to 7.14 cfs of water throughout the year, with an additional 13.25 cfs from April 1 to September 30 and 8 cfs from April 1 to June 15. In addition to the diversion from Butte Creek, Rancho Esquon has water rights to Hamlin Slough, which is a tributary to Butte Creek and also part of the Butte Creek adjudication. The ranch utilizes groundwater to meet demands not met by surface water.

Durham Mutual Water Company

Durham Mutual Water Company was created by area residents. The company provides surface water for agricultural uses from Butte Creek. Durham Mutual Water Company is part of the Butte Creek adjudication, and has first priority rights to 44.7 cubic feet per second (cfs). The water is diverted at Durham Mutual Dam, and is then conveyed to customers in the service area.

A.5.6. Pentz Subinventory Unit

The Pentz Sub-Inventory Unit (SIU) covers an area of about 1,900 acres in the northern portion of the East Butte Inventory Unit. It is bordered by Butte Creek to the north, the North Fork of Dry Creek to the south, foothills to the east, and Highway 99 to the west. The land uses within this SUI are non-irrigated native vegetation, pasture, and low density residential. Current groundwater use in the Pentz SUI is minimal. Pentz is located at the edge of the foothills, so the terrain is starting to become rocky and more difficult to develop. The low levels of development correspond to low water uses in the region. The main source of water is groundwater, and it is used for domestic water supply.

A.5.7. Richvale Subinventory Unit

The Richvale Subinventory Unit is located on the west side of the East Butte Subbasin. Richvale contains Richvale Irrigation District, an agricultural surface water supplier, and the Little Dry Creek Unit of the California Department of Fish and Game.

Richvale Irrigation District

Richvale Irrigation District was formed by a vote of the landowners on June 23, 1930 to provide agricultural water. Richvale is allocated 27% of 555,000 acre-feet (i.e. 149,850 acre-feet) of water annually acquired by the Joint Water District pursuant to pre-1914 water rights, subject to deficiency limitations in the May 1969 agreement.

The Joint Water District and associated agreements are described in greater detail under the Biggs-West Gridley Water District. In addition, Richvale has a riparian water right on Little Dry Creek for 18,300 acre-feet that can only be used during April – September. The District encompasses a land area of approximately 33,000 irrigable acres in Butte County. Richvale distributes its water supplies annually during the irrigation season, generally commencing by charging its water distribution system with surface water supplies from Thermalito Afterbay in April each year, and generally completing its water distribution by October 31 each year. The District may continue water distribution from November to January for rice straw decomposition, to benefit wildlife habitat in the Butte Basin, and to comply with restrictions on rice straw burning. Water supplies distributed during times of shortage are allocated pursuant to a proration and water duty imposed upon crops grown by district landowners as determined by the Board of Directors.

Little Dry Creek Unit (DFG)

DFG bought 3,736 acres of what was formally the Schohr Ranch in 1988 and 1999. This property is a secondary annex to the Richvale Irrigation District and the Biggs-West Gridley Water District. It has water rights to Butte Creek, the 833 drain, and the Cherokee Canal. The main source of water is the 100 drain from Richvale Irrigation District, which enters approximately the center of the Unit from the north and eventually flows into Butte Creek (within the Unit). Water is lifted primarily by low lift pumps into delivery channels to be distributed throughout the area. The water issues in the Little Dry Creek Unit are layered with legal easements and court decisions as to how the water is to be shared with the neighbors. There are six agricultural wells on the property located along the northern boundary.

The water flow is primarily north to south. Five of these wells came with the purchase of the property. DFG installed one well on the area, which has a 16-inch casing and is 500-feet deep to produce approximately 5,000 gpm. Well water is used primarily in the spring before irrigation water is available and in the fall when the agricultural canals are down for rice harvest. In addition, the wells are used to irrigate many wildlife plantings. Water rights to Butte Creek have not been used so that the water can be left in the channel for in-stream flows to help with the salmon issues in Butte Creek. The Little Dry Creek Unit has not been fully developed or funded by DFG, and water allotments have not been fully used. Drought years reduce irrigation district water and drastically increase well water use. Estimated water use at full development is approximately 16,000 acre-feet.

A.5.8. Thermalito Subinventory Unit

The Thermalito subinventory unit is located on the east side of the East Butte subbasin. Thermalito contains part of the City of Oroville, as well as agricultural areas that are not served by a water supplier. Portions of Thermalito Irrigation District and California Water Service Company-Oroville are both included within the Thermalito subinventory unit, and they both provide urban water to Oroville residents. The southern portion of the Thermalito subinventory unit is south of the Thermalito Afterbay, and consists primarily of agricultural land that uses groundwater to irrigate crops.

Thermalito Water and Sewer District

Thermalito Water and Sewer District was originally organized as an agricultural water supplier in 1922. There are approximately 14,000 acres within the service area, with 4,000 to 5,000 acres being served by Thermalito. There is a population of approximately 11,000 in the District and 2,982 connections. The farmers that originally used the majority of the water in Thermalito farmed olives, figs, cotton, and oranges. Agriculture slowly declined within the District due to a combination of factors, including marginal soil. Thermalito now delivers only potable water to a combination of residential, industrial, and governmental users.

Thermalito obtains its surface water from the Concow Reservoir (also known as Wilenor Reservoir). The water enters the West Branch of the Feather River through Concow Creek, then is released from Oroville Dam and delivered to the District through the Thermalito Power Canal. Thermalito also has five groundwater wells that combine with surface water for a total capacity of 10 mgd (11.2 TAF/yr). However, it is more energy efficient to deliver surface water, so groundwater is used only as a backup. Last year, approximately 1,900 acre-feet of water were supplied within the service area. Thermalito obtained appropriative water rights in 1928 and 1929 to 45% of the stored water in Concow Reservoir, which amounts to a total of 7,225 acre-feet. In 1985, a SWRCB decision allowed the District to receive 8,200 acre-feet. Thermalito uses about 2,000 acre-feet of the 8,200 acre-feet water allotment.

The District stores some of its water in a 2.5 million-gallon storage tank in the distribution center, and another 7,225 acre-feet within Concow Reservoir. Losses of water within the District are believed to be insignificant. Thermalito discovered that many of the apparent leaks were caused by old meters, which had slowed down and were under-indicating the water delivered. As the old meters are replaced, calculations indicate that less water is lost throughout the system.

Thermalito collects sewage within its service area, which is conveyed to a plant run by the Joint Powers Authority, which includes Thermalito, the Sewer Commission Oroville Region (SCOR), and the Lake Oroville Area Public Utilities District. Together they send around 4.5 million gallons per day (MGD) of treated wastewater into the Feather River.

Thermalito has some concerns within its District. It is trying to extend water mains to vacant land to help accelerate development. The District also has estimated that the water treatment plant will need to be expanded within 8-10 years. The current capacity of the treatment plant is 4.5 MGD. The plant full build-out capacity is 10 MGD. During periods of high turbidity in the raw water, groundwater wells can be utilized to avoid excessive backwashing of the treatment plant filters. Groundwater wells can also be utilized supplement plant output during peak consumption.

California Water Service Company, Oroville

California Water Service Company, Oroville (CalWater-Oroville) is a private water supplier that purchased a local water district in Oroville in 1927. CalWater-Oroville provides water within the Oroville city limits, minus areas served by other Oroville water suppliers (Thermalito Water & Sewer and South Feather Water & Power).

The population within CalWater-Oroville is approximately 10,400 and almost all of the water that CalWater-Oroville provides is dedicated to urban use (residential, industrial, and commercial). The company does provide agricultural water to farmers along the delivery canal. However, during a drought the agricultural users are the first to be cut back.

CalWater-Oroville purchases its raw water supply from PG&E, which diverts water from the West Branch of the Feather River, which travels along PG&E's ditch and is dumped into Lake

Oroville from PG&E's Lime Saddle Power House. The water is then picked up on the Powers Canal at station 14. The company also purchases Table A Water from Butte County.

CalWater-Oroville has four groundwater wells, but they are only used during PG&E shutdowns or during high demand periods. The average water quantity supplied by the company is 4.85 TAF/yr. The peak daily use is approximately 6.5 mgd. The average daily use during high demand is 5.5 mgd. CalWater-Oroville has two reservoirs and two storage tanks, providing a total of 7.209 million gallons of storage.

Conveyance losses from the Miocene Canal, used for irrigation customers do occur, but they are difficult to determine with any certainty because quantities vary with deliveries. Losses in the distribution system are a minor concern. CalWater-Oroville detects major losses through pressure gauges on pumps, and the company has a leak detection program that checks the entire system for leaks once or twice a year. This program has found and repaired several leaks. Also, operators check daily for unusual changes in meter readings, which may indicate a leak or other anomaly.

CalWater-Oroville has access to a considerable supply of water with two raw water sources and 4 deep water wells. The past 4 years of drought confirm conservation is important even though there is ample water available for this district.

A.5.9. Western Canal Subinventory Unit

The Western Canal Subinventory Unit is on the west side of the East Butte Subbasin. Western Canal contains the portion of the Western Canal Water District that is east of Butte Creek.

Western Canal Water District

The WCWD was formed to provide agricultural water by vote of landowners on December 18, 1984. The District purchased the Western Canal Company water system from the PG&E, which had acquired it from Great Western Power Company. The canal was originally developed by the Western Canal Company, which began operations in 1915. The District encompasses a land area of approximately 59,000 irrigable acres in both Butte and Glenn Counties, with approximately 30,700 acres in the East Butte Subbasin and 14,000 in the West Butte Subbasin.

WCWD's original diversion was located at the Western Canal Company's Dam on the Feather River. The diversion facilities and upstream portion of the Western Canal were displaced by the Oroville Reservoir Complex. The supply is now provided by two outlet structures located on the northwest corner of the Thermalito Afterbay. The maximum combined outlet flow is 1,250 cubic feet per second.

The pre-1914 surface water rights of the District comprise 150,000 acre-feet of natural flow of the Feather River, subject to reduction during drought, and 145,000 acre-feet from upstream stored water that is not subject to reduction. Water from the North Fork of the Feather River is stored in a series of reservoirs, known as the Feather River North Fork Project. This water must be taken during the period of March through October (also known as the "quantified period").

Additionally WCWD maintains a water right on Butte Creek for up to 11,400 acre-feet, which can be diverted only during the period of April 1 through June 15.

On May 27, 1969, PG&E entered into an agreement with the DWR to provide for the diversion of Feather River water below Oroville Dam. This agreement spells out the timing and quantity of deliveries by the DWR to WCWD. During drought years, WCWD'S rights to natural flows (150,000 AF) are reduced up to 50% in any one year, not to exceed 100% in seven years.

The District does not own any irrigation wells. Any groundwater used within WCWD is from individual landowners' wells. Many landowners have constructed agricultural production wells to provide a conjunctive-use capability during drought years. A number of the farms to the north of the main canal were entirely dependent upon groundwater supplies until canals and low-lift pumps were installed to provide surface water supply. Current groundwater use within the district boundaries is estimated to be 7,000 acre-feet annually.

WCWD's recent cropping pattern is approximately 90% rice and 10% in other uses (orchards, wildlife habitat and row crops). The cropping pattern is determined through user applications to WCWD and the use of aerial photographs. WCWD is currently observing a minor conversion of rice to orchard crops at slow pace in certain areas of the District.

The conveyance losses within the District are estimated to be about 5%. The losses are calculated from the total diversions from Thermalito Afterbay less the total metered water diversions from the delivery system. Conveyance losses also include losses from water that is conveyed to lands in Glenn County. A portion of WCWD is in Glenn County, and the water must be transported through the Butte County part of the District before it is delivered. In addition, WCWD provides environmental water supply to the Howard Slough Unit of the California Department of Fish and Wildlife in Glenn County.

Finally, WCWD also provides water under obligation to the 1922 Agreement Lands located in Butte Sink. These lands are managed for waterfowl habitat using Butte Creek natural flow and return rice flows and supplemented by WCWD water when flows are inadequate to maintain habitat purposes.

A.6. Foothill Inventory Unit

The Foothill Inventory Unit encompasses approximately 217,300 acres in the foothills of Butte County. The approximate change in elevation within the unit is 1,200 feet. The Foothill Unit contains the city of Paradise as well as a portion of the city of Oroville. The foothills have limited groundwater, and the majority of the water is supplied from surface water.

A.6.1. Cohasset Subinventory Unit

The Cohasset Subinventory Unit is located at the northern end of the Foothill Inventory Unit. The terrain in Cohasset is not conducive to agriculture, so the water use within the area is mainly domestic. The population is approximately 3,500 residents, and they utilize groundwater. The per capita water use is limited in the area because of low yields from wells.

A.6.2. Ridge Subinventory Unit

The Ridge Subinventory Unit is in the center of the Foothill Subinventory Unit, bordered on the north by Butte Creek and on the south by the Feather River. The Ridge contains the City of Paradise and surrounding urban developments, and water supply is a mix of surface water and groundwater. Del Oro Water Company and Paradise Irrigation District provide water to these urban areas.

Del Oro Water Company

Del Oro Water Company serves multiple unincorporated urban areas around the Town of Paradise, Stirling City, Magalia, and the Upper Stilson Canyon area northeast of Chico. Del Oro has five separate service areas: Buzztail, Lime Saddle, Magalia, Paradise Pines, and Stirling Bluffs. The service areas are separated geographically and by the sources of water they utilize.

Buzztail District was acquired by Del Oro from Buzztail Community Services District at the end of 2015. Buzztail is approximately 0.27 square miles, with 35 metered service connections and is served by one groundwater well. The well was not metered prior to 2016, so production data is not available; however 4.58 acre-feet were delivered to customers in 2015.

The Lime Saddle District is approximately 4.64 square miles, with 392 metered service connections (primarily residential). All connections are metered, and losses are not found to be significant. Lime Saddle has two groundwater wells, and also has a contract with Butte County for 300 acre-feet of surface water from Lake Oroville. With the completion of the Regional Intertie Project in 2012, Lime Saddle is able to draw, treat, and distribute sufficient water from Lake Oroville to serve the entire District. In 2015, Lime Saddle treated 128 acre-feet of water from Lake Oroville. In addition, Lime Saddle’s two groundwater wells produced 66.51 acre-feet in 2015.

The Magalia District is approximately 0.74 square miles, with 280 metered service connections, which are primarily residential. Magalia has two groundwater wells, which produced approximately 37.69 acre-feet in 2015. In addition to local groundwater wells, Magalia receives surface water from the Stirling Bluffs District. All connections are metered.

The Paradise Pines District is approximately 7.17 square miles, primarily utilizes groundwater, and has 4,808 metered service connections. In addition to local groundwater wells, Paradise Pines receives surface water from the Stirling Bluffs District. The primary water service is for single family residential dwellings. Paradise Pines has four active groundwater wells, which produced 741 acre-feet in 2015. All connections are metered.

The Stirling Bluffs District is approximately 1.35 square miles, with 164 metered service connections. Water use in the area is primarily residential. Stirling Bluffs has a contract to receive up to 365 acre-feet per year of water from PG&E through the Hendrick Canal. In 2015, they diverted 47.05 acre-feet of this water. All connections are metered.

The remaining water from Stirling Bluffs is available for transfer to Paradise Reservoir, which Paradise Irrigation District treats and wheels to Paradise Pines or Magalia. In 2015, of the 365 acre-feet, approximately 327 acre-feet was available to transfer. In 2015, Paradise Pines received 192.50 acre feet and Magalia received 39.95 acre-feet. This water can also be wheeled to Lime Saddle in an emergency.

Del Oro maintains and agreement with Paradise Irrigation District (PID) for the purposes of procuring additional surface water for Lime Saddle, Magalia, and Paradise Pines when necessary. Del Oro last purchased additional surface water from PID in 2012, with 58.56 acre-feet delivered to Lime Saddle. Since the completion of the Regional Intertie Project described above, Del Oro has not purchased water from PID. Del Oro does not expect to purchase water from PID again, barring an emergency situation.

Paradise Irrigation District

Located in central Butte County, California, the Paradise Irrigation District was established in 1916 to supply water to an area of approximately 11,250 acres. PID currently relies predominately on surface water sourced from the Little Butte Creek watershed, a minor stream in the Sacramento Valley drainage that rises in the northwestern foothills of the Sierra Nevada and lies wholly within Butte County. Although a perennial creek, Little Butte Creek receives a relatively large amount of precipitation and resulting runoff. Little Butte Creek conveys surface water and storm runoff into the Paradise Reservoir and Magalia Reservoir; the latter is located approximately one half mile north of the community of Magalia and approximately one mile north of the PID's service area. The PID has three water permits allowing diversion of water from Little Butte Creek: two storage rights and a direct flow right. The average runoff for the watershed is approximately 15,960 acre-feet per year.

Storage is provided by two reservoirs impounded by the Paradise and Magalia Dams located north of Paradise. The upstream reservoir, Paradise Lake, is the main storage facility with a storage capacity of approximately 11,500 acre-feet. Downstream of Paradise Dam, storage behind the Magalia Dam is presently restricted to approximately 800 acre-feet, as the reservoir operating level has been reduced due to dam seismic stability concerns. If repaired, the capacity of Magalia Reservoir is approximately 2,570 acre-feet. The District has approximately 6,000 acre-feet of additional water rights that are not being utilized because of a lack of storage.

Due to the reduced water level behind Magalia Dam, gravity feed to the water treatment plant was no longer possible. A pump station was installed at the base of Magalia Reservoir to pump raw water from the reservoir to the treatment plant. In 2007, a bypass pipeline was installed to provide gravity water to the treatment plant in addition to serving as an alternative source location if Magalia Reservoir is contaminated. The District supplies the majority of the Town's residents using a gravity distribution system and storage facilities with a total capacity of approximately 9.5 million gallons.

The Paradise Irrigation District was established in 1916 to supply water to an area of approximately 11,250 acres with a population of approximately 1,000 people. The District was formed with the express purpose of providing agricultural water to the Paradise area. The District was authorized to operate by the California Water Code, Division 11, Section 20500 to 29978 derived from the 1897 Irrigation District law. The District was organized to bond itself to the extent of $350,000 to finance the Magalia Reservoir project.

Construction of the Magalia Dam on Little Butte Creek was begun in 1916 and completed in 1917. The Little Butte Creek watershed was chosen because of the relatively large amounts of precipitation and resulting runoff it received, even though it was seasonal. Magalia Dam was located approximately one-half mile north of the community of Magalia and approximately two miles north of the service area. During the early years, Magalia Reservoir water was used almost solely for irrigation, as domestic supplies were obtained from private wells. The primary agricultural crops within the area at that time were pears, apples, walnuts, olives and grapes. The reservoir's capacity was 1,950 acre-feet and water was delivered through an open canal that followed the eastern wall of Little Butte Creek Canyon.

On January 5, 1932, following a period of acute water shortage, the District's customers were asked to vote on whether or not they would permit the installation of water meters. Ballots were mailed out to 650 water consumers and the issue was voted down by a vote of 262 to 172. In May 1933, the District's directors called a meeting to find ways and means of financially sustaining PID. The meeting was attended by 200 customers and the following plan was adopted:

1. That each individual tract or establishment in the District be charged $6.00 for service.
2. That water used between April and November be paid for at the rate of $3.00 per acre-foot. This was a special charge for water users only.
3. If two or more families lived on one tract, they would be subject to a $6.00 service charge for each family or household.

By 1934, meters were installed to all customers amidst a large uproar of the people.

In March of 1934, PID secured a loan of $260,500 from the Reconstruction Finance Corporation, a federal agency. The outstanding indebtedness of the District at that time was $521,020. This included $12,000 worth of irrigation bonds purchased from PID by the State of California in December 1927. These securities bore interest at 6% and maturity dates between 1941 and 1955. A $160,000 Works Progress Administration project for laying pipe in the District was approved on January 24, 1942. The Federal Reconstruction Corporation made available $140,000 in bonds to purchase the pipe and fittings for the project.

The method for transporting water out of Magalia Reservoir was upgraded in 1954 when a steel pipeline was constructed to replace the open canal. This was necessary due to water losses, contamination and debris in the water. One attempt to increase the capacity of the reservoir was the installations of flashboards in the spillway structure. This provided an additional 600 acre-feet of storage, but was later abandoned for safety reasons. The water supply was augmented by purchasing water from PG&E's Hendricks Canal, an option that is no longer available to the District.

The Mosquito Junction Dam (later the Paradise Dam and Reservoir) and Reservoir Project was proposed in 1956 to fulfill the growing requirements for water for both irrigation and domestic use. A special election was held in January 1956 to decide on $1,500,000 worth of general obligation bonds to finance the project. The measure was approved by a majority of only 53% of the total votes cast. The Mosquito Junction Dam and Reservoir was located approximately two miles upstream from Magalia Reservoir and would provide an additional 6,300 acre-feet of storage area. Construction began on April 20, 1956 and in June 1956 the name was changed to Paradise Dam and Reservoir. This project increased the total usable capacity for the District to 8,350 acre-feet.

Remedial works were completed on Magalia Dam in 1964. The work consisted of stabilizing the existing dam by adding fill material to flatten the downstream slope of the western section below the county road. Approximately 13,000 cubic yards of earth were utilized in the reconstruction. Also 3,200 cubic yards of crushed drain and transition rock were placed on the bottom 3 to 8 feet of the embankment. The Bechtel Corporation served as engineer for the District, and District personnel and equipment were used whenever possible.

Paradise Dam was raised an additional 24.5 feet in 1976 increasing the available storage to 11,497 acre-feet. This project cost four million dollars and increased the District's total capacity to 14,140 acre-feet (a 69% increase), which has since been recalculated and determined to be 14,071 (1992 Topography and Hydrography Study, Harlan-Tait). In 1997, this was further reduced to 12,293 acre-feet as a result of a Magalia Reservoir draw down required by the Division of Safety of Dams due to concerns of seismic stability.

A water filtration plant was added to the District's water system in 1986 due to the increased turbidity within the reservoirs during the winter months. The filtration plant had the capacity to filter six million gallons (mgd) of water per day which met flow requirement during the winter but in the summer unfiltered water was added to the system to meet peak summer flow. The community would not approve a full filtration plant due to the costs involved.

An evaluation of alternatives for expanding the capacity of the existing treatment plant was presented by Brown & Caldwell, September, 1990. The need for the study was driven by changes in drinking water regulations which required the treatment of all surface water supplies. An election was held in June 1992 and the community voted to borrow five million dollars from the Department of Water Resources and to sell Certificates of Participation in the amount of eight million to finance the enlargement project. The measure was approved by a majority of 65% of the voters. In January, 1995 the new treatment plant was completed and placed in service. The new filtration plant has the capacity to treat 22.8 mgd.

A.7. Mountain Inventory Unit

The Mountain Unit includes approximately 407,100 acres in the mountains on the eastern side of the County. The steep terrain limits groundwater accessibility to areas of fractured or jointed rock. There is limited development in the mountain area, so there is little water demand. There are no subinventory units within Mountain, but a portion of the area is provided water from South Feather Water and Power Agency.

South Feather Water and Power Agency

The South Feather Water and Power Agency provides surface water for urban and agricultural uses. The Agency is also within the North Yuba Subbasin, so the District is described in detail in that section.

A.8. North Yuba Inventory Unit

The North Yuba Inventory Unit covers about 47,300 acres in the southeastern portion of the county. The Feather River to the north and west, the Butte County lines to the south, and the foothills to the east border it. North Yuba contains part of the city of Oroville, with a variety of agricultural crops in the remainder of the unit. The primary source of agricultural water is groundwater. North Yuba does not contain any inventory sub-units, but some areas receive water from South Feather Water and Power Agency and California Water Service Company, Oroville.

South Feather Water and Power Agency

South Feather Water and Power Agency, originally named Oroville Wyandotte Irrigation District (“OWID”), has roots extending back to the California gold rush. The ditch system utilized by the Agency today to distribute its irrigation water is a modification and expansion of the ditch network constructed by early miners who diverted water from tributaries of the Feather River to their mining claims.

In 1852, a small ditch company was organized to construct a ditch from the South Fork of the Feather River to the mining sites at Forbestown, Wyandotte, Honcut, Ophir, and Bangor. The Palermo Ditch, completed in 1856 by the Feather River and Ophir Water Company, was a major impetus to the growth of gold mining within the area occupied by the present City of Oroville where rich gold deposits were discovered in 1849. Oroville-Wyandotte Irrigation District was formed in 1919. Originally, the canals in Oroville-Wyandotte were constructed to convey water for hydraulic mining. Most of the infrastructure was built in the 1850s and 1860s, but due to severe environmental damage and associated erosion, hydraulic mining was outlawed in 1884. Two land and water companies, Palermo and South Feather, emerged in the area to take advantage of the existence of the infrastructure.

The land and water companies formed with the intent to sell land to Southern Californians to grow citrus fruits and olives, and they thought that the land would be attractive because it had a water supply.

However, the companies fell onto hard times because the construction costs exceeded original estimates, and the land was not selling as quickly as expected. Around this time, the Wright Act was passed, following the formation of irrigation districts that could levy land taxes. The prospect of collecting taxes was very appealing to the struggling companies, so they formed the Oroville-Wyandotte Irrigation District in 1919.

All residents in the area were not in favor of forming the irrigation district because they did not want to pay the land taxes. Therefore, when Oroville-Wyandotte was formed, customers of the original land and water companies were allowed to receive Oroville-Wyandotte water without needing to join the irrigation district. These customers would receive water at the same priority level as district customers and pay the same rate.

In the years following its formation, Oroville-Wyandotte was constantly faced with problems due to inadequate funding and lack of water supply. To alleviate both problems, it proposed and constructed the South Fork Power Project, which built 8 dams, 17 tunnels, 21 miles of canals and conduits, 4 hydroelectric power plants and 21 miles of road. As a part of this plan, water from the facilities must be delivered to North Yuba Water District to fulfill its water rights on the system. Power from the hydroelectric plants (as well as a hydro-plant built later) was and continues to be sold to PG&E. Today, South Feather Water and Power Agency encompasses 38,320 acres.

South Feather Water and Power Agency serves a population of 17,000, with 6,120 domestic water accounts and 525 irrigation accounts. Urban demand is expected to rise as the historical growth rate of 1.2% is increased because of the Oroville community’s accelerated expansion plans.

Supplied water is used for agricultural, residential, and commercial purposes. South Feather Water and Power Agency does not keep track of cropping patterns within the Agency. The land has been subdivided into small parcels, or ranchettes, most of which are not commercial farms. Some farms irrigate, but some do not, such as those producing olive crops. The primary crops are citrus and olives, and viticulture is increasing as well. Viticulture is not commercial yet, but produces wines that are only sold locally.

South Feather Water and Power Agency has four major reservoirs: Little Grass Valley Sly Creek, Lost Creek, Ponderosa, and Miner’s Ranch, which total approximately 172 TAF of storage. Sly Creek Reservoir is fed partially by Slate Creek, which is part of the Yuba River system. North Yuba Water District receives water through the Forbestown Ditch from lost Creek Reservoir. The remainder of the water is for use. There are three canal systems within the Agency that provide raw water to agricultural customers: Forbestown, Bangor, and Palermo. South Feather

Water and Power Agency does not use groundwater but there are some pockets of land within the Agency that have independent private wells.

South Feather Water and Power Agency has both pre-1914 and appropriative water rights totaling 800 TAF, which is more water than is available from within the watershed. The Agency can take 172,145 acre-feet of water from the South Fork of the Feather River and the Yuba River and store it in its reservoirs. South Feather Water and Power Agency uses 27 TAF of water within their service area. The system is 100% metered (or volume-measured for raw water delivery systems, using instruments such as “miner’s-inch” boxes). Losses within the domestic system are believed to be negligible. In 1990, there were up to 160 leaks due to the poor condition of the old steel pipeline system, but with repairs there are now only 6-7 leaks. South Feather Water and Power Agency has completed an aggressive steel pipeline replacement project for their urban deliveries. Losses in the agricultural systems are more significant, with 93% in the Forbestown Canal, and approximately 70-80% in the remainder of the system. In recent years, it has coated canal areas with profuse leaks with concrete, and fixed sections with major leaks. Consideration has been given to rehabilitating the entire ditch system, but the cost is estimated between $15-$20 million. The ditch system is already subsidized by the power division, so the Agency cannot justify spending additional money on that system. The Agency would consider repairing the leaks if it could sell the water, but wheeling fees charged by the DWR have made transfers financially prohibitive.

A.9. Vina Inventory Unit

The Vina Inventory Unit includes approximately 88,100 acres in the northern valley area of Butte County. The Butte County line to the north, Big Chico Creek to the south, Sacramento River to the west, and the foothills to the east border it. Vina includes part of the city of Chico and agricultural land in the western half, with orchards as the major crop type. The predominant source of water is groundwater.

A.9.1. California Water Service Company, Chico

California Water Service Company, Chico (Cal Water Chico) is a private company that has been serving the water supply needs of the greater Chico area since 1926, when it purchased three smaller districts in the area. The greater Chico area includes some areas of Butte County as well as the City of Chico.

There are approximately 102,155 people in the service area, but Cal Water Chico does not provide water to the entire population within the service area because there are some private wells sprinkled within this area. Supplied water is used solely for urban purposes. Some water is provided to businesses for landscaping. Cal Water Chico has no surface water supply, so it takes all of its water from 68 deep wells. On average, the company supplies 25.9 TAF a year. In 2015 Cal Water Chico supplied 18.2 TAF due to conservation efforts driven by State mandated drought regulations.

There are 9 tanks (4 above ground) that are used for storage, for a total combined storage of 5.2 million gallons. In principle, losses are tracked by Cal Water Chico's central engineering department. The company has few leaks in the Cal Water Chico's distribution system that are repaired immediately when detected. All wells are monitored and 100% of the connections were metered by the end of 2014.

The treatment facility for the City of Chico is owned and operated by the City. The City of Chico operates and maintains a modern 12 MGD capacity, secondary treatment, activated sludge, wastewater treatment plant with future expandability to 15 MGD capacity. The Chico treatment plant is operating at a capacity to treat 9 MGD but currently receives 7.0 MGD from Cal Water's Chico service area. Treated wastewater from the Chico Wastewater Treatment Plant is not recycled at this point. The facility is in good to excellent condition and has good performance. The effluent is discharged into the Sacramento River from an outfall located 8,600 feet west of the wastewater treatment plant.

Cal Water Chico does not foresee any immediate supply problems within its service area. Its management believes that the water supply is adequate for future growth. The company plans to drill additional wells and pump more water to fulfill higher future demands but is also actively investigating surface water opportunities and recycled water opportunities in the Chico area.

A.10. West Butte Inventory Unit

The West Butte Inventory Unit encompasses approximately 93,900 acres on the west side of Butte County. It is bordered by Big Chico Creek to the north, the foothills to the northeast, the County line to the south, the Sacramento River to the west, and Butte Creek to the east. West Butte includes the town of Durham and part of the city of Chico, as well as agricultural land and environmental refuge areas. The primary source of water is groundwater, although Llano Seco Rancho and M&T Incorporated receive Sacramento River water through the CVP, and several water suppliers have water rights on Butte Creek.

A.10.1. Angel Slough Subinventory Unit

The Angel Slough Subinventory Unit covers an area of about 5,400 acres in the southwest portion of the West Butte Inventory Unit. In summer, in a normal year, at least 70% of this area is supported by groundwater. To the northern and easterly directions it is bordered by the M&T Sub-inventory Unit. The Llano Seco Sub-Inventory Unit borders it to the south and to the west it is bordered by the Sacramento River.

A.10.2. Durham/Dayton Subinventory Unit

Durham/Dayton subinventory unit is the area surrounding the communities of Durham, Dayton and part of Chico, located in the northeast of the West Butte Subbasin. Land use in the area includes urban land use around Durham, Dayton, and Chico, as well as extensive agricultural use, with primarily orchard crops.

Dayton Mutual Water Company

Dayton Mutual Water Company provides surface water to meet the area's agricultural water needs. Rice is the primary crop in the area, with small pockets of other crops. Dayton Mutual has water rights to Butte Creek and the West Branch of the Feather River (diverted through Butte Creek). PG&E diverts water from the West Branch of the Feather River through the Toadtown Canal to generate hydroelectric power before discharging flows to Butte Creek. Dayton Mutual has rights to 3.334 cfs of this water. In addition, Dayton Mutual has first priority rights to 16 cfs of water from Butte Creek.

Durham Irrigation District

The Durham Irrigation District (DID/District) provides domestic water services to approximately 350 parcels in an area south of the City of Chico. In 1935, the Bidwell Municipal Utility District took over a small private water utility that was inadequately serving the town of Durham. The new utility district drilled a new well, installed pumping equipment, and started delivering water to customers. The service area soon embraced the entire town of Durham, supplying 86 services with domestic and commercial water supplies, as well as water for fire protection. Bidwell Municipal Utility District was dissolved by voter mandate and all of its properties were turned over to Butte County. The county waterworks district (Butte County Water Works District No. 1) was then organized to operate the Durham water system under the County Board of Supervisors. However, this method of operation resulted in the rendering of unsatisfactory service and local interests expressed a desire to convert to the type of district that could be managed by a local board of directors. The Durham Irrigation District was formed to provide domestic water and was approved by the voters on February 17, 1948. At that time the District encompassed a total area of 93 acres.

A.10.3. Llano Seco Subinventory Unit

The Llano Seco Subinventory Unit is located in the southwest corner of the West Butte Subbasin. It is composed of the Llano Seco Rancho, which is largely a refuge area.

Llano Seco Rancho

Llano Seco Rancho (also known as Parrott Ranch) was historically agricultural, but a portion of the land was purchased by the U.S. Fish and Wildlife Service (FWS) in 1990. Approximately 2,570 acres were purchased outright, and is now owned by FWS as a reserve. The remaining 6,580 acres still belongs to the Parrott Investment Company, Inc. (PIC), but FWS purchased conservation easements, which are essentially the developmental rights to the land. PIC owns all other rights within the conservation easement areas. On the conservation easements held by FWS, PIC has converted some agricultural acres (mainly rice acreage) to wetland type habitats as well as grasslands.

The Ranch has two water rights, one to the Sacramento River and one to Butte Creek. The major water right is a riparian right on the Sacramento River, which is delivered to the Ranch through the M&T pumping plant. In addition, the Ranch has a water contract with PG&E to the

West Branch Feather River water delivered into Butte Creek through the Toadtown Canal. Finally, the Ranch has a low priority water right to Butte Creek water. Feather River and Butte Creek water is diverted at Parrott-Phelan Dam, and then conveyed to Llano Seco through Edgar Slough and the Parrott Lateral. The FWS and the DFG have an agreement with the Ranch and M&T to have their portion of the Butte Creek water right stay in Butte Creek for in-stream flow benefit for salmon. This agreement allows for the pooling of water during portions of the year to help meet salmon needs.

Llano Seco Rancho (DFW)

The California Department of Fish and Wildlife (DFW) bought 1,521 acres of the Llano Seco Rancho, also known as Parrott Ranch, which it calls the Llano Seco Unit of the Upper Butte Basin Wildlife Area. Llano Seco Rancho maintains the water rights to the property purchased by DFG. However, DFG was granted in the deed to the property the ability to buy water from Llano Seco Rancho.

In addition to surface water purchased from Llano Seco Ranch, the Llano Seco Unit has one deep well on the property that produces approximately 5,000 gpm. This well was primarily installed for drought protection but is used when water is needed for crop purposes during delays in water delivery and when water is unavailable from other sources. The well was installed in 1994 and has a 16-inch casing and a depth of 500 feet.

Llano Seco Rancho (USFWS)

The Llano Seco Unit was established in 1989 as part of the North Central Valley Wildlife Management Area. It is part of the historic Llano Seco Rancho, the last intact Mexican land grant in California. This historic area is bounded by the Sacramento River to the west and is bisected by Angel Slough in the center and Little Chico Creek to the east. This diverse landscape includes riparian floodplains, uplands and wetland basins. The Llano Seco Unit consists of two distinct areas: Sanctuary I (967 acres) and Sanctuary II (765 acres). Managed wetlands comprise nearly half of the total acreage, and consist mostly of seasonally flooded wetlands, with some semi-permanent and permanent wetlands. The remaining acreage is comprised of grasslands, vernal pools, and irrigated pasture with some riparian forest habitats. The Unit supports large populations of wintering waterfowl, as well as other species such as: bald eagle, mountain lion, bobcat, State-listed as threatened greater sandhill cranes, Swainson's hawk, federally threatened giant garter snakes and valley elderberry longhorn beetle, federally endangered vernal pool tadpole shrimp and vernal pool fairy shrimp, and species of concern California linderiella and Ferris's milk-vetch. Sanctuary I has no public use and is an inviolate sanctuary. Sanctuary II has a non-consumptive wildlife-dependent public use including wildlife observation, photography, environmental education and interpretation.

A.10.4. M&T Subinventory Unit

M&T Subinventory Unit is in the northwest corner of the West Butte Inventory Unit and contains the M&T Chico Ranch.

M&T Chico Ranch

M&T Chico Ranch is a large agricultural land owner, with primary crops including rice, dry beans, almonds, walnuts, and prunes. It is approximately 13.5 square miles, primarily bordered by Big Chico Creek to the north, the city of Chico to the east and part of the Sacramento River to the west.

M&T receives water from both surface water sources and groundwater sources. M&T has surface water rights to the West Branch of the Feather River water in Butte Creek, and to surplus Butte Creek flows. M&T has a Sacramento River Settlement Contract with USBR that was created to address the impacts of constructing Shasta Dam. Under its contract with USBR, the total amount of water rights agreed upon is 16,980 acre-feet of Sacramento River water and a Project water supply of 976 acre-feet for a total of 17,956 acre-feet.

As part of the approval process on M&T/Llano Seco's 1996 Sacramento River pumping plant relocation, they developed an agreement with the U.S. Fish and Wildlife Service (FWS) and California Department of Fish and Wildlife (CDFW) to bypass certain flows (maximum of 40 cfs) in Butte Creek to improve the fishery. The bypassed water, also known as (b)(2) water, may amount to 20,000 acre-feet annually and will be considered a part of the habitat restoration program of the Central Valley Project Improvement Act (CVPIA). Bypass period occurs for nine months from October – June of every year. No water will be bypassed from July-September of every year. Since this will be part of the CVPIA, USBR provides a substitute supply of 20,000 acre-feet of CVP water on the condition that FWS and M&T/Llano Seco guarantee that the bypassed flows reach the Sacramento River to keep the CVP whole.

If M&T/Llano Seco leave a portion of their Butte Creek water right in Butte Creek, there may be potential groundwater impacts because the water will no longer flow down Edgar Slough to the ranches south and west of Chico. Edgar Slough is a major winter drain for the city of Chico but also conveys Butte Creek water to M&T/Llano Seco/Dayton Mutual. The slough loses approximately 20% of its flow to groundwater, so reducing flows to M&T/Llano Seco/Dayton Mutual could reduce percolation to groundwater.

A.10.5. Western Canal Subinventory Unit

The Western Canal Water District is an agricultural water district that provides surface water to an area that primarily grows rice. The District is split by Butte Creek, with approximately 24% in the West Butte Inventory Unit, 52% in the East Butte Inventory Unit, and the remaining 24% in Glenn County. The District is described in greater detail under the East Butte Subbasin.

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B. Butte County Stream Gages and Monitoring Wells

This appendix provides lists of stream gages and groundwater monitoring wells in Butte County.

B.1. Butte County Stream Gages

Numerous stream gages have existed in Butte County and continue to exist today. Data for these gages are available through the California Data Exchange Center (CDEC), from the U.S. Geological Survey (USGS), and through the DWR Water Data Library (WDL). In many cases, data for a particular gage is available from more than one source. For example, several USGS gages are also reported through CDEC. A list of past and current locations in Butte County providing surface water flow and/or storage information is provided in Table B.1. The sites listed include those identified as being located in Butte County by CDEC and USGS. The list includes 34 CDEC sites and 89 USGS sites.

Table B.1. Historical and Current Surface Water Flow and Storage Monitoring Sites in Butte County.

Source	Name	Site ID	Latitude	Longitude
CDEC	BANGOR CANAL	BNG	39.5040	-121.4540
CDEC	BIG CHICO CREEK NEAR CHICO	BIC	39.7684	-121.7786
CDEC	BUTTE CREEK NR CHICO	BCK	39.7260	-121.7089
CDEC	BUTTE CREEK NR DURHAM	BCD	39.6780	-121.7775
CDEC	BUTTE CREEK NR GRIDLEY	BCG	39.3856	-121.8889
CDEC	BUTTE CREEK NR WESTERN CANAL	BWC	39.5557	-121.8365
CDEC	BW-12 IMPORT TO BUTTE CREEK	BBW	39.8857	-121.6103
CDEC	CHEROKEE CANAL NR RICHVALE	CHC	39.4647	-121.7447
CDEC	FEATHER MF NR MERRIMAC	FTM	39.7080	-121.2690
CDEC	FEATHER NF AT PULGA	FPL	39.7940	-121.4510
CDEC	FEATHER RIVER AT MERRIMAC	MER	39.7090	-121.2700
CDEC	FEATHER RIVER AT OROVILLE	FTO	39.5220	-121.5470
CDEC	FEATHER RIVER NEAR GRIDLEY	GRL	39.3666	-121.6474
CDEC	FEATHER SF AT PONDEROSA	FTP	39.5480	-121.3030
CDEC	FORBESTOWN DITCH (OROV-WYAN CANAL)	FBD	39.5500	-121.1800
CDEC	HENDRICKS CANAL	HDC	39.9340	-121.5290
CDEC	KELLY RIDGE POWER PLANT	KLL	39.5330	-121.4830
CDEC	LINDO CHANNEL NR CHICO	LCH	39.7492	-121.8689
CDEC	MIOCENE CANAL	MIC	39.6900	-121.5600
CDEC	MUD CREEK NEAR CHICO	MUC	39.7834	-121.8867
CDEC	NF FEATHER R BL GRIZZLY CREEK	F56	39.8525	-121.3914
CDEC	NORTH FORK FEATHER RIVER AT PULGA	NFP	39.7940	-121.4510
CDEC	NORTH FORK FEATHER RIVER AT PULGA	PLG	39.7940	-121.4510
CDEC	OROVILLE DAM	ORO	39.5400	-121.4930
CDEC	PALERMO CANAL	PLC	39.5330	-121.4820

Source	Name	Site ID	Latitude	Longitude
CDEC	PARROT DIV FROM BUTTE CREEK	BPD	39.7089	-121.7542
CDEC	SLY CREEK	SLC	39.5840	-121.1160
CDEC	SOUTH HONCUT CREEK NEAR BANGOR	SFH	39.3682	-121.3719
CDEC	THERMALITO AFTERBAY	TAB	39.4500	-121.6330
CDEC	THERMALITO DIVERS POOL	THD	39.5280	-121.5430
CDEC	THERMALITO FOREBAY	TFR	39.5190	-121.6290
CDEC	THERMALITO TOTAL	TMT	39.4580	-121.6380
CDEC	TOTAL RELEASE-FEATHER R BLW THERMALITO	THA	39.4500	-121.6330
CDEC	WEST BRANCH FEATHER RIVER NEAR MAGALIA	WFR	39.8140	-121.5712
USGS	ANGEL SL A ORD FERRY RD NR ORDBEND CA	11390140	39.6277	-121.9447
USGS	BANGOR CN BL MINERS RANCH RES NR OROVILLE CA	11396330	39.5041	-121.4555
USGS	BIG CHICO C A CHICO CA	11384200	39.7271	-121.8633
USGS	BIG CHICO C A UPPER PARK GOLF COURSE A CHICO CA	11384004	39.7668	-121.7794
USGS	BIG CHICO C NR CHICO CA	11384000	39.7763	-121.7539
USGS	BUTTE C A BUTTE MEADOWS CA	11389700	40.0682	-121.5747
USGS	BUTTE C BL CENTERVILLE DIV DAM NR PARADISE CA	11389780	39.8668	-121.6339
USGS	BUTTE C BL DIV DAM NR STIRLING CITY	11389720	39.9813	-121.5886
USGS	BUTTE C BL FKS OF BUTTE DIV DAM NR DE SABLA CA	11389740	39.9013	-121.6244
USGS	BUTTE C NR CHICO CA	11390000	39.7260	-121.7089
USGS	BUTTE C NR DURHAM CA	11390010	39.6766	-121.7794
USGS	CALIFORNIA WATER SERVICE OUTLET A OROVILLE CA	11406830	39.5282	-121.5561
USGS	CAMP C NR PULGA CA	11404380	39.8293	-121.4241
USGS	CAMP C PP NR PULGA CA	11404383	39.8263	-121.4216
USGS	CENTERVILLE PH NR PARADISE CA	11389775	39.7888	-121.6575
USGS	COMBINED FLOW MERRIMAC PONDEROSA PULGA POE CA	11404902	39.7082	-121.2705
USGS	COMBINED FLOW N F FEATHER R PULGA + POE PP CA	11404901	39.7229	-121.4694
USGS	COMBINED FLOW OF 11396395 + 11396396 CA	11396397	39.5621	-121.2805
USGS	COMPUTED INFLOW TO LK OROVILLE CA	11406799	39.5349	-121.4750
USGS	CONCOW C NR YANKEE HILL CA	11406000	39.7624	-121.5275
USGS	CRESTA PH NR PULGA CA	11404360	39.8260	-121.4097
USGS	DATA FROM 11-4055 + 11-4060 CA	11406099	39.7624	-121.5275
USGS	DE SABLA PH NR PARADISE CA	11389750	39.8693	-121.6319
USGS	DIV TO FEATHER R FISH HATCHERY NR OROVILLE CA	11406930	39.5179	-121.5541
USGS	DRY CR N NELSON CA	11390210	39.5816	-121.6994
USGS	EDWARD HYATT PH NR OROVILLE CA	11406820	39.5354	-121.4752
USGS	EDWARD HYATT PH POWER RELEASE NR OROVILLE	11406818	39.5354	-121.4752
USGS	EDWARD HYATT PH PUMPBACK NR OROVILLE CA	11406819	39.5354	-121.4752
USGS	FEATHER R A BIDWELL BAR CA	11397500	39.5541	-121.4386
USGS	FEATHER R A OROVILLE CA	11407000	39.5216	-121.5477
USGS	FEATHER R A OROVILLE R ONLY CA	11406999	39.5216	-121.5477
USGS	FEATHER R NR GRIDLEY CA	11407150	39.3666	-121.6472

Source	Name	Site ID	Latitude	Longitude
USGS	FORBESTOWN PH NR FORBESTOWN CA	11396290	39.5499	-121.2777
USGS	FORKS OF BUTTE PP NR PARADISE CA	11389747	39.8713	-121.6336
USGS	GOLD RUN TRIB NR NELSON CA	11390200	39.5891	-121.6886
USGS	KANAKA PH NR FEATHER FALLS CA	11396396	39.5621	-121.2805
USGS	KELLY RIDGE PH NR OROVILLE CA	11396329	39.5321	-121.4914
USGS	LITTLE BUTTE C NR MAGALIA CA	11389950	39.8104	-121.5844
USGS	LITTLE CHICO C TRIB A FOREST RANCH CA	11390045	39.8777	-121.6747
USGS	LK OROVILLE NR OROVILLE CA	11406800	39.5349	-121.4747
USGS	LONG RAVINE BL DIV DAM A STIRLING CITY CA	11405220	39.9068	-121.5422
USGS	LOST C NR CLIPPER MILLS CA	11396000	39.5735	-121.1416
USGS	LOST C RES NR CLIPPER MILLS CA	11395600	39.5727	-121.1355
USGS	MF FEATHER R NR MERRIMAC CA	11394500	39.7082	-121.2705
USGS	MINERS RANCH CN BL PONDEROSA DAM NR FORBESTOWN CA	11396310	39.5499	-121.3066
USGS	MUD C A COHASSET RD NR CHICO CA	11384340	39.8265	-121.8261
USGS	MUD C NR CHICO CA	11384350	39.7838	-121.8861
USGS	N HONCUT C NR BANGOR CA	11407300	39.3421	-121.4914
USGS	NEW CAMP FAR WEST RES NR WHEATLAND CA	11423700	39.5002	-121.3158
USGS	NF FEATHER R A BIG BEND CA	11405000	39.7143	-121.4691
USGS	NF FEATHER R A PULGA CA	11404500	39.7943	-121.4516
USGS	NF FEATHER R BL GRIZZLY C CA	11404330	39.8524	-121.3925
USGS	NF FEATHER R BL POE DAM CA	11404400	39.8088	-121.4355
USGS	OROVILLE WYANDOTTE CN NR CLIPPER MILLS CA	11395500	39.5541	-121.1930
USGS	PALERMO CN A ENTERPRISE CA	11396500	39.5346	-121.3455
USGS	PALERMO CN A OROVILLE DAM CA	11406810	39.5329	-121.4830
USGS	PGE LATERAL A INTAKE NR OROVILLE CA	11406900	39.4893	-121.6878
USGS	PHILBROOK C BL PHILBROOK DAM NR BUTTE MEADOWS CA	11405120	40.0299	-121.4777
USGS	PHILBROOK RES NR BUTTE MEADOWS CA	11405100	40.0296	-121.4761
USGS	POE PH BL POE DAM NR JARBO GAP CA	11404900	39.7229	-121.4694
USGS	RICHVALE CN A INTAKE NR OROVILLE CA	11406890	39.5052	-121.6861
USGS	SACRAMENTO R A GOOSE LK PMP NR ORDBEND CA	11388800	39.5663	-121.9864
USGS	SACRAMENTO R NR HAMILTON CITY (DWR FURNISHED)	11383800	39.7515	-121.9955
USGS	SCOTTS JOHN C NR STIRLING CITY CA	11389650	40.1090	-121.4269
USGS	SF FEATHER R A ENTERPRISE CA	11397000	39.5374	-121.3469
USGS	SF FEATHER R A PONDEROSA DAM CA	11396350	39.5477	-121.3041
USGS	SF FEATHER R BL FORBESTOWN DAM CA	11396200	39.5513	-121.2094
USGS	SF FEATHER R NR FORBESTOWN CA	11396300	39.5521	-121.2814
USGS	SLY C RES NR STRAWBERRY VALLEY CA	11395400	39.5817	-121.1142
USGS	SNAG LK (ROUND VALLEY RES) NR JONESVILLE CA	11405075	40.0738	-121.4558
USGS	SPRING VALLEY D NR YANKEE HILL CA	11405500	39.7632	-121.5294
USGS	SUCKER RUN A KANAKA DIV NR FEATHER FALLS CA	11396395	39.5621	-121.2805
USGS	SUCKER RUN NR FORBESTOWN CA	11396400	39.5532	-121.3022

Source	Name	Site ID	Latitude	Longitude
USGS	SUTTER BUTTE CN A INTAKE NR OROVILLE CA	11406910	39.4504	-121.6583
USGS	THERMALITO AFTERBAY NR OROVILLE CA	11406870	39.4582	-121.6391
USGS	THERMALITO AFTERBAY REL TO FEATHER R NR OROVILLE	11406920	39.4563	-121.6372
USGS	THERMALITO DIV POOL NR OROVILLE CA	11406825	39.5293	-121.5466
USGS	THERMALITO FOREBAY NR OROVILLE CA	11406840	39.5154	-121.6300
USGS	THERMALITO PH NR OROVILLE CA	11406850	39.5146	-121.6297
USGS	THERMALITO PH PUMPBACK NR OROVILLE CA	11406849	39.5146	-121.6297
USGS	THERMALITO POWER RELEASE NR OROVILLE CA	11406848	39.5146	-121.6297
USGS	TOADTOWN CN AB BUTTE CAN NR STIRLING CITY CA	11389800	39.8857	-121.6108
USGS	WB FEATHER R BL HENDRICKS DIV DAM CA	11405200	39.9340	-121.5297
USGS	WB FEATHER R BL SNAG LK NR JONESVILLE CA	11405085	40.0732	-121.4533
USGS	WB FEATHER R NR PARADISE CA	11405300	39.7866	-121.5627
USGS	WB FEATHER R NR YANKEE HILL CA	11406500	39.6985	-121.5616
USGS	WESTERN CN A INTAKE NR OROVILLE CA	11406880	39.5052	-121.6861
USGS	WOODLEAF PH NR WOODLEAF CA	11396090	39.5549	-121.2041
USGS	WYMAN RAVINE TRIB NR PALERMO CA	11407400	39.3824	-121.5797

B.2. Butte County Monitoring Wells

Within the Butte County portion of the Sacramento Valley groundwater basin, groundwater level monitoring is conducted by a cooperative effort between Butte County and the Department of Water Resources Northern Region Office (DWR NRO). Water levels are monitored in a network of approximately 140 wells in March, July, August, and October. The number of wells and type are summarized for these wells in Section 4.3.2 of the WI&A, along with a figure showing well locations. A list of individual monitoring wells is provided in table B.2.

Table B.2. Butte County Groundwater Level Monitoring Wells.

State Well Number	Well Use	Sub-basin	CASGEM Program	BMO Program
17N01E10A001M	Residential	East Butte	Voluntary	BMO
17N01E17F001M	Observation	East Butte	CASGEM	BMO
17N01E17F002M	Observation	East Butte	CASGEM	BMO
17N01E17F003M	Observation	East Butte	CASGEM	BMO
17N01E24A002M	Observation	East Butte	CASGEM	
17N01E24A003M	Observation	East Butte	CASGEM	BMO
17N01E24A004M	Observation	East Butte	CASGEM	BMO
17N01E24A005M	Observation	East Butte	CASGEM	BMO
17N01E24A006M	Observation	East Butte	CASGEM	BMO
17N02E14A001M	Irrigation	East Butte	Voluntary	BMO
17N02E14H001M	Other	East Butte	Voluntary	BMO
17N02E16C001M	Residential	East Butte	Voluntary	

State Well Number	Well Use	Sub-basin	CASGEM Program	BMO Program
17N02E19J001M	Other	East Butte	Voluntary	BMO
17N03E05C001M	Irrigation	East Butte	Voluntary	
17N03E05C003M	Irrigation	East Butte	Voluntary	
17N03E08G001M	Residential	East Butte	Voluntary	
17N03E08K002M	Residential	East Butte	Voluntary	
17N03E13B002M	Irrigation	East Butte	Voluntary	
17N03E16N001M	Residential	East Butte	CASGEM	BMO
18N01E01H001M	Irrigation	East Butte	Voluntary	
18N01E13A002M	Irrigation	East Butte	Voluntary	BMO
18N01E13M001M	Residential	East Butte	Voluntary	
18N01E15D002M	Residential	East Butte	CASGEM	BMO
18N01E21L001M	Irrigation	East Butte	Voluntary	
18N01E35L001M	Observation	East Butte	CASGEM	BMO
18N02E11D001M	Irrigation	East Butte	Voluntary	
18N02E16F001M	Irrigation	East Butte	CASGEM	BMO
18N02E25M001M	Irrigation	East Butte	Voluntary	BMO
18N02E32H001M	Residential	East Butte	Voluntary	BMO
18N02E32Q001M	Unknown	East Butte	Voluntary	
18N02E32Q002M	Residential	East Butte	Voluntary	
18N03E05K001M	Irrigation	East Butte	Voluntary	
18N03E08B003M	Irrigation	East Butte	Voluntary	BMO
18N03E18F001M	Irrigation	East Butte	Voluntary	
18N03E21G001M	Irrigation	East Butte	CASGEM	BMO
19N01E09Q001M	Irrigation	East Butte	Voluntary	BMO
19N01E09R001M	Irrigation	East Butte	Voluntary	
19N01E27Q001M	Observation	East Butte	Voluntary	BMO
19N01E28R001M	Residential	East Butte	Voluntary	
19N01E35B001M	Observation	East Butte	CASGEM	BMO
19N01E35B002M	Observation	East Butte	CASGEM	BMO
19N01E35B003M	Observation	East Butte	CASGEM	BMO
19N02E07K002M	Observation	East Butte	CASGEM	BMO
19N02E07K003M	Observation	East Butte	CASGEM	BMO
19N02E07K004M	Observation	East Butte	CASGEM	BMO
19N02E13Q001M	Observation	East Butte	CASGEM	BMO
19N02E13Q002M	Observation	East Butte	CASGEM	BMO
19N02E13Q003M	Observation	East Butte	CASGEM	BMO
19N02E15N002M	Irrigation	East Butte	Voluntary	BMO
19N02E17A001M	Residential	East Butte	Voluntary	
19N02E34J001M	Residential	East Butte	Voluntary	
19N03E05N001M	Other	East Butte	Voluntary	
19N03E05N002M	Residential	East Butte	Voluntary	BMO

State Well Number	Well Use	Sub-basin	CASGEM Program	BMO Program
19N03E16Q001M	Residential	East Butte	Voluntary	BMO
19N03E19N001M	Irrigation	East Butte	Voluntary	
19N03E21C001M	Residential	East Butte	Voluntary	
19N03E22A001M	Industrial	East Butte	Voluntary	
19N04E32P001M	Irrigation	East Butte	Voluntary	
20N01E35C001M	Residential	East Butte	CASGEM	BMO
20N01W04J001M	Irrigation	East Butte	Voluntary	BMO
20N01W11N002M	Stockwatering	East Butte	Voluntary	BMO
20N02E08H003M	Residential	East Butte	Voluntary	BMO
20N02E09G001M	Observation	East Butte	CASGEM	BMO
20N02E09L001M	Irrigation	East Butte	CASGEM	BMO
20N02E15H001M	Observation	East Butte	CASGEM	BMO
20N02E15H002M	Observation	East Butte	CASGEM	BMO
20N02E16P001M	Irrigation	East Butte	Voluntary	BMO
20N02E24C001M	Observation	East Butte	CASGEM	BMO
20N02E24C002M	Observation	East Butte	CASGEM	BMO
20N02E24C003M	Observation	East Butte	CASGEM	BMO
20N02E28N001M	Other	East Butte	Voluntary	BMO
20N03E31M001M	Observation	East Butte	CASGEM	BMO
20N03E33L001M	Other	East Butte	CASGEM	BMO
21N02E20P001M	Irrigation	East Butte	Voluntary	BMO
21N02E26E003M	Observation	East Butte	CASGEM	BMO
21N02E26E004M	Observation	East Butte	CASGEM	BMO
21N02E26E005M	Observation	East Butte	CASGEM	BMO
21N02E26E006M	Observation	East Butte	CASGEM	BMO
21N03E22C001M	Residential	East Butte	Voluntary	BMO
21N03E29J003M	Residential	East Butte	Voluntary	BMO
21N03E32B001M	Irrigation	East Butte	CASGEM	BMO
22N02E18J001M	Residential	East Butte	Voluntary	
17N03E03D001M	Irrigation	North Yuba	CASGEM	BMO
17N03E13N001M	Irrigation	North Yuba	Voluntary	
17N04E08A001M	Irrigation	North Yuba	Voluntary	
17N04E09N002M	Other	North Yuba	Voluntary	BMO
17N04E22B001M	Residential	North Yuba	Voluntary	BMO
18N03E25N001M	Irrigation	North Yuba	Voluntary	
18N04E08M001M	Irrigation	North Yuba	Voluntary	
18N04E16C001M	Irrigation	North Yuba	Voluntary	
18N04E28L001M	Irrigation	North Yuba	Voluntary	
19N04E31F001M	Residential	North Yuba	Voluntary	BMO
CWS-01	Municipal-Oroville	North Yuba		BMO

State Well Number	Well Use	Sub-basin	CASGEM Program	BMO Program
CWS-02	Municipal-Oroville	North Yuba		BMO
CWS-03	Municipal-Oroville	North Yuba		BMO
22N01E09B001M	Residential	Vina	Voluntary	BMO
22N01E20K001M	Residential	Vina	Voluntary	BMO
22N01E28J001M	Observation	Vina	CASGEM	BMO
22N01E28J003M	Observation	Vina	CASGEM	BMO
22N01E28J005M	Observation	Vina	CASGEM	BMO
22N01W05M001M	Irrigation	Vina	CASGEM	
23N01E18A001M	Residential	Vina	Voluntary	BMO
23N01E29P002M	Irrigation	Vina	Voluntary	BMO
23N01E33A001M	Irrigation	Vina	Voluntary	BMO
23N01W03H002M	Observation	Vina	CASGEM	BMO
23N01W03H003M	Observation	Vina	CASGEM	BMO
23N01W03H004M	Observation	Vina	CASGEM	BMO
23N01W09E001M	Irrigation	Vina	CASGEM	
23N01W10E001M	Irrigation	Vina	Voluntary	BMO
23N01W10M001M	Observation	Vina	CASGEM	BMO
23N01W14R002M	Irrigation	Vina	Voluntary	
23N01W16E001M	Irrigation	Vina	Voluntary	
23N01W25G001M	Irrigation	Vina	Voluntary	BMO
23N01W27L001M	Residential	Vina	Voluntary	BMO
23N01W28M002M	Observation	Vina	CASGEM	BMO
23N01W28M003M	Observation	Vina	CASGEM	BMO
23N01W28M004M	Observation	Vina	CASGEM	BMO
23N01W28M005M	Observation	Vina	CASGEM	BMO
23N01W31M001M	Observation	Vina	CASGEM	BMO
23N01W31M002M	Observation	Vina	CASGEM	BMO
23N01W31M003M	Observation	Vina	CASGEM	BMO
23N01W31M004M	Observation	Vina	CASGEM	BMO
23N01W36P001M	Residential	Vina	Voluntary	BMO
23N02W25C001M	Irrigation	Vina	Voluntary	BMO
CWSCH01	Municipal-Chico	Vina/West Butte		BMO
CWSCH02	Municipal-Chico	Vina/West Butte		BMO
CWSCH03	Municipal-Chico	Vina/West Butte		BMO
CWSCH04	Municipal-Chico	Vina/West Butte		BMO
CWSCH05	Municipal-Chico	Vina/West Butte		BMO
CWSCH06	Municipal-Chico	Vina/West Butte		BMO
CWSCH07	Municipal-Chico	Vina/West Butte		BMO
20N01E02H003M	Observation	West Butte	CASGEM	BMO

State Well Number	Well Use	Sub-basin	CASGEM Program	BMO Program
20N01E10C002M	Irrigation	West Butte	Voluntary	BMO
20N01E13Q002M	Irrigation	West Butte	Voluntary	
20N01E18L001M	Observation	West Butte	CASGEM	BMO
20N01E18L002M	Observation	West Butte	CASGEM	BMO
20N01E18L003M	Observation	West Butte	CASGEM	BMO
20N02E06Q001M	Irrigation	West Butte	CASGEM	BMO
21N01E08K002M	Irrigation	West Butte	CASGEM	
21N01E10B003M	Irrigation	West Butte	Voluntary	BMO
21N01E12D001M	Irrigation	West Butte	Voluntary	
21N01E12K001M	Irrigation	West Butte	Voluntary	
21N01E13F001M	Irrigation	West Butte	Voluntary	
21N01E13L002M	Observation	West Butte	CASGEM	BMO
21N01E13L003M	Observation	West Butte	CASGEM	BMO
21N01E13L004M	Observation	West Butte	CASGEM	BMO
21N01E14Q002M	Irrigation	West Butte	Voluntary	
21N01E21C001M	Irrigation	West Butte	Voluntary	
21N01E25K001M	Residential	West Butte	Voluntary	BMO
21N01E26K001M	Irrigation	West Butte	Voluntary	BMO
21N01E27B001M	Irrigation	West Butte	CASGEM	
21N01E27D001M	Residential	West Butte	Voluntary	BMO
21N01E28F001M	Irrigation	West Butte	CASGEM	
21N01W11A001M	Observation	West Butte	CASGEM	BMO
21N01W11A002M	Observation	West Butte	CASGEM	BMO
21N01W11A003M	Observation	West Butte	CASGEM	BMO
21N01W13J001M	Observation	West Butte	CASGEM	BMO
21N01W13J002M	Observation	West Butte	CASGEM	BMO
21N01W13J003M	Observation	West Butte	CASGEM	BMO
21N01W23J001M	Irrigation	West Butte	Voluntary	BMO
21N01W24B001M	Irrigation	West Butte	CASGEM	BMO
21N01W35K002M	Irrigation	West Butte	Voluntary	BMO
21N02E07C001M	Irrigation	West Butte	Voluntary	BMO
21N02E18C001M	Observation	West Butte	CASGEM	BMO
21N02E18C002M	Observation	West Butte	CASGEM	BMO
21N02E18C003M	Observation	West Butte	CASGEM	BMO
21N02E30L001M	Residential	West Butte	CASGEM	BMO
21N02E32E001M	Irrigation	West Butte	Voluntary	
22N01E29R001M	Irrigation	West Butte	CASGEM	BMO
22N01E32E004M	Residential	West Butte	Voluntary	BMO
22N01E35E001M	Irrigation	West Butte	CASGEM	BMO
22N02E30C002M	Observation	West Butte	CASGEM	BMO

C. Subinventory Unit Land Use and Water Budgets

This appendix presents land use and water budget information for Butte County subinventory units (SIUs) (Figure C.1). This information is analogous to information presented in Sections 3 and 5 of the WI&A, but describes individual SIUs that make up the WI&A inventory units (IUs). Information for the following SIUs is provided:

- Vina IU (C.1)
    - Vina SIU (C.1.1)
- West Butte IU (C.2)
    - Angel Slough SIU (C.2.1)
    - Durham/Dayton SIU (C.2.2)
    - Llano Seco SIU (C.2.3)
    - M&T SIU (C.2.4)
    - Western Canal SIU (West Butte Portion) (C.2.5)
- East Butte IU (C.3)
    - Biggs-West Gridley SIU (C.3.1)
    - Butte SIU (C.3.2)
    - Butte Sink SIU (C.3.3)
    - Cherokee SIU (C.3.4)
    - Esquon SIU (C.3.5)
    - Pentz SIU (C.3.6)
    - Richvale SIU (C.3.7)
    - Thermalito SIU (C.3.8)
    - Western Canal SIU (East Butte Portion) (C.3.9)
- North Yuba IU (C.4)
    - North Yuba SIU (C.4.1)
- Foothill IU (C.5)[1]
    - Cohasset SIU (C.5.1)
    - Ridge SIU (C.5.2)

For each SIU, the following information are provided:

- Figure showing general land use from 1995 to 2014 in five-year intervals
- Figure showing annual irrigated agricultural land use by general crop type from 2000 to 2014[2]

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[1] For the Foothill IU, information describing the Cohasset and Ridge SIUs represent the portion of the IU included in the Butte Basin Groundwater Model (BBGM) domain. Detailed land use and water budgets for other portions of the IU have not been prepared at this time.

[2] These figures include estimated annual idle acres, which are estimated as total acreage within each SIU, minus all other land use types (crops, developed lands, wetlands, and non-irrigated native lands). As a result, annual estimates of idle land are subject to relatively greater uncertainty than other land uses, as is apparent for SIUs with

- Tables showing annual land use
- Figures showing average annual land surface (root zone) water budget inflows and outflows by general land use category
- Figure showing total annual inflows and outflows, 2000 to 2014
- Table showing annual inflows and outflows for 2000 to 2014 with summary statistics and averages by hydrologic year type[3]

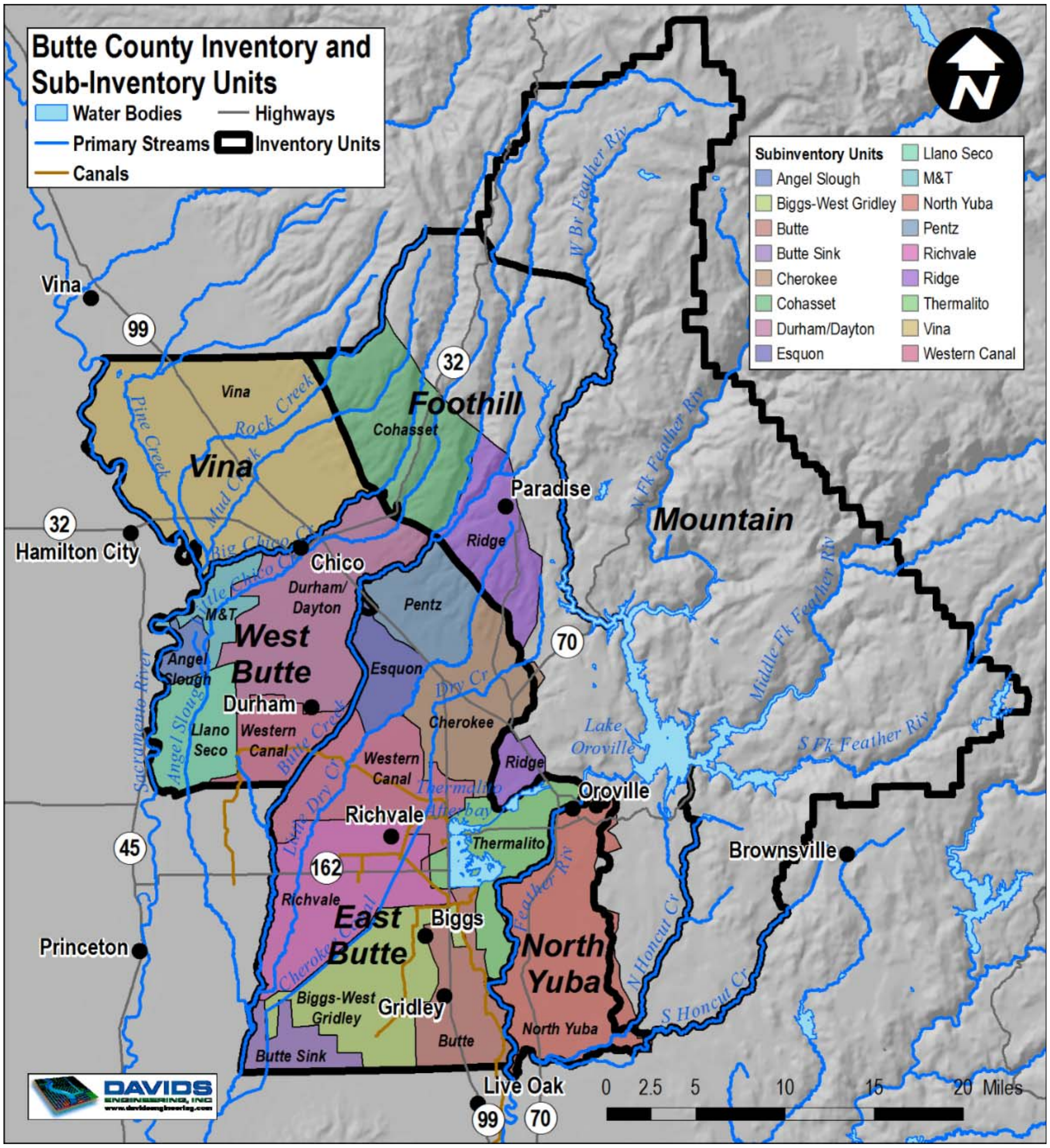

Figure C.1. Butte County Water Inventory and Analysis Inventory Units and Subinventory Units.

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relatively limited irrigated agriculture. Because idle lands are hydrologically similar to non-irrigated lands, these uncertainties are not believed to significantly affect water budget results.

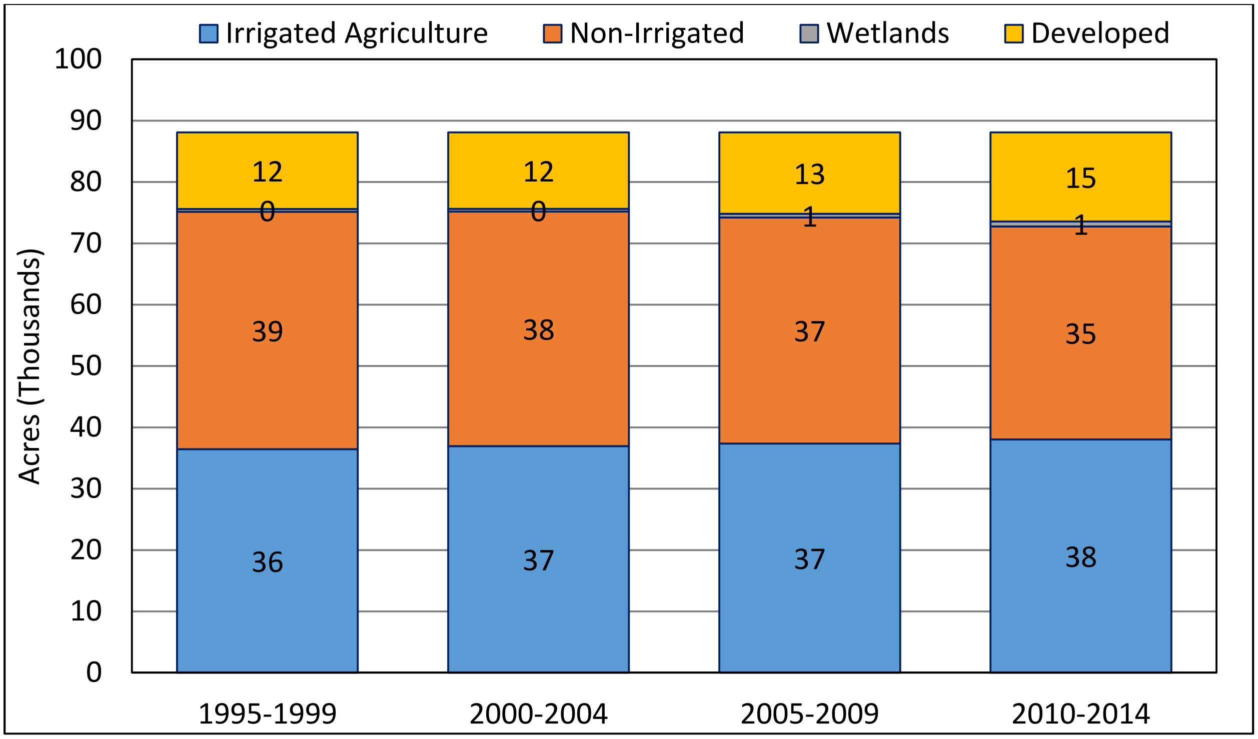
[3] Hydrologic year types are characterized as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), and Critical (C) based on the Sacramento Valley Water Year Index, as described in Section 4 of the WI&A.

C.1. Vina Inventory Unit

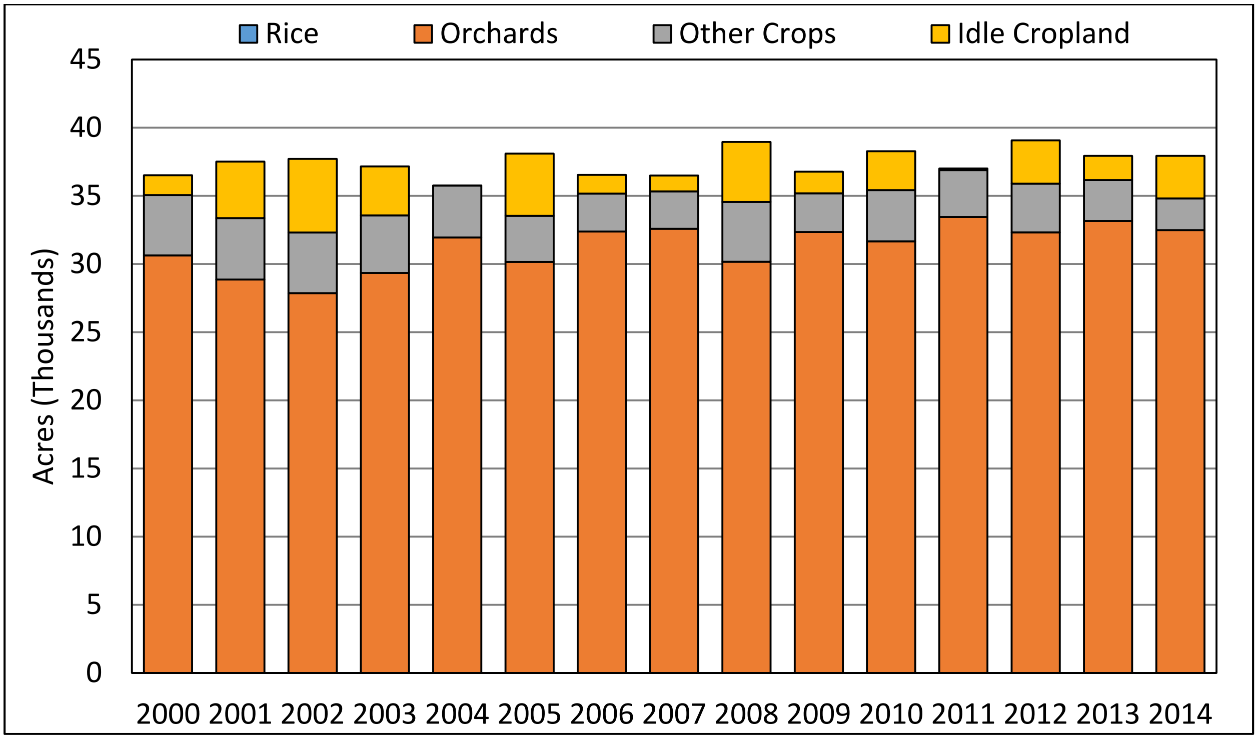
C.1.1. Vina Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

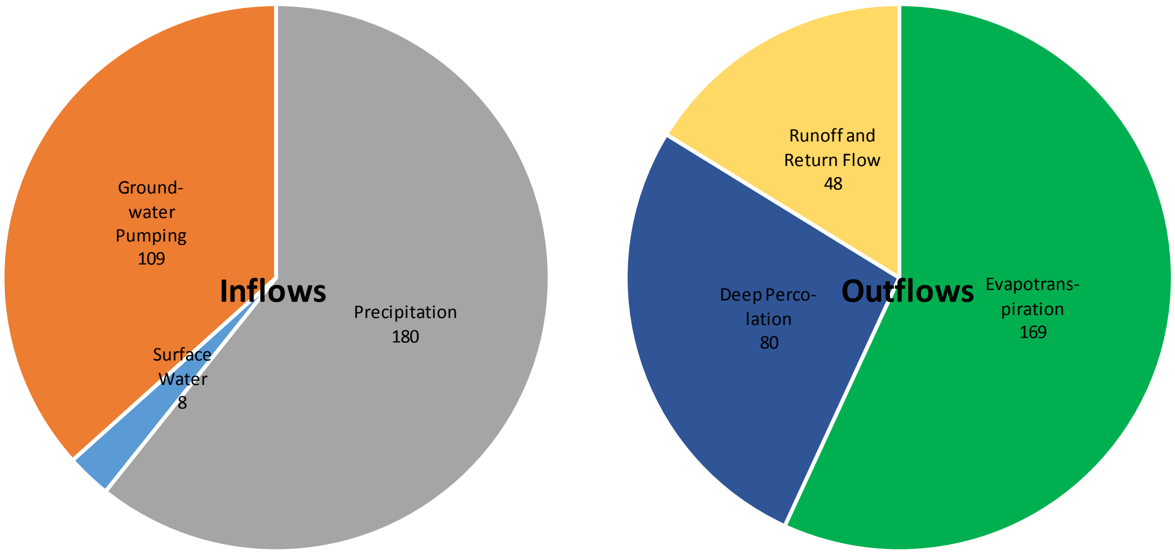
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	0	14,763	10,505	4,890	478	1,089	997	2,338	1,462	35,058	36,520
2001	0	13,552	10,417	4,402	498	1,229	1,097	2,176	4,150	33,370	37,520
2002	0	12,628	10,652	4,152	433	1,118	1,363	1,965	5,401	32,310	37,711
2003	0	13,192	11,720	3,992	438	1,219	1,464	1,551	3,586	33,576	37,162
2004	0	14,178	13,116	4,283	380	952	1,727	1,116	17	35,752	35,769
2005	0	13,088	13,504	3,084	475	580	1,451	1,351	4,568	33,532	38,100
2006	0	12,952	14,664	4,349	423	1,053	1,534	193	1,379	35,167	36,546
2007	0	13,184	14,564	4,407	433	1,131	1,445	170	1,153	35,335	36,488
2008	0	11,587	13,832	4,102	649	1,123	1,301	1,968	4,392	34,562	38,954
2009	0	12,615	14,935	4,410	391	1,040	1,353	450	1,587	35,194	36,781
2010	0	12,304	14,460	4,332	576	843	1,238	1,667	2,856	35,422	38,278
2011	0	12,370	16,213	4,236	632	1,096	1,236	1,111	123	36,893	37,016
2012	0	12,100	15,604	4,027	597	1,379	1,208	976	3,185	35,892	39,077
2013	0	11,917	16,945	3,715	582	887	1,121	993	1,776	36,159	37,936
2014	0	11,976	16,997	2,986	537	109	1,181	1,035	3,114	34,821	37,935
Min	0	11,587	10,417	2,986	380	109	997	170	17	32,310	35,769
Max	0	14,763	16,997	4,890	649	1,379	1,727	2,338	5,401	36,893	39,077
Average	0	12,827	13,875	4,091	501	990	1,314	1,271	2,583	34,870	37,453

Other Land Use

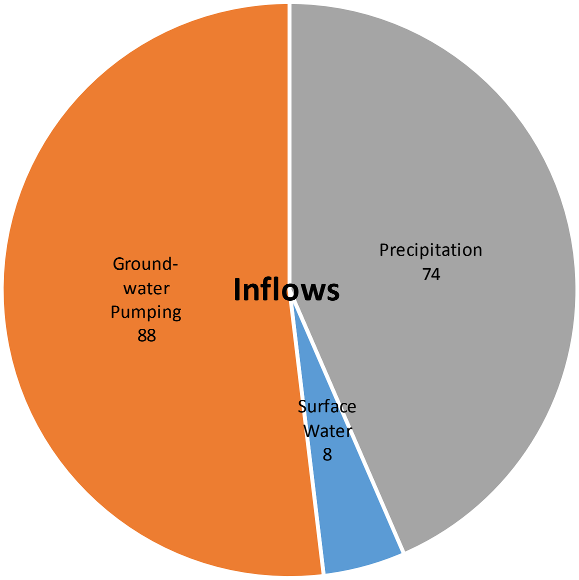
Year	Wetlands	Developed	Non-Irrigated	Total
2000	472	12,706	38,389	51,567
2001	446	12,201	37,920	50,567
2002	444	12,141	37,791	50,376
2003	441	12,430	38,055	50,926
2004	454	12,819	39,044	52,318
2005	473	12,333	37,181	49,988
2006	547	13,230	37,765	51,541
2007	606	13,571	37,423	51,599
2008	633	13,144	35,357	49,133
2009	720	14,139	36,447	51,307
2010	757	14,046	35,007	49,810
2011	852	14,856	35,363	51,072
2012	806	14,298	33,907	49,011
2013	818	14,712	34,622	50,152
2014	815	14,689	34,649	50,152
Min	441	12,141	33,907	49,011
Max	852	14,856	39,044	52,318
Average	619	13,421	36,595	50,635

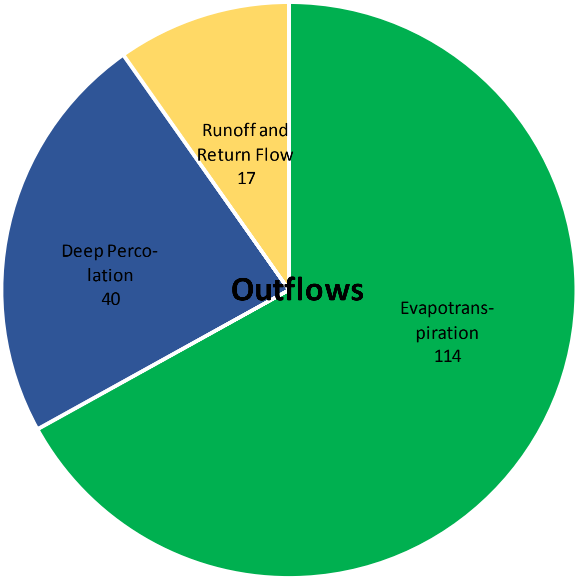
Water Budgets

Vina Inventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)

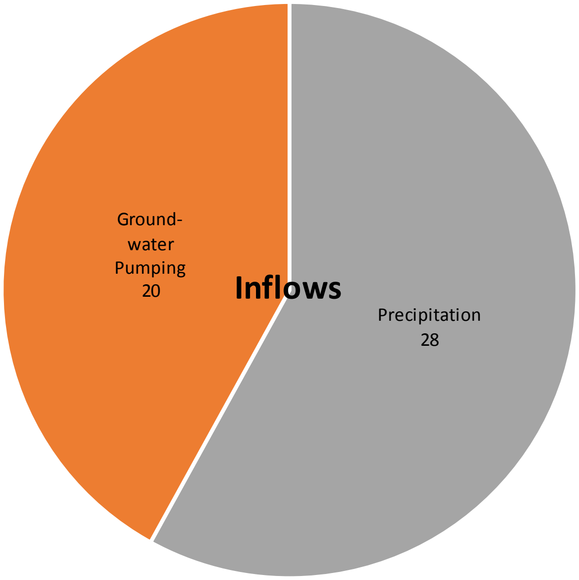


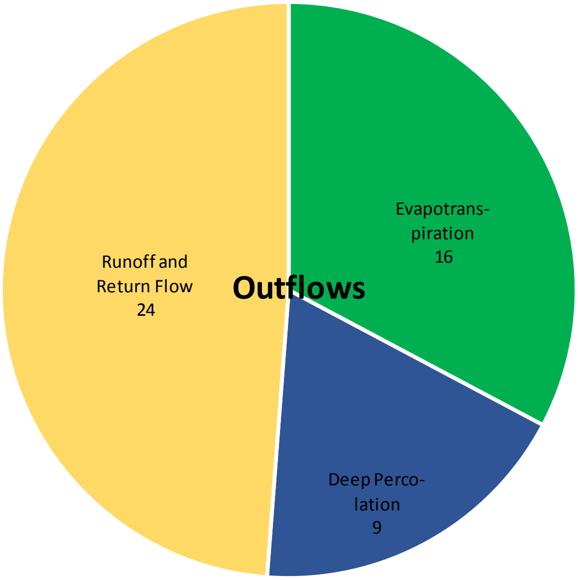
Vina Inventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



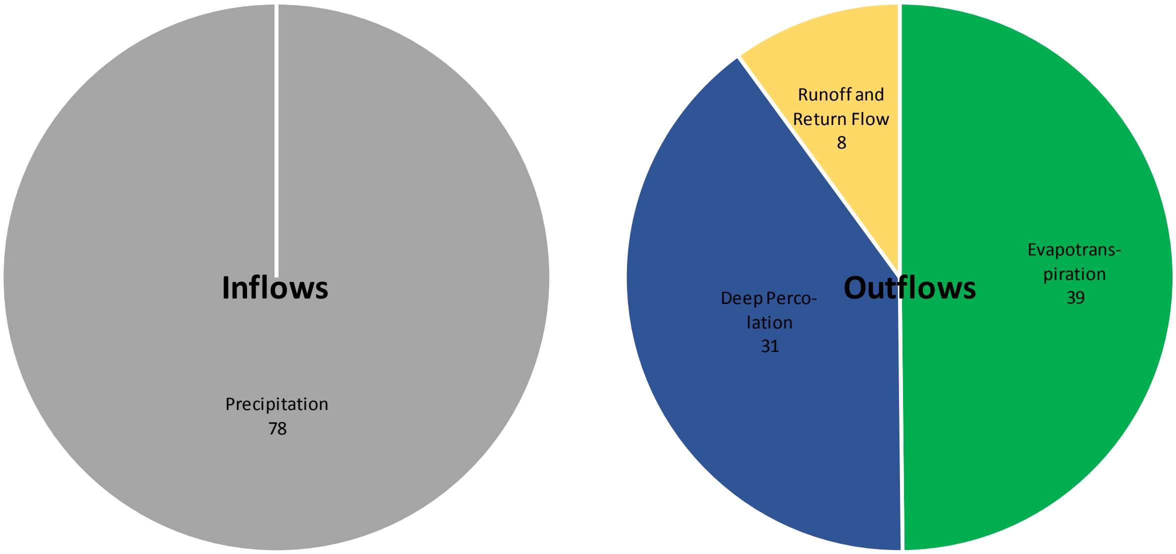


Vina Inventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

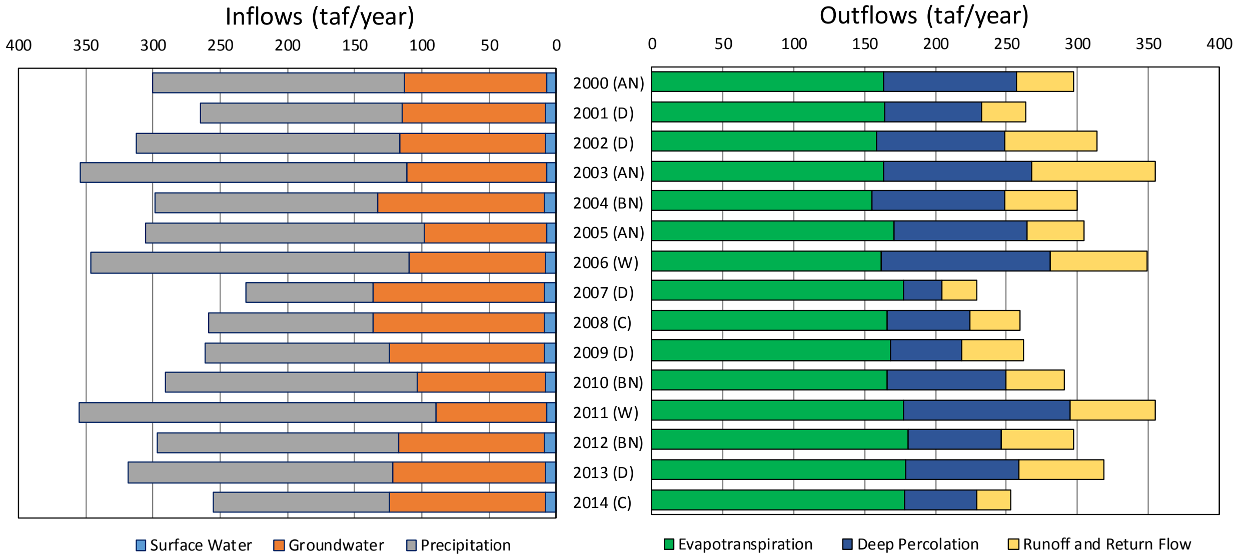




Vina Inventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Vina Inventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



Subinventory Unit Water Budget

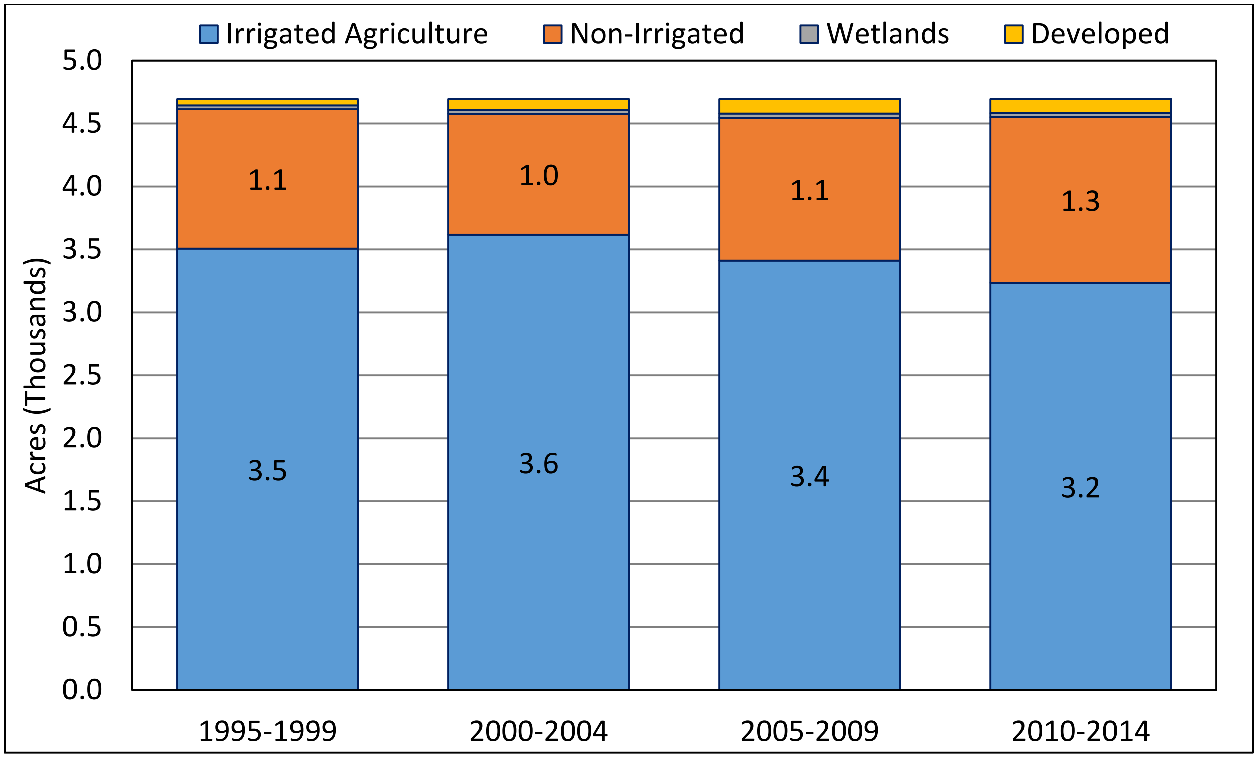
Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	187	7	106	163	94	40	-2
2001 (D)	150	8	107	164	68	31	0
2002 (D)	196	8	109	158	91	65	-1
2003 (AN)	243	7	104	163	105	87	2
2004 (BN)	166	9	124	155	94	51	-1
2005 (AN)	208	7	91	171	93	40	2
2006 (W)	237	8	102	162	119	68	2
2007 (D)	95	9	127	177	27	24	-2
2008 (C)	122	9	128	166	59	35	-1
2009 (D)	136	9	116	169	50	43	2
2010 (BN)	188	8	96	166	84	41	1
2011 (W)	265	7	82	177	118	60	2
2012 (BN)	180	9	108	181	65	51	-1
2013 (D)	197	8	114	179	79	60	8
2014 (C)	131	8	116	179	50	24	-7
Minimum	95	7	82	155	27	24	-7
Maximum	265	9	128	181	119	87	8
Average	180	8	109	169	80	48	0
Averages by Hydrologic Year Type							
Wet (W)	251	7	92	169	119	64	2
Above Normal (AN)	213	7	100	166	97	56	0
Below Normal (BN)	178	8	109	167	81	48	0
Dry (D)	155	8	115	169	63	45	2
Critical (C)	127	8	122	172	55	30	-4

C.2. West Butte Inventory Unit

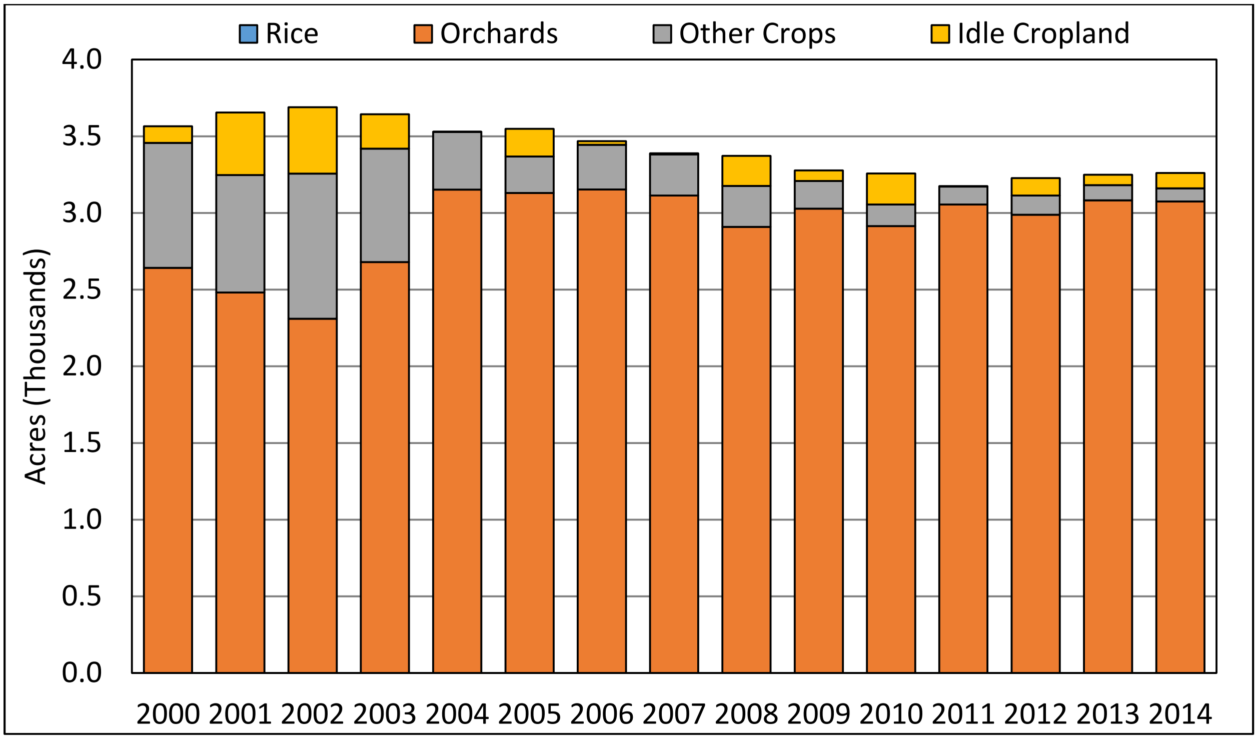
C.2.1. Angel Slough Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

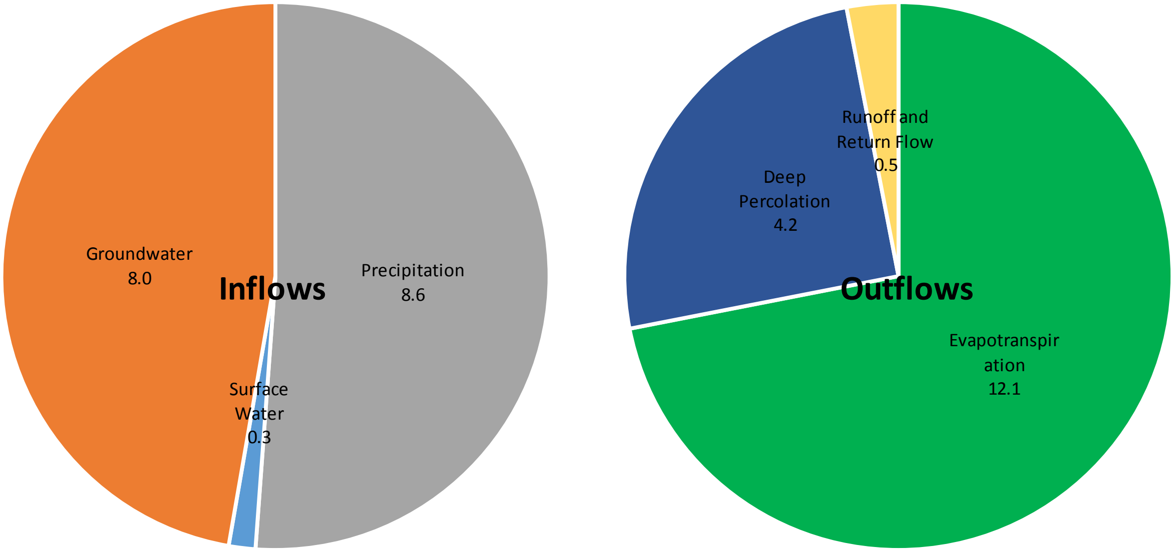
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	0	1,242	1,400	0	0	221	81	512	109	3,456	3,565
2001	0	1,139	1,342	0	0	224	71	471	408	3,248	3,655
2002	0	1,007	1,304	0	0	221	79	646	433	3,256	3,689
2003	0	1,100	1,579	0	0	319	82	339	224	3,419	3,643
2004	0	1,188	1,965	0	0	281	96	0	1	3,528	3,530
2005	0	1,077	2,052	0	0	154	84	0	181	3,368	3,549
2006	0	1,035	2,118	0	0	200	91	0	24	3,444	3,468
2007	0	1,054	2,060	0	0	174	94	0	8	3,381	3,389
2008	0	948	1,961	0	0	175	92	0	196	3,176	3,373
2009	0	993	2,035	0	0	87	94	0	69	3,209	3,278
2010	0	966	1,949	0	0	47	93	0	202	3,055	3,257
2011	0	932	2,123	0	0	23	94	0	3	3,172	3,175
2012	0	931	2,058	0	0	31	93	0	114	3,113	3,227
2013	0	885	2,197	0	0	19	80	0	68	3,182	3,250
2014	0	888	2,186	0	0	2	83	0	100	3,160	3,261
Min	0	885	1,304	0	0	2	71	0	1	3,055	3,175
Max	0	1,242	2,197	0	0	319	96	646	433	3,528	3,689
Average	0	1,026	1,889	0	0	145	87	131	143	3,278	3,420

Other Land Use

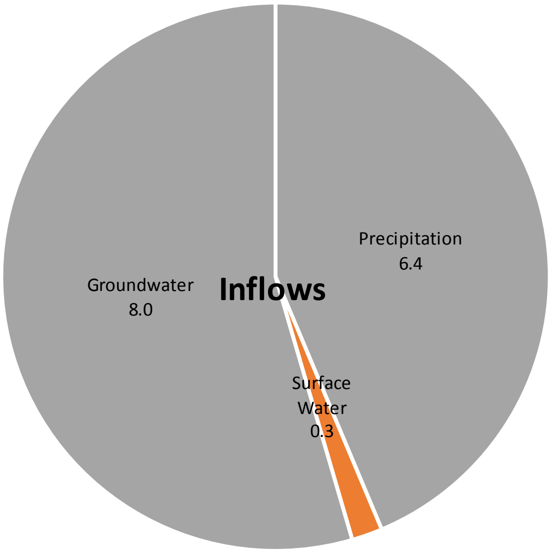
Year	Wetlands	Developed	Non-Irrigated	Total
2000	35	68	1,026	1,129
2001	28	68	943	1,039
2002	27	74	904	1,006
2003	30	92	929	1,051
2004	37	125	1,004	1,165
2005	33	113	1,000	1,146
2006	34	116	1,077	1,227
2007	34	119	1,152	1,305
2008	33	115	1,174	1,322
2009	34	118	1,266	1,417
2010	33	114	1,291	1,437
2011	33	115	1,372	1,520
2012	32	113	1,323	1,468
2013	31	108	1,306	1,445
2014	31	107	1,296	1,434
Min	27	68	904	1,006
Max	37	125	1,372	1,520
Average	32	104	1,138	1,274

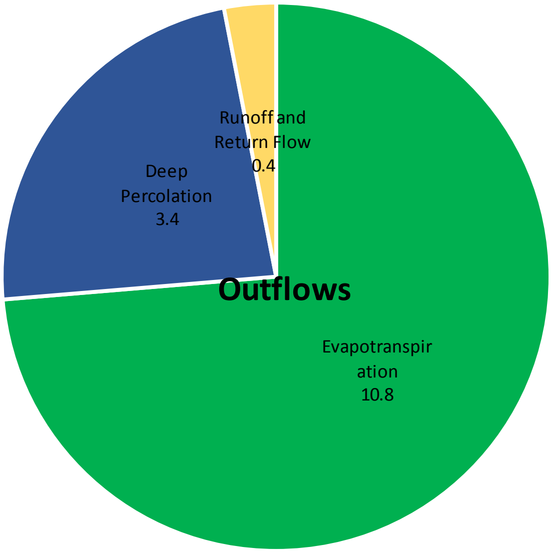
Water Budgets

Angel Slough Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)

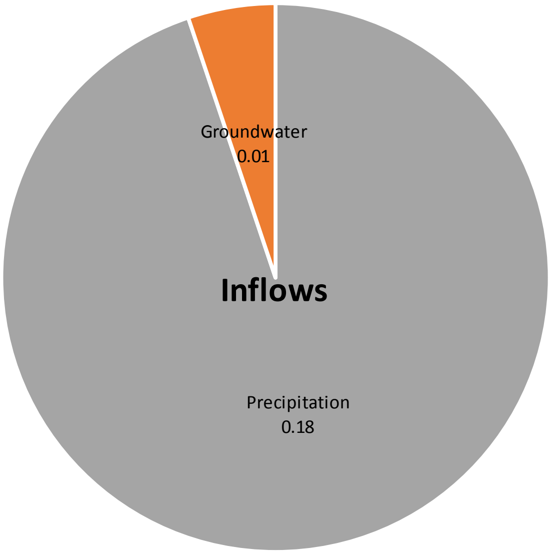


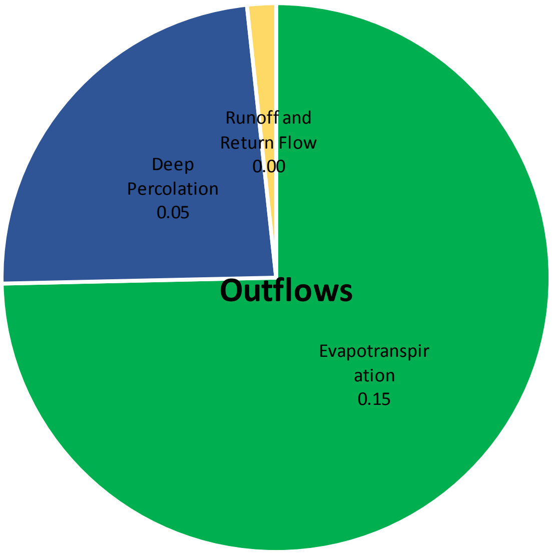
Angel Slough Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



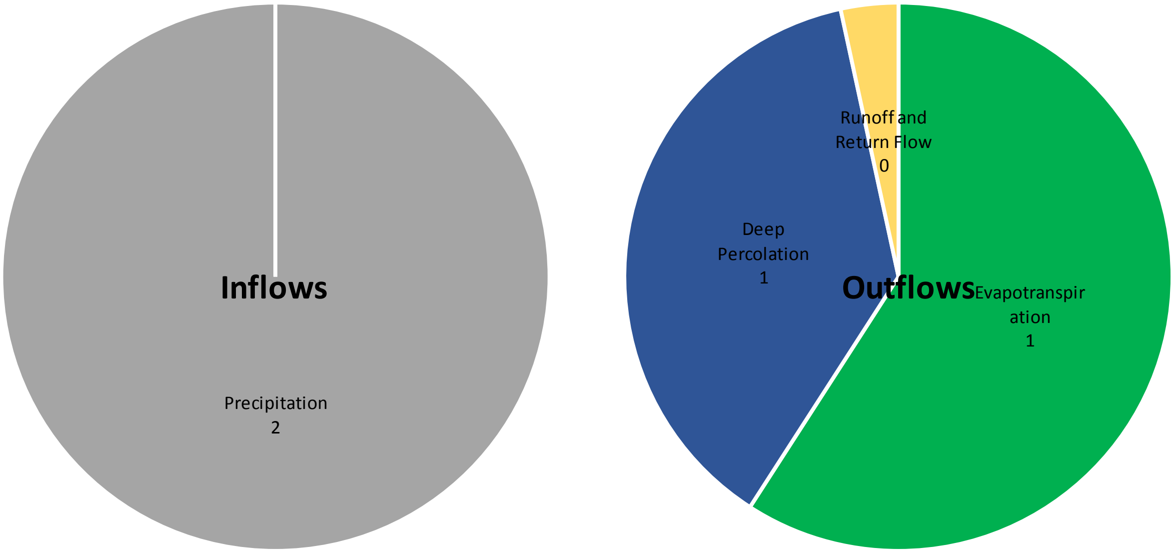


Angel Slough Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

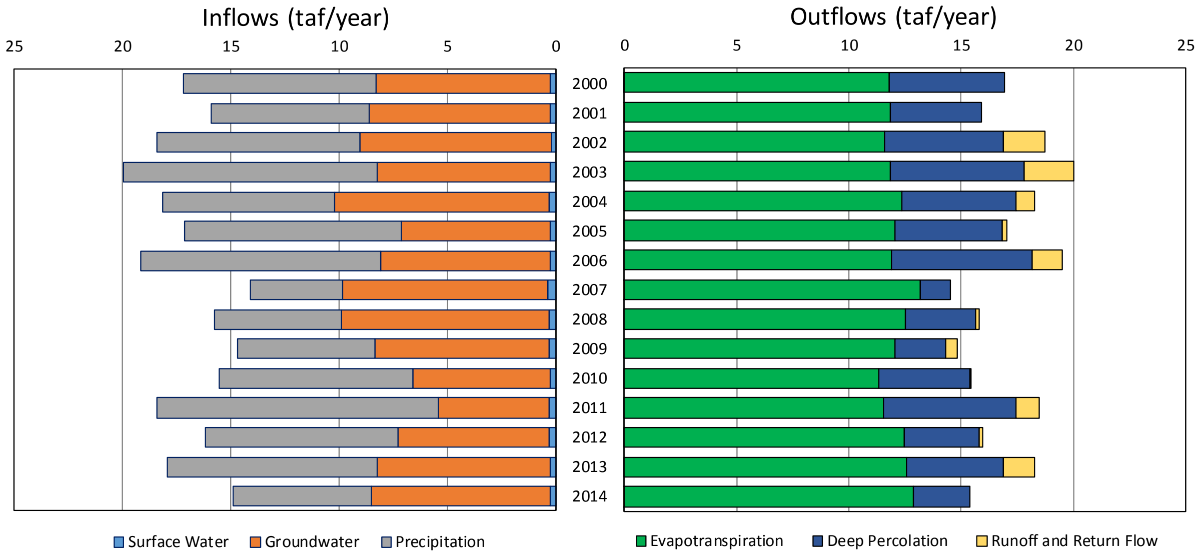




Angel Slough Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Angel Slough Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



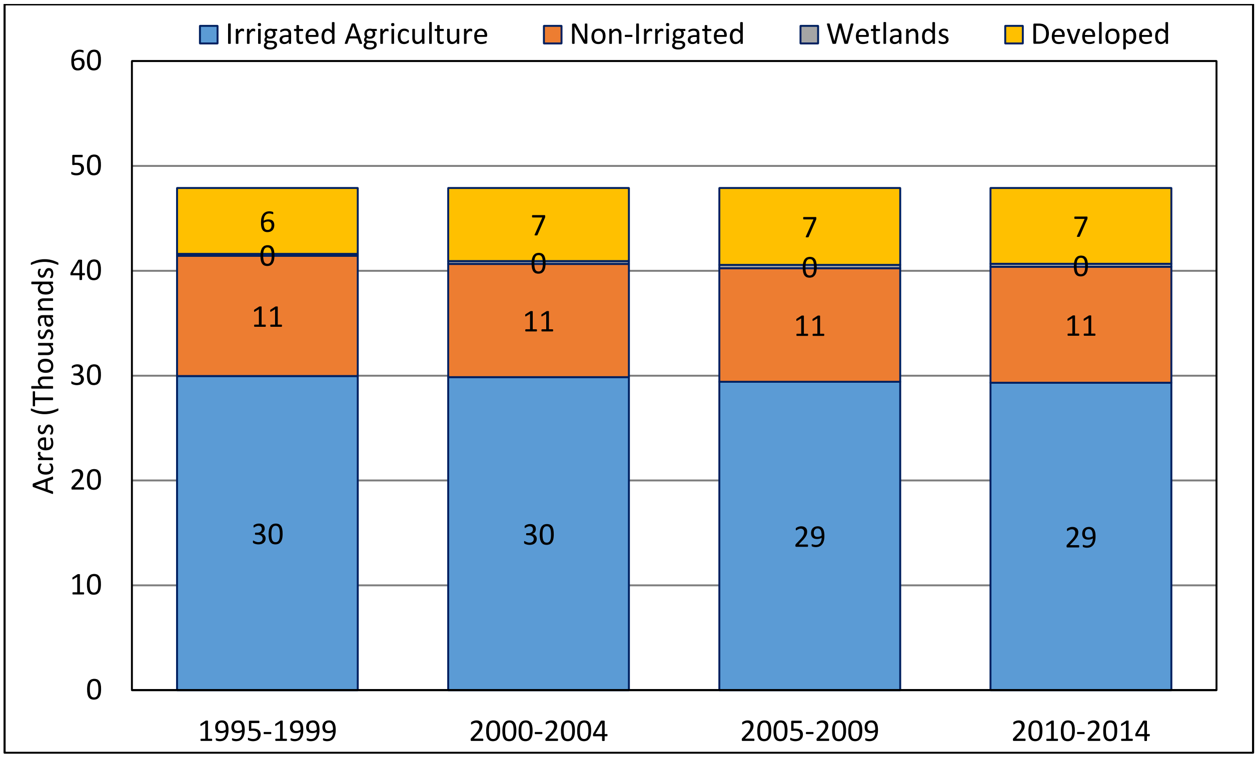
Subinventory Unit Water Budget

	Inflows (taf)			**Outflows (taf)**			
Water Year	**Precipi-tation**	**Surface Water**	**Ground-water**	**Evapotrans-piration**	**Deep Percolation**	**Runoff and Return Flow**	**Change in Storage (taf)**
2000 (AN)	8.9	0.2	8.1	11.8	5.1	0.0	-0.2
2001 (D)	7.3	0.3	8.3	11.8	4.1	-0.2	-0.2
2002 (D)	9.4	0.2	8.8	11.6	5.3	1.8	0.3
2003 (AN)	11.7	0.2	8.0	11.9	5.9	2.3	0.1
2004 (BN)	7.9	0.3	9.9	12.4	5.1	0.8	0.0
2005 (AN)	10.0	0.2	6.9	12.1	4.8	0.2	0.0
2006 (W)	11.0	0.2	7.8	11.9	6.3	1.3	0.3
2007 (D)	4.3	0.3	9.5	13.2	1.3	-0.8	-0.5
2008 (C)	5.9	0.3	9.6	12.5	3.2	0.1	0.0
2009 (D)	6.3	0.3	8.0	12.1	2.3	0.5	0.1
2010 (BN)	8.9	0.2	6.3	11.3	4.1	0.0	-0.1
2011 (W)	12.9	0.3	5.2	11.6	5.9	1.0	0.1
2012 (BN)	8.9	0.3	7.0	12.5	3.3	0.2	-0.3
2013 (D)	9.7	0.3	8.0	12.6	4.3	1.4	0.6
2014 (C)	6.4	0.3	8.2	12.9	2.5	-1.0	-0.6
Minimum	4.3	0.2	5.2	11.3	1.3	-1.0	-0.6
Maximum	12.9	0.3	9.9	13.2	6.3	2.3	0.6
Average	8.6	0.3	8.0	12.1	4.2	0.5	0.0
Averages by Hydrologic Year Type							
Wet (W)	12.0	0.3	6.5	11.7	6.1	1.2	0.2
Above Normal (AN)	10.2	0.2	7.7	11.9	5.3	0.8	0.0
Below Normal (BN)	8.6	0.3	7.7	12.1	4.2	0.3	-0.1
Dry (D)	7.4	0.3	8.5	12.3	3.4	0.5	0.1
Critical (C)	6.1	0.3	8.9	12.7	2.8	-0.4	-0.3

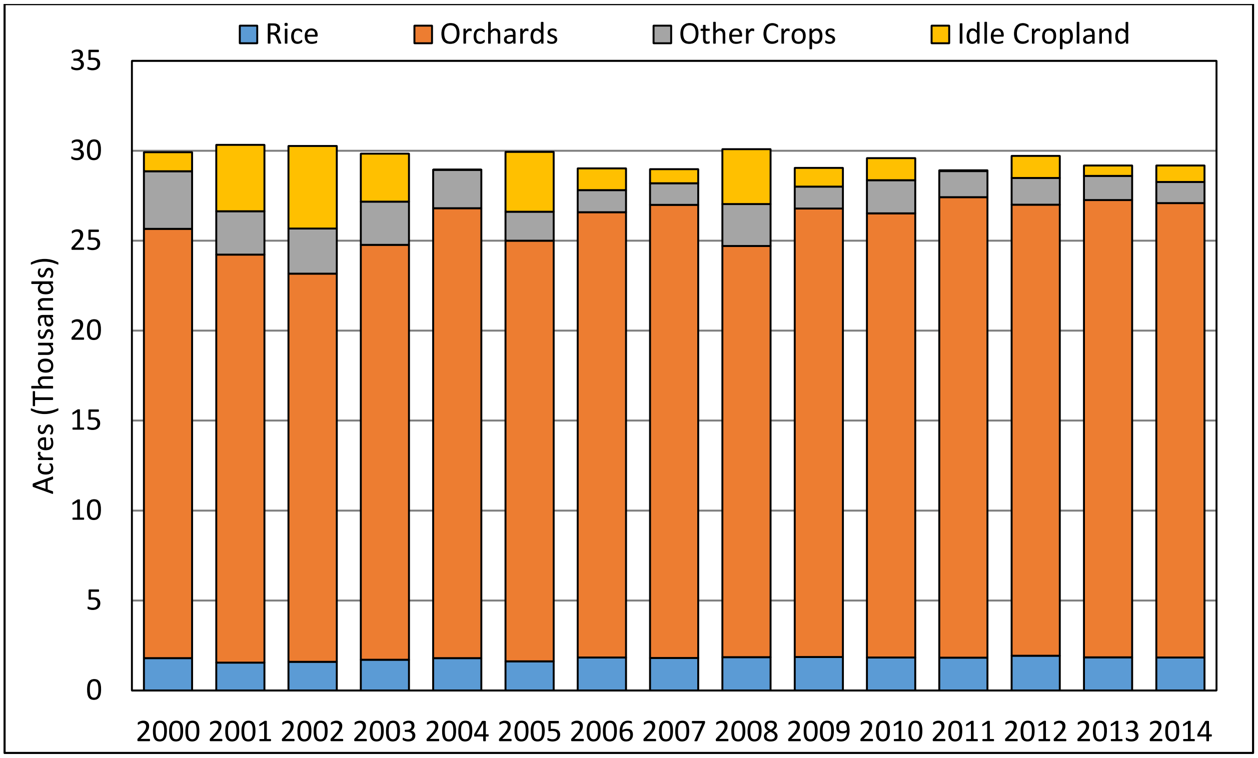
C.2.2. Durham/Dayton Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

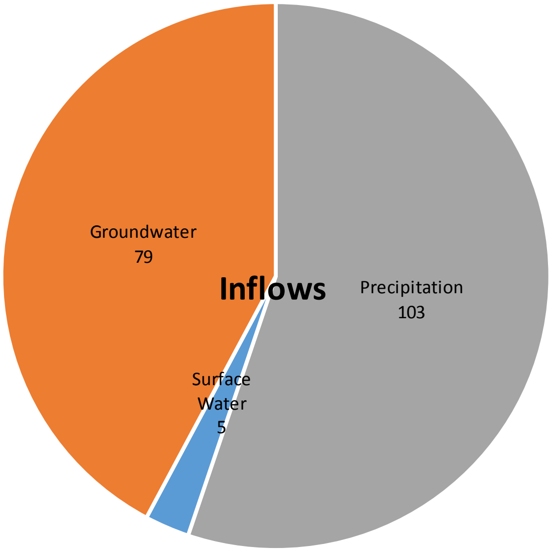
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	1,798	19,203	2,830	1,115	718	550	884	1,765	1,061	28,863	29,923
2001	1,548	18,310	2,752	982	637	465	645	1,303	3,688	26,641	30,329
2002	1,591	17,321	2,792	887	580	430	621	1,458	4,591	25,681	30,271
2003	1,704	18,503	3,128	874	563	469	557	1,377	2,663	27,174	29,837
2004	1,793	19,976	3,555	995	488	402	752	984	4	28,944	28,948
2005	1,616	18,160	3,931	673	621	165	498	950	3,327	26,615	29,942
2006	1,832	18,750	4,543	926	535	342	721	162	1,212	27,811	29,024
2007	1,807	19,266	4,456	894	569	337	683	185	783	28,197	28,980
2008	1,850	16,932	4,290	764	871	284	536	1,507	3,051	27,035	30,086
2009	1,853	18,760	4,809	800	570	249	662	309	1,042	28,010	29,052
2010	1,830	18,379	4,828	736	753	170	513	1,155	1,228	28,363	29,591
2011	1,822	18,523	5,561	686	830	216	567	669	38	28,875	28,913
2012	1,927	18,360	5,326	641	751	337	547	602	1,229	28,490	29,719
2013	1,836	18,096	5,949	609	772	177	543	623	577	28,606	29,182
2014	1,832	18,154	5,922	492	697	22	582	569	918	28,269	29,186
Min	1,548	16,932	2,752	492	488	22	498	162	4	25,681	28,913
Max	1,927	19,976	5,949	1,115	871	550	884	1,765	4,591	28,944	30,329
Average	1,776	18,446	4,311	805	664	308	621	908	1,694	27,838	29,532

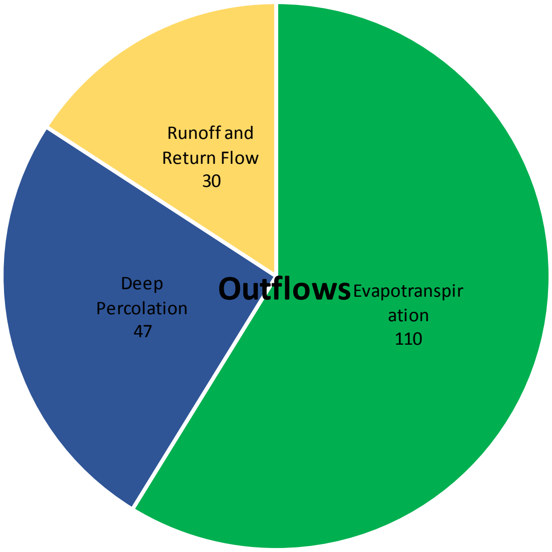
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	230	6,641	11,099	17,970
2001	244	6,561	10,759	17,565
2002	271	6,748	10,604	17,622
2003	302	7,136	10,617	18,056
2004	360	7,733	10,852	18,945
2005	330	7,131	10,490	17,951
2006	342	7,566	10,962	18,870
2007	334	7,538	11,042	18,914
2008	296	6,993	10,519	17,807
2009	315	7,403	11,123	18,841
2010	289	7,137	10,876	18,303
2011	316	7,337	11,329	18,981
2012	286	7,064	10,825	18,175
2013	301	7,286	11,124	18,711
2014	298	7,285	11,124	18,707
Min	230	6,561	10,490	17,565
Max	360	7,733	11,329	18,981
Average	301	7,171	10,890	18,361

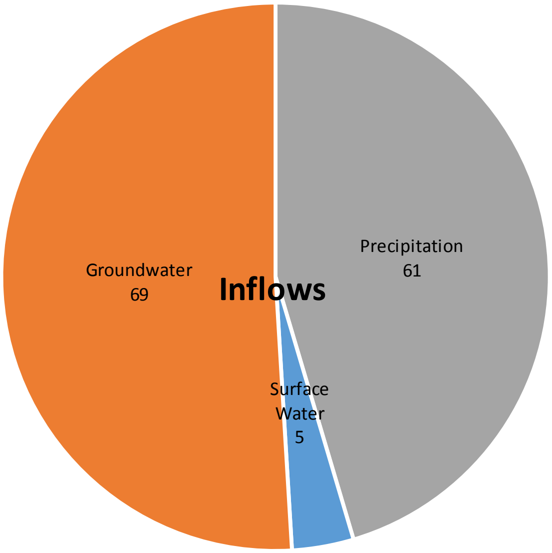
Water Budgets

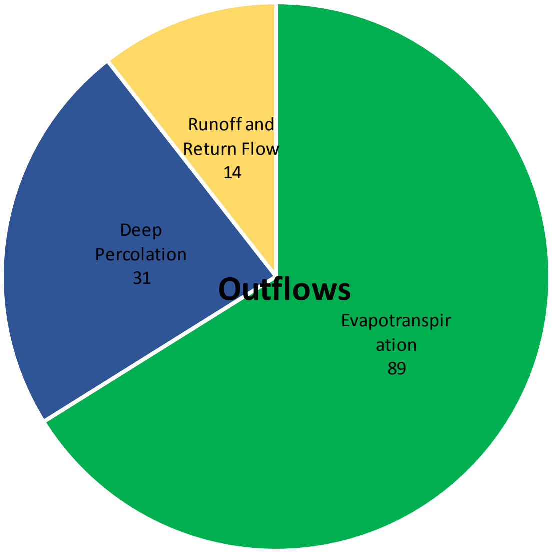
Durham/Dayton Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



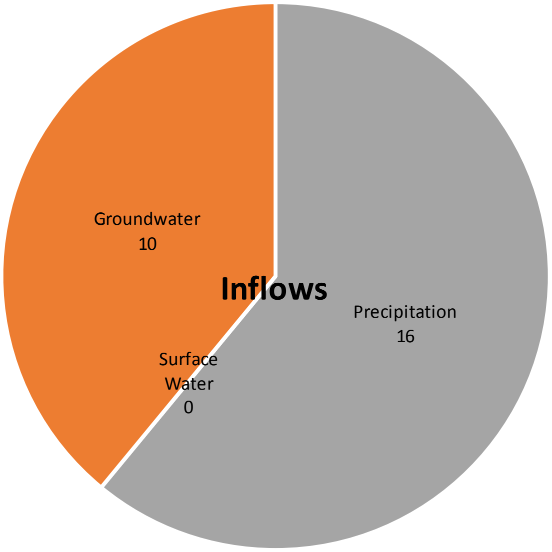


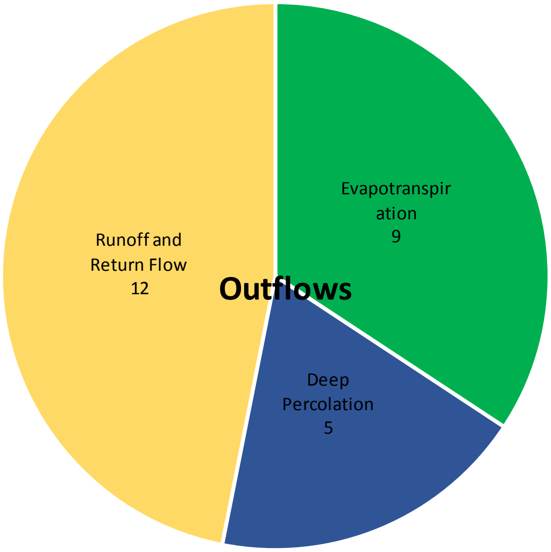
Durham/Dayton Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



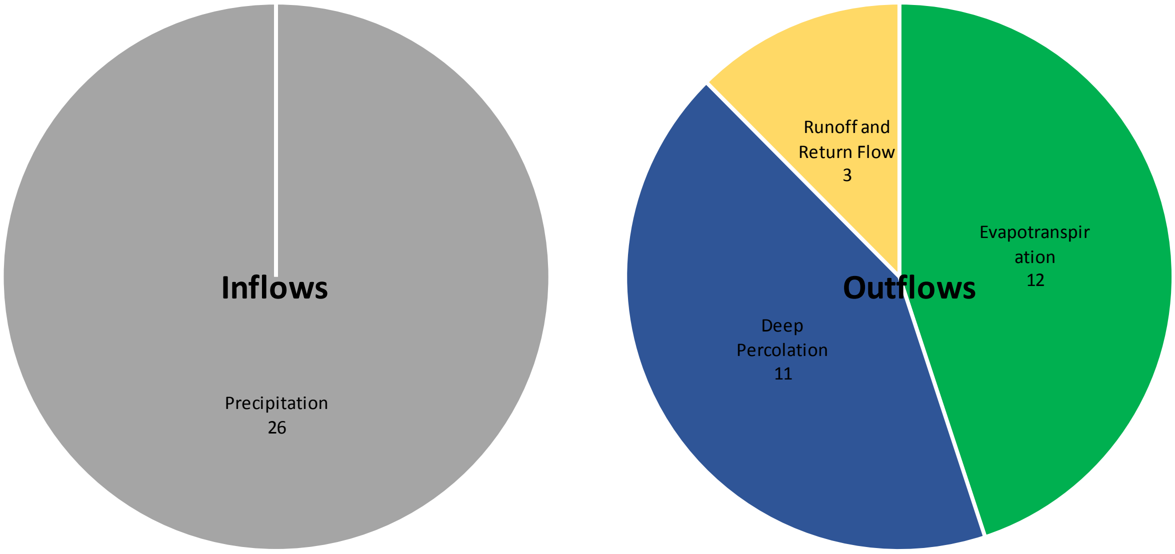


Durham/Dayton Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

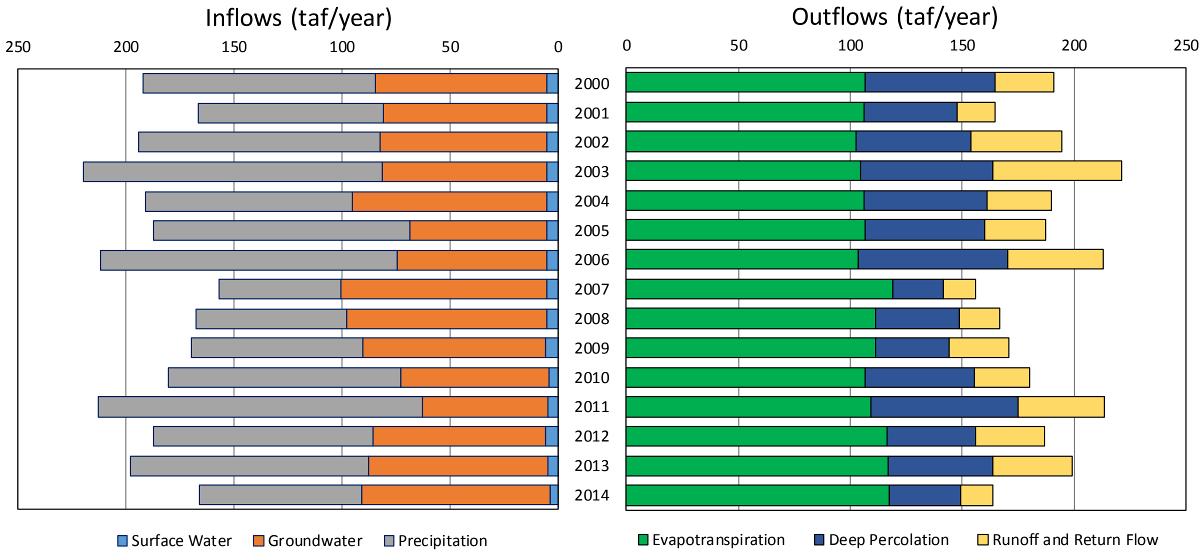




Durham/Dayton Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Durham/Dayton Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



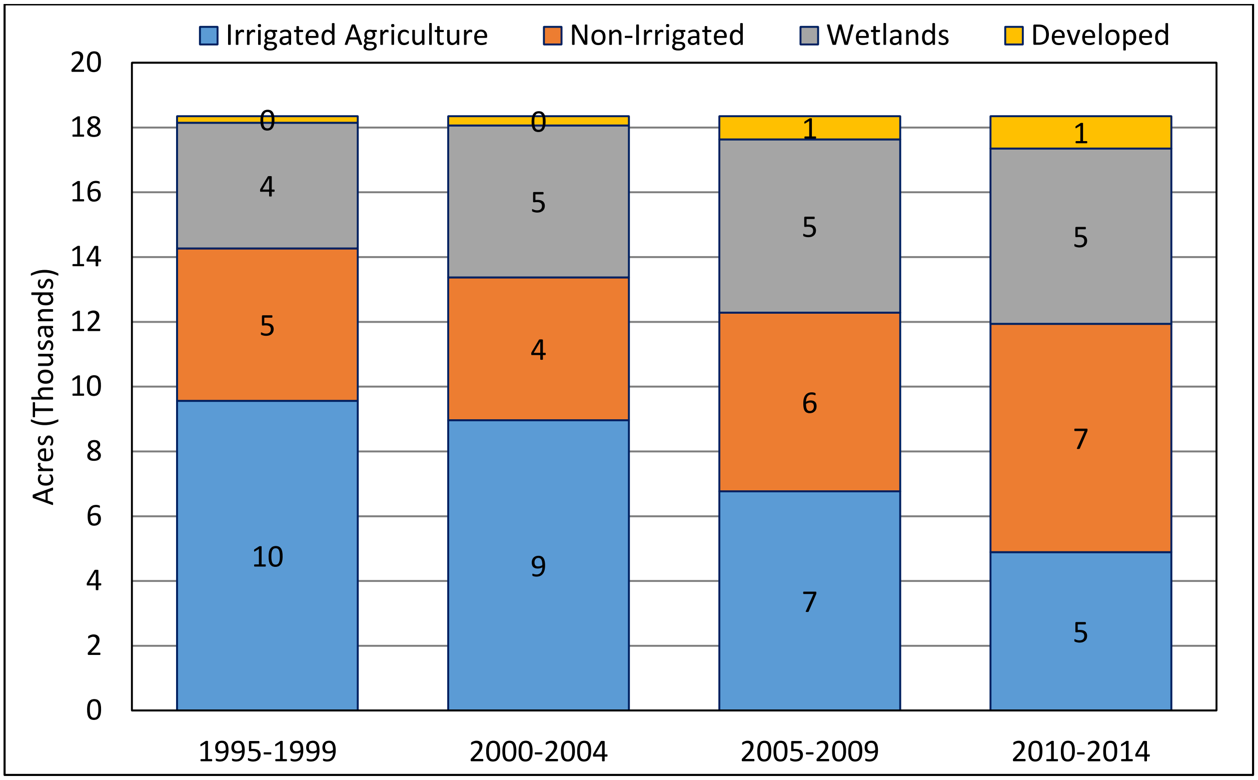
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	108	5	79	107	58	26	-1
2001 (D)	85	5	76	106	41	17	-1
2002 (D)	112	5	77	103	52	41	0
2003 (AN)	139	5	76	105	59	58	2
2004 (BN)	95	5	90	106	55	29	-1
2005 (AN)	119	5	63	107	53	27	1
2006 (W)	137	5	69	103	67	43	0
2007 (D)	56	5	95	119	23	14	0
2008 (C)	70	5	93	111	38	18	-2
2009 (D)	79	6	85	111	33	27	2
2010 (BN)	108	4	68	107	49	25	0
2011 (W)	150	5	58	109	66	39	1
2012 (BN)	101	6	80	116	40	31	-1
2013 (D)	111	5	83	117	47	36	4
2014 (C)	75	4	88	117	32	15	-3
Minimum	56	4	58	103	23	14	-3
Maximum	150	6	95	119	67	58	4
Average	103	5	79	110	47	30	0
Averages by Hydrologic Year Type							
Wet (W)	144	5	64	106	66	41	1
Above Normal (AN)	122	5	73	106	57	37	1
Below Normal (BN)	101	5	80	110	48	28	-1
Dry (D)	89	5	83	111	39	27	1
Critical (C)	72	4	90	114	35	16	-2

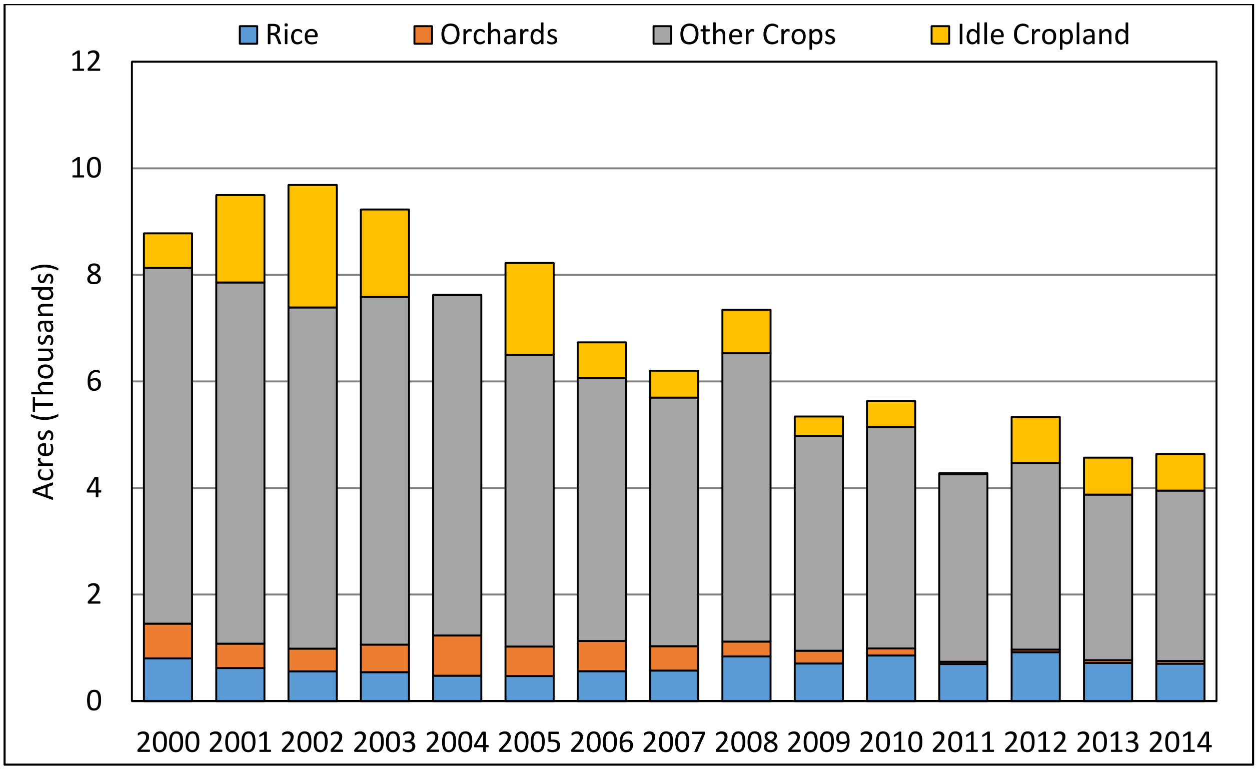
C.2.3. Llano Seco Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

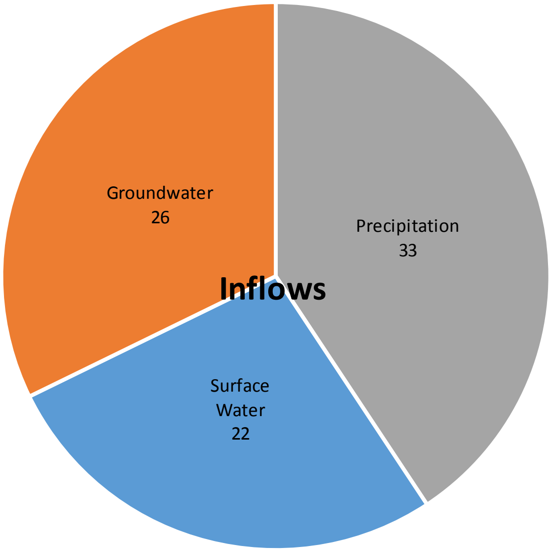
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	803	582	57	12	0	1,948	2,794	1,934	648	8,131	8,779
2001	621	377	70	10	0	1,738	3,063	1,977	1,642	7,856	9,498
2002	559	335	85	8	0	1,329	3,508	1,565	2,298	7,388	9,686
2003	543	379	131	8	0	1,267	3,681	1,578	1,641	7,587	9,228
2004	477	489	258	7	0	467	5,088	833	6	7,619	7,625
2005	472	350	197	5	0	231	4,120	1,127	1,721	6,501	8,223
2006	562	337	222	8	0	375	4,454	110	665	6,068	6,733
2007	574	281	166	8	0	341	4,191	137	504	5,698	6,202
2008	837	163	110	7	0	320	3,670	1,422	817	6,530	7,347
2009	707	143	89	8	0	209	3,756	62	368	4,974	5,343
2010	855	73	54	7	0	139	3,495	519	488	5,143	5,631
2011	697	17	19	7	0	129	3,390	0	18	4,259	4,277
2012	920	17	24	6	0	175	3,330	0	862	4,472	5,333
2013	717	17	29	6	0	108	2,998	0	695	3,875	4,570
2014	704	18	28	5	0	15	3,182	0	689	3,951	4,640
Min	472	17	19	5	0	15	2,794	0	6	3,875	4,277
Max	920	582	258	12	0	1,948	5,088	1,977	2,298	8,131	9,686
Average	670	238	103	7	0	586	3,648	751	871	6,003	6,874

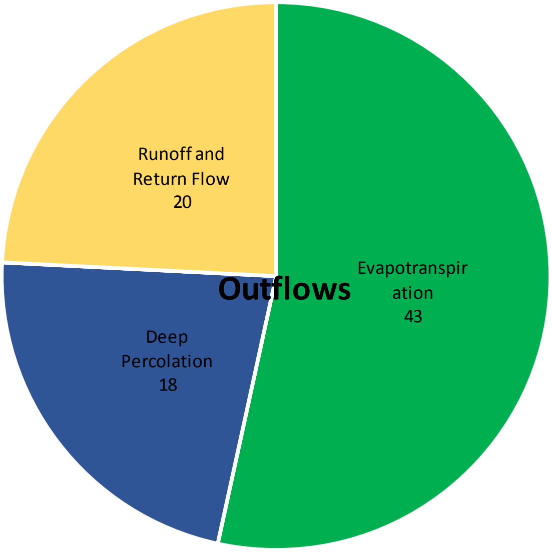
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	4,378	267	4,927	9,572
2001	4,329	216	4,309	8,853
2002	4,424	251	3,989	8,664
2003	4,881	275	3,967	9,123
2004	5,446	423	4,857	10,726
2005	5,267	498	4,363	10,128
2006	5,439	691	5,489	11,618
2007	5,471	781	5,897	12,149
2008	5,130	702	5,172	11,004
2009	5,440	909	6,659	13,008
2010	5,291	909	6,519	12,720
2011	5,529	1,046	7,498	14,074
2012	5,207	972	6,839	13,018
2013	5,510	1,037	7,234	13,781
2014	5,534	1,033	7,145	13,711
Min	4,329	216	3,967	8,664
Max	5,534	1,046	7,498	14,074
Average	5,152	667	5,658	11,477

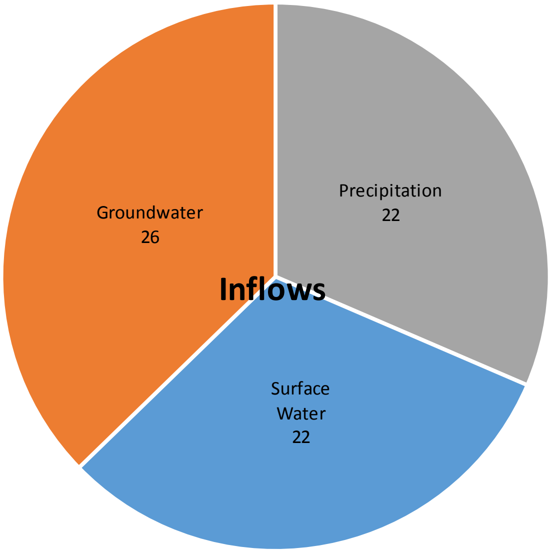
Water Budgets

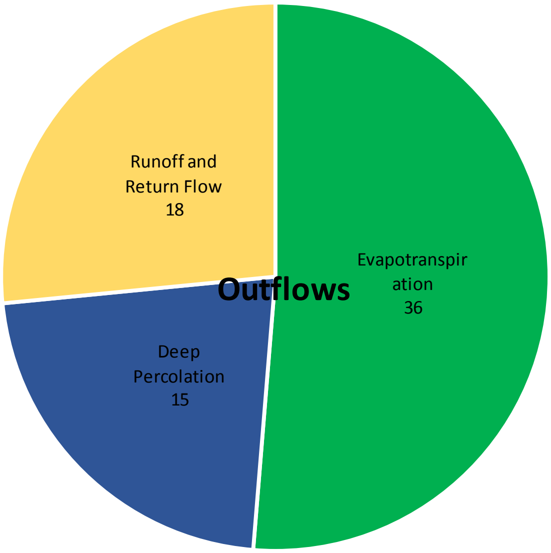
Llano Seco Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



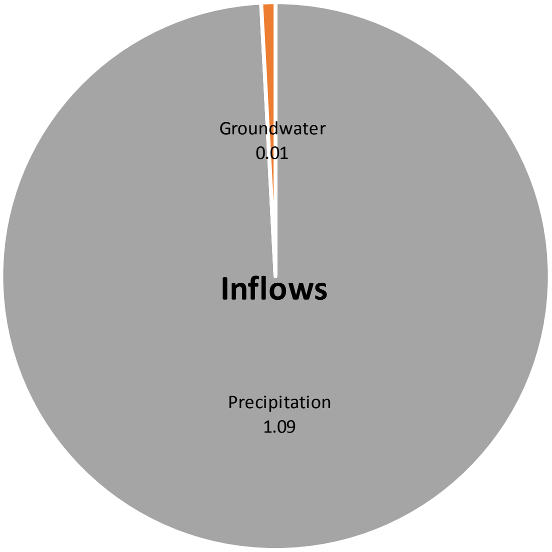


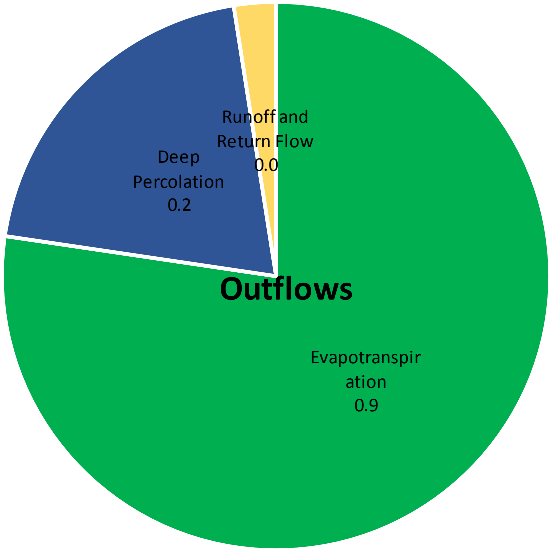
Llano Seco Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



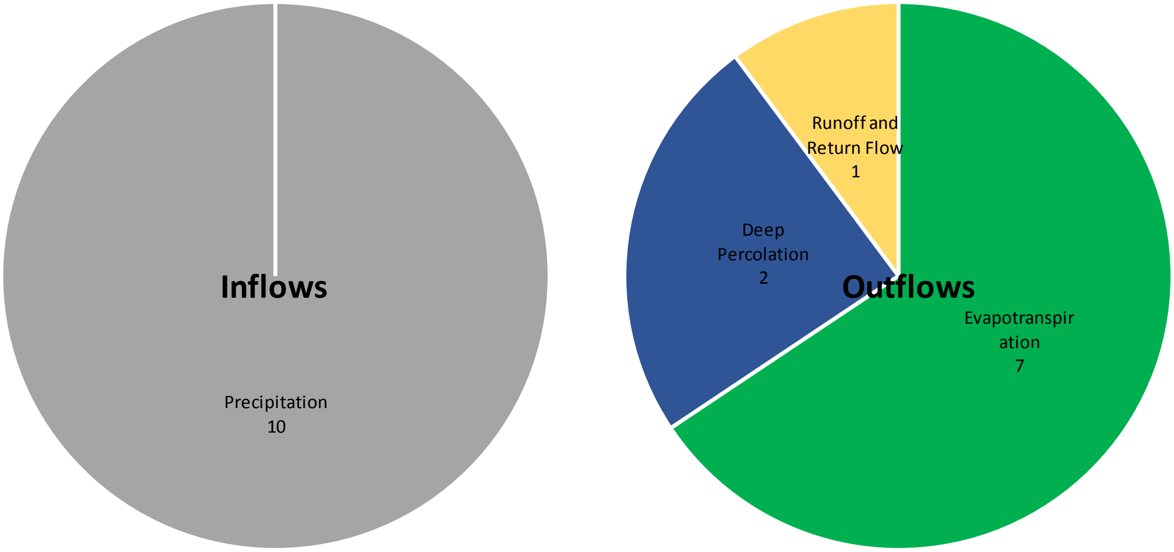


Llano Seco Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

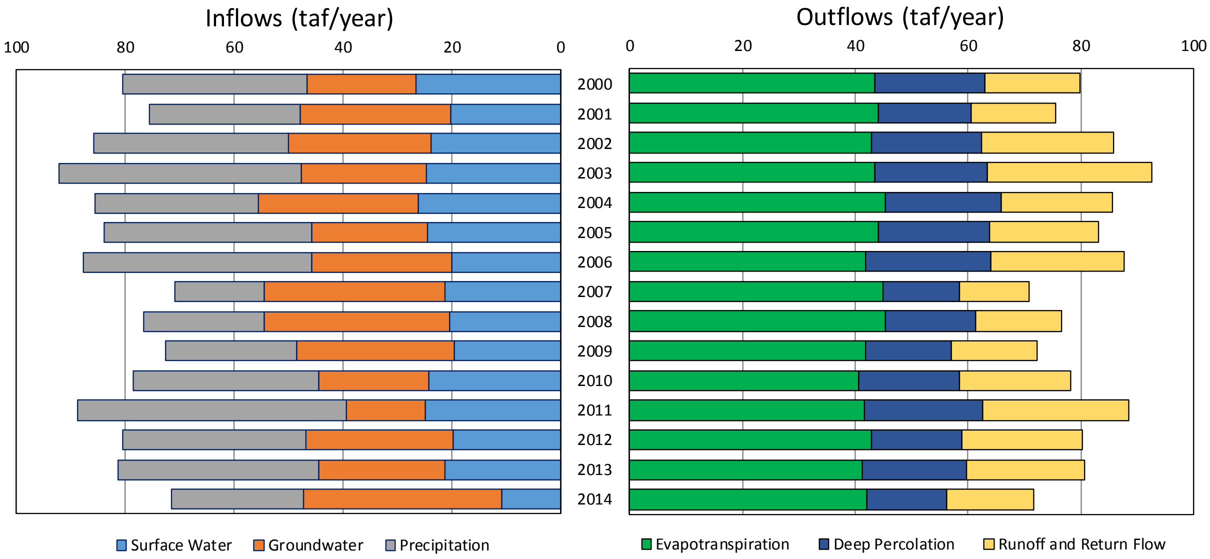




Llano Seco Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Llano Seco Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



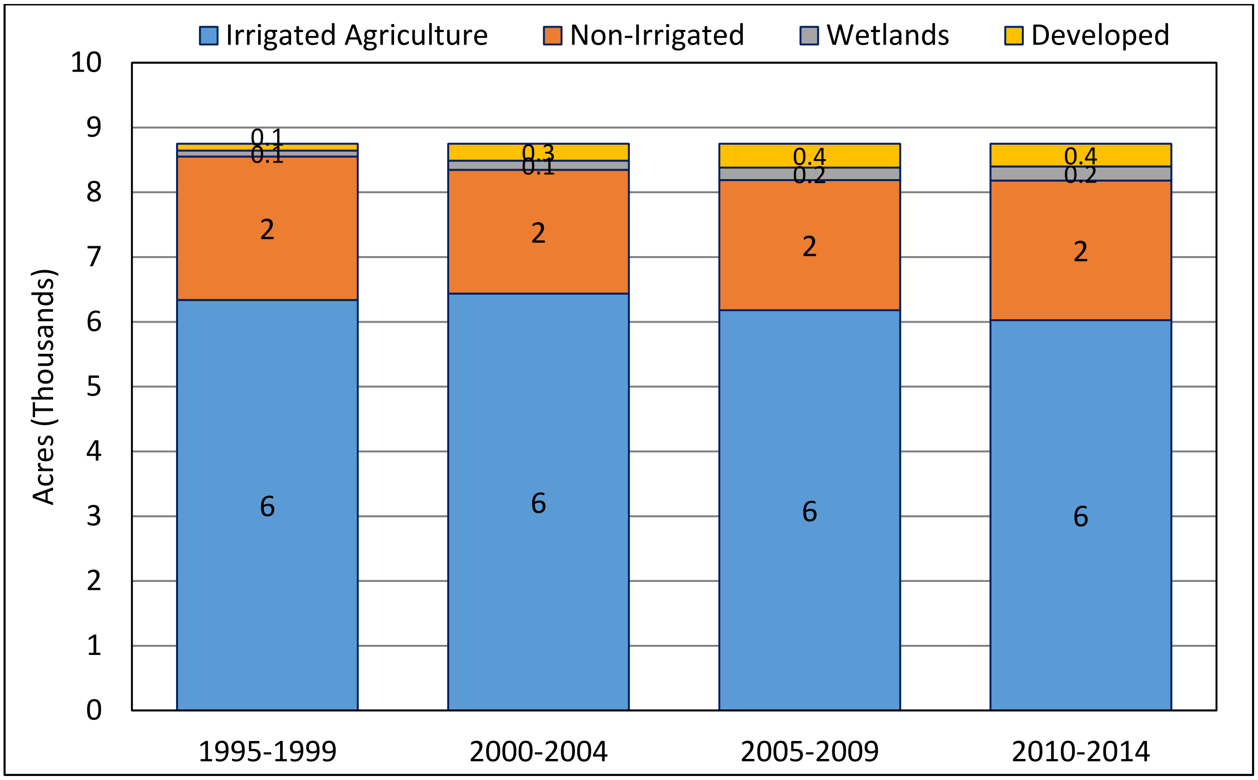
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	34	26	20	44	19	17	0
2001 (D)	28	20	28	44	16	15	0
2002 (D)	36	24	26	43	20	23	0
2003 (AN)	44	25	23	44	20	29	1
2004 (BN)	30	26	29	45	21	20	-1
2005 (AN)	38	24	21	44	20	19	0
2006 (W)	42	20	26	42	22	24	-2
2007 (D)	16	21	33	45	13	12	0
2008 (C)	22	20	34	45	16	15	0
2009 (D)	24	19	29	42	15	15	-2
2010 (BN)	34	24	20	41	18	20	0
2011 (W)	49	25	14	42	21	26	-1
2012 (BN)	34	20	27	43	16	21	0
2013 (D)	37	21	23	41	18	21	1
2014 (C)	24	11	36	42	14	15	-1
Minimum	16	11	14	41	13	12	-2
Maximum	49	26	36	45	22	29	1
Average	33	22	26	43	18	20	0
Averages by Hydrologic Year Type							
Wet (W)	46	22	20	42	22	25	-1
Above Normal (AN)	39	25	21	44	20	22	0
Below Normal (BN)	33	23	26	43	18	20	0
Dry (D)	28	21	28	43	17	17	0
Critical (C)	23	16	35	44	15	15	0

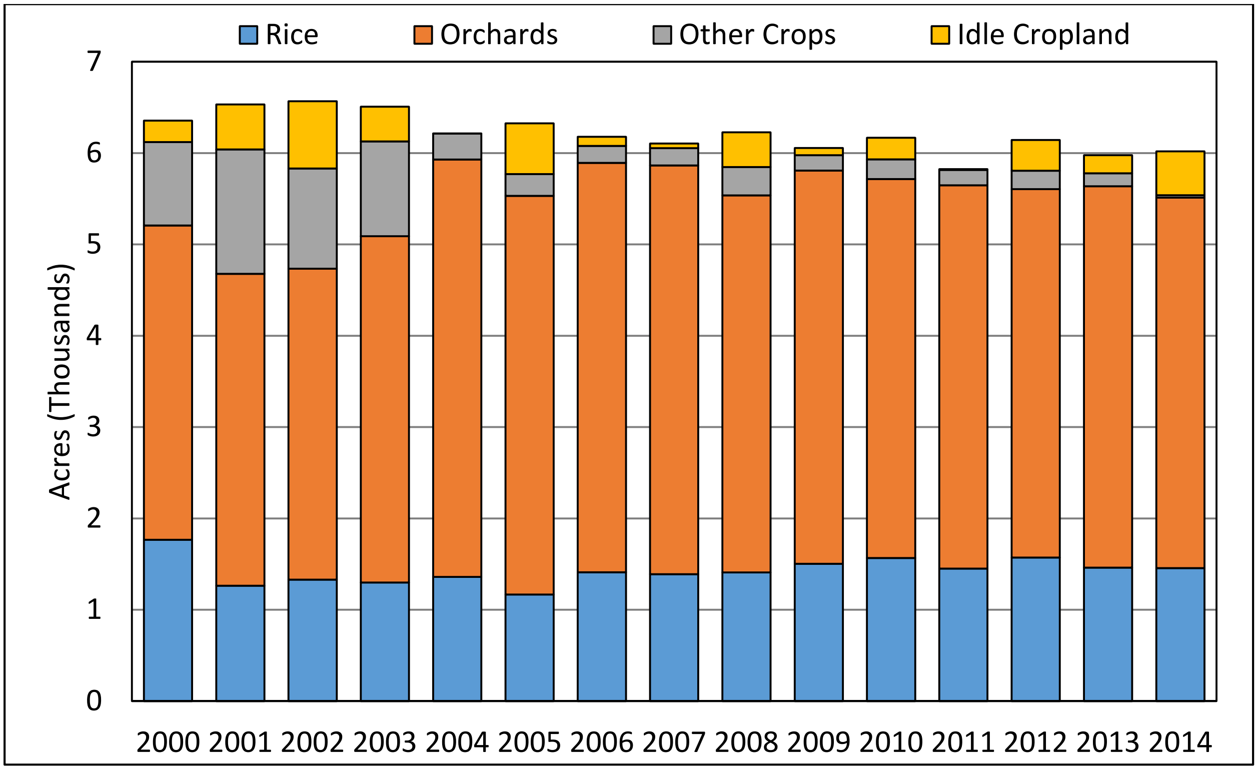
C.2.4. M&T Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

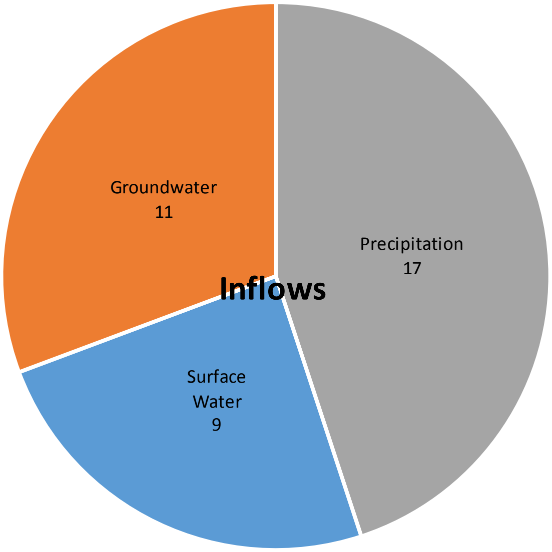
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	1,767	2,154	755	525	6	432	24	457	234	6,121	6,355
2001	1,263	2,058	820	530	5	379	24	959	493	6,040	6,533
2002	1,331	1,902	951	547	4	308	23	766	736	5,832	6,568
2003	1,298	1,998	1,196	590	8	302	19	717	382	6,127	6,509
2004	1,360	2,172	1,686	709	4	160	15	109	1	6,214	6,215
2005	1,168	2,063	1,754	536	11	103	13	122	557	5,770	6,326
2006	1,410	1,988	1,779	713	3	162	13	11	100	6,079	6,179
2007	1,390	2,023	1,722	727	3	169	12	9	51	6,054	6,106
2008	1,409	1,793	1,644	684	6	161	11	139	380	5,847	6,227
2009	1,504	1,886	1,691	725	3	148	11	10	80	5,976	6,056
2010	1,567	1,808	1,607	729	4	99	10	108	236	5,932	6,168
2011	1,452	1,715	1,759	717	4	159	10	0	8	5,816	5,825
2012	1,572	1,718	1,663	650	3	191	10	0	337	5,806	6,143
2013	1,461	1,681	1,865	626	3	133	9	0	199	5,778	5,978
2014	1,456	1,686	1,864	503	3	17	9	0	480	5,539	6,018
Min	1,168	1,681	755	503	3	17	9	0	1	5,539	5,825
Max	1,767	2,172	1,865	729	11	432	24	959	736	6,214	6,568
Average	1,427	1,910	1,517	634	5	195	14	227	285	5,929	6,214

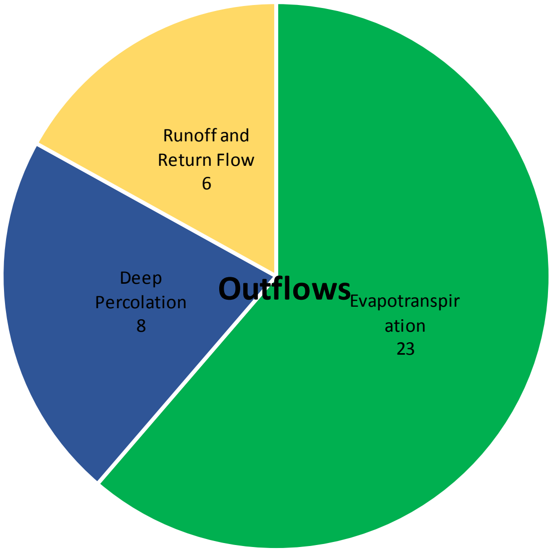
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	118	166	2,110	2,394
2001	122	193	1,901	2,216
2002	136	238	1,808	2,182
2003	145	297	1,798	2,240
2004	189	407	1,938	2,534
2005	184	373	1,866	2,423
2006	189	378	2,003	2,570
2007	198	380	2,066	2,643
2008	184	351	1,987	2,522
2009	203	361	2,129	2,693
2010	194	342	2,046	2,581
2011	245	378	2,301	2,924
2012	198	330	2,078	2,606
2013	229	354	2,189	2,772
2014	223	349	2,158	2,731
Min	118	166	1,798	2,182
Max	245	407	2,301	2,924
Average	184	326	2,025	2,535

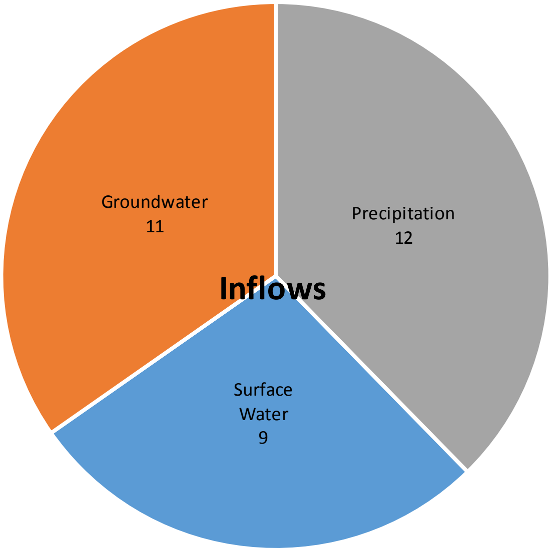
Water Budgets

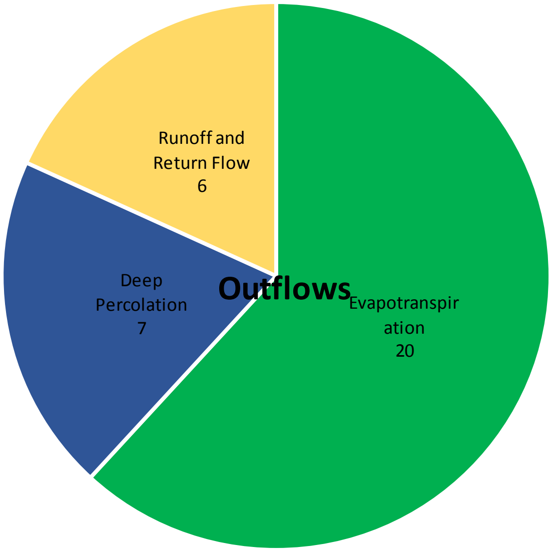
M&T Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



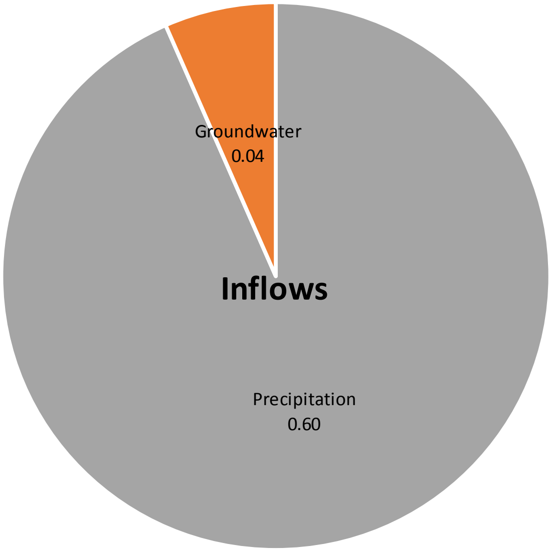


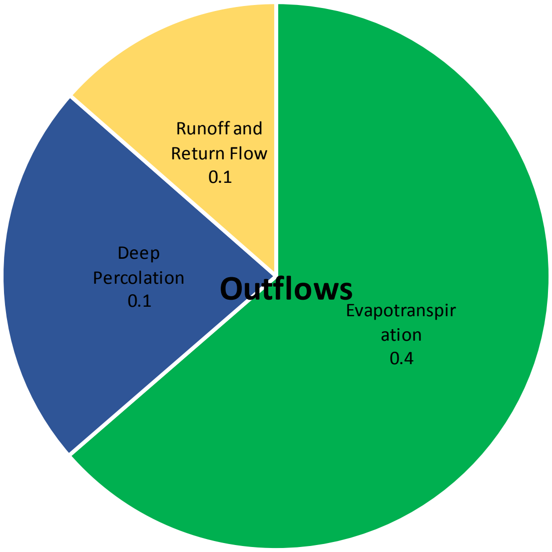
M&T Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



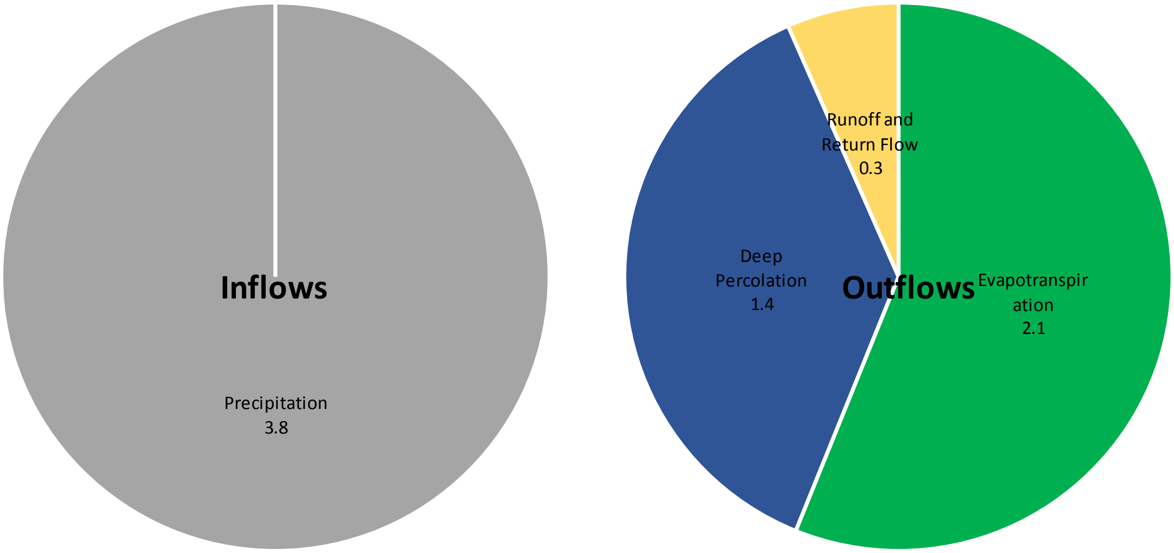


M&T Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

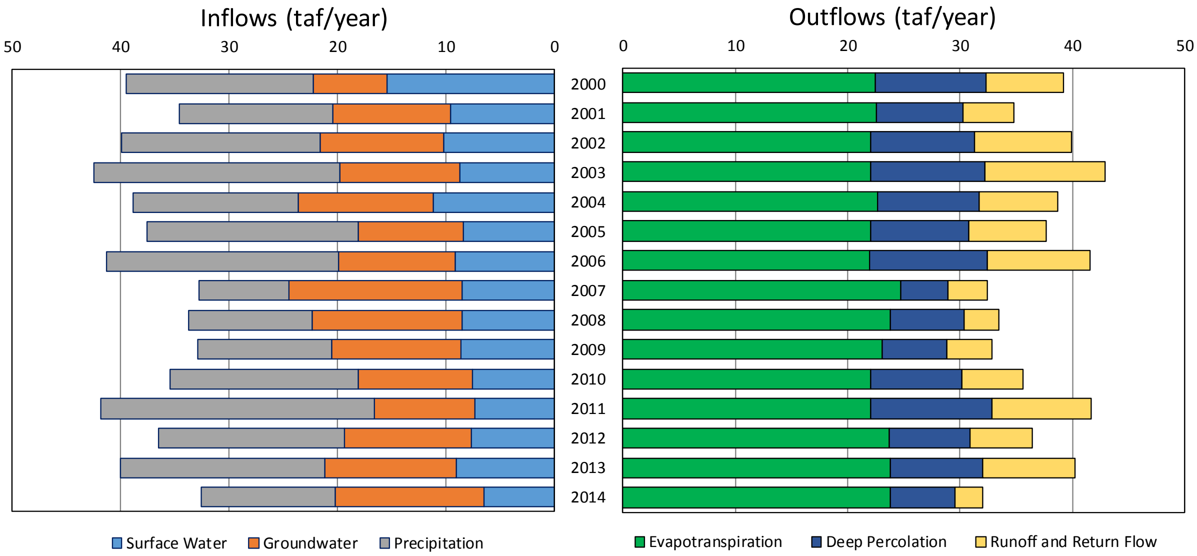




M&T Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



M&T Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



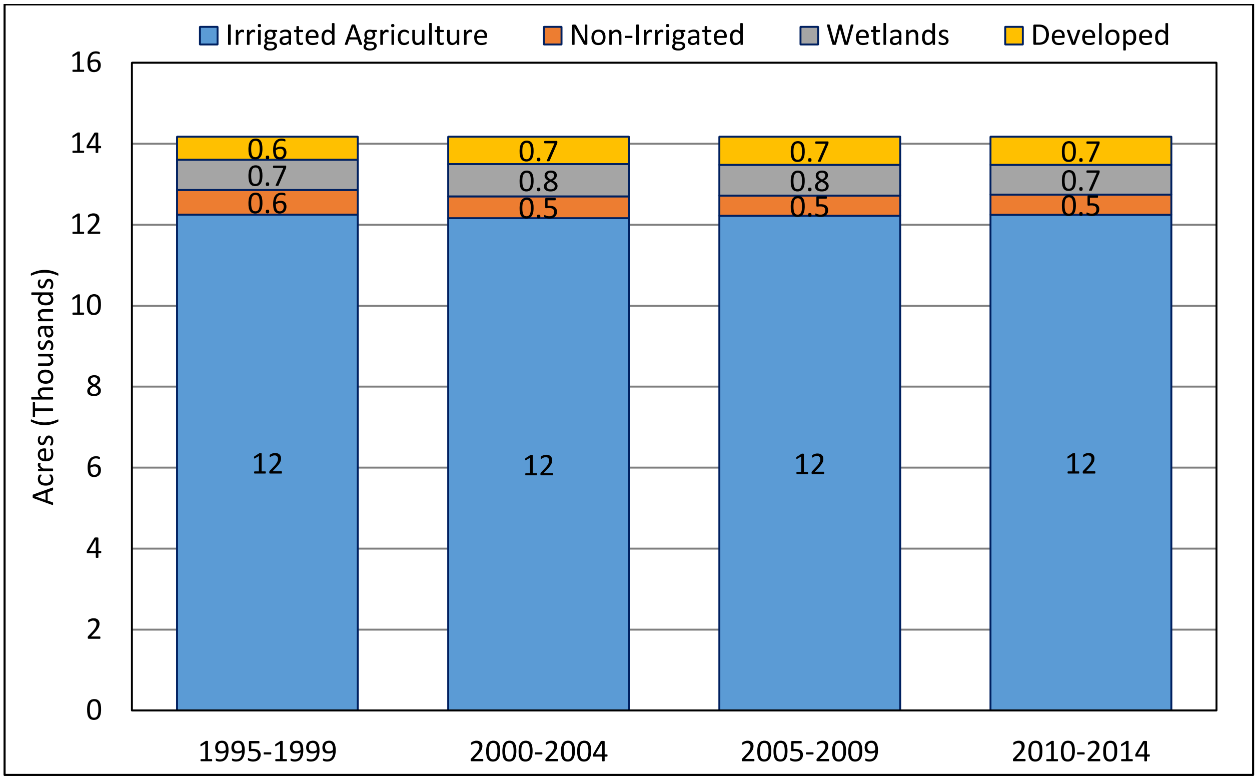
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	17	15	7	22	10	7	0
2001 (D)	14	10	11	23	8	5	0
2002 (D)	18	10	11	22	9	9	0
2003 (AN)	23	9	11	22	10	11	0
2004 (BN)	15	11	12	23	9	7	0
2005 (AN)	19	8	10	22	9	7	0
2006 (W)	21	9	11	22	11	9	0
2007 (D)	8	9	16	25	4	4	0
2008 (C)	11	8	14	24	7	3	0
2009 (D)	12	9	12	23	6	4	0
2010 (BN)	17	8	11	22	8	5	0
2011 (W)	25	7	9	22	11	9	0
2012 (BN)	17	8	12	24	7	6	0
2013 (D)	19	9	12	24	8	8	1
2014 (C)	12	6	14	24	6	2	-1
Minimum	8	6	7	22	4	2	-1
Maximum	25	15	16	25	11	11	1
Average	17	9	11	23	8	6	0
Averages by Hydrologic Year Type							
Wet (W)	23	8	10	22	11	9	0
Above Normal (AN)	20	11	9	22	10	8	0
Below Normal (BN)	17	9	12	23	8	6	0
Dry (D)	14	9	12	23	7	6	0
Critical (C)	12	7	14	24	6	3	0

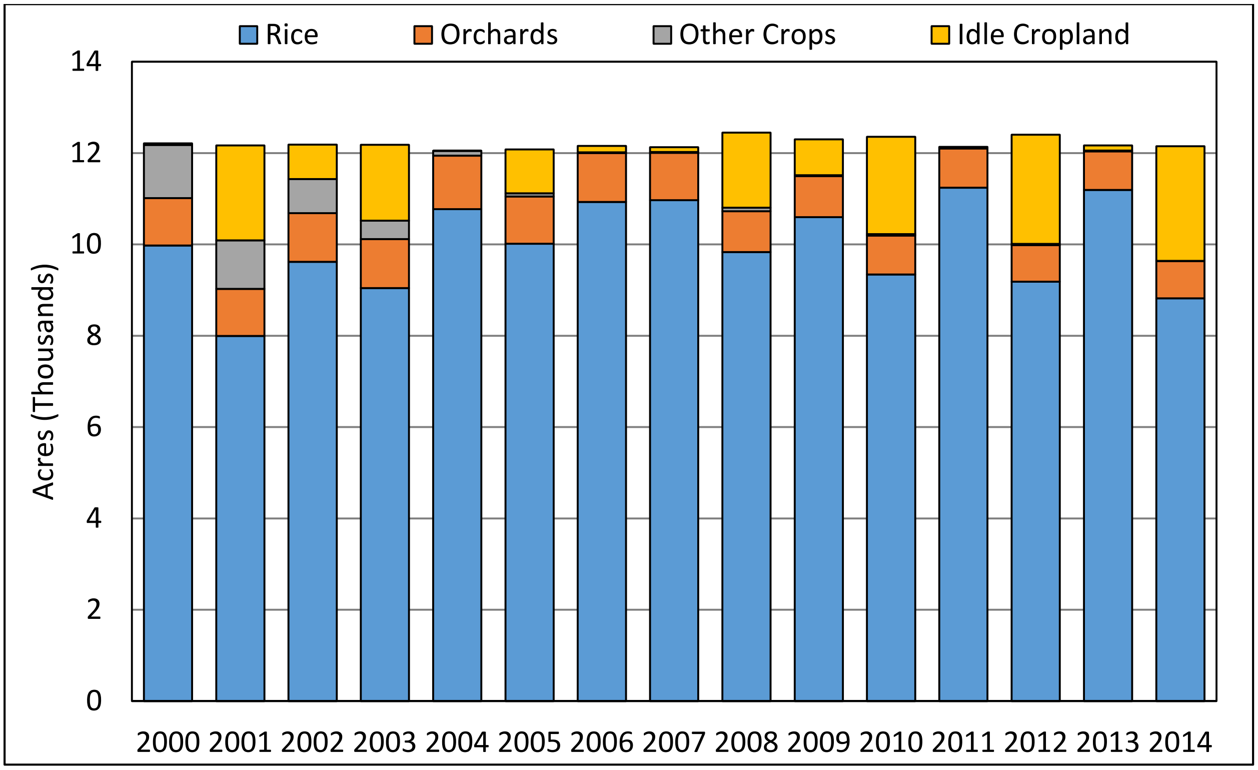
C.2.5. Western Canal Subinventory Unit (West Butte Portion)

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

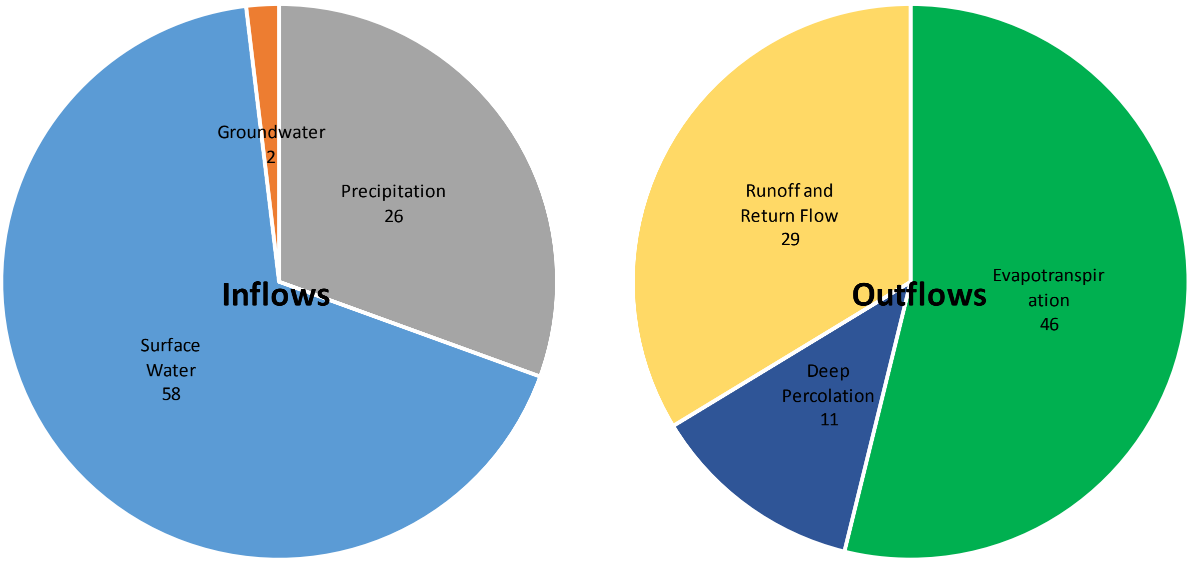
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	9,978	388	82	390	176	0	1,025	138	37	12,177	12,214
2001	7,994	354	109	390	179	0	867	194	2,080	10,087	12,167
2002	9,619	363	166	401	135	0	695	53	754	11,432	12,186
2003	9,042	363	192	382	136	0	320	86	1,658	10,522	12,180
2004	10,774	384	256	447	82	0	1	104	3	12,047	12,050
2005	10,015	368	260	307	102	2	1	66	961	11,119	12,080
2006	10,929	368	256	372	73	6	2	9	140	12,015	12,155
2007	10,969	382	242	337	76	11	2	7	103	12,025	12,128
2008	9,834	317	193	262	121	14	2	59	1,643	10,803	12,446
2009	10,597	372	218	247	59	14	2	6	786	11,515	12,301
2010	9,342	375	190	205	82	14	1	17	2,130	10,226	12,356
2011	11,241	384	227	167	80	20	2	0	14	12,122	12,136
2012	9,184	375	206	146	71	27	2	0	2,392	10,011	12,402
2013	11,194	380	243	149	72	17	2	0	114	12,055	12,169
2014	8,818	386	251	119	63	2	2	0	2,511	9,641	12,152
Min	7,994	317	82	119	59	0	1	0	3	9,641	12,050
Max	11,241	388	260	447	179	27	1,025	194	2,511	12,177	12,446
Average	9,969	371	206	288	101	8	195	49	1,022	11,186	12,208

Other Land Use

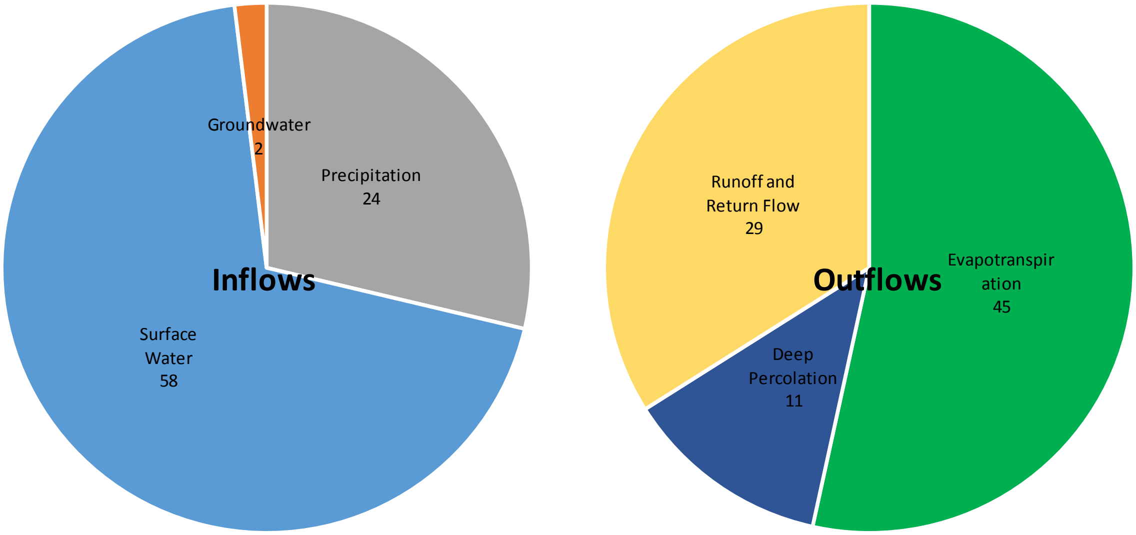
Year	Wetlands	Developed	Non-Irrigated	Total
2000	792	610	559	1,962
2001	803	648	557	2,008
2002	791	675	524	1,990
2003	809	691	496	1,995
2004	810	757	558	2,125
2005	816	760	519	2,095
2006	777	720	523	2,020
2007	780	737	530	2,047
2008	690	613	427	1,729
2009	737	663	475	1,875
2010	696	641	483	1,819
2011	776	740	524	2,040
2012	675	638	460	1,773
2013	764	729	514	2,006
2014	766	742	515	2,024
Min	675	610	427	1,729
Max	816	760	559	2,125
Average	765	691	511	1,967

Water Budgets

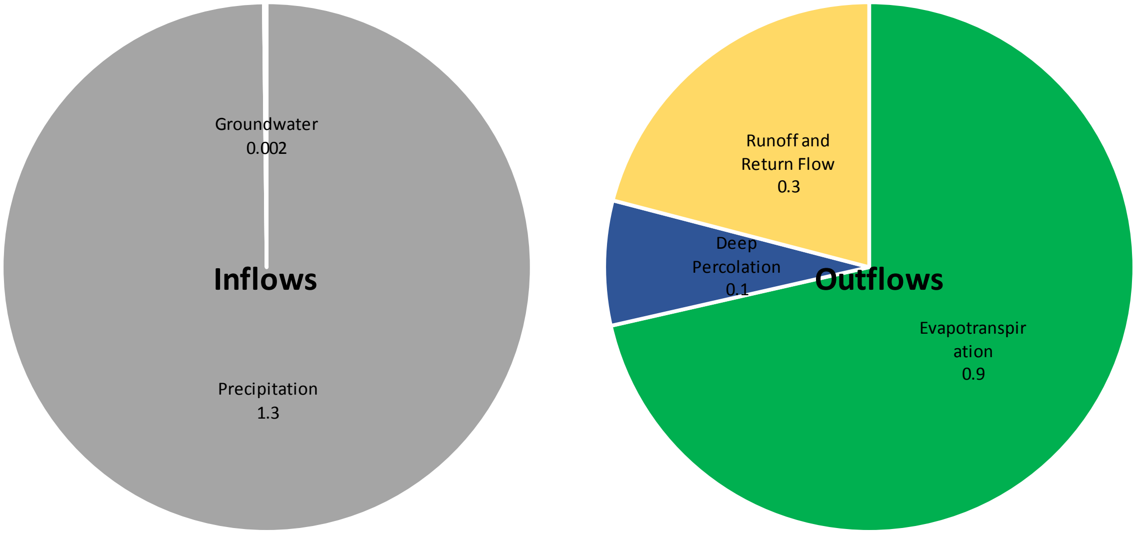
Western Canal (West Butte Portion) Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



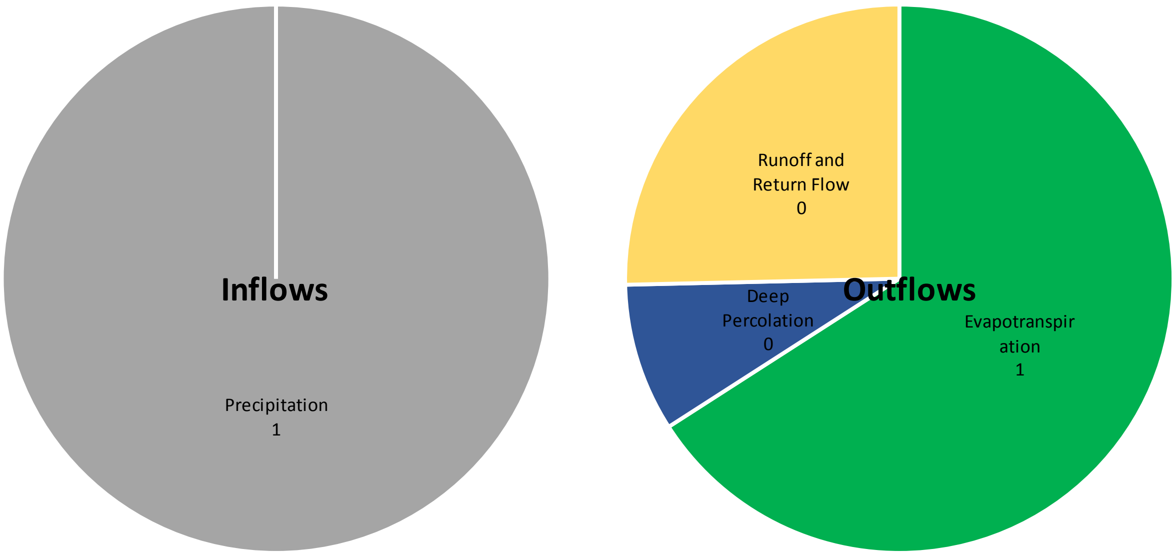
Western Canal (West Butte Portion) Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



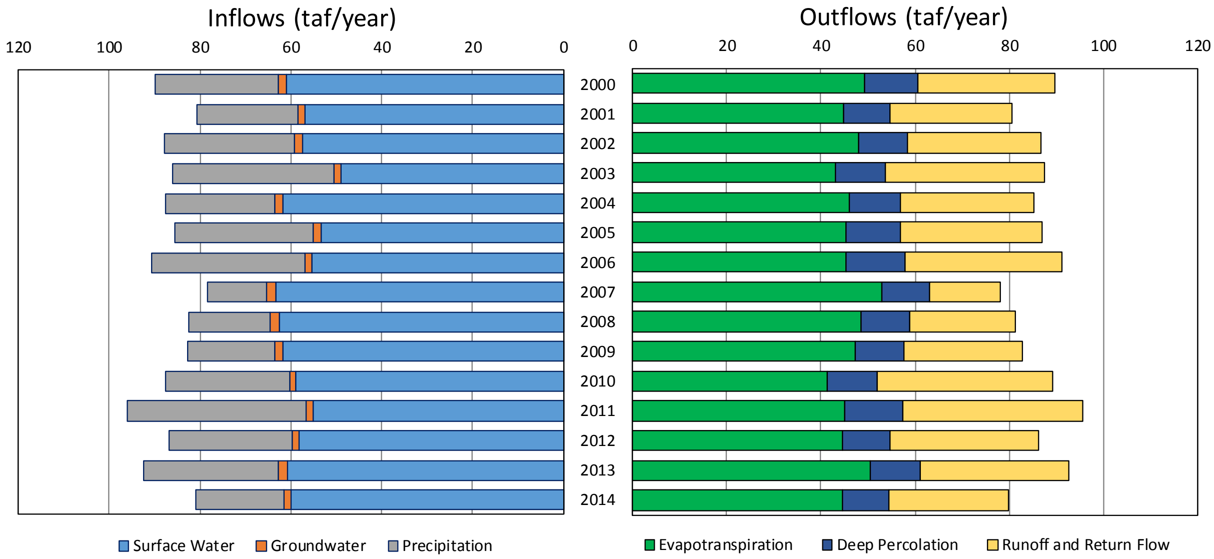
Western Canal (West Butte Portion) Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Western Canal (West Butte Portion) Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Western Canal (West Butte Portion) Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



Subinventory Unit Water Budget

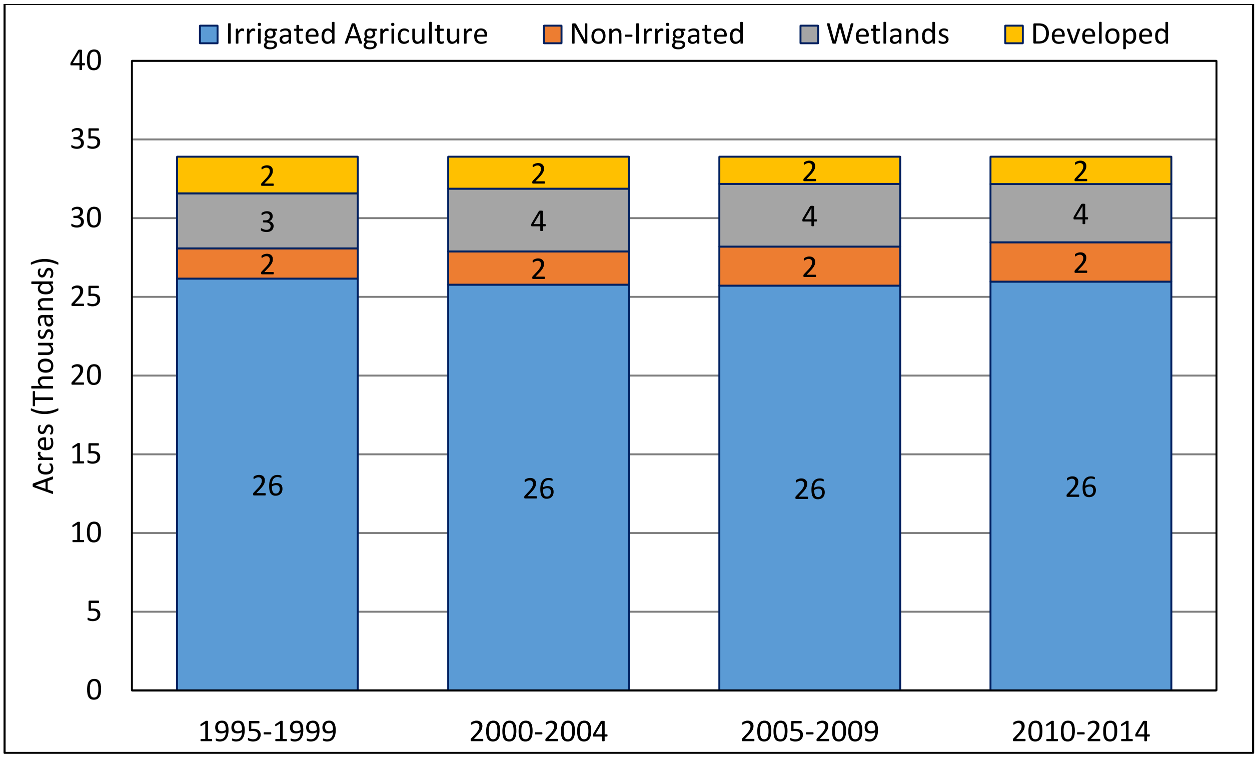
	Inflows (taf)			Outflows (taf)			
Water Year	**Precipi-tation**	**Surface Water**	**Ground-water**	**Evapotrans-piration**	**Deep Percolation**	**Runoff and Return Flow**	**Change in Storage (taf)**
2000 (AN)	27	61	2	49	11	29	0
2001 (D)	22	57	2	45	10	26	0
2002 (D)	29	57	2	48	10	28	-1
2003 (AN)	36	49	1	43	10	34	1
2004 (BN)	24	62	2	46	11	28	-2
2005 (AN)	31	53	2	45	12	30	2
2006 (W)	34	55	1	45	13	33	1
2007 (D)	13	63	2	53	10	15	0
2008 (C)	18	63	2	48	11	22	-1
2009 (D)	19	62	2	47	10	25	0
2010 (BN)	27	59	1	41	11	37	2
2011 (W)	40	55	1	45	12	38	0
2012 (BN)	27	58	2	45	10	32	0
2013 (D)	30	61	2	50	11	31	0
2014 (C)	19	60	2	45	10	26	-1
Minimum	13	49	1	41	10	15	-2
Maximum	40	63	2	53	13	38	2
Average	26	58	2	46	11	29	0
Averages by Hydrologic Year Type							
Wet (W)	37	55	1	45	12	36	0
Above Normal (AN)	31	54	2	46	11	31	1
Below Normal (BN)	26	60	1	44	11	32	0
Dry (D)	23	60	2	49	10	25	0
Critical (C)	19	61	2	47	10	24	-1

C.3. East Butte Inventory Unit

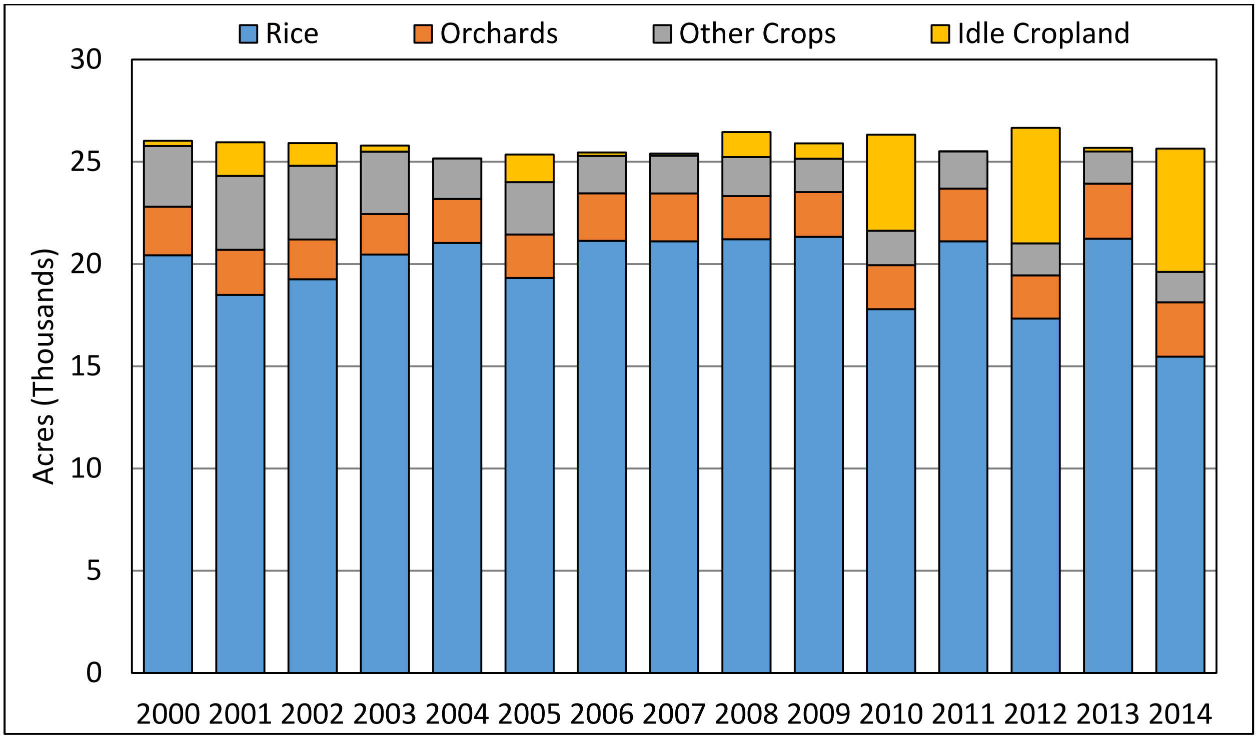
C.3.1. Biggs-West Gridley Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

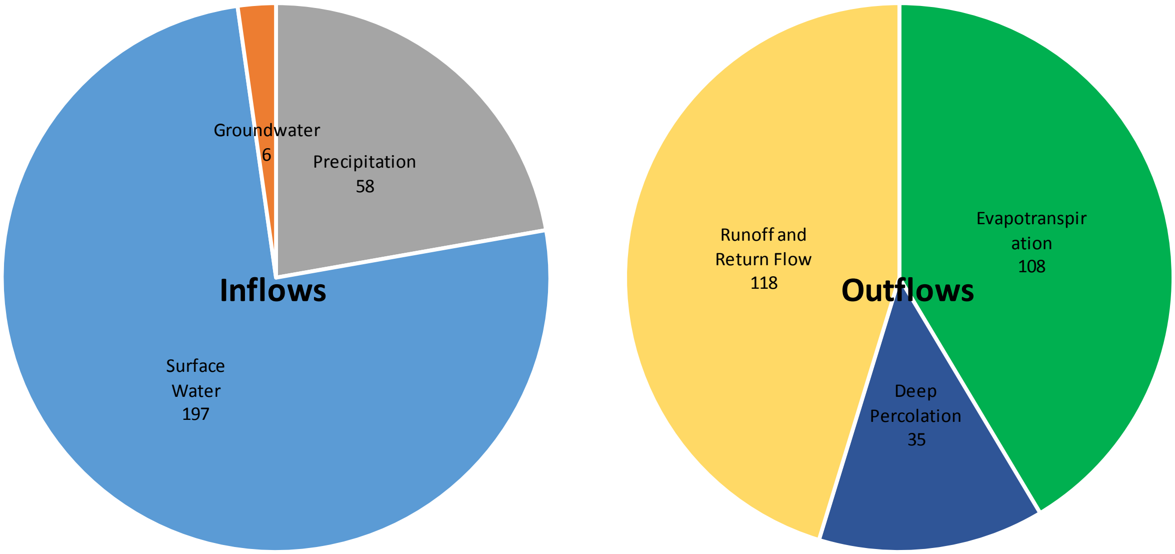
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	20,431	6	603	1,408	358	651	1,941	379	249	25,777	26,026
2001	18,489	7	542	1,298	359	888	1,904	824	1,647	24,311	25,958
2002	19,256	6	572	1,052	314	893	1,857	856	1,115	24,805	25,920
2003	20,461	6	674	953	358	1,144	1,447	455	299	25,496	25,795
2004	21,036	5	907	1,001	235	528	1,414	32	1	25,158	25,159
2005	19,318	5	1,157	608	354	250	1,127	1,190	1,349	24,008	25,357
2006	21,134	6	1,152	941	229	411	1,394	21	165	25,289	25,455
2007	21,112	7	1,153	953	227	386	1,413	48	106	25,298	25,405
2008	21,216	5	952	762	390	353	1,172	390	1,222	25,239	26,461
2009	21,333	3	1,163	850	175	222	1,358	48	749	25,151	25,900
2010	17,798	5	1,129	777	238	148	1,265	274	4,692	21,632	26,324
2011	21,112	5	1,542	764	262	144	1,506	170	12	25,504	25,516
2012	17,332	5	1,246	640	224	260	1,211	97	5,647	21,014	26,662
2013	21,237	7	1,783	665	242	118	1,333	119	179	25,505	25,684
2014	15,472	14	1,884	539	226	15	1,400	68	6,027	19,618	25,645
Min	15,472	3	542	539	175	15	1,127	21	1	19,618	25,159
Max	21,333	14	1,884	1,408	390	1,144	1,941	1,190	6,027	25,777	26,662
Average	19,782	6	1,097	881	279	427	1,449	331	1,564	24,254	25,818

Other Land Use

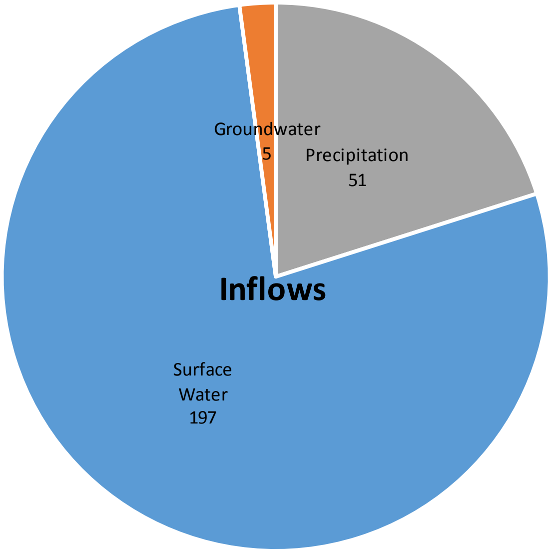
Year	Wetlands	Developed	Non-Irrigated	Total
2000	3,884	2,294	1,702	7,879
2001	3,829	2,137	1,982	7,947
2002	3,847	1,998	2,141	7,986
2003	4,038	1,846	2,226	8,110
2004	4,305	1,888	2,554	8,747
2005	4,245	1,735	2,569	8,548
2006	4,121	1,814	2,517	8,451
2007	4,084	1,853	2,565	8,501
2008	3,641	1,537	2,268	7,445
2009	3,853	1,696	2,457	8,006
2010	3,611	1,606	2,365	7,582
2011	3,862	1,869	2,660	8,390
2012	3,409	1,535	2,300	7,244
2013	3,817	1,825	2,580	8,222
2014	3,839	1,839	2,583	8,261
Min	3,409	1,535	1,702	7,244
Max	4,305	2,294	2,660	8,747
Average	3,892	1,831	2,364	8,088

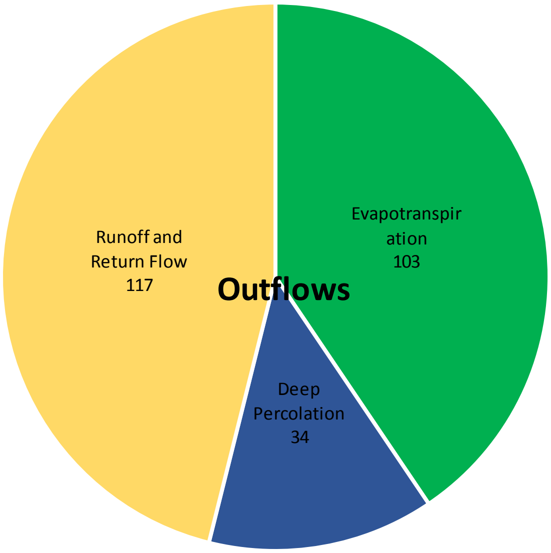
Water Budgets

Biggs-West Gridley Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)

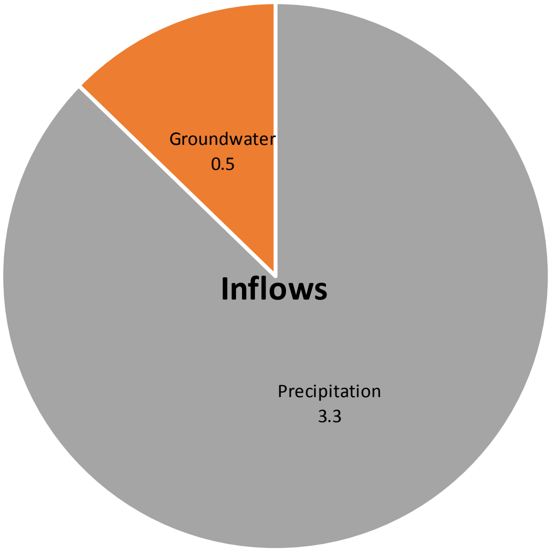


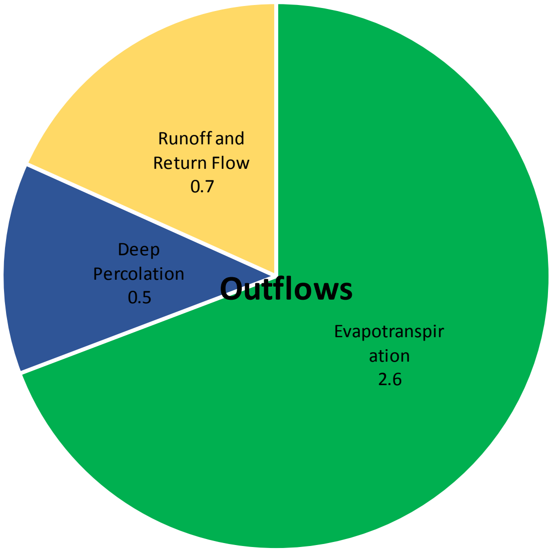
Biggs-West Gridley Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



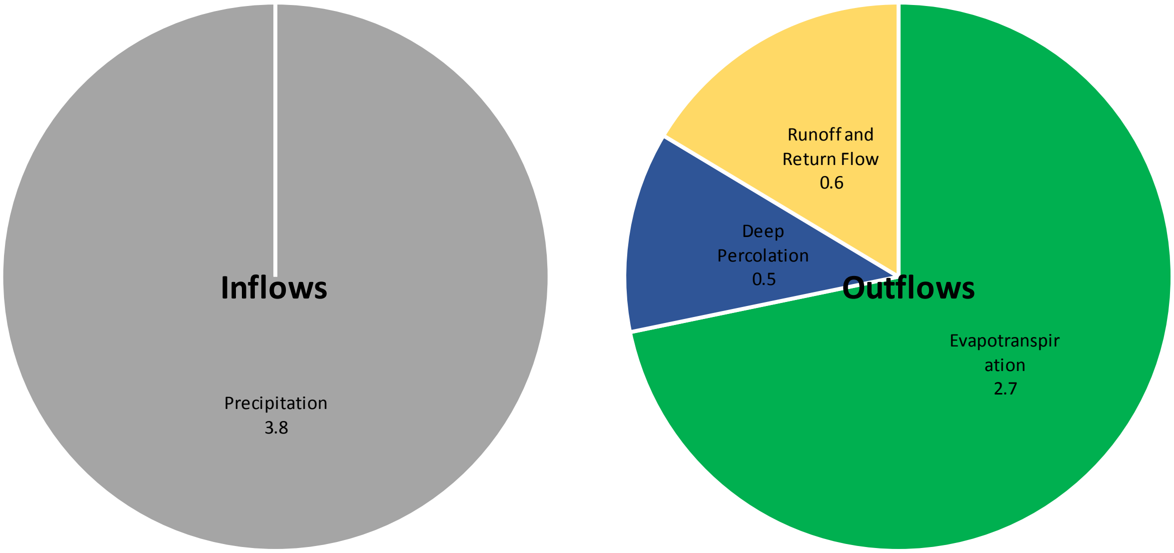


Biggs-West Gridley Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

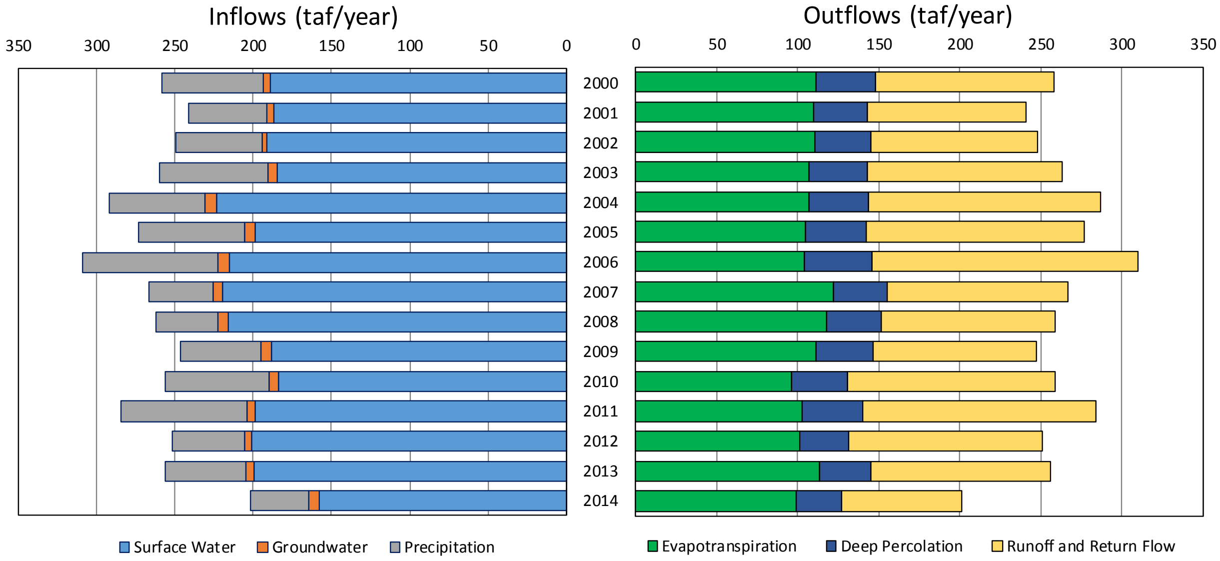




Biggs-West Gridley Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Biggs-West Gridley Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



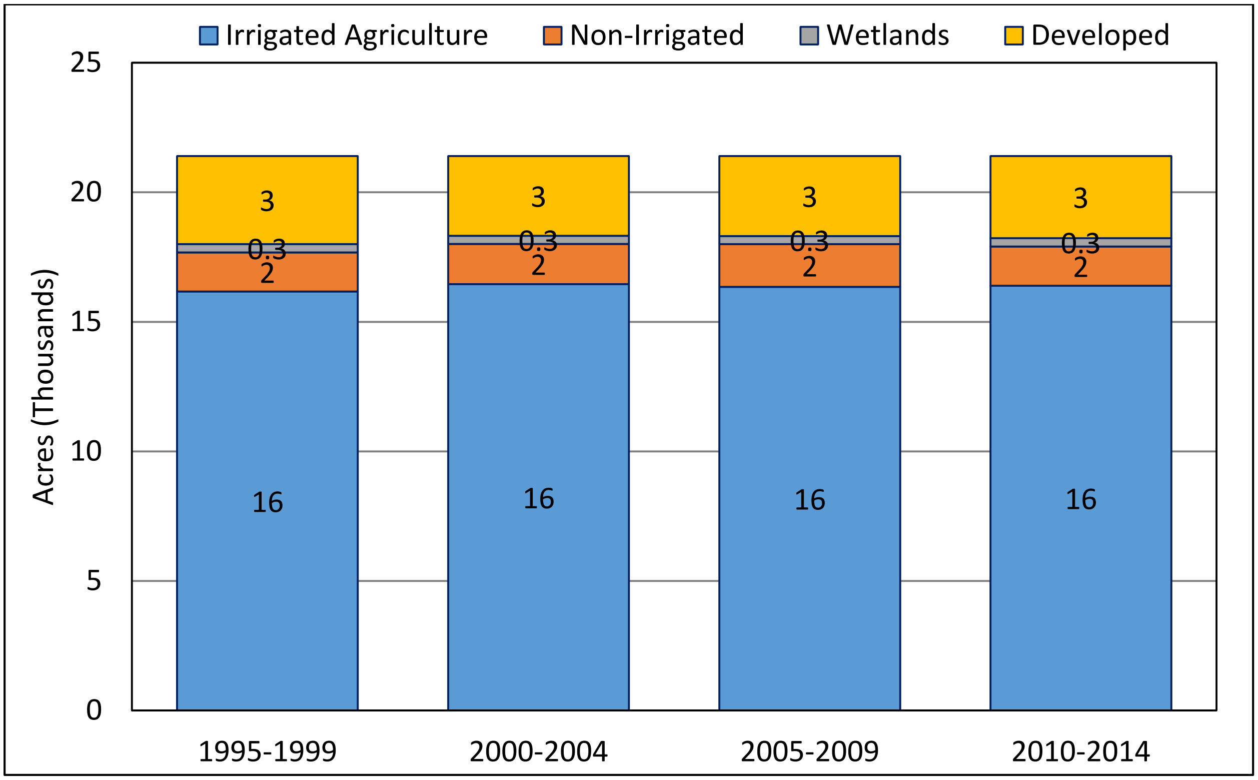
Subinventory Unit Water Budget

Water Year	Inflows (taf) Precipi-tation	Inflows (taf) Surface Water	Inflows (taf) Ground-water	Outflows (taf) Evapotrans-piration	Outflows (taf) Deep Percolation	Outflows (taf) Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	65	189	5	112	36	110	0
2001 (D)	50	187	4	110	33	98	0
2002 (D)	55	191	3	111	34	103	-2
2003 (AN)	69	184	7	107	36	120	4
2004 (BN)	61	223	8	107	37	144	-5
2005 (AN)	67	198	7	105	37	135	4
2006 (W)	87	215	7	104	42	164	1
2007 (D)	41	220	6	122	33	112	0
2008 (C)	40	216	6	118	34	107	-3
2009 (D)	52	188	6	111	35	101	1
2010 (BN)	67	184	6	96	35	128	3
2011 (W)	81	199	5	102	37	144	0
2012 (BN)	46	201	5	101	30	119	-1
2013 (D)	51	199	6	114	31	111	0
2014 (C)	37	157	7	99	28	74	-1
Minimum	37	157	3	96	28	74	-5
Maximum	87	223	8	122	42	164	4
Average	58	197	6	108	35	118	0
Averages by Hydrologic Year Type							
Wet (W)	84	207	6	103	40	154	0
Above Normal (AN)	67	190	6	108	37	122	2
Below Normal (BN)	58	203	6	101	34	130	-1
Dry (D)	50	197	5	113	33	105	0
Critical (C)	38	187	7	108	31	90	-2

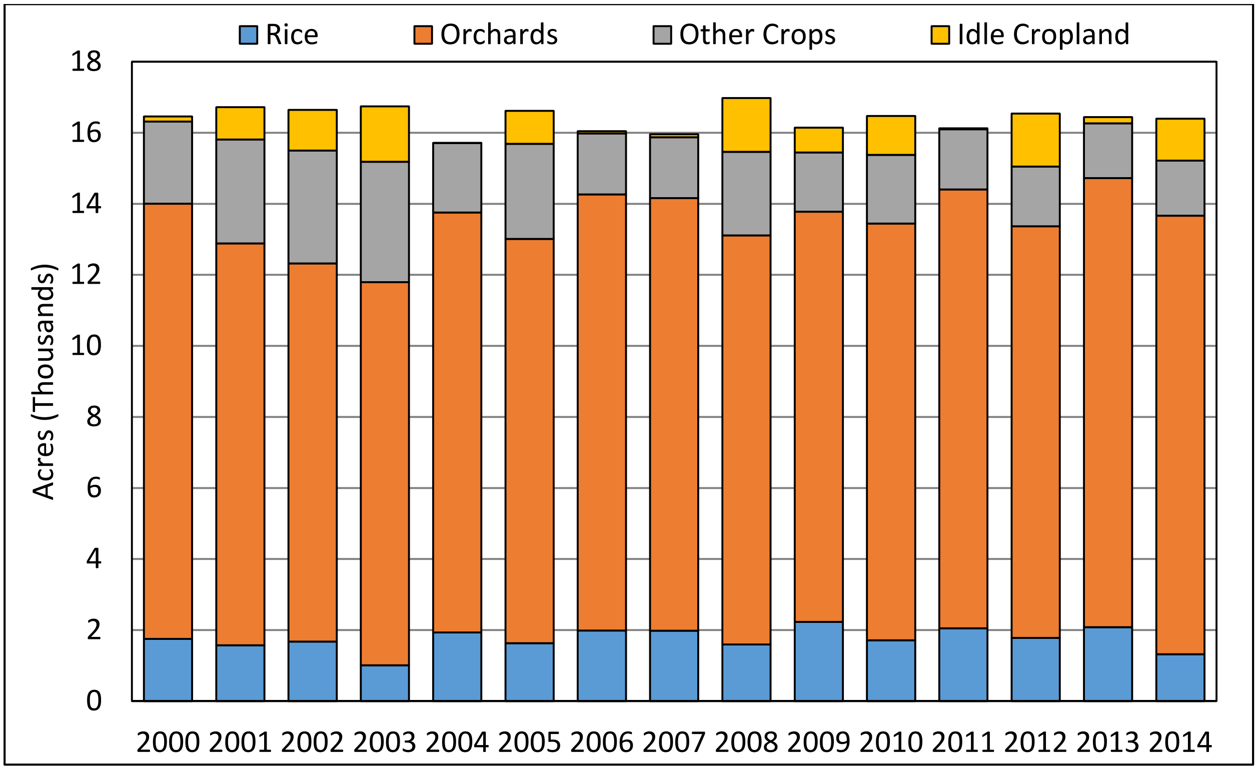
C.3.2. Butte Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

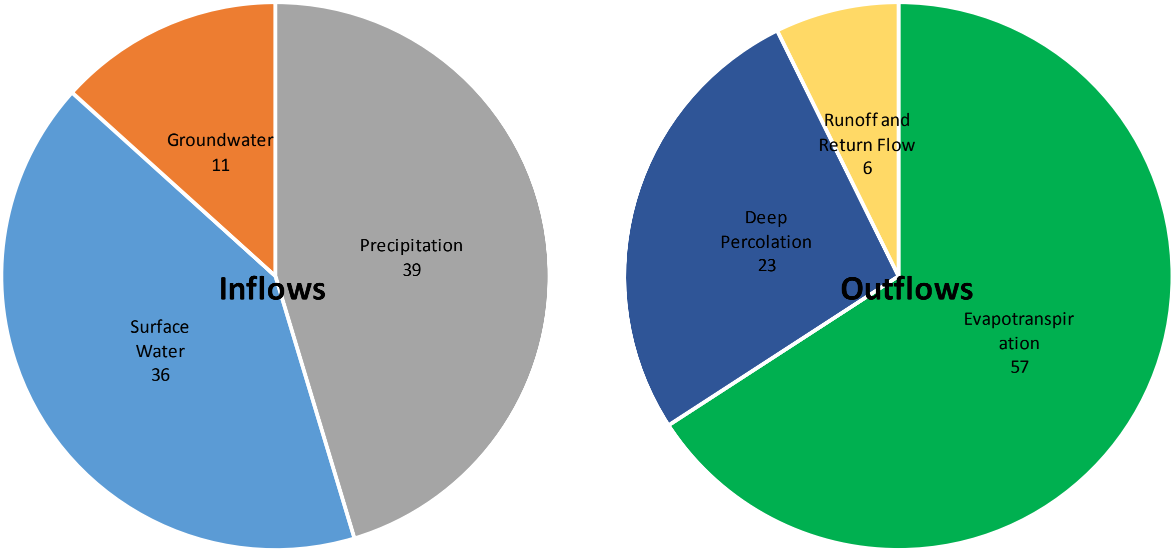
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	1,754	86	4,077	4,044	4,043	586	1,441	286	143	16,315	16,458
2001	1,571	88	3,858	3,661	3,709	773	1,255	893	914	15,809	16,723
2002	1,677	105	4,035	3,176	3,328	828	1,292	1,060	1,143	15,500	16,644
2003	1,011	113	4,321	2,782	3,565	1,077	1,184	1,130	1,558	15,184	16,742
2004	1,932	161	5,299	3,300	3,064	590	1,200	165	2	15,711	15,713
2005	1,632	133	5,405	1,968	3,874	286	959	1,430	930	15,688	16,618
2006	1,989	184	6,044	3,260	2,788	439	1,233	47	63	15,983	16,046
2007	1,984	207	5,842	3,405	2,723	395	1,247	73	82	15,875	15,957
2008	1,594	168	4,962	2,554	3,833	335	1,107	913	1,512	15,465	16,977
2009	2,233	238	5,892	3,266	2,150	213	1,331	125	699	15,447	16,146
2010	1,713	250	5,616	3,065	2,800	127	1,172	634	1,096	15,378	16,473
2011	2,049	268	6,396	2,914	2,778	92	1,336	268	25	16,100	16,125
2012	1,781	267	6,014	2,734	2,573	219	1,235	226	1,494	15,049	16,543
2013	2,082	256	7,417	2,482	2,489	69	1,249	222	176	16,266	16,442
2014	1,319	271	7,742	2,024	2,309	9	1,324	218	1,179	15,216	16,395
Min	1,011	86	3,858	1,968	2,150	9	959	47	2	15,049	15,713
Max	2,233	271	7,742	4,044	4,043	1,077	1,441	1,430	1,558	16,315	16,977
Average	1,755	186	5,528	2,976	3,068	402	1,238	513	734	15,666	16,400

Other Land Use

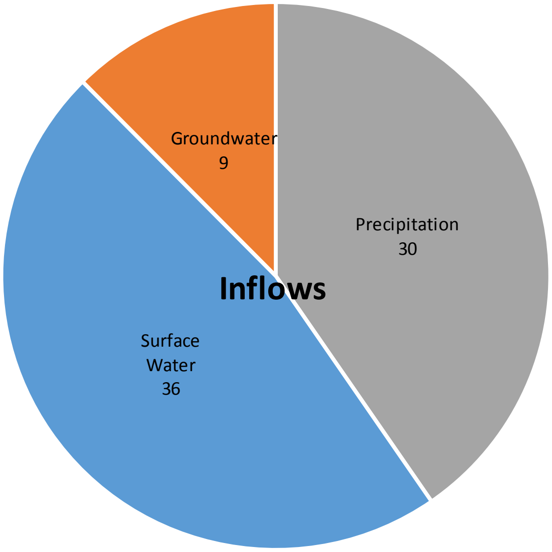
Year	Wetlands	Developed	Non-Irrigated	Total
2000	330	3,312	1,297	4,940
2001	300	2,955	1,420	4,675
2002	301	2,910	1,544	4,755
2003	293	2,812	1,552	4,656
2004	342	3,396	1,947	5,685
2005	304	2,844	1,633	4,780
2006	327	3,262	1,763	5,352
2007	338	3,331	1,772	5,441
2008	267	2,730	1,425	4,421
2009	324	3,270	1,658	5,252
2010	303	3,082	1,539	4,925
2011	354	3,322	1,598	5,273
2012	298	3,076	1,481	4,855
2013	330	3,157	1,468	4,955
2014	332	3,194	1,477	5,003
Min	267	2,730	1,297	4,421
Max	354	3,396	1,947	5,685
Average	316	3,110	1,572	4,998

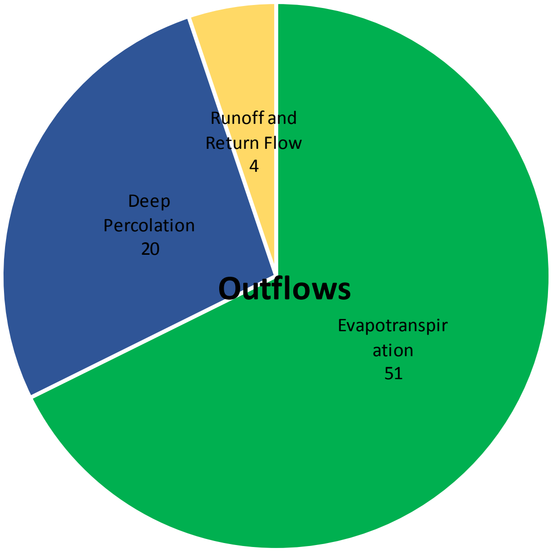
Water Budgets

Butte Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)

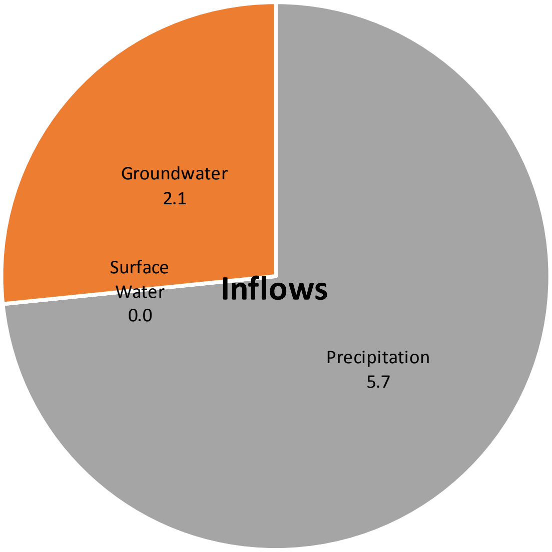


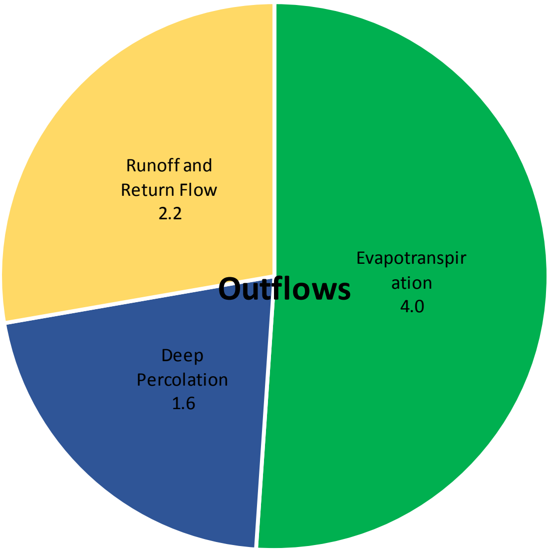
Butte Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



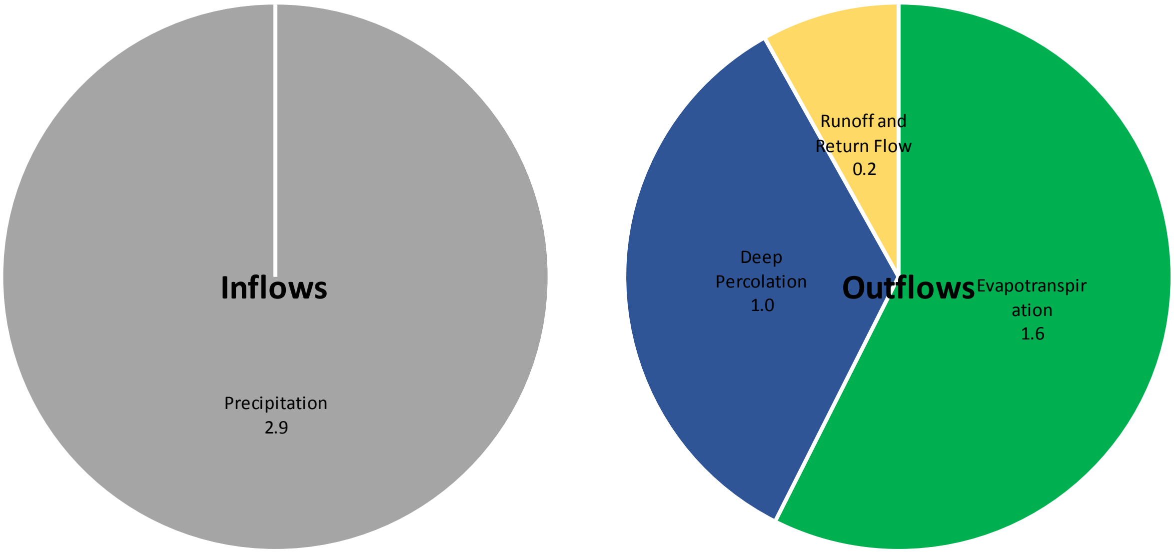


Butte Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

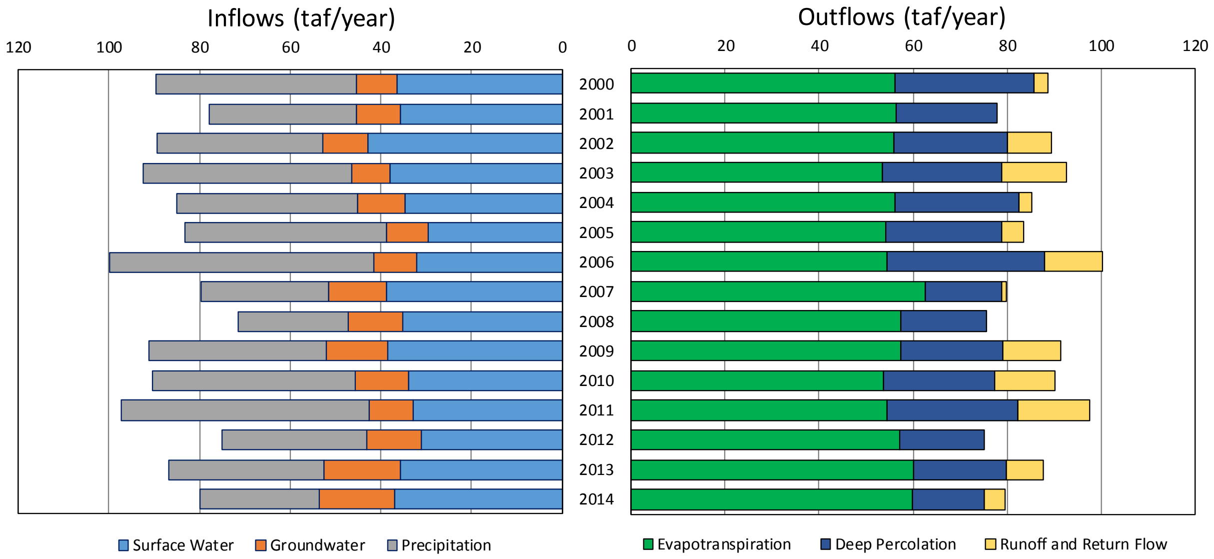




Butte Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Butte Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



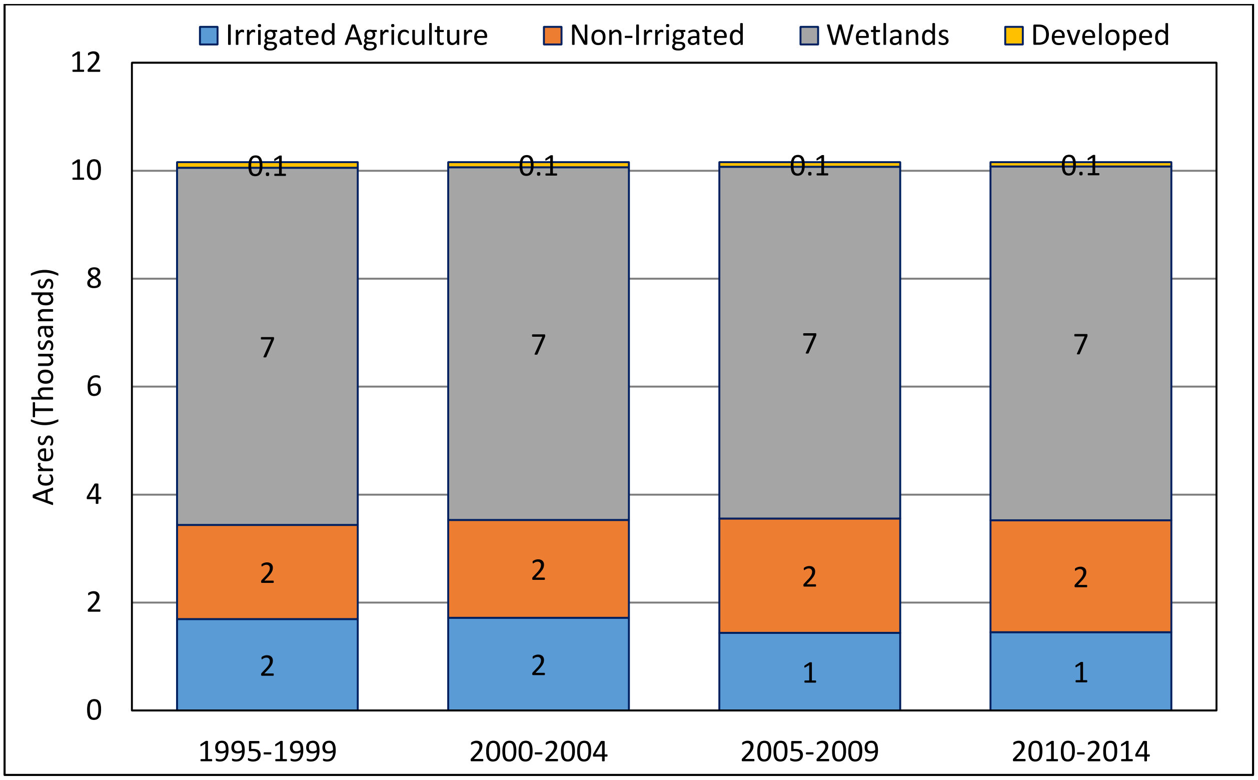
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	**Surface Water**	**Ground-water**	**Evapotrans-piration**	**Deep Percolation**	**Runoff and Return Flow**	
2000 (AN)	44	36	9	56	30	3	-1
2001 (D)	33	36	10	56	21	0	-1
2002 (D)	36	43	10	56	24	9	0
2003 (AN)	46	38	9	53	25	14	0
2004 (BN)	40	35	10	56	27	3	0
2005 (AN)	44	30	9	54	25	5	1
2006 (W)	58	32	9	54	34	12	0
2007 (D)	28	39	13	63	16	1	0
2008 (C)	24	35	12	57	18	-5	-1
2009 (D)	39	38	14	57	22	12	0
2010 (BN)	45	34	12	54	24	13	0
2011 (W)	55	33	10	54	28	15	1
2012 (BN)	32	31	12	57	18	-1	-1
2013 (D)	34	36	17	60	20	8	1
2014 (C)	26	37	17	60	15	4	0
Minimum	24	30	9	53	15	-5	-1
Maximum	58	43	17	63	34	15	1
Average	39	36	11	57	23	6	0
Averages by Hydrologic Year Type							
Wet (W)	57	33	9	54	31	14	0
Above Normal (AN)	45	35	9	55	27	7	0
Below Normal (BN)	39	33	11	56	23	5	0
Dry (D)	34	38	13	58	21	6	0
Critical (C)	25	36	14	59	17	0	0

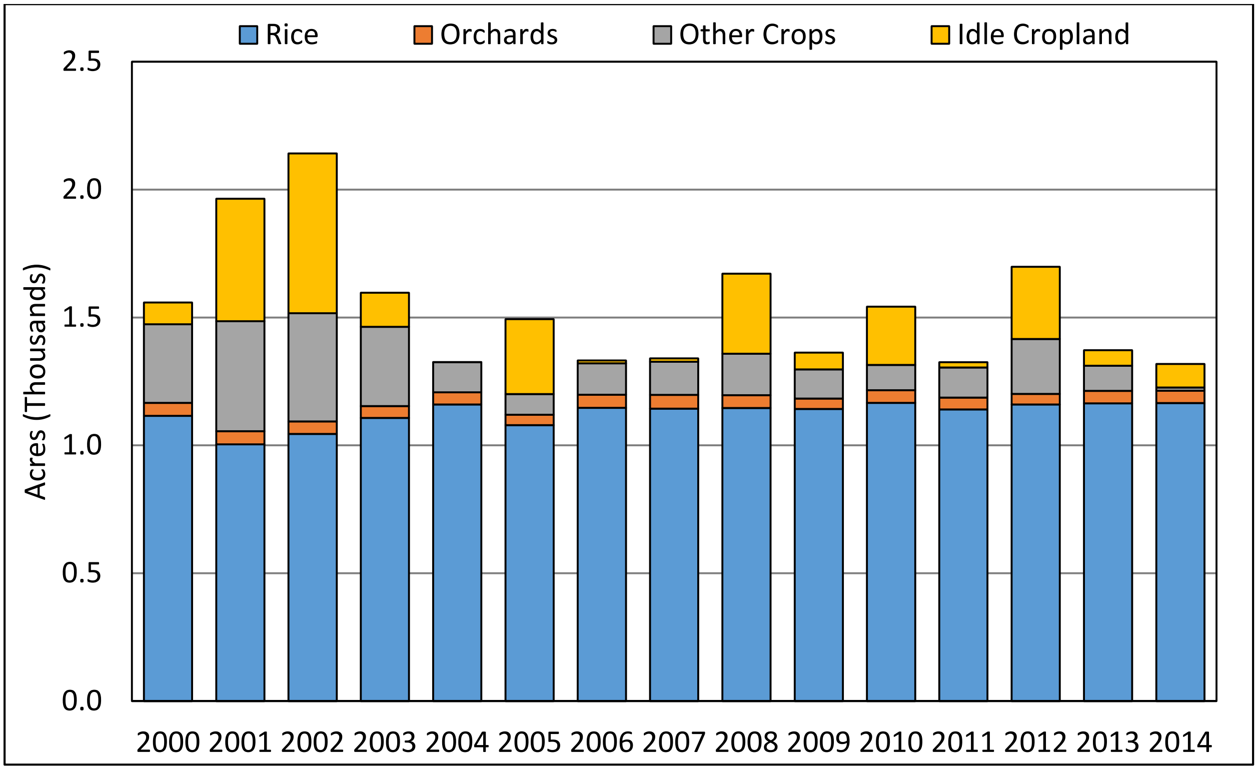
C.3.3. Butte Sink Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

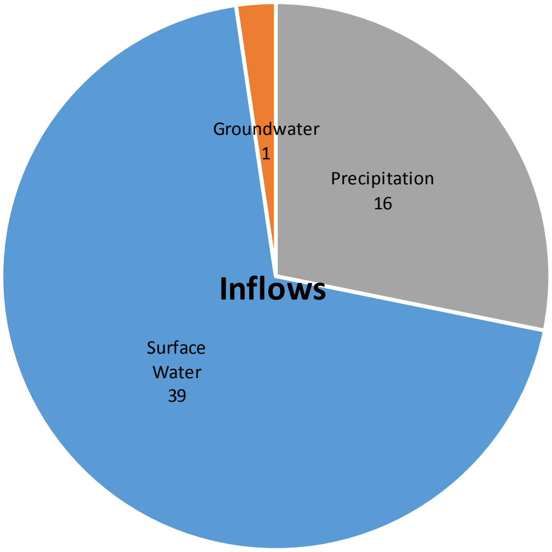
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	1,116	44	0	7	0	55	0	253	85	1,474	1,559
2001	1,004	38	0	13	0	100	0	330	479	1,485	1,964
2002	1,045	32	0	17	0	123	0	300	625	1,517	2,142
2003	1,107	26	0	21	0	180	0	131	133	1,464	1,597
2004	1,160	21	0	27	0	117	0	0	0	1,325	1,325
2005	1,079	19	0	22	0	81	0	0	293	1,200	1,494
2006	1,147	23	0	28	0	122	0	0	11	1,321	1,332
2007	1,144	25	0	29	0	130	0	0	13	1,327	1,340
2008	1,146	25	0	25	0	162	0	0	313	1,359	1,671
2009	1,142	13	0	28	0	114	0	0	66	1,297	1,363
2010	1,166	22	0	27	0	99	0	0	228	1,314	1,542
2011	1,140	21	0	26	0	118	0	0	20	1,305	1,325
2012	1,160	19	0	22	0	215	0	0	282	1,416	1,698
2013	1,165	27	0	22	0	98	0	0	61	1,311	1,372
2014	1,166	29	0	19	0	13	0	0	92	1,226	1,318
Min	1,004	13	0	7	0	13	0	0	0	1,200	1,318
Max	1,166	44	0	29	0	215	0	330	625	1,517	2,142
Average	1,126	26	0	22	0	115	0	68	180	1,356	1,536

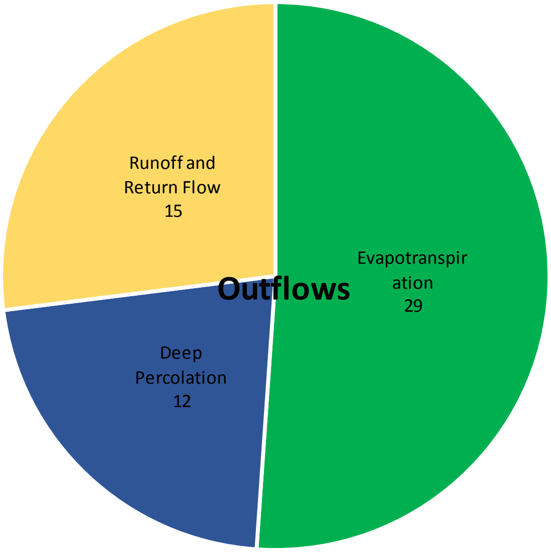
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	6,912	105	1,584	8,600
2001	6,452	97	1,645	8,195
2002	6,194	92	1,731	8,017
2003	6,526	94	1,942	8,562
2004	6,582	92	2,160	8,833
2005	6,425	89	2,151	8,665
2006	6,596	89	2,142	8,827
2007	6,595	88	2,136	8,818
2008	6,362	82	2,044	8,487
2009	6,596	83	2,116	8,796
2010	6,474	80	2,063	8,616
2011	6,640	81	2,113	8,833
2012	6,385	78	1,997	8,460
2013	6,616	83	2,088	8,786
2014	6,653	84	2,103	8,840
Min	6,194	78	1,584	8,017
Max	6,912	105	2,160	8,840
Average	6,534	88	2,001	8,622

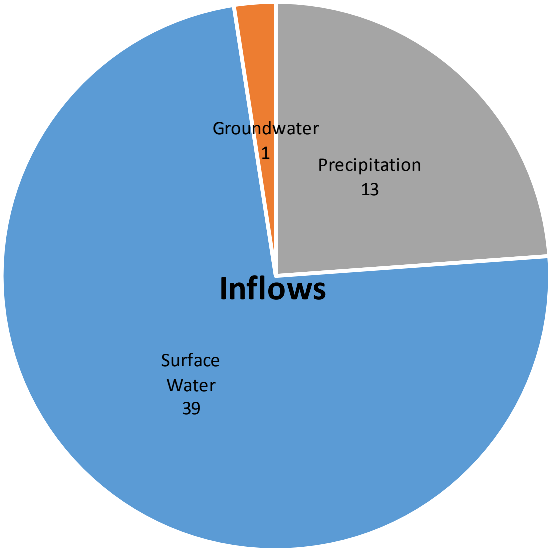
Water Budgets

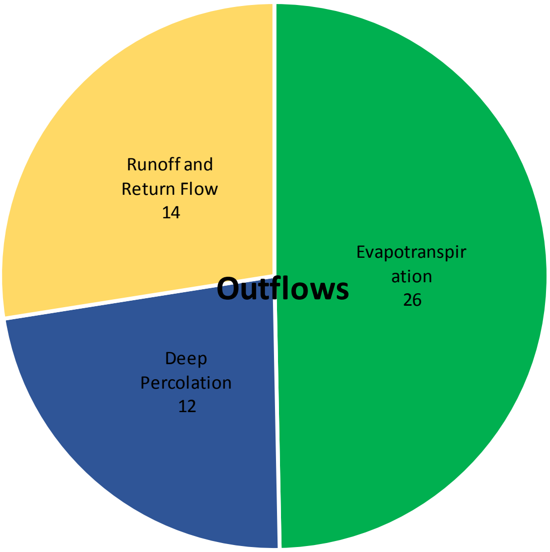
Butte Sink Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



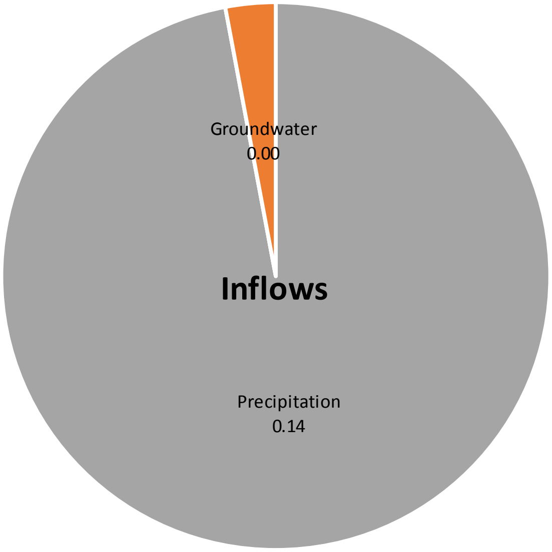


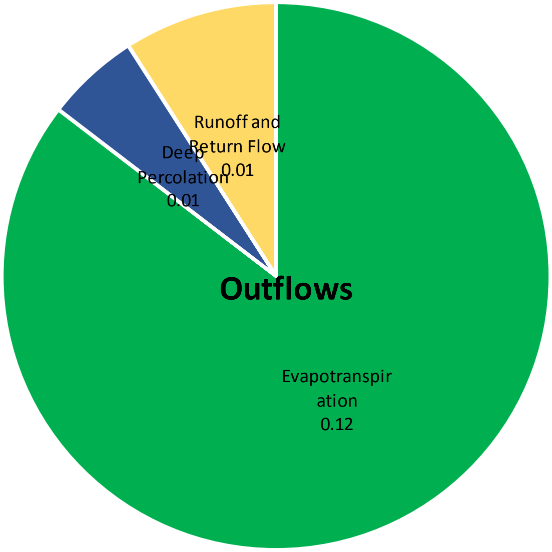
Butte Sink Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



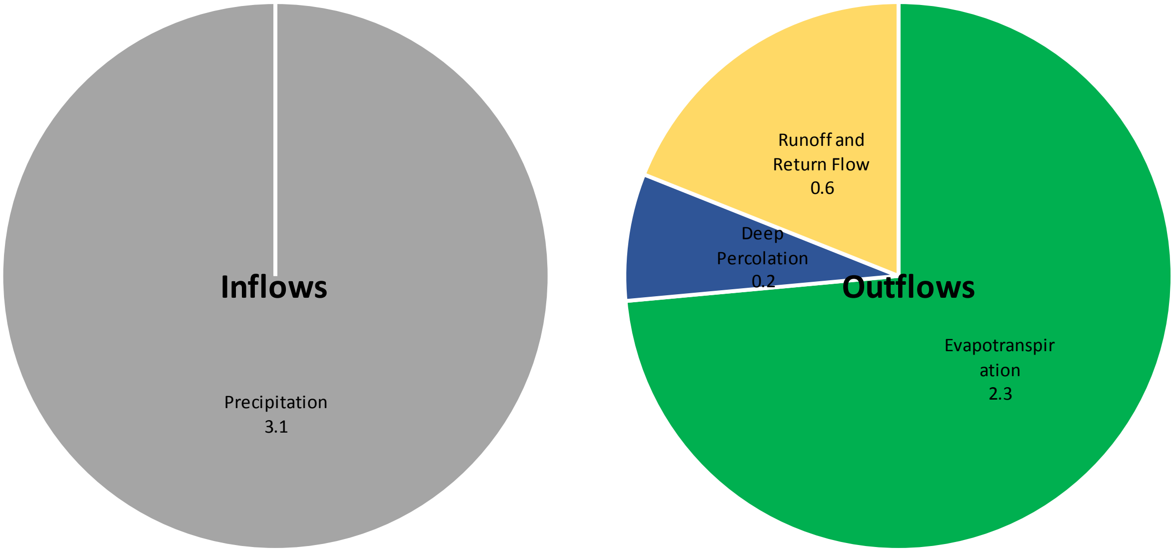


Butte Sink Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

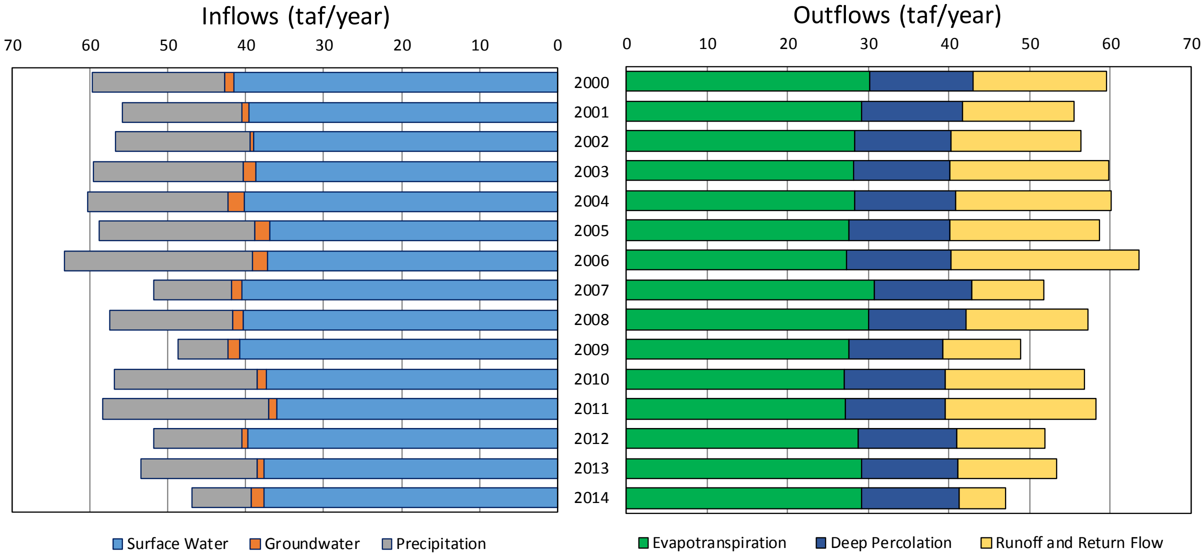




Butte Sink Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Butte Sink Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



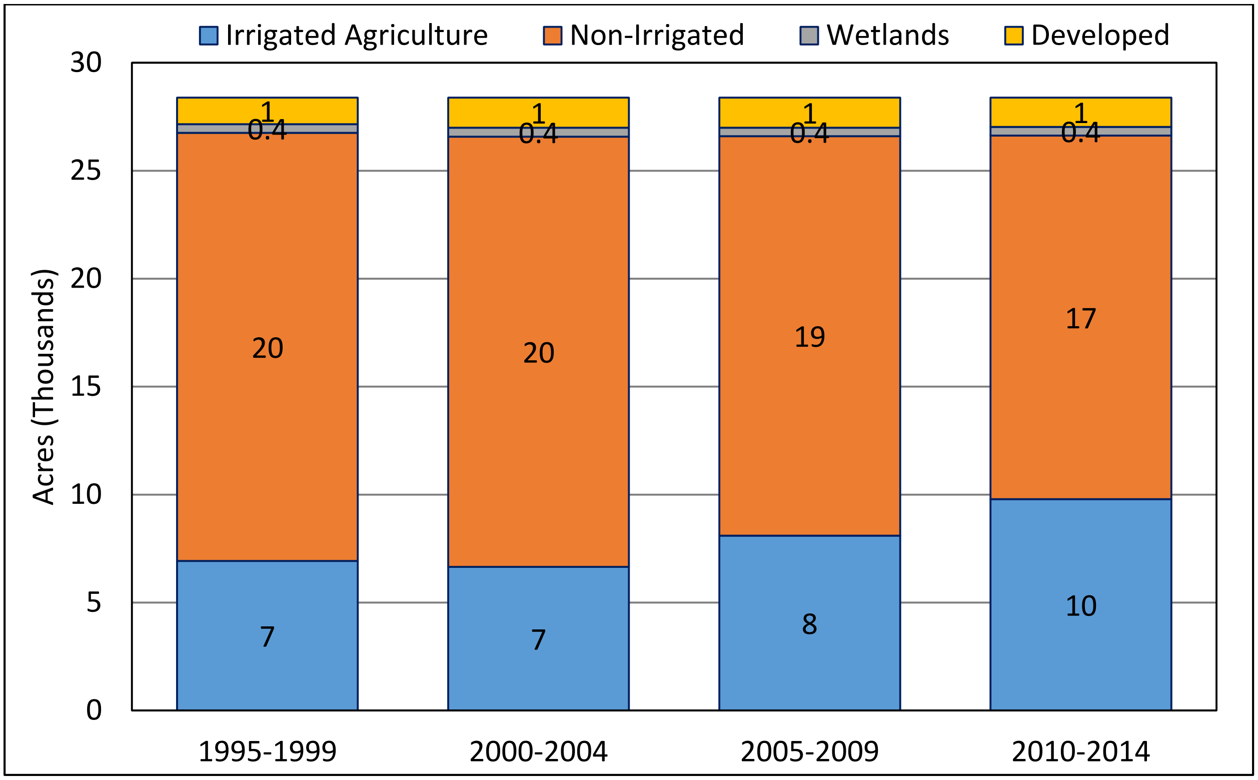
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	17	42	1	30	13	17	0
2001 (D)	15	40	1	29	13	14	0
2002 (D)	17	39	0	28	12	16	0
2003 (AN)	19	39	2	28	12	20	0
2004 (BN)	18	40	2	28	12	19	-1
2005 (AN)	20	37	2	28	13	19	0
2006 (W)	24	37	2	27	13	23	0
2007 (D)	10	40	1	31	12	9	0
2008 (C)	16	40	1	30	12	15	0
2009 (D)	6	41	1	28	12	10	0
2010 (BN)	18	37	1	27	13	17	0
2011 (W)	21	36	1	27	12	19	0
2012 (BN)	11	40	1	29	12	11	0
2013 (D)	15	38	1	29	12	12	0
2014 (C)	8	38	2	29	12	6	0
Minimum	6	36	0	27	12	6	-1
Maximum	24	42	2	31	13	23	0
Average	16	39	1	29	12	15	0
Averages by Hydrologic Year Type							
Wet (W)	23	37	1	27	13	21	0
Above Normal (AN)	19	39	2	29	12	18	0
Below Normal (BN)	16	39	1	28	12	16	0
Dry (D)	13	40	1	29	12	12	0
Critical (C)	12	39	1	30	12	10	0

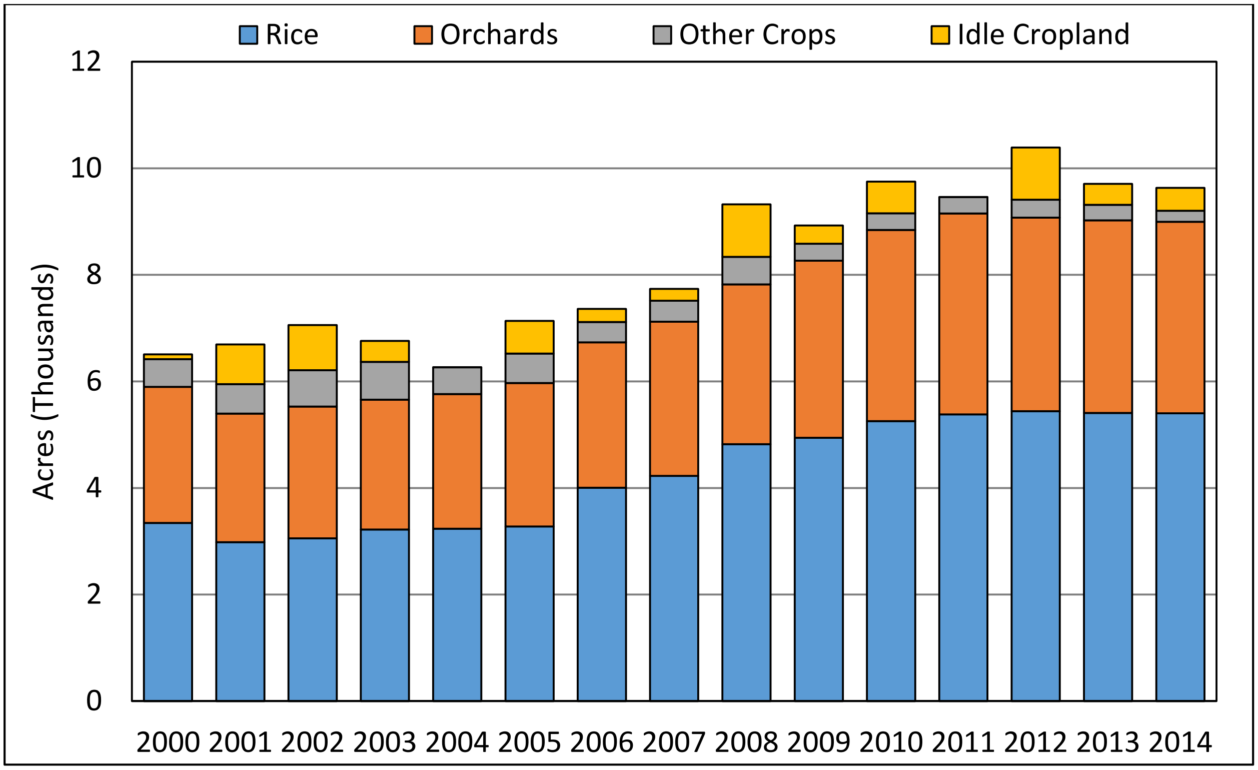
C.3.4. Cherokee Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

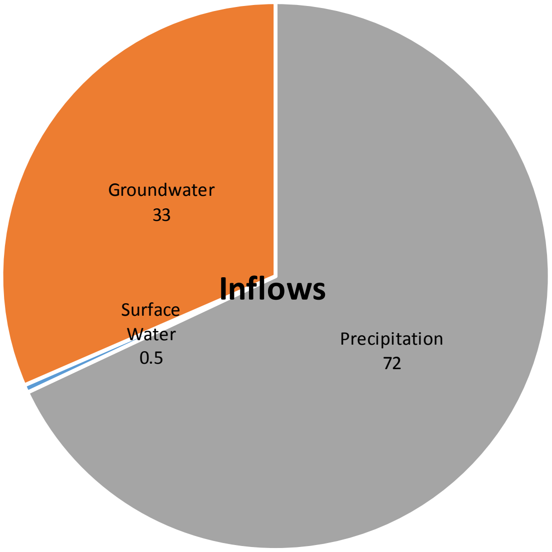
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	3,345	1,544	0	162	847	197	188	134	91	6,418	6,509
2001	2,983	1,494	0	166	754	189	199	164	745	5,949	6,693
2002	3,056	1,437	0	128	906	178	211	293	848	6,209	7,057
2003	3,222	1,539	0	97	801	203	220	286	391	6,368	6,759
2004	3,236	1,660	0	66	801	136	235	133	1	6,266	6,267
2005	3,278	1,583	36	49	1,024	92	221	239	614	6,522	7,136
2006	4,006	1,532	45	66	1,085	140	211	32	247	7,116	7,363
2007	4,228	1,561	49	66	1,216	146	195	55	224	7,515	7,738
2008	4,822	1,318	50	61	1,572	145	164	206	988	8,337	9,325
2009	4,944	1,473	61	64	1,724	129	175	15	344	8,584	8,928
2010	5,256	1,463	63	64	1,999	100	149	63	595	9,155	9,750
2011	5,382	1,469	83	61	2,158	136	147	24	2	9,459	9,461
2012	5,442	1,440	80	53	2,061	165	147	24	980	9,411	10,391
2013	5,407	1,465	87	54	2,010	114	155	24	393	9,315	9,708
2014	5,401	1,483	87	44	1,981	14	164	27	431	9,202	9,633
Min	2,983	1,318	0	44	754	14	147	15	1	5,949	6,267
Max	5,442	1,660	87	166	2,158	203	235	293	988	9,459	10,391
Average	4,267	1,497	43	80	1,396	139	185	115	459	7,722	8,181

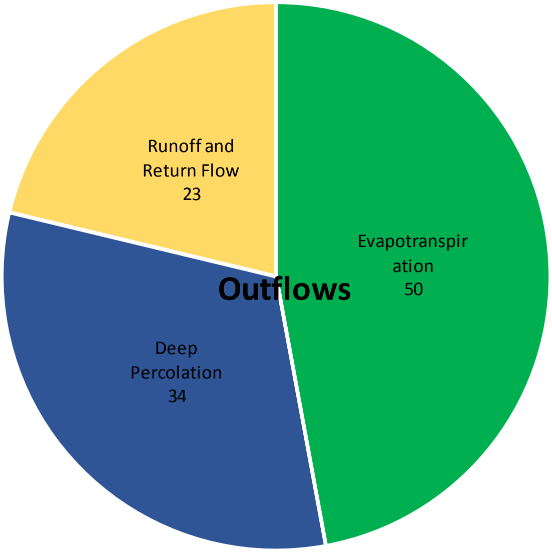
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	439	1,354	20,085	21,878
2001	419	1,349	19,927	21,695
2002	403	1,345	19,583	21,330
2003	400	1,400	19,829	21,629
2004	412	1,520	20,189	22,121
2005	390	1,433	19,428	21,251
2006	403	1,452	19,170	21,025
2007	407	1,449	18,793	20,649
2008	368	1,265	17,431	19,063
2009	396	1,368	17,696	19,459
2010	389	1,309	16,939	18,637
2011	417	1,397	17,113	18,927
2012	382	1,290	16,325	17,997
2013	412	1,396	16,871	18,680
2014	414	1,407	16,933	18,755
Min	368	1,265	16,325	17,997
Max	439	1,520	20,189	22,121
Average	403	1,382	18,421	20,206

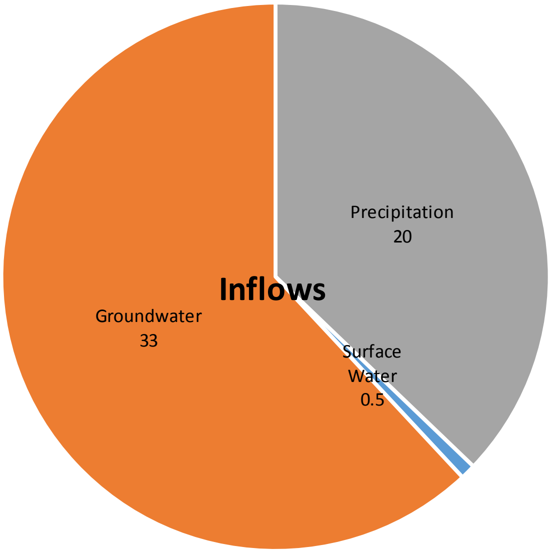
Water Budgets

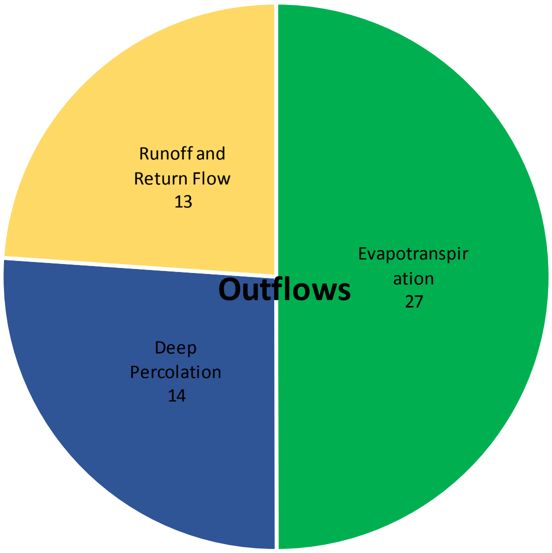
Cherokee Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



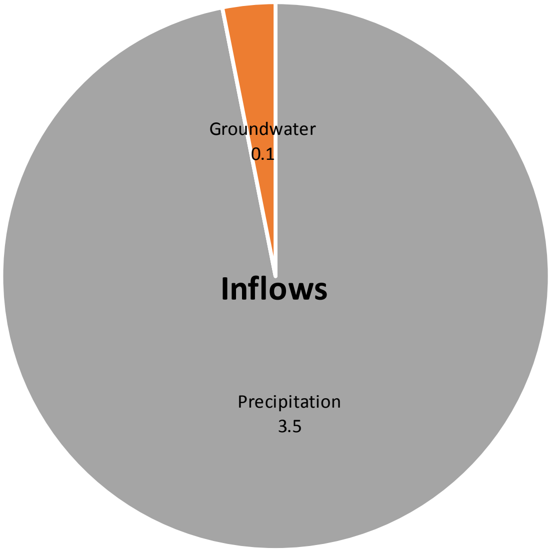


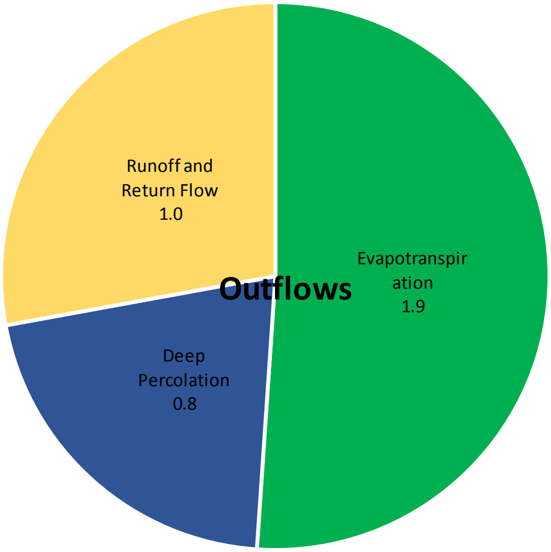
Cherokee Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



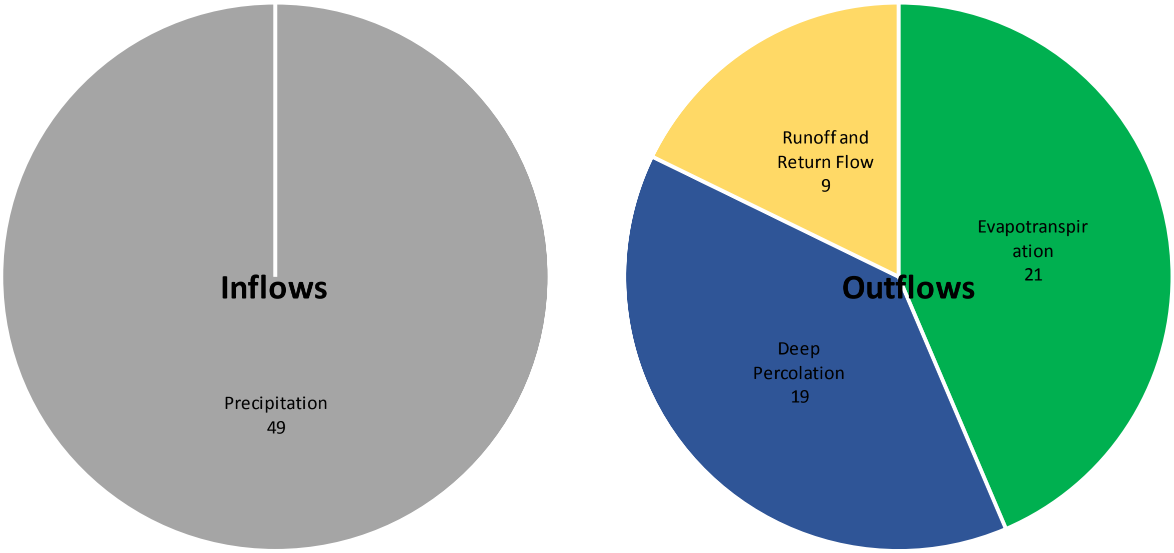


Cherokee Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

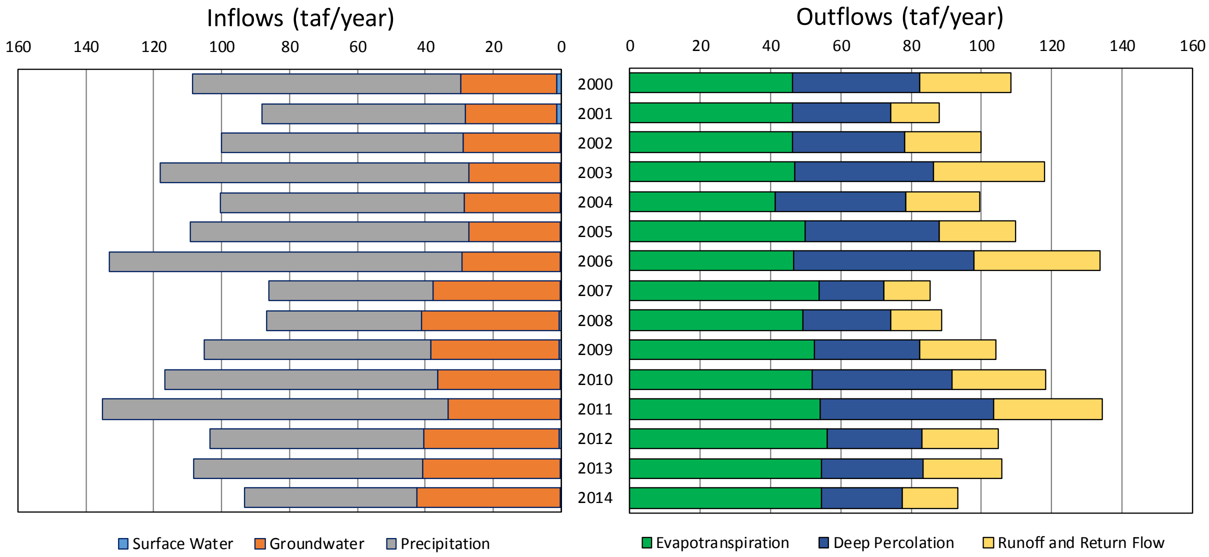




Cherokee Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Cherokee Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



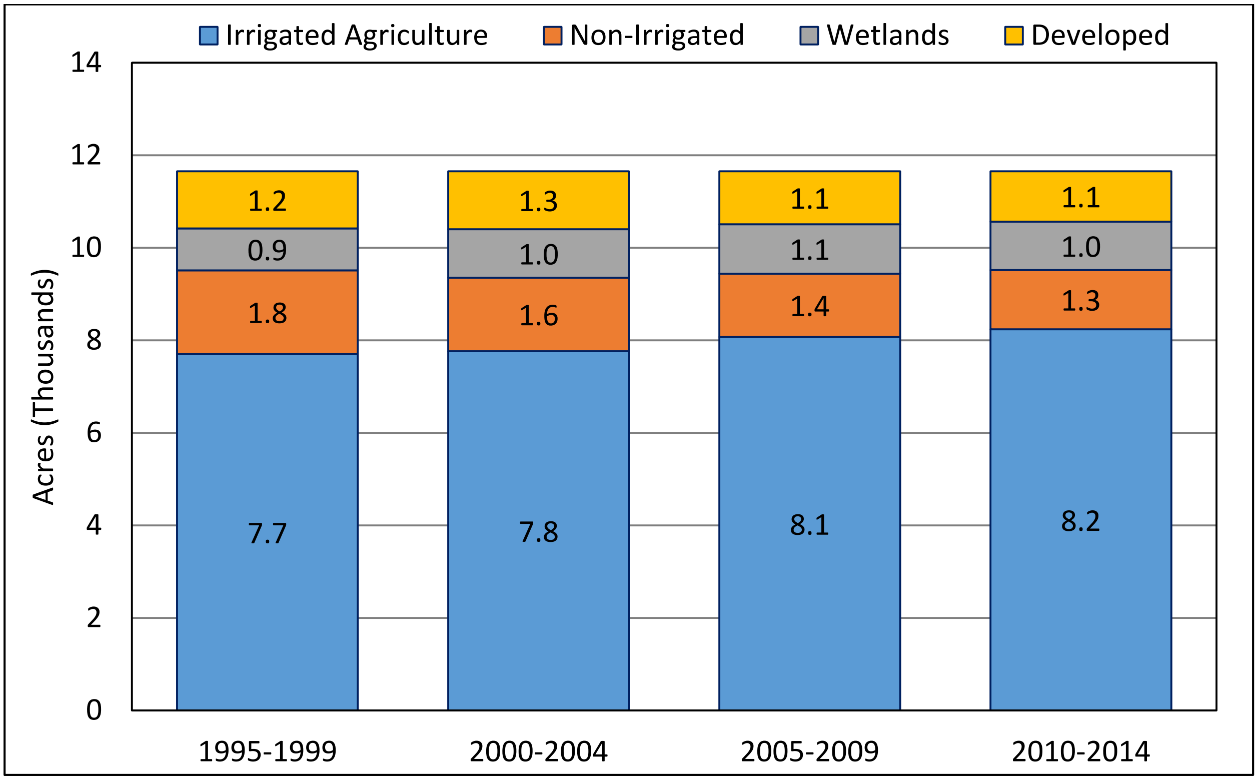
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	79	1	28	46	36	26	0
2001 (D)	60	1	27	46	28	14	0
2002 (D)	71	0	28	46	32	22	0
2003 (AN)	91	0	27	47	39	31	1
2004 (BN)	72	0	28	41	37	21	-1
2005 (AN)	82	0	27	50	38	22	2
2006 (W)	104	0	29	46	51	36	0
2007 (D)	48	0	37	54	19	13	2
2008 (C)	46	0	41	49	25	14	-1
2009 (D)	67	0	38	53	30	22	1
2010 (BN)	80	0	36	52	40	27	1
2011 (W)	102	0	33	54	49	31	0
2012 (BN)	63	0	40	56	27	22	0
2013 (D)	67	0	40	54	29	22	1
2014 (C)	51	0	42	54	23	16	-1
Minimum	46	0	27	41	19	13	-1
Maximum	104	1	42	56	51	36	2
Average	72	0	33	50	34	23	0
Averages by Hydrologic Year Type							
Wet (W)	103	0	31	50	50	33	0
Above Normal (AN)	84	1	27	48	38	26	1
Below Normal (BN)	72	0	35	50	35	23	0
Dry (D)	63	1	34	51	28	19	1
Critical (C)	48	0	41	52	24	15	-1

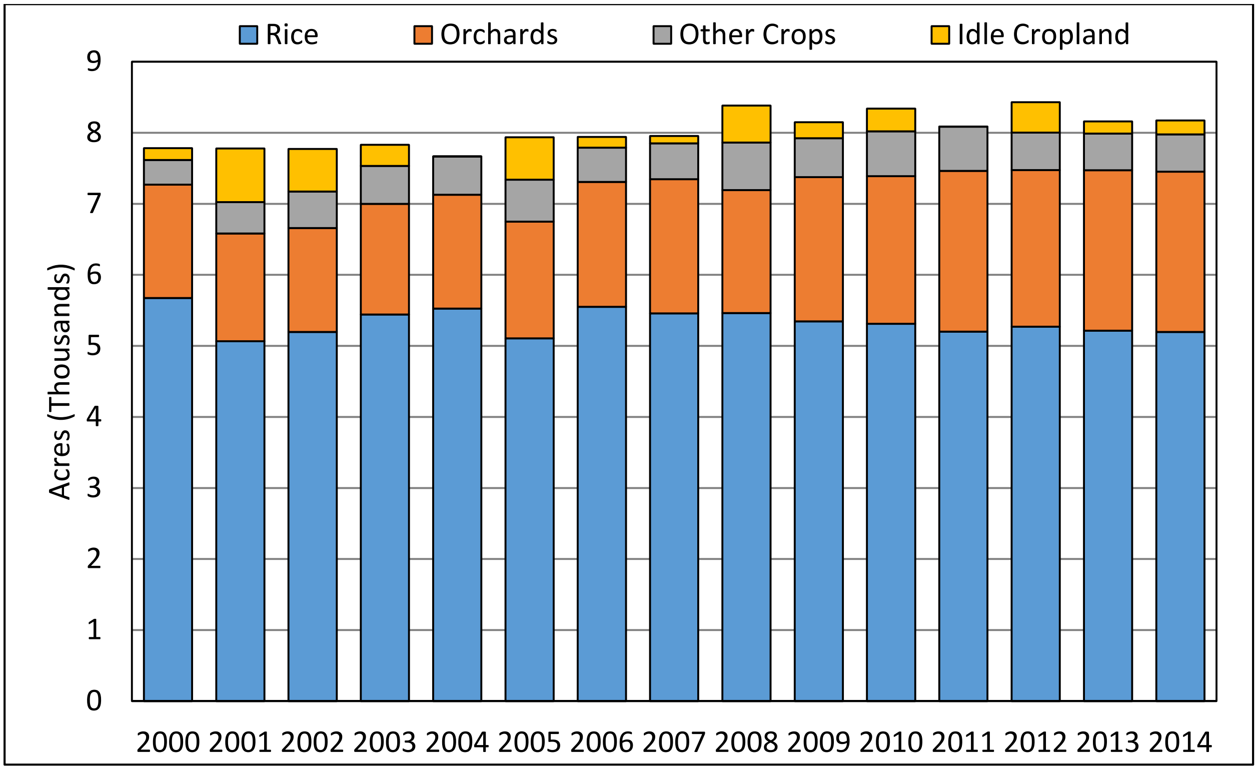
C.3.5. Esquon Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

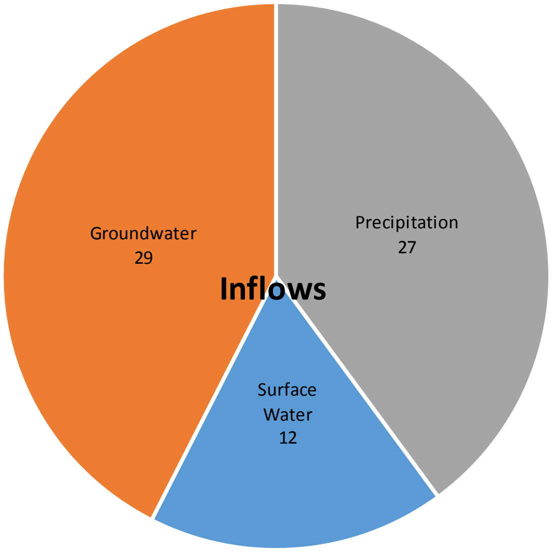
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	5,675	1,471	102	0	22	27	206	114	168	7,616	7,785
2001	5,066	1,396	100	0	22	25	251	165	756	7,024	7,780
2002	5,198	1,342	103	0	16	21	309	184	600	7,173	7,773
2003	5,441	1,427	112	0	21	24	323	185	298	7,533	7,831
2004	5,526	1,469	123	0	11	13	411	115	1	7,666	7,667
2005	5,106	1,477	147	0	19	7	393	192	598	7,340	7,938
2006	5,550	1,550	196	0	12	10	460	13	152	7,789	7,941
2007	5,459	1,678	199	0	12	8	485	11	105	7,851	7,955
2008	5,461	1,538	166	0	28	8	459	202	522	7,862	8,384
2009	5,346	1,781	238	0	10	3	521	24	224	7,923	8,148
2010	5,312	1,833	230	0	14	1	499	131	320	8,020	8,340
2011	5,202	1,946	299	0	16	0	581	42	1	8,086	8,087
2012	5,272	1,899	288	0	15	0	493	35	430	8,001	8,431
2013	5,216	1,915	329	0	15	0	483	33	170	7,989	8,159
2014	5,197	1,920	322	0	14	0	493	33	195	7,978	8,174
Min	5,066	1,342	100	0	10	0	206	11	1	7,024	7,667
Max	5,675	1,946	329	0	28	27	581	202	756	8,086	8,431
Average	5,335	1,643	197	0	16	10	424	98	303	7,723	8,026

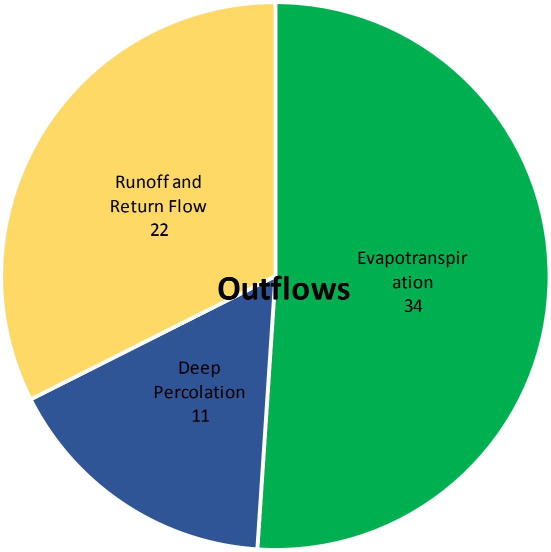
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	953	1,263	1,655	3,871
2001	996	1,231	1,649	3,875
2002	1,033	1,234	1,615	3,882
2003	1,081	1,231	1,513	3,824
2004	1,179	1,312	1,497	3,989
2005	1,112	1,183	1,423	3,718
2006	1,092	1,198	1,424	3,714
2007	1,097	1,189	1,414	3,700
2008	975	1,050	1,246	3,271
2009	1,056	1,115	1,336	3,507
2010	1,008	1,058	1,249	3,316
2011	1,094	1,132	1,342	3,568
2012	967	1,038	1,219	3,224
2013	1,082	1,112	1,303	3,496
2014	1,083	1,109	1,290	3,482
Min	953	1,038	1,219	3,224
Max	1,179	1,312	1,655	3,989
Average	1,054	1,164	1,412	3,629

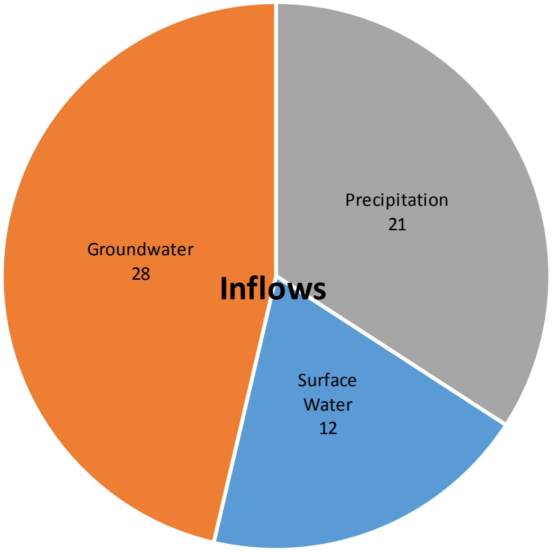
Water Budgets

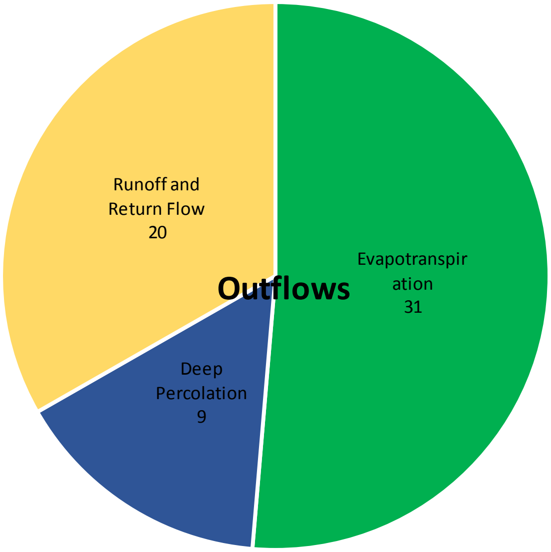
Esquon Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



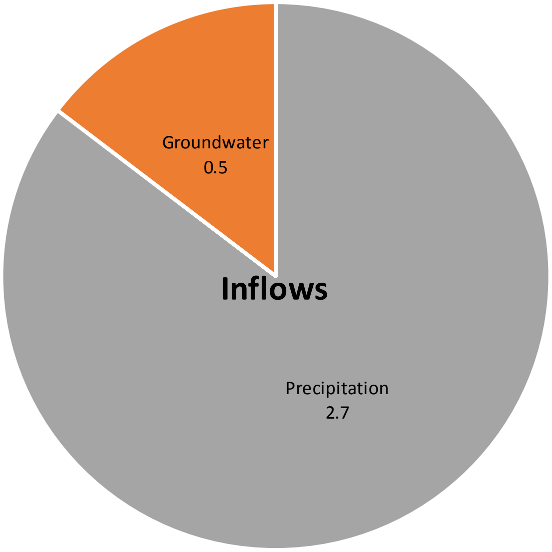


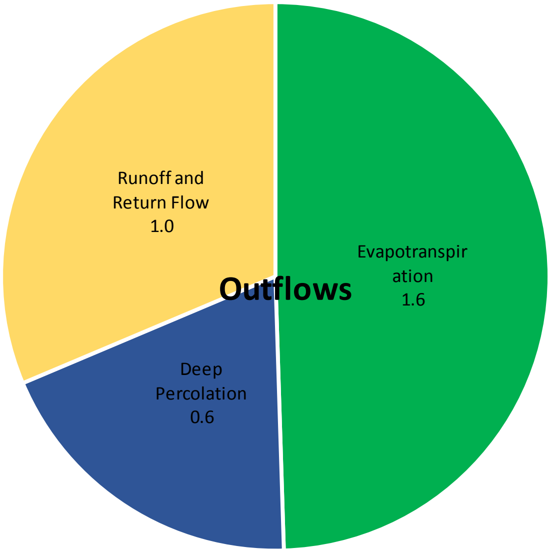
Esquon Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



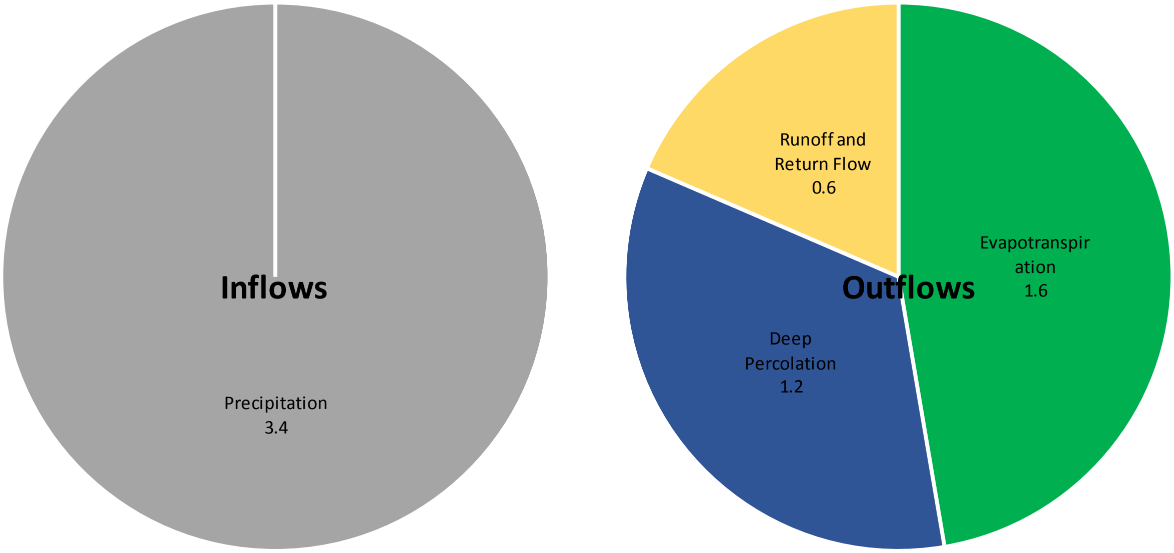


Esquon Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

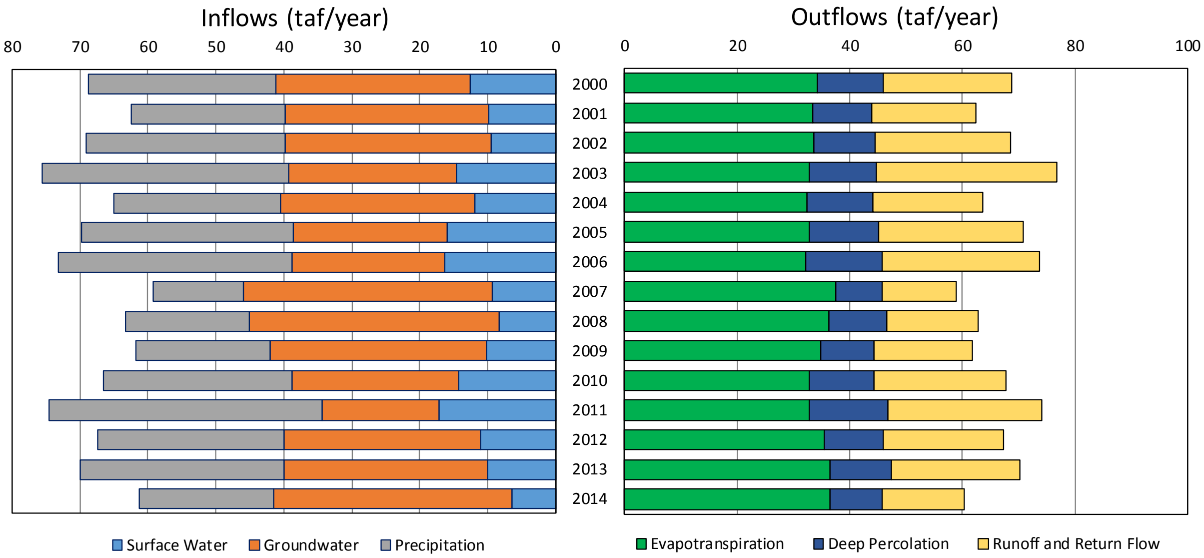




Esquon Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Esquon Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



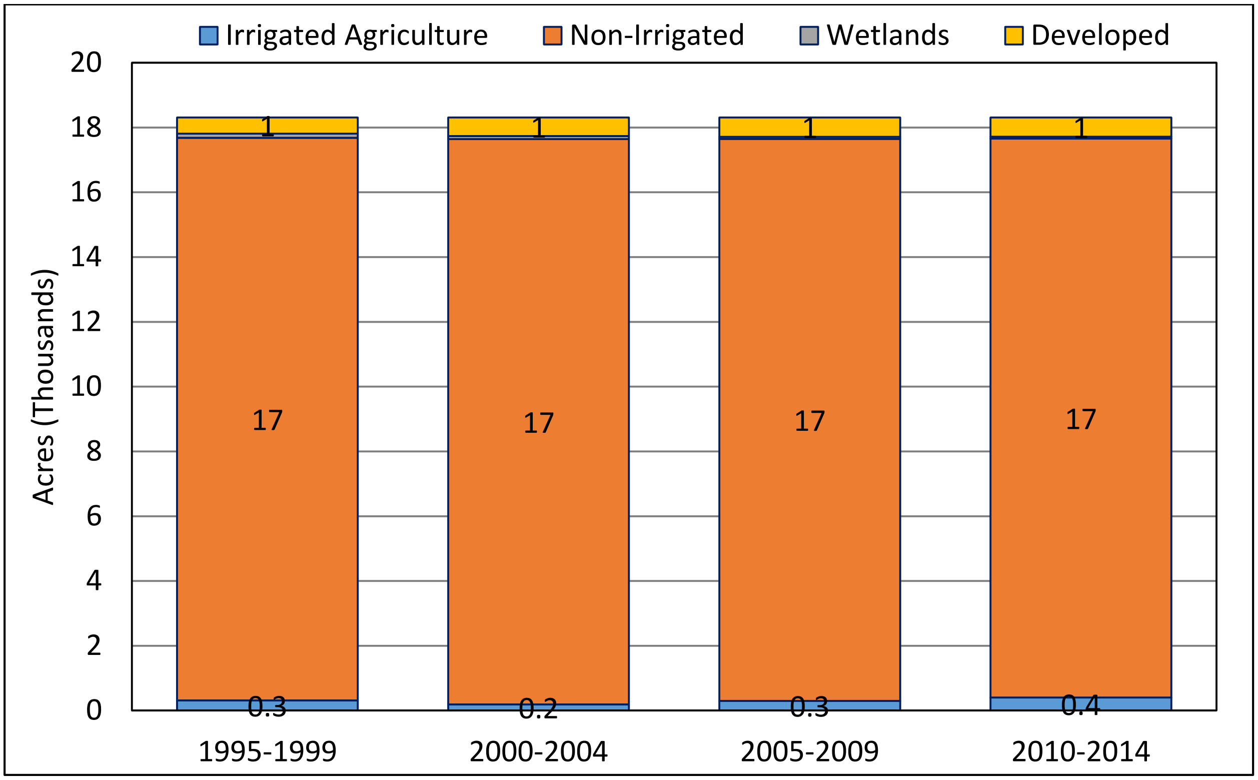
Subinventory Unit Water Budget

Water Year	Inflows (taf) Precipi-tation	Inflows (taf) Surface Water	Inflows (taf) Ground-water	Outflows (taf) Evapotrans-piration	Outflows (taf) Deep Percolation	Outflows (taf) Runoff and Return Flow	Change in Storage (taf)
2000 (AN)	28	13	29	34	12	23	0
2001 (D)	23	10	30	33	10	18	0
2002 (D)	29	9	30	34	11	24	-1
2003 (AN)	36	15	25	33	12	32	1
2004 (BN)	24	12	29	32	12	20	-1
2005 (AN)	31	16	23	33	12	26	1
2006 (W)	34	16	23	32	14	28	0
2007 (D)	13	9	37	38	8	13	0
2008 (C)	18	8	37	36	10	16	0
2009 (D)	20	10	32	35	9	18	0
2010 (BN)	28	14	25	33	11	23	1
2011 (W)	40	17	17	33	14	27	0
2012 (BN)	28	11	29	36	10	21	0
2013 (D)	30	10	30	36	11	23	1
2014 (C)	20	7	35	37	9	14	-1
Minimum	13	7	17	32	8	13	-1
Maximum	40	17	37	38	14	32	1
Average	27	12	29	34	11	22	0
Averages by Hydrologic Year Type							
Wet (W)	37	17	20	33	14	28	0
Above Normal (AN)	32	14	25	33	12	27	1
Below Normal (BN)	27	12	27	34	11	21	0
Dry (D)	23	10	32	35	10	19	0
Critical (C)	19	7	36	36	10	15	-1

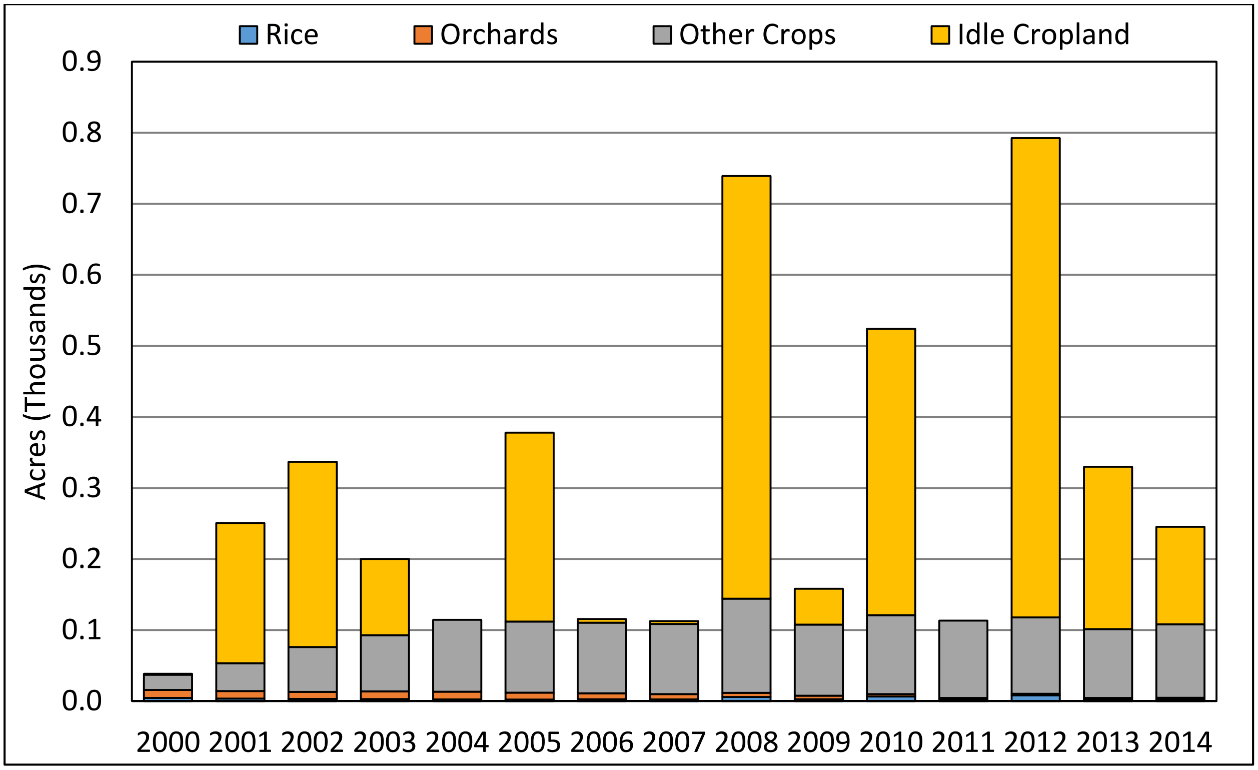
C.3.6. Pentz Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

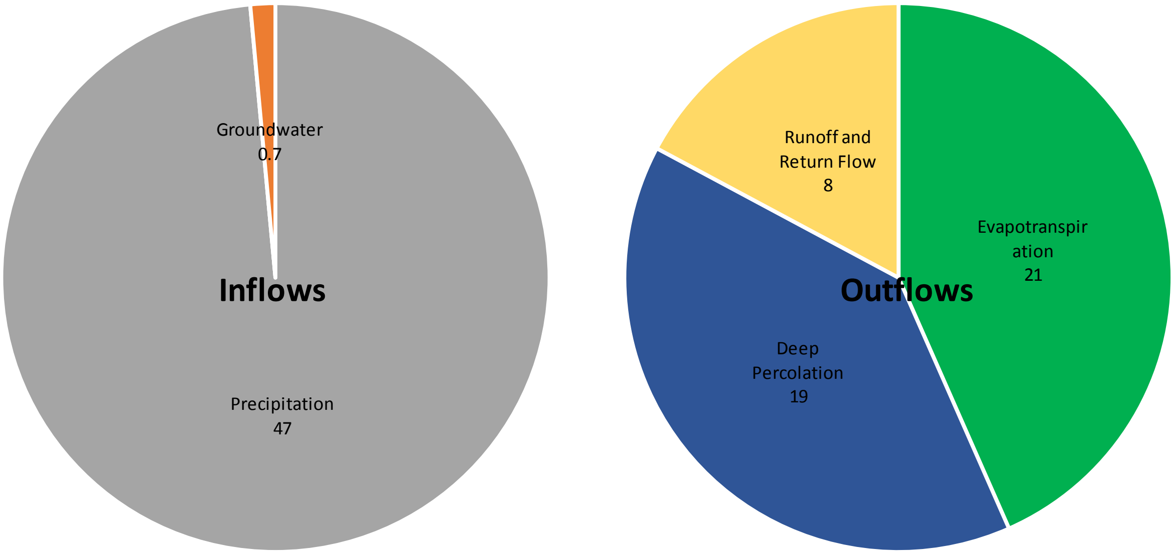
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	4	11	0	0	0	0	17	5	1	37	39
2001	4	11	0	0	0	0	36	4	197	53	251
2002	3	10	0	0	0	0	58	5	261	76	337
2003	3	11	0	0	0	0	75	5	107	93	200
2004	2	11	0	0	0	0	100	1	0	115	115
2005	2	10	0	0	0	0	93	7	266	112	378
2006	3	9	0	0	0	0	99	0	5	110	116
2007	3	8	0	0	0	0	98	0	4	109	113
2008	6	6	0	0	0	0	96	37	595	144	739
2009	3	5	0	0	0	0	99	1	51	108	158
2010	7	3	0	0	0	0	99	12	403	121	524
2011	2	2	0	0	0	0	99	10	0	113	113
2012	8	2	0	0	0	0	99	9	675	118	793
2013	3	2	0	0	0	0	88	9	228	102	330
2014	3	2	0	0	0	0	93	10	137	108	245
Min	2	2	0	0	0	0	17	0	0	37	39
Max	8	11	0	0	0	0	100	37	675	144	793
Average	4	7	0	0	0	0	83	8	195	101	297

Other Land Use

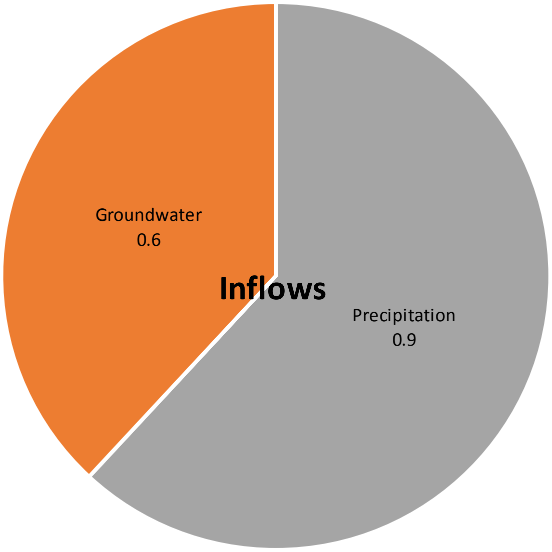
Year	Wetlands	Developed	Non-Irrigated	Total
2000	128	542	17,604	18,274
2001	110	551	17,401	18,062
2002	94	565	17,316	17,975
2003	80	593	17,439	18,112
2004	63	618	17,517	18,198
2005	62	599	17,274	17,935
2006	63	613	17,521	18,197
2007	63	610	17,526	18,200
2008	60	579	16,935	17,573
2009	63	602	17,489	18,154
2010	61	586	17,141	17,788
2011	63	596	17,540	18,199
2012	61	579	16,880	17,520
2013	63	600	17,320	17,983
2014	63	606	17,398	18,067
Min	60	542	16,880	17,520
Max	128	618	17,604	18,274
Average	73	589	17,353	18,016

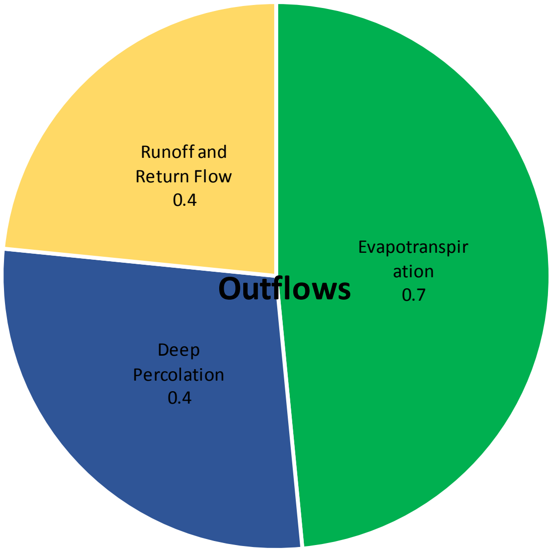
Water Budgets

Pentz Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)

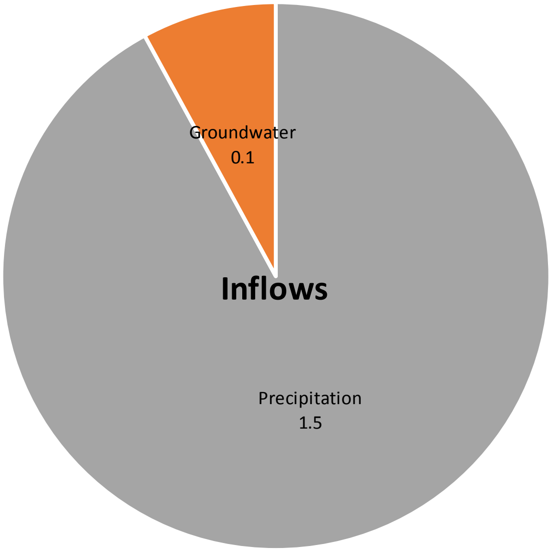


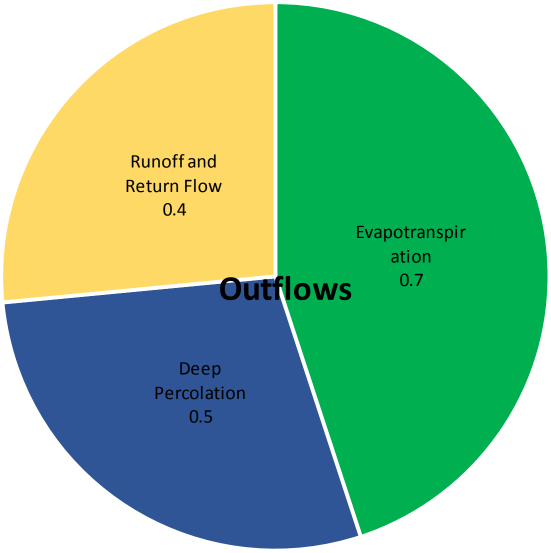
Pentz Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



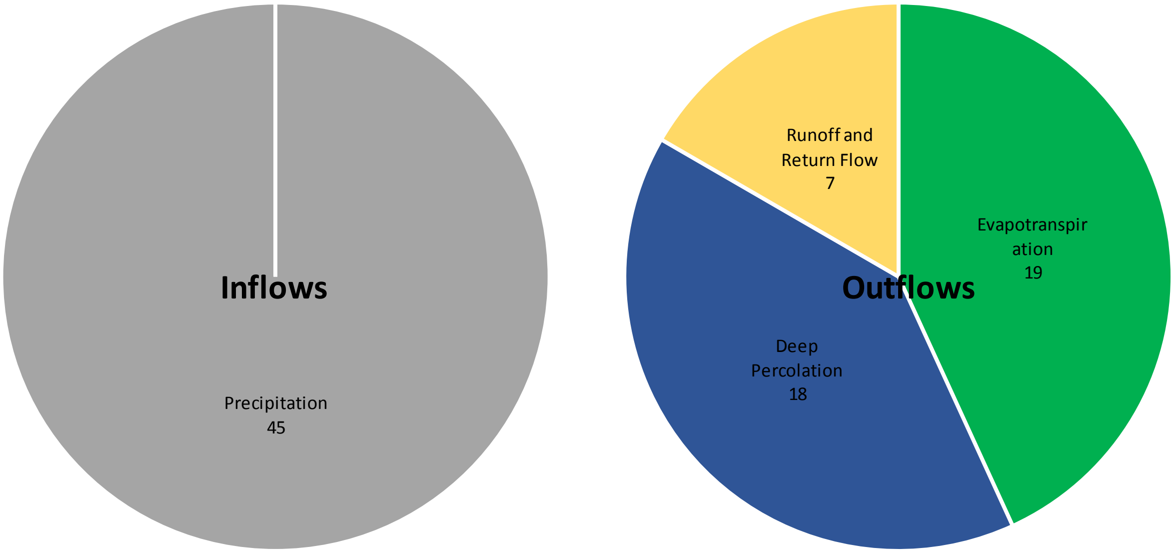


Pentz Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

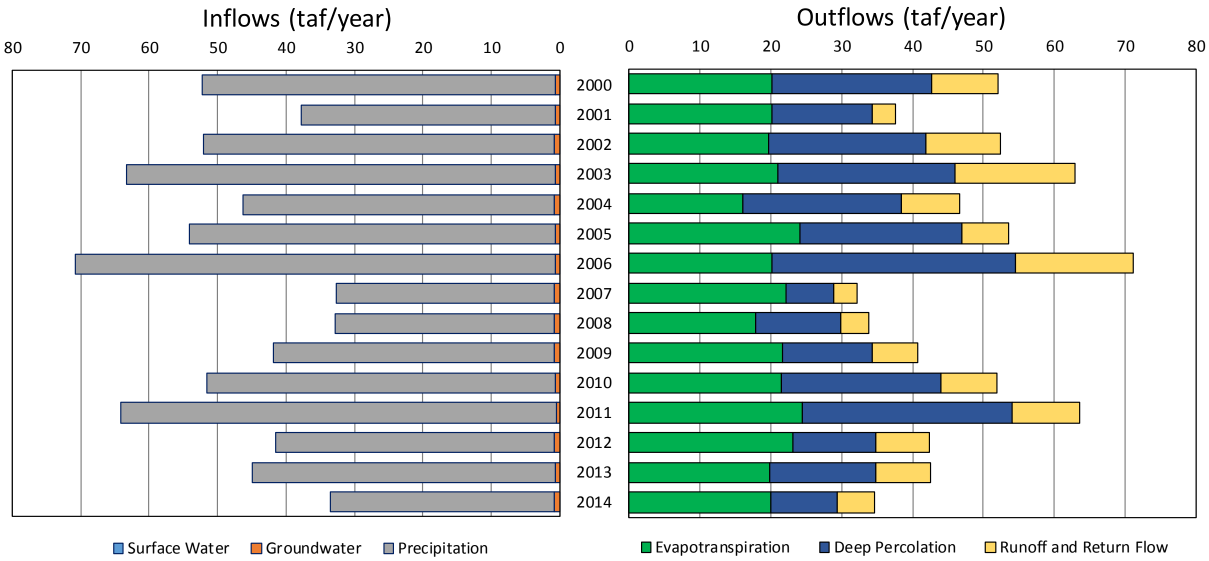




Pentz Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Pentz Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



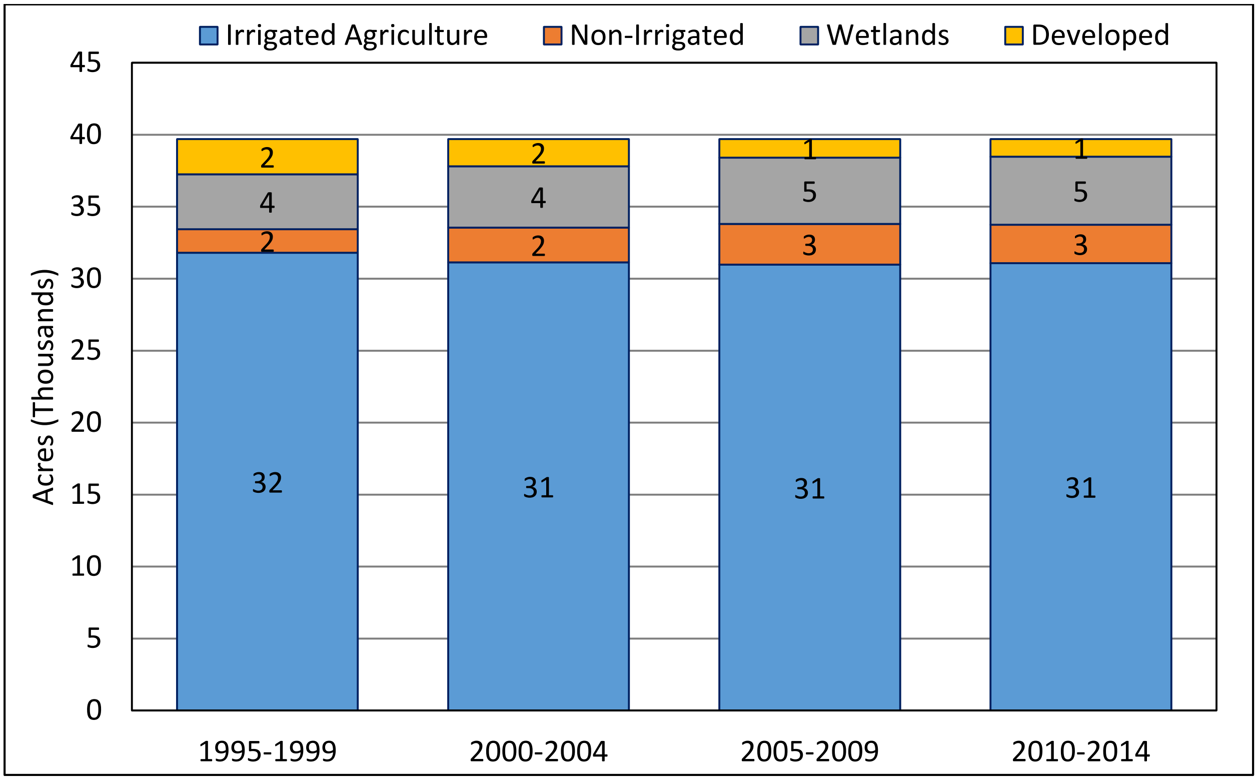
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	52	0	1	20	22	9	0
2001 (D)	37	0	1	20	14	3	0
2002 (D)	51	0	1	20	22	11	0
2003 (AN)	63	0	1	21	25	17	0
2004 (BN)	46	0	1	16	22	8	0
2005 (AN)	53	0	1	24	23	6	1
2006 (W)	70	0	1	20	34	17	-1
2007 (D)	32	0	1	22	7	3	1
2008 (C)	32	0	1	18	12	4	0
2009 (D)	41	0	1	22	13	7	0
2010 (BN)	51	0	1	21	23	8	0
2011 (W)	64	0	1	24	30	10	0
2012 (BN)	41	0	1	23	12	8	0
2013 (D)	44	0	1	20	15	8	2
2014 (C)	33	0	1	20	9	5	-1
Minimum	32	0	1	16	7	3	-1
Maximum	70	0	1	24	34	17	2
Average	47	0	1	21	19	8	0
Averages by Hydrologic Year Type							
Wet (W)	67	0	1	22	32	13	0
Above Normal (AN)	56	0	1	22	24	11	0
Below Normal (BN)	46	0	1	20	19	8	0
Dry (D)	41	0	1	21	14	6	1
Critical (C)	32	0	1	19	11	5	-1

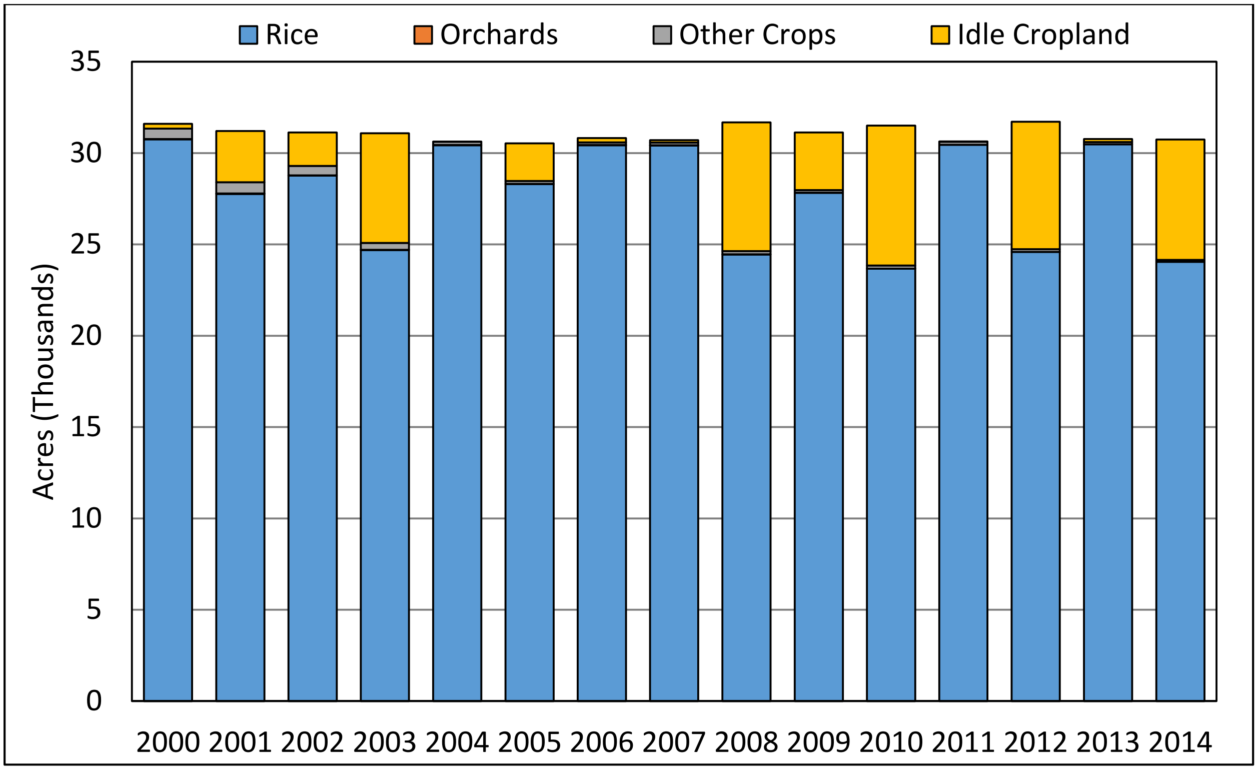
C.3.7. Richvale Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

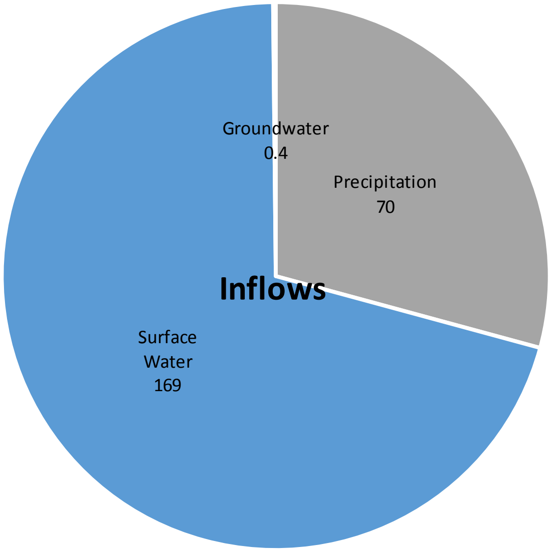
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	30,749	0	0	16	0	266	188	119	262	31,338	31,600
2001	27,764	0	0	21	0	290	202	125	2,803	28,403	31,206
2002	28,767	0	0	16	0	206	185	118	1,839	29,292	31,132
2003	24,692	0	0	15	0	156	137	84	6,004	25,084	31,088
2004	30,426	0	0	16	0	27	120	29	2	30,617	30,619
2005	28,305	0	0	10	0	14	119	21	2,059	28,470	30,529
2006	30,431	0	0	11	0	28	115	3	229	30,589	30,818
2007	30,415	0	0	9	0	30	115	3	133	30,573	30,706
2008	24,454	0	0	6	0	27	104	46	7,046	24,637	31,683
2009	27,825	0	0	4	0	26	109	9	3,159	27,973	31,132
2010	23,673	0	0	2	0	23	106	44	7,658	23,847	31,505
2011	30,451	0	0	0	0	27	117	29	11	30,623	30,634
2012	24,590	0	0	0	0	40	104	4	6,979	24,739	31,717
2013	30,480	0	0	0	0	23	101	0	163	30,603	30,766
2014	24,043	0	0	0	0	3	106	0	6,589	24,152	30,741
Min	23,673	0	0	0	0	3	101	0	2	23,847	30,529
Max	30,749	0	0	21	0	290	202	125	7,658	31,338	31,717
Average	27,804	0	0	8	0	79	129	42	2,996	28,063	31,058

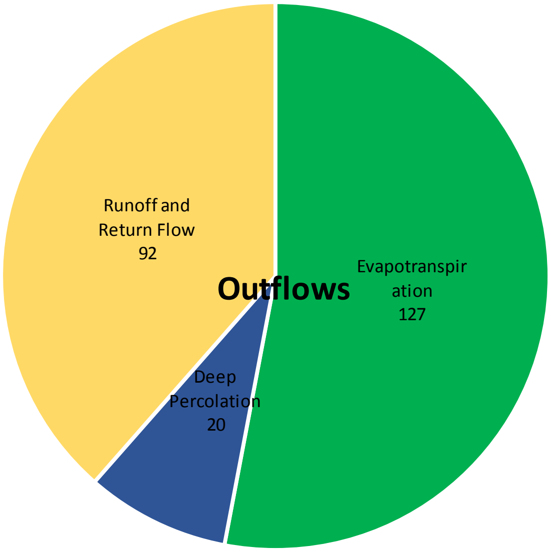
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	4,076	2,322	1,701	8,098
2001	4,104	2,156	2,232	8,492
2002	4,123	1,920	2,524	8,567
2003	4,339	1,636	2,635	8,610
2004	4,666	1,414	3,000	9,079
2005	4,595	1,443	3,131	9,169
2006	4,676	1,330	2,874	8,880
2007	4,741	1,353	2,899	8,992
2008	4,348	1,139	2,528	8,016
2009	4,677	1,202	2,688	8,566
2010	4,514	1,139	2,541	8,193
2011	4,896	1,318	2,850	9,064
2012	4,458	1,083	2,440	7,981
2013	4,856	1,297	2,779	8,932
2014	4,875	1,306	2,777	8,958
Min	4,076	1,083	1,701	7,981
Max	4,896	2,322	3,131	9,169
Average	4,530	1,470	2,640	8,640

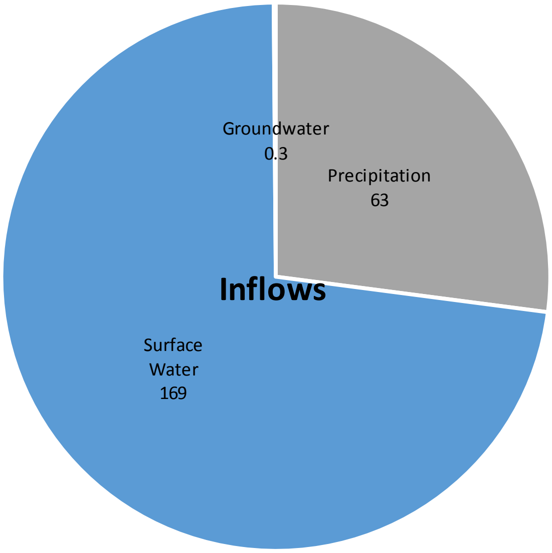
Water Budgets

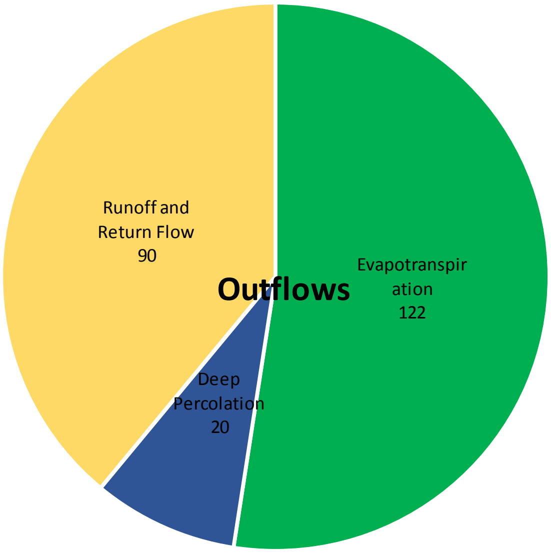
Richvale Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



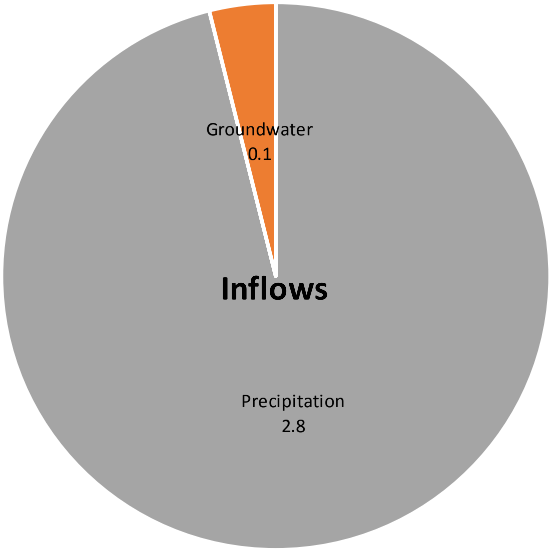


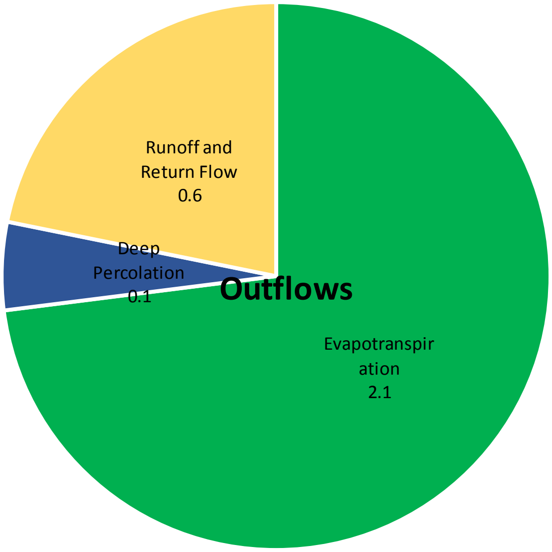
Richvale Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



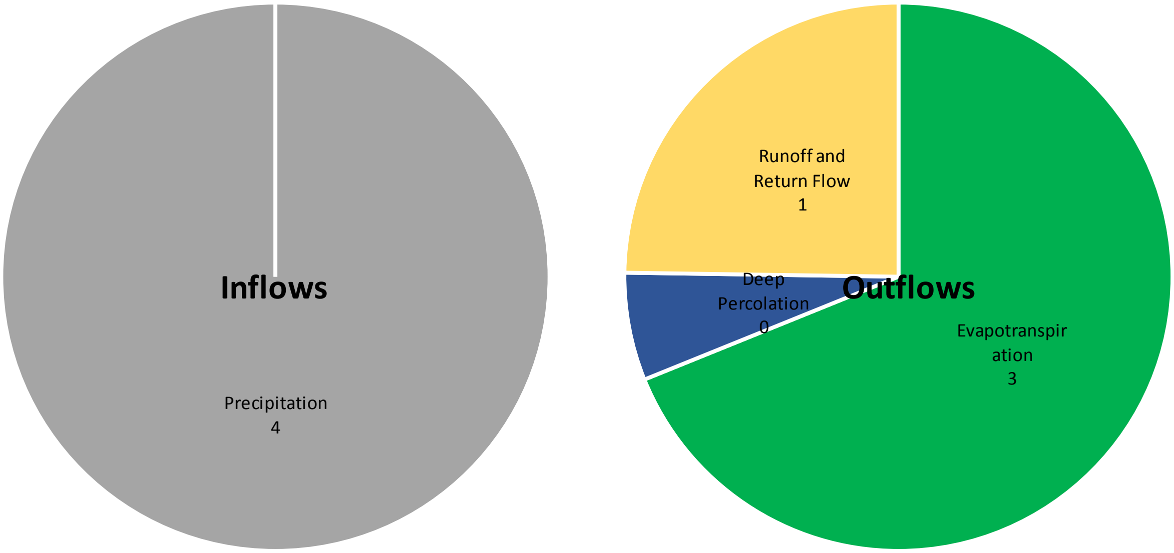


Richvale Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

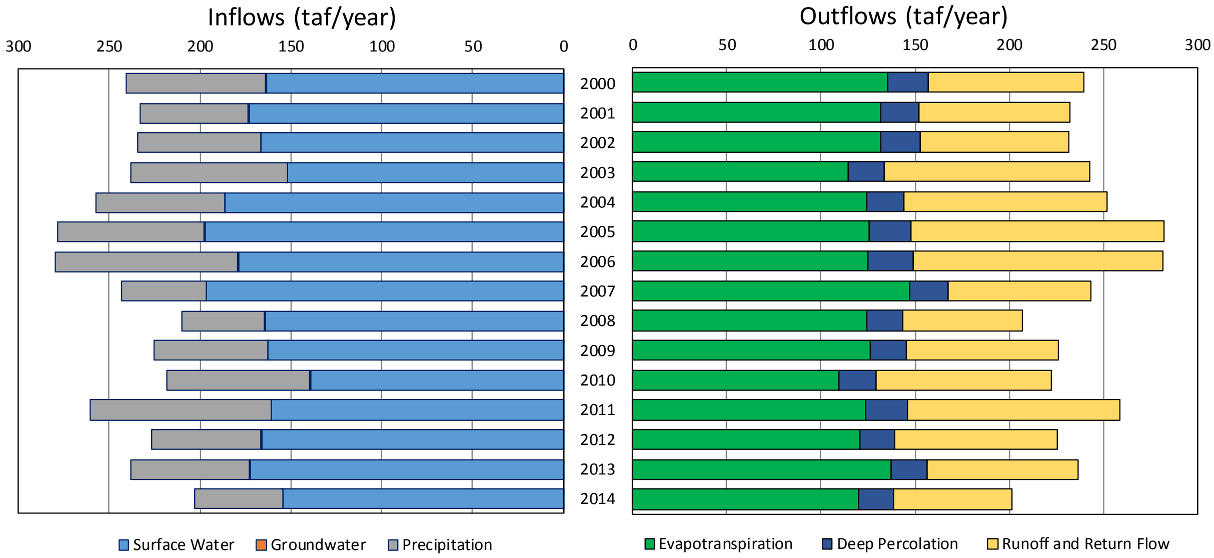




Richvale Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Richvale Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



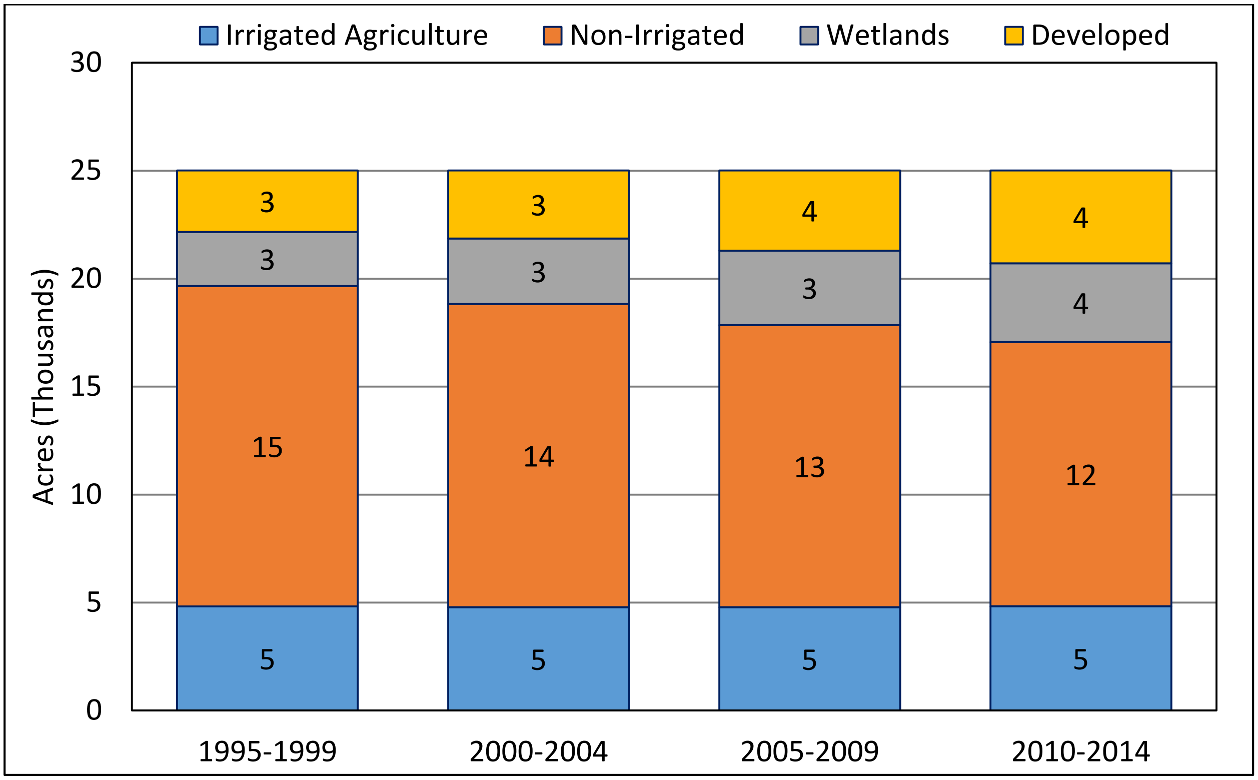
Subinventory Unit Water Budget

	Inflows (taf)			**Outflows (taf)**			
Water Year	**Precipi-tation**	**Surface Water**	**Ground-water**	**Evapotrans-piration**	**Deep Percolation**	**Runoff and Return Flow**	**Change in Storage (taf)**
2000 (AN)	77	163	0	136	21	83	0
2001 (D)	60	173	0	132	20	80	-1
2002 (D)	67	166	0	132	20	79	-2
2003 (AN)	86	152	0	115	19	109	5
2004 (BN)	71	186	0	125	20	107	-6
2005 (AN)	81	197	0	126	23	134	4
2006 (W)	100	179	0	125	24	132	2
2007 (D)	46	196	0	147	21	75	0
2008 (C)	45	164	0	125	19	63	-3
2009 (D)	63	162	0	126	19	81	1
2010 (BN)	79	139	0	110	20	93	4
2011 (W)	99	161	0	124	22	113	-1
2012 (BN)	60	166	0	121	18	86	-1
2013 (D)	65	172	0	137	19	80	-1
2014 (C)	48	154	0	120	18	63	-1
Minimum	45	139	0	110	18	63	-6
Maximum	100	197	0	147	24	134	5
Average	70	169	0	127	20	92	0
Averages by Hydrologic Year Type							
Wet (W)	100	170	0	124	23	123	0
Above Normal (AN)	81	171	0	125	21	109	3
Below Normal (BN)	70	164	0	118	19	96	-1
Dry (D)	60	174	0	135	20	79	-1
Critical (C)	47	159	0	122	18	63	-2

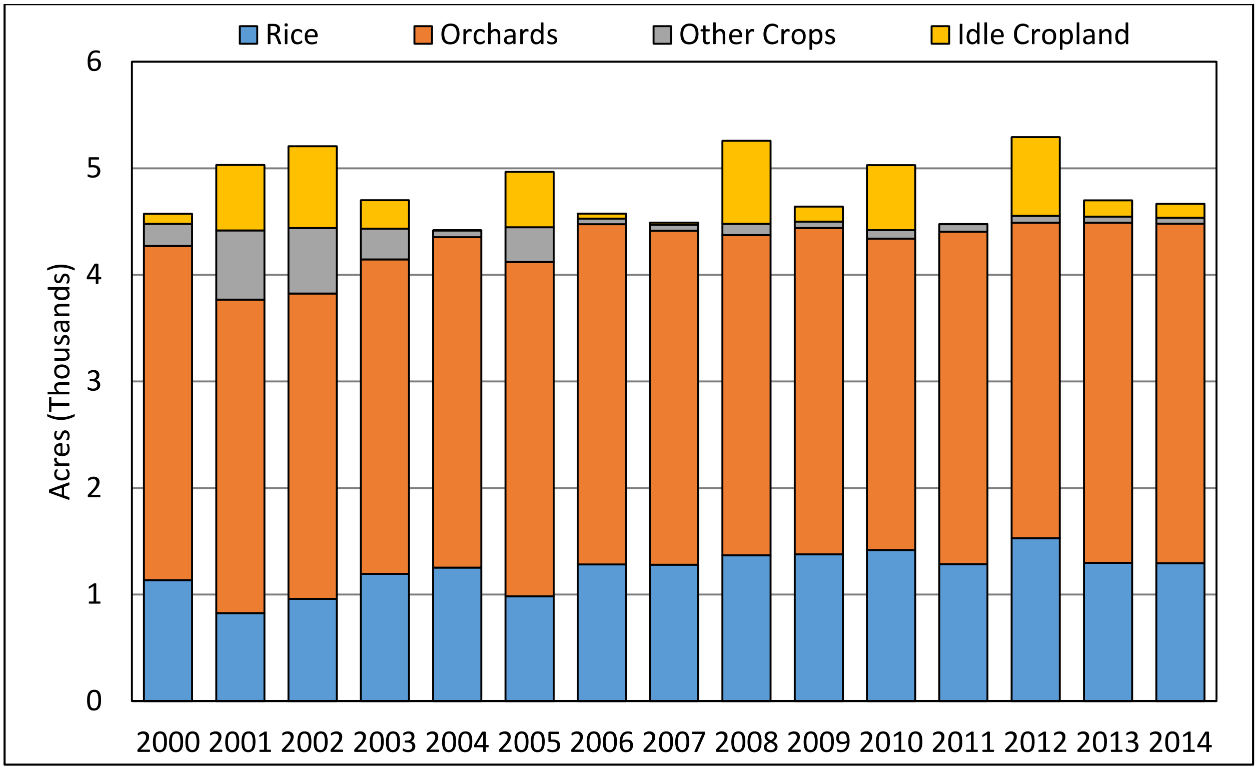
C.3.8. Thermalito Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

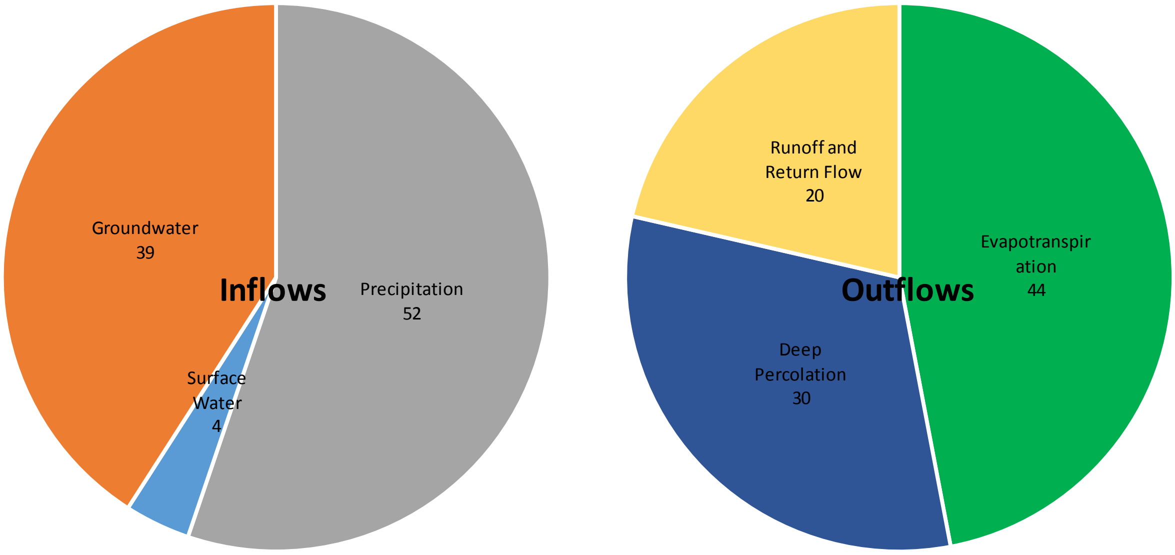
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	1,136	50	2,558	168	359	40	91	76	95	4,478	4,573
2001	827	39	2,399	155	349	37	80	532	615	4,417	5,031
2002	960	25	2,366	103	371	26	78	511	768	4,440	5,208
2003	1,195	22	2,525	101	301	24	62	203	268	4,433	4,701
2004	1,254	14	2,739	96	251	0	52	11	1	4,417	4,418
2005	984	13	2,813	58	253	0	50	277	520	4,447	4,967
2006	1,284	13	2,854	81	243	0	52	2	47	4,529	4,575
2007	1,280	15	2,801	86	232	1	54	2	21	4,470	4,491
2008	1,369	13	2,654	76	261	1	53	52	779	4,479	5,258
2009	1,378	14	2,729	76	242	1	55	4	142	4,499	4,641
2010	1,418	14	2,578	70	260	1	55	23	610	4,419	5,029
2011	1,285	16	2,809	62	234	1	58	11	2	4,475	4,477
2012	1,530	13	2,660	57	229	2	56	7	739	4,554	5,293
2013	1,297	14	2,918	44	216	1	48	7	154	4,545	4,699
2014	1,296	14	2,916	36	218	0	51	6	130	4,536	4,666
Min	827	13	2,366	36	216	0	48	2	1	4,417	4,418
Max	1,530	50	2,918	168	371	40	91	532	779	4,554	5,293
Average	1,233	19	2,688	85	268	9	59	115	326	4,476	4,802

Other Land Use

Year	Wetlands[4]	Developed	Non-Irrigated	Total
2000	2,854	3,089	14,498	20,440
2001	2,831	3,030	14,121	19,982
2002	2,905	3,046	13,855	19,805
2003	3,211	3,247	13,854	20,313
2004	3,361	3,363	13,872	20,596
2005	3,309	3,367	13,370	20,046
2006	3,451	3,611	13,376	20,438
2007	3,508	3,789	13,225	20,522
2008	3,405	3,779	12,571	19,756
2009	3,585	4,029	12,759	20,372
2010	3,548	4,117	12,319	19,984
2011	3,714	4,405	12,417	20,536
2012	3,549	4,220	11,952	19,720
2013	3,698	4,381	12,235	20,314
2014	3,710	4,396	12,241	20,347
Min	2,831	3,030	11,952	19,720
Max	3,714	4,405	14,498	20,596
Average	3,376	3,725	13,111	20,211

Water Budgets

Thermalito Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



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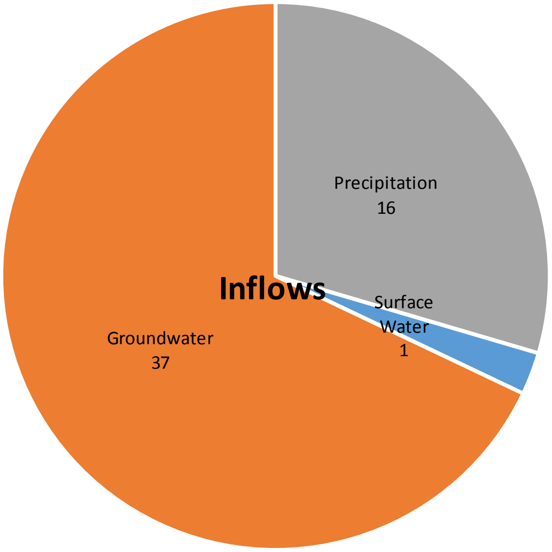
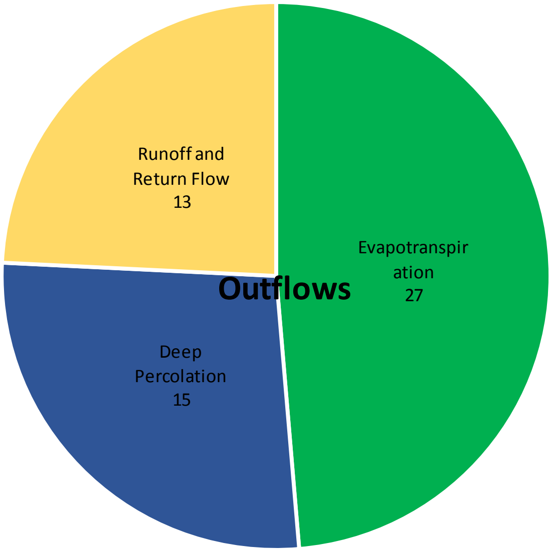
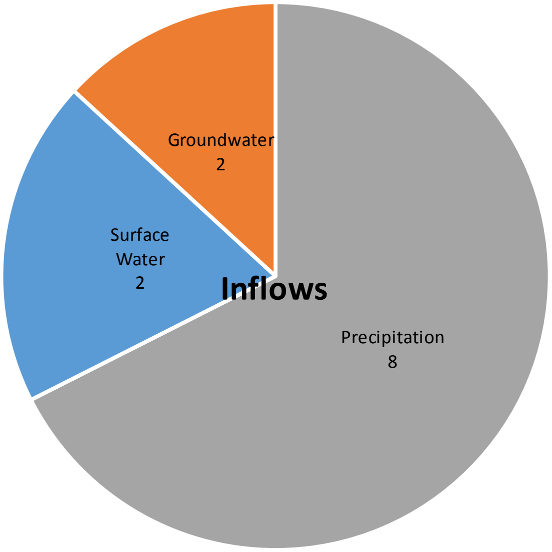
[4] Within the East Butte Inventory Unit, Thermalito Afterbay is classified as wetlands for purposes of this report and represents approximately 3,000 acres.

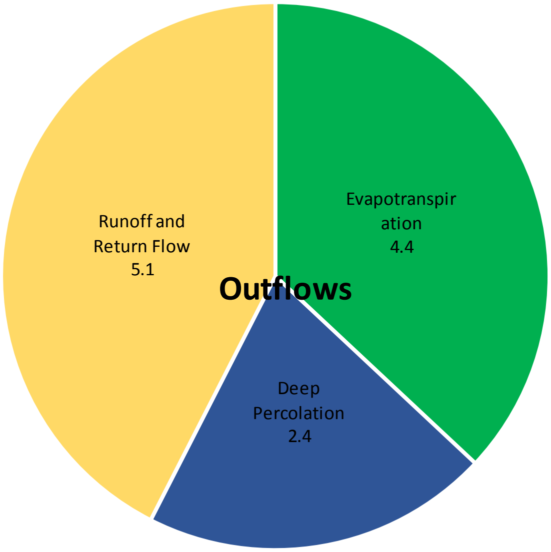
Thermalito Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



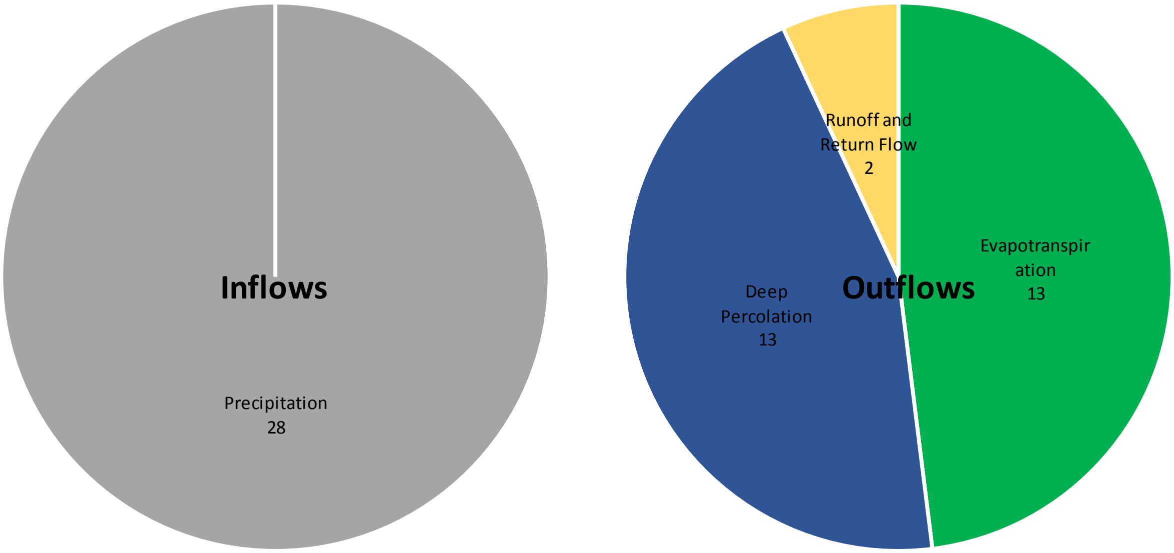


Thermalito Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

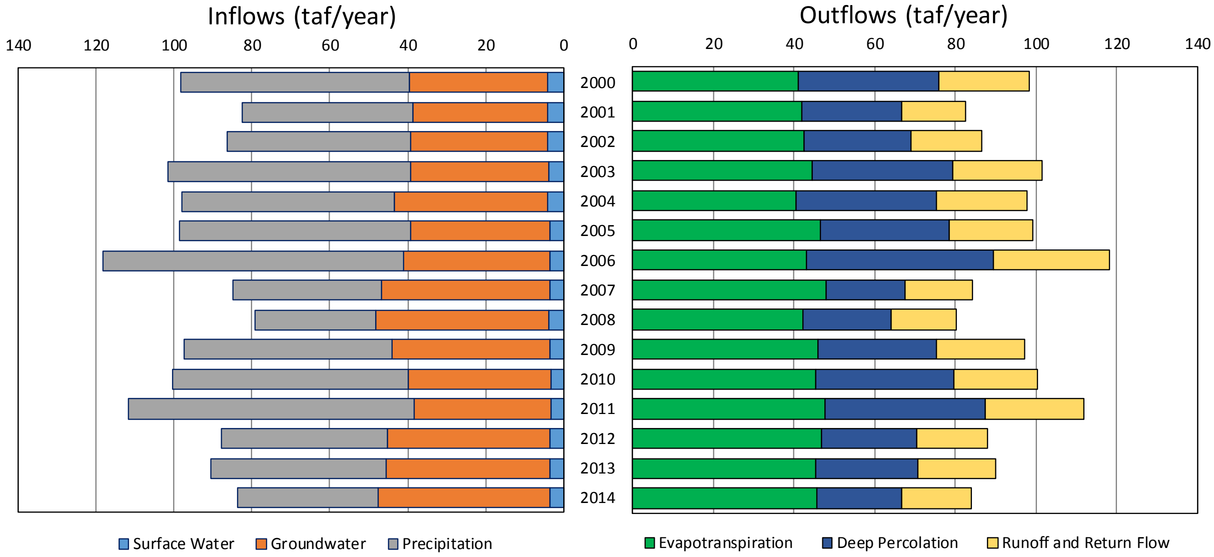




Thermalito Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Thermalito Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



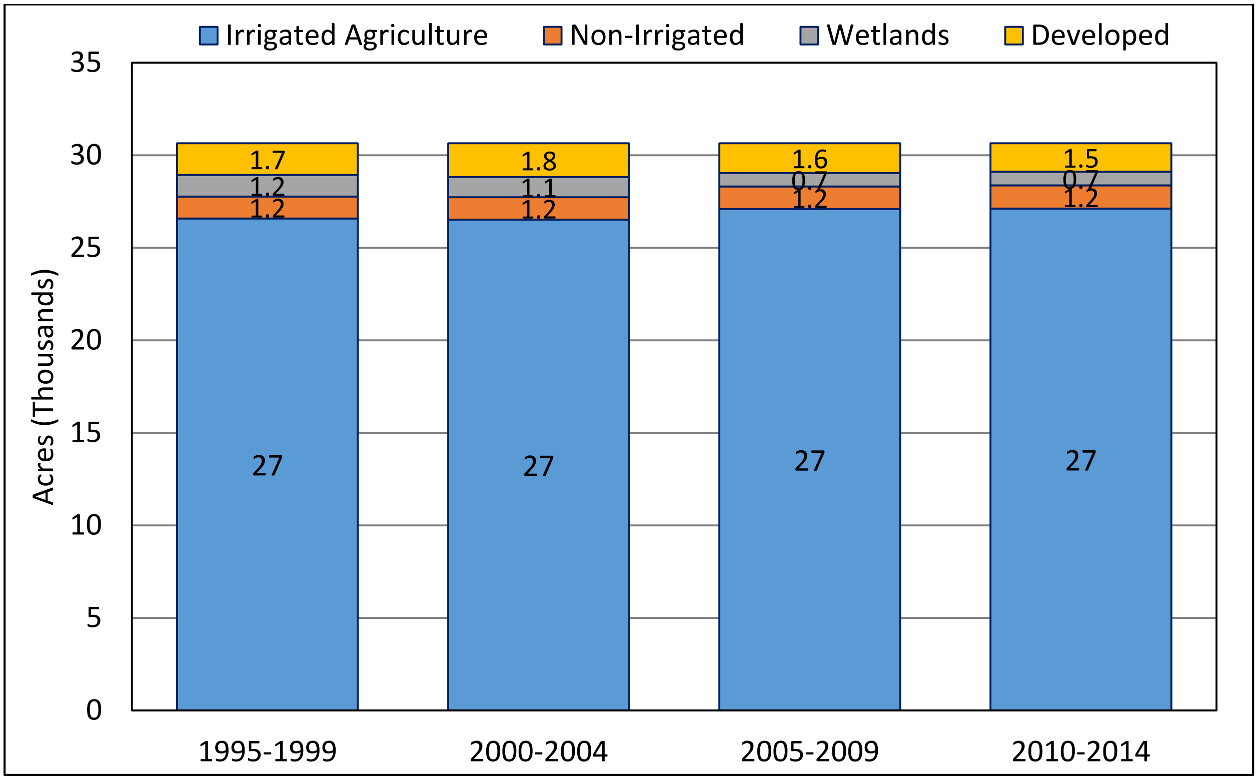
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	59	4	36	41	35	22	0
2001 (D)	44	4	35	42	25	16	0
2002 (D)	47	4	35	42	27	17	0
2003 (AN)	62	4	35	45	35	22	0
2004 (BN)	54	4	39	40	35	23	0
2005 (AN)	59	4	36	46	32	21	1
2006 (W)	77	3	37	43	46	29	0
2007 (D)	38	3	43	48	19	17	2
2008 (C)	31	4	44	42	22	16	-1
2009 (D)	53	4	41	46	29	22	1
2010 (BN)	61	3	37	45	34	21	0
2011 (W)	73	3	35	48	40	25	0
2012 (BN)	43	4	42	47	23	18	0
2013 (D)	45	4	42	45	25	19	1
2014 (C)	36	3	44	46	21	17	0
Minimum	31	3	35	40	19	16	-1
Maximum	77	4	44	48	46	29	2
Average	52	4	39	44	30	20	0
Averages by Hydrologic Year Type							
Wet (W)	75	3	36	45	43	27	0
Above Normal (AN)	60	4	36	44	34	22	0
Below Normal (BN)	53	4	39	44	31	20	0
Dry (D)	46	4	39	45	25	18	1
Critical (C)	34	4	44	44	21	17	-1

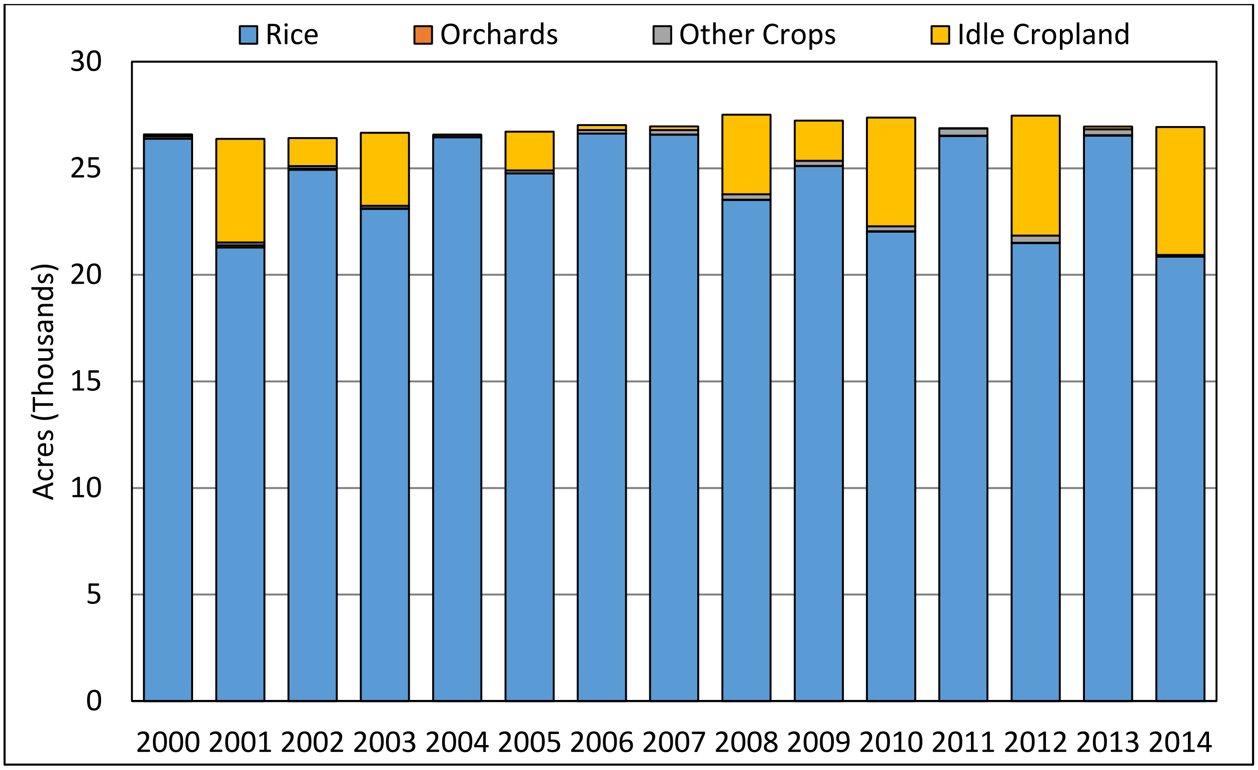
C.3.9. Western Canal Subinventory Unit (East Butte Portion)

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

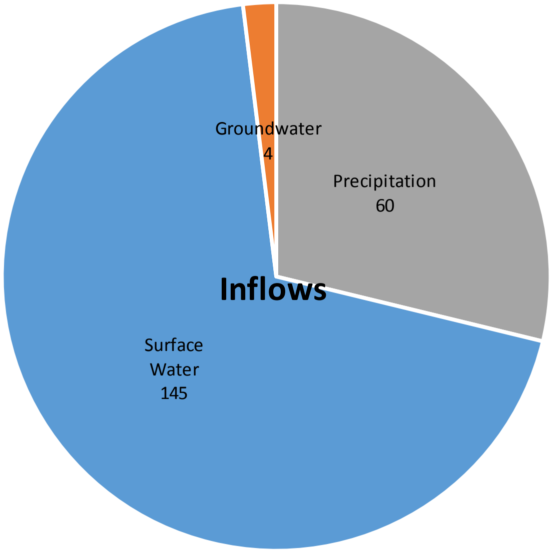
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	26,390	0	0	111	0	11	55	13	10	26,580	26,590
2001	21,287	0	0	100	0	13	68	49	4,865	21,518	26,382
2002	24,932	0	0	52	0	10	77	35	1,313	25,105	26,417
2003	23,098	0	0	24	0	9	73	34	3,431	23,238	26,670
2004	26,459	0	0	2	0	2	95	15	6	26,571	26,577
2005	24,763	0	3	2	0	33	67	33	1,818	24,901	26,719
2006	26,626	0	4	2	0	93	69	2	234	26,796	27,030
2007	26,578	0	6	2	0	144	60	2	173	26,791	26,964
2008	23,519	0	7	2	0	176	41	34	3,736	23,779	27,514
2009	25,104	0	9	2	0	199	37	4	1,882	25,355	27,237
2010	22,035	0	10	2	0	180	28	21	5,104	22,276	27,380
2011	26,518	0	14	2	0	295	23	15	11	26,867	26,878
2012	21,490	0	12	2	0	307	19	14	5,625	21,844	27,469
2013	26,533	0	15	2	0	245	20	14	129	26,830	26,959
2014	20,850	0	16	1	0	31	22	16	6,001	20,935	26,936
Min	20,850	0	0	1	0	2	19	2	6	20,935	26,382
Max	26,626	0	16	111	0	307	95	49	6,001	26,867	27,514
Average	24,412	0	6	20	0	117	50	20	2,289	24,626	26,915

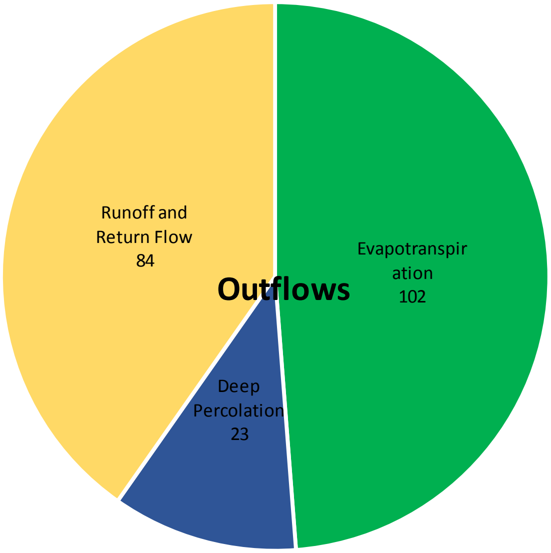
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	1,196	1,755	1,108	4,059
2001	1,206	1,805	1,255	4,266
2002	1,161	1,804	1,266	4,231
2003	1,039	1,753	1,186	3,979
2004	835	1,992	1,245	4,071
2005	801	1,817	1,312	3,930
2006	735	1,659	1,225	3,618
2007	753	1,673	1,258	3,684
2008	639	1,397	1,098	3,134
2009	702	1,497	1,212	3,411
2010	678	1,415	1,175	3,268
2011	794	1,643	1,334	3,770
2012	668	1,383	1,129	3,179
2013	775	1,617	1,297	3,689
2014	779	1,634	1,300	3,713
Min	639	1,383	1,098	3,134
Max	1,206	1,992	1,334	4,266
Average	851	1,656	1,227	3,733

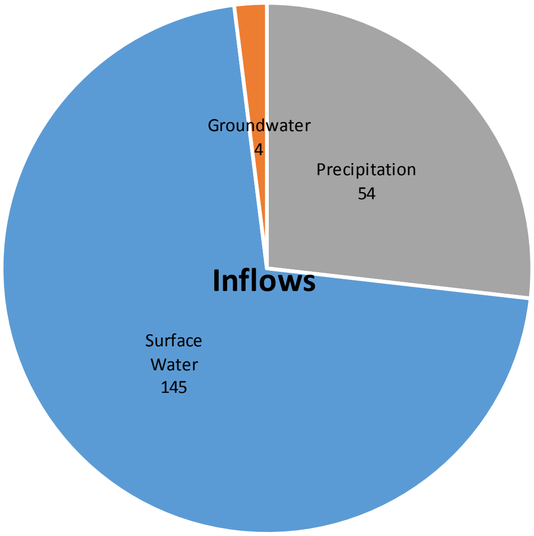
Water Budgets

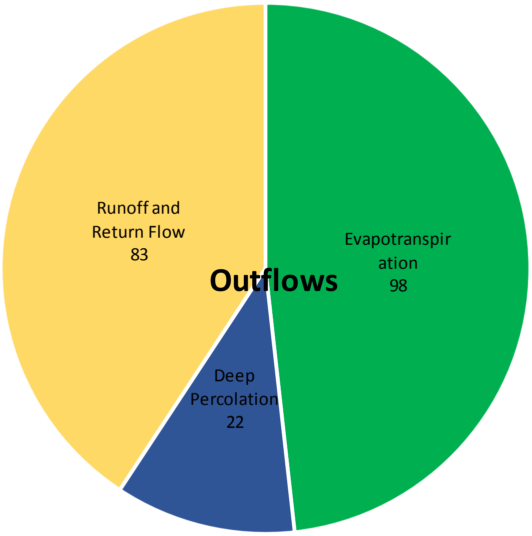
Western Canal (East Butte Portion) Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



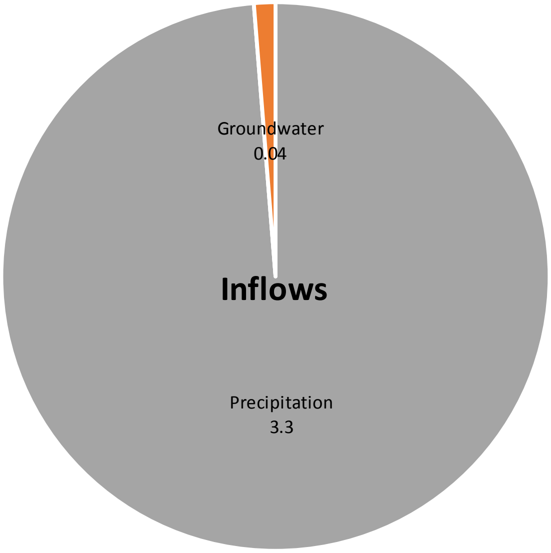


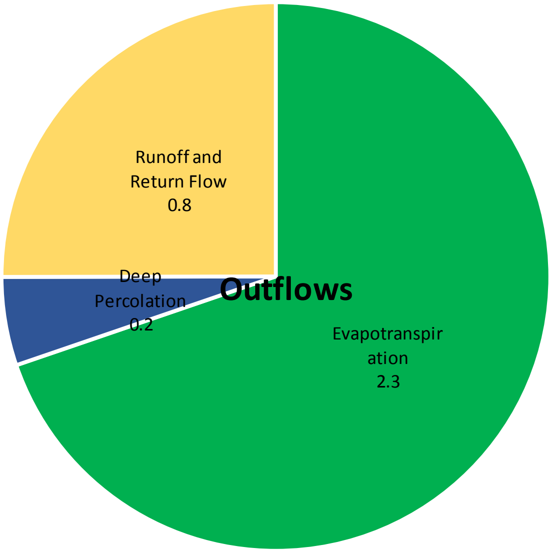
Western Canal (East Butte Portion) Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



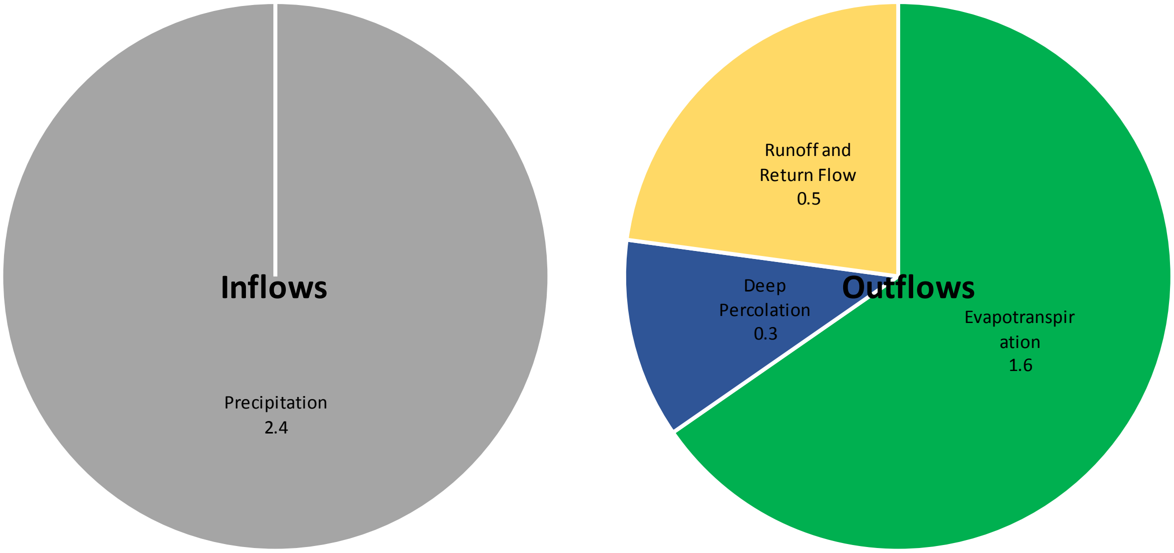


Western Canal (East Butte Portion) Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Fee

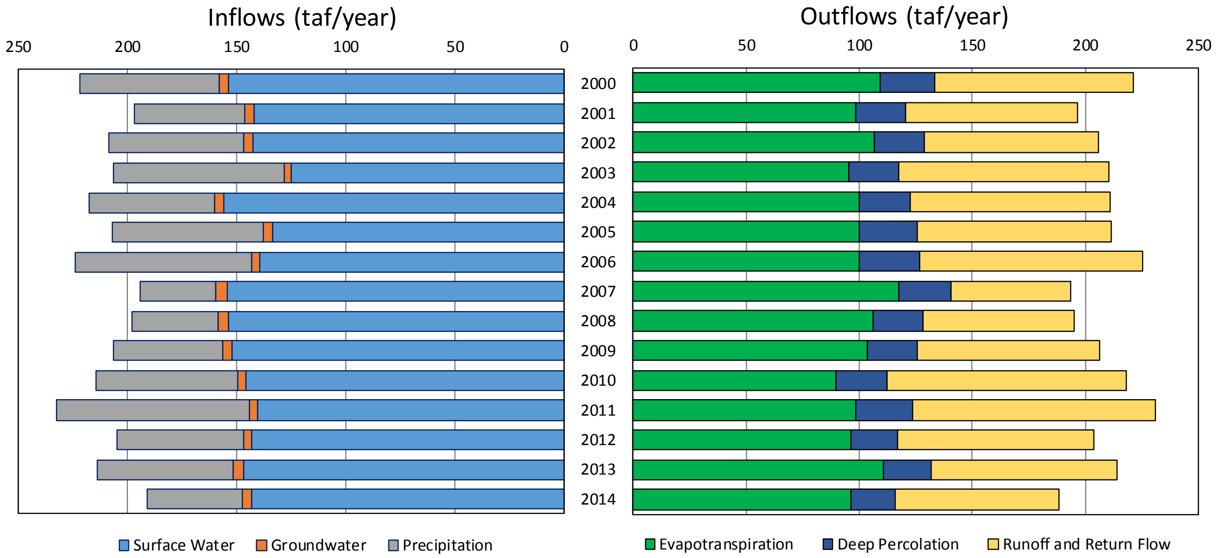




Western Canal (East Butte Portion) Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Western Canal (East Butte Portion) Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



Subinventory Unit Water Budget

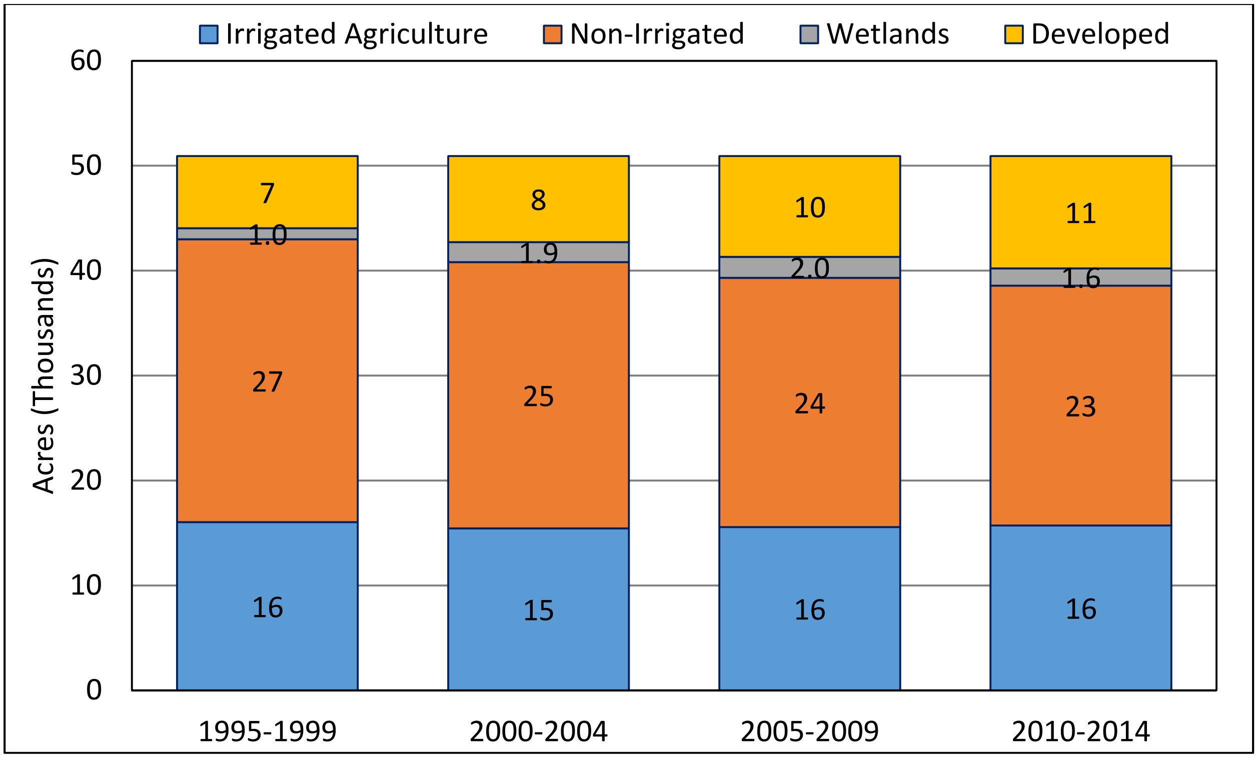
Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	64	154	4	109	24	88	0
2001 (D)	51	142	4	98	22	76	0
2002 (D)	62	142	4	107	22	77	-2
2003 (AN)	78	125	3	95	22	93	4
2004 (BN)	57	156	4	100	23	88	-6
2005 (AN)	69	134	4	100	25	86	5
2006 (W)	81	139	4	100	27	99	2
2007 (D)	35	154	5	117	23	53	-1
2008 (C)	39	154	5	106	22	67	-3
2009 (D)	50	152	4	104	22	81	0
2010 (BN)	65	146	3	90	22	106	4
2011 (W)	88	140	3	98	26	107	-1
2012 (BN)	58	143	4	97	20	87	-1
2013 (D)	62	147	5	111	22	82	0
2014 (C)	44	143	4	96	20	72	-3
Minimum	35	125	3	90	20	53	-6
Maximum	88	156	5	117	27	107	5
Average	60	145	4	102	23	84	0
Averages by Hydrologic Year Type							
Wet (W)	85	140	4	99	26	103	0
Above Normal (AN)	70	137	4	102	24	89	3
Below Normal (BN)	60	148	4	96	22	94	-1
Dry (D)	52	148	4	107	22	74	-1
Critical (C)	41	149	4	101	21	69	-3

C.4. North Yuba Inventory Unit

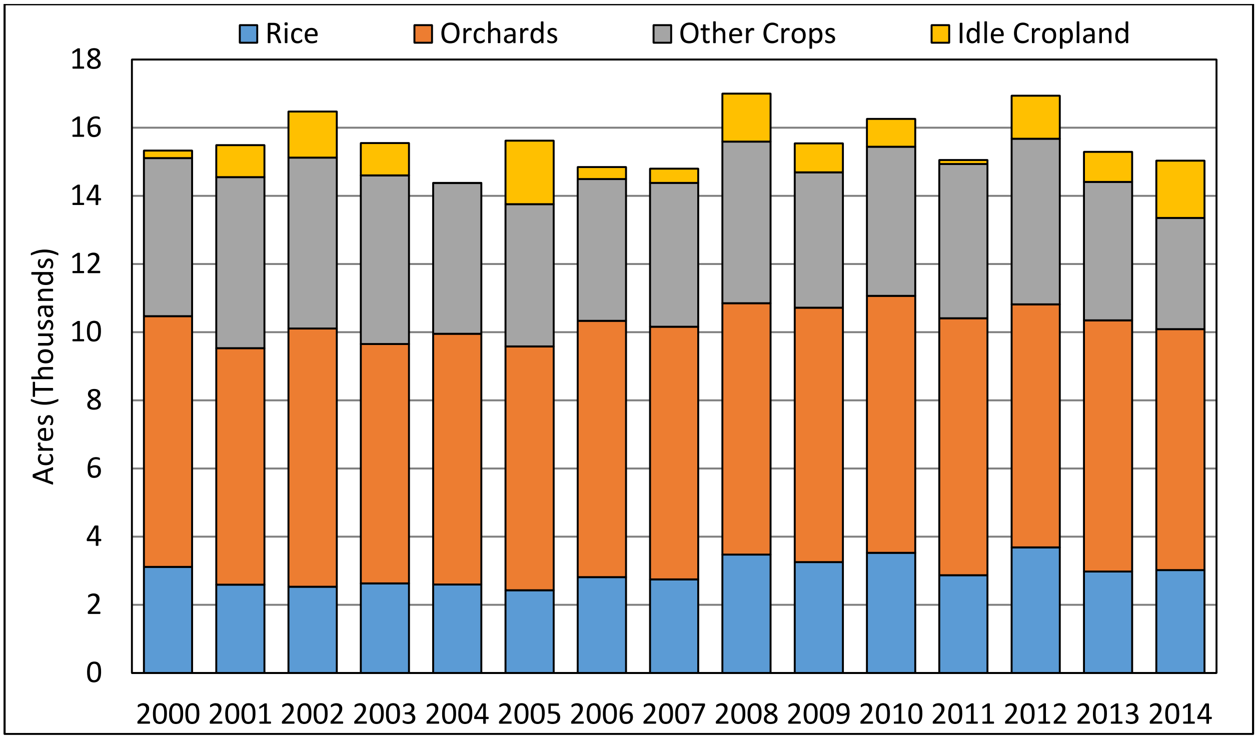
C.4.1. North Yuba Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

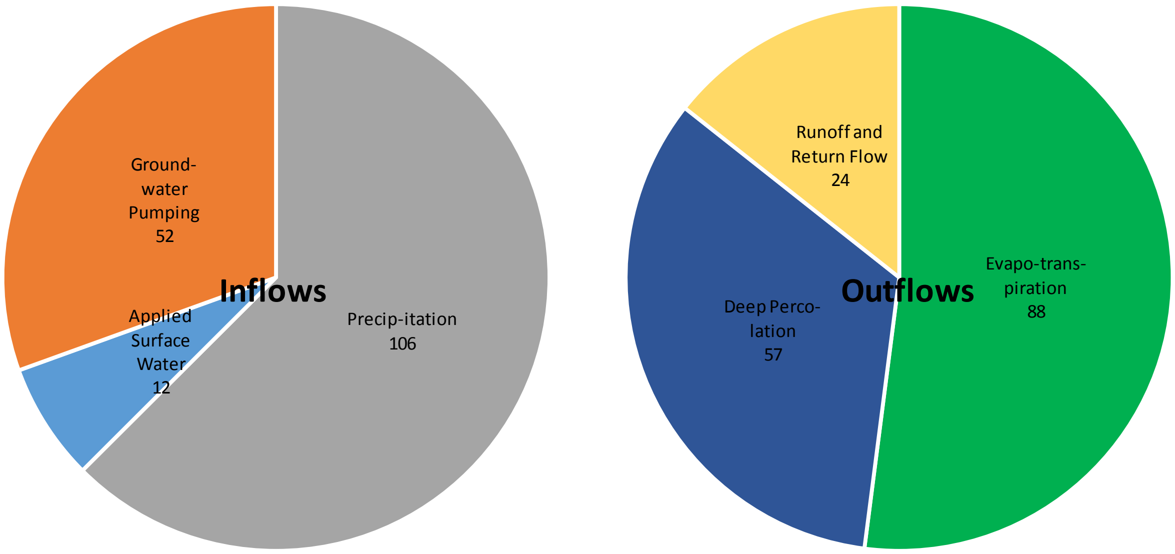
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	3,112	64	2,438	1,851	3,004	961	3,510	171	219	15,111	15,331
2001	2,595	56	2,388	1,785	2,707	1,075	3,619	325	939	14,551	15,490
2002	2,534	54	2,415	1,553	3,553	990	3,725	301	1,351	15,125	16,475
2003	2,629	62	2,560	1,495	2,907	1,074	3,573	303	946	14,603	15,549
2004	2,596	74	2,876	1,540	2,868	517	3,789	117	5	14,376	14,381
2005	2,430	77	2,698	1,119	3,258	399	3,354	422	1,862	13,758	15,620
2006	2,813	74	2,930	1,590	2,930	720	3,393	47	352	14,496	14,848
2007	2,750	77	2,800	1,643	2,890	861	3,252	109	420	14,381	14,801
2008	3,477	72	2,435	1,448	3,419	1,089	2,929	723	1,412	15,592	17,003
2009	3,256	82	2,687	1,648	3,049	910	2,922	138	848	14,691	15,540
2010	3,525	85	2,519	1,619	3,319	863	2,755	756	818	15,440	16,258
2011	2,870	90	2,717	1,594	3,141	1,086	2,756	682	116	14,936	15,051
2012	3,687	87	2,610	1,478	2,955	1,614	2,638	609	1,264	15,677	16,941
2013	2,976	88	2,952	1,407	2,925	927	2,454	680	885	14,407	15,293
2014	3,022	93	3,006	1,151	2,819	117	2,595	549	1,685	13,352	15,036
Min	2,430	54	2,388	1,119	2,707	117	2,454	47	5	13,352	14,381
Max	3,687	93	3,006	1,851	3,553	1,614	3,789	756	1,862	15,677	17,003
Average	2,951	76	2,669	1,528	3,050	880	3,151	396	875	14,700	15,574

Other Land Use

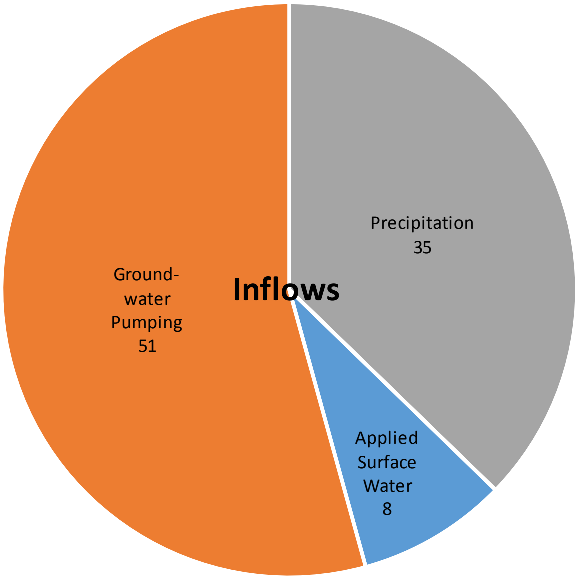
Year	Wetlands	Developed	Non-Irrigated	Total
2000	1,542	7,680	26,367	35,589
2001	1,700	7,775	25,956	35,431
2002	1,842	7,887	24,715	34,445
2003	2,076	8,562	24,733	35,371
2004	2,359	9,120	25,060	36,539
2005	2,168	8,957	24,176	35,300
2006	2,144	9,557	24,371	36,072
2007	2,059	9,838	24,222	36,119
2008	1,758	9,518	22,641	33,917
2009	1,837	10,150	23,393	35,380
2010	1,663	10,234	22,764	34,662
2011	1,677	10,892	23,299	35,869
2012	1,551	10,333	22,095	33,979
2013	1,670	10,958	23,000	35,627
2014	1,685	11,089	23,110	35,884
Min	1,542	7,680	22,095	33,917
Max	2,359	11,089	26,367	36,539
Average	1,849	9,503	23,993	35,346

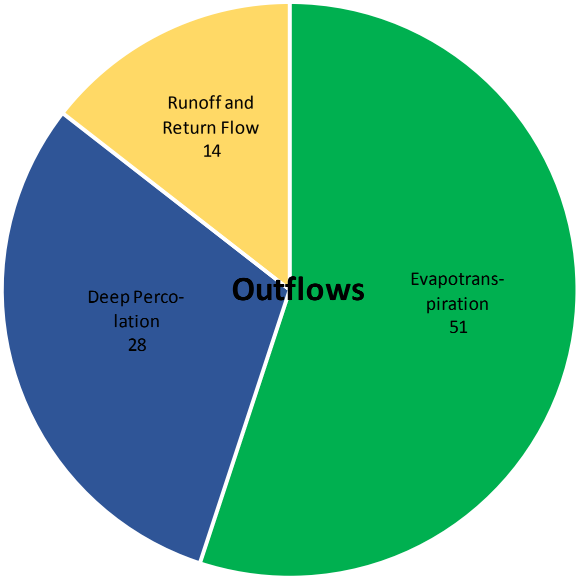
Water Budgets

North Yuba Inventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)

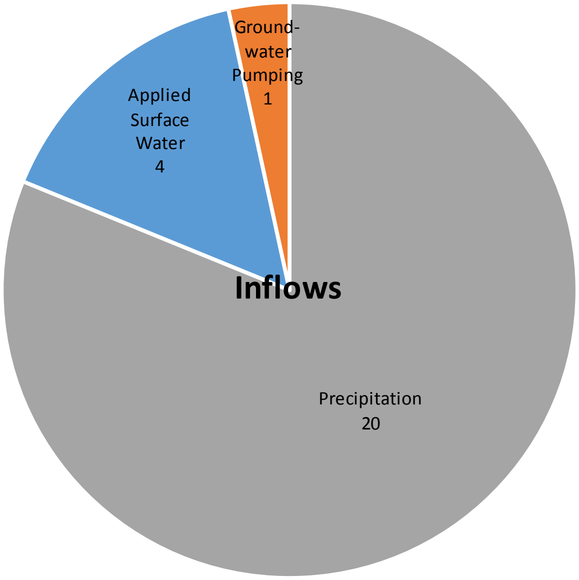


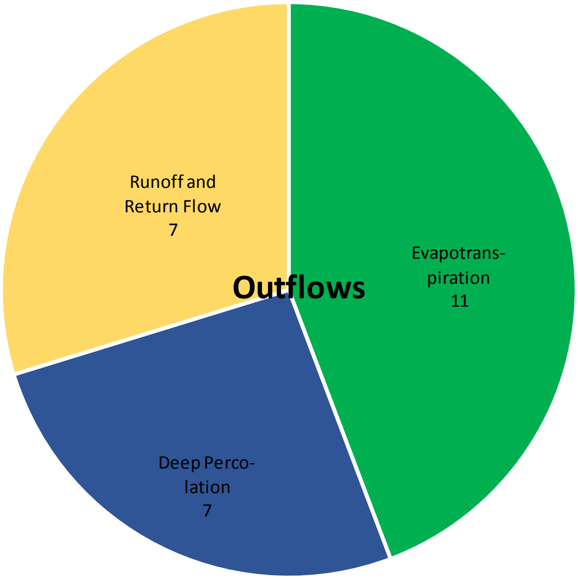
North Yuba Inventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



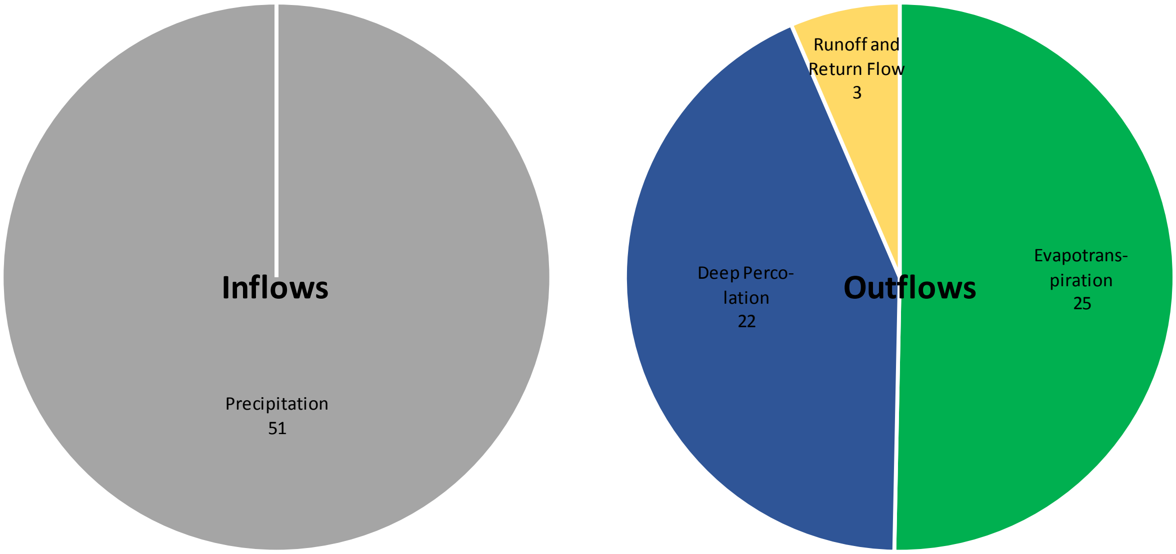


North Yuba Inventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

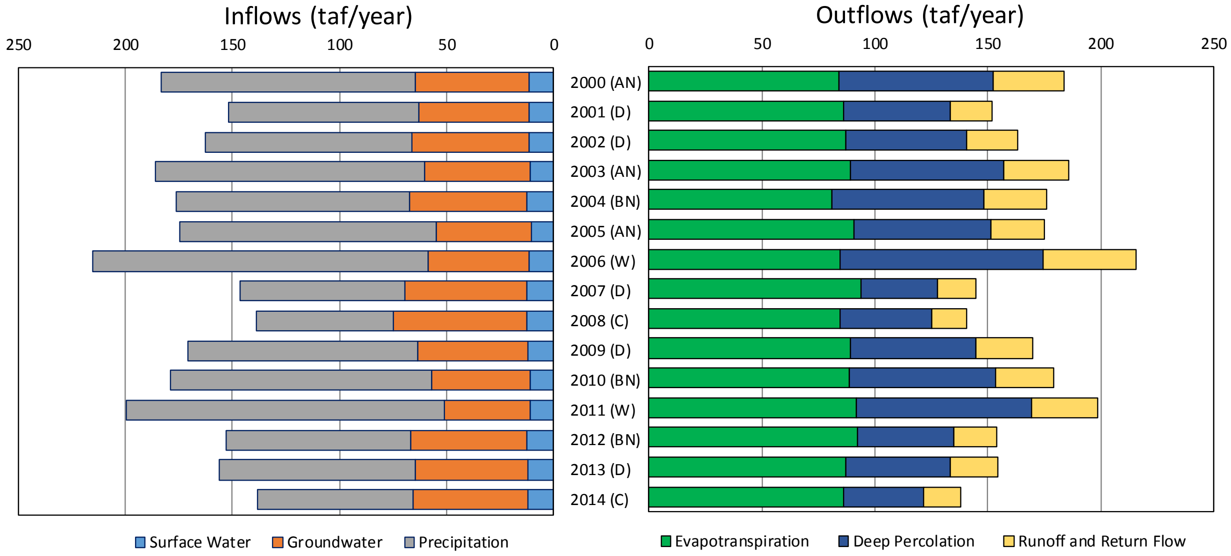




North Yuba Inventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



North Yuba Inventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



Subinventory Unit Water Budget

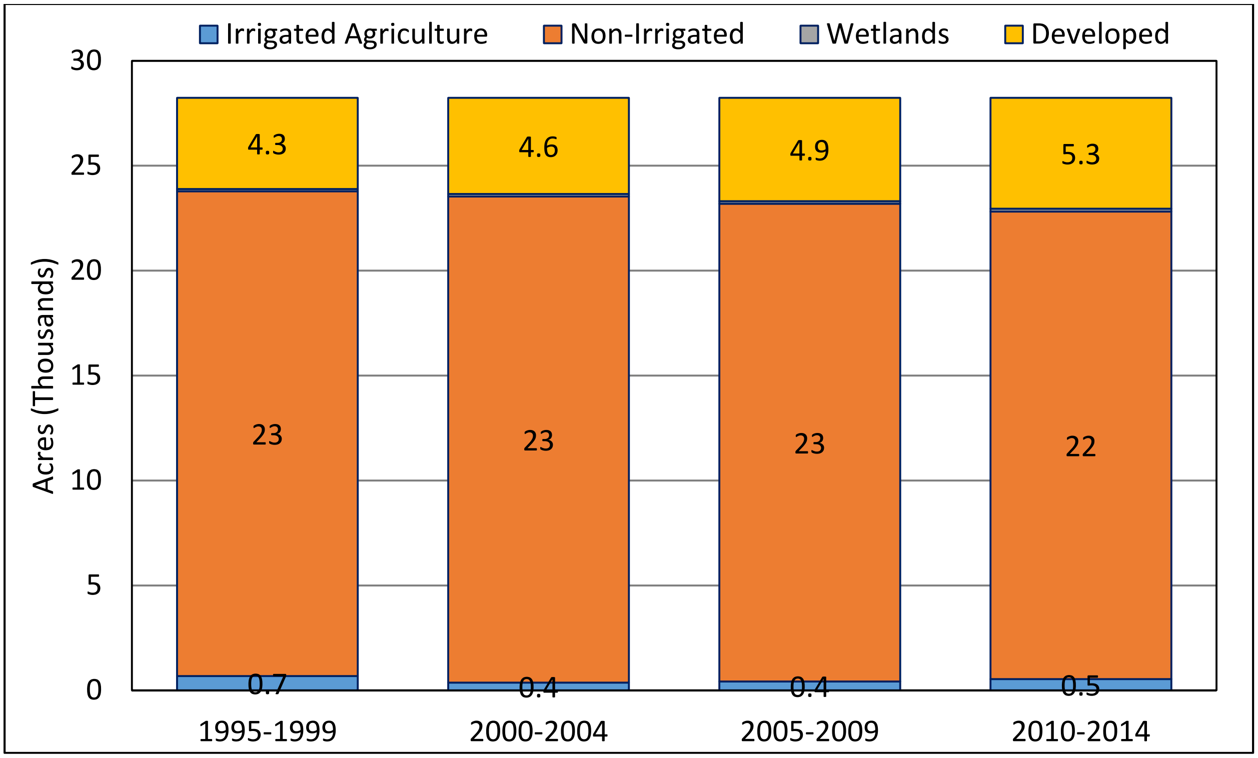
	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
Water Year	**Precipitation**	**Surface Water**	**Groundwater**	**Evapotranspiration**	**Deep Percolation**	**Runoff and Return Flow**	
2000 (AN)	119	11	53	84	68	31	1
2001 (D)	89	12	51	86	47	18	0
2002 (D)	96	12	55	87	53	23	1
2003 (AN)	125	11	49	89	68	29	1
2004 (BN)	109	13	55	81	67	28	-1
2005 (AN)	120	11	44	91	61	24	1
2006 (W)	157	12	47	85	90	41	-1
2007 (D)	77	12	57	94	34	17	3
2008 (C)	64	13	62	84	41	16	-3
2009 (D)	107	12	51	89	55	25	1
2010 (BN)	122	11	46	89	65	26	0
2011 (W)	148	11	41	92	78	29	0
2012 (BN)	86	13	54	92	43	19	0
2013 (D)	91	12	53	87	46	21	1
2014 (C)	73	12	54	86	36	16	-1
Minimum	64	11	41	81	34	16	-3
Maximum	157	13	62	94	90	41	3
Average	106	12	52	88	57	24	0
Averages by Hydrologic Year Type							
Wet (W)	153	11	44	88	84	35	0
Above Normal (AN)	121	11	49	88	66	28	1
Below Normal (BN)	106	12	51	87	58	24	0
Dry (D)	92	12	54	89	47	21	1
Critical (C)	68	12	58	85	38	16	-2

C.5. Foothill Inventory Unit

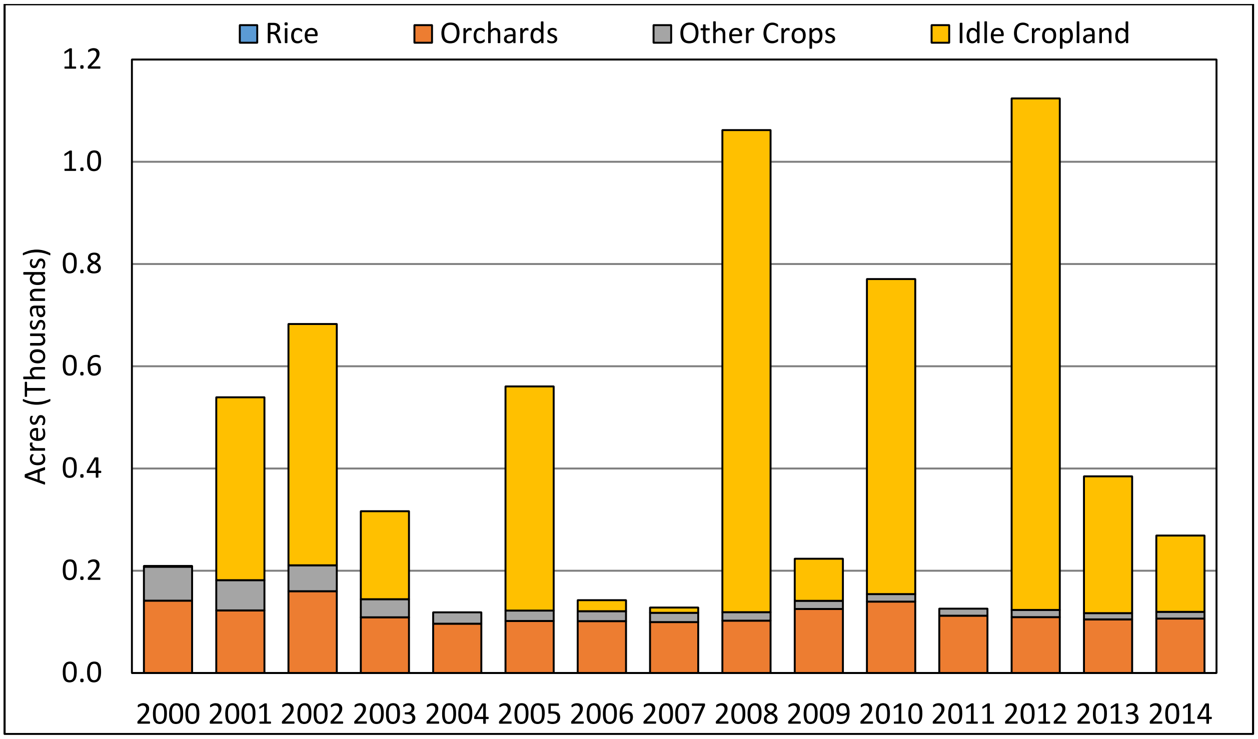
C.5.1. Cohasset Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

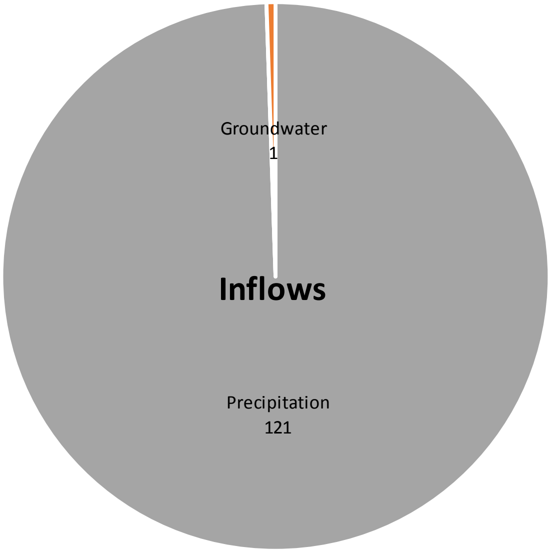
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	0	0	0	0	13	0	0	0	0	13	13
2001	0	0	0	0	29	0	0	0	390	29	419
2002	0	0	0	0	42	0	0	0	518	42	560
2003	0	0	0	0	65	0	0	0	215	65	280
2004	0	0	0	0	69	0	0	0	0	69	69
2005	0	0	0	0	88	0	0	0	506	88	594
2006	0	0	0	0	69	0	0	0	7	69	76
2007	0	0	0	0	69	0	0	0	0	69	69
2008	0	0	0	0	102	0	0	0	1,263	102	1,365
2009	0	0	0	0	53	0	0	0	111	53	165
2010	0	0	0	0	73	0	0	0	855	73	928
2011	0	0	0	0	69	0	0	0	5	69	73
2012	0	0	0	0	68	0	0	0	1,425	68	1,493
2013	0	0	0	0	72	0	0	0	463	72	536
2014	0	0	0	0	68	0	0	0	288	68	355
Min	0	0	0	0	13	0	0	0	0	13	13
Max	0	0	0	0	102	0	0	0	1,425	102	1,493
Average	0	0	0	0	63	0	0	0	403	63	466

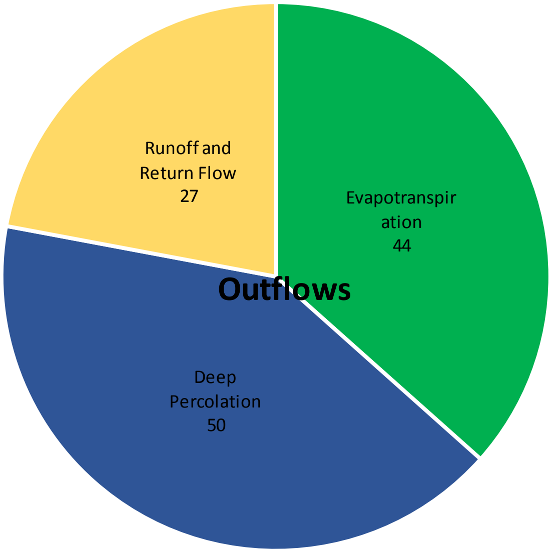
Other Land Use

Year	Wetlands	Developed	Non-Irrigated	Total
2000	52	357	37,901	38,309
2001	59	435	37,411	37,904
2002	66	517	37,179	37,763
2003	76	609	37,357	38,043
2004	86	702	37,466	38,254
2005	82	690	36,957	37,729
2006	82	701	37,464	38,246
2007	80	700	37,474	38,254
2008	75	674	36,208	36,958
2009	77	695	37,387	38,158
2010	73	680	36,642	37,395
2011	73	693	37,484	38,250
2012	71	674	36,085	36,829
2013	73	697	37,017	37,787
2014	73	706	37,188	37,967
Min	52	357	36,085	36,829
Max	86	706	37,901	38,309
Average	73	635	37,148	37,856

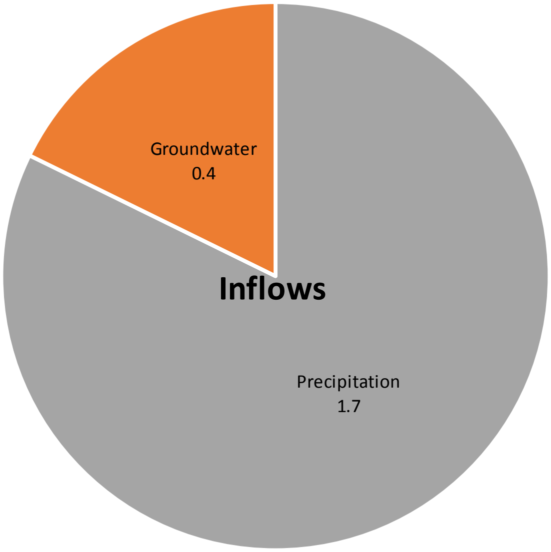
Water Budgets

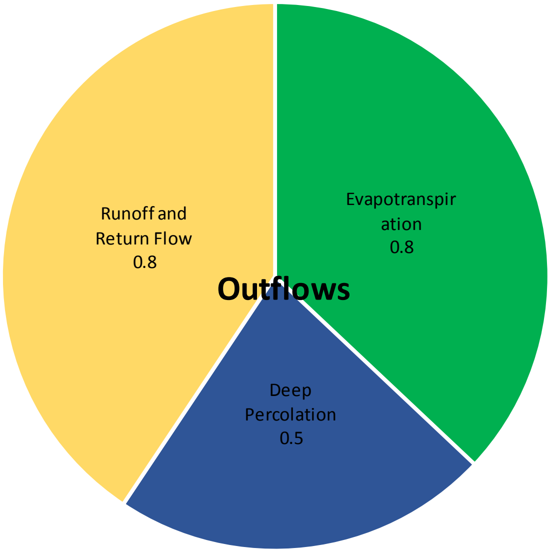
Cohasset Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)



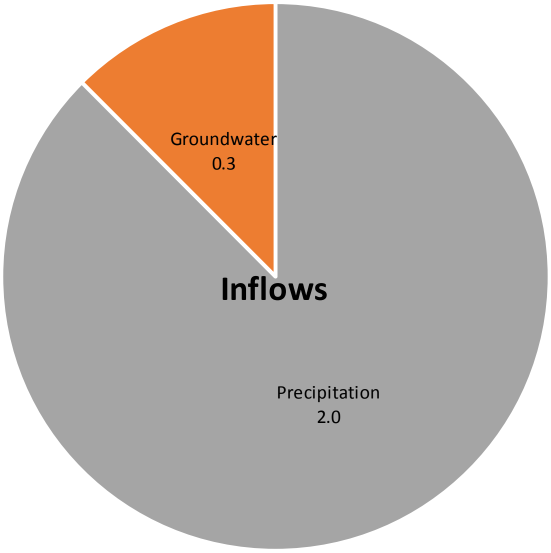


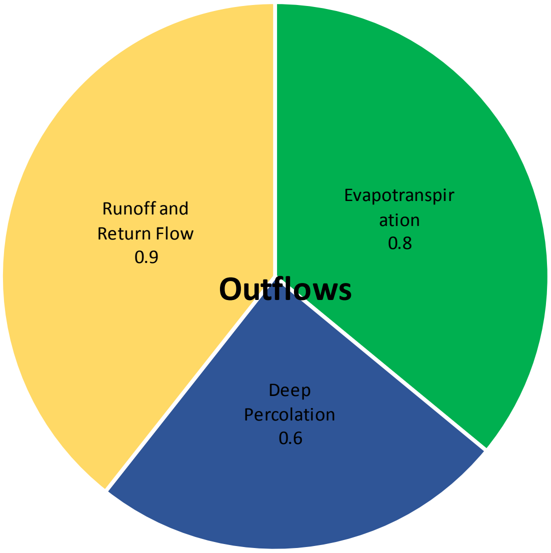
Cohasset Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



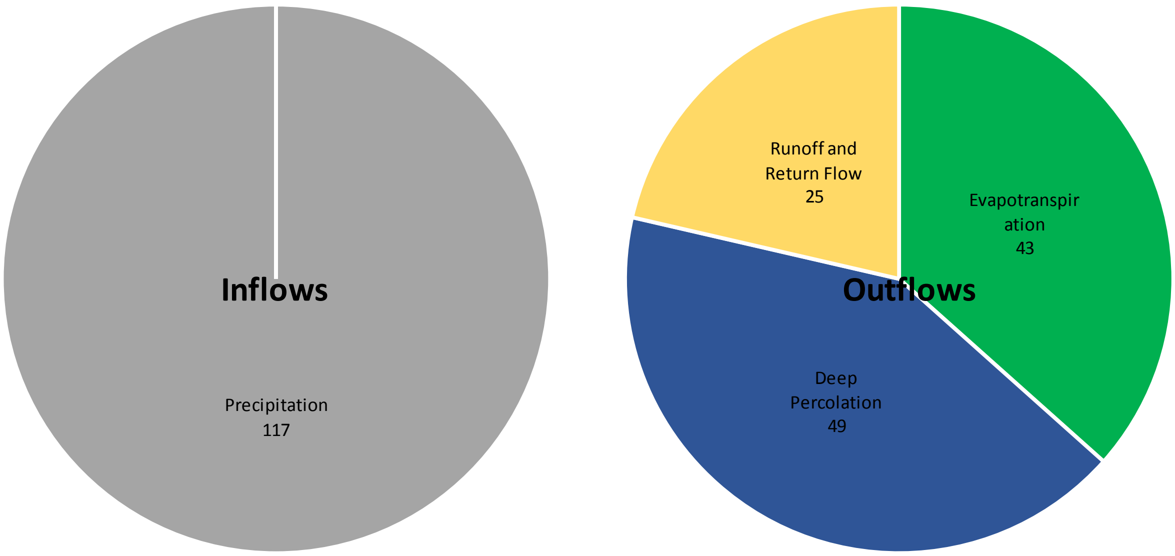


Cohasset Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

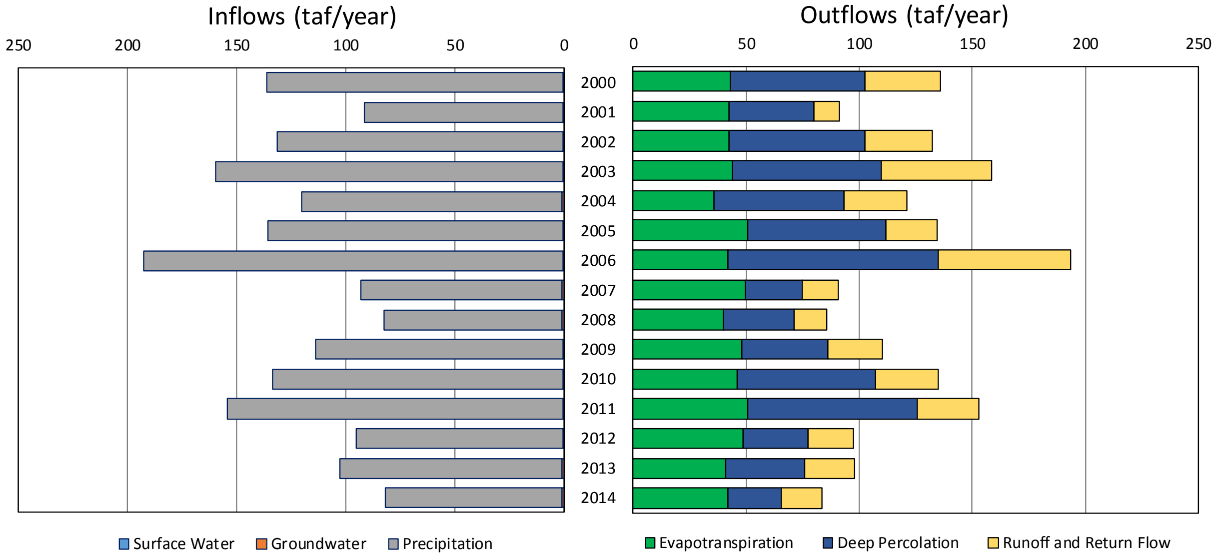




Cohasset Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Cohasset Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



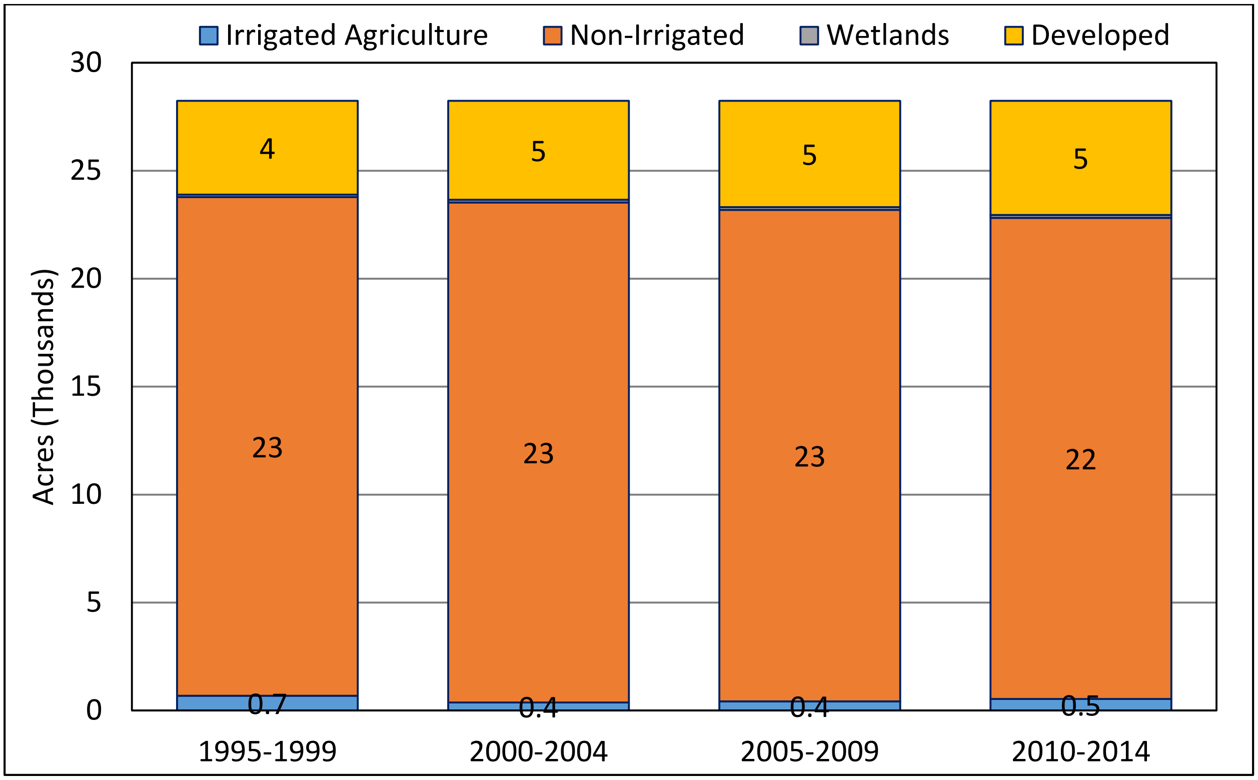
Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	136	0	0	43	60	33	0
2001 (D)	91	0	1	43	37	11	1
2002 (D)	131	0	1	42	60	30	-1
2003 (AN)	159	0	1	44	66	49	1
2004 (BN)	119	0	1	36	58	28	-1
2005 (AN)	135	0	1	50	61	23	2
2006 (W)	192	0	1	42	93	59	-2
2007 (D)	92	0	1	50	25	16	2
2008 (C)	82	0	1	40	32	14	-2
2009 (D)	113	0	1	48	38	24	2
2010 (BN)	133	0	1	46	61	28	-1
2011 (W)	154	0	1	51	75	27	0
2012 (BN)	95	0	1	49	28	20	0
2013 (D)	102	0	1	41	35	22	4
2014 (C)	81	0	1	42	24	18	-2
Minimum	81	0	0	36	24	11	-2
Maximum	192	0	1	51	93	59	4
Average	121	0	1	44	50	27	0
Averages by Hydrologic Year Type							
Wet (W)	173	0	1	46	84	43	-1
Above Normal (AN)	143	0	1	46	62	35	1
Below Normal (BN)	116	0	1	43	49	25	-1
Dry (D)	106	0	1	45	39	21	2
Critical (C)	81	0	1	41	28	16	-2

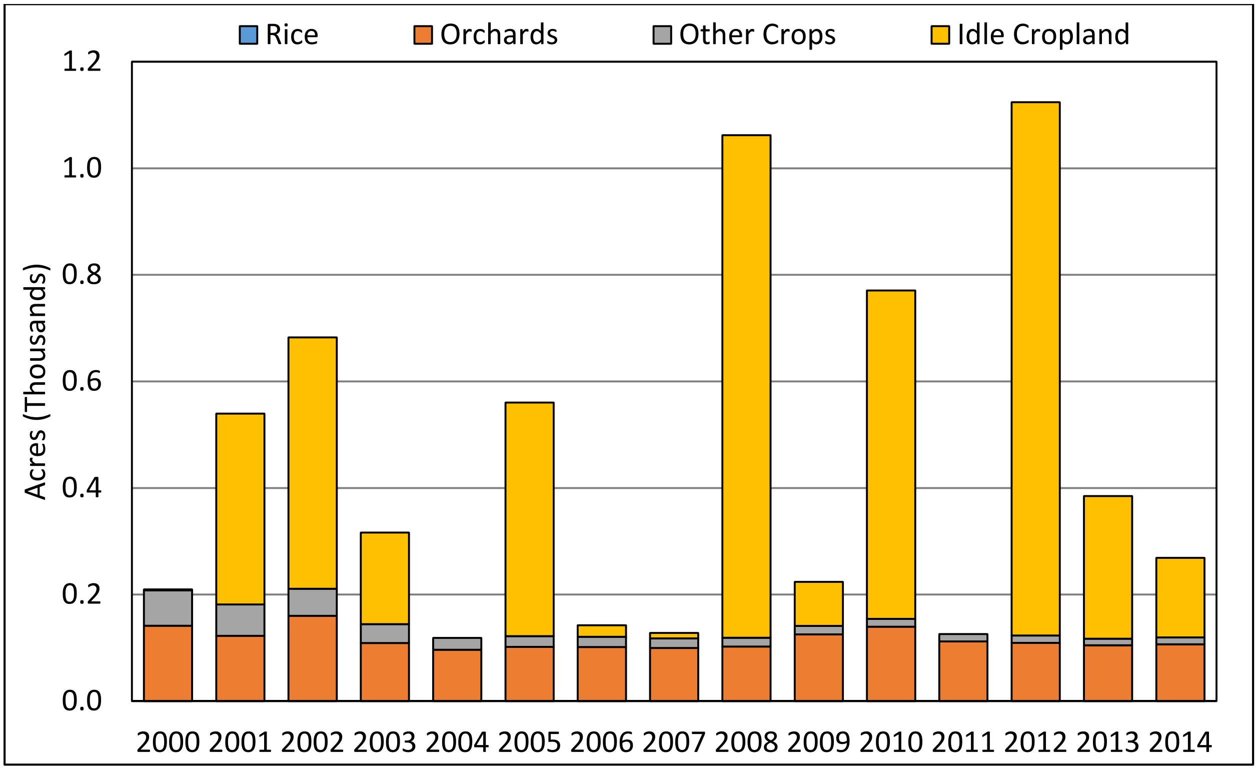
C.5.2. Ridge Subinventory Unit

Land Use

General Land Use



Irrigated Agricultural Land Use



Irrigated Agricultural Land Use

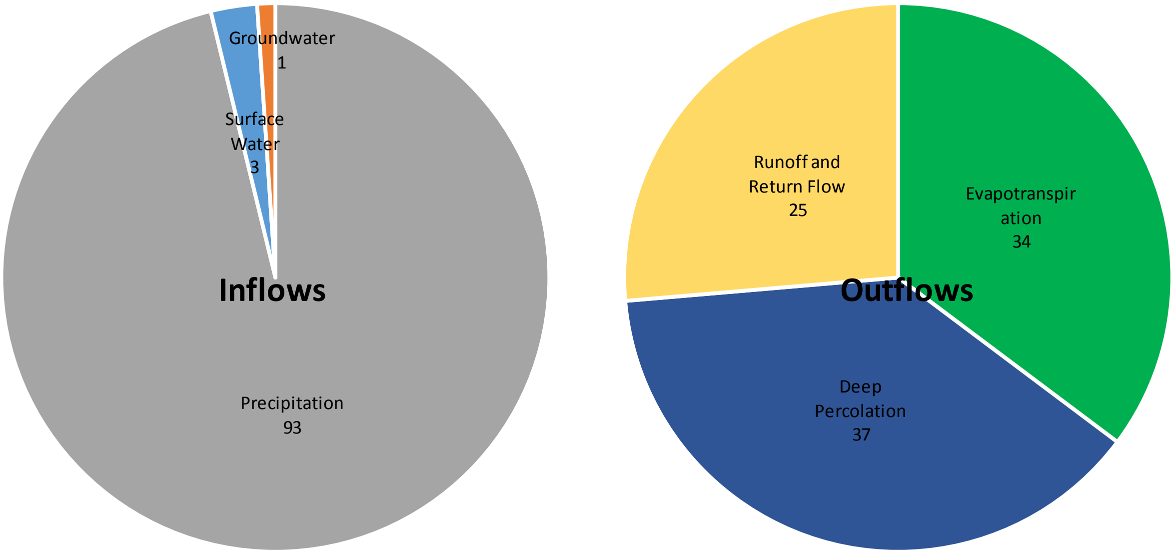
Year	Rice	Almonds	Walnuts	Prunes	Other Trees and Vines	Grain	Pasture and Alfalfa	Field and Annual	Idle Cropland	Total Cropped	Total (w/Idle)
2000	0	0	0	0	142	0	66	0	2	208	210
2001	0	0	0	0	123	0	59	0	358	182	540
2002	0	0	0	0	160	0	51	0	472	211	683
2003	0	0	0	0	109	0	36	0	172	145	316
2004	0	0	0	0	96	0	22	0	0	119	119
2005	0	0	0	0	102	0	20	0	439	122	561
2006	0	0	0	0	102	0	19	0	22	121	143
2007	0	0	0	0	100	0	18	0	10	118	128
2008	0	0	0	0	102	0	17	0	943	119	1,062
2009	0	0	0	0	125	0	16	0	83	141	224
2010	0	0	0	0	140	0	15	0	616	155	771
2011	0	0	0	0	112	0	14	0	0	126	126
2012	0	0	0	0	109	0	14	0	1,001	123	1,124
2013	0	0	0	0	105	0	12	0	268	117	385
2014	0	0	0	0	107	0	13	0	149	120	269
Min	0	0	0	0	96	0	12	0	0	117	119
Max	0	0	0	0	160	0	66	0	1,001	211	1,124
Average	0	0	0	0	116	0	26	0	302	142	444

Other Land Use

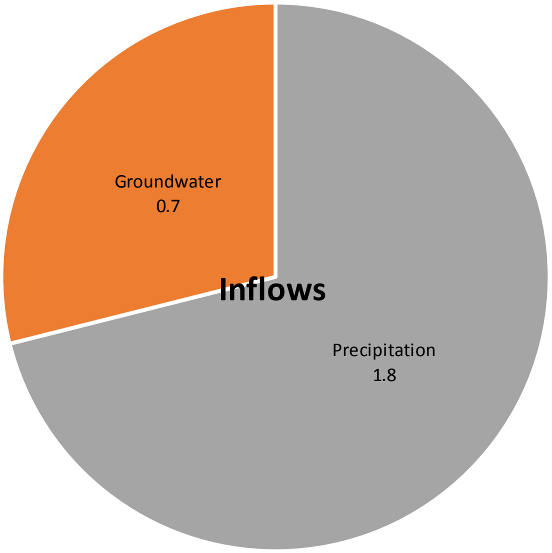
Year	Wetlands	Developed	Non-Irrigated	Total
2000	122	4,531	23,373	28,026
2001	120	4,500	23,076	27,696
2002	118	4,517	22,918	27,553
2003	120	4,644	23,155	27,919
2004	120	4,725	23,272	28,117
2005	120	4,689	22,866	27,675
2006	125	4,892	23,076	28,093
2007	128	4,981	22,999	28,108
2008	126	4,905	22,143	27,174
2009	132	5,148	22,733	28,012
2010	132	5,133	22,200	27,465
2011	138	5,341	22,630	28,110
2012	134	5,192	21,786	27,112
2013	138	5,365	22,348	27,851
2014	139	5,392	22,435	27,967
Min	118	4,500	21,786	27,112
Max	139	5,392	23,373	28,117
Average	128	4,930	22,734	27,792

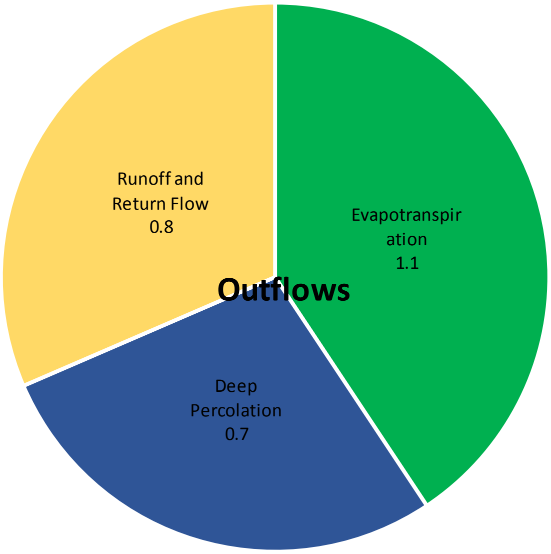
Water Budgets

Ridge Subinventory Unit Average Annual Inflows and Outflows (Thousands of Acre-Feet)

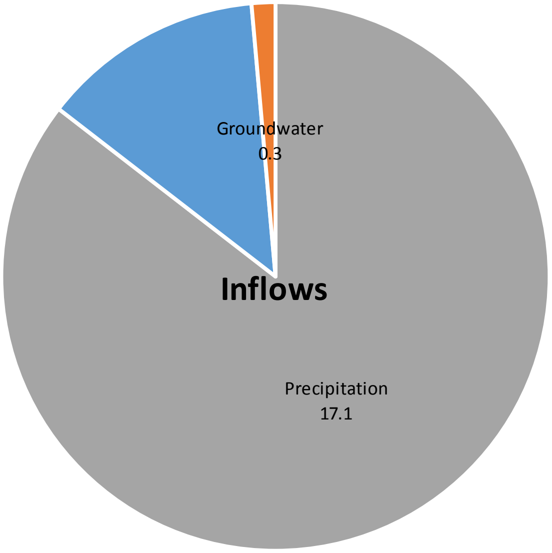


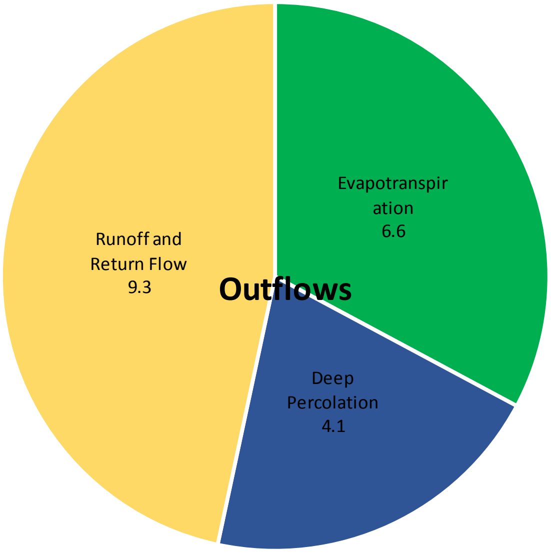
Ridge Subinventory Unit Agricultural Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



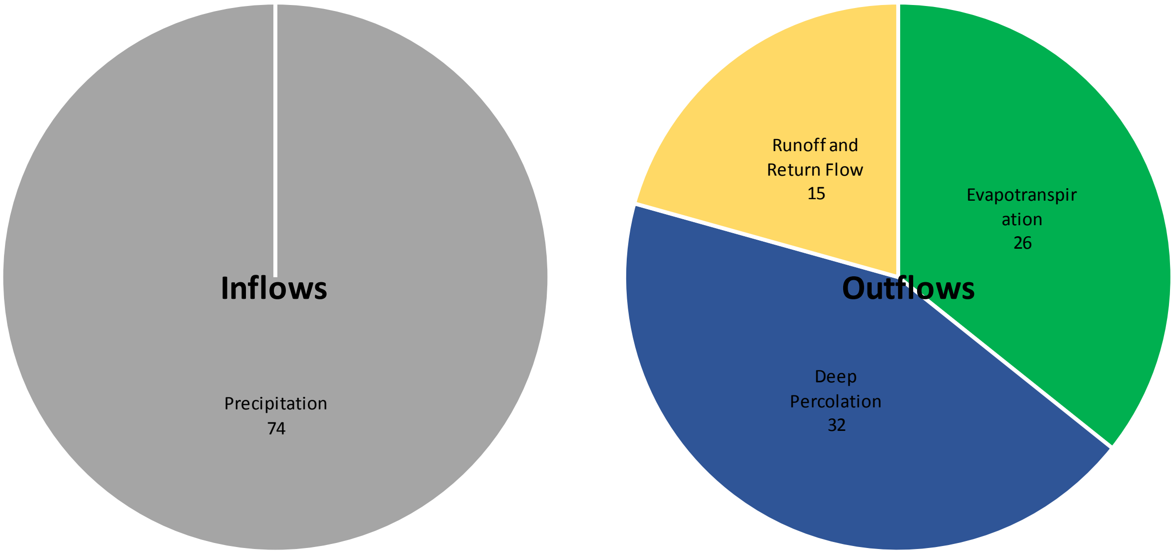


Ridge Subinventory Unit Developed Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)

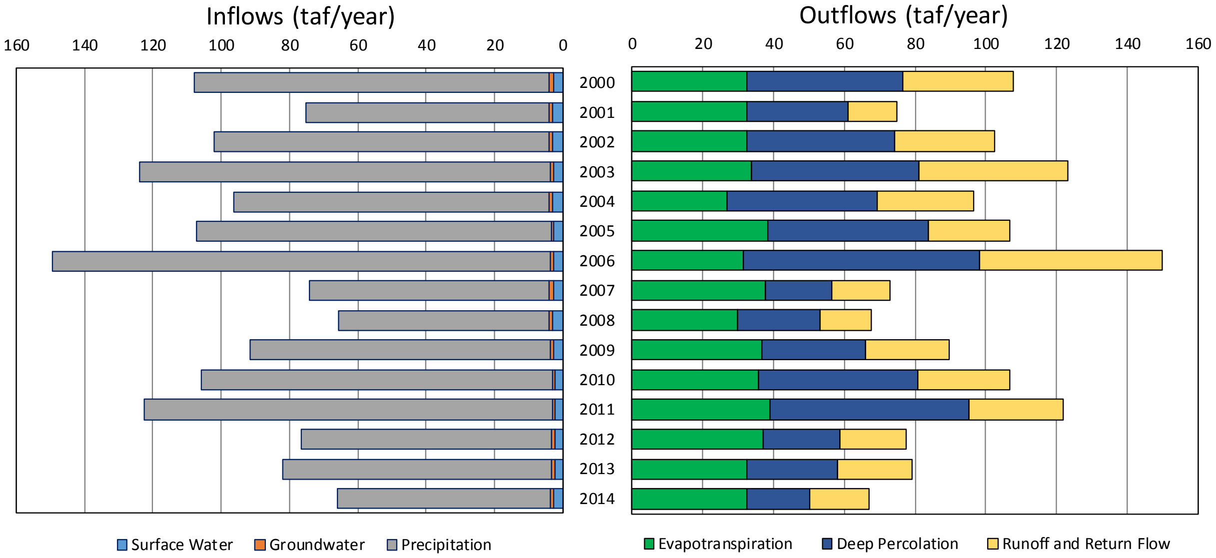




Ridge Subinventory Unit Native Area Average Annual Inflows and Outflows (Thousands of Acre-Feet)



Ridge Subinventory Unit 2000-2014 Water Year Inflows and Outflows (Thousands of Acre-Feet)



Subinventory Unit Water Budget

Water Year	Inflows (taf)			Outflows (taf)			Change in Storage (taf)
	Precipi-tation	Surface Water	Ground-water	Evapotrans-piration	Deep Percolation	Runoff and Return Flow	
2000 (AN)	104	3	1	33	44	31	0
2001 (D)	71	3	1	32	29	14	1
2002 (D)	98	3	1	33	42	28	0
2003 (AN)	120	3	1	34	47	42	0
2004 (BN)	92	3	1	27	43	27	0
2005 (AN)	104	3	1	39	45	23	1
2006 (W)	146	3	1	32	67	52	-1
2007 (D)	70	3	1	38	19	16	2
2008 (C)	62	3	1	30	23	14	-1
2009 (D)	88	3	1	37	29	23	1
2010 (BN)	103	2	1	36	45	26	-1
2011 (W)	120	2	1	39	56	27	0
2012 (BN)	73	2	1	37	22	19	0
2013 (D)	79	2	1	33	25	21	3
2014 (C)	62	2	1	32	18	17	-2
Minimum	62	2	1	27	18	14	-2
Maximum	146	3	1	39	67	52	3
Average	93	3	1	34	37	25	0
Averages by Hydrologic Year Type							
Wet (W)	133	2	1	35	61	39	0
Above Normal (AN)	109	3	1	35	46	32	1
Below Normal (BN)	89	2	1	33	37	24	0
Dry (D)	81	3	1	34	29	21	1
Critical (C)	62	3	1	31	21	16	-1

D. Assessment of Butte County Drought Impacts, 2012-2015

(Provided on following page)

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DAVIDS ENGINEERING, INC

Specialists in Agricultural Water Management
Serving Stewards of Western Water since 1993

Technical Memorandum

To: Butte County Department of Water and Resource Conservation

From: Davids Engineering

Date: March 28, 2016 (revised June 8, 2016)

Subject: **Assessment of Butte County Drought Impacts, 2012-2015**

Background and Overview

Previous analyses (Butte County Groundwater Inventory, DWR 2005; I&A Report 2001; and Butte Basin Groundwater Model Update, Water Management Scenario 2008) have estimated impacts to the basin of drought conditions. Two broad questions arise – (1) can we provide reasonable basin-wide estimates on the increased demand on the basin as a result of the drought, and (2) how do the previous analyses compare to the current 2012 – 2015 drought?

Butte County Department of Water and Resource Conservation (BCDWRC) has reported on groundwater elevations in relation to their period of record. Anecdotally, an increase in groundwater irrigation during winter months due to limited precipitation has been reported, though increased irrigation has not been quantified. This raises another important question: how does the increased groundwater demand affect overall groundwater demands in groundwater only areas and the basin as a whole?

Cutbacks to Settlement Contractors and curtailments to other surface water users in the County in 2015 resulted in increased pumping in those areas. Increased monitoring was conducted by the districts and in cooperation with BCDWRC to assess how the basin responds to the pumping. The amount of pumping in the districts has been estimated based on planted acres, surface water delivery and well metering. A hypothetical cutback scenario was analyzed in the Butte Basin Groundwater Model Update (2008). That scenario was limited to assessing the effect of increased pumping within the district boundaries without considering potential lowering of water levels in the surrounding areas of the basin due to drought conditions.

Davids Engineering (DE) has compiled available information describing land use within the Butte Basin for 2013, 2014, and 2015 and prepared estimates of groundwater pumping for agricultural irrigation through the 2015 irrigation season for comparison to prior years. This effort supports BCDWRC drought monitoring efforts while additionally providing updated datasets for the Butte Basin Groundwater Model (BBGM) and Butte County Water Inventory & Analysis (WI&A).

This technical memorandum (TM) summarizes the results of the analysis of agricultural supply and demand impacts of drought between 2012 and 2015 as estimated by the Integrated Water Flow Model (IWFM) Demand Calculator (IDC) component of the BBGM. The analysis is based on comparison of recent drought years to a baseline period of 2001 to 2007 that, on average, approximates long-term historical hydrology and recent land use patterns. First, hydrologic impacts of drought are examined including consideration of precipitation and streamflows. Next, land use changes are reviewed to support understanding of potential effects of land use on demands and changes in net recharge that have occurred during recent drought years. Then surface water supplies, groundwater pumping, reference evapotranspiration, crop evapotranspiration, and crop water demands are reviewed. Finally, potential impacts of drought on net recharge of the groundwater system are discussed. This analysis presents results of input data developed for the BBGM (precipitation, land use, diversions, crop evapotranspiration) and results from the IDC component of the BBGM that estimates complete land surface water budget (irrigation water demands, deep percolation).

Hydrologic Impacts of Drought

For purposes of this assessment, drought is generally defined by below normal precipitation and resulting reduction in available water supplies to support agricultural, urban, and environmental water demands. All else equal, reduced precipitation in Butte County and the watersheds it relies upon results in decreased surface water supplies, increased irrigation demands, and decreased groundwater recharge, although these impacts do not occur in direct proportion to decreased precipitation. Impacts on surface water supplies depend upon dynamics in the timing and amount of precipitation received as snowfall, melting and runoff of accumulated snowfall, reservoir storage and operations, and water rights considerations. Similarly, irrigation demands are influenced primarily by the timing and amount of precipitation occurring on the valley floor, along with reference evapotranspiration as influenced by solar radiation, temperature, wind speed, humidity, and other factors. Net recharge of the underlying groundwater system is influenced by a combination of these factors.

Precipitation

Precipitation for the WI&A has been estimated based on five weather stations utilized in the BBGM. For each station, a representative percentage of precipitation is utilized to calculate average precipitation for the region, based on the area represented by each station and long term average precipitation trends across the region. The stations and representative percentages include Chico University Farm (51 percent), Oroville (35 percent), Paradise (8 percent), Colusa (4 percent), and Marysville (2 percent).

For the 2001-2007 period, average water year[1] precipitation based on the weighted average of the stations described above was 28.5 inches, as compared to 27.7 inches on average for the 45-year period from 1971 to 2015 (103 percent of the long term average). In contrast, water year precipitation totals in recent drought years have been substantially less, totaling 24.8, 26.9, 19.2, and 22.1 inches for 2012, 2013, 2014, and 2015, respectively. On average during the recent drought, water year precipitation has been approximately 82 percent of the 2001-2007 average. Water year precipitation totals are shown graphically in Figure 1, along with averages for the 2001-2007 and 1971-2015 periods.

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[1] The water year refers to the period from October 1 to September 30 each year. For example, the 2001 water year began on October 1, 2000 and ended September 30, 2001. This definition of a water year is commonly used in California due to the rainy season typically beginning in October 1 each year. Precipitation and snowfall received between October 1 and the following spring contribute to available water supplies for the irrigation period that follows.

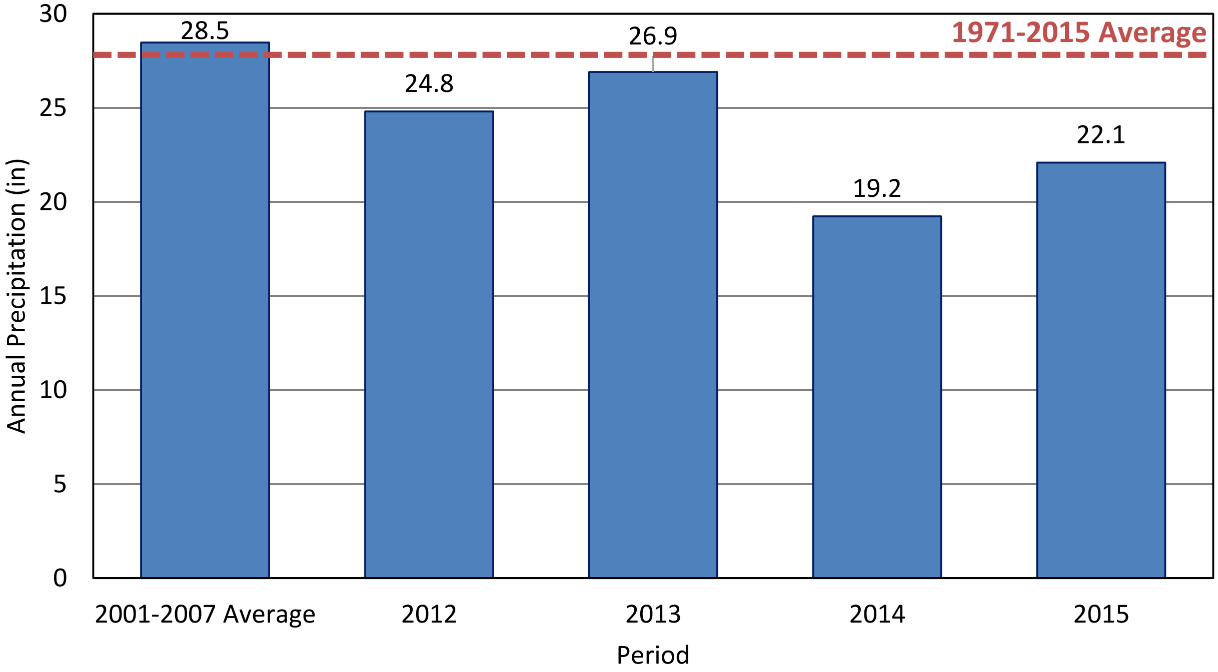

Figure 1. Average Precipitation for 2001-2007 and by Water Year for 2012-2015 Drought Period.

Streamflows

Primary surface streams providing water supplies in Butte County include the Feather River and Butte Creek. Some water is also diverted from the Sacramento and other, minor sources. To evaluate drought impacts on surface streams, streamflows for the primary surface streams are reviewed. For the Feather River, estimates of full natural flow for the Feather River at Oroville gage are presented. Full natural flow represents the estimated streamflow that would occur without the impacts of reservoir storage and releases and provides a better representation of hydrologic impacts of drought than do actual flow data by removing the effects of storage. For Butte Creek, actual flows for the Butte Creek near Chico gage are presented, which are impacted to some extent by hydropower and reservoir operations in the upper watershed. In each case, total flow volumes are reviewed on a water year basis, along with April to July flows. By examining trends in April to July flows, one can evaluate impacts of drought on snowmelt and corresponding surface water supplies during the primary irrigation season, which occurs between April and September.

Feather River

For the period 2001-2007, average water year Feather River full natural flow was 4.09 maf[2], as compared to 4.32 maf on average for the 45-year period from 1971 to 2015 (95 percent of the long term average). In contrast, water year totals in recent drought years have been substantially less, totaling 2.86, 3.13, 1.72, and 2.02 maf for 2012, 2013, 2014, and 2015, respectively. On average during the recent drought, water year Feather River full natural flow has been approximately 59 percent of the 2001-2007 average. Water year full natural flow volumes are shown graphically in Figure 2, along with averages for the 2001-2007 and 1971-2015 periods. Volumes are expressed in thousands of acre-feet (taf).

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[2] maf = million acre-feet

For the period 2001-2007, average April to July Feather River full natural flow was 1.67 maf, as compared to 1.67 maf on average for the 45-year period from 1971 to 2015 (100 percent of the long term average). In contrast, totals in recent drought years have been substantially less, totaling 1.36, 0.76, 0.57, and 0.38 maf for 2012, 2013, 2014, and 2015, respectively. On average during the recent drought, April to July Feather River full natural flow has been approximately 46 percent of the 2001-2007 average. April to July full natural flow volumes are shown graphically in Figure 3, along with averages for the 2001-2007 and 1971-2015 periods.

Butte Creek

For the period 2001-2007, average water year Butte Creek flow into the valley floor was 305 taf[3], as compared to 292 taf on average for the 45-year period from 1971 to 2015 (104 percent of the long term average). In contrast, water year totals in recent drought years have been substantially less, totaling 189, 218, 116, and 125 taf for 2012, 2013, 2014, and 2015, respectively. On average during the recent drought, water year Butte Creek flow has been approximately 53 percent of the 2001-2007 average. Water year flow volumes are shown graphically in Figure 4, along with averages for the 2001-2007 and 1971-2015 periods.

For the period 2001-2007, average April to July Butte Creek flow into the valley floor was 109 taf, as compared to 95 taf on average for the 45-year period from 1971 to 2015 (115 percent of the long term average). In contrast, totals in recent drought years have been substantially less, totaling 84, 46, 37, and 23 taf for 2012, 2013, 2014, and 2015, respectively. On average during the recent drought, April to July Butte Creek flow has been approximately 43 percent of the 2001-2007 average. April to July flow volumes are shown graphically in Figure 5, along with averages for the 2001-2007 and 1971-2015 periods.

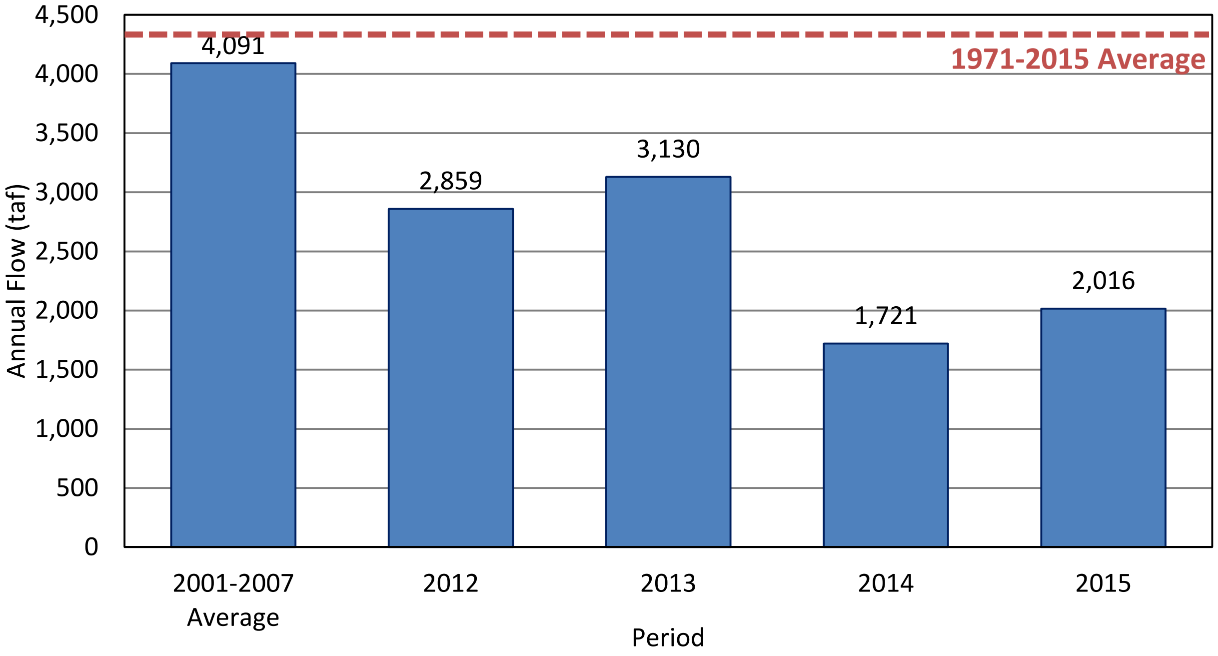

Figure 2. Average Feather River Full Natural Flow for 2001-2007 and by Water Year for 2012-2015 Drought Period.

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[3] taf = thousand acre-feet

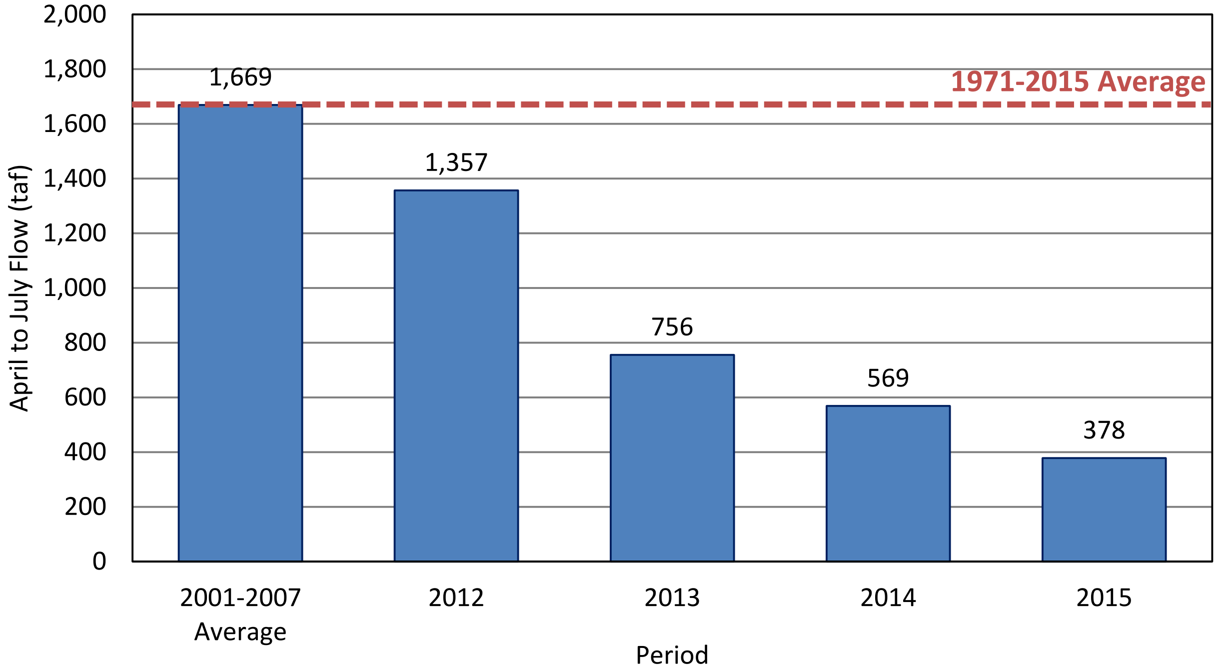

Figure 3. Average Feather River April-July Full Natural Flow for 2001-2007 and each April-July for 2012-2015 Drought Period.

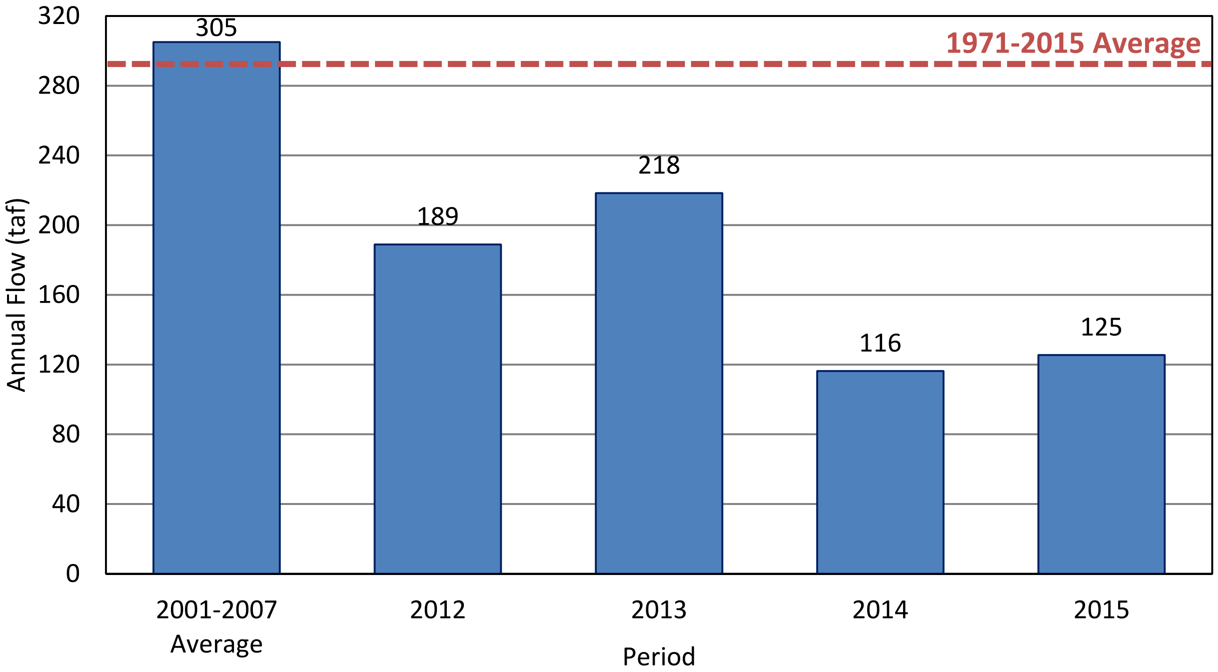

Figure 4. Average Butte Creek Flow for 2001-2007 and by Water Year for 2012-2015 Drought Period.

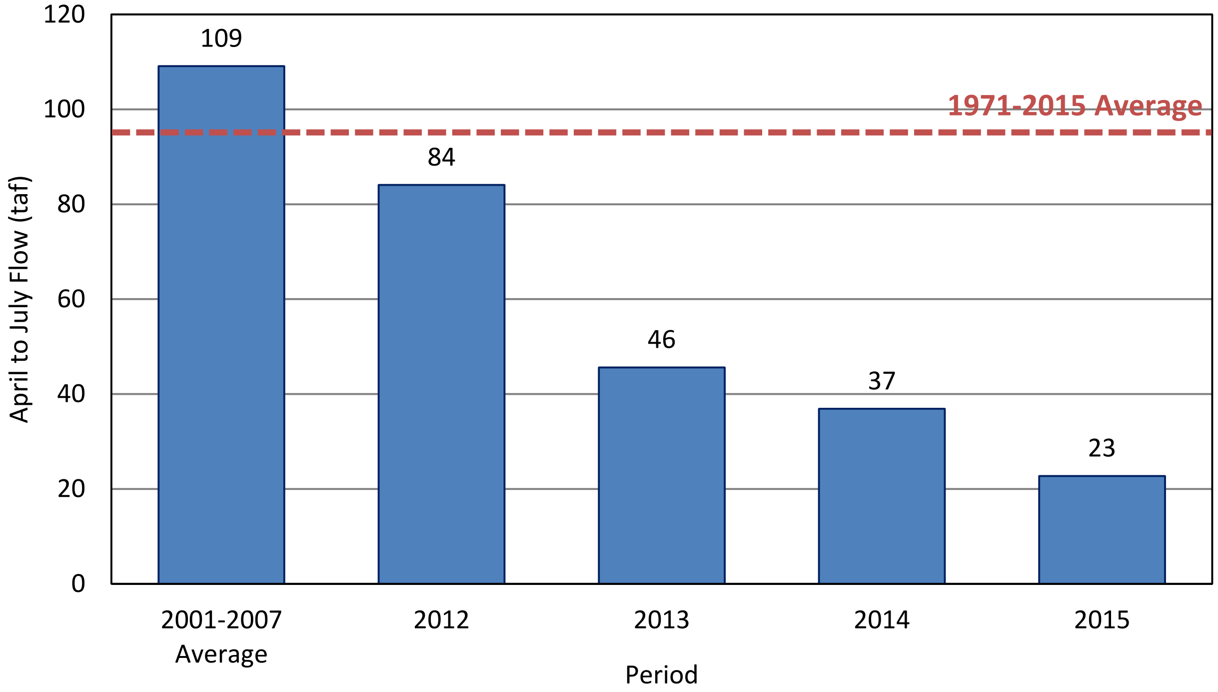

Figure 5. Average Butte Creek April-July Flow for 2001-2007 and each April-July for 2012-2015 Drought Period.

Comparison of Irrigated Land Use between Baseline Period and Recent Drought Years

Irrigated land uses between the 2001-2007 baseline period and 2012-2015 drought years are summarized based on land use surveys conducted by the Department of Water Resources and agricultural commissioner crop report data. Changes in land use influence irrigation demands and have the potential to mediate or exacerbate the effects of drought. As demonstrated below, changes in irrigated land use are not likely to have substantially affected water demands between the baseline and drought period. Irrigated land uses are summarized for the County as a whole and for two general areas within the County. These are the Feather River Settlement Contracts (FRSC) area, which is primarily supplied with surface water from Lake Oroville via Thermalito Afterbay and consists of rice, and other "mixed supply" areas, which are primarily supplied with groundwater and consist of orchards but have access to surface water in some cases (Figure 6[4]). The FRSC area includes the following subinventory units from the WI&A: Biggs-West Gridley, Butte, Butte Sink, Richvale, and Western Canal. The "Mixed Supply" area includes the following subinventory units from the WI&A: Angel Slough, Cherokee, Durham/Dayton, Esquon, Llano Seco, M&T, North Yuba, Pentz, Thermalito, and Vina.

As indicated in Figure 7, irrigated acreage in Butte County averaged approximately 248 thousand acres between 2001 and 2007, and varied between approximately 233 and 257 thousand acres during the 2012 to 2015 drought period, averaging 241 thousand acres (97 percent of the 2001-2007 average)[5]. Reduced acreages in 2012, 2014, and 2015 (as compared to 2013 and the 2001-2007 baseline period)

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[4] Figure 6 additionally identifies the Foothill area, which does not contain significant irrigated cropland but is an area of potential recharge from percolation of precipitation.

[5] In contrast to the "irrigated agriculture" land use category described in the 2016 Water Inventory and Analysis report, irrigated acreage quantified as part of this drought impacts assessment includes managed wetlands and excludes acres associated with temporary idling of cropland.

are primarily the result of idling of rice for water transfers (2012 and 2014) and fallowing due to reduced surface water supplies (2015). These reductions are more clearly demonstrated in Figure 8, which includes only the FRSC area.

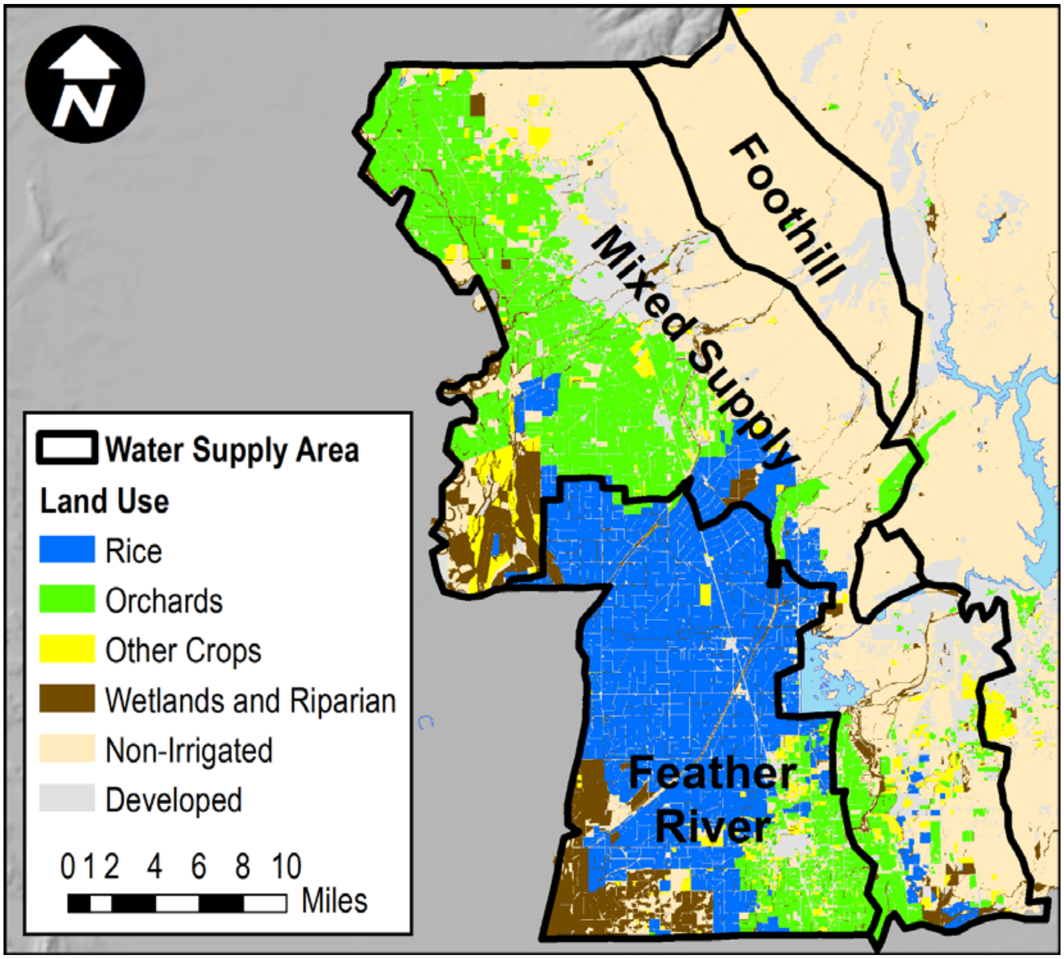

Figure 6. Butte County Feather River, Mixed Supply, and Foothill Areas.

As indicated in Figure 9, irrigated acreage in Butte County outside of the FRSC area (the "Mixed Supply" area) was relatively similar between the baseline and drought periods. Comparing 2014 and 2015 to the baseline period, there has been some reduction in rice acreage and acreage of other, non-permanent crops.

All else equal, changes in irrigated land use between the baseline period and recent drought years are not likely to have greatly influenced irrigation demands. Rather, drought effects such as decreased precipitation and streamflows are likely to have a greater effect. One possible exception is 2013, a year in which the rice acreage was almost fully planted due to no crop idling based water transfers or curtailed Feather River water supplies in the FRSC area.

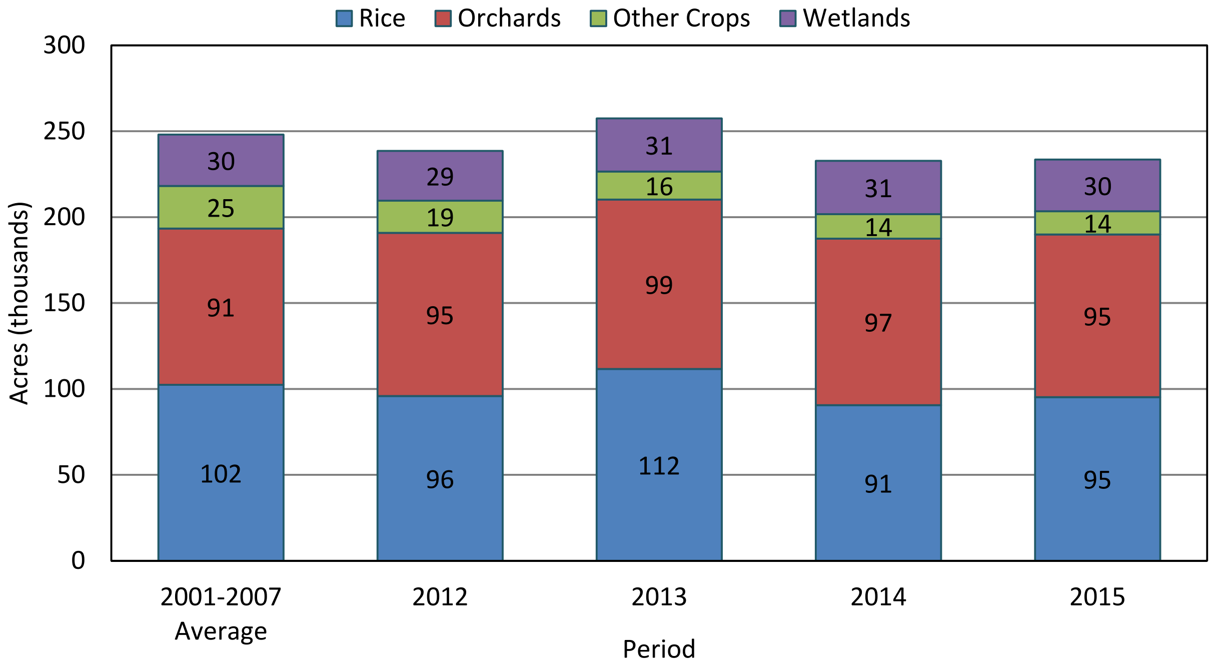

Figure 7. Butte County Irrigated Land Uses for 2001-2007 and by Water Year for 2012-2015 Drought Period.

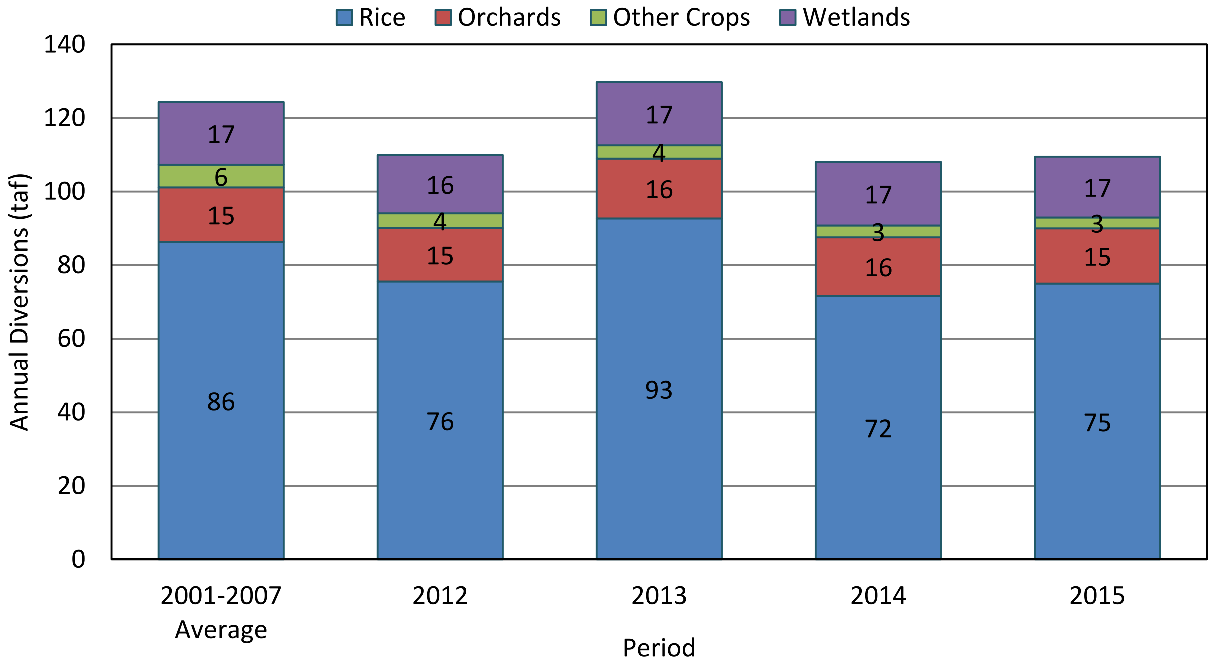

Figure 8. Butte County FRSC Area Irrigated Land Uses for 2001-2007 and by Water Year for 2012-2015 Drought Period.

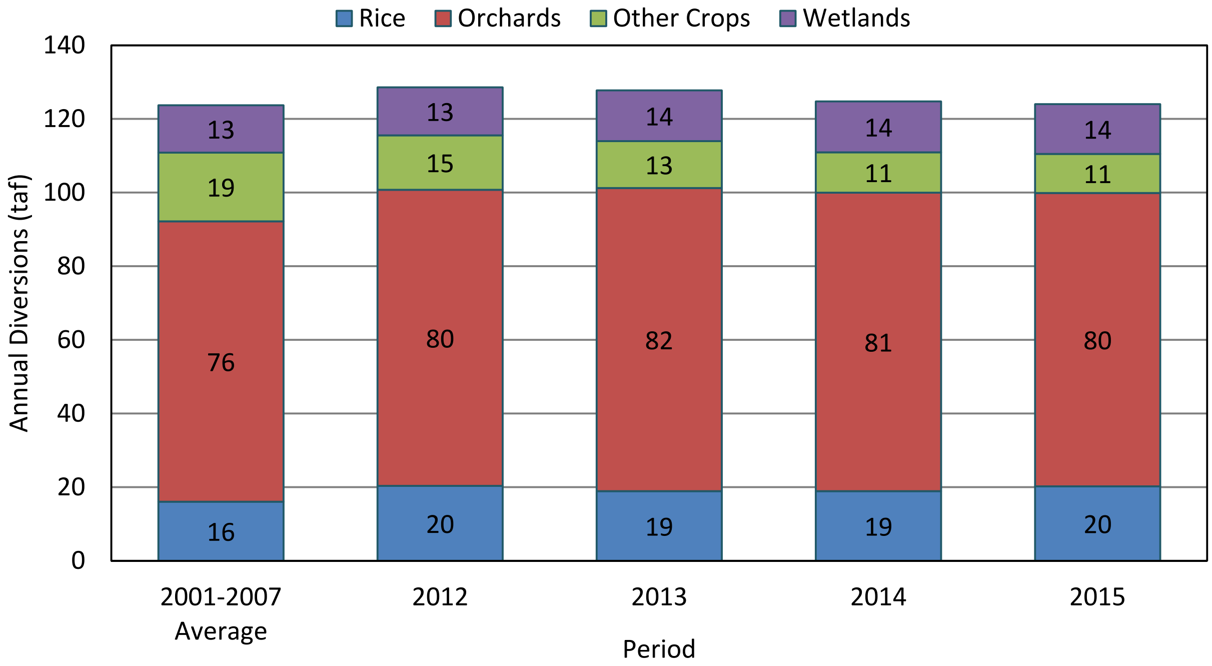

Figure 9. Butte County Mixed Supply Area Irrigated Land Uses for 2001-2007 and by Water Year for 2012-2015 Drought Period.

Irrigation Water Supplies

Reliance on surface water and groundwater supplies for irrigation between the baseline and drought period are summarized below. For surface water supplies, County-wide estimates of diversions for irrigation are summarized, and then divided based on supply source, including the Feather River, Butte Creek, the Sacramento River, and other sources[6]. For groundwater pumping, County-wide estimates are presented, and then shown for the FRSC area relying primarily on surface water for irrigation and the remaining areas of the County relying primarily on groundwater for irrigation.

Surface Water Supplies

As indicated in Figure 10, surface water supplies in 2012 and 2013 were similar to the baseline period, with estimated diversions of 766 and 785 taf in 2012 and 2013, respectively, and 792 taf for the baseline period (2001-2007). Estimated diversions were less in 2014 and 2015, at 692 and 431 taf, respectively. Overall, surface water supplies averaged 669 taf annually between 2012 and 2015, or 84 percent of diversions during the baseline period. Surface water supplies were 87 and 54 percent of the average for the baseline period in 2014 and 2015, respectively. Reduced surface water supplies in 2014 and 2015 result from a combination of factors, including the following:

- Reduced FRSC diversions resulting from idling and reduced fall/winter water use for rice straw decomposition and habitat (2014),
- Curtailment of FRSC surface water supplies (2015), and
- Reduced availability of surface water from Butte Creek during both years.

As demonstrated in Figure 10, the primary source of surface water for irrigation in Butte County is water from the Feather River diverted from the Afterbay to the FRSC area, which has been a relatively reliable

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[6] Other sources include miscellaneous riparian diversions and surface water supplies from the Feather River watershed other than the Feather River Settlement Contractors (e.g., South Feather Water and Power).

source of water during the recent drought. Substantial reductions in this supply occurred in 2014 and 2015 for the reasons stated above. Similar reductions occurred in Butte Creek due to reduced water availability and curtailment of diversions. Supplies from Butte Creek are relatively sensitive to drought, with supplies from the Sacramento River and other sources being more reliable.

Estimates of historical diversions are subject to uncertainty. In particular, estimates for 2015 for Butte Creek, the Sacramento River, and other sources should be considered provisional. Diversions from the Feather River for the FRSC area are based on reported values.

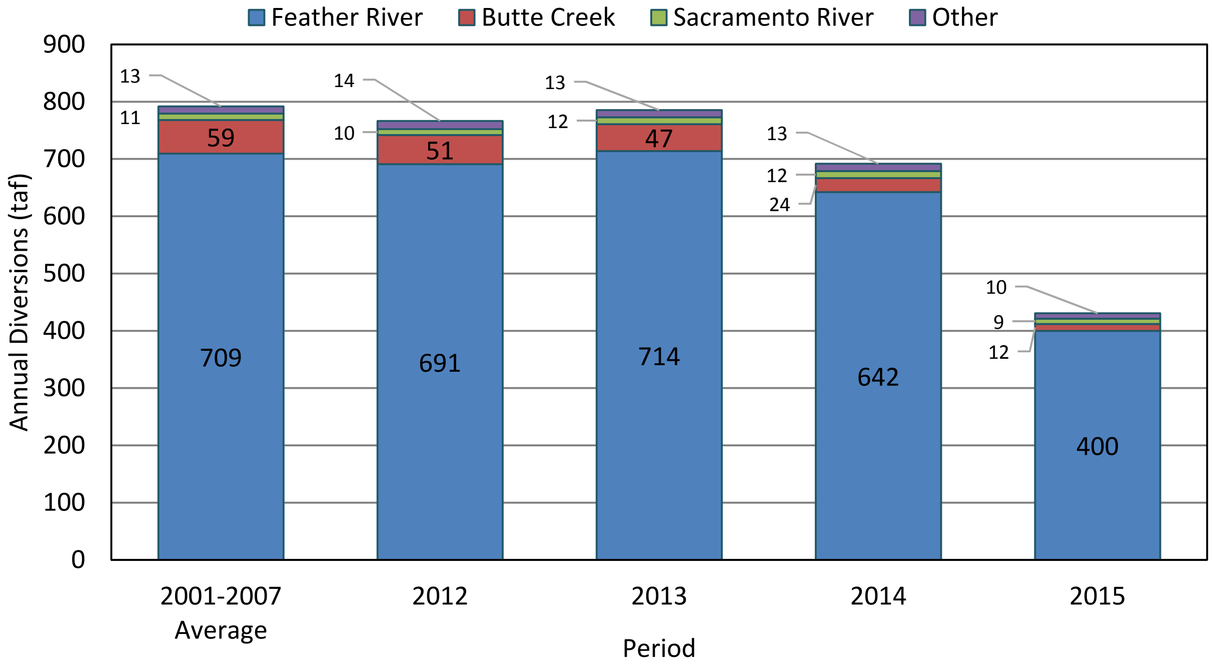

Figure 10. Butte County Surface Water Diversions for 2001-2007 and by Water Year for 2012-2015 Drought Period by Water Source.

Groundwater Pumping

Groundwater pumping in this analysis is estimated based on the difference between estimated agricultural irrigation demands and available surface water to meet those demands. Irrigation demands not met by surface water diversions are assumed to be met by groundwater. Irrigation demands have been estimated using the IDC component of the BBGM. As indicated in Figure 11, estimates of groundwater pumping for irrigation averaged approximately 365 taf during the baseline period and increased during the recent drought period to 385, 398, 438, and 592 taf in 2012, 2013, 2014, and 2015, respectively. Average pumping between 2012 and 2015 was approximately 453 taf, or 124 percent of the average for the baseline period. As illustrated in Figure 12, the increase in groundwater as a source of irrigation supply in 2015 relative to 2014 of approximately 154 taf resulted primarily from increased pumping in the FRSC area (126 taf greater than in 2014), which is primarily due to curtailment of available surface water supplies. By comparison in Figure 13, reliance on groundwater as a source of supply increased in the Mixed Supply area of the County from approximately 344 taf in the 2001 to 2007 baseline period to 395 taf on average between 2012 and 2015 (115 percent of the average for the baseline period). Groundwater pumping in the Mixed Supply area is estimated to have been 436 taf in 2015 (127 percent of the baseline period average). This increase is due to a combination of reduced surface water supply and reduced precipitation to meet crop water demands.

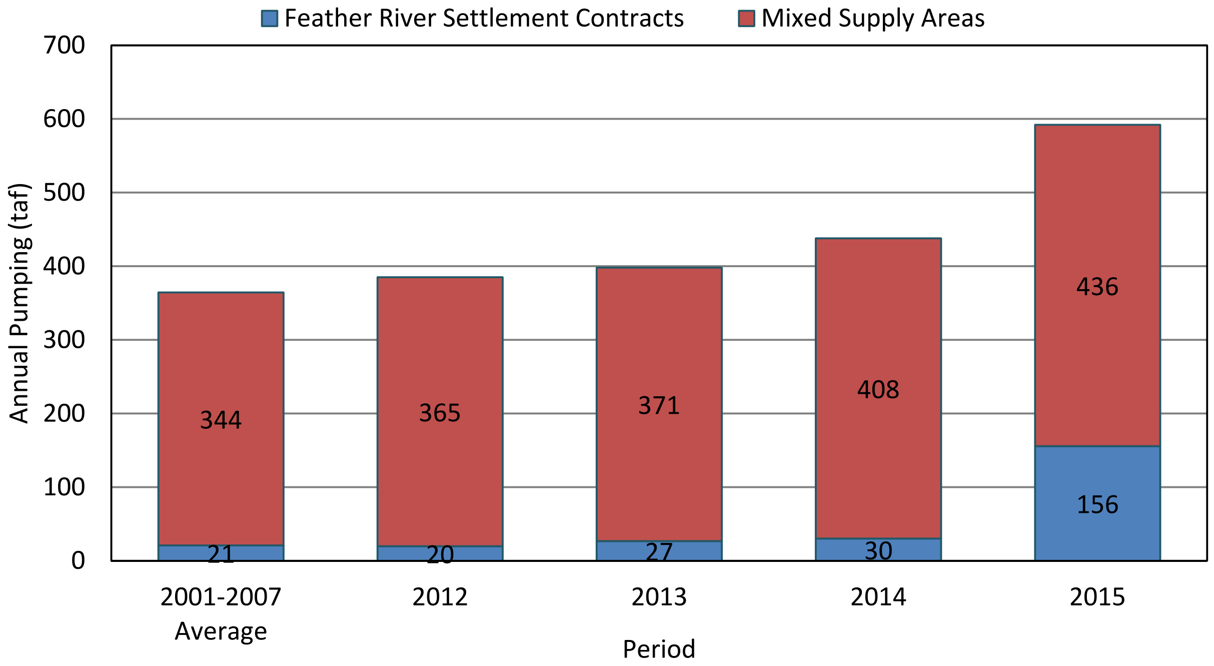

Figure 11. Butte County Estimated Groundwater Pumping for Irrigation for 2001-2007 and by Water Year for 2012-2015 Drought Period.

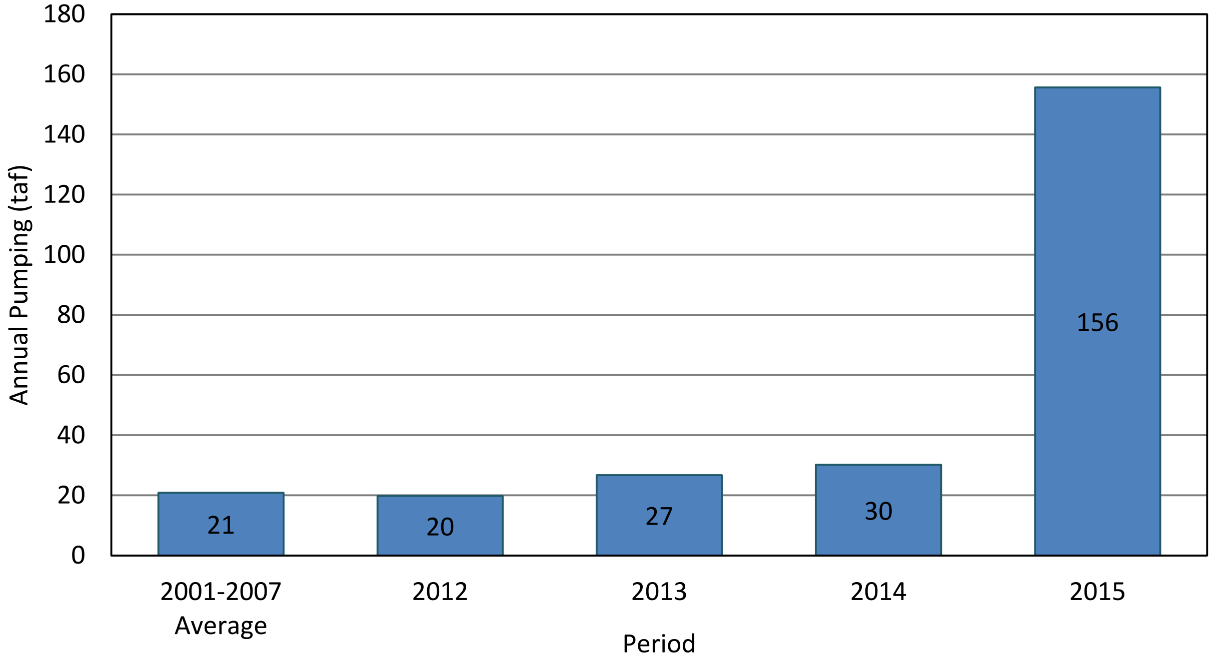

Figure 12. Butte County FRSC Area Estimated Groundwater Pumping for Irrigation for 2001-2007 and by Water Year for 2012-2015 Drought Period.

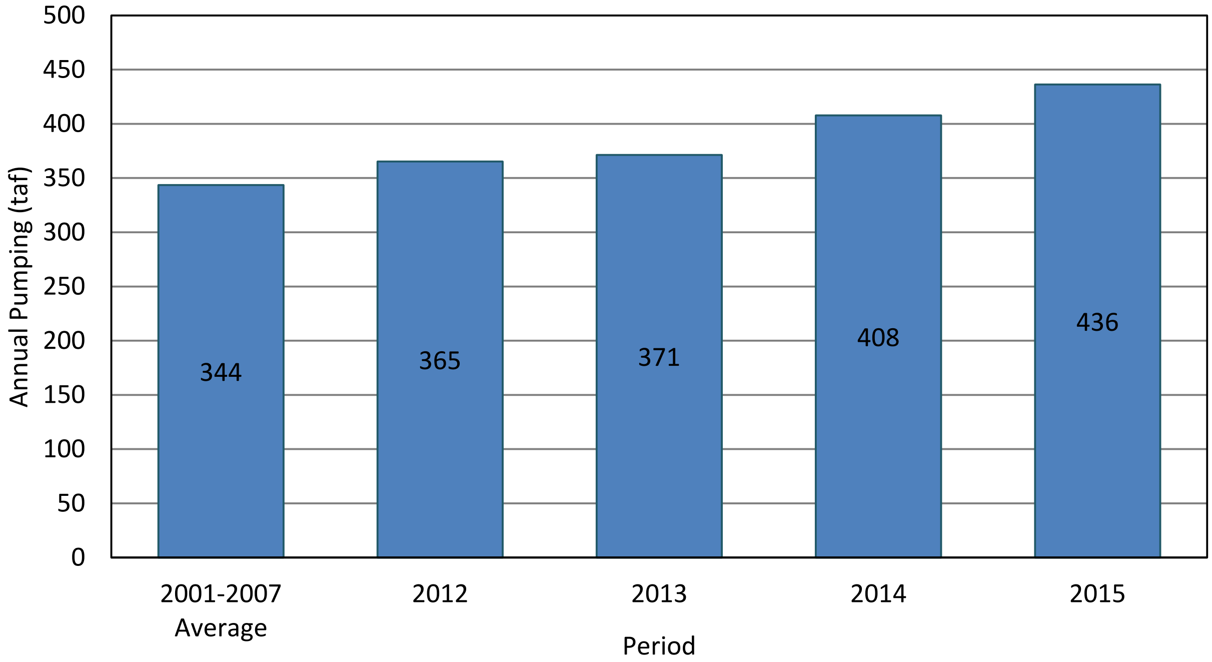

Figure 13. Butte County Mixed Supply Area Estimated Groundwater Pumping for Irrigation for 2001-2007 and by Year for 2012-2015 Drought Period.

Irrigation Demands

Irrigation demands between the baseline and drought period are described below. These demands are estimated using the IDC component of the BBGM. As discussed previously, changes in land use are not believed to have greatly influenced irrigation demands between the baseline and drought periods. As a result, differences in irrigation demands are believed to have resulted primarily from drought impacts on precipitation and available irrigation water supplies. Irrigation demands are evaluated by considering reference evapotranspiration (ET), a measure of atmospheric demand for water as influenced by radiation, temperature, wind speed, and humidity; crop evapotranspiration, which incorporates the influence of reference ET and the actual crops grown; and applied water demands, which incorporate crop ET and considerations of irrigation efficiency to estimate total irrigation requirements. Specifically, annual estimates of reference ET and crop ET between the baseline period and drought period are compared, and monthly estimates of applied water demands for orchard crops between the two periods are compared. The monthly applied water estimates help to illustrate how applied water demands are influenced by drought, particularly with respect to irrigation during the winter and spring.

Reference Evapotranspiration

Reference ET, as estimated based on the California Irrigation Management Information System (CIMIS) weather station at Durham, averaged approximately 50.4 inches between 2001 and 2007 on an annual basis (Figure 14). Between 2012 and 2015, annual reference ET has ranged from 50.1 to 52.9 inches and averaged 51.4 inches (102 percent of the baseline period average). The relatively similar reference ET between the baseline and drought periods indicates that, all else equal, irrigation demands are likely influenced more by reduced precipitation during drought than by other factors related to weather on the valley floor.

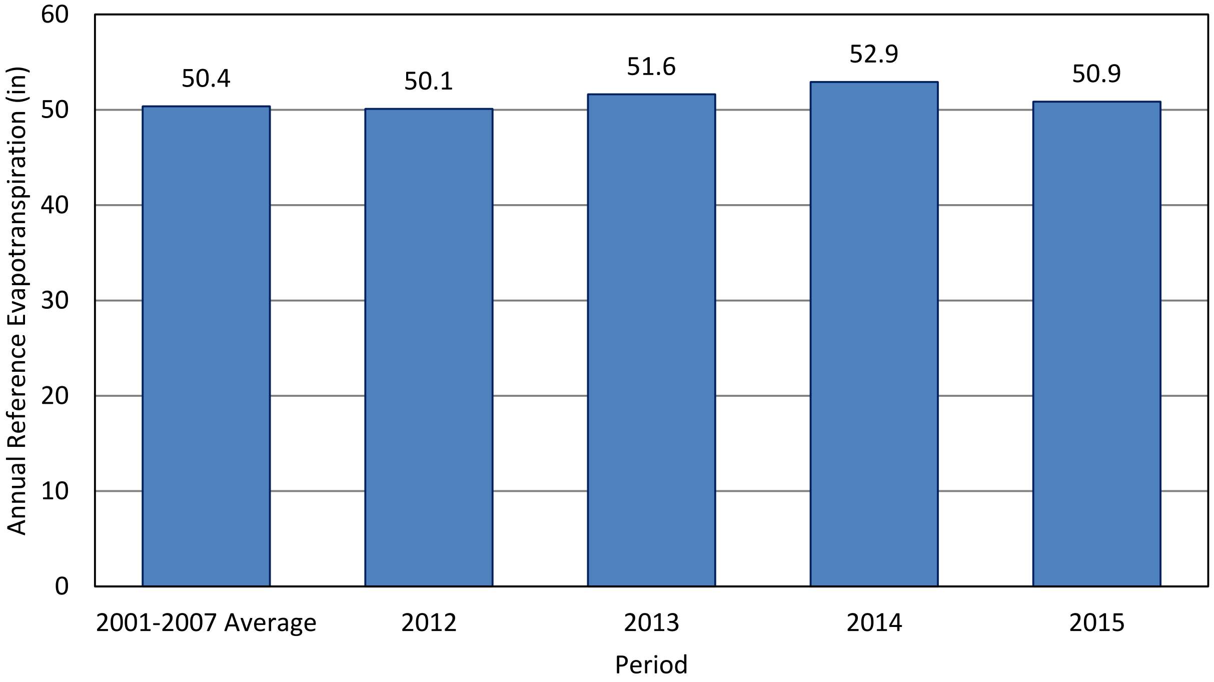

Figure 14. Butte County Estimated Reference Evapotranspiration for 2001-2007 and by Water Year for 2012-2015 Drought Period.

Crop Evapotranspiration

Crop evapotranspiration estimates for Butte County are presented in Figure 15 for the baseline and drought periods. Crop ET is divided into ET of applied water (the amount of ET resulting from irrigation) and ET of precipitation (the amount of ET resulting from precipitation). The ET of applied water provides an estimate of the amount of irrigation water required to produce a crop assuming an irrigation efficiency of 100 percent. In other words, it represents the minimum irrigation requirement (not including frost protection, leaching, or other non-consumptive crop water needs).

As indicated, total crop ET has been somewhat greater during the drought period than the baseline period, with the greatest crop ET occurring in 2013. ET in 2013 was greater than other years primarily due to increased planted acreage during that year. Total crop ET averaged 846 taf annually for the baseline period and ranged from 826 to 914 taf between 2012 and 2015, with an average of 863 taf (102 percent of the baseline period average). ET of applied water averaged 636 taf annually for the baseline period and ranged from 611 to 687 taf between 2012 and 2015, with an average of 653 taf (103 percent of the baseline period average). ET of applied water during the drought period was greater than the baseline period in all years but 2012, reflecting the influence of reduced precipitation on applied water demands.

Figure 16 shows that ET of applied water for the FRSC area was generally less during the drought period than the baseline period (353 taf as compared to 366 taf, or 96 percent of the baseline period average). This is due to the ET of applied water for rice (the primary crop in this area) being relatively insensitive to precipitation and due to reduced acreage during the drought period due to crop idling for transfer and due to curtailment of surface water supplies in 2015. Conversely, ET of applied water increased during the drought period for Mixed Supply areas of the County (300 taf as compared to 269 taf, or 111 percent of the baseline period average) (Figure 17). These areas are dominated by orchards, for which the amount of irrigation required is strongly influenced by precipitation timing and amounts.

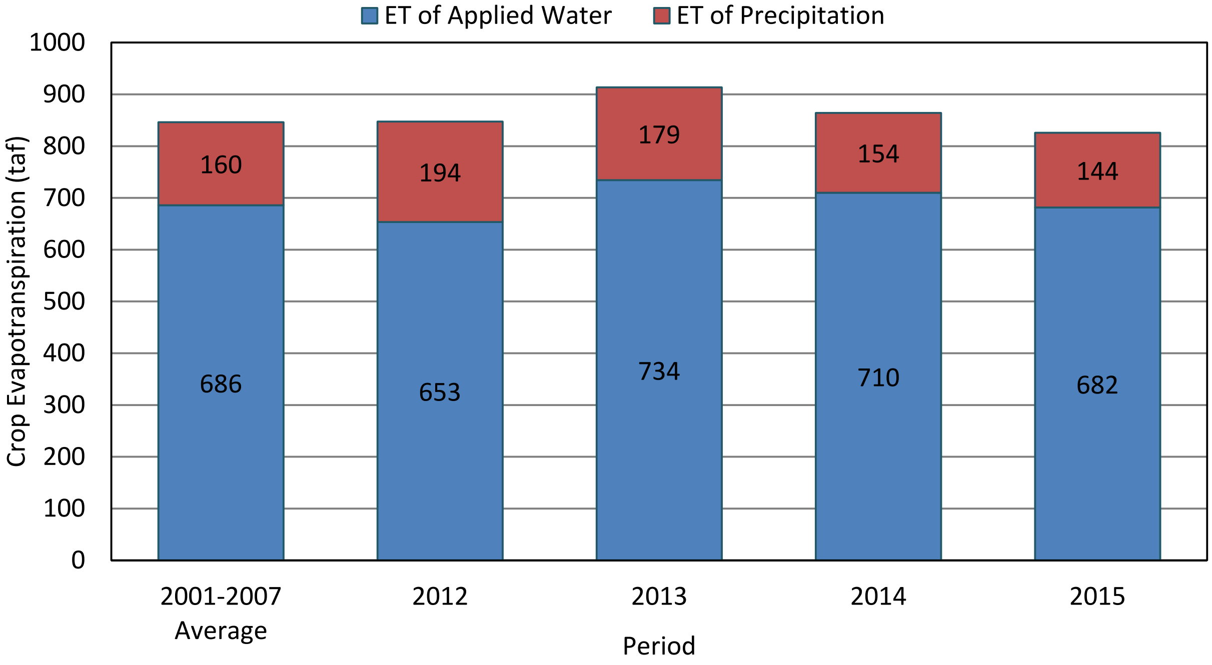

Figure 15. Butte County Estimated Crop Evapotranspiration for 2001-2007 and by Water Year for 2012-2015 Drought Period.

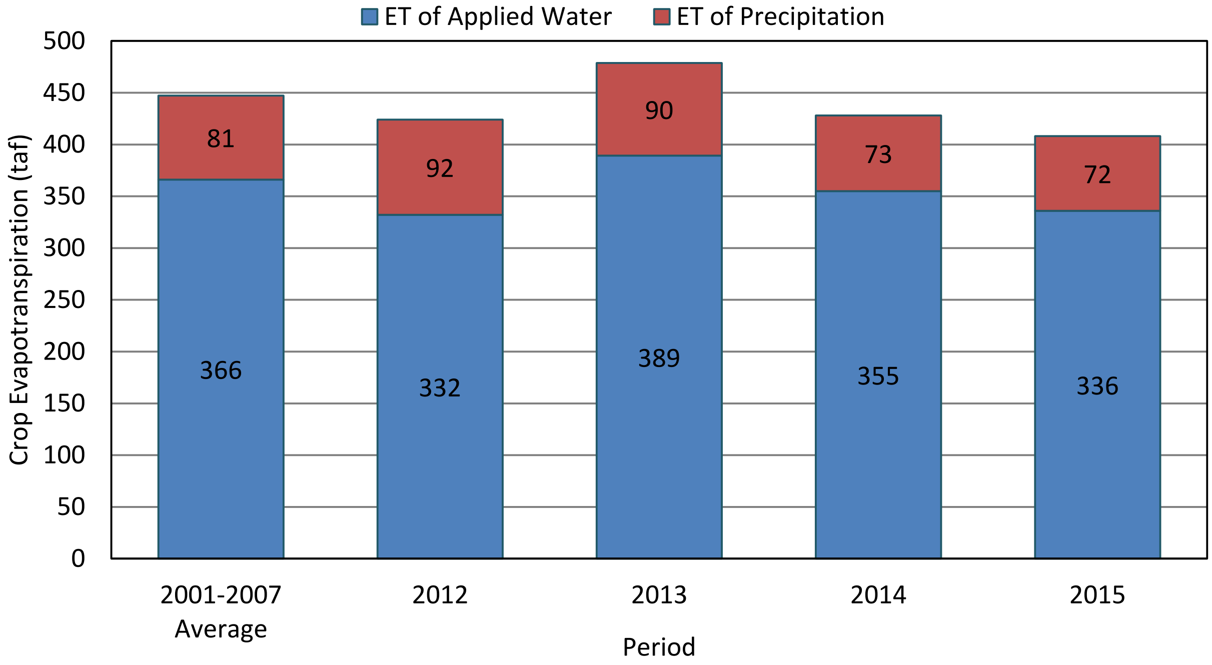

Figure 16. Butte County FRSC Area Estimated Crop Evapotranspiration for 2001-2007 and by Water Year for 2012-2015 Drought Period.

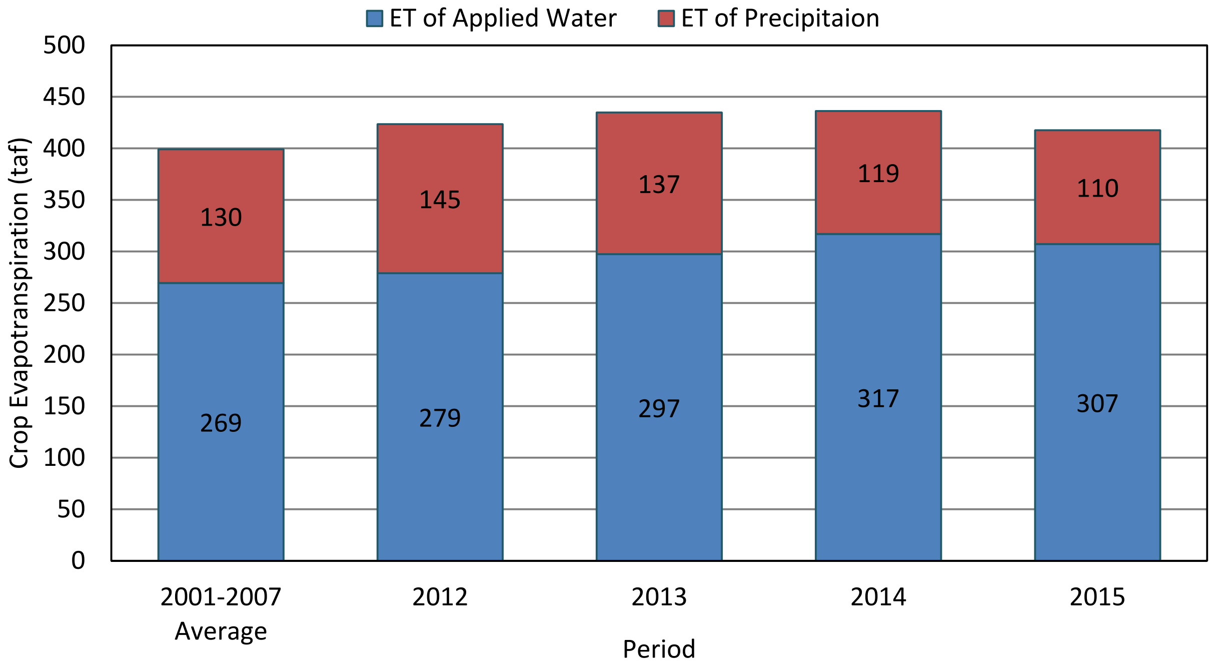

Figure 17. Butte County Mixed Supply Area Estimated Crop Evapotranspiration for 2001-2007 and by Water Year for 2012-2015 Drought Period.

Monthly Applied Water Demands for Orchards

It has been observed that during periods of drought, irrigation of orchards between January and March may occur to supplement precipitation stored in the root zone and support development of the crop canopy. In order to evaluate impacts of drought on orchard water demands, applied water requirements estimated using the BBGM for the 2012 to 2015 drought period have been developed and compared to the 2001 to 2007 baseline period. These estimates are shown in Figure 18, which presents estimated average monthly applied water for orchards for the baseline and drought periods. For each month the estimated applied water, expressed in inches of depth, is shown. As indicated, applied water amounts for orchards during the drought period are greater than the baseline period between January and March, supporting the observation that irrigation is likely to occur during these months in drought years and providing an estimate of the amount of water applied.

On an annual basis, average applied water requirements for orchards were 30.5 inches for the 2001 to 2007 baseline period, as compared to 31.9 inches between 2012 and 2015 (1.4 inches greater). Estimated applied water between October and March was 2.9 inches for the baseline period and 4.4 inches for 2012 to 2015 (1.5 inches greater). This suggests that the primary impact of drought on orchard water demands is to increase irrigation water requirements during the winter period.

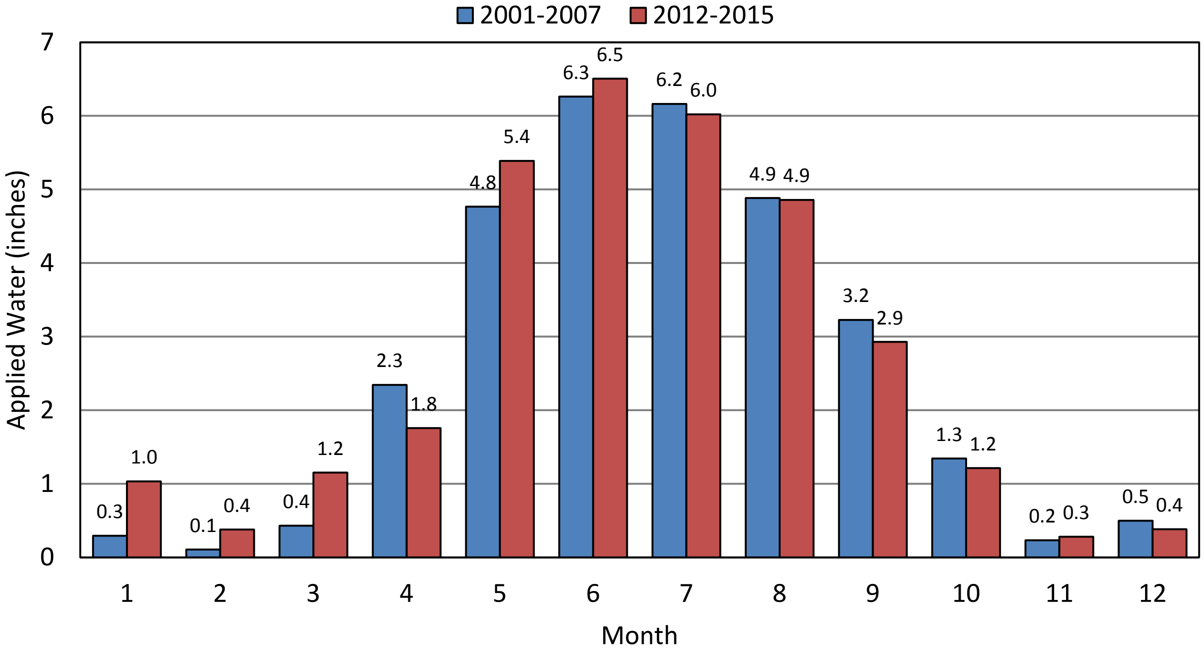

Figure 18. Butte County Orchard Estimated Applied Water for 2001-2007 and for 2012-2015 Drought Period.

To better understand winter orchard demands during drought as compared to baseline conditions, average monthly orchard demands estimated using the BBGM for the months of January, February, and March are summarized in Figure 19 for the 2001-2007 baseline periods and for each year from 2012 to 2015. As indicated, the BBGM suggests that winter orchard applied water demands have been consistently greater between 2012 and 2015 than average demands for the 2001-2007 period and similar for each year, averaging 2.6 inches during the drought, as compared to 0.8 inches for the baseline period. The timing of winter demands estimated by the BBGM differs across drought years, however:

- During 2012, the BBGM predicts substantial irrigation during the months of January and March,
- During 2013, the BBGM predicts substantial irrigation during the months of January and February,
- During 2014, the BBGM predicts substantial irrigation during January, and
- During 2015, the BBGM predicts substantial irrigation during March.

Differences in the timing of winter demands result from differences in timing and amounts of precipitation from prior months and during the January to March period. For example, January and February applied water demands were estimated to be small during 2015, presumably due to substantial precipitation that occurred in December 2014 and February 2015.

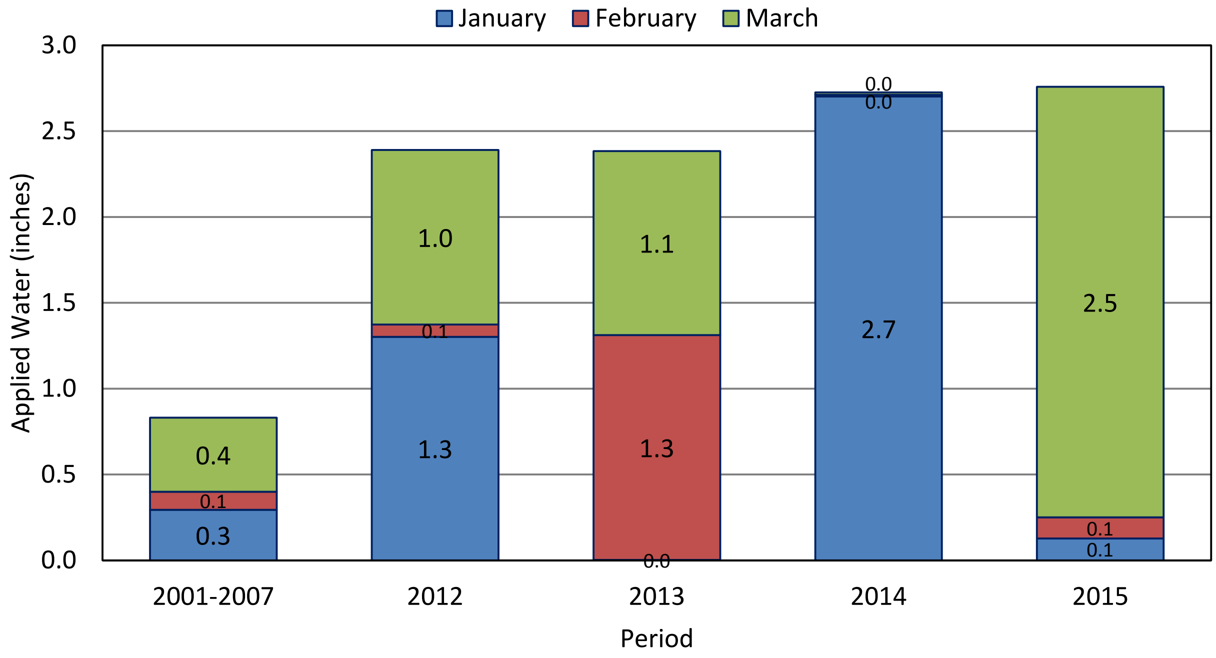

Figure 19. Butte County Orchard Estimated January to March Applied Water by Month for 2001-2007 and for 2012-2015 Drought Period.

Deep Percolation

Deep percolation, or the vertical downward movement of water from the root zone to the underlying groundwater system, is an important source of recharge. Deep percolation results from both precipitation and irrigation processes. In order to understand potential impacts of drought on groundwater recharge, estimates of deep percolation of applied water and deep percolation of precipitation are summarized for the 2001-2007 baseline period and for the 2012-2015 drought period. These estimates were developed using the IDC component of the BBGM.

Deep Percolation of Applied Water

Deep percolation of applied water estimates for Butte County are presented in Figure 20 for the baseline and drought periods. Deep percolation of applied water is divided based on the FRSC and Mixed Supply areas. As indicated, total deep percolation of applied water has been less during the drought period than the baseline period, averaging 195 taf between 2012 and 2015 as compared to 213 taf between 2001 and 2007 (91 percent of the baseline period). For the FRSC area, deep percolation of applied water has also been less during the drought period than the baseline period, averaging 88 taf between 2012 and 2015 as compared to 100 taf between 2001 and 2007 (88 percent of the baseline period). For the Mixed Supply area, deep percolation of applied water has also been less during the drought period than the baseline period, averaging 106 taf between 2012 and 2015 as compared to 113 taf between 2001 and 2007 (95 percent of the baseline period).

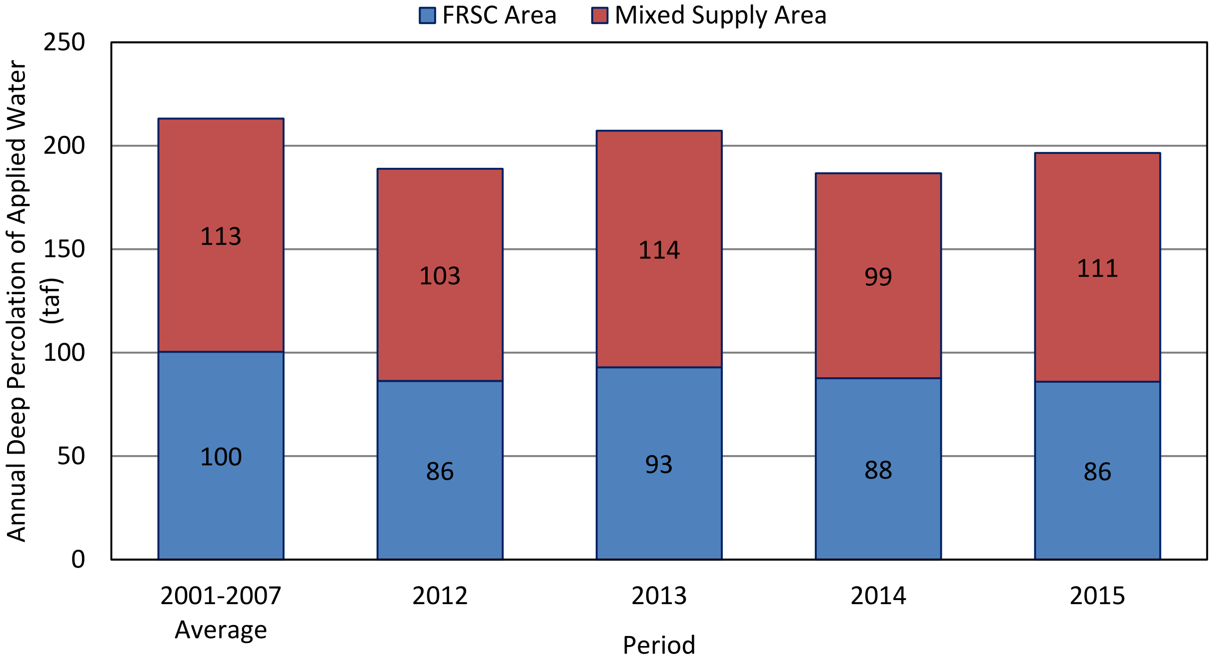

Figure 20. Butte County Estimated Deep Percolation of Applied Water for 2001-2007 and by Water Year for 2012-2015 Drought Period.

Deep Percolation of Precipitation

Deep percolation of precipitation estimates for Butte County are presented in Figure 21 for the baseline and drought periods. Deep percolation of precipitation is divided based on the FRSC and Mixed Supply areas, as well as the Cohasset and Ridge foothill areas, which may be an important source of recharge. For the FRSC and Mixed Supply areas, non-irrigated lands of native vegetation are also included. A substantial portion of the Mixed Supply area includes non-irrigated lands where recharge from deep percolation of precipitation occurs (for example in the Vina subregion).

As indicated in Figure 21, total deep percolation of precipitation has been substantially less during the drought period than the baseline period, averaging 187 taf between 2012 and 2015 as compared to 305 taf between 2001 and 2007 (61 percent of the baseline period). For the FRSC, Mixed Supply, and Foothill areas deep percolation of precipitation was similarly less during the drought period than the baseline period as follows:

- FRSC Area: 18 taf annually between 2012 and 2015, compared to 25 taf between 2001 and 2007 (72 percent of baseline period average)
- Mixed Supply Area: 121 taf annually between 2012 and 2015, compared to 188 taf between 2001 and 2007 (64 percent of baseline period average)
- Foothill Area: 48 taf annually between 2012 and 2015, compared to 92 taf between 2001 and 2007 (52 percent of baseline period average)

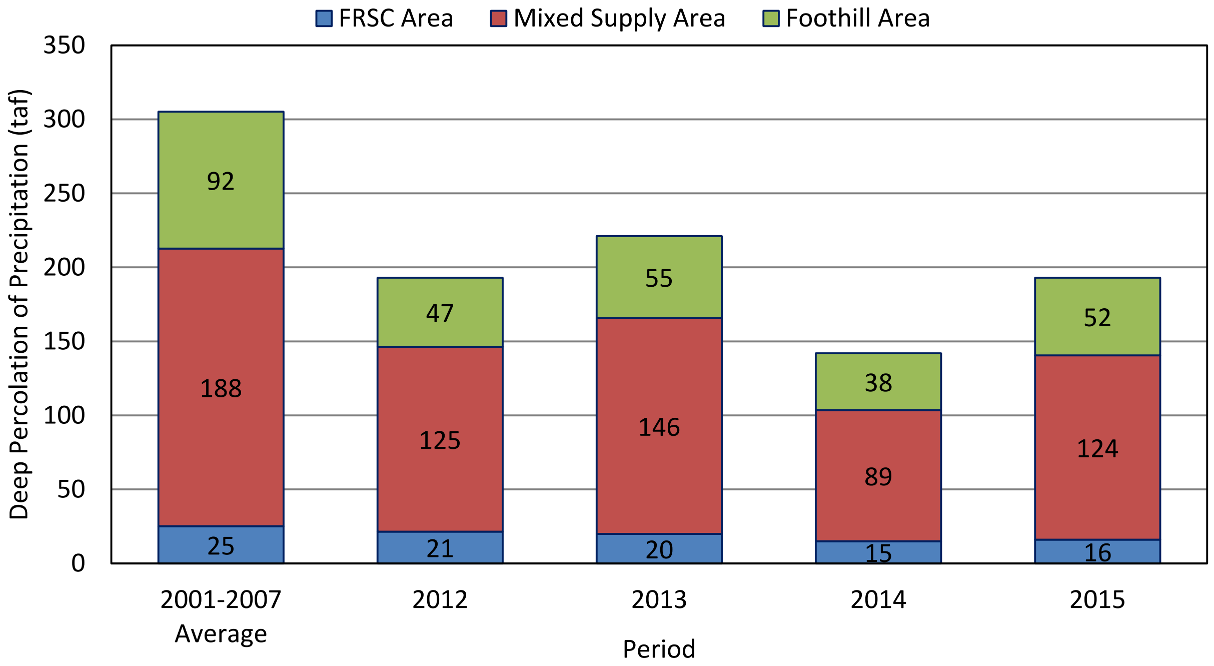

Figure 21. Butte County Estimated Deep Percolation of Precipitation for 2001-2007 and by Water Year for 2012-2015 Drought Period.

Summary

The recent 2012 to 2015 drought period is marked by a reduction in precipitation and surface water supplies, including important spring runoff from snowmelt. Reduced precipitation on the valley floor has led to increased irrigation demands, particularly for non-rice crops, which are more dependent on precipitation to meet irrigation water demands, particularly during the late winter/early spring. The reduction in surface water supplies has led to increased demand for groundwater to meet crop irrigation requirements. This is particularly true for 2015, when Butte Creek water supplies were curtailed and FRSC supplies were curtailed for the first time since 1992. Impacts of the drought are summarized in Table 1 on the following page by providing a comparison of average values for the drought period to the baseline period. For each component of the system considered, the difference and percent difference of the drought period from the baseline period is provided.

Over this same period, groundwater recharge from precipitation in the form of deep percolation of precipitation on irrigated and non-irrigated lands has decreased. The combination of the drought impacts of reduced supplies and reduced recharge from precipitation is that net recharge of the groundwater system has declined during the 2012 to 2015 period, as compared to the 2001 to 2007 baseline period. Additional information describing seepage from and accretions to streams, canals, and drains is needed to fully quantify impacts of drought on groundwater recharge; however observations can be made regarding the impact of drought on net recharge from the irrigated and non-irrigated land surfaces in the County.

Table 1. Comparison of 2012-2015 Drought Period to 2001-2007 Baseline Period for Components of the System Evaluated.

System Component	Period		Difference	
	2001-2007 (Baseline)	2012-2015 (Drought)	Absolute	Percent
Precipitation				
Valley Floor Precipitation (inches)	28.5	23.3	-5.2	-18%
Water Year Streamflows				
Feather River Full Natural Flow (maf)	4.09	2.43	-1.66	-41%
Butte Creek Flow (taf)	305	162	-143	-47%
April-July Streamflows				
Feather River Full Natural Flow (maf)	1.67	0.76	-0.90	-54%
Butte Creek Flow (taf)	109	47	-62	-57%
Irrigated Acres (Thousands)				
FRSC Area	124	114	-10	-8%
Mixed Supply Area	124	126	3	2%
Butte County (Total)	248	241	-7	-3%
Surface Water Supplies (Diversions)				
Lake Oroville (taf)	709	612	-98	-14%
Butte Creek (taf)	59	34	-25	-43%
Sacramento River (taf)	11	11	0	-2%
Other (taf)	13	12	0	-3%
Butte County (Total)	792	669	-123	-16%
Groundwater Pumping				
FRSC Area (taf)	21	58	37	178%
Mixed Supply Area (taf)	344	395	52	15%
Butte County (Total)	364	453	89	24%
Reference Evapotranspiration				
Reference Evapotranspiration (inches)	50.4	51.4	1.0	2%
Crop Evapotranspiration				
FRSC Area (taf)	447	435	-12	-3%
Mixed Supply Area (taf)	399	428	29	7%
Butte County (Total)	846	863	17	2%
Crop Evapotranspiration of Applied Water				
FRSC Area (taf)	366	353	-13	-4%
Mixed Supply Area (taf)	269	300	31	11%
Butte County (Total)	636	653	18	3%
Deep Percolation of Applied Water				
FRSC Area (taf)	100	88	-12	-12%
Mixed Supply Area (taf)	113	107	-6	-5%
Butte County (Total)	213	195	-18	-9%
Deep Percolation of Precipitation				
FRSC Area (taf)	25	18	-7	-28%
Mixed Supply Area (taf)	188	121	-67	-36%
Foothill Area (taf)	92	48	-44	-48%
Butte County (Total)	305	187	-118	-39%

Potential Impacts on Groundwater Recharge

Key components of groundwater recharge are the vertical flows to and from the groundwater system. Flows to the groundwater system include deep percolation of applied water and precipitation. Flows from the groundwater system include groundwater pumping. Other flows include seepage from and accretions to streams, canals, and drains. Despite not accounting for these flows in the current drought assessment, observations can be made about drought impacts on groundwater recharge on irrigated and non-irrigated land surfaces in the County by comparing estimates of deep percolation and groundwater pumping for the 2012 to 2015 drought and 2001 to 2007 baseline periods.

Figure 22 shows county-wide estimates of deep percolation of applied water, deep percolation of precipitation, and groundwater pumping for the baseline period and the years 2012 through 2015. Deep percolation, which represents an inflow to the groundwater system, is shown as a positive number. Groundwater pumping, which represents an outflow from the groundwater system, is shown as a negative number. Additionally, the land surface net recharge (deep percolation minus groundwater pumping) is shown, representing the net recharge occurring from vertical flows into and out of the root zone on irrigated and non-irrigated lands.

As indicated in Figure 22, it is estimated that net recharge from these processes averaged approximately 154 taf during the baseline period, and that net extraction has occurred during the drought, ranging from net recharge of 30 taf to net extraction of 202 taf annually with average net extraction of 71 taf. Thus, it is estimated that the average annual net recharge resulting from deep percolation and groundwater pumping (and not considering stream seepage and accretions) has decreased by approximately 225 taf for the drought period compared to the baseline period.

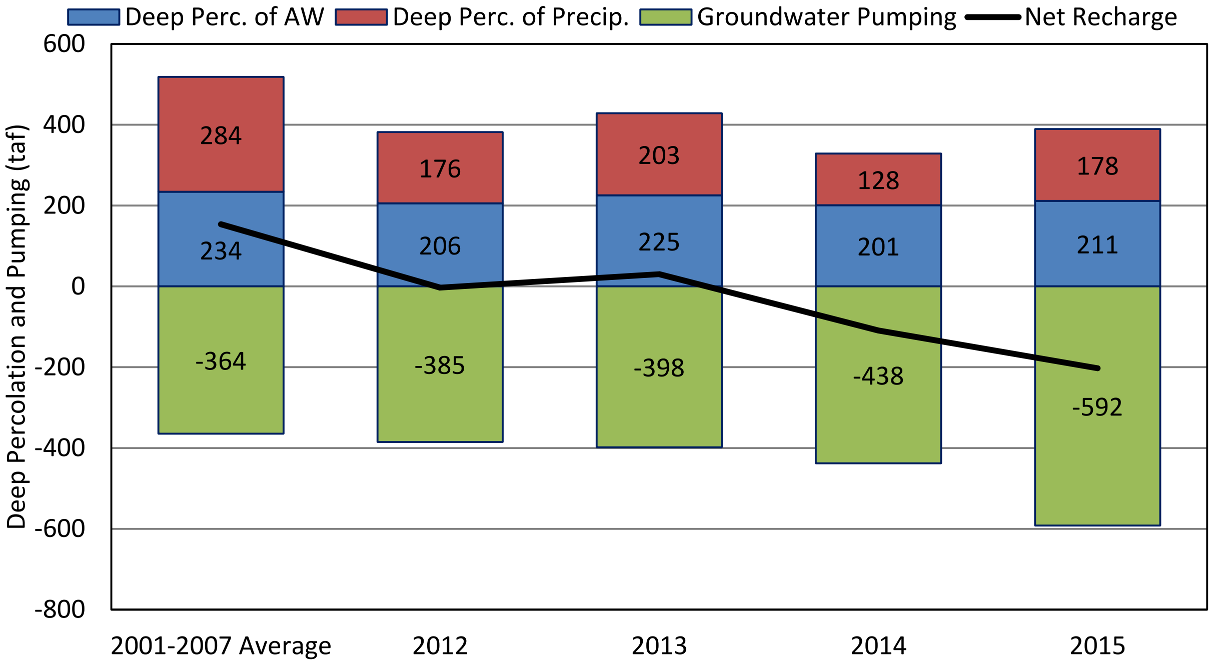

Figure 22. Butte County Estimated Deep Percolation, Groundwater Pumping, and Land Surface Net Recharge (Deep Percolation – Pumping) for 2001-2007 and by Water Year for 2012-2015 Drought Period.

For the FRSC area (Figure 23) it is estimated that net recharge from these processes averaged approximately 105 taf during the baseline period, and that net recharge has decreased during the drought, with net recharge of approximately 88 taf, 86 taf, and 72 taf in 2012, 2013, and 2014, respectively, and net extraction of 54 taf in 2015. During the drought period, net recharge has averaged approximately 48 taf annually. Thus, it is estimated that the average annual net recharge resulting from deep percolation and groundwater pumping (and not considering stream seepage and accretions) has decreased by approximately 56 taf for the drought period compared to the baseline period.

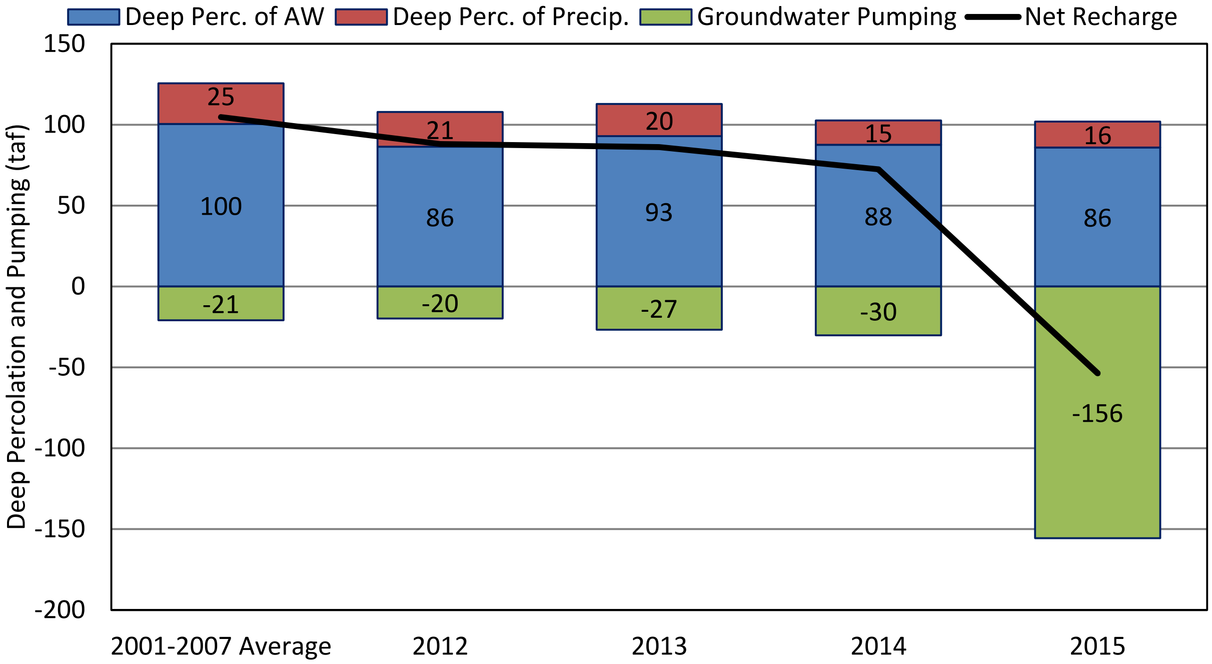

Figure 23. Butte County FRSC Area Estimated Deep Percolation, Groundwater Pumping, and Land Surface Net Recharge (Deep Percolation – Pumping) for 2001-2007 and by Water Year for 2012-2015 Drought Period.

For the Mixed Supply area (Figure 24) it is estimated that net extraction from deep percolation and pumping averaged approximately 43 taf during the baseline period, and that net extraction has increased during the drought, ranging from 111 taf to 220 taf annually and averaging 167 taf. Thus, it is estimated that the average annual net extraction resulting from deep percolation and groundwater pumping (and not considering stream seepage and accretions) has increased by approximately 124 taf for the drought period compared to the baseline period.

For the Foothill area, where deep percolation of applied water and groundwater pumping are essentially zero, it is estimated that net recharge from deep percolation averaged approximately 92 taf during the baseline period, and that net recharge has decreased during the drought, ranging from 38 taf to 55 taf annually and averaging 48 taf (Figure 25). Thus, it is estimated that the average annual net recharge (not considering stream seepage and accretions) has decreased by approximately 44 taf for the drought period compared to the baseline period.

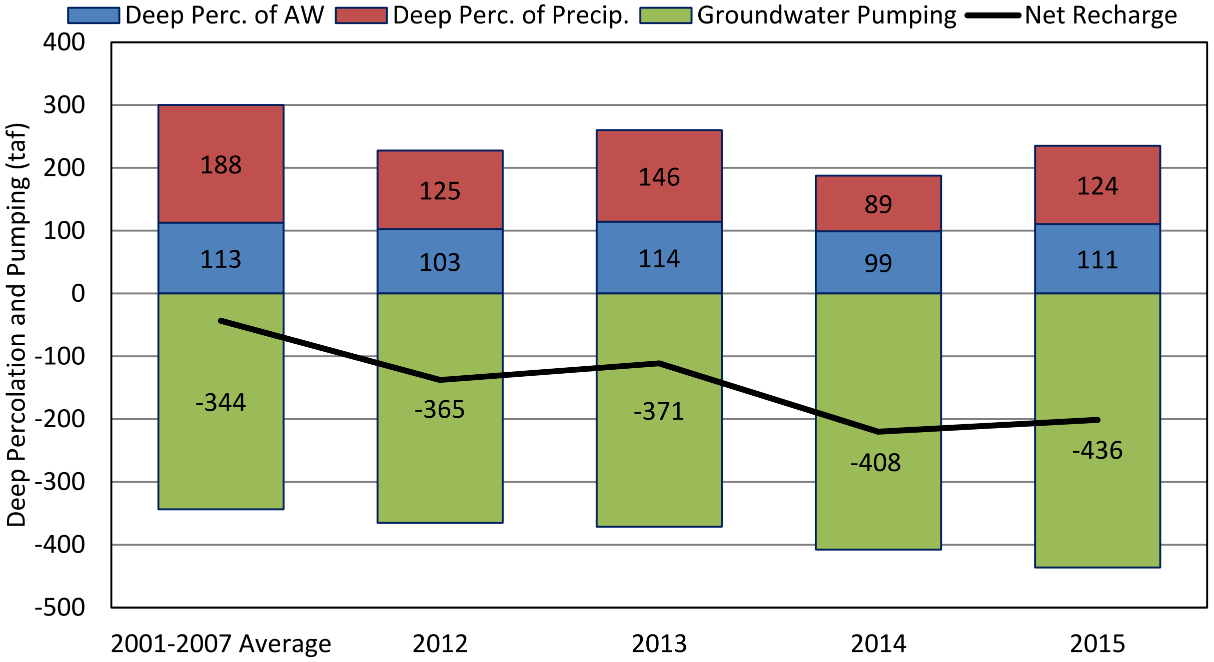

Figure 24. Butte County Mixed Supply Area Estimated Deep Percolation, Groundwater Pumping, and Land Surface Net Recharge (Deep Percolation – Pumping) for 2001-2007 and by Water Year for 2012-2015 Drought Period.

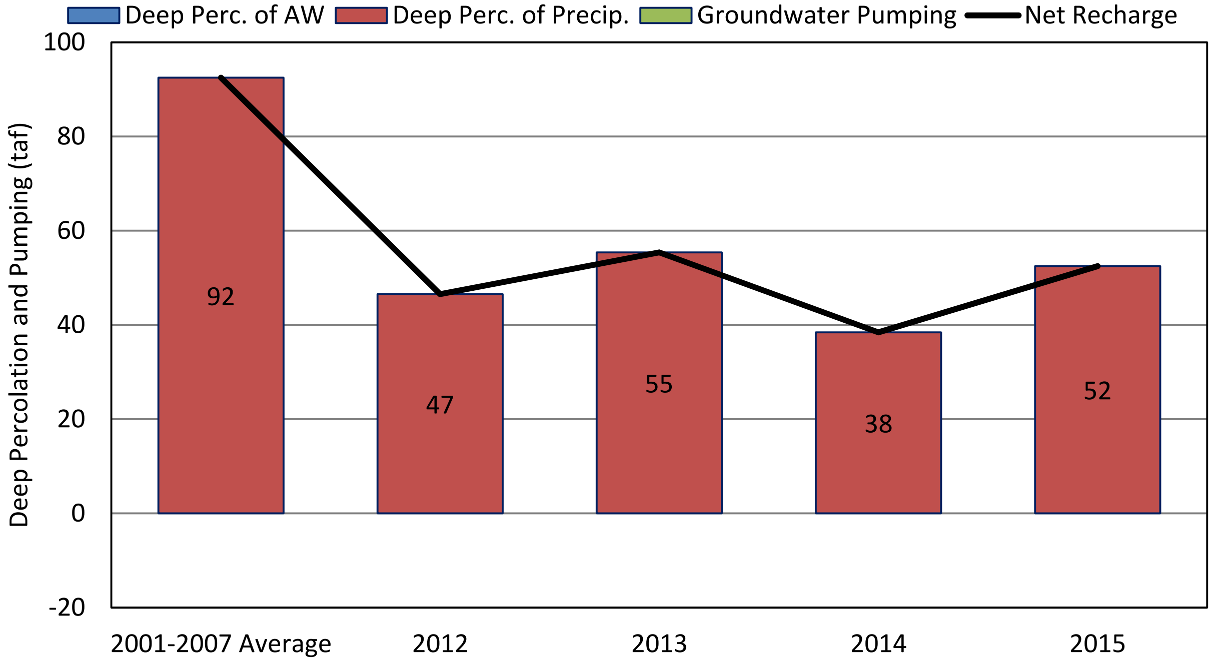

Figure 25. Butte County Foothill Area Estimated Deep Percolation, Groundwater Pumping, and Land Surface Net Recharge (Deep Percolation – Pumping) for 2001-2007 and by Water Year for 2012-2015 Drought Period.

Based on the analysis presented herein, the primary impacts of drought on groundwater recharge are reductions in available surface water supplies, which lead to increased groundwater pumping, and decreased deep percolation of precipitation. Increases in crop irrigation requirements and evapotranspiration of applied water experienced during drought also impact recharge to a lesser extent.

Comparison to Prior Estimates of Drought Impacts

Normal and drought year water supplies and demands were estimated as part of the Butte County Water Inventory and Analysis (WI&A) prepared in 2001. As part of the analysis of agricultural supplies and demands, normal and drought years were defined as follows:

- Normal Year – Cropping pattern, ET rates, and precipitation from 1997
- Drought Year – Cropping pattern and ET rates from 1997; precipitation from 1977

In addition to reducing precipitation to 1977, reductions in surface water supplies and resulting increases in groundwater pumping were estimated.

In order to compare the analysis presented herein to the 2001 WI&A, the following are compared:

- Surface water diversions (compared to surface water "supplies" from the 2001 WI&A),
- Groundwater pumping (compared to groundwater "supplies" from the 2001 WI&A),
- Net recharge of applied water[7]

Surface water diversions were estimated to decrease from 774 taf to 591 taf for the 2001 WI&A between normal and drought years. This represents a decrease of 183 taf, or 24%. For the current analysis, surface water diversions were estimated to decrease from 792 taf to 669 taf between the 2001-2007 average and the 2012-2015 average, a decrease of 123 taf, or 16%. The decrease is less than for the 2001 WI&A analysis in part because in that analysis the drought year is meant to represent a year in which Feather River and other surface water supplies are curtailed. Comparison of the 2001-2007 average (normal year) to 2015 (a curtailment year) suggests a decrease in surface water diversions from 792 taf to 431 taf (361 taf, or 46%).

Groundwater pumping was estimated to increase from 439 taf to 641 taf for the 2001 WI&A between normal and drought years. This represents an increase of 202 taf, or 46%. For the current analysis, groundwater pumping was estimated to increase from 364 taf to 453 taf between the 2001-2007 average and the 2012-2015 average, an increase of 89 taf, or 24%. The increase is less than for the 2001 WI&A analysis in part because in that analysis the drought year is meant to represent a year in which Feather River and other surface water supplies are curtailed. Comparison of the 2001-2007 average (normal year) to 2015 (a curtailment year) suggests an increase in groundwater pumping from 364 taf to 592 taf (228 taf, or 63%).

Net recharge of applied water was estimated to decrease from -281 taf to -419 taf for the 2001 WI&A between normal and drought years. This represents a decrease of 138 taf, or 49%. For the current analysis, net recharge of applied water was estimated to decrease from -151 taf to -258 taf between the 2001-2007 average and the 2012-2015 average, a decrease of 107 taf, or 71%. The decrease is less than for the 2001 WI&A analysis in part because in that analysis the drought year is meant to represent a year in which Feather River and other surface water supplies are curtailed. Comparison of the 2001-2007 average (normal year) to 2015 (a curtailment year) suggests a decrease in net recharge of applied water from -151 taf to -395 taf (244 taf, or 162%).

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[7] Calculated as Deep Percolation of Applied Water – Groundwater Pumping.

Comparison of the current analysis to the 2001 WI&A normal and drought year water supplies and net recharge of applied water shows general agreement: during drought years, surface water diversions decrease, groundwater pumping increases, and net recharge of applied water decrease. Changes in these components of the water balance are reasonably similar, with average changes in hydrology being somewhat less for the comparison of 2012-2015 average conditions to 2001-2007 baseline conditions than for the comparison of 2015 conditions to 2001-2007 baseline conditions. These two comparisons for the current analysis tend to bound (changes are less than and greater than, respectively) the 2001 WI&A.

A limitation of the 2001 WI&A is that cumulative effects of drought are not examined, with a drought year representing a historically rare condition in which Feather River supplies are curtailed. Additionally, the evaluation of net recharge for the 2001 WI&A analysis does not consider deep percolation of precipitation, an important source of recharge. When the focus is narrowed to net recharge of applied water alone, without considering recharge from precipitation, the results have the potential to be misleading, suggesting unsustainable conditions. The current analysis provides a more robust depiction of potential impacts of drought on the groundwater system by accounting for the contribution of precipitation to groundwater recharge and considering cumulative effects of drought across years, including both Feather River full supply and curtailment years. Additional consideration of seepage from and accretions to streams, canals, and drains is needed along with consideration of subsurface boundary inflows and outflows to fully characterize impacts of drought on the groundwater system. These components of the system can be incorporated through future application of the BBGM.