4. Butte Water District

This section of the Feather River Regional AWMP contains plan components specific to Butte Water District (BWD).

4.1 Table of Contents

Contents

4. Butte Water District 4-1
4.1 Table of Contents 4-1
4.2 Introduction 4-3
4.3 Cross-Reference to Requirements of SBx7-7 4-5
4.4 Plan Preparation and Adoption 4-9
4.4.1 Regulatory Compliance 4-9
4.4.2 Public Participation and Adoption 4-9
4.4.3 Regional Coordination 4-9
4.5 Background and Description of Service Area 4-10
4.5.1 History and Organization 4-10
4.5.2 Size and Location of Service Area 4-12
4.5.3 Distribution and Drainage System 4-12
4.5.4 Terrain and Soils 4-19
4.5.5 Climate 4-23
4.5.6 Operating Rules and Regulations 4-24
4.5.7 Water Delivery Measurement and Calculation 4-24
4.5.8 Water Rate Schedules and Billing 4-25
4.5.9 Water Shortage Allocation Policies and Contingency Plan 4-26
4.5.10 Policies Addressing Wasteful Use of Water 4-26
4.6 Inventory of Water Supplies 4-26
4.6.1 Introduction 4-26
4.6.2 Surface Water Supply 4-26
4.6.3 Groundwater Supply 4-27
4.6.4 Other Water Supplies 4-30
4.6.5 Water Quality Monitoring Practices 4-30
4.7 Water Balance 4-31
4.7.1 Overview 4-31
4.7.2 Analytical Approach 4-31
4.7.3 Water Use 4-37
4.7.4 Drainage 4-47
4.7.5 Water Accounting (Summary of Water Balance Results) 4-49
4.8 Climate Change 4-57
4.9 Efficient Water Management Practices and Water Use Efficiency 4-58
4.9.1 Efficient Water Management Practices 4-58

4.9.2 Evaluation of Water Use Efficiency Improvements 4-65
4.10 Attachments 4-75
4.10.1 Public Coordination and Adoption 4-77
4.10.2 Rules and Regulations 4-79
4.10.3 Potential Projects to Enhance Water Management Capabilities 4-87

Tables

Table 4.1. Cross-Reference of Relevant Sections of the California Water Code to BWD 2014 AWMP.5
Table 4.2. Characteristics of Dominant Soils in Butte Water District. 4-20
Table 4.3. Mean Daily Weather Parameters by Month at Durham CIMIS Station (October 1984 to September 2012). 4-24
Table 4.4. Water Balance Flow Paths, Supporting Data, and Estimated Uncertainty. 4-35
Table 4.5. Crop and Idle Acres, 1999-2012. 4-38
Table 6.6. Average Acreages and Annual Evapotranspiration Rates by Crop. 4-42
Table 4.7. Estimated Winter Diversions and Applied Water for Managed Wetlands and Rice Straw Decomposition. 4-43
Table 4.8. Total Groundwater Recharge, 1999-2012. 4-44
Table 4.9. Net Groundwater Recharge, 1999-2012. 4-46
Table 4.10. Crop Idling Water Transfer Volumes, 1999-2012. 4-46
Table 4.11. Estimated Surface Outflow Volumes, 1999-2012. 4-47
Table 6.12. Estimated Tailwater Volumes, 1999-2012. 4-48
Table 4.13. Distribution and Drainage System Annual Water Balance Results, 1999-2012. 4-53
Table 4.14. Farmed Lands Annual Water Balance Results, 1999-2012. 4-53
Table 4.15. EWMP Implementation Status. 4-61
Table 4.16. Summary of WUE Improvements by EWMP. 4-67
Table 4.17. WUE Improvement Categories. 4-71
Table 4.18. Applicability of EWMPs to WUE Improvement Categories. 4-73
Table 4.19. Evaluation of Relative Magnitude of Past and Future WUE Improvements by EWMP. ... 4-74

Figures

Figure 4.1. Organizational Chart. 4-12
Figure 4.2. Boundary Flows and Irrigation and Drainage Facilities. 4-17
Figure 4.3. Water Balance Structure. 4-33
Figure 4.4. Crop and Idle Acres, 1999-2012. 4-38
Figure 4.5. March to September 2009 SEBAL Actual ET. 4-40
Figure 4.6. Average Monthly Consumptive Use of Water. 4-41
Figure 4.7. Conceptualization of Shallow Groundwater Interception in Rice Growing Areas 4-45
Figure 4.8. District Water Balance 1999-2012. 4-50
Figure 4.9. Average Monthly Inflows, 1999-2012. 4-51
Figure 4.10. Average Monthly Outflows, 1999-2012. 4-52

4.2 Introduction

This 2016 Agricultural Water Management Plan (AWMP) update has been prepared in accordance with the requirements of the Water Conservation Act of 2009 (SBx7-7) and Executive Order B-29-15, issued April 1, 2015. As an agricultural water supplier in Butte County and Sutter County, BWD works to ensure the long term reliability, quality, and affordability of local surface water and groundwater supplies. Development of this AWMP represents a substantial effort by BWD to evaluate its water management activities, including the development of detailed water balances spanning the period from 1999 to 2014. Additionally, BWD has evaluated the implementation of the full range of Efficient Water Management Practices (EWMPs) described in SBx7-7 with respect to its water management objectives and activities and has evaluated resulting Water Use Efficiency (WUE) improvements.

The AWMP includes the following:

- Cross-reference of plan components to requirements of SBx7-7 and Executive Order B-29-15,
- Description of the process to prepare and adopt the plan,
- Background and description of the service area,
- Inventory of water supplies,
- Water balance analysis of historical water use,
- Evaluation of potential climate change impacts and adaptation strategies,
- Evaluation of water management activities and opportunities related to EWMPs and WUE improvements

BWD has participated in several local, regional, and statewide water management activities, as described throughout this AWMP. BWD previously prepared an SBx7-7 compliant AWMP in 2014.

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4.3 Cross-Reference to Requirements of SBx7-7

Table 4.1 provides a cross-reference of the requirements of the California Water Code (CWC) to the AWMP sections contained herein.

Table 4.1. Cross-Reference of Relevant Sections of the California Water Code and Executive Order B-29-15 to BWD 2015 AWMP.

California Water Code, Division 6, Part 2.55. Sustainable Water Use and Demand Reduction

Chapter 4. Agricultural Water Suppliers				
Division	Subdivision	Paragraph	Code Language	Applicable AWMP Section(s)
10608.48	(a)		On or before July 31, 2012, an agricultural water supplier shall implement efficient water management practices pursuant to subdivisions (b) and (c).	**II.4.9.1**
	(b)		Agricultural water suppliers shall implement all of the following critical efficient management practices:	(see below)
		(1)	Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2)	**II.4.9.1, II.4.5.7**
		(2)	Adopt a pricing structure for water customers based at least in part on quantity delivered.	**II.4.5.8, II.4.9.1**
	(c)		Agricultural water suppliers shall implement additional efficient management practices, including, but not limited to, practices to accomplish all of the following, if the measures are locally cost effective and technically feasible:	(see below)
		(1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	**II.4.9.1**
		(2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	**II.4.9.1**
		(3)	Facilitate the financing of capital improvements for on-farm irrigation systems.	**II.4.9.1**
		(4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at the farm level. (B) Conjunctive use of groundwater. (C) Appropriate increase of groundwater recharge. (D) Reduction in problem drainage. (E) Improved management of environmental resources. (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	**II.4.9.1**
		(5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance, and reduce seepage.	**II.4.9.1**
		(6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	**II.4.9.1**
		(7)	Construct and operate supplier spill and tailwater recovery systems.	**II.4.9.1**
		(8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area.	**II.4.9.1**
		(9)	Automate canal control structures.	**II.4.9.1**
		(10)	Facilitate or promote customer pump testing and evaluation.	**II.4.9.1**
		(11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.	**II.4.9.1**
		(12)	Provide for the availability of water management services to water users. These services may include, but are not limited to, all of the following: (A) On-farm irrigation and drainage system evaluations. (B) Normal year and real-time irrigation scheduling and crop evapotranspiration information. (C) Surface water, groundwater, and drainage water quantity and quality data. (D) Agricultural water management educational programs and materials for farmers, staff, and the public.	**II.4.9.1**
		(13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	**II.4.9.1**
		(14)	Evaluate and improve the efficiencies of the supplier's pumps.	**II.4.9.1**
10608.48	(d)		Agricultural water suppliers shall include in the agricultural water management plans required pursuant to Part 2.8 (commencing with Section 10800) a report on which efficient water management practices have been implemented and are planned to be implemented, an estimate of the water use efficiency improvements that have occurred since the last report, and an estimate of the water use efficiency improvements estimated to occur five and 10 years in the future. If an agricultural water supplier determines that an efficient water management practice is not locally cost effective or technically feasible, the supplier shall submit information documenting that determination.	**II.4.9.1, II.4.9.2**

California Water Code, Division 6, Part 2.8. Agricultural Water Management Planning

Chapter 3. Agricultural Water Management Plans
Article 1. General Provisions

Division	Subdivision	Paragraph	Code Language	Applicable AWMP Section(s)
10820	(a)		An agricultural water supplier shall prepare and adopt an agricultural water management plan in the manner set forth in this chapter on or before December 31, 2012, and shall update that plan on December 31, 2015, and on or before December 31 every five years thereafter.	**II.4.2, II.4.4, II.4.10.1**
10821	(a)		An agricultural water supplier required to prepare a plan pursuant to this part shall notify each city or county within which the supplier provides water supplies that the agricultural water supplier will be preparing the plan or reviewing the plan and considering amendments or changes to the plan. The agricultural water supplier may consult with, and obtain comments from, each city or county that receives notice pursuant to this subdivision.	**II.4.10.1**
	(b)		The amendments to, or changes in, the plan shall be adopted and submitted in the manner set forth in Article 3 (commencing with Section 10840).	**II.4.10.1**
Article 2. Contents of Plans				
Division	Subdivision	Paragraph	Code Language	Applicable AWMP Section(s)
10826			An agricultural water management plan shall be adopted in accordance with this chapter. The plan shall do all of the following:	(see below)
	(a)		Describe the agricultural water supplier and the service area, including all of the following:	(see below)
		(1)	Size of the service area.	**II.4.5.2**
		(2)	Location of the service area and its water management facilities.	**II.4.5.3**
		(3)	Terrain and soils.	**II.4.5.4**
		(4)	Climate.	**II.4.5.5**
		(5)	Operating rules and regulations.	**II.4.5.6**
		(6)	Water delivery measurements or calculations.	**II.4.5.7**
		(7)	Water rate schedules and billing.	**II.4.5.8**
		(8)	Water shortage allocation policies.	**II.4.5.9**
10826	(b)		Describe the quantity and quality of water resources of the agricultural water supplier, including all of the following:	(see below)
		(1)	Surface water supply.	**II.4.6.2**
		(2)	Groundwater supply.	**II.4.6.3**
		(3)	Other water supplies.	**II.4.6.4**
		(4)	Source water quality monitoring practices.	**II.4.6.5**
		(5)	Water uses within the agricultural water supplier's service area, including all of the following: (A) Agricultural. (B) Environmental. (C) Recreational. (D) Municipal and industrial. (E) Groundwater recharge. (F) Transfers and exchanges. (G) Other water uses.	**II.4.7.3**
		(6)	Drainage from the water supplier's service area.	**II.4.7.4**
10826	(b)	(7)	Water accounting, including all of the following: (A) Quantifying the water supplier's water supplies. (B) Tabulating water uses. (C) Overall water budget.	**II.4.7.5**
		(8)	Water supply reliability.	**II.4.5.9**
	(c)		Include an analysis, based on available information, of the effect of climate change on future water supplies.	**II.4.8**
	(d)		Describe previous water management activities.	**II.4.2, II.4.5, II.4.6, II.4.9**
	(e)		Include in the plan the water use efficiency information required pursuant to Section 10608.48.	**II.4.9.2**
Article 3. Adoption and Implementation of Plans				
Division	Subdivision	Paragraph	Code Language	Applicable AWMP Section(s)
10841			Prior to adopting a plan, the agricultural water supplier shall make the proposed plan available for public inspection, and shall hold a public hearing on the plan. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned agricultural water supplier pursuant to Section 6066 of the Government Code. A privately owned agricultural water supplier shall provide an equivalent notice within its service area and shall provide a reasonably equivalent opportunity that would otherwise be afforded through a public hearing process for interested parties to provide input on the plan. After the hearing, the plan shall be adopted as prepared or as modified during or after the hearing.	**II.4.10.1**

10842			An agricultural water supplier shall implement the plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan, as determined by the governing body of the agricultural water supplier.	**II.4.9**
10843	(a)		An agricultural water supplier shall submit to the entities identified in subdivision (b) a copy of its plan no later than 30 days after the adoption of the plan. Copies of amendments or changes to the plans shall be submitted to the entities identified in subdivision (b) within 30 days after the adoption of the amendments or changes.	**II.4.10.1**
	(b)		An agricultural water supplier shall submit a copy of its plan and amendments or changes to the plan to each of the following entities:	(see below)
		(1)	The department.	**II.4.10.1**
		(2)	Any city, county, or city and county within which the agricultural water supplier provides water supplies.	**II.4.10.1**
		(3)	Any groundwater management entity within which jurisdiction the agricultural water supplier extracts or provides water supplies.	**II.4.10.1**
		(4)	Any urban water supplier within which jurisdiction the agricultural water supplier provides water supplies.	**II.4.10.1**
		(5)	Any city or county library within which jurisdiction the agricultural water supplier provides water supplies.	**II.4.10.1**
		(6)	The California State Library.	**II.4.10.1**
		(7)	Any local agency formation commission serving a county within which the agricultural water supplier provides water supplies.	**II.4.10.1**
10844	(a)		Not later than 30 days after the date of adopting its plan, the agricultural water supplier shall make the plan available for public review on the agricultural water supplier's Internet Web site.	**II.4.10.1**
	(b)		An agricultural water supplier that does not have an Internet Web site shall submit to the department, not later than 30 days after the date of adopting its plan, a copy of the adopted plan in an electronic format. The department shall make the plan available for public review on the department's Internet Web site.	**Not Applicable**

Governor Edmund G. Brown Executive Order B-29-15

Item 12. Agricultural Water Suppliers (more than 25,000 acres)		
Item	Order Language	Applicable AWMP Section(s)
12	Agricultural water suppliers that supply water to more than 25,000 acres shall include in their required 2015 Agricultural Water Management Plans a detailed drought management plan that describes the actions and measures the supplier will take to manage water demand during drought. The Department shall require those plans to include quantification of water supplies and demands for 2013, 2014, and 2015 to the extent data is available. The Department will provide technical assistance to water suppliers in preparing the plans.	**II.4.5.9, II.4.7, II.4.10.5**

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4.4 Plan Preparation and Adoption

4.4.1 Regulatory Compliance

As described previously, this AWMP has been prepared in accordance with SBx7-7 and the CWC and with Executive Order B-29-15.

4.4.2 Public Participation and Adoption

Requirements of the CWC and Government Code 6066 related to public review and adoption of AWMPs include the following:

- CWC §10821(a) – An agricultural water supplier required to prepare an AWMP must notify each city or county within which it supplies water that the AWMP will be prepared.
- CWC §10841 – Prior to adopting an AWMP, agricultural water suppliers must make the plan available for public inspection and hold a public hearing. Prior to the hearing, notice of the time and place must be published within the supplier's jurisdiction pursuant to Section 6066 of the Government Code.
- Government Code §6066 – Publication of notice shall be once a week for two successive weeks in a newspaper of general circulation.
- CWC §10843 – A copy of the adopted AWMP must be provided to the following entities within 30 days of the date of adoption:
    - The California Department of Water Resources (DWR),
    - Any city or county within which the supplier provides water,
    - Any groundwater management entity within which the supplier extracts or supplies water,
    - Any urban water supplier within which the supplier provides water,
    - Any city or county library within which the supplier provides water,
    - The California State Library, and
    - Any local agency formation commission serving a county within which the supplier provides water.
- CWC §10844 – Within 30 days of the date of adoption, the supplier must make the AWMP available on its website (if applicable), or submit an electronic copy to be made available by DWR.

The public participation and adoption process for BWD is documented in Section 4.10.1.

4.4.3 Regional Coordination

This AWMP was originally developed as part of the Feather River Regional AWMP (FRRAWMP), which was funded by a Proposition 204 grant awarded by DWR to the Northern California Water Association (NCWA). Development of the plan included coordination among the following Feather River water suppliers and water management entities:

- Joint Water Districts

  - Biggs – West Gridley Water District (BWGWD)
  - Butte Water District (BWD)
  - Richvale Irrigation District (RID)
  - Sutter Extension Water District (SEWD)
- Western Canal Water District (WCWD)
- Lower Feather Water Users
  - Feather Water District (FWD)
  - Garden Highway Mutual Water Company (GHMWC)
  - Plumas Mutual Water Company (PMWC)
  - Tudor Mutual Water Company (TMWC)
  - Sutter Butte – Butte Slough Water Users Association

Additionally, development of the FRRAWMP included consultation with representatives of the Butte County Department of Water and Resource Conservation, the California Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, and the DWR Northern Region.

The preparation of a regional AWMP for the Feather River region provides the opportunity to evaluate water management within the region as a whole and exposes interdependencies between agricultural water suppliers and other water uses, including other agriculture in the region and terrestrial and aquatic ecosystems. Water use in the region can be described as "cascading" where water diverted and applied on an individual farm or within an individual supplier service area that is not consumed to produce crops or habitat vegetation moves down through the system and remains available for other beneficial uses.

This 2016 update to BWD's AWMP has been prepared by BWD and builds upon and updates the 2014 FRRAWMP.

4.5 Background and Description of Service Area

4.5.1 History and Organization

Butte Water District (BWD or District) was originally proposed, organized, and formed in 1952, with the hope that it would begin operation for the 1953 irrigation season. As Richvale Irrigation District (RID), Biggs-West Gridley Water District (BWGWD), and Sutter Extension Water District (SEWD) had individually done during their formation in previous years, BWD would purchase a percentage of the Sutter-Butte Canal Company's water rights and canal system. The Butte County Board of Supervisors held hearings on whether or not to grant permission to an organizing committee to form BWD, but representatives of private ditch companies that would be included in BWD protested over the payment of a service fee that they had paid to the Sutter-Butte Canal Company that would be continued after the formation of BWD. Although the district was formed in 1952, these protests led to a delay in issuing bonds in order to finance the operation of BWD. On April 10, 1956, another revenue bond election was held to purchase the remainder of the Sutter-Butte Canal Company's canal system and pre-1914 water rights, which expanded the area within the BWD service area. Following this expansion of BWD, the Sutter-Butte Canal Company was

liquidated in 1957, and RID, BWGWD, BWD, and SEWD organized to form the Joint Water Districts Board (Joint Districts) to coordinate their efforts in managing the Sutter-Butte Canal Company distribution system which they all shared a portion of (McGee 1980). In 1969, the Joint Districts entered into a settlement agreement with the State regarding their water right for the diversion of up to 555,000 af from the Feather River at the Thermalito Afterbay following its construction and the construction of Lake Oroville as part of the State Water Project (Joint Board 1969). BWD currently contains approximately 27,000 acres of irrigable land within its 32,000 acre service area, of which approximately 16,000 acres have been served by the district in recent years[1]. The remaining irrigable lands rely primarily on private groundwater pumping for irrigation.

BWD is a California Water District responsible for providing irrigation water to agricultural water users within its service area. Since before its formation, a variety of crops have been grown within the district's service area. The main crops are orchards, consisting primarily of walnuts and almonds in recent years. Orchards make up over 50% of the irrigable acreage served by the District and approximately 57% of irrigable lands in the BWD service area, including areas relying solely on groundwater for irrigation.

BWD is entitled to approximately 133,000 af of the Joint Districts allowed diversions from the Feather River under its 1969 agreement with the State, which is based on a pre-1914 water right and subject to reduction under certain conditions, as described below.

The District is divided into four divisions and is represented by a board of directors made up of five members. Each director is elected for a four-year term by landowners within the district. The board of directors elect a board president to run the meetings, a vice-president to serve if the board president is unavailable, and a board treasurer. The general manager is principal administrative officer of the district and serves as secretary to the board of directors.

Currently, there are six full-time district employees. They include the general manager, office assistant, operations manager, and three system operators. The staff additionally perform winter maintenance activities outside of the irrigation season and run fall and winter water deliveries for rice straw decomposition, waterfowl and shorebird habitat, and in some cases orchard irrigation beginning in October and continuing through or March in some years. An organizational chart of the district is provided in Figure 4.1.

[1] Based on annual reports of the Joint Districts Board. Excludes fallowed acres.

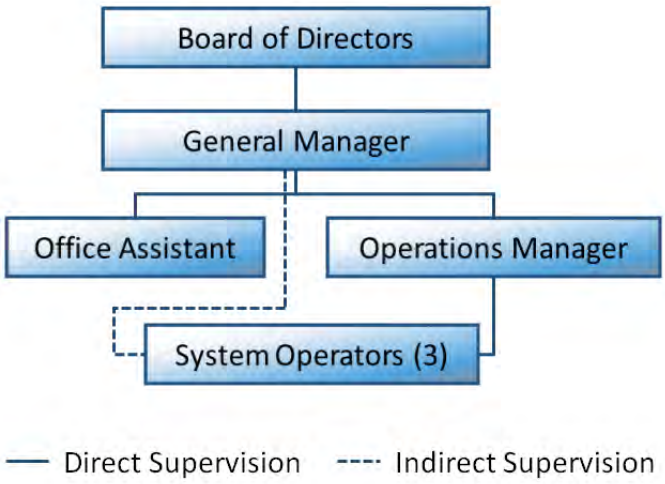

Figure 4.1. Organizational Chart.

4.5.2 Size and Location of Service Area

BWD is located in the Sacramento Valley south of Thermalito Afterbay, west of the Feather River, and northeast of the Sutter Buttes. The cities of Biggs and Gridley lie within the district along its western boundary, with BWGWD to the west of the boundary (Figure 4.2). The district is bounded on the north by Thermalito Afterbay and on the east by the Feather River. The boundary between Butte County and Sutter County divides BWD, with the northern portion in Butte County and southern portion in Sutter County. There are several internal "islands" of land surrounded by BWD that are not included within the district service area. One of these includes the city of Live Oak. Approximately 15,700 acres within the service area are planted to orchards, and 7,400 acres are planted to rice. The remaining cropland is a mixture of pasture, and row crops.

The location of BWD's service area relative to the Sacramento Valley as a whole and the Feather River Region is shown in Volume 1, Section 2 of this AWMP.

4.5.3 Distribution and Drainage System

The BWD distribution system is shown in Figure 4.2. The figure shows the service area and surrounding areas, irrigation and drainage facilities, other waterways (including natural waterways), and points of inflow and outflow from the district.

The main and lateral distribution system is an open, gravity flow system and is operated via upstream level control. Daily diversions are adjusted through coordination with the Joint Districts manager who in turn coordinates releases with DWR operators of Thermalito Afterbay. Water level fluctuations in the afterbay result in fluctuations in releases to BWD and the other Joint Districts which are propagated through the districts' distribution systems to varying degrees.

Water is conveyed by the canal and lateral system through a series of control structures used to maintain desired upstream water levels, subject to certain physical and operational constraints.

This enables consistent gravity delivery through turnouts. At the ends of the laterals are safety spills or "safeties," which are used to convey operational spillage into drains and sloughs and to deliver water to downstream water users in some cases.

Water is diverted into BWD from the Thermalito Afterbay via the Sutter-Butte Canal. The Sutter-Butte Canal is owned collectively by the Joint Water Districts but flows south directly through Butte Water District, and is operated by Butte Water District staff south of the Looney Gates. The canal serves as the main canal for the BWD distribution system. The Sutter-Butte Canal has a capacity of approximately 800 cfs and a length of approximately 16 miles within BWD. Water is delivered from the Sutter-Butte Canal into district facilities including individual turnouts and private ditches on the Canal and to BWD operated and maintained laterals. Primary laterals supplied by the Sutter-Butte Canal include Lateral 4 (capacity of 80 cfs) and Chandon Lateral (capacity of 200 cfs). The BWD distribution system includes 17 laterals totaling about 42 miles in length. For the period 1999 to 2014, BWD received between approximately 91,000 af and 138,000 af to serve district customers[2]. The average annual diversion for this period was 112,000 af. Annual diversions depend upon a combination of factors, including demands from the district's customers and infrequent reductions resulting from the district's settlement agreement with the State.

Within BWD, the Sutter-Butte Canal includes 12 primary control structures, three of which are automated. There are plans in place to fully automate a fourth structure, the Pennington Weir. Deliveries are made to fields at approximately 580 individual turnouts. There are approximately 20 miles of primary drains within BWD; in two locations, drainwater recovery pumps are installed and drainwater can be recovered and reused. It is also estimated that there are in excess of 100 miles of secondary drains that carry water to primary drains and natural waterways. Excess system flows in the distribution system, if present, can be released from the system at approximately 20 safety spills or "safeties". Many of the safeties additionally serve as delivery points for downstream water users which lie downgradient of the existing distribution system and pump delivered water from the drains.

Unlike the other Joint Districts, a substantial portion of water provided by BWD to its customers is delivered through privately-owned ditches maintained by groups or associations of landowners.

BWD also owns two groundwater wells in Sutter County in the southern portion of the district that have been used for groundwater substitution water transfers. The wells could also be used to supplement surface water supplies but have not been used for this purpose historically.

The district is divided into four operational divisions. The divisions operate under the supervision of the operations manager and general manager. Within divisions, actual field operations are

[2] Expressed on a water year basis (October – September) based on reports of the Joint Districts Board. Deliveries to other districts through the Sutter-Butte canal including RID, BWGWD, and SEWD are excluded. Estimated conveyance losses within the Sutter Butte Canal incurred from serving other districts that are not accounted for against BWD's allotment are also excluded. Total annual diversions may exceed the District's 133,000 af entitlement in part due to non-allotted winter diversions for wildlife habitat and rice straw decomposition.

executed by the three system operators (the operations manager is also responsible for the fourth division). Division sizes average approximately 4,100 acres. The divisions have been delineated to achieve uniform division of workloads among operators.

Drainage in BWD occurs through both naturally occurring waterways and man-made drains, which all flow to the west or south. Drains in the northern part of the district are operated and maintained by Reclamation District 833 (RD833) and tend to flow west. Drains and sloughs include Hamilton Drain, Meyers Drain, and Brooks Drain. Drainage in the southern portion of the district tends to flow south; there are three reclamation districts that operate and maintain drains within BWD flowing south. From the west to the east, they are Reclamation District 2054 (RD2054), Reclamation District 2056 (RD2056), and Reclamation District 777 (RD777). Natural waterways and sloughs that collect surface drainage from man-made drains and convey it to the south through BWD include Snake Creek, Morrison Slough, and Live Oak Slough.

The distribution system and drainage systems within BWD are integrated. For example, there are 2 recycle pumps located within the district where water can be lifted out of drains and put back into the distribution system for downstream use, although they are seldom used, as drain water is relied upon as a source of supply by downstream growers within the district. Drains and natural waterways primarily purposed to provide drainage. There are locations within BWD where water is also delivered into drains or natural sloughs intentionally for downstream irrigation use. In most of these cases, the downstream grower uses a private lift pump to lift water to their fields for irrigation. The irrigation and drainage system consists primarily of unlined ditches, although pipelines have been installed in areas with seepage problems, as described later in this section.

As described previously, cropping in BWD consists of a combination of orchards, rice, row crops, and pasture. BWD's delivery practices have been established to best suit the needs of its customers. For orchards and other non-ponded crops grown in the district, a combination of pressurized and surface irrigation methods are used, and delivery requests are filled on a rotational basis or on an arranged-demand basis, as practical. Orders are generally filled with a minimum of 24-hours lead time, but are often filled with less lead time when operational constraints allow. For rice, water has historically been delivered on an arranged-demand basis for flood up in the spring. Growers place orders directly with system operators, and water deliveries are generally made in the sequence received, subject to operational constraints. Once rice is established, continuous deliveries are made as needed to maintain rice pond levels (except when deliveries are ceased and water is held or drained to support chemical applications), with potential periodic adjustments to match crop evapotranspiration and deep percolation rates while limiting tailwater outflow. For additional detail describing water management objectives for rice production, see Volume I, Section 4 of this AWMP.

The irrigation season generally begins in April or May. Deliveries and associated diversions typically decrease from August to September in preparation for harvest. Fall and winter deliveries for rice decomposition and waterfowl habitat, of which there are relatively few in BWD, begin in October and continue through January. From the period of 1999 through 2014, deliveries during

the primary irrigation season (April through September) display a somewhat decreasing trend. Between 1999 and 2014, deliveries were been between 62,000 and 97,000 af with an average of 81,000 af. Reductions in deliveries over time are due to several factors, including increased urbanization in the greater Biggs, Gridley, and Live Oak areas; orchard growers converting from flood irrigation using surface water to pressurized irrigation such as microspray and drip using groundwater or less surface water; and water transfers reducing surface water demand. Deliveries during the fall and winter between 1999 and 2014 have generally increased in the last decade. One factor resulting in increased winter deliveries is the passage of the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991, which phased out rice straw burning, except under special circumstances, between 1992 and 2001. As an alternative, rice straw is now commonly decomposed via winter flooding between October and January, which also provides important habitat benefits for migratory waterfowl and shorebirds.

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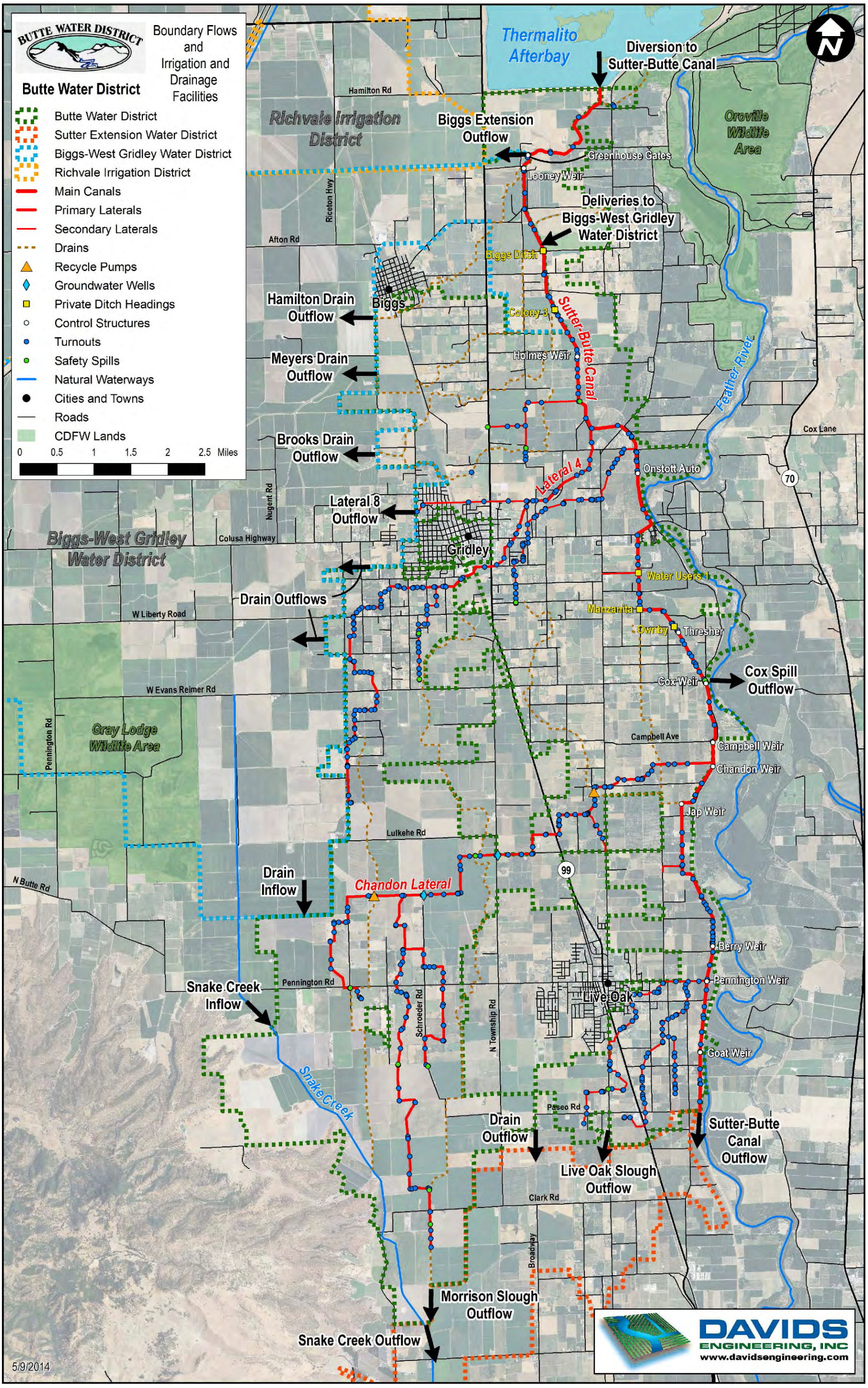

Figure 4.2. Boundary Flows and Irrigation and Drainage Facilities.

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4.5.4 Terrain and Soils

Located on the Sacramento Valley floor, BWD's topography is generally flat. Land surface elevation varies from approximately 110 feet above mean sea level in the northern portion of the District to about 70 feet in the south. The land falls to the south at approximately 0.5 feet per thousand feet (0.05 percent) on average. Accordingly, drainage within the district generally flows to the south through the RD2054, RD2056, and RD777 drains and natural waterways and sloughs such as Snake Creek, Morrison Slough, and Live Oak Slough. It is worth noting that there is an area in the northern portion of the district where drainage flows west into BWGWD towards Butte Creek.

Soils underlying over half of the land within the District are identified as loamy alluvium. Most of the remaining land is underlain by either clayey alluvium or a mixture of clayey alluvium and loamy alluvium. A total of 13 soil map units, as defined by the Natural Resources Conservation Service (NRCS 2006a, 2009b), comprise approximately 91 percent of the irrigated area. Characteristics of these map units are summarized in Table 4.2. For the soils characterized as loamy alluvium, available water holding capacity is typically five to fifteen inches in the top five feet, and the soils are moderately well drained with varying saturated hydraulic conductivity (i.e., permeability). For soils characterized as clayey alluvium, available water capacity is typically between three and seven inches in the top five feet, and the soils are poorly drained with very low saturated hydraulic conductivity. Sand lenses exist in some areas, allowing for preferential flow between the surface water and groundwater systems. The depth to shallow groundwater, where present, is typically between zero and six feet. Soil characteristics vary from being well suited for orchard and other non-ponded crops to being well suited for rice. The spatial distribution of cropping is consistent with soil suitability.

Table 4.2. Characteristics of Dominant Soils in Butte Water District.

Soil Map Unit	Percent of Area	Land-form(s)	Slope Range	Parent Material	Available Water Holding Capacity	Drainage	Saturated Hydraulic Conductivity Class	Restrictive Layer	Depth to Water Table	Typical Profile[1]	
Boga-Loemstone Complex	21%	terraces on valleys	0 to 1 percent	loamy alluvium over dense silty alluvium	9.5 to 14.5 inches in top 5 feet	moderately well drained	low	dense material at 40 to 80 inches	35 to 72 inches	0 - 6 inches:	loam
										6 - 53 inches:	clay loam
										53 - 73 inches:	loam
										73 - 80 inches:	dense material
Gridley Taxadjunct Loam	12%	terraces on valleys	0 to 2 percent	loamy and clayey alluvium over cemented loamy alluvium	3.9 inches in top 5 feet	somewhat poorly drained	very low	duripan at 20 to 40 inches	15 to 20 inches	0 - 10 inches:	loam
										10 - 20 inches:	clay loam
										20 - 22 inches:	clay loam
										22 - 60 inches:	cemented material
Liveoak Sandy Clay Loam	10%	terraces on valleys	0 to 2 percent	channel deposited loamy alluvium	10.0 inches in top 5 feet	moderately well drained	high	none	30 to 65 inches	0 - 53 inches:	sandy clay loam
										53 - 60 inches:	sandy loam
Conejo-Tisdale Complex	9%	terraces on valleys	0 to 2 percent	loamy alluvium	5.4 to 7.1 inches in top 5 feet	well drained	very low	dense material or bedrock at 20 to 60 inches	none within soil profile	0 - 42 inches:	loam
										42 - 46 inches:	weathered bedrock

Soil Map Unit	Percent of Area	Land-form(s)	Slope Range	Parent Material	Available Water Holding Capacity	Drainage	Saturated Hydraulic Conductivity Class	Restrictive Layer	Depth to Water Table	Typical Profile[1]	
Subaco Clay	8%	basin floors on valleys	0 to 2 percent	clayey alluvium	3.9 inches in top 5 feet	poorly drained	moderately low	bedrock at 20 to 40 inches	27 inches	0 - 26 inches:	clay
Tisdale Clay Loam	6%	terraces on valleys	0 to 2 percent	mixed loamy alluvium	5.4 inches in top 5 feet	well drained	very low	bedrock at 20 to 40 inches	none within soil profile	0 - 31 inches:	clay loam
										31 - 35 inches:	bedrock
Oswald Clay	6%	basin floors on valleys	0 to 2 percent	clayey alluvium	5.3 inches in top 5 feet	poorly drained	very low	bedrock at 20 to 40 inches	30 inches	0 - 33 inches:	clay
										33 - 37 inches:	weathered bedrock
Duric Xerarents-Eastbiggs Complex	5%	terraces on valleys	0 to 1 percent	clayey alluvium over cemented loamy alluvium	2.3 to 7.1 inches in top 5 feet	somewhat poorly drained	very low	duripan at 6 to 80 inches	4 inches to more than 60 inches	0 - 10 inches:	clay loam
										10 - 13 inches:	clay
										13 - 60 inches:	cemented material
Liveoak Sandy Loam	4%	terraces on valleys	0 to 2 percent	loamy and sandy alluvium	8.4 inches in top 5 feet	moderately well drained	high	none	30 to 60 inches	0 - 61 inches:	sandy loam
										61 - 71 inches:	sand
										71 - 75 inches:	gravelly sand
Gridley Clay Loam	4%	terraces on valleys	0 to 1 percent	clayey alluvium	6.5 inches in top 5 feet	moderately well drained	moderately low	bedrock at 20 to 40 inches	none within soil profile	0 - 19 inches:	clay loam
										19 - 37 inches:	clay

Soil Map Unit	Percent of Area	Land-form(s)	Slope Range	Parent Material	Available Water Holding Capacity	Drainage	Saturated Hydraulic Conductivity Class	Restrictive Layer	Depth to Water Table	Typical Profile[1]	
Gridley Taxadjunct Clay Loam	3%	terraces on valleys	0 to 2 percent	clayey and loamy alluvium over cemented loamy alluvium	3.9 inches in top 5 feet	somewhat poorly drained	very low	duripan at 20 to 40 inches	15 to 20 inches	0 - 21 inches:	clay loam
										21 - 60 inches:	cemented coarse sandy loam
Gianella Fine Sandy Loam	3%	flood plains on valleys	0 to 1 percent	stratified coarse-loamy alluvium	9.5 inches in top 5 feet	moderately well drained	high	none	80 inches	0 - 12 inches:	fine sandy loam
										12 - 19 inches:	loam
										19 - 28 inches:	fine sandy loam
										28 - 48 inches:	loam
										48 - 57 inches:	sandy loam
										57 - 80 inches:	loamy sand
Marcum-Gridley Clay Loams	2%	terraces on valleys	0 to 1 percent	loamy alluvium	7.4 inches in top 5 feet	moderately well drained	very low	bedrock at 40 to 80 inches	none within soil profile	0 - 28 inches:	clay loam
										28 - 40 inches:	clay
										40 - 43 inches:	clay loam
										43 - 62 inches:	bedrock

1. For complexes, which contain a combination of distinct map units, the typical profile describes the primary map unit.

4.5.5 Climate

The climate statistics presented in this section are based on the Durham CIMIS station (#12) for the period October 1984 to September 2012. The station is located approximately 15 miles north of BWD's service area and considered representative of BWD's climate and the Feather River region as a whole. Monthly climate statistics are summarized in Table 4.3.

BWD has a climate typical of the eastern Sacramento Valley, with mild winters with mild to moderate precipitation and warm to hot, dry summers. Average daily maximum temperatures range from a low of about 54°F in December to a high of approximately 91°F in July. Mean daily minimum temperatures range from a low of approximately 37°F in January to a high of about 60°F in July. Average annual reference evapotranspiration (ET_o) is approximately 49 inches, ranging from a low of one inch in December and January to a high of over seven inches in June and July. Approximately 75 percent of annual ET_o occurs in the six-month period from April through September.

Average annual precipitation is approximately 22.7 inches, with 17.3 inches or slightly more than 75 percent occurring in the five month period from November through March.

Even during the peak summer period, the average maximum relative humidity reaches 90 percent, which is indicative of an irrigated area, and remains near or above 90 percent throughout the year. Minimum relative humidity ranges between approximately 35 to 40 percent during the summer and roughly 50 to 65 percent during the wet winter months.

Average wind speed is lowest in August (3.5 miles per hour) and greatest during late winter and early spring, exceeding five miles per hour, on average.

There are no significant microclimates within the district that affect water management or operations.

Table 4.3. Mean Daily Weather Parameters by Month at Durham CIMIS Station (October 1984 to September 2012).

Month	Total ET_o (in)	Total Precip. (in)	Average Daily Temperature (F)			Average Relative Humidity (%)			Average Wind Speed (mi/hr)
			Avg.	Min.	Max.	Avg.	Min.	Max.	
January	1.1	4.3	45.4	37.2	54.9	81	64	95	4.6
February	1.9	3.8	49.7	39.5	61.0	73	52	92	5.2
March	3.2	3.0	53.7	42.0	66.1	69	46	92	5.2
April	4.6	1.4	59.0	45.5	72.6	62	38	89	5.0
May	6.2	1.2	66.0	52.1	79.7	58	36	88	4.9
June	7.1	0.7	72.1	57.7	86.2	57	36	87	4.6
July	7.2	0.1	75.7	60.3	90.9	60	38	90	3.7
August	6.4	0.1	73.9	58.1	90.2	59	36	90	3.5
September	4.9	0.4	69.8	54.5	86.9	57	33	88	3.7
October	3.4	1.4	61.8	48.3	78.0	59	34	87	3.9
November	1.6	2.5	51.1	40.3	63.9	73	49	92	4.1
December	1.1	3.7	44.5	36.1	54.3	79	61	94	4.7
Annual	48.8	22.7	60.2	47.6	73.7	66	44	90	4.4

4.5.6 Operating Rules and Regulations

The district's operating rules and regulations (R&Rs) are occasionally reviewed and revised as needed to address changing conditions. The R&Rs prescribe conditions that ensure distribution of irrigation water to users in an orderly, efficient, and equitable manner; they are available to water users in pamphlet form and are included at the end of this chapter in Section 4.10.2 for convenient reference.

4.5.7 Water Delivery Measurement and Calculation

BWD measures delivery volumes in a manner sufficient to support effective water management and equitable billing to customers. BWD is below the minimum acreage threshold required for mandatory compliance with the delivery measurement requirements of the Water Conservation Act of 2009 (SBx7-7) and California Code of Regulations Title 23 §597 (CCR 23 §597), and is therefore not subject to the law. The measurement requirements of SBx7-7 state that agricultural water suppliers subject to the law shall measure the volume of water delivered to customers with sufficient accuracy to (1) enable reporting of aggregated farm-gate delivery data to the state, and (2) adopt a pricing structure for water customers based at least in part on the quantity of water delivered. In addition, CCR 23 §597 specifies minimum accuracy requirements for delivery measurement devices and requires certification of volumetric delivery measurement accuracy by a California registered professional engineer.

BWD has evaluated customer delivery measurement options and potential costs that would be incurred if BWD chose to implement volumetric measurement and billing in accordance with SBx7-7 measurement requirements. Modifications to existing delivery infrastructure to support

improved delivery measurement may be undertaken over time, subject to funding and project prioritization.

4.5.8 Water Rate Schedules and Billing

Historically, BWD has charged customers for irrigation water deliveries on a flat rate, per-acre basis, plus a stand-by charge. The standby charge, as of 2016, was $5 per acre. Rates are updated periodically by the Board of Directors. The per-acre rates for the 2016 primary irrigation season (i.e. April to October) were $25 per acre for gravity deliveries to orchards or row crops (with a maximum of 8 irrigations), $27 per acre for gravity deliveries to alfalfa, $30 per acre for gravity deliveries to pasture (with a maximum of 15 irrigations), and $36 per acre for gravity deliveries to rice. Due to the large number of small parcels in BWD, there is also a minimum flat rate charge of $80, regardless of acreage. For deliveries via a pump/drain, a 50% discount may be applied depending on irrigation method, and for one-time deliveries a 50% discount may be applied depending on irrigation method. Water is available during the winter period (November to January) at a rate of $12 per acre for gravity deliveries and $6 per acre for pump/drain deliveries.

Additionally, BWD has had an agreement in place in recent years to provide surplus water supplies (if available) to customers outside of its service area in RID. When water is purchased by landowners in the secondary service area of RID, a water charge of $5 per acre-foot is applied, plus a $1 per acre-foot wheeling charge to cover RID costs. The estimated delivery amount is one acre-foot per acre.

In addition to the primary and secondary service areas, RID holds agreements to provide water to certain landowners outside of and adjacent to its service area. These agreements allow for the purchase of surplus water from BWD and conveyance (or wheeling) of the water by RID. Water is provided at the following rates:

- April to October irrigation season ($50 per acre, total)
    - $36 per acre BWD water charge, plus 25 percent = $45 per acre
    - $5 per acre RID wheeling charge
- November to January winter water season ($20 per acre, total)
    - $12 per acre BWD water charge, plus 25 percent = $15 per acre
    - $5 per acre RID wheeling charge

The service agreements with outside landowners allow for delivery of up to 6.46 af per acre, which is RID's estimated water duty for rice. Water use by the outside landowners is measured by RID.

Standby assessments are issued in two installments due April 10 and September 10 each year. Two applications for water service, one for summer water and one for winter water, are made annually by customers in the service area and outside of the service area. For each application, the landowner specifies the Farm Service Agency (FSA) Field number, irrigated acreage, and type of irrigation, along with landowner information. Bills are issued at the time of application and are due by April 1 for summer water and before water delivery for winter water. A penalty may be assessed to customers not submitting payment by the specified due date.

4.5.9 Water Shortage Allocation Policies and Drought Management Plan

On April 1, 2015 Governor Brown issued Executive Order B-29-15, mandating agricultural water suppliers to include a detailed Drought Management Plan (DMP) describing actions and measures taken to manage water demand during drought. BWD has historically experienced very reliable surface water supplies with a full surface water supply of approximately 133,000 acre-feet available in all but four years (1977, 1991, 1992, and 2015) since construction of Lake Oroville and its subsequent 1969 settlement agreement with the State. During years in which curtailment is allowed under the agreement, BWD's water supply can be reduced by up to approximately 50 percent, as discussed in greater detail in the attached DMP (Section II.4.10.4).

The DMP describes and expands upon BWD's shortage allocation policies, including discussion of a broad range of actions undertaken during drought to manage available water supplies and meet customer demands to the maximum extent possible. The DMP includes components recommended by DWR in its 2015 AWMP Guidebook (DWR 2015). BWD's DMP describes the determination of available water supply, drought responses, and water shortage impacts. The description of water shortage impacts includes a discussion of 2015 supply and demand conditions available at the time of preparation of this DMP. A description of supplies and demands for 2013 and 2014, also required under Executive Order B-29-15, is included in the water balance section of this AWMP (II.4.7).

4.5.10 Policies Addressing Wasteful Use of Water

BWD actively prohibits the wasteful use of water, as described in its R&Rs (Section 4.10.2). Enforcement actions include withholding water for careless, negligent, or willful wasteful use. The district's policies regarding unauthorized uses of water and enforcement are described in detail in the R&Rs. Water use that could be considered waste within the district remains available to provide groundwater recharge or is available for downstream agricultural or environmental water uses; regardless, the district actively prohibits excessive water use.

4.6 Inventory of Water Supplies

4.6.1 Introduction

This section provides a brief description of surface water and groundwater supplies within SEWD as well as a description of BWD water quality monitoring practices.

4.6.2 Surface Water Supply

As described in Section 4.5.1, BWD is entitled to approximately 133,000 af of the Joint Districts allowed diversions from the Feather River under its 1969 agreement with the State, which is based on a pre-1914 water right and subject to reduction under certain conditions, as described previously. Additionally, BWD and individual water users within BWD can reuse surface water entering the district via Snake Creek and other minor surface inflows. BWD does not typically utilize this water, as it is depended on by BWD customers.

4.6.3 Groundwater Supply

BWD overlies portions of the East Butte and Sutter subbasins of the Sacramento Valley groundwater basin. Approximately 98% and 2% of the District's service area overlies the East Butte and Sutter subbasins, respectively. The water-bearing formations of the East Butte subbasin consist of a combination of Holocene, Pleistocene, and Pliocene deposits and alluvium. The water-bearing formations of the Sutter subbasin consist of a combination of Holocene, Pleistocene, Pliocene, Miocene-Pliocene, and Oligocene-Miocene deposits and alluvium. BWD additionally overlies a small portion of the Sutter subbasin of the Sacramento Valley groundwater basin. The formations, size, and other features of the subbasins are described in Volume I, Section 2.7.2 of this AWMP.

BWD has a history of actively participating in groundwater management initiatives in the East Butte and Sutter subbasins and Butte and Sutter counties as a whole. Most recently, BWD has embarked on the implementation of the Sustainable Groundwater Management Act of 2014 (SGMA) as a local Groundwater Sustainability Agency (GSA). SGMA represents a major shift in the management of California's groundwater resources, allowing local agencies to prepare and adopt Groundwater Sustainability Plans (GSPs) or Alternative Plans tailored to achieving sustainability of underlying groundwater basins and subbasins through local actions. For the East Butte and Sutter subbasins, each of which have been designated as medium priority basins under the Law, a GSP, combination of GSPs, or suitable Alternative Plan addressing the entirety of each subbasin separately must be prepared and submitted to DWR. GSPs must be submitted by January 31, 2022, while Alternative Plans must be submitted by January 31, 2017. Within each subbasin, several options exist, including the following:

- One GSA representing the entire subbasin preparing a single GSP or Alternative Plan,
- Multiple GSAs representing the entire subbasin preparing a single GSP or Alternative Plan,
- Multiple GSAs representing the entire subbasin preparing multiple, coordinated GSPs and/or Alternative Plans.

At the time of preparation of this AWMP, the following agencies had elected to form GSAs in the East Butte subbasin:

- Richvale Irrigation District (9/1/2015)
- Biggs-West Gridley Water District (9/24/2015)
- Butte Water District (10/1/2015)
- Western Canal Water District (10/15/2015)
- Sutter Extension Water District (10/27/2015)
- County of Butte (10/27/2015)
- City of Live Oak (11/24/2015)
- Butte College (12/3/2015)
- City of Biggs (12/3/2015)
- Thermalito Water & Sewer District (12/3/2015)
- City of Gridley (12/29/2015)

- City of Oroville (2/9/2016)
- Reclamation District No. 2054 (4/13/2016)
- Reclamation District No. 1004 (5/4/2016)

At the time of preparation of this AWMP, the following agencies had elected to form GSAs in the Sutter subbasin:

- Sutter Community Services District (10/1/2015)
- Sutter Extension Water District (10/27/2015)
- Reclamation District No. 2054 (4/13/2016)

Moving forward, BWD will actively collaborate with GSAs and eligible interested parties in the subbasins to sustainably manage available groundwater resources. The development and use of surface water supplies by BWD and others over the past century has greatly contributed to the sustainability of the groundwater system through beneficial recharge and prevention of pumping that would otherwise have occurred.

At the time of preparation of this AWMP, BWD has elected to form a GSA for the East Butte subbasin and is also in the process of working with water managers in the Sutter subbasin to evaluate whether to prepare and submit a GSP or Alternative Plan as described in the California Code of Regulations Title 23 §358 et seq.

Prior to SGMA, BWD adopted an AB3030 compliant groundwater management plan (GMP) in 1996 with the purpose of managing and monitoring groundwater resources within the district (BWD 1995). As part of GMP implementation, BWD coordinates and cooperates with other local water management entities to preserve, protect, and monitor groundwater extraction, distribution, and allocation within the basin. Components of BWD's GMP include the following:

- Control of saline water intrusion,
- Identification and management of well head protection areas and recharge areas,
- Regulation of migration of contaminated groundwater,
- Administration of a well abandonment and well destruction program,
- Mitigation of overdraft conditions,
- Replenishment of groundwater extracted by water producers,
- Groundwater level and storage monitoring,
- Development of relationships with State and Federal regulatory agencies,
- Facilitation of conjunctive use operations, and
- Implementation of the groundwater management plan.

Additionally, as a member of the Butte Basin Water Users Association, BWD was a participant in the development of the Butte County GMP finalized in 2004. The Butte County GMP accomplishes the following (CDM 2004):

- Supports the long-term maintenance of high quality groundwater resources within the county for agricultural, environmental, rural domestic and urban needs;
- Documents the county's existing groundwater management programs;
- Describes potential actions to increase the effectiveness of groundwater management; and
- Meet requirements of available grant funding opportunities.

Objectives of the Butte County GMP include the following:

- Minimize the long-term drawdown of groundwater levels,
- Protect groundwater quality,
- Prevent inelastic land surface subsidence resulting from groundwater pumping,
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality,
- Minimize the effect of groundwater pumping on surface water flows and quality,
- Evaluate groundwater replenishment and cooperative management projects, and
- Provide effective and efficient management of groundwater recharge projects and areas.

In addition to developing the Butte County GMP, the county board of supervisors approved a groundwater management ordinance in 2004 to support the development of quantitative Basin Management Objectives (BMOs). Specific BMOs address the following:

- Groundwater levels,
- Groundwater quality, and
- Inelastic land subsidence,

Additionally, BWD was a participant in the development of the Sutter County GMP finalized in 2012. The Sutter County GMP accomplishes the following (Wood Rogers 2012):

- Provides a publicly available summary of the groundwater system underlying the county and its role in overall water supply,
- Formulates goals and objectives to support management of groundwater to meet current and future demands,
- Establishes a plan for county involvement in ongoing monitoring and management of groundwater, and
- Maintains eligibility for DWR grant funding to increase understanding of the groundwater system.

Goals and BMOs of the Sutter County GMP include the following:

- Groundwater Management Goals
    - Promote responsible groundwater use to sustain the resource,
    - Provide information to support responsible stewardship of the resource,
    - Discourage activities that could reduce long-term availability of high-quality groundwater.

- Basin Management Objectives
    - Groundwater levels,
    - Groundwater quality,
    - Inelastic land subsidence,
    - Surface water,
    - Coordination.

As described in section 4.5, BWD owns two groundwater wells in Sutter County. These wells are used in certain years to increase statewide water supplies through groundwater pumping in lieu of surface water diversions. Private pumping within BWD for irrigation is estimated to have been approximately 23,000 af annually in recent years.

4.6.4 Other Water Supplies

BWD does not have access to water supplies other than those described previously in section 4.6.

4.6.5 Water Quality Monitoring Practices

BWD actively monitors groundwater quality within its service area. BWD monitoring activities as well as other past and ongoing water quality monitoring efforts are described below.

Surface Water

BWD does not actively monitor surface water quality; however, water quality monitoring has been performed in the past by BWD and continues to be performed by other water and resource management entities including DWR, the U.S. Geological Survey, the county, other water suppliers, and through water quality coalitions, as described in the following paragraphs. Surface water and within BWD is of good quality for irrigation and wildlife habitat.

Growers within BWD participate in the Sacramento Valley Water Quality Coalition and/or the California Rice Commission Coalition, which conduct monitoring of surface water quality in compliance with the Central Valley Regional Water Quality Control Board's Irrigated Lands Regulatory Program (ILRP). The monitoring program includes sampling and testing of a host of parameters for hundreds of samples collected annually from sites strategically distributed throughout the Sacramento River basin, which includes the Feather River region.

BWD is a party to a settlement agreement with DWR and three other districts (BWGWD, RID, and WCWD) that addresses yield losses from lower water temperatures that result from the operation of Lake Oroville, as compared to pre-reservoir conditions. As part of the process to develop the settlement agreement, BWD, DWR, and the other districts developed and implemented a method to estimate rice yield reductions through detailed monitoring of water temperatures and yields.

Groundwater

BWD monitors groundwater quality within its service area at both its two production wells and its dedicated monitoring well. Water quality parameters monitored include electrical conductivity, temperature, pH, TDS, arsenic, and boron. Temperature, pH, and electro conductivity are

monitored on a monthly basis when district wells are being operated and somewhat less frequently when they are not in use. Comprehensive testing including TDS, arsenic, and boron are conducted annually in June or July. The water is generally of good quality for irrigation, though elevated arsenic requires mixing of groundwater with Feather River water.

In 2014, NCWA prepared a groundwater quality assessment report for the Sacramento Valley to evaluate the sources of salt and nitrate loads and potential long-term effects on surface water and groundwater resources. This information supports understanding of sustainable management of surface water and groundwater supplies, including conjunctive management opportunities and limitations. The primary objectives of the assessment were to (1) identify where known groundwater quality impacts exist, (2) prioritize high vulnerability areas, and (3) evaluate opportunities to incorporate existing groundwater monitoring efforts to achieve water management objectives.

4.7 Water Balance

4.7.1 Overview

This section describes the various uses of water within BWD between 1999 and 2014, followed by detailed water balances for key accounting centers within the district. Water balances are presented for both the distribution and drainage system (i.e. canals and drains) and farmed lands, and for the district as a whole. The water balances quantify all substantial inflows to and outflows from the BWD service area on a water year basis (October – September). The period from 1999 to 2014 has been chosen because it depicts recent changes in water management as well as current management conditions. Key drivers of water management variability across years include precipitation timing and amounts and crop idling for water transfers. Limited supplies in years of surface water reduction are also a strong driver but did not occur between 1999 and 2014.

The remainder of this section includes the following subsections:

- Analytical Approach – Description of mass balance approach for water balance analysis, methodologies for estimation of individual flow paths, and uncertainty in flow path estimates;
- Water Uses – Description of water use for agricultural, environmental and recreational, municipal and industrial, groundwater recharge, and transfer and exchange purposes;
- Drainage – Description of drainage occurring within and flowing from the district; and
- Water Accounting (Water Balance Summary) – Summary of monthly and annual inflows to and outflows from the district, including a discussion of existing water management and performance.

4.7.2 Analytical Approach

The BWD water balance includes separate accounting centers for the distribution and drainage system and the farmed lands within the service area. A total of 26 individual flow paths are estimated. A schematic of the water balance structure is provided in Figure 4.3. The schematic

identifies sources and destinations of water, accounting centers, and individual flow paths by which water enters and leaves the system.

For BWD, the majority of the water entering the district via the Sutter-Butte Canal is delivered to other of the Joint Districts or lost in conveyance of the water to other of the Joint Districts and thus unavailable to meet BWD customer demands. As a result, in order to characterize water management by BWD, "allotted diversions" by BWD are presented, which represent total inflows to the Sutter-Butte Canal, minus deliveries to other districts and losses resulting from conveyance to others, including return flows to the Feather River at Cox Spill. Estimated losses from conveyance to SEWD through the Sutter Butte Canal, calculated as 17.6 percent of allotted gravity diversions by SEWD, are reported explicitly as part of the BWD water balance. Cox Spill return flows to the Feather River are reported in the regional water balance (Volume I, Section 4). Additionally, note that BWD's net diversions may exceed estimated water usage by BWD as reported in Joint District hydrology reports due to winter diversions during the non-allotted period from November to March.

Mass Balance

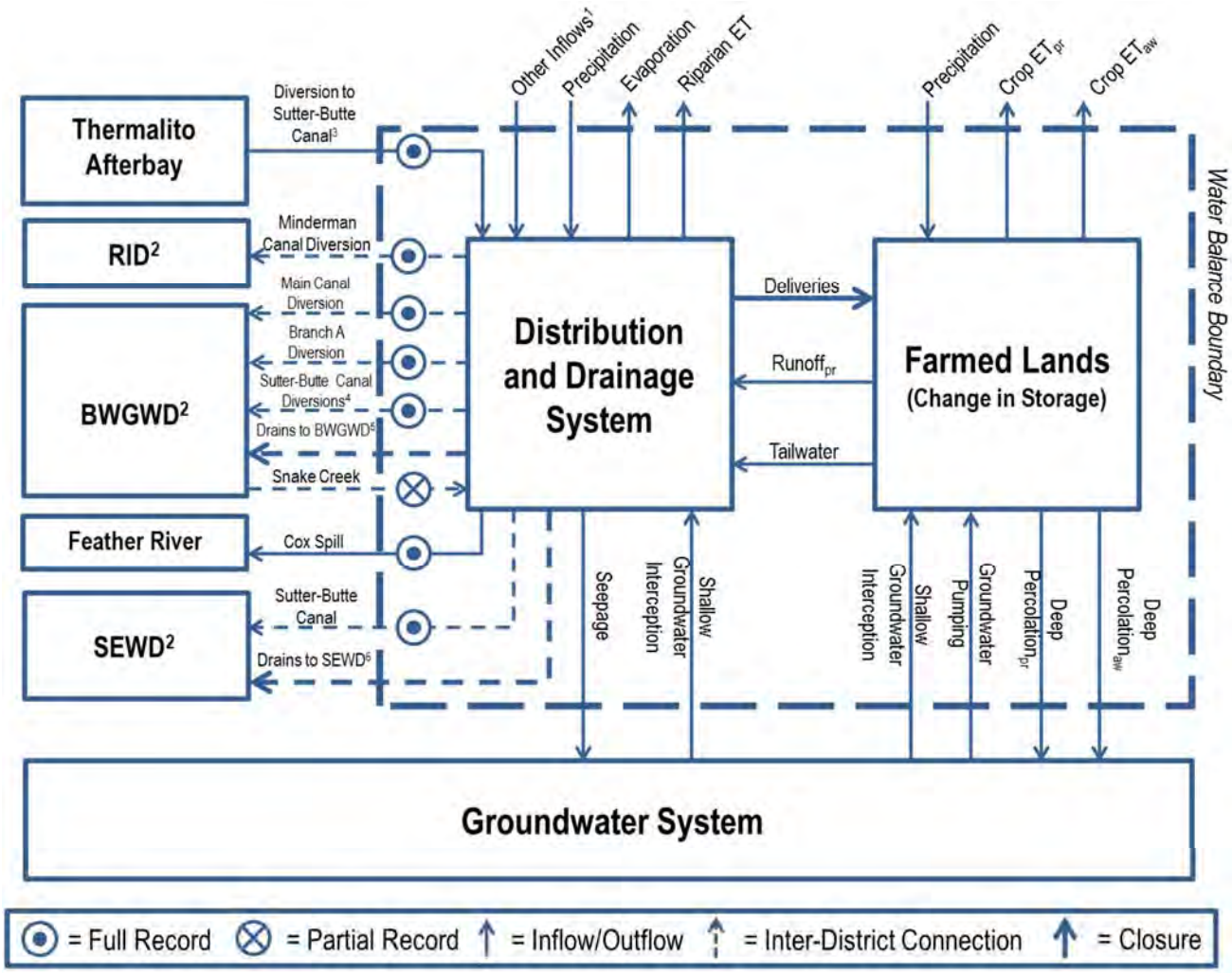
In general, flow paths are quantified on a monthly basis. For each accounting center, water volumes associated with certain flow paths are estimated independently based on measured data or calculated estimates, and the remaining flow is then calculated based on the principal of conservation of mass (Equation 4.1), which states that the difference between total inflows to and total outflows from an accounting center for a given period of time is equivalent to the change in stored water within that accounting center. For the distribution and drainage system, the change in storage is assumed to be zero on a monthly basis. For the farmed lands, the monthly change in storage varies, reflecting changes in the volume of water ponded in rice and managed wetlands areas as well as changes in soil moisture stored in the root zone. Over the course of a year the change in storage across all farmed lands is expected to be near zero.

$$Inflows - Outflows = Change\ in\ Storage\ (monthly\ time\ step) \qquad [4.1]$$

The flow path that is calculated using Equation 4.1 is referred to as the "closure term" because the mass balance equation is solved for or "closed" on the unknown quantity. The closure term is selected based on consideration of the availability of data or other information to support an independent estimate as well as the volume of water representing the flow path relative to the size of other flow paths. Generally speaking, the largest, most uncertain flow path is selected as the closure term.

Flow Path Estimation and Uncertainty

Individual flow paths were estimated based on direct measurements or based on calculations using measurements and other available data. As described previously, those flow paths not estimated independently were calculated as the closure term of each accounting center.



1. Other inflows include minor tributaries and drains.
2. RID is Richvale Irrigation District, BWGWD is Biggs-West Gridley Water District, and SEWD is Sutter Extension Water District.
3. Although the Sutter-Butte Canal is a Joint District facility, it is considered part of the BWD distribution system for the purposes of the water balance.
4. Sutter-Butte canal diversions includes the lateral 8 diversion.
5. Drains to BWGWD includes Hamilton Drain, Brooks Drain, and Meyers Drain, along with other minor sloughs and drains.
6. Drains to SEWD include Snake Creek, Morrison Slough (RD 2056), Live Oak Slough (RD 777), and other drains.

Figure 4.3. Water Balance Structure.

The analysis results for each flow path are reported with a high level of precision (nearest whole acre-foot) that implies a higher degree of accuracy than is actually justified. The estimated percent uncertainty (approximately equivalent to a 95 percent confidence interval) in each measured or calculated flow path has been estimated as part of the water balance analysis. Based on the relative magnitude of each flow path, the resulting uncertainty in each closure term can be estimated by assuming that errors in estimates are random (Clemmens and Burt 1997). Errors in estimates for individual flow paths may cancel each other out to some degree, but the combined error due to uncertainty in the various estimated flow paths is ultimately expressed in the closure term.

For the distribution and drainage system accounting center, aggregated surface outflows were calculated as the closure term, based on the assumption that the change in storage over time is zero. Total outflows were distributed across each individual outflow waterway (i.e. creeks and drains) based on available outflow measurements and estimated drainage areas tributary to each outflow location. Aggregated surface outflows were selected as the closure term because of the combination of the lack of available outflow data, generally large magnitude, and relative uncertainty of the flow path.

For the farmed lands accounting center, deliveries were calculated as the closure term. Deliveries were selected as the closure term because historical measurements were not readily available for the full period of analysis and they represent the largest inflow into the farmed lands accounting center. Deliveries calculated via closure include deliveries by BWD from its canals, laterals, and drains, as well as any district or private reuse of water or unaccounted groundwater pumping.

Table 4.4 lists each flow path included in the water balance indicating which accounting center(s) it belongs to; whether it is an inflow or an outflow; whether it was measured or calculated; the supporting information and assumptions used to determine it; the estimated uncertainty, expressed as a percent; and average values for the period of analysis. Results for both the full water year and for the primary irrigation season (April to September) are provided. As indicated, estimated uncertainties vary from 5% to 100% of the average volume for the irrigation season, with uncertainties generally being less for measured flow paths and greater for calculated flow paths.

The estimated uncertainty of each closure term is also shown. As indicated, the estimated uncertainty in aggregated surface outflows is 40% for the water year as a whole and 38% for the irrigation season. The estimated uncertainty in deliveries is 20% for the water year as a whole and 15% for the irrigation season. The uncertainty in deliveries decreases for the irrigation season due to the lack of precipitation from winter storms.

Table 4.4. Water Balance Flow Paths, Supporting Data, and Estimated Uncertainty.

Account-ing Center	Flow Path Type	Flow Path	Source	Supporting Data	Water Year (Oct. - Sept.) Average Volume (af)	Water Year (Oct. - Sept.) Estimated Uncertainty	Irrigation Season (Apr. - Sept.) Average Volume (af)	Irrigation Season (Apr. - Sept.) Estimated Uncertainty
District Distribution and Drainage System	Inflow	Allotted Deliveries to Butte Water District	Calculation	Joint Water Districts Board Measurement Data	108,088	20%	97,926	18%
		SEWD Conveyance Losses	Calculation	SEWD Allotted Deliveries x 0.176	27,690	10%	20,655	10%
		Other Inflows	Calculation	Estimated as zero	0	100%	0	100%
		Snake Creek	Calculation	Estimated in BWGWD Water Balance	22,065	23%	14,297	29%
		Precipitation	Calculation	Quality-controlled precipitation from CIMIS, estimated canal surface area	374	15%	79	15%
		Shallow Groundwater Interception	Calculation	Estimated as closure of regional water balance. Distributed within region based on area, drain miles, and average depth to groundwater.	4,366	70%	5,068	70%
		Runoff of Precipitation	Calculation	IDC analysis, NRCS soils characteristics, CIMIS precipitation data	9,687	25%	1,265	25%
		Tailwater	Calculation	Estimated as 20% of Deliveries	24,243	30%	21,552	30%
	Outflow	**Deliveries (to Farmed Lands)**	**Closure (Farmed Lands)**	**Closure term of Farmed Lands water balance**	**80,811**	**20%**	**71,839**	**15%**
		Evaporation	Calculation	CIMIS reference ET, estimated evaporation coefficient, estimated wetted surface area	943	15%	837	15%
		Riparian ET	Calculation	CIMIS reference ET, estimated crop coefficient based on 2009 SEBAL analysis, estimated riparian area	156	15%	122	15%
		Seepage	Calculation	NRCS soils data, published seepage rates by soil type, estimated wetted area, estimated wetted duration	34,705	35%	24,076	35%
		Drains to BWGWD	**Closure (District Distribution and Drainage System)**	**Difference between total inflows and measured/estimated outflows for Distribution and Drainage System accounting center, distributed according to drainage area and available data, BWGWD Operational Data, California Water Data Library Sites A00910 and A02980**	**23,969**	**40%**	**19,190**	**38%**
		Other Drains			**55,928**		**44,777**	
Farmed Lands	Inflow	Precipitation	Calculation	Quality-controlled precipitation from CIMIS station, reported cropped area	49,406	15%	10,428	15%
		Deliveries	**Closure (Farmed Lands)**	**Difference between measured/estimated inflows and total outflows for Farmed Lands accounting center, including estimated Tailwater as percentage of Deliveries**	**80,811**	**20%**	**71,839**	**15%**
		Shallow Groundwater Interception	Calculation	Estimated as closure of regional water balance. Distributed within region based on area, drain miles, and average depth to groundwater.	2,910	70%	3,378	70%
		Groundwater Pumping	Calculation	Estimated pumping based on estimated groundwater acres and associated applied water estimated from IDC.	22,981	25%	19,092	25%
	Outflow	Tailwater	Calculation	Estimated as 20% of Deliveries	24,243	30%	21,552	30%
		Crop ET of Applied Water	Calculation	CIMIS reference ET; estimated crop coefficients based on SEBAL 2009 analysis; crop acreages from WCWD records, DWR land use surveys, and agricultural commissioner crop reports; Integrated Water Flow Model Demand Calculator (IDC) analysis to divide total ET into applied water and precipitation components	60,717	10%	50,012	10%
		Crop ET of Precipitation	Calculation		27,056	10%	17,408	10%
		Runoff of Precipitation	Calculation	IDC analysis, NRCS soils characteristics, CIMIS precipitation data	9,687	25%	1,265	25%
		Deep Percolation of Applied Water	Calculation	IDC analysis, NRCS soils characteristics, CIMIS precipitation data, Integrated Water Flow Model Demand Calculator (IDC) analysis to divide total deep perc. into applied water and precipitation components	22,211	35%	12,550	35%
		Deep Percolation of Precipitation	Calculation		12,147	35%	3,663	35%
	Change in Storage		Calculation	IDC Analysis	48	50%	-1,714	50%

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4.7.3 Water Use

The district supplies agricultural irrigation water and also provides water for environmental use to provide wildlife habitat within and outside its service area. These water uses are described in greater detail in the remainder of this section.

Agricultural

Agricultural irrigation is by far the dominant water use in the BWD service area. Between 1999 and 2014, there were an average of approximately 16,000 cropped acres supplied water by BWD, with an average of 1,600 additional acres of fallow or idle land. BWD does not provide surface water for the irrigation of all crops within its service area. A portion of the agricultural lands within BWD's boundaries rely exclusively on groundwater or incidental reuse of tailwater for irrigation. These lands represent approximately 10,000 acres and are included in the water balance for purposes of analysis but are not supplied water by BWD.

Table 4.5 and Figure 4.4 present estimated BWD crop acreages for the period of analysis. As indicated, the main crops in the district are permanent orchard crops, primarily walnuts and prunes, which were grown on an average of 8,200 acres between 1999 and 2014, representing 51% of the total cropped area, or 47% of the irrigable area. Between 1999 and 2014, rice was grown on an average of 6,500 acres or 40% of total cropped area. A variety of other crops including field and truck crops, pasture and hay are grown on the remaining land, which accounts for an average of 1,300 acres or 8% of total cropped area. The acreage of these various other crops has been decreasing over time. The increase in idle acres in 2003, 2008, 2010, 2012, and 2014 resulted from crop idling-based water transfers.

Table 4.5. Crop and Idle Acres, 1999-2014.

Year	Crop Acreage by Type					
	Rice	Orchards	Other	Idle	Total Cropped	Total with Idle
1999	6,207	9,795	1,435	416	17,437	17,853
2000	6,280	9,280	1,494	439	17,054	17,493
2001	6,226	9,151	1,406	691	16,783	17,474
2002	6,896	8,388	1,430	700	16,714	17,414
2003	4,390	8,081	1,331	3,950	13,802	17,752
2004	7,806	8,188	1,220	421	17,214	17,635
2005	7,694	8,115	1,206	614	17,014	17,628
2006	7,620	7,966	1,196	630	16,782	17,412
2007	7,892	7,820	1,452	555	17,163	17,718
2008	3,944	8,205	1,730	3,636	13,878	17,514
2009	7,924	8,093	1,560	460	17,576	18,036
2010	4,514	8,108	1,086	3,783	13,709	17,492
2011	7,961	7,914	1,127	435	17,002	17,437
2012	4,982	7,376	1,185	3,961	13,543	17,504
2013	8,052	7,117	1,198	737	16,367	17,104
2014	4,971	7,359	1,232	3,830	13,562	17,392
Average	6,460	8,185	1,330	1,579	15,975	17,554

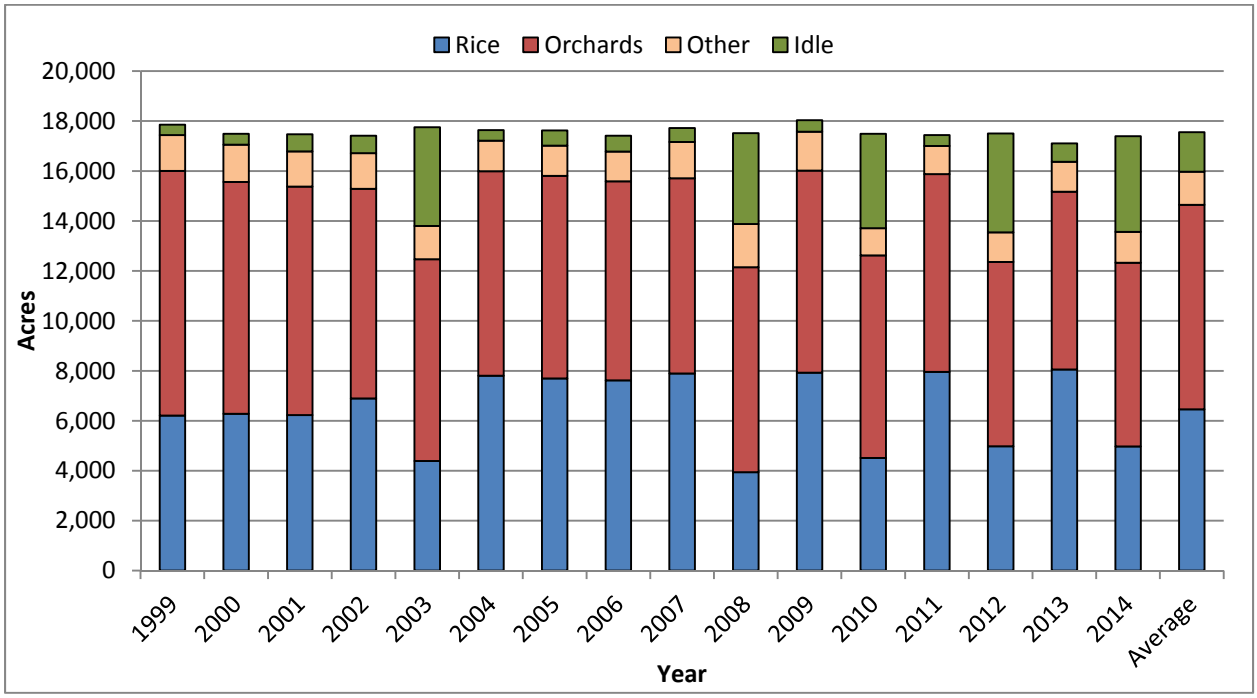

Figure 4.4. Crop and Idle Acres, 1999-2014[3].

[3] Total acres vary somewhat from year to year reflecting estimated changes in total irrigable acres resulting from rural development and changes in areas of native vegetation.

Crop evapotranspiration (ET) was estimated using a crop coefficient approach, whereby estimated crop- and time-specific water use coefficients were multiplied by reference ET (ET_o) to calculate the total consumptive use of water for the farmed lands over time. Crop coefficients specific to the Sacramento Valley were developed based on actual ET estimates from a remote sensing analysis using the Surface Energy Balance Algorithm for Land (SEBAL). The analysis used ground and satellite data to compute actual ET from March to September for individual 30-meter satellite pixels within Glenn and Colusa counties in 2009. Spatially distributed cropping data from DWR land use surveys for Glenn and Colusa counties for 2009 were combined with quality-controlled reference evapotranspiration (ET_o) from CIMIS to calculate crop coefficients representing actual ET over the course of the growing season[4]. A map showing March to September ET estimates for BWD from SEBAL for 2009 is provided in Figure 4.5.

[4] Ideally, the crop coefficient analysis would have included portions of Butte, Sutter, and Yuba counties within the Feather River region; however, DWR land use surveys were not available for 2009 for these counties. Crop coefficients developed for Glenn and Colusa counties are considered reasonably representative for the region as a whole.

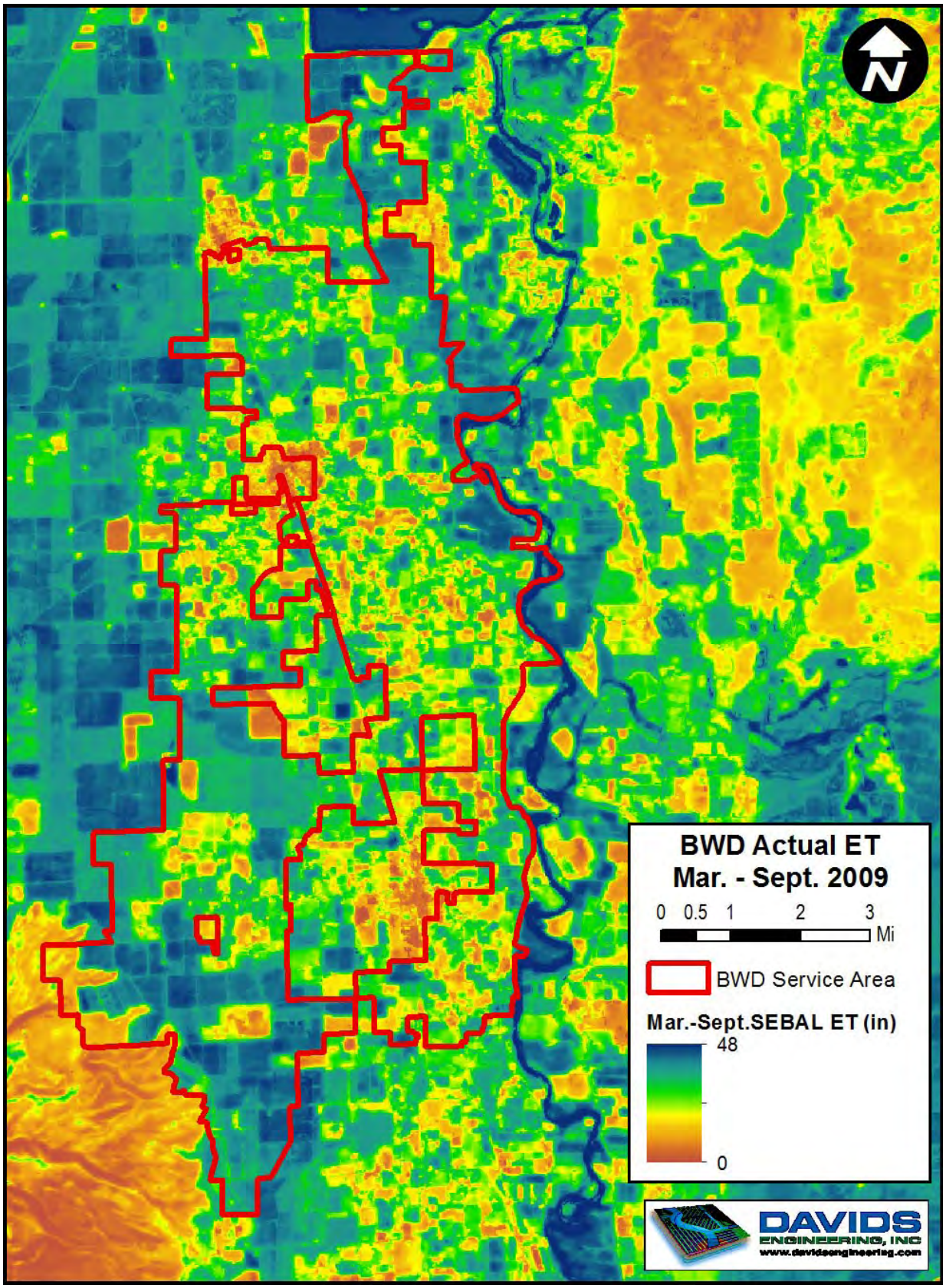

Figure 4.5. March to September 2009 SEBAL Actual ET.

A root zone water balance simulation was developed for each crop using the Integrated Water Flow Model (IWFM) Demand Calculator (IDC) Version 4.0 developed by DWR to estimate the portions of total ET derived from applied water (ET_{aw}) and from precipitation (ET_{pr}). ET values for each crop, expressed in units of acre-feet per acre were multiplied by the corresponding acreage in each year to compute total water volumes consumed for agricultural purposes.

For rice, the IDC model simulates ponding during the growing season and during the decomposition period in the fall and winter. As a result, precipitation occurring when ponds are full runs off of the fields and is not available to contribute to crop ET. Precipitation stored in the soil during the winter is available for extraction. For non-ponded crops, runoff and infiltration of precipitation are modeled for individual precipitation events. Precipitation entering the soil may be stored and available to support crop ET, or it may leave the root zone as deep percolation. One result of the differences in irrigation and cultural practices between rice and non-ponded crops is that ET_{pr} is significantly less for rice. Additional detail describing rice water management is provided in Volume I, Section 2.

The monthly consumptive use of water in BWD ranges from approximately 1 inch of total ET in December and January to nearly 6 inches in June and July. A majority of ET is derived from applied water, and ET_{aw} ranges from approximately 0.7 inches in December and January to approximately 4.7 inches in July for the irrigable area. The average monthly consumptive use of water is presented in Figure 4.6.

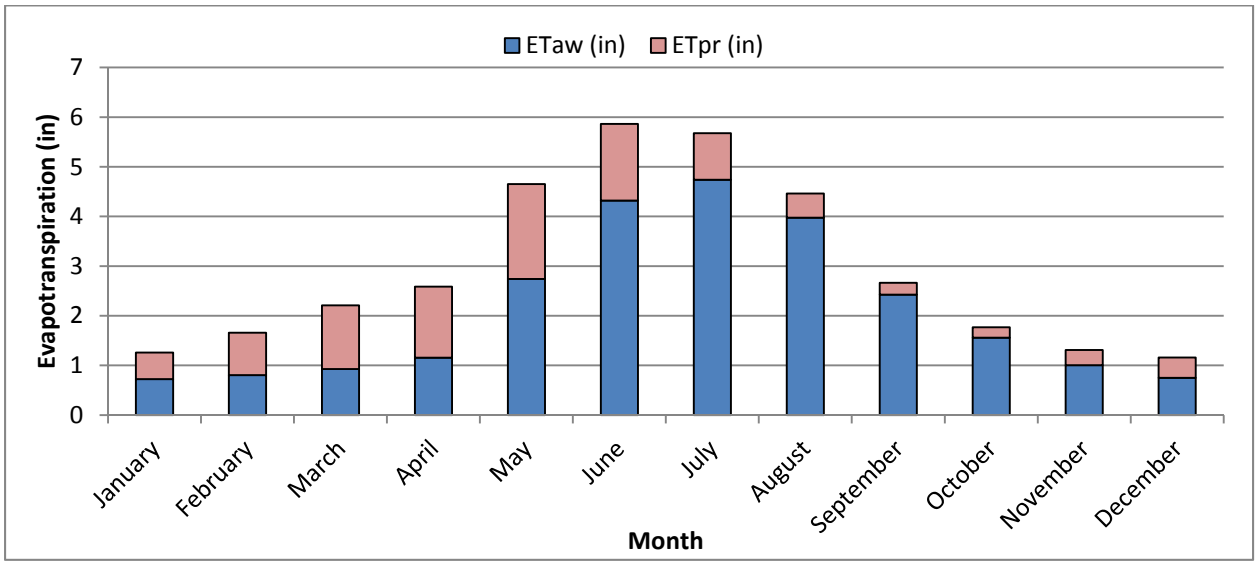

Figure 4.6. Average Monthly Consumptive Use of Water.

The annual consumptive use of water by crops in BWD is approximately 45 inches of total crop ET for rice, approximately 37 inches for permanent orchard crops and approximately 34 inches for various other crops, as shown in Table 4.6. ET_{aw} ranges from approximately 24 inches to 39 inches. For rice, approximately 39 inches of the 45 inches of total ET are derived from applied irrigation water. On average, approximately 28 inches of 37 inches of total ET are derived from applied irrigation water district-wide.

Table 6.6. Average Acreages and Annual Evapotranspiration Rates by Crop.

Crop	Average Acres	Average Evapotranspiration (in)		
		ET_c	ET_{aw}	ET_{pr}
Rice	6,460	45.2	38.8	6.5
Orchards	8,185	36.6	25.0	11.6
Other	1,330	34.4	23.7	10.7
Idle	1,579	10.0	0.0	10.0
Totals	17,554	37.2	27.7	9.5

ET_c and ET_{aw} vary from year to year due to differences in atmospheric water demand (ET_o) and differences in the timing and amount of precipitation available to support crop growth and offset crop irrigation requirements. Total annual ET varied between approximately 78,000 af and 98,000 af during the 1999 to 2014 period, with an average annual volume of 88,000 af. On average, approximately 61,000 af of ET were derived from applied irrigation water (69% of total ET) and 27,000 af of ET were derived from precipitation (31% of total ET).

Other uses of applied irrigation water include winter flooding for habitat and rice straw decomposition (discussed in the following section), leaching of salts, and frost protection for orchard crops. Due to the low salinity of groundwater in BWD and in surface water diverted from the Feather River, the required leaching fraction is small for the crops grown in the district and has not been estimated at this time. Additionally, water applied for frost protection is typically applied outside of the irrigation season and is a minor use; thus, it has not been estimated at this time.

Environmental and Recreational

Approximately 60 percent or 4,000 acres of the rice fields in BWD are estimated to be flooded in the winter following harvest to aid in rice straw decomposition and to create winter habitat for migratory waterfowl and shorebirds along the Pacific Flyway. Use of water during the winter for rice decomposition and waterfowl habitat increased substantially between 1992 and 2001, largely driven by the phasing out of burning of rice straw as a result of the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991. Winter flooded acres have remained relatively steady since around 2000.

Diversions and estimated applied water for rice straw decomposition and wildlife habitat within BWD are provided in Table 4.7. These estimates are based on measured diversions and estimated applied water (delivery term from water balance analysis) for the October – March period. Some water delivered during October is for irrigation of orchard crops. Diversions are zero between February and March, although private reuse of available water may occur and is included in the estimated applied water.

Table 4.7. Estimated Winter Diversions and Applied Water for Managed Wetlands and Rice Straw Decomposition.

Water Year	Winter Net Diversions (af)	Applied Water (af)[1]
1999	1,808	4,466
2000	11,344	9,328
2001	3,490	6,384
2002	10,534	6,135
2003	10,080	5,902
2004	7,578	4,559
2005	3,572	4,624
2006	9,624	5,776
2007	13,412	15,674
2008	6,120	13,938
2009	9,016	4,972
2010	15,670	6,257
2011	12,392	5,374
2012	14,030	18,460
2013	11,064	14,759
2014	22,864	16,940
Average	9,191	7,989

1. Estimated based on water balance analysis. Includes deliveries plus reuse.

The water supplied during the winter period provides critical habitat to support migratory waterfowl and shorebirds while also creating recreational opportunities. Aside from this, there are no recreational water uses within the district.

In addition to use of water within the district to provide winter habitat, surface outflows from BWD flow to BWGWD and SEWD where they can enter Gray Lodge Wildlife Area, the Butte Sink, and ultimately the Sutter Bypass, providing important flows to support migration of salmon and steelhead and other downstream uses of water for wildlife habitat, such as diversions by Sutter National Wildlife Refuge to support seasonal wetlands. Outflows from the BWD service area are discussed in greater detail in the drainage and water balance sections.

Municipal and Industrial

BWD does not provide any municipal or industrial water at this time. The cities of Gridley and Live Oak are encompassed by the district's boundary.

Groundwater Recharge

Groundwater recharge that occurs within the district's service area consists of seepage from canals and private ditches, as well as deep percolation of precipitation and applied irrigation water. Distributed recharge through seepage and deep percolation provides a means to replenish the groundwater system to the benefit of BWD water users, the communities of Biggs, Gridley, and Live

Oak, other individuals within BWD, and surrounding areas overlying the East Butte and Sutter groundwater subbasins.

Estimates of recharge were developed as part of the water balance analysis. Specifically, canal and drain seepage estimates were calculated based on estimated soil hydraulic characteristics along with estimated canal and drain wetted perimeters, overall lengths, and wetting frequency. Deep percolation of applied irrigation water and precipitation were calculated based on estimated applied irrigation water amounts over time as influenced by ET_o, precipitation, crop, and soil type, and simulated by the IDC model described previously.

Estimated annual seepage and deep percolation volumes for water years 1999 to 2014 are provided in Table 4.8, along with total recharge expressed as a volume and as a depth of water for each year.

Table 4.8. Total Groundwater Recharge, 1999-2014.

Water Year	Canal Seepage (af)	Deep Percolation of Applied Water (af)	Deep Percolation of Precipitation (af)	Total Recharge	
				af	af/ac
1999	35,355	21,627	12,300	69,282	2.6
2000	35,355	25,898	15,731	76,985	2.9
2001	35,355	21,288	10,376	67,019	2.7
2002	35,355	25,218	14,523	75,096	3.0
2003	35,355	19,531	14,227	69,114	3.2
2004	35,355	24,017	15,107	74,480	3.0
2005	35,355	21,564	14,613	71,532	2.8
2006	31,889	23,994	22,441	78,324	3.2
2007	35,355	22,120	4,815	62,290	2.5
2008	35,355	21,668	9,389	66,412	3.0
2009	35,355	21,957	6,873	64,185	2.6
2010	31,889	20,297	13,208	65,394	2.9
2011	35,355	22,258	21,244	78,857	3.1
2012	31,889	20,418	10,077	62,383	2.8
2013	35,355	23,195	6,821	65,371	2.5
2014	35,355	20,320	2,602	58,277	2.7
Average	34,705	22,211	12,147	69,063	2.8

Total recharge between 1999 and 2014 ranged from approximately 58,000 af to 79,000 af per year, or from 2.5 af to 3.2 af per acre per year. On average between 1999 and 2014, total recharge was estimated to be approximately 69,000 af per year (2.8 af/ac-year), with approximately 50% of recharge originating from canal seepage, 32% of from deep percolation of applied water, and 18% from deep percolation of precipitation.

Groundwater level monitoring data and field observations suggest that the shallow groundwater system and regional aquifer may be coupled within portions of BWD's service area at certain times and that an unsaturated aquifer zone may thus not be present to receive recharge. Depth to water in residential and irrigation wells is commonly less than ten feet, and drains flow in some areas

even when irrigation is not occurring. These conditions likely result from limited groundwater pumping in the area historically along with sustained use of surface water for irrigation over past decades. As a result, it is likely that a substantial portion of the water percolating into the soil from ponded fields and seeping from canals may be unable to flow downward and rather flows horizontally to where it is intercepted by non-ponded vegetation or by drains, providing base flow. Shallow groundwater interception is shown conceptually in Figure 4.7 and discussed in a regional context in Volume I of this AWMP.

Even in areas where an unsaturated zone is present, water infiltrating into the soil in ponded fields may encounter impermeable layers caused by plow pan or natural soil features and flow laterally to adjacent lands or provide base flow for drains. Additional information is needed to distinguish shallow groundwater interception in areas where the shallow and regional groundwater systems are coupled from areas with perched shallow groundwater.

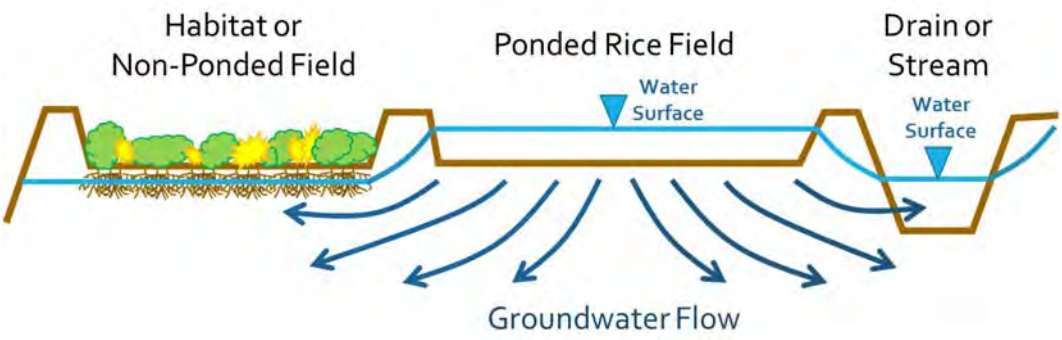

Figure 4.7. Conceptualization of Shallow Groundwater Interception in Rice Growing Areas.

Groundwater recharge net of well pumping and shallow groundwater interception was calculated by subtracting estimated pumping volumes from total recharge volumes. Shallow groundwater interception occurs when drains, creeks, or other waterways intercept or "gain" water from the shallow groundwater system, which may be perched or connected to the regional aquifer. Additionally, shallow groundwater can be intercepted and consumed by natural or other non-ponded vegetation. Net annual recharge estimates for 1999 to 2014are provided in Table 4.9.

Table 4.9. Net Groundwater Recharge, 1999-2012.

Year	Total Recharge (af)	Groundwater Pumping (af)	Shallow Groundwater Interception (af)	Net Recharge	
				af	af/ac
1999	69,282	16,360	7,276	45,645	1.7
2000	76,985	17,657	7,276	52,052	2.0
2001	67,019	19,058	7,276	40,685	1.5
2002	75,096	19,820	7,276	47,999	1.8
2003	69,114	16,437	7,276	45,400	1.7
2004	74,480	20,944	7,276	46,260	1.8
2005	71,532	17,702	7,276	46,554	1.7
2006	78,324	18,228	7,276	52,821	2.0
2007	62,290	26,747	7,276	28,267	1.1
2008	66,412	24,615	7,276	34,521	1.3
2009	64,185	28,892	7,276	28,016	1.1
2010	65,394	24,453	7,276	33,665	1.3
2011	78,857	18,800	7,276	52,780	2.0
2012	62,383	25,095	7,276	30,012	1.1
2013	65,371	36,697	7,276	21,398	0.8
2014	58,277	36,184	7,276	14,817	0.6
Average	69,063	22,981	7,276	38,806	1.5

Net recharge varied from approximately 15,000 af to 53,000 af per year between 1999 and 2014, or 0.6 af to 2.0 af per acre per year. On average between 1999 and 2014, net recharge was estimated to be approximately 39,000 af per year (1.5 af/ac-year).

Transfers and Exchanges

The district participated in nine voluntary water transfers between 1999 and 2014 with parties outside of the region. Surface water was made available for transfer through five crop idling-based transfers and four groundwater substitution transfers. For crop idling water transfers, participating landowners idled land within the district and transferred the surface water that would have been applied and consumed in lieu of the project. The quantity of water transferred was based on DWR estimates of the annual evapotranspiration of applied water for rice (3.3 af/ac). The amount of water transferred from crop idling is estimated in Table 4.10.

Table 4.10. Crop Idling Water Transfer Volumes, 1999-2014.

Year	Idle Acreage	Transfer Volume (af)
2003	3,441	11,355
2008	3,032	10,006
2010	3,116	10,281
2012	3,309	10,919
2014	3,267	10,780

Pumping amounts from groundwater substitution in 2009, 2010, 2013, and 2014 were 4,102 af, 3,846 af, 3,838 af, and 4,708 af, respectively. Pumping amounts were decreased by 12% to determine the transferable amount based on estimated stream depletion.

Additionally, BWD and SEWD have historically provided water to other of the Joint Districts through local water transfers. The primary recipients of within-region transfers have been BWGWD and RID. Water was provided in seven of the nine years between 2006 and 2014, ranging from 3,000 af to 26,000 af annually with an average transfer amount of 14,000 af. Historically, BWD has provided approximately 55% of the water transferred, with SEWD providing the remaining 45%.

Other Water Uses

Other incidental uses of water within BWD may include watering of roads for dust abatement or agricultural spraying. The volume of water used for such purposes is small relative to other uses and has not been quantified as part of this AWMP.

4.7.4 Drainage

Surface Outflows

Surface drains within BWD convey runoff of precipitation, surface inflows from upgradient lands, runoff of irrigation water (tailwater), and provide shallow groundwater relief by capturing canal seepage and intercepting shallow groundwater. Surface drains are also an important source of water for crop season irrigation and winter flooding. All water leaving the district as surface outflows is available for reuse by downstream water users and the environment. Annual surface outflows are summarized in Table 4.11.

Water year boundary outflows ranged from approximately 58,000 af to 104,000 af between 1999 and 2014 with an average of 80,000 af. Based on estimated outflow flow rates and estimated tributary areas above each outflow location, total boundary outflows been divided among the two primary outflow locations. It is estimated that approximately 30% of total outflows flow to BWGWD with the remaining 70% of outflows flowing to SEWD.

Tailwater

The private farmed lands water balance includes an estimate of the volume of tailwater entering the distribution and drainage system that is available for reuse. A portion of this volume is reused internally by the district and individual water users and is accounted for in the estimated deliveries; the remainder is available for reuse by downgradient water users in BWGWD and SEWD. Table 4.12 presents the estimated annual tailwater volumes between water years 1999 and 2014.

Tailwater entering the distribution and drainage system between 1999 and 2014 ranged from approximately 19,000 af to 29,000 af per year. The overall average tailwater for this period was 24,000 af per year.

Table 4.11. Estimated Surface Outflow Volumes, 1999-2014.

Water Year	Drains to BWGWD (af)	Drains to SEWD (af)	Total Boundary Outflows (af)
1999	17,434	40,680	58,114
2000	21,665	50,552	72,218
2001	20,534	47,912	68,446
2002	29,125	67,959	97,085
2003	31,198	72,796	103,994
2004	24,538	57,255	81,793
2005	20,181	47,089	67,270
2006	27,139	63,325	90,464
2007	22,888	53,406	76,294
2008	22,934	53,513	76,447
2009	25,769	60,128	85,897
2010	27,526	64,227	91,753
2011	28,295	66,021	94,316
2012	21,276	49,645	70,921
2013	21,486	50,134	71,619
2014	21,518	50,210	71,728
Average	23,969	55,928	79,897

Table 6.12. Estimated Tailwater Volumes, 1999-2014.

Water Year	Tailwater (af)
1999	28,112
2000	29,112
2001	26,449
2002	27,902
2003	19,616
2004	26,619
2005	22,621
2006	23,648
2007	29,143
2008	24,490
2009	23,145
2010	18,656
2011	19,334
2012	22,251
2013	24,646
2014	22,145
Average	24,243

Reuse

BWD can recover water into the distribution system at two pump stations; however they are typically not used because the water is recovered and reused downstream in drains by BWD customers. It is estimated that approximately 30% of annual applied surface water within BWD is through reuse, or approximately 25,000 af annually. Reuse by water users in BWD reduces diversion requirements from the afterbay and results in district-scale water use efficiencies that would otherwise not be attained. Implications of reuse at the district and regional scales are further discussed in the following section.

4.7.5 Water Accounting (Summary of Water Balance Results)

The BWD water balance structure was shown previously in Figure 4.3. The water balance was prepared for the distribution and drainage system and for farmed lands. Additionally, the water balance can be summarized for the BWD service area as a whole ("Water Balance Boundary" shown in Figure 4.3). An accounting center representing the groundwater system is also included in Figure 4.3 to account for exchanges between the root zone and the underlying groundwater system; however, a complete balance for the underlying aquifer has not been developed because not all inflows and outflows into the groundwater system (such as horizontal boundary flows) have been estimated.

As depicted in Figure 4.3 and discussed previously, interconnection exists between the accounting centers due to recapture and reuse of water by both the BWD distribution system and directly by water users. Specifically, surface runoff of applied water (tailwater) flows back into the distribution and drainage system. Within the drainage system, reuse of water originating as tailwater, operational spillage, or from other sources is practiced by individual water users. This water recovery and reuse results in higher levels of aggregate performance than would otherwise occur.

The water balance results are presented on a water year basis for 1999 through 2014. Underlying the annual time step is a more detailed water balance in which all flow paths are estimated on a monthly basis.

District-Wide and Individual Accounting Center Water Balance Results

A district-wide water balance combining individual inflows and outflows into general categories is shown in Figure 4.8 for the water year and for the April to September irrigation season. Average volumes are presented for each inflow and outflow category, as well as average volumes expressed in acre-feet per acre. Average monthly inflows to and outflows from BWD are further summarized in Figures 4.9 and 4.10, respectively.

Detailed annual water balance results for the distribution and drainage system are summarized in Table 4.13. Detailed annual water balance results for the farmed lands are summarized in Table 4.14. In each table, performance indicators discussed in the following section are provided.

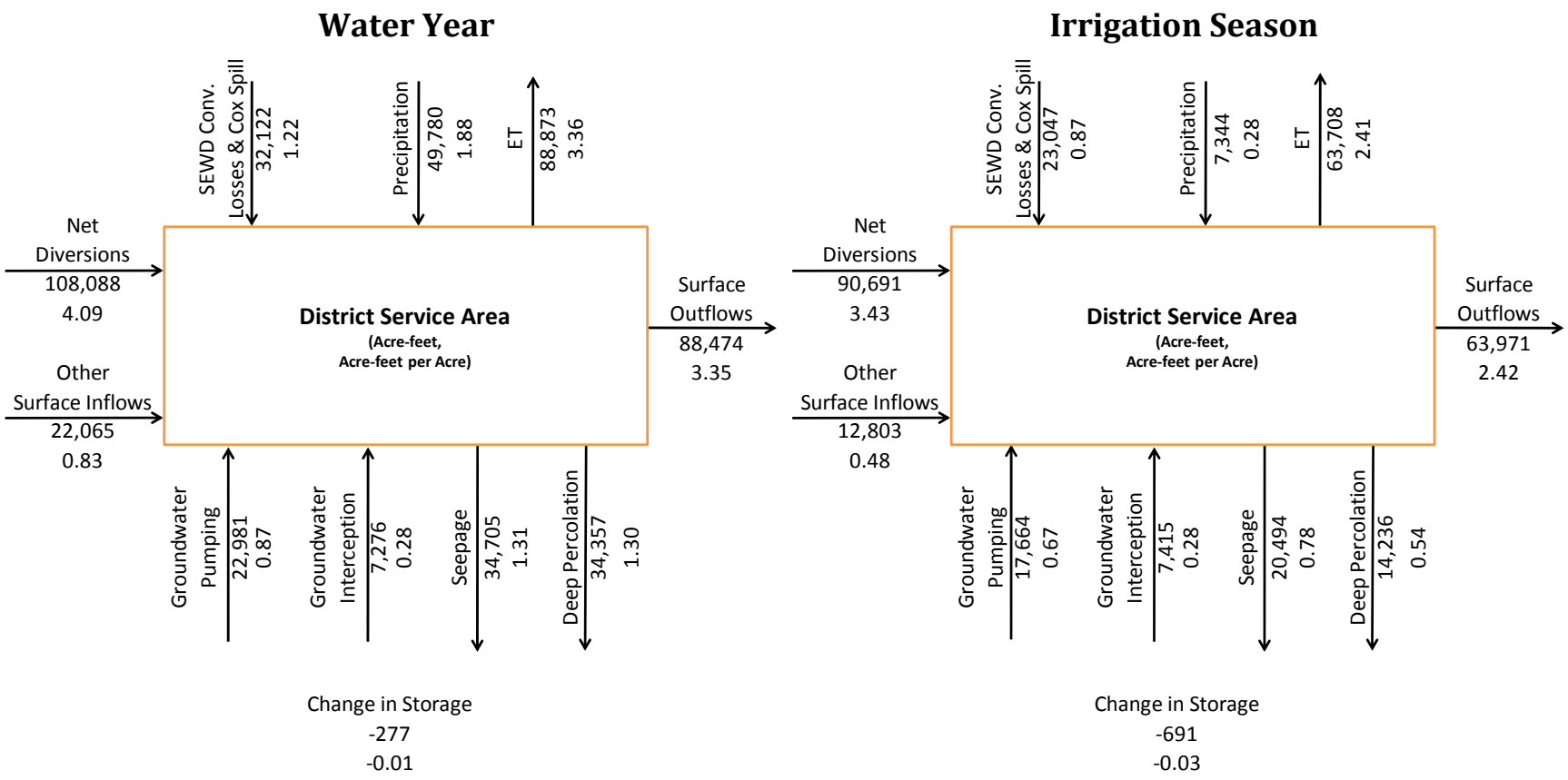

Figure 4.8. District Water Balance 1999-2014.

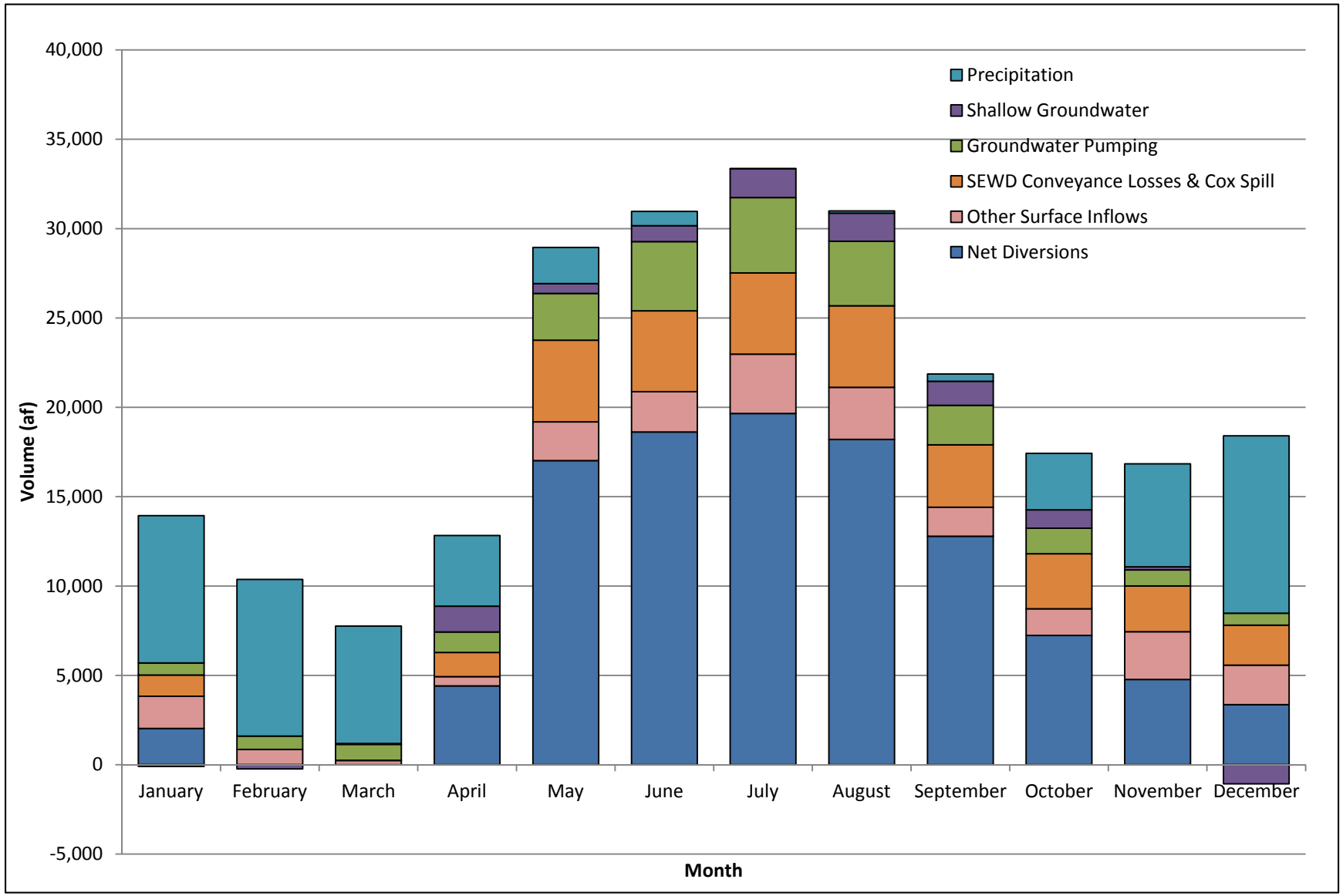

Figure 4.9. Average Monthly Inflows, 1999-2014.

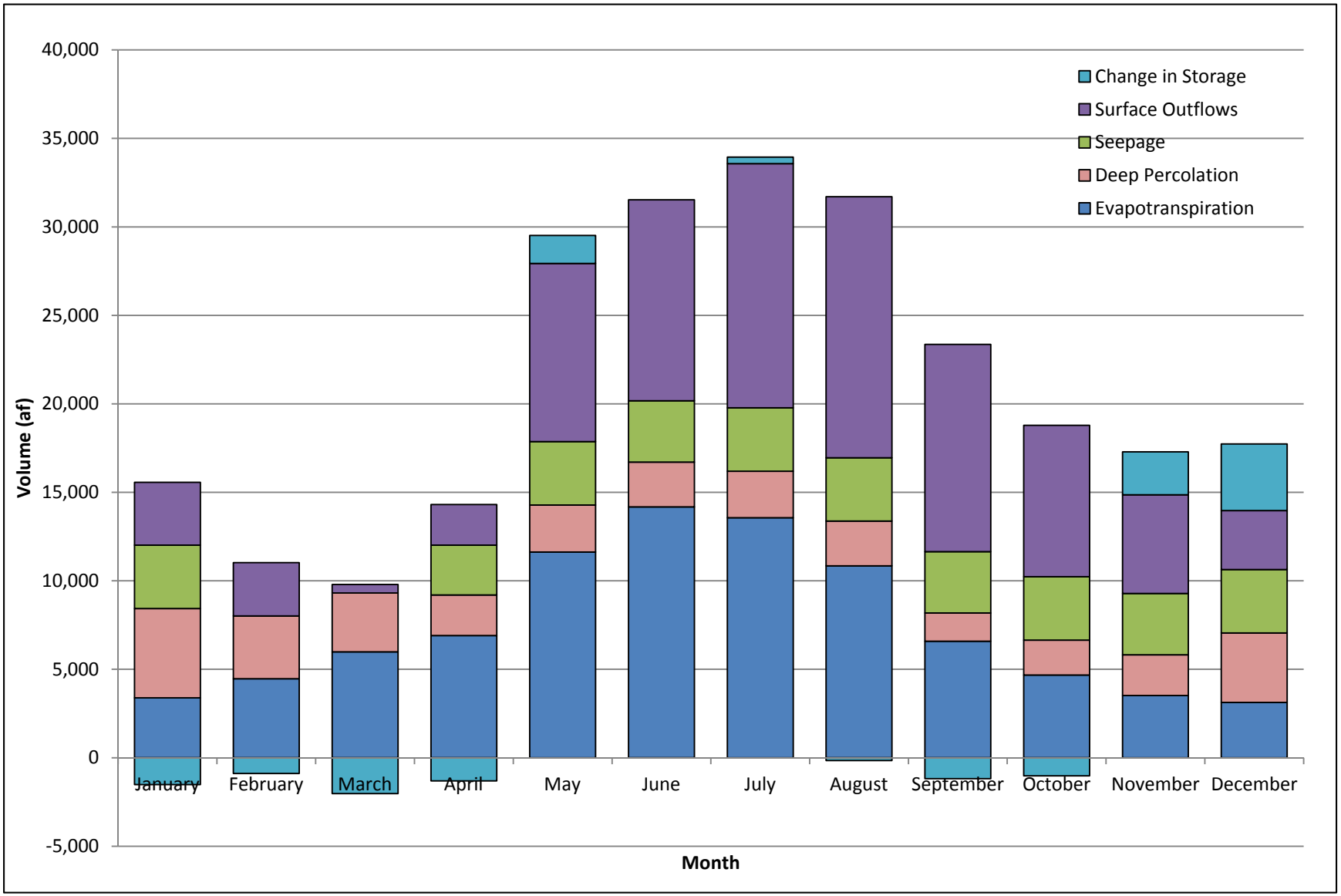

Figure 4.10. Average Monthly Outflows, 1999-2014.

Table 4.13. Distribution and Drainage System Annual Water Balance Results, 1999-2014.

Water Year	Inflows (af)							Outflows (af)					Performance Indicators	
	Net Diversions	SEWD Conveyance Losses	Snake Creek	Precipitation	Shallow Groundwater Interception	Runoff of Precipitation	Tailwater	Deliveries	Evaporation	Riparian ET	Seepage	Boundary Outflows	Delivery Fraction	Water Management Fraction
1999	105,068	25,957	18,692	330	4,366	5,741	28,112	93,707	938	152	35,355	58,114	0.89	0.994
2000	111,670	27,205	20,819	433	4,366	12,158	29,112	97,041	994	156	35,355	72,218	0.87	0.994
2001	108,944	27,880	18,255	338	4,366	6,908	26,449	88,163	1,015	161	35,355	68,446	0.81	0.994
2002	133,408	28,669	20,610	401	4,366	11,256	27,902	93,008	1,005	159	35,355	97,085	0.70	0.995
2003	117,288	26,694	22,347	472	4,366	15,071	19,616	65,386	964	154	35,355	103,994	0.56	0.995
2004	104,556	29,881	29,147	386	4,366	12,078	26,619	88,730	994	160	35,355	81,793	0.85	0.994
2005	87,121	29,439	23,489	465	4,366	11,575	22,621	75,402	901	146	35,355	67,270	0.87	0.994
2006	96,958	27,179	29,727	563	4,366	19,756	23,648	78,828	871	145	31,889	90,464	0.81	0.995
2007	117,606	32,130	22,213	242	4,366	4,252	29,143	97,143	989	170	35,355	76,294	0.83	0.994
2008	107,532	27,805	21,669	307	4,366	8,411	24,490	81,634	976	168	35,355	76,447	0.76	0.994
2009	119,204	26,611	18,706	302	4,366	7,133	23,145	77,150	907	157	35,355	85,897	0.65	0.995
2010	102,506	27,513	22,283	423	4,366	11,056	18,656	62,188	828	145	31,889	91,753	0.61	0.995
2011	99,764	26,732	28,317	575	4,366	15,970	19,334	64,447	800	139	35,355	94,316	0.65	0.995
2012	93,098	27,197	23,296	341	4,366	7,455	22,251	74,170	868	156	31,889	70,921	0.80	0.994
2013	109,723	27,058	19,617	254	4,366	4,640	24,646	82,153	1,013	163	35,355	71,619	0.75	0.994
2014	114,966	25,087	13,856	149	4,366	1,526	22,145	73,817	1,030	165	35,355	71,728	0.64	0.993
Minimum	87,121	25,087	13,856	149	4,366	1,526	18,656	62,188	800	139	31,889	58,114	0.56	0.993
Maximum	133,408	32,130	29,727	575	4,366	19,756	29,143	97,143	1,030	170	35,355	103,994	0.89	0.995
Average	108,088	27,690	22,065	374	4,366	9,687	24,243	80,811	943	156	34,705	79,897	0.75	0.994

Table 4.14. Farmed Lands Annual Water Balance Results, 1999-2014.

Water Year	Inflows (af)				Outflows (af)						Change in Storage (af)	Performance Indicators		
	Deliveries	Precipitation	Shallow Groundwater Interception	Groundwater Pumping	ET of Applied Water	ET of Precipitation	Deep Percolation of Applied Water	Deep Percolation of Precipitation	Runoff of Precipitation	Tailwater		Deliveries (af/ac)	Surface Water Supply Fraction	Crop Consumptive Use Fraction
1999	93,707	43,660	2,910	16,360	60,306	28,861	21,627	12,300	5,741	28,112	-308	5.37	0.85	0.55
2000	97,041	57,372	2,910	17,657	63,695	28,117	25,898	15,731	12,158	29,112	269	5.69	0.85	0.56
2001	88,163	44,546	2,910	19,058	62,907	26,903	21,288	10,376	6,908	26,449	-154	5.25	0.82	0.59
2002	93,008	53,042	2,910	19,820	63,499	26,946	25,218	14,523	11,256	27,902	-564	5.56	0.82	0.56
2003	65,386	62,507	2,910	16,437	46,829	31,055	19,531	14,227	15,071	19,616	911	4.74	0.80	0.57
2004	88,730	51,026	2,910	20,944	63,829	24,759	24,017	15,107	12,078	26,619	-2,799	5.15	0.81	0.58
2005	75,402	61,430	2,910	17,702	52,405	32,438	21,564	14,613	11,575	22,621	2,230	4.43	0.81	0.56
2006	78,828	74,496	2,910	18,228	52,156	31,954	23,994	22,441	19,756	23,648	513	4.70	0.81	0.54
2007	97,143	31,965	2,910	26,747	75,358	22,721	22,120	4,815	4,252	29,143	357	5.66	0.78	0.61
2008	81,634	40,569	2,910	24,615	63,655	23,211	21,668	9,389	8,411	24,490	-1,096	5.88	0.77	0.60
2009	77,150	39,842	2,910	28,892	67,194	23,728	21,957	6,873	7,133	23,145	-1,235	4.39	0.73	0.63
2010	62,188	55,918	2,910	24,453	49,769	29,870	20,297	13,208	11,056	18,656	2,614	4.54	0.72	0.57
2011	64,447	76,000	2,910	18,800	47,952	36,166	22,258	21,244	15,970	19,334	-766	3.79	0.77	0.58
2012	74,170	45,058	2,910	25,095	57,911	29,436	20,418	10,077	7,455	22,251	-314	5.48	0.75	0.58
2013	82,153	33,471	2,910	36,697	75,064	20,716	23,195	6,821	4,640	24,646	150	5.02	0.69	0.63
2014	73,817	19,599	2,910	36,184	68,952	16,011	20,320	2,602	1,526	22,145	954	5.44	0.67	0.63
Minimum	62,188	19,599	2,910	16,360	46,829	16,011	19,531	2,602	1,526	18,656	-2,799	3.79	0.67	0.54
Maximum	97,143	76,000	2,910	36,697	75,358	36,166	25,898	22,441	19,756	29,143	2,614	5.88	0.85	0.63
Average	80,811	49,406	2,910	22,981	60,717	27,056	22,211	12,147	9,687	24,243	48	5.07	0.78	0.58

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Characterization of Water Management and Performance

District

Monthly inflow and outflow patterns provide insight into water management at the district-scale, which is influenced by water management and irrigation practices for the major crops grown, orchards and rice. The observed monthly patterns are expected to differ from individual fields, reflecting the full population of fields in the district.

Diversions begin in April or May and continue at relatively steady levels through August, when they decrease as fields are prepared for harvest, including draining of rice fields. Diversions continue in October and November for late orchard irrigation and to flood rice fields for decomposition and habitat. Diversions cease in mid-January in preparation for the next year's rice crop. Surface inflows, primarily from Snake Creek, tend to follow a similar pattern to diversions, as they result largely from upstream irrigation, demonstrating the "cascading" characteristic of irrigation in the region, where return flows from upstream water users are available for downstream agricultural and environmental uses.

Monthly ET generally follows the pattern of ET_o, increasing in the spring and summer as temperatures and available solar radiation increase, and decreasing in the winter. Actual ET rates are relatively similar to reference values due to the availability of adequate surface water supplies to support crop growth. Deep percolation and seepage are relatively constant over time due to the use of available surface water during the majority of the year, with deep percolation increasing somewhat in the winter as a result of precipitation and decreasing prior to planting and following harvest. Surface outflows follow the general pattern of diversions, increasing during irrigation.

The monthly change in storage reflects rice growing and winter flooding as well, with water going into storage in April and May, remaining relatively constant in June and July, and returning to the system as fields are drained in August and September. Storage then increases again October through December and is drained in January through February in preparation for planting.

On a water use basis, substantial recharge of the groundwater system occurs as a result of the use of surface water within BWD. It is estimated that approximately 39,000 af of groundwater recharge net of groundwater pumping and shallow groundwater interception occur annually within the district. It is estimated that approximately 7,000 af of shallow groundwater interception occurs annually. Groundwater interception supports the growth of native vegetation and provides base flow for streams and drains.

Comparing total inflows to BWD to total outflows to meet consumptive irrigation demands plus recoverable return flows available for use by others or the environment, a Water Management Fraction (WMF) may be calculated[5]. This indicator describes the amount of the total water supply not lost irrecoverably to evaporation from the canal and drain system (Equation 4.2).

[5] The WMF is based on methodologies to quantify the efficiency of agricultural water use developed by DWR (DWR 2012b) and has been broadened to include all beneficial ET as well as all water supplies.

$$Water\ Management\ Fraction = \frac{Evapotranspiration + Return\ Flows}{Inflows} \quad [4.2]$$

Over the period from 1999 to 2014, the WMF was 0.994, indicating that essentially all available water supply is used to meet irrigation demands or is recoverable for downstream surface water and groundwater uses.

Distribution and Drainage System

Inflows to the distribution and drainage system in the BWD service area include diversions from the Sutter-Butte Canal (which originates at Thermalito Afterbay), precipitation falling directly into canals and drains, inflows from BWGWD via Snake Creek, runoff of precipitation from farmed lands, shallow groundwater interception, and tailwater inflows from farmed lands. Outflows include deliveries, surface outflows to SEWD and BWGWD, seepage, evaporation, and riparian ET.

The objective of BWD operations is to meet the irrigation and environmental water demands of its customers. The water balance results indicate several characteristics of water management by BWD, its customers, and other water users in the district boundary but not served by the district. Comparing total deliveries to meet irrigation demand to diversions provides a measure of the effectiveness of system operation. A Delivery Fraction (DF), representing the ratio of deliveries to diversions may be calculated to provide an indicator of distribution and drainage system performance (Equation 4.3)[6].

$$Delivery\ Fraction = Deliveries/Diversions \quad [4.3]$$

The DF ranged from 0.56 to 0.89 between 1999 and 2014 with an overall average of 0.75. DF values increase as a result of limiting operational spillage and recovery and reuse of available water in the system by individual water users.

Farmed Lands

Inflows to the farmed lands include deliveries[7], groundwater pumping from private wells, and precipitation. Outflows include ET, tailwater, runoff of precipitation, and deep percolation. Additionally, as discussed previously, appreciable changes in stored water in the surface layer occur within the district as a result of rice production and winter flooding.

The objective of irrigation in BWD is to meet crop and environmental water demands in the most effective and efficient manner practical. Like the distribution and drainage system water balance, the farmed lands water balance provides insight into water management by BWD and growers.

Comparing total surface water supply (other than precipitation falling on farmed lands) to total irrigation supply including groundwater pumping, a surface water supply fraction (SWSF) may be

[6] Although the surface water supply includes sources other than diversions (e.g., precipitation inflows), the DF is calculated to include only diversions as this is the portion of surface water supply directly managed by BWD.
[7] As described previously, deliveries include deliveries by BWD and reuse by individual water users.

calculated as an indicator of the relative amount of the total irrigation supply derived from surface water (Equation 4.4).

$$Surface\ Water\ Supply\ Fraction = Deliveries\ /\ (Deliveries + Groundwater\ Pumping) \quad [4.4]$$

The SWSF ranged from approximately 0.67 to 0.85 between 1999 and 2014 with an average value of 0.78. This value demonstrates the reliability of and reliance on surface water supplies within BWD. In the rare event of reduced surface water allocations due to surface water shortages, private groundwater pumping can be increased to some extent to minimize lost production, resulting in decreased SWSF for those years. Even in years of reduced supply, surface water is the primary water source to meet demands.

Comparing crop ET_{aw} to total irrigation supplies, a crop consumptive use fraction (CCUF) may be calculated as an indicator of the relative amount of applied irrigation water consumed to grow the crop (Equation 4.5) (DWR 2012b).

$$Crop\ Consumptive\ Use\ Fraction = Crop\ ET\ of\ Applied\ Water\ /\ (Deliveries + Groundwater\ Pumping) \quad [4.5]$$

Between 1999 and 2014, the CCUF ranged from 0.54 to 0.68 with an overall average of 0.58. These CCUF values are calculated at the field scale and thus are not reflective of water reuse within the district. Based on estimated reuse of approximately 25,000 af of surface water by individual water users annually, the average CCUF at the district scale is estimated to be 0.85[8].

4.8 Climate Change

Climate change has the potential to directly impact surface water resources in the Feather River region and to indirectly impact groundwater resources. Due to the similarity in the nature of diversion agreements with the State among the primary water suppliers relying on the Feather River and due to similarity in cropping, climate, soils, and other factors, potential effects of climate change, impacts on water management, and actions by individual suppliers or through regional coordination to help mitigate future impacts are described for the region as a whole in Volume I, Section 5 of this regional AWMP. In particular, the following are discussed:

- Potential effects of climate change within the region;
- Resulting potential impacts on water resources including water supply, water demand, water quality, and flood control;
- Ongoing and potential future actions to help mitigate future impacts; and
- Additional resources regarding water resources planning to address climate change.

[8] Estimated as annual ET_{aw}/(deliveries + groundwater pumping – private reuse).

4.9 Efficient Water Management Practices and Water Use Efficiency

4.9.1 Efficient Water Management Practices

BWD seeks to efficiently manage water supplies to meet water management objectives, considering operational and financial constraints. Although supplying water to less than 25,000 acres, similar to other water supplier in the region, BWD implements technically feasible Efficient Water Management Practices (EWMPs) at locally cost-effective levels. Activities related to each of the EWMPs being implemented are summarized in Table 4.15. Water use efficiency improvements achieved through these activities may include increased local and statewide water supplies and water supply reliability, increased local flexibility, increased in-stream flow, improved water quality, and improved energy efficiency.

In 2003, BWD worked with DWR and Western Development and Storage to prepare a comprehensive evaluation of historical conserved water (BWD 2003). The evaluation considered both consumptive and non-consumptive uses of water within the district and provided a detailed analysis of historical consumptive and non-consumptive water use. Conserved water volumes were estimated based on changes in land use, cropping, and irrigation practices over time.

Other notable water management actions that BWD has implemented include the following:

- Provision of flexible deliveries for the range of crops grown and irrigation methods employed;
- Support of on-farm physical and management improvements;
- Implementation of a SCADA system for real-time monitoring of key district inflow and outflow sites;
- Installation of two partially-automated and one fully-automated control structures along Sutter-Butte canal to improve service and reduce spillage;
- Evaluation of opportunities to further improve service through automation of control structures and flow measurement in key locations;
- Conversion of open ditches to pipelines in areas with seepage issues;
- Recovery of drainwater into the distribution for reuse at two locations;
- Evaluation of opportunities to improve delivery of surface water to drip and microsprinkler irrigation systems on orchards, to maintain surface water customer base for local and regional sustainability; and
- Ongoing coordination with DWR operations and other water management entities to evaluate and improve policies to allow for more flexible deliveries and storage.

As part of this plan, reconnaissance level cost estimates have been prepared for potential future water management improvements identified during field visits and meetings with BWD staff. Additionally, potential benefits of the improvements have been estimated. These improvements will be implemented over time as determined to be locally cost effective or to meet regional and statewide water management objectives as applicable given the flow-through nature of water management in the region, whereby water not consumed is available for reuse by downstream

water users and the environment, and as funding becomes available from internal or other sources. The evaluation of potential water management improvements is included in Section 4.10.3. Additionally, opportunities to improve the joint facilities used to convey water from the afterbay to BWD have been evaluated and are described in Section 10.1.

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Table 4.15. EWMP Implementation Status.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
10608.48.b(1)	Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2).	Not Required	• Deliveries are measured in a manner to support effective water management and equitable billing. • Evaluated customer delivery measurement options.	• Continue existing practices. • Consider customer delivery measurement improvements, contingent on availability of funding and project prioritization.
10608.48.b(2)	Adopt a pricing structure for water customers based at least in part on quantity delivered.	Being Implemented	• Irrigation events are limited as reasonable by crop type, with additional charges for subsequent irrigation deliveries. • Developed customer accounting and reporting system with billing capabilities that could be adapted for other pricing structures.	• Continue existing pricing.
10608.48.c(1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Lands with exceptionally high water duties or whose irrigation contributes to significant problems are not found within the BWD. Furthermore, BWD's rules and regulations prohibit wasteful use of water, preventing exceptional water duties or significant problems from occurring. Water applied but not consumed to produce crops provides beneficial groundwater recharge or is available for downstream uses.	
10608.48.c(2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils	Not Technically Feasible	• There is no available water from municipal or industrial uses that meets all health and safety criteria within the service area.	• BWD is willing to consider opportunities for use of available recycled water if it meets all health and safety criteria.
10608.48.c(3)	Facilitate financing of capital improvements for on-farm irrigation systems	Being Implemented	• BWD provides at-cost labor and materials to assist landowners in improving on-farm irrigation systems. • BWD evaluated opportunities to maintain and increase surface water customer base for growers using pressurized irrigation.	• Continue to provide at-cost labor and materials for on-farm improvements, as resources allow. • Encourage landowners and growers to use available surface water through improved delivery to pressurized irrigation systems or other means.
10608.48.c(4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented	• BWD water rates promote goal A by limiting irrigation events to the reasonable amount as determined by crop type, with additional charges for irrigation deliveries above a specified amount. • BWD water rates promote goals B and C by encouraging the use of available surface water supplies, which provides beneficial groundwater recharge through deep percolation. Groundwater is then available in years of surface water shortage while maintaining long term sustainability of the groundwater system. • BWD water rates promote goal E by providing a reliable, affordable source of water to maintain waterfowl habitat, primarily winter flooding of rice fields.	• Continue to promote goals A, B, C, and E through current water rates.
10608.48.c(5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage	Being Implemented	• BWD evaluated small-scale conversions from open ditches to pipelines. • BWD has installed approximately 3,000 feet of pipeline in areas with seepage problems within the district since 2010. Additionally, a similar amount of pipeline was installed in the preceding decade. • BWD has evaluated lining along the Sutter-Butte canal; however, it is not locally cost effective at this time. Also, any seepage reduction from canal lining would reduce beneficial groundwater recharge.	• Continue pipeline installations in areas with seepage problems as appropriate and as time and funding allow.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
10608.48.c(6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits	Being Implemented	• BWD provides a high degree of flexibility to customers by providing orders with 24-hour notice, in most cases. • BWD evaluated opportunities to further improve service through comprehensive modernization including automation of control structures along Sutter-Butte canal, enhancement of conveyance capacity, and flow measurement at lateral headings. • BWD evaluated opportunities to maintain and increase surface water customer base for growers using pressurized irrigation through enhanced delivery service.	• Explore funding options and proceed with automation, increased conveyance capacity, and flow measurement improvements, contingent on availability of funding and project prioritization. • Encourage landowners and growers to use available surface water through improved delivery to pressurized irrigation systems or other means.
10608.48.c(7)	Construct and operate supplier spill and tailwater recovery systems	Being Implemented	• Drainwater recovery into the distribution system for reuse can currently be accomplished via pumping in two locations within BWD; however, individual BWD water users currently rely on the drainwater as a source of supply. • BWD installed two partially-automated and one fully-automated control structures along Sutter-Butte canal to improve service and reduce spillage. • BWD evaluated further automation of Sutter-Butte canal and flow measurement at lateral headings, which will reduce operational spillage. • BWD and the other Joint Districts implemented a SCADA system to allow for real time monitoring of Sutter-Butte Canal flows and operational spillage at Cox Spill.	• Continue drainwater recovery into the distribution system for reuse, as appropriate. • Install an additional automated structure along Sutter-Butte canal at Pennington Weir. • Explore options and proceed with automation and flow measurement improvements, contingent on availability of funding and project prioritization.
10608.48.c(8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area	Being Implemented	• An adequate amount of surface water is available for irrigation in most years. During shortage years, groundwater is used conjunctively with reduced surface water supplies to meet demand. • Shortage allocation policies are designed to facilitate the conjunctive use of groundwater in surface water shortage years. • BWD participates in voluntary groundwater substitution transfers to increase statewide water supplies. • BWD has chosen to implement SGMA as a GSA and is actively coordinating with other water managers in the subbasins it overlies.	• Continue usage of surface water when available and conjunctive use of surface water and groundwater during periods of shortage to meet demand. • Encourage landowners and growers to use available surface water through improved delivery to pressurized irrigation systems or other means. • Continue voluntary groundwater substitution transfers. • Continue to implement SGMA as a GSA.
10608.48.c(9)	Automate canal control structures	Being Implemented	• Evaluated automation of Sutter-Butte canal as part of comprehensive modernization plan. • BWD installed two partially-automated and one fully-automated control structures along Sutter-Butte canal.	• Install an additional automated structure along Sutter-Butte canal at Pennington Weir. • Explore options and proceed with automation along Sutter-Butte canal, contingent on availability of funding and project prioritization.
10608.48.c(10)	Facilitate or promote customer pump testing and evaluation	Being Implemented	• BWD has developed a website, in part to promote available programs regarding pump testing and evaluation through links on the website and through communication with landowners and growers. • BWD requires flowmeters on private groundwater pumps used to pump water into the distribution system during curtailment years, which supports pump performance evaluation.	• Continue promoting customer pump testing and evaluation through available programs. • Continue requiring flowmeters on private groundwater pumps used to pump water into the distribution system during curtailment years.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
10608.48.c(11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.	Being Implemented	• The general manager serves as water conservation coordinator and is responsible for implementing AWMP.	• The general manager will continue to serve as water conservation coordinator.
10608.48.c(12)	Provide for the availability of water management services to water users.	Being Implemented	• BWD promotes awareness of water management services such as CIMIS and Federal Conservation Programs through links on their website and through communication with landowners and growers. • BWD holds annual meetings to discuss available water management services and other issues of interest with landowners and growers. • BWD provides at-cost labor and materials for on-farm improvements, subject to resource availability. • BWD evaluated opportunities to maintain and increase surface water customer base for growers using pressurized irrigation through enhanced delivery service.	• Continue promoting available water management services and holding annual meetings. • Continue to provide at-cost labor and materials for on-farm improvements. • Encourage landowners and growers to use available surface water through improved delivery to pressurized irrigation systems or other means.
10608.48.c(13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented	• Conducts ongoing interactions with DWR SWP operations. • BWD is a voluntary participant in ACWA, NCWA, BCWC, and BBWUA. • BWD is a voluntary participant in NSVIRWMP. • BWD is a voluntary participant in FRRAWMP. • BWD participates in Joint District interactions with SWP operations. • BWD completed a comprehensive conservation study in 2003 in cooperation with DWR to quantify historical water savings (i.e. water left in storage) through conservation by the district and its water users. • BWD is implementing SGMA as a GSA.	• Continue interactions with DWR SWP operations. • Continue to evaluate policies of agencies that provide BWD with water. • Continue to participate in local, regional, and statewide committees and associations. • Continue to participate in local and regional planning initiatives.
10608.48.c(14)	Evaluate and improve the efficiencies of the supplier's pumps.	Being Implemented	• BWD regularly inspects district wells and performs maintenance and repairs as appropriate. • BWD inspects and repairs drainwater recovery pumps as necessary.	• Continue to inspect, maintain, and repair pumps as necessary.

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4.9.2 Evaluation of Water Use Efficiency Improvements

CWC §10608.48(d) requires that AWMPs include:

> *… a report on which efficient water management practices have been implemented and are planned to be implemented, an estimate of the water use efficiency improvements that have occurred since the last report, and an estimate of the water use efficiency improvements estimated to occur five and 10 years in the future.*

A description of EWMPs that have been implemented by BWD has been provided previously in Section 4.9.1. This section provides an evaluation of EWMP implementation and an estimate of water use efficiency (WUE) improvements that have occurred in the past and are expected to occur in the future.

The value of evaluating water use efficiency (WUE) improvements (and EWMP implementation in general) from BWD's perspective is to identify what the benefits of EWMP implementation are and to identify those additional actions that hold the potential to support and advance the district's water management objectives. BWD's water management objectives include the long term reliability, quality, and affordability of local surface water and groundwater supplies and providing the best possible service its customers. To that end, BWD has taken action to develop and maintain reliable surface water and groundwater supplies, to prevent or reduce losses from the distribution system in order to increase operational efficiency, to promote the efficient use of water at the farm level, and to meet changing environmental and other demands that affect the flexibility with which the district can deliver water. BWD's water management activities are consistent with these objectives and have resulted in substantial local and statewide benefits.

First and foremost among the issues that must be considered in any evaluation of the benefits of EWMP implementation and resulting WUE improvements is how water management actions affect the water balance (Davenport and Hagan, 1982; Keller, et al., 1996; Burt, et al., 2008; Clemmens, et al., 2008; Canessa, et al., 2011). Accordingly, any evaluation of EWMP implementation and WUE improvements for BWD must consider how water balance changes relate to the district's water management objectives. For example, flows to deep percolation and seepage that could be considered losses in some settings are critical to maintain the long-term sustainability of the underlying groundwater basin. Reductions in these flows resulting from EWMP implementation could be considered WUE improvements at the farm or district scale, but have the consequential effect of diminishing recharge of the underlying groundwater system. Other flows that could be considered losses at the farm or district scale such as spillage and tailwater are also recoverable. For example, spillage from the BWD distribution and drainage systems is available for beneficial use by downgradient water users. The only distribution and drainage system or on-farm losses that are not recoverable within the BWD service areas, the underlying groundwater basin, or the Feather River region as a whole are canal and drain water surface evaporation. These components represent a small portion of BWD's water supply (less than one percent as indicated previously). An implication of this is that very little "new" water can be made available through water conservation in BWD's service area to increase overall water supply; however, there may be

opportunities to change the timing and amount of water used to meet local, regional, or statewide objectives, as discussed in Volume I, Section 3 of this AWMP.

An important step in evaluating EWMP implementation and water use efficiency improvements is a comprehensive, quantitative, multi-year water balance (see Section 4.7). The quantitative understanding of the water use enables identification of targeted flow paths for WUE improvements, along with improved understanding of the beneficial impacts and consequential effects of EWMP implementation at varying spatial and temporal scales. The water balance enables evaluation of potential changes in water use amounts and timing for any given change in water management.

Even where comprehensive, multi-year water balances have been developed, evaluating water balance impacts and WUE improvements is not a trivial task. Issues of spatial and temporal scale and relatively small changes in flow paths resulting from many water management improvements (relative to day to day and year to year variation in water diversions and use) coupled with inaccuracies inherent in even the best water measurement greatly complicate the evaluation of water balance impacts. The implications of recoverable and irrecoverable losses at varying scales further complicate the evaluation of WUE improvements, and consequential, potentially unintended effects must be considered.

As part of assembling this AWMP, BWD has identified the targeted flow paths associated with implementation of each EWMP, the water management benefits of each EWMP and the potential consequential effects of implementation. A brief discussion of the benefits associated with implementation of each EWMP is provided, along with a brief discussion of consequential effects that must be considered. A summary of targeted flow paths, beneficial impacts, and consequential effects associated with implementation of each EWMP by BWD is provided in Table 4.16.

Table 4.16. Summary of WUE Improvements by EWMP.

Water Code Reference No.	EWMP	Implementation Status	Targeted Flow Path(s)	Benefits	Consequential Effects	Notes (See End of Table)
10608.48.b (1)	Measure the volume of water delivered to customers with sufficient accuracy.	Not Required	Deliveries, Spillage, Tailwater, Diversions, Drainage Outflows	Delivery measurement can encourage efficient on-farm water use, and has the potential to lead to reduced deliveries, dependent on pricing. Reduced deliveries result in reduced diversions, which result in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation.	1
10608.48.b (2)	Adopt a pricing structure based at least in part on quantity delivered.	Being Implemented	Deliveries, Spillage, Tailwater, Deep Percolation, Diversions, Drainage Outflows	Pricing structures based on quantity delivered may result in increased efficiency of on-farm water use, which has the potential to lead to reduced deliveries. Reduced deliveries result in opportunities to expand agricultural production or surface water use within the service area, reduce groundwater pumping, or reduce diversions, which results in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation.	1
10608.48.c (1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Not Applicable	Not Applicable	Not Applicable	2
10608.48.c (2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	Not Technically Feasible	Not Applicable	Not Applicable	Not Applicable	2
10608.48.c (3)	Facilitate financing of capital improvements for on-farm irrigation systems.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Groundwater Pumping, Drainage Outflows	Assisting in on-farm improvements through the provision of at-cost labor and materials can result in reduced deliveries due to increased delivery efficiency and/or reduced tailwater and, in some cases, deep percolation. Reduced deliveries result in opportunities to expand agricultural production or surface water use within the service area, reduce groundwater pumping, or reduce diversions, which results in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1

Water Code Reference No.	EWMP	Implementation Status	Targeted Flow Path(s)	Benefits	Consequential Effects	Notes (See End of Table)
10608.48.c (4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented	Varies	BWD's pricing structure promotes goal (A), resulting in on-farm benefits as described for the volumetric pricing EWMP (10608.48.b(2)). Provision of surface water at lower rates than the cost of groundwater pumping incentivizes goals (B) and (C) and improves the reliability of regional water supplies while maintaining and enhancing ecosystems. Provision of water at affordable rates incentivizes goal (E) by offering a reasonably priced, reliable source of water to maintain waterfowl habitat, primarily winter flooding of rice fields.	Consequential effects of pricing structures based on quantity delivered are the same as described for the volumetric pricing EWMP (10608.48.b(2)).	1
10608.48.c (5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.	Being Implemented	Deliveries, Spillage, Tailwater, Deep Percolation, Seepage, Diversions, Drainage Outflows	Benefits of lining, pipeline, and regulating reservoirs are reductions in losses such as seepage, operational spillage, and drainage outflows. In addition, regulating reservoirs provide improved consistency in deliveries, potentially providing a modest reduction in on-farm deliveries due to reduced tailwater and, in some cases, deep percolation and tailwater. Due to the proximity of the district's system to Thermalito Afterbay and heavy soils, which limit seepage losses, these benefits do not outweigh the costs at this time. Water quality benefits may occur through reduced tailwater outflow.	Reduced seepage and deep percolation result in reduced beneficial recharge of the underlying groundwater system. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	Being Implemented	Deliveries, Spillage, Tailwater, Deep Percolation, Diversions, Drainage Outflows	Flexible water ordering and deliveries result in reduced operational spillage, tailwater, and, in some cases, seepage and deep percolation. It can also result in a modest reduction in deliveries due to on-farm reductions in tailwater and deep percolation. System improvements result in greater operational efficiency and reductions in spillage. Additionally, water quality benefits may occur through reduced tailwater outflow. In aggregate, reduced losses (both on-farm and at the district level) can lead to reduced deliveries. Reduced deliveries result in opportunities to expand agricultural production or surface water use within the service area, reduce groundwater pumping, or reduce diversions, which results in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (7)	Construct and operate supplier spill and tailwater recovery systems.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Drainage Outflows	Reuse of operational spillage and tailwater results in decreased required diversions. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment. Tailwater may be of diminished quality as compared to other available water supplies. Spillage and tailwater recovery using pumps requires the use of electricity or fuel as a component, increasing energy demand.	1

Water Code Reference No.	EWMP	Implementation Status	Targeted Flow Path(s)	Benefits	Consequential Effects	Notes (See End of Table)
10608.48.c (8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area.	Being Implemented	Diversions, Deliveries, Deep Percolation, Groundwater Pumping	Conjunctive management provides multiple benefits: • Maintain local and statewide water supply reliability • Enhance aquatic and wetlands ecosystems • Reduce energy requirements for irrigation Encouraging growers to use available surface water instead of groundwater provides beneficial groundwater recharge through deep percolation. Groundwater is then available in years of surface water shortage while maintaining the long term sustainability of the groundwater system.	Not Significant	1
10608.48.c (9)	Automate canal control structures.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Drainage Outflows	Automation results in reduced operational spillage and reduced deliveries due to increased delivery efficiency, which reduces on-farm tailwater and, in some cases, deep percolation. Reduced deliveries result in opportunities to expand agricultural production or surface water use within the service area, reduce groundwater pumping, or reduce diversions, which results in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (10)	Facilitate or promote customer pump testing and evaluation.	Being Implemented	None	Improved pumping efficiency by BWD's customers results in decreased energy demand and reduced pumping costs for customers. There are no direct benefits to BWD.	Not Significant	
10608.48.c (11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	Being Implemented	Varies	See Comment	See Comment	3
10608.48.c (12)	Provide for the availability of water management services to water users.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Groundwater Pumping, Drainage Outflows	Promoting available water management services can increase efficiency of on-farm water use, which has the potential of leading to reduced deliveries. Reduced deliveries result in reduced diversions, which result in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented	Diversions	Increased flexibility and storage for the surface water supply could result in reductions in losses to operational spillage, tailwater, and drainage outflows. Additionally, water quality benefits may occur through reduced tailwater outflow.	Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (14)	Evaluate and improve the efficiencies of the supplier's pumps.	Being Implemented	None	Improved pumping efficiency of BWD's pumps and prioritizing repairs or replacement based on pump evaluations results in decreased energy demand and reduced pumping costs for BWD and increases pump reliability. There are no direct impacts to water balance flow paths.	Not Significant	

Water Code Reference No.	EWMP	Implementation Status	Targeted Flow Path(s)	Benefits	Consequential Effects	Notes (See End of Table)

Notes:

1. BWD works to balance tradeoffs between incentivizing water conservation (both districtwide and on-farm) and maintaining long-term surface water and groundwater reliability.
2. Such lands or conditions do not exist in BWD. As a result, it is not technically feasible to implement this EWMP.
3. Implementation of the AWMP by BWD's water conservation coordinator and other staff as appropriate is the mechanism by which all EWMPs are implemented and targeted benefits are realized.

WUE definitions vary. For purposes of evaluating WUE improvements associated with EWMP implementation by BWD, specific WUE improvement categories or objectives have been identified that correspond to each EWMP. Potential WUE improvements include reduction of irrecoverable losses, increased local supply, increased local flexibility, increased in-stream flow, improved water quality, and improved energy efficiency. Definitions for each of the WUE improvement categories have been developed and are provided in Table 4.17. Note that the WUE improvement categories are not mutually exclusive in many cases. For example, reductions in irrecoverable losses could be used to increase local supply. The applicability of each EWMP to each WUE improvement category based on BWD's water management activities has been identified and is presented in Table 4.18.

Table 4.17. WUE Improvement Categories.

Water Use Efficiency Improvement Category	Definition
Reduce Irrecoverable Losses	Reduce losses that cannot be recovered and used by the water supplier or downgradient users (e.g. evaporation and flows to salt sinks).
Increase Local Supply (and Supply Reliability)	Reduce losses and/or increase storage locally to increase supply available to meet demands, including both near-term (within an irrigation season) and long-term (over more than one year).
Increase Local Flexibility	Improve the supplier's ability to divert, pump, convey, control, and deliver available water supplies to meet customer demands.
Increase In-Stream Flow	Increase flow in natural waterways to benefit fisheries or meet other environmental objectives.
Improve Water Quality	Increase the quality of targeted water bodies (i.e. streams, lakes, or aquifers).
Improve Energy Efficiency	Increase the efficiency of water supplier or customer pumps.

In order to more explicitly report an estimate of WUE improvements and an estimate of WUE improvements expected to occur five and ten years in the future, BWD has estimated the qualitative magnitude (expressed as None, Limited, Modest, or Substantial in order of increasing relative magnitude) for the targeted flow paths associated with each EWMP relative to the applicable WUE improvement categories identified in Table 4.18. Past WUE improvements are estimated relative to no historical implementation. WUE improvements relative to the time of the last plan are not applicable as BWD has not previously prepared an AWMP. Future WUE improvements are estimated for five years in the future (2020) relative to 2015 and for ten years in the future (2025) relative to 2015. The result of this evaluation is provided in Table 4.19.

BWD will continue to seek out and implement water management actions that meet its overall water management objectives and result in WUE improvements. The continuing review of water management within BWD, coupled with exploration of innovative opportunities to improve water management will result in future management improvements by the district and additional WUE improvements.

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Table 4.18. Applicability of EWMPs to WUE Improvement Categories.

Water Code Reference No.	EWMP	Implementation Status	Potential Water Use Efficiency Improvement Category					
			Reduce Irrecoverable Losses	Increase Local Supply	Increase Local Flexibility	Increase In-Stream Flow	Improve Water Quality	Improve Energy Efficiency[1]
10608.48.b (1)	Measure the volume of water delivered to customers with sufficient accuracy.	Not Required		✓		✓	✓	✓
10608.48.b (2)	Adopt a pricing structure based at least in part on quantity delivered.	Being Implemented		✓		✓	✓	
10608.48.c (1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Not Applicable to BWD					
10608.48.c (2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	Not Technically Feasible	Not Applicable to BWD					
10608.48.c (3)	Facilitate financing of capital improvements for on-farm irrigation systems.	Being Implemented		✓		✓	✓	✓
10608.48.c (4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented		✓		✓	✓	
10608.48.c (5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.	Being Implemented		✓	✓	✓	✓	
10608.48.c (6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	Being Implemented		✓	✓	✓	✓	✓
10608.48.c (7)	Construct and operate supplier spill and tailwater recovery systems.	Being Implemented		✓	✓	✓	✓	
10608.48.c (8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area.	Being Implemented		✓				
10608.48.c (9)	Automate canal control structures.	Being Implemented		✓	✓	✓	✓	
10608.48.c (10)	Facilitate or promote customer pump testing and evaluation.	Being Implemented						✓
10608.48.c (11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	Being Implemented	The activities of the Water Conservation Coordinator and other BWD staff to achieve WUE improvements through implementation of the AWMP are described individually by EWMP.					
10608.48.c (12)	Provide for the availability of water management services to water users.	Being Implemented		✓		✓	✓	✓
10608.48.c (13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented		✓	✓	✓	✓	
10608.48.c (14)	Evaluate and improve the efficiencies of the supplier's pumps.	Being Implemented						✓

1. Includes reducing energy demands.

Table 4.19. Evaluation of Relative Magnitude of Past and Future WUE Improvements by EWMP.

Water Code Reference No.	EWMP	Implementation Status	Marginal WUE Improvement[1,2]			
			Past		Future	
			Relative to No Historical Implementation[3]	Since Last AWMP[4]	5 Years in Future[5]	10 Years in Future[5]
10608.48.b (1)	Measure the volume of water delivered to customers with sufficient accuracy	Not Required	None	None	None to Substantial, Depending on Funding	
10608.48.b (2)	Adopt a pricing structure based at least in part on quantity delivered	Being Implemented	Limited	None	None to Substantial, Depending on Funding	
10608.48.c (1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Not Applicable to BWD			
10608.48.c (2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	Not Technically Feasible	Not Applicable to BWD			
10608.48.c (3)	Facilitate financing of capital improvements for on-farm irrigation systems	Being Implemented	Limited	Limited	None	
10608.48.c (4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented	Modest (Goals A, B, C & E)	Limited	None to Modest, Depending on Funding and Opportunities	
10608.48.c (5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage	Being Implemented	Modest	Limited	Limited to Modest, Depending on Funding and Opportunities	
10608.48.c (6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits	Being Implemented	Substantial	Modest	None to Modest, Depending on Funding	
10608.48.c (7)	Construct and operate supplier spill and tailwater recovery systems	Being Implemented	Modest	Limited	None to Modest, Depending on Funding	
10608.48.c (8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area	Being Implemented	Substantial	Modest	None to Substantial, Depending on Funding and Opportunities	
10608.48.c (9)	Automate canal control structures	Being Implemented	Modest	Modest	None to Substantial, Depending on Funding	
10608.48.c (10)	Facilitate or promote customer pump testing and evaluation	Being Implemented	None	Limited	Limited	None
10608.48.c (11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	Being Implemented	The activities of the Water Conservation Coordinator and other BWD staff to achieve WUE improvements through implementation of the EWMPs are described individually by EWMP.			
10608.48.c (12)	Provide for the availability of water management services to water users.	Being Implemented	Modest	Limited	Limited	None
10608.48.c (13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented	Modest	Substantial	None to Modest, Depending on Outcomes	
10608.48.c (14)	Evaluate and improve the efficiencies of the supplier's pumps.	Being Implemented	Substantial	Limited	None to Limited, Depending on Funding	

1. As noted herein and throughout this analysis, reductions in losses that result in WUE improvements at the farm or district scale do not typically result in WUE improvements at regional scale, except in the case of evaporation reduction. All losses to seepage, spillage, tailwater, and deep percolation are recoverable within the BWD service area or by downgradient water users. Opportunities to achieve WUE through changes to the timing and amounts of water use may exist in some cases.

2. Quantitative estimates of improvements are not available. Rather, qualitative estimates are provided as follows, in increasing relative magnitude: None, Limited, Modest, and Substantial.

3. WUE Improvements occurring in recent years relative to if they were not being implemented.

4. WUE Improvements occurring in recent years relative to the level of implementation at time of last AWMP. Not applicable, as BWD has not previously prepared an AWMP.

5. WUE Improvements expected in 2020 (five years in the future) and 2025 (ten years in the future), relative to level of implementation in recent years.

4.10 Attachments

This section includes the following attachments:

- 4.10.1 – Public Coordination and Adoption
- 4.10.2 – Rules and Regulations
- 4.10.3 – Potential Projects to Enhance Water Management Capabilities
- 4.10.4 – Drought Management Plan

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4.10.1 Public Coordination and Adoption

Documentation of BWD's process for public review of this AWMP and adoption by its board of directors is provided on the following pages.

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BUTTE WATER DISTRICT RESOLUTION NO 2016-08

RESOLUTION TO ADOPT BUTTE WATER DISTRICT'S AGRICULTURAL WATER MANAGEMENT PLAN AND DROUGHT MANAGEMENT PLAN

WHEREAS, the California Legislature enacted SB X7-7, the Conservation Act of 2009 (Water Code Section 10820 et seq.), Part 2.8 of which is known as the Agricultural Water Management Planning Act and which mandates that every agricultural water supplier providing water for more than 25,000 irrigated acres prepare an Agricultural Water Management Plan (the "Plan"); and

WHEREAS, for those agricultural water suppliers with at least 10,000 but less than 25,000 irrigated acres, such as the Butte Water District (the "District"), a Plan is required only if sufficient funding has been provided specifically for that purpose (CCR §597.1 (e)); and

WHEREAS, Governor Edmund G. Brown, by Executive Order B-37-16 dated May 9, 2016, directed the California Department of Water Resources (the "Department") to require a Plan for all water suppliers with over 10,000 irrigated acres of land; and

WHEREAS, the District supplies water to more than 10,000 but less than 25,000 irrigated acres; and

WHEREAS, California Water Code sections 10841 and 10843 require the Plan be adopted after public review and hearing, and filed with the Department within 30 days of adoption; and

WHEREAS, the District properly noticed a public hearing regarding its Plan and the public hearing was held by the District's Board of Directors on December 8, 2016; and

WHEREAS, the District did prepare and shall file its Plan with the Department by January 7, 2017.

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the District that:

(1) The District's Plan is hereby adopted and ordered filed with the District;

(2) The General Manager is hereby authorized and directed to file the District's Plan with the Department within 30 days after this date;

(3) The General Manger is hereby authorized and directed to implement the District's Plan which includes elements of water use efficiency;

PASSED AND ADOPTED at regular meeting of the Board of Directors of the Butte Water District, held on December 8, 2016.

AYES: 4

NOS: 0

ABSTAIN: 0

ABSENT: 1

BUTTE WATER DISTRICT

By _____

Darin Pantaleoni, President of the Board

ATTEST:

_____

Mark Orme, Secretary/Manager to the Board of Directors

PROOF OF PUBLICATION

No._____

In The Matter of

_____

PUBLIC HEARING 2016 AGRICULTURAL

WATER MANAGEMENT PLAN UPDATE

(State of California)
(County of Butte) as
The undersigned resident of the County of Butte, State of California, says:

That I am, and at all time herein mentioned was a citizen of the United States and not a party to nor interested in the above entitled matter; that I am the principal clerk of the printer and publisher of:

The Gridley Herald

That said newspaper is one of general circulation as defined by Section 6000 Government Code of the State of California, Case No. 27,207 by the Superior Court of the State of California, in and for the County of Butte; that said newspaper at all times herein mentioned was printed and published twice a week (on Wednesdays and Fridays) in the City of Gridley and County of Butte; that the notice of which the annexed is a true printed copy, was published in said newspaper on the following days:

NOVEMBER 23, 30, 2016

I certify (or declare), under penalty of perjury, that the foregoing is true and correct, at Gridley, California.

Dated **NOVEMBER 30, 2016**
at Gridley, California

(Signature)

Notice of Public Hearing to Adopt Butte Water District's 2016 Agricultural Water Management Plan Update

Notice is hereby given that on December 8, 2016 at 1:30 p.m., or as soon thereafter as the matter may be heard, the Butte Water District (BWD) Board of Directors will hold a Public Hearing regarding the adoption of the 2016 Update of the District's Agricultural Water Management Plan, which is part of the Feather River Regional Agricultural Water Management Plan (FRRAWMP) and was prepared pursuant to California Water Code sections 10800 et seq. and Governor Brown's Executive Order B-29-15. The AWMP update and FRRAWMP contain information regarding an agricultural water supplier's service area, information regarding the quantity and quality of its water resources, as well as the District's Drought Management Plan. BWD will receive comments regarding the AWMP update at the hearing, and then adopt the AWMP update as drafted or modified during or after the hearing. The BWD Board of Directors meeting to hear public comments regarding its AWMP update will take place at 735 Virginia Street, Gridley, CA 95948. Prior to the meeting, a copy of the proposed AWMP update will be available for public inspection at the same location. For more information, please call 530-846-3100.

Publish: November 23, 30, 2016 (The Gridley Herald)

DIRECTORS:

Joe Bozzo
Charles Etcheverry
Ronald Giovannetti
Darin Pantaleoni
Dale Smith

BUTTE WATER DISTRICT

Mark Orme
Manager-Secretary

735 Virginia Street
Gridley, California
95948

Phone 530-846-3100
Fax 530-846-2519
buttewaterdistrict.org

November 23, 2016

Butte County
Department of Water & Resource Conservation
308 Nelson Avenue
Oroville, CA 95965

RE: Notice of Intent to Prepare 2016 Agricultural Management Plan

To Whom It May Concern:

Butte Water District (BWD) is in the process of preparing a 2016 Agricultural Water Management Plan (AWMP) in accordance with Senate Bill x7-7 (SBx7-7), also known as the Water Conservation Act of 2009, which modifies Division 6 of California Water Code, adding Part 2.55 (commencing with §10608) and replacing Part 2.8 (commencing with §10800).

The public review draft of the AWMP will be available for inspection from November 23 through December 7, 2016. Copies of the draft plan will be available at the BWD office located 735 Virginia Street, Gridley, CA 95948, as well as on the District's website: buttewaterdistrict.org.

The District will conduct a public hearing on the AWMP on December 8, 2016 at 1:30pm at the BWD office, after which the District may adopt the plan. Public notices of the hearing will be advertised in the Gridley Herald prior to the hearing date.

For further information, please contact me at (530)846-3100.

Regards,

Mark Orme, General Manager
Butte Water District

DIRECTORS:

Joe Bozzo
Charles Etcheverry
Ronald Giovannetti
Darin Pantaleoni
Dale Smith

BUTTE WATER DISTRICT

Mark Orme
Manager-Secretary

735 Virginia Street
Gridley, California
95948

Phone 530-846-3100
Fax 530-846-2519
buttewaterdistrict.org

November 23, 2016

Sutter County Development Services
1130 Civic Center Blvd.
Yuba City, CA 95993

RE: Notice of Intent to Prepare 2016 Agricultural Management Plan

To Whom It May Concern:

Butte Water District (BWD) is in the process of preparing a 2016 Agricultural Water Management Plan (AWMP) in accordance with Senate Bill x7-7 (SBx7-7), also known as the Water Conservation Act of 2009, which modifies Division 6 of California Water Code, adding Part 2.55 (commencing with §10608) and replacing Part 2.8 (commencing with §10800).

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For further information, please contact me at (530)846-3100.

Regards,

Mark Orme, General Manager
Butte Water District

DIRECTORS:

Joe Bozzo
Charles Etcheverry
Ronald Giovannetti
Darin Pantaleoni
Dale Smith

BUTTE WATER DISTRICT

Mark Orme
Manager-Secretary

735 Virginia Street
Gridley, California
95948

Phone 530-846-3100
Fax 530-846-2519
buttewaterdistrict.org

November 23, 2016

City of Gridley
685 Kentucky Street
Gridley, CA 95948

RE: Notice of Intent to Prepare 2016 Agricultural Management Plan

To Whom It May Concern:

Butte Water District (BWD) is in the process of preparing a 2016 Agricultural Water Management Plan (AWMP) in accordance with Senate Bill x7-7 (SBx7-7), also known as the Water Conservation Act of 2009, which modifies Division 6 of California Water Code, adding Part 2.55 (commencing with §10608) and replacing Part 2.8 (commencing with §10800).

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For further information, please contact me at (530)846-3100.

Regards,

Mark Orme, General Manager
Butte Water District

DIRECTORS:

Joe Bozzo
Charles Etcheverry
Ronald Giovannetti
Darin Pantaleoni
Dale Smith

BUTTE WATER DISTRICT

Mark Orme
Manager-Secretary

735 Virginia Street
Gridley, California
95948

Phone 530-846-3100
Fax 530-846-2519
buttewaterdistrict.org

November 23, 2016

City of Biggs
PO Box 307
Biggs, CA 95917

RE: Notice of Intent to Prepare 2016 Agricultural Management Plan

To Whom It May Concern:

Butte Water District (BWD) is in the process of preparing a 2016 Agricultural Water Management Plan (AWMP) in accordance with Senate Bill x7-7 (SBx7-7), also known as the Water Conservation Act of 2009, which modifies Division 6 of California Water Code, adding Part 2.55 (commencing with §10608) and replacing Part 2.8 (commencing with §10800).

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For further information, please contact me at (530)846-3100.

Regards,

Mark Orme, General Manager
Butte Water District

DIRECTORS:

Joe Bozzo
Charles Etcheverry
Ronald Giovannetti
Darin Pantaleoni
Dale Smith

BUTTE WATER DISTRICT

Mark Orme
Manager-Secretary

735 Virginia Street
Gridley, California
95948

Phone 530-846-3100
Fax 530-846-2519
buttewaterdistrict.org

November 23, 2016

City of Live Oak
9955 Live Oak Blvd.
Live Oak, CA 95953

RE: Notice of Intent to Prepare 2016 Agricultural Management Plan

To Whom It May Concern:

Butte Water District (BWD) is in the process of preparing a 2016 Agricultural Water Management Plan (AWMP) in accordance with Senate Bill x7-7 (SBx7-7), also known as the Water Conservation Act of 2009, which modifies Division 6 of California Water Code, adding Part 2.55 (commencing with §10608) and replacing Part 2.8 (commencing with §10800).

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For further information, please contact me at (530)846-3100.

Regards,

Mark Orme, General Manager
Butte Water District

4.10.2 Rules and Regulations

BWD's rules and regulations are provided on the following pages.

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Butte Water District

BY-LAWS

and

RULES AND REGULATIONS
FOR DISTRIBUTION OF WATER

OFFICE: 735 VIRGINIA STREET
GRIDLEY, CALIFORNIA 95948

Telephone 916-846-3110

Officer of the
BUTTE WATER DISTRICT
M.W. Carlin
Frank Hatamiya
Charles Herrington
Phillip Haynes
Robert Waller

SECRETARY
MANAGER
Lester Breeding

Gridley 3100

TO THE LANDOWNERS AND WATER USERS OF THE BUTTE WATER DISTRICT:

Butte Water District is a State Agency governed by a board of directors elected by the people. It operates under the authority conferred by the Water Code. It makes no profit and is operated for the sole benefit of the lands and the people within its boundaries. The benefits they can derive from it will be measured by the extent to which the people within the district cooperate to make it a success.

These By-Laws, Rules and Regulations have been adopted by the Board of Directors under the authority of the Water Code and are a part of the law governing this District comparable to county or municipal ordinances.

All records of the District are open to public inspection during the hours when the office of the district is open to the public. All officials and employees will cheerfully furnish any information concerning the affairs of the district. LANDOWNERS ARE REQUESTED TO AVAIL THEMSELVES OF THIS SOURCE OF INFORMATION.

This booklet is available for free distribution.

BOARD OF DIRECTORS
of the
BUTTE WATER DISTRICT

BY-LAWS
of
BUTTE WATER DISTRICT

ARTICLE I

The Board of Directors shall meet in regular session on the third Wednesday in each month, at the hour of 9:00 o'clock A.M. at the office of said District, provided, however, that the date and hour of holding such regular monthly meeting may be changed at any time by resolution of the Board of Directors entered on its minutes not less than thirty days prior to such change becoming effective. Every regular meeting and every special meeting may be adjourned from time to time and said adjourned meeting shall constitute a regular meeting or special meeting as the case may be.

Special meetings may be called, or held on consent of all directors, as provided by the California Water District Law, and when so called or held, any business of the District may be transacted whether notice that said business was to be acted upon at said special meeting, was given or not.

ARTICLE II

The office of said District shall be at 735 Virginia Street, Gridley, California but the location of said office may be changed by resolution entered on the minutes of the Board not less than thirty days before such change becomes effective.

ARTICLE III

The Directors shall choose from among its members, a President to hold office at the pleasure of the board, who shall preside at all meetings of the Board and shall perform all other duties usually incumbent on such officer, and all duties required of him by law or order of the Board of Directors. In his absence or inability to act his duties shall devolve upon a temporary chairman to be selected from their own number by the other directors.

ARTICLE IV

The Board shall appoint a Secretary to hold office at the pleasure of the Board, who shall keep a full and correct record of the proceedings of the Board of Directors, and shall have charge af all books, maps, and papers of the District, except those required by the Assessor, Collector, Treasurer, or Manager. He shall perform all duties usually appertaining to such office, and those required by law or the order of the Board. The Secretary need not be a resident or holder of title to land in the District and his salary shall be fixed by resolution of the Board. The Board may by resolutton establish a bond for the Secretary to carry. The Board may employ an assistant Secretary to assist the Secretary in the administration of the affairs of his office.

4

ARTICLE V

The offices of Assessor, Tax Collector and Treasurer of the District shall be consolidated into one office.

The person holding such office shall as Treasurer keep a full and correct record of the finances of the District. He shall keep, in a separate book for that purpose, a record of each warrant drawn by him, on order of the Directors, showing the date, number, the name of the person to whom and for what services the same was issued. He shall also perform all duties usually encumbent on such office and all duties required of him by law, and all duties required of him by the terms of the bonds issued by this District. He shall draw no warrants unless ordered by the Directors, except for salaries which have been fixed by the Board. He may, with the approval of the Board, appoint a deputy whose salary and bond if any, shall be fixed by the Board.

The person holding such consolidated office, shall as Assessor keep a full and correct record of all work done by him and shall do all things required of him to be done as provided by law.

5

The person holding such consolidated office, shall as Tax Collector collect all taxes or assessments due the District and shall keep an accurate record thereof showing the amounts collected, on what parcels and from whom collected. He may, with the approval of the Board, appoint a deputy whose salary, and bond, if any, shall be fixed by the Board.

The salary for the consolidated office of Assessor, Tax Collector and Treasurer, shall be fixed by resolution of the Board, and said officer may be required to carry an official bond in such sum as may be fixed by the Board of Directors.

ARTICLE VI

The Board shall also employ a Manager of the District who shall attend to the maintenance and operation of the works of the District, and the distribution of water and such other duties as may be delegated to him by the Board. The salary of the Manager shall be fixed by resolution of the Board.

ARTICLE VII

The Directors, in addition to the powers conferred by law, shall have full power and authority to do any and all things necessary to effect the work of irrigation of lands of the District, and for the management and control of the same and of the affairs of the District.

6

The Directors shall have such powers as are now or may be hereafter conferred on them by law. Each Director shall receive the sum of Twenty Dollars ($20.00) for each meeting he attends and for each day actually engaged in business of the District on order of the Board, and in addition his necessary actual expenses when on business for the District, but no mileage shall be paid for traveling to or from the Board meetings.

Prior to Feb. 15 of each year the Board shall by resolution adopt rules and regulations, not inconsistent herewith, for the operation of the District and sale and distribution of water, and fix the rates to be charged for water for that year.

ARTICLE VIII

All claims against the District shall be presented in writing, and filed with the Secretary.

ARTICLE IX

These By-Laws may be amended in the manner specified in Section 35305 of the Water Code as now worded or as the same may be hereafter amended.

ARTICLE X

Should a vacancy exist in any of the offices of the District, it may be filled by appointment by a majority of the Board of Directors.

7

ARTICLE XI

All elected officers of the District shall hold office respectively for the period prescribed by law and until their successors are elected and qualified. Election of officers shall be held on the first Tuesday after the first Monday in November in each odd numbered year. The election shall be held and conducted and notice thereof shall be given as provided in Sec. 1, Part 3 (Uniform District Election Law Commencing With Section 23500) as added to Division 12 of the Election Code and part 4, Division 13 of the Water Code. For the purposes of said election there shall be but one election precinct the boundaries of which shall be coterminous with the boundaries of the District. Each holder of title or evidence of title shall have the right to vote at any and all elections held in the District.

RULES AND REGULATIONS

for the Distribution of Water

in the Butte Water District

and

Rates of Tolls and Charges

For the Use Thereof

Adopted: November 16, 1966

DEFINITIONS AND GENERAL PROVISIONS

"DISTRICT" means Butte Water District functioning under the California Water District Law.

"BOARD" means the Board of Directors of District.

"SECRETARY" means the Secretary of the Board.

"MANAGER" means the Manager appointed by the Board.

"WORKS" includes dams, wells, conduits pumps and power plants.

"CONDUITS" includes canals, laterals, ditches, drains, flumes, pipes, measuring and control devices therein and their appurtenances.

"OPERATE" and "OPERATION" includes use, maintenance and repair.

"CONSUMER" includes water user, or user of other services of District.

"RULES" include regulations.

"CHARGES" include water tolls, and rates. The singular number includes the plural and the plural, the singular.

RULE 1—WATER USE

District was organized for the purpose of supplying irrigation service for orchards and farm crops. The water quality and district facilities are not suitable for domestic use, raising of fish, or use for industrial or commercial purposes. Any service for purposes other than the growing of agricultural crops will only be provided on a special order of the Board of Directors entered in its minutes.

RULE 2—CONTROL OF SYSTEM

The operation of the works of the District shall be under the exclusive management and control of the Manager, and no other persons, except his employees and assistants, shall have any right to interfere with said works in any manner, except in case of an order from the Board.

RULE 3—DITCHTENDERS AND OTHER EMPLOYEES

The Manager will employ such ditchtenders and other assistants as he may deem necessary for the proper operation of the system subject to the approval of the Board.

RULE 4—CONTROL DEVICES

No gate, takeout, siphon or other structures or device shall be installed or placed in any conduit belonging to the District except in pursuance of plans adopted or orders made by the Board.

RULE 5—UNAUTHORIZED USE OF WORKS

No person shall divert or take water from any conduit belonging to the District or under its control, or make any opening therein, or change, molest, disturb or interfere with any gate, takeout, or other structure or device in any such conduit without permission of the ditchtender in charge thereof or the Manager.

RULE 6—PRIVATE CONDUITS

All private conduits shall be maintained and kept clean by the users thereof at no cost to the District and shall be of sufficient size to carry the irrigation head ordered. The Manager, or his representative, may examine private conduits before water is turned in to determine whether the conduits are in proper condition to carry water. In case any conduit is found not to be in such proper condition, the water shall not be turned into it until the condition is corrected.

No person shall divert or take water through a private conduit by making an opening in a conduit belonging to the District or change, molest, disturb or interfere with any gate, takeout or any other structure or device in any District conduit without permission of the Ditchtender in charge thereof or the Manager.

Where a conduit must be constructed or enlarged to carry water from an existing

District conduit to land to be served, the landowners or users requesting water must provide the right of way and construct or enlarge at no cost to the District a conduit from said land to a District conduit designated by the Manager and approved by the Board.

The Distrct shall have control of all diverting gates and weirs in private conduits to the extent necessary to enforce the delivery of water in accordance with these Rules, but the District shall not thereby assume or incur any liability for the operation of such gates and weirs. Only District employees or persons delegated by them shall have authority to open such diverting gates and weirs, and they shall have full authority to close such gates and weirs as soon as the proper amount of water for each irrigation has been discharged. Such gates and weirs may be equipped with locks, and the keys thereof shall be under the control of the Manager.

RULE 7—OWNERSHIP OF WATER

All water within the District is the property of the District and is subject to diversion and use by the District. No purchaser of water from the District acquires any proprietary right therein by reason of such use, nor does such purchaser acquire any right to re-sell such water, or to use it on premises or for a purpose other than for which it was applied and as stated in the

application. The District expressly asserts the right to re-capture, re-use and resell all water that passes from the premises described in the application as the place of use, and asserts its right to all water within the District.

RULE 8—DISTRIBUTION OF WATER

Except as otherwise herein provided, all water shall be apportioned ratably to the land in the District, upon such landowners making proper application therefor under these rules and making payment of the charges fixed by the Board. Upon failure of any landowner to make application for water or pay charges, the water to which such landowner would be entitled may be alloted by the District to other landowners offering to make the required payments therefor.

RULE 9—APPLICATION FOR WATER

Landowner or user desiring water for annual crops or new plantings shall make application for water, at the District office. The application shall tate the crops and acreage of each crop the applicant is intending to irrigate, and shall state the name of the owner, name of tenant, or tenants, acreage and location of acreage for which water is desired, and such other matters as the Board may deem necessary. Where the applicant is not the owner of the land on which the water is to be used, the District may require the landowner to also sign the

application. The application shall grant a right to the Disrict to control all private conduits, and to install, maintain, control and regulate all meters, measuring devices, delivery gates or other structures in any private conduit necessary for the distribution, measurement and control of the water for which application is made. Provided, however, such control and rights shall not impose a duty to excerise the same, or liability for damages resulting from the use of such conduits or otherwise arising. The time within which applications for water must be made may be extended or changed by resolution or order of the Board of Directors.

RULE 10—DELIVERY OF WATER

All requests for water service must be made in writing on forms prepared by the District and must be delivered at the District's office or to the ditchtender in charge of the delivery at least twenty-four (24) hours before the water is needed. Effort will be made to make delivery as soon as reasonably practical.

All shut-off orders must be sent to the District office or given to the ditchtender not later than 5 o'clock P.M. on the day before such shut-off is desired. When service is desired for shorter periods than one day the shut-off order must accompany the request for service.

Water must be used continuously by the water user throughout the period of delivery, both day and night.

RULE 11—FIXED RATES OF CHARGES

The rates of charges for the use of water, which may include a service charge and penalties and interest on delinquency and the time of payment of such charges may be fixed and determined annually by the Board prior to the fifteenth day of February of each year.

RULE 12—DISCONTINUING SERVICE FOR UNPAID CHARGES

If water charges are not paid when due the Board may, in its discretion, shut off the service of water until the charges are paid. This includes the right to shut off water regardless of the type of crop being irrigated or the use to which the water is being put and regardless of whether the user thereof is a landowner, tenant or other user.

In the event any water charges are unpaid at the end of an irrigation season on any particular land, the district may, in its discretion, refuse to serve water to that land in the following or subsequent seasons, until all such unpaid water charges are paid in full. This shall include the right to refuse service of water although the user of the

water for which charges remain unpaid was not the owner of the land, and although the ownership of the land may have changed since the water for which the charges remain unpaid, was used.

In the event service of water is shut off as hereinbefore provided for, neither the Board, the District, or its officers, agents or employees, shall be liable for any damage that may occur as a result thereof.

RULE 13—LANDOWNERS RESPONSIBLE FOR WATER CHARGES

Landowners shall be responsible for all water charges not paid when the same become due regardless of whether or not the land is being rented, leased or farmed by other than the landowner, and regardless of the person or persons requesting and making application for water.

Nothing herein contained, however, shall deprive the District of any other rights it may have to enforce payment of charges.

RULE 14—ACREAGE SURVEYS

The District shall have the right to make a survey for the purpose of determining the acreage on which water was used, allowed to stand, and over which it is permitted to flow or drain. The Charges for water will be on the gross acreage covered with water regardless of acreage actually planted.

RULE 15—ACKNOWLEDGMENTS

Whenever required by the District through its servants and employees, each landowner or water user, personally or through his agents, shall sign and deliver to the District a memorandum in writing acknowledging the acreage planted to each crop. If no survey is made by the District as hereinbefore provided, then said acknowledgment shall be binding upon the landowner and water user as to the acreage planted and type of crop. Any claim by a landowner or water user for a refund of water charges shall be made prior to harvest of the crop on the lands for which such refund is claimed.

RULE 16—ABANDONED USE OF WATER

Any person desiring to abandon any use of water shall deliver to the Secretary a written notice of such intention of abandonment and concurrently tender payment in full of all installments of water charge due at the date of delivery of notice.

RULE 17—WASTE OF WATER

Any water user, who in the opinion of the Manager, is wasting water (on roads, vacant land, or on land previously or presently irrigated) either wilfully, carelessly, negligently, or on account of defective private conduits, or who floods any portion of his land to an unreasonable depth or use

an unreasonable amount of water in order to properly irrigate other portions; or whose land has been improperly checked for the economical use of water, or allows an unnecessary amount of water to escape from any tailgate, will be refused the use of water until such conditions are remedied.

The District reserves the right to refuse delivery of water when it appears to the satisfaction of the Manager that the proposed use, or method of use, will require such excessive quantities of water as will constitute waste.

RULE 18—SHORTAGE OF WATER

When, through lack of water, lack of conduit capacity, or for any other reason, it is not possible to deliver throughout the District or any portion thereof, the full supply of water required by the water users, such supply as can be delivered will be equitably prorated until such time as delivery of a full supply can be given.

RULE 19—COMPLAINTS

All complaints as to service, lack of water, or other unsatisfactory conditions, should be made immediately, in writing, addressed to the Manager of the District, at the District office.

RULE 20—ACCESS TO LAND

The authorized ditchtenders and other agents of the District shall have free access

at all times to all lands irrigated from the canal system and to all conduits for the purpose of inspection, examination, measurements, surveys, or other necessary purposes of the District, with the right to install, maintain, control and regulate all meters or other measuring devices, gates, turnouts, or other structures necessary or proper for the measurement and distribution of water.

The District assumes no liability for damages to persons or property occasioned through defective conduits.

RULE 21—DAMAGE TO WORKS

Any person who shall permit any equipment, livestock, poultry, or waterfoul to damage or injure any works of the District, who shall damage, injure or destroy by burning or otherwise any such works, or who shall dump any rubbish therein or thereon, or erect fences on District rights-of-way, shall pay to the District upon demand all expenses incurred in the replacement of such property, or in the removal of such rubbish or fences.

RULE 22—ENFORCEMENT OF RULES

Failure or refusal of any landowner or water user to comply with these Rules or any interference by any such landowner, water user, his servants or employees, with the rights, duties or obligations of the District, or its employees, shall entitle the District to discontinue the service of water

to the lands of such owner or user until the landowner or water user shall furnish satisfactory proof to the Board of his intention to comply with these Rules or cease such interference, and shall remove any default existing at the time service of water is discontinued.

RULE 23--NON-LIABILITY OF DISTRICT

(a) The District will not be liable for any damage of any kind or nature resulting directly or indirectly from any private conduit, or the water flowing therein, or by reason of lack of capacity therein or for negligent, wasteful or other use or handling of water by the consumers therefrom.

(b) **Delivery of Water.** Most of the water furnished by the District flows through many miles of open ditches, and is subject to pollution, shortages, fluctuation in flow, and interruption in service. District employees are forbidden to make any agreements binding the District to serve an uninterrupted constant supply of water. All water furnished by the District will be on the basis of irrigation deliveries and every consumer putting the water to other uses does so at his own risk and by doing so assumes all liability for, and agrees to hold the District, and its officers, and employees free and harmless from liability and damages that may occur as a result of the defective water quality, shortages, fluctuation

in flow, and interruptions in service.

District sells water as a commodity only and not as a guaranteed service and will not be liable for defective quality of water, shortage of water either temporary or permanent, or for failure to deliver such water.

(c) **PUMPING:** Pumping by consumers of District water is done at the consumers risk and the District assumes no liability for damages to pumping equipment or other damages as a result of turbulent water or shortages or excess of water, or other cause.

(d) **Conduits, etc.:** District assumes no liability for damages to persons or property occasioned through defective conduits, meters, or measuring devices.

PENALTY FOR UNAUTHORIZED TAKING OF WATER PENAL CODE: Sec. 592

"Every person who shall, without authority of the owner or managing agent, and with intent to defraud, take water from any canal, ditch, flume or reservoir used for the purpose of holding or conveying water for manufacturing, agriculture, mining, irrigating or generation of power, or domestic uses or who shall without like authority raise, lower or otherwise disturb any gate or other apparatus thereof, used for the control of measurement of water; or who shall empty or place or cause to be emptied or placed into any such canal, ditch, flume or reservoir, any rubbish, filth or obstruction to the free flow of the water IS GUILTY OF A MISDEMEANOR."

4.10.3 Potential Projects to Enhance Water Management Capabilities

A description of potential projects to enhance BWD water management capabilities is provided on the following pages.

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4.10.4 Drought Management Plan

Background and Overview

On April 1, 2015 Governor Brown issued Executive Order B-29-15, mandating agricultural water suppliers to include a detailed Drought Management Plan (DMP) describing actions and measures taken to manage water demand during drought. BWD has historically experienced relatively reliable water supplies with a full surface water supply of 133,000 acre-feet available in all but four years (1977, 1991, 1992, and 2015) since construction of Lake Oroville and its subsequent 1969 settlement agreement with the State. During years in which curtailment is allowed under the agreement, BWD's water supply can be reduced by up to approximately 50 percent, as discussed in greater detail below.

The District recognizes the need for fair, consistent policies to address periods when customer demands exceed available surface water supplies. This DMP describes and expands upon BWD's shortage allocation policies, including discussion of a broad range of actions undertaken during drought to manage available water supplies and meet customer demands to the maximum extent possible.

The DMP includes components recommended by DWR in its 2015 AWMP Guidebook (DWR 2015). BWD's DMP describes the determination of available water supply, drought responses, and water shortage impacts. The description of water shortage impacts includes a discussion of 2015 supply and demand conditions available at the time of preparation of this DMP. A description of supplies and demands for 2013 and 2014, also required under Executive Order B-29-15, is included in the water balance section of this AWMP (II.4.7).

As stipulated in the 1969 agreement, BWD's water supply depends on Lake Oroville inflow. BWD's surface water supply can be reduced under the following conditions:

- DWR forecasted April to July unimpaired runoff into Lake Oroville is less than 600,000 af[9], or
- Total current year predicted and prior year actual deficiencies in unimpaired runoff (as compared to 2,500,000 af) exceed 400,000 af for one or more successive prior water years with less than 2,500,000 af of runoff.

When a reduction is allowed, the Joint Board allotment of 560,000 af can be reduced by up to 50 percent in any one year, but not by more than 100 percent in any seven consecutive years. Additionally, reductions in any given year cannot exceed the percent reduction experienced for agricultural use by State Water Project (SWP) contractors.

Historically during years of curtailment, DWR has curtailed Joint Board water supplies by the full allowed amount, 50 percent, in each instance. For BWD, which is entitled to 24 percent of the Joint District supply, the curtailment year apportionment is 66,500 af.

[9] The final, official forecast must be made by April 10 of each year.

Additionally, under the 1969 settlement agreement, the Joint Districts receive an additional 35,000 af of surface water supply in a year with 50 percent reduction. This 35,000 af is divided equally among the Joint Districts, providing an additional 8,750 af to each. As a result, BWD's surface water supply in a year with 50 percent reduction is 75,250 af, or approximately 57 percent of the normal year supply of 133,000 af.

Despite water supply being dictated by the 1969 settlement agreement with the State, monitoring of hydrologic conditions to assess available water supply is important to BWD's water management across the full range of hydrologic conditions experienced. To inform District decisions related to available water supply and to inform growers of supply conditions, the District actively monitors water supply information reported by the Department of Water Resources (DWR) and others for Lake Oroville and the Feather River watershed as a whole. Information monitored includes storm activity, accumulated precipitation and snow, water year indices, reservoir storage and releases, and projected and actual reservoir inflow. This valuable information supports the District and its customers in planning for water management and in making cropping decisions in all years. The value of monitoring a broad range of hydrologic information is amplified in years of drought.

Drought Responses

This section describes actions and activities undertaken by BWD to address surface water shortage, including discussion of existing shortage allocation policies, coordination and collaboration, supply management and demand management.

Shortage Allocation Policies

During past shortage years, BWD has reduced demands through mandatory idling of a portion of the acres planted to rice and a reduction in the number of irrigations provided to orchards. Typically, orchards receive six to eight irrigations per year. Under a 50% reduction in surface water supplies, it is estimated that only three or four irrigations would be made available. Water shortage allocation policies are evaluated on a year by year basis by the board of directors and modified as appropriate.

In addition to the two groundwater wells owned by the district, it is estimated that there are more than 220 operable private irrigation wells within the BWD service area, some of which have the potential to supplement surface water supplies in cut back years. Many of these wells serve as the primary source of irrigation supply in all years.

Coordination and Collaboration

BWD coordinates and collaborates extensively with others regarding local and regional water management in all years. These activities intensify during periods of drought in order to minimize adverse drought impacts across a range of stakeholders. Examples of collaboration and coordination activities include the following:

- Regular coordination with the other Joint Districts, WCWD, and DWR with regard to Feather River water supplies and demands, including monthly or more frequent calls with DWR SWP operators.

- Reporting of information to DWR and other governmental entities as necessary.
- Close coordination with Butte and Sutter counties regarding groundwater conditions and monitoring.
- Outreach to interested parties including Farm Bureau, legislators and legislative staff, government agency staff, media representatives, and others regarding surface water and groundwater management.

Supply Management

Extraordinary Operational Measures
In recent years, BWD has made improvements to both distribution system infrastructure and operational practices to improve overall distribution system management and to increase operational efficiency. During periods of surface water shortage, BWD takes additional, extraordinary measures to further increase operational efficiency and to maximize the beneficial use of available water supplies. Highlights of BWD activities to increase operational efficiency include the following:

- Adoption of the 2014 Feather River Regional Agricultural Water Management Plan (FRRAWMP), which included the identification of approximately $18 million in modernization and boundary flow measurement improvements. These projects have the potential to substantially increase operational efficiency. It is anticipated that these improvements will be implemented over time subject to funding and project prioritization.
- Increased coordination among operators and with customers to reduce surface outflows resulting from operational spillage and tailwater. These improvements are achieved through a combination of more frequent spill monitoring and more frequent flow adjustments in the system in response to grower demands.
- Implementation of a policy to allow for more flexible use of private pumping capacity.
- Increased coordination with the JWDB manager and SWP operations to more flexibly divert water and to closely and continuously track diversion amounts.

Supply Augmentation
BWD water supplies have been generally sufficient during years with full surface water supply. Historical contributions of surface water recharge to the underlying groundwater system allow growers within BWD to utilize available groundwater in years of surface water shortage to augment available water supplies. The District owns two groundwater wells that are typically used for groundwater substitution to increase local and statewide water supplies during drought and other dry years. BWD allows growers to optimize the use of available groundwater during drought through its pumping policy. The conjunctive management of surface water and groundwater supplies is a key component of BWD's drought management strategy.

Demand Management
BWD encourages efficient on-farm water management to control demand on an ongoing basis. During curtailment years, these efforts are enhanced through extraordinary actions, which may include the following:

- Additional education and outreach, including grower meetings and individual consultations.
- Allocation of available water supplies, including limitation of winter water use in 2014 (a full supply year) and limited summer and winter water use in 2015 (a curtailment year).
- Enhanced enforcement of rules and regulations.

These actions are summarized in the remainder of this section.

Outreach and Incentives
During periods of reduced supply, BWD increases outreach efforts to encourage on-farm water conservation and to keep growers informed of hydrologic conditions and any changes to BWD policies and practices to manage limited water supplies. In years of supply reduction, District staff meet with growers prior to the start of the irrigation season to discuss surface water availability and water management objectives and opportunities.

Allocation of Available Supplies
Under reduced surface water supply conditions, BWD apportions available surface water as described previously under its shortage allocation policies.

Enhanced Enforcement of Rules and Regulations
BWD's Rules and Regulations (AWMP Attachment II.4.10.2) disallow the waste of water (Rule 17). Under this rule, BWD has the authority to refuse delivery of water until wasteful conditions are remedied. During periods of water supply shortage, BWD may increase enforcement of rules related to the waste of water. Apportionment of surface water supplies during shortage years implicitly discourages water waste.

Water Shortage Impacts

Supplier Revenues and Expenses
The District's water charges are determined using a fixed (per-acre) rate dependent on the time of year (summer vs. winter). As a result, revenues have been greatly reduced in curtailment years due to large reductions in planted acres. In addition to reduced water charges to irrigation customers, revenues decrease as a result of decreased water sales through water transfers.

In addition to reduced revenues during curtailment years, operating costs increase substantially due to several factors. Increased expenditures include the following:

- Increased staff time providing enhanced operations, irrigation customer service, and outreach to the public.
- Increased reliance on outside water management assistance (consultants and legal) for Lake Oroville operations coordination, water rights protection, and other drought-related issues.
- Increased weed control costs due to low canal flows.

Impacts on Water Supplies

To illustrate actions by BWD and its customers to manage available water supplies during drought, water supplies for 2015 are summarized and compared to prior years. **All estimates for 2015 are preliminary and subject to revision.** The years 1999 through 2014 represent years where the full surface water supply was available for diversion by BWD. The year 2015 represents a year in which the District's normal JWDB supply of 133,000 af was curtailed by 50%, representing an overall reduction of approximately 43% of BWD's JWDB supply due to the availability of an additional 8,750 af through the 1969 settlement agreement with the State, as described previously.

Average April through October diversions for BWD from 1999 to 2014 are shown in Figure 1, along with preliminary estimates of diversions for 2015. Total average diversions between April and October were 98,000 af between 1999 and 2014 and 76,000 af in 2015.

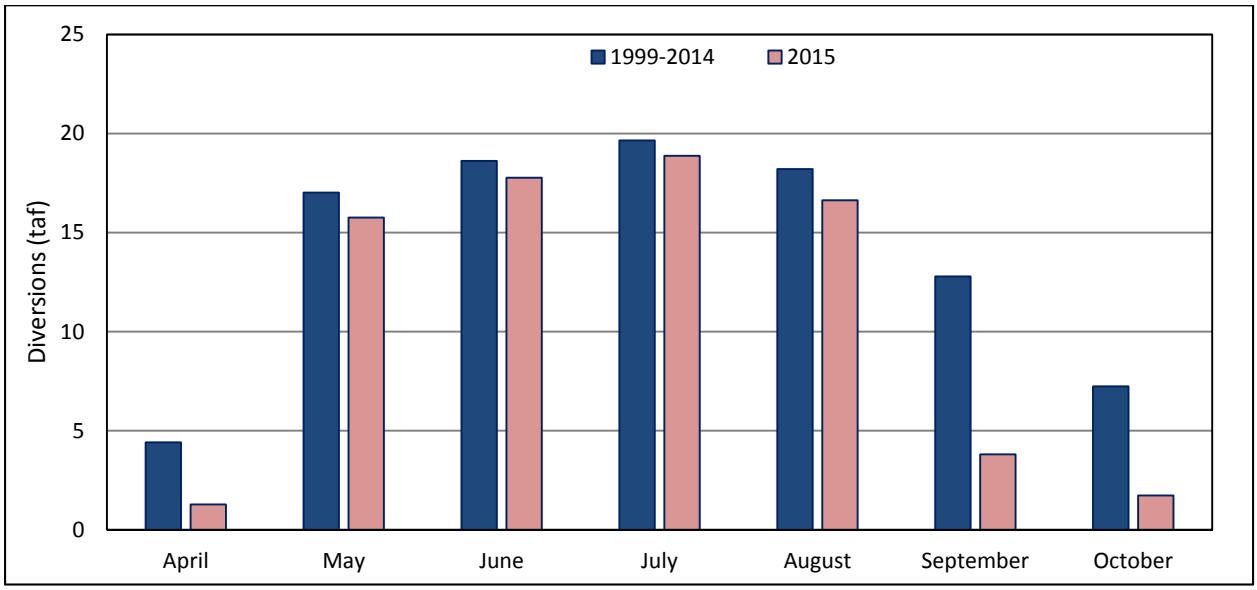

Figure 1. BWD April to October Diversions, 1999-2014 Average and 2015 Preliminary.

Average monthly estimates of groundwater pumping for BWD from 1999 to 2014 are shown in Figure 2, along with preliminary estimates of groundwater pumping for April through October 2015. The increase in groundwater pumping in 2015 in response to curtailment was approximated by estimating the additional acreage irrigated using groundwater in 2015 in response to curtailment (3,600 acres) and assuming an average duty of 4.0 af/ac. Thus, the total additional pumping resulting from curtailment is estimated to be approximately 14,500 af. Considering baseline private pumping within BWD's service area, total April to October pumping during 2015 was estimated to be 34,000 af. Monthly pumping volumes shown in Figure 2 were estimated based on the portion of estimated irrigation demand occurring each month.

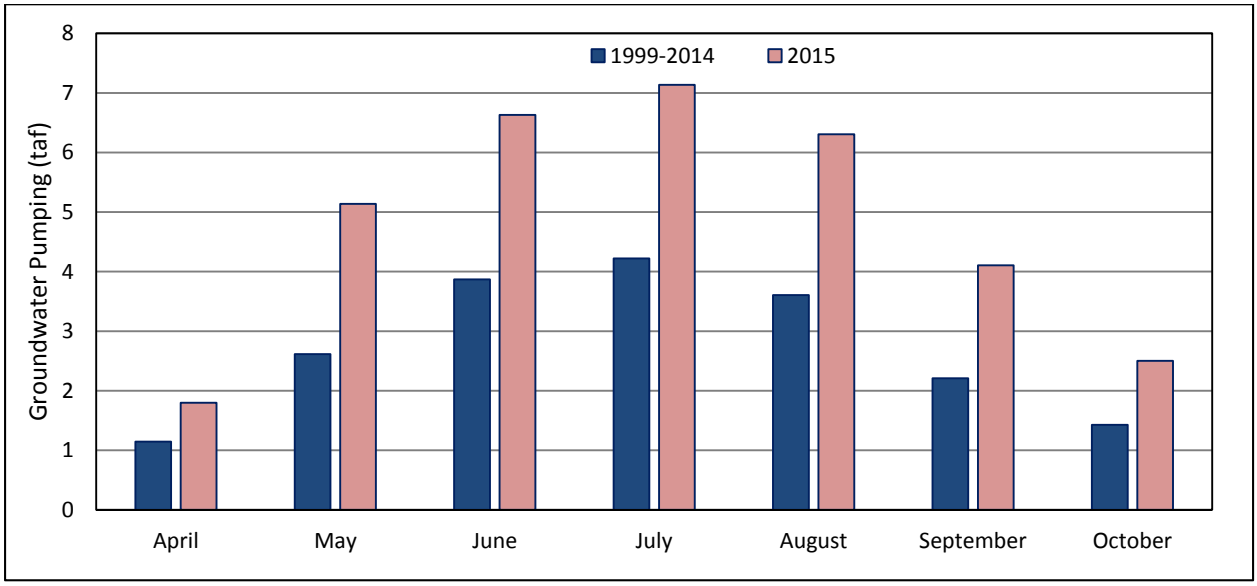

Figure 2. BWD April to October Private Groundwater Pumping, 1999-2014 Average and 2015 Preliminary.

Total diversions and groundwater pumping, which represent the primary sources of irrigation supply in BWD, are shown in Figure 3. Total average diversions and groundwater pumping between April and October were 117,000 af between 1999 and 2014 and 109,000 af in 2015.

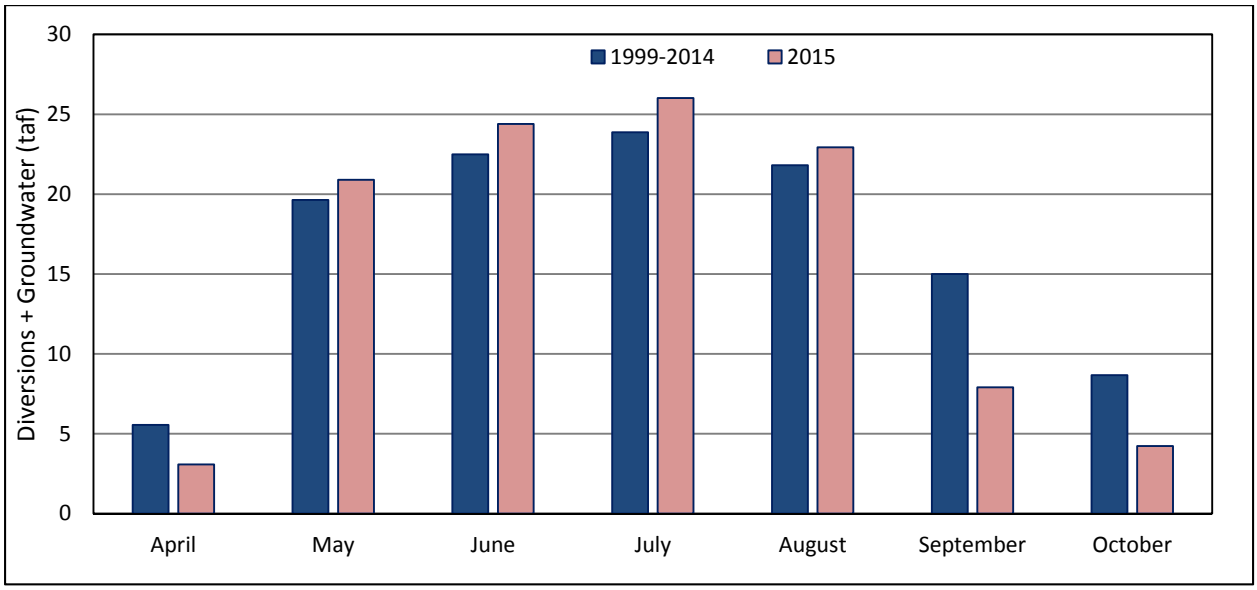

Figure 3. BWD April to October Diversions and Private Groundwater Pumping, 1999-2014 Average and 2015 Preliminary.

Demand Impacts

To illustrate impacts on demand caused by drought, demands for 2015, to the extent available, are summarized and compared to prior years. **All estimates for 2015 are preliminary and subject to revision.** The years 1999 through 2014 represent years where the full surface water supply was

available for diversion by BWD. The years 1999 through 2014 represent years where the full surface water supply was available for diversion by BWD. The year 2015 represents a year in which the District's normal JWDB supply of 133,000 af was curtailed by 50%, representing an overall reduction of approximately 43% of BWD's JWDB supply due to the availability of an additional 8,750 af through the 1969 settlement agreement with the State, as described previously.

Average monthly estimated deliveries for BWD from 1999 to 2014 are shown in Figure 4, along with preliminary estimates of deliveries for April through October 2015. Total average deliveries between April and October were 72,000 af between 1999 and 2014 and 61,000 af in 2015.

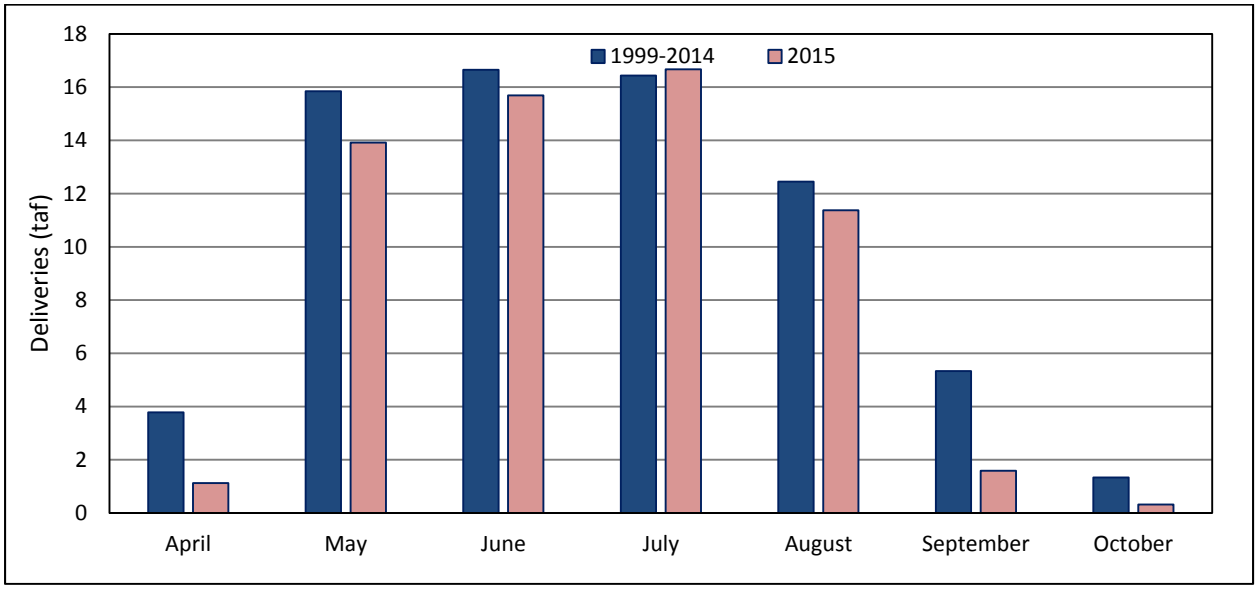

Figure 4. BWD April to October Deliveries, 1999-2014 Average and 2015 Preliminary.

References

DWR. 2015. A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2015 Agricultural Water Management Plan. California Department of Water Resources.

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