

# **Agricultural Water Management Plan**

**Developed for the Department of Water Resources**

**By  
The Merced Irrigation District**

**In compliance with the  
Senate Bill (SB) X7-7 of 2009**

**Adopted by the MID Board of Directors  
September 3, 2013**

## **Preface**

The Merced Irrigation District (MID or District) has prepared this Agricultural Water Management Plan (AWMP or Plan) in compliance with SB X7-7. The development of this AWMP has provided MID with an opportunity to further gauge its performance in meeting the District's water resources management goals, which include providing a reliable, high quality and affordable water supply that benefits the entire region.

To support its water resources management goals, MID's water management practices are centered on its robust and effective conjunctive use activities and its' long standing commitment to water conservation and system efficiency. The effectiveness of these management practices are gauged in this Plan by comparing key metrics to its 2002 plan, which was developed by MID after it voluntarily entered into an MOU under AB3616.

There are several ongoing activities, both internal and external to MID, that may impact its management practices and key metric performances in future Plans. These activities and their potential impact, both positive and negative, are discussed in Section 1, Introduction.

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## SECTION 1. INTRODUCTION

The Merced Irrigation District (MID, District, or Merced ID) has prepared this Agricultural Water Management Plan (AWMP or Plan) in compliance with the Water Conservation Act of 2009 (SB X7-7). SB X7-7 has mandated certain agricultural water suppliers to meet the following requirements:

- Prepare and adopt an SB X7-7 Agricultural Water Management Plan (AWMP)
- Implement efficient Water Management Practices (EWMPs)
- Submit documentation for Agricultural Water Measurement Regulation compliance
- Submit an Aggregated Farm-Gate Delivery Report

The Plan is organized according to the framework indicated in SB X7-7 §10826 and includes a discussion of the implementation status for each of the EWMPs presented in SB X7-7 §10608.48. These EWMPs are grouped in the following two categories:

- Critical Efficient Management Practices
- Conditional Efficient Water Management Practices.

As a conjunctive use District, one year would not adequately be reflective of MID operations. Therefore, for water balance purposes, the period between 2000 and 2008 was used to represent a continuous period experiencing different hydrologic water year types including critical dry years and wet years. More recent information was presented for elements not involving water balance calculations.

A copy of the current MID *Rules for the Distribution and Use of Water* are included in Appendix A. Appendix B describes the Root Zone model used to estimate effective precipitation, crop ET, and the fractions of crop water demand met from applied water and from precipitation. Appendix C describes the structure of the water balance and presents water balance results. Appendix D provides information on MID's water rights and Appendix E is a copy of the MID Groundwater Management Plan. Appendix F is Water Measurement and Reporting. Appendix G contains other documentation such as the public notice for this plan as well as the Board Resolution adopting this Plan. Note that the Aggregated Farm-Gate Delivery report was submitted under separate cover and is not included in the Plan.

In addition to the mandatory components of the Plan, the District's water resources management practices, which are centered on its robust and effective conjunctive use activities and its' long standing commitment to water conservation and system efficiency, are discussed. This discussion is intended to serve as a backdrop to the AWMP and includes a background on the evolution of its management goals, and foreseeable activities that may impact its future management activities as well as key components of future SBX 7-7 updates.

## **1.1 MID Water Resources Management and Conjunctive Use**

Merced ID is a conjunctive use district that has rights to surface water supplies and lies over a sizeable groundwater basin that readily receives and yields water. MID owns and operates 235 groundwater wells. The vast majority of Merced ID's wells are left on stand-by to be operated for irrigation during years of surface water shortages. Some wells are operated annually to serve high-ground parcels.

## **1.2 Background**

Shortly after Merced ID's formation in 1919, both surface water and groundwater sources have been conjunctively used to meet water demands in the basin. Originally, these demands were predominately for agricultural irrigation, although, over time, the magnitude of municipal and industrial pumping increased as the urban centers within Merced ID's territory grew.

Prior to the passage of Proposition 13 in 1978, MID assessed all landowners within the District uniformly, regardless of their use of surface water. This provided an incentive for irrigators to use District supplies (from both the Merced River and District wells). Following the passage of Proposition 13, the District began to charge for water service, first on a flat rate basis depending on allocation in a given year, and later on a volumetric basis. As an economic choice, some MID customers opted to develop and use groundwater because, in many places within the District, groundwater could be developed below the cost of District water.

During the course of the 1987-1992 drought when surface water supplies were limited and water costs increased 44 percent, many MID customers constructed private groundwater wells for additional water supply. As would be expected, once an investment is made to construct a private well, the tendency is to use the well rather than surface water. This tendency was compounded by the growing use of low-volume, pressurized on-farm application systems, which are better adapted to groundwater sources than to surface water supplies. By the end of the 1987-1992 drought, groundwater elevations were generally declining throughout the District, clearly indicating that the basin was in an overdraft condition.

In 1993, MID entered into a cooperative program with the City of Merced to plan for the region's future water supply. Completed in 1995 and updated in 2001, the Merced Water Supply Plan (MWSP) concluded that, through planned conjunctive management of MID's water resources, the region's future agricultural and Municipal and Industrial (M&I) demands, including selected environmental water demands, could be satisfied. Based on these findings, MID embarked on an aggressive program to restore and expand its conjunctive water management capability. Emphasis was placed on programs and facilities that would increase surface water use within MID by expanding service to lands previously served only by groundwater and by winning back users who in earlier years had converted to groundwater supplies. In addition MID transferred water to growers outside its boundary but within its Sphere of Influence.

Further, Merced ID initiated an aggressive in-lieu recharge program based on operational criteria for groundwater wells, and capital improvement projects yielding more than 54,000 AF in a normal year. The projects also considered energy reduction and using off-peak power.

In 2011 Merced ID launched its first intentional groundwater recharge project with an estimated yield of more than 15,000 AF annually at full development. The project will be operated most aggressively in years of abundant surface water.

A reverse in the trend where more customers are reverting to surface water has been realized. The reasons are mostly related to: (a) improved level of service through a centralized, flexible water ordering system, flexible water deliveries and modernized and automated infrastructure. In addition to the explicit steps taken by MID, other factors influenced the trend including: (a) lower groundwater levels; (b) higher

energy cost exacerbated by the lower groundwater table which made MID surface water costs more comparable; (c) lower groundwater quality resulting from a saline water wedge creeping from a saline water sink underneath the SJR into the western areas of the District as a result of lower groundwater levels; (d) a buildup of a salt water profile at the root zone of plants relying on groundwater supplies for their drip and micro spray systems that in many cases significantly impacted crop yields requiring flushing from MID surface water which has minimal salts; and (e) using MID neutral PH balanced water reduced or eliminated the reliance on chemical additives to fight salt build ups in drip and micro spray lines and meeting other fertilizers and pesticides product label requirements.

### **1.3 Current Practices**

Merced ID's normal operating objective is to maximize surface water use subject to availability in order to preserve groundwater for use in years when surface supplies are limited. Thus, the proportions of surface water use and groundwater use vary from year to year depending primarily on surface water availability and to some extent on cropping patterns and weather conditions. During an average wet year, 99 percent of Merced ID's water supply comes from surface water sources compared to 92 percent from surface water in an average dry year (this can be as low as 79 percent in certain dry years, such as 2008). The remainder of the supply comes from groundwater.

The nature of MID's overall conjunctive water management program can be revealed only through a time series analysis spanning several years and during hydrologic water year types. For this reason, a key component of the Plan is the District's annual water balance analysis. It provides a unified framework for linking measured inflows and outflows, such as surface water releases and operational discharges, with estimated values, such as deep percolation. This framework allows insightful analysis of the likely effects of implementation of the various Efficient Water Management Practices considered under SB X7-7.

MID utilizes the reaches of its surface and groundwater facilities and resources to optimize the use of the resources as feasible. As discussed, growers' reliance on MID to meet their demands in wet or dry years decreased their need to install private wells. It is the tendency of most growers to use their private wells in wet or dry years due to convenience and compatibility with low volume emitters. MID has, over the years, supplied various levels of groundwater depending on the overall hydrology, weather, cropping and length of season. This powerful tool combined water rates competitive with groundwater pumping are aimed to reduce dependence on groundwater for supply to growers within the MID.

A central point to consider in understanding the operation of MID facilities is the complexity of the system. On one level, the MID distribution system operates in a typical fashion with facilities designed and operated to deliver water effectively to irrigation customers. However, because MID uses natural channels for conveyance of both delivered water and storm drainage, at some points, delivered water and storm drainage water are commingled. In addition, because the natural channels in the MID system provide relief from flood flows, during the early part of the irrigation season the flood control function is superimposed on the irrigation function.

As a result of the mix of functions performed by MID facilities, it is sometimes difficult to distinctly quantify improvements in irrigation service that have resulted from recent enhancements to MID facilities and operation. Based on data going back to 1970, one clear index of the impact of recent operational improvements and policy changes on irrigation service is that the average irrigation season length from 2000 to 2008 is 23 days longer than the average season length between 1970 through 1999. Hence by providing service for a larger portion of the growing season, growers have a lesser need to resort to supplemental groundwater supply.



Complimentary to its Conjunctive Use operations is MID’s focus on water conservation and system efficiency. A major emphasis of its capital improvement program is to improve the distribution system to better integrate reuse into operations, leading to better water conservation. MID also possesses several smaller reservoirs (i.e., regulating basins) monitored and controlled by a Supervisory Control and Data Acquisition (SCADA) network that are used for regulating flows and balancing the supplies and demands of the system. These activities lead to increased conveyance system efficiencies. Furthermore MID completed a number of projects that reduce operational discharges while at the same time improving the service for growers that used to receive flows near the decommissioned spills.

Certain canals have been designated by Merced ID for raw water supply for future surface water treatment plant(s) at each of the three major cities within Merced ID’s designated place of use, as well as certain unincorporated areas. Based on this designation, only surface water from the Merced River or pumped groundwater from Merced ID’s wells are allowed in said designated canals, preserving the sanitary status of the canals, anticipating a shift of urban communities to surface water in the future. This shift is anticipated to occur once the groundwater basin reaches a certain threshold , in regards to quality and levels, and require the cities to begin using treated surface water for municipal supply (currently all cities and communities within Merced ID’s place of use rely on groundwater for all of their water needs).

## **1.4 Foreseeable Actions that may Impact Water Resources Management**

MID is a leader in regional water resources management, including conjunctive use, water conservation and system efficiency. As such, it continually strives to improve its management tools and practices and adapt to changing conditions. To further these efforts, MID has embarked on several major initiatives that will also allow it to increase the resolution of various components of future plans. These efforts are briefly described as follows:

- **Enterprise Data Management System (EDMS):** An SQL-based database is the core of this system which interacts and interchanges data between a Geographic Information System (GIS), water record database, a water order and billing software, a work order management system, and a facilities inventory application. This is an extensive undertaking that began in 2008 and is expected to be completed by 2017. However, substantial benefits of this effort are realized as each phase of the EDMS is implemented.
- **Water Resources Management Plan:** The plan will assess District assets and provide a long range capital improvement plan focused on system modernization to promote conservation and enhance system efficiency. The plan is expected to be completed in 2 years and will be driven in part by a stakeholder based process that includes MID growers, neighboring water districts and growers, the local farm bureau, as well as the cities and the County.
- **Water Resources Model:** This is a basin-wide, open stakeholder based process. The model is expected to provide valuable information to the District’s water balance. The model is anticipated to be completed in 2 years.

Planned conjunctive use for the future could be compromised depending on the outcome of the State’s vision for water planning and the strategic importance of the Merced basin. This would be disastrous for the region. Since conjunctive use only becomes beneficial when surface and groundwater usage are balanced, MID could be compelled to forfeit its engagement in conjunctive use activities, including groundwater supply and recharge, if offsetting surface water supplies are not available in most years as a result of any State and regulatory decision or action.

*~End of Section ~*



*Crocker Dam*

## **SECTION 2: PUBLIC PARTICIPATION, REGIONAL COORDINATION (§10826 (d)) AND PLAN ADOPTION AND SUBMITTAL (§10841)**

### **2.1 Public Participation**

Public participation in the development of this Plan included:

- Review of the publicly noticed presentation of the draft plan at the Merced Irrigation District Advisory Committee (MIDAC) meeting on July 10, 2013
- Notification of MID's intent to update its AWMP was made via letters to required agencies and a notice in the Merced Sun Star on July 26, 2013 and August 9, 2013;
- Posting of the draft Plan on the District's web page after August 6, 2013;
- Review of the publicly noticed presentation of the draft Plan at a special hearing of the MID Board of Directors on September 3, 2013 ; and
- Approval of the final Agricultural Water Management Plan at a regularly scheduled Board of Directors meeting on September 3, 2013.

In addition to the specific public outreach activities discussed above, MID maintains a continuous public outreach program via formal and informal processes. For example, the public is invited to attend all Board meetings where time is reserved on each agenda for public comment. The Board members are accessible to the public by phone, e-mail, special appointment and at Board meetings. The District maintains a website where the agendas of all Board meetings are published along with the recent Board minutes, newsletters and other important information. The public can provide comments on District matters via e-mail using a link on the MID website ([www.mercedid.org](http://www.mercedid.org)). In addition, the District has a Public and Government Relations Officer who has ongoing communications with interested parties District wide. The District also distributes a newsletter periodically to publicize important local, state and federal issues impacting its constituents. The District maintains an open exchange of information with local newspapers and, if necessary, issues press releases on matters of importance to the public. The District also relies, to a certain extent, on employees in the field to keep customers informed of the latest water management information.

### **2.2 Regional Coordination and Previous Water Management Activities (§10826 (d))**

MID is a leader in regional water resources management and has been collaborating with regional partners since its inception. This commitment to collaborative water resources planning is evidenced by several major past and current activities, as discussed below. Major activities include:

- Merced Streams Group (late 1930s)
- Merced River Development Project (1960s)
- AB3616 Water Management Plan (WMP), 2002
- Merced Water Supply Plan (1993)
- Castle Dam Flood Control Project (also a regulating basin), 1998
- Vernalis Adaptive Management Plan (1989 to 2011)

- Surface/Groundwater Optimization Program (SUGWOP), 1989 to present
- Merced Area Groundwater Pool Interests (MAGPI), 1997
- Merced Integrated Regional Water Management Plan (2013)
- Water Resources Model for the Merced Basin (Start around September 2013)

### ***Merced Streams Group***

MID works with the City of Merced and the County of Merced in maintaining the capacity of a portion of creeks identified by the Army Corps of Engineers, as necessary for flood protection purposes. These portions generally tend to be portions also used to convey irrigation water. The cooperation has been in existence since at least 1950s.

### ***Merced River Development Project (1960s)***

MID, in cooperation with Pacific Gas and Electric, the Department of Water Resources, the Federal Energy Regulatory Commission, the Bureau of Land Management, the Army Corps of Engineers and the California Department of Fish and Game, as well as MID growers and local land owners, cooperated to design, construct, and set parameters for the new project during the early 1960s.

### ***AB3616 Water Management Plan (WMP)***

MID voluntarily prepared a Water Management Plan (WMP) according to the MOU finalized on November 13, 1996 by the advisory committee for AB3616, which established the Agricultural Water Management Council (AWMC). As a signatory of the MOU since 1999, MID documented its performance with the Efficient Water Management Practices established by the Agricultural Water Suppliers as California outlined in the MOU. The WMP was adopted by the MID Board of Directors and submitted it to the AWMC. The plan was further reviewed by DWR staff before its adoption by the AWMC. MID demonstrated meeting all required EWMPs per the plan.

### ***Merced Water Supply Plan***

In 1993, MID entered into a cooperative program with the City of Merced to plan for the region's future water supply. Completed in 1995 and updated in 2001, the Merced Water Supply Plan (MWSP) was founded on the conclusion that, through planned conjunctive management of MID's water resources, the region's future agricultural and M&I demands, including selected environmental water demands, could be satisfied. Based on these findings, MID embarked on an aggressive program to restore and expand its conjunctive water management capability. Emphasis was placed on programs and facilities that would increase surface water use within MID by expanding service to lands previously served only by groundwater and by winning back users who in earlier years had converted to groundwater supplies.

### ***Castle Dam Flood Control Project (also a regulating basin)***

MID, the County of Merced and the Army Corps of Engineers collaborated on a multi-purpose project to provide flood control and a water regulating basin known as Castle Dam. The Castle Dam irrigation pool on Canal Creek was completed around 1998 by the Army Corps of Engineers as a multi-purpose flood control reservoir including an irrigation pool. The pool provides approximately 400 AF (AF) of regulating storage and has cut nearly 24 hours off the time required to initiate flow changes at the head of the Livingston Canal.

### ***Vernalis Adaptive Management Plan***

Under the San Joaquin River Agreement, since 2000 Merced ID and others provided water to help support a scientific study that included meeting a pulse flow of up to 110,000 AF of supplemental water

for a 31-day period in the San Joaquin River at Vernalis, California, during April and May for ecological resources as prescribed in the Vernalis Adaptive Management Plan (VAMP). The specific amount of the April/May supplemental flow provided each year was determined annually by the Hydrology Group of the San Joaquin River Technical Committee, which included technical representatives from the San Joaquin River Group Authority (SJRG), US Department of Interior (USDOI), Bureau of Reclamation (BOR) and United States Fish and Wildlife Service (USFWS). The agreement, as amended, expired on December 31, 2011.

### ***Surface/Groundwater Optimization Program (SUGWOP), 1989 to Present***

The program started in 1989 and was mainly funded by revenue from the VAMP transfers. The program components were developed independently by MID, but interestingly coincide with EWMPs for SB X7-7. The previous WMP addressed SUGWOP in more detail. This program will be replaced by the outcome of the Water Resources Management Plan and guidance from SB X7 7.

### ***Merced Area Groundwater Pool Interests (MAGPI)***

MAGPI's mission is to develop technical data and management strategies to improve the health of the Merced Groundwater Basin, which has generally been in overdraft since 1997. Currently chaired by MID, MAGPI members and non-member interest groups include most of the agencies with water supply, water quality and water management authority in the region. MAGPI's vision is to maximize conjunctive water management for reliable local, regional and state-wide water supply and to:

- Expand the in-basin use of surface water
- Expand groundwater production capability
- Continue water conservation efforts
- Monitor groundwater condition with the goal to establish
  - A live updatable water budget
  - Protocols for tracking basin "health"
- Establish a basin Joint Power Authority

In 2008, MAGPI established a subcommittee to encourage cooperative planning among additional aspects of water resources management beyond groundwater management and to lay the groundwork for development of the region's first IRWM Plan. MAGPI completed the Merced Regional Acceptance Process application in April 2009 and subsequently secured a DWR IRWM Planning Grant in February 2012 to develop the first Merced IRWM Plan (MIRWMP). Most relevant to this plan are technical data documenting the status of the Merced Groundwater Basin which help to support the District's conjunctive use management practices.

### ***Merced Integrated Regional Water Management Plan (2013)***

In 2012, MAGPI transferred responsibility for development of the MIRWMP to the interim Regional Water Management Group (RWMG), which is comprised of MID, the County of Merced and the City of Merced. The interim RWMG assembled a Work Plan Management Committee (WPMC), which consists of staff members from each of the interim RWMG agencies. The interim RWMG is responsible for overseeing this first Merced IRWM planning process, and each of its members have committed to continue to support the MIRWMP as a member of the RWMG following adoption of the plan and implementation of the long-term governance structure.

The MIRWM process has been a strongly stakeholder-driven process. The RWMG is advised by a Regional Advisory Committee (RAC) that represents the broad interests of the Merced Region and shapes the direction of the IRWM program. The RAC was formed in May 2012 following an open application

process. All parties that applied for inclusion on the RAC were accepted as either a full member or alternate and officially appointed by the MID Board of Directors, in consultation with member agencies represented by the RWMG. The RAC currently consists of 23 members and 16 alternates representing broad interests and perspectives in the region, including:

- Water Supply Interests
- Wastewater Interests
- Stormwater Interests
- Flood Control Interests
- Local Government
- Agricultural Interests
- Other Business Interests (non-agriculture)
- Environmental Interests
- Other Institutional Interests (e.g. UC Merced)
- Disadvantaged Community and Environmental Justice Interests
- Recreational Interests
- Community/Neighborhood Interests

The RAC has met monthly since May 2012 to discuss regional water management issues and identify regional water management needs, goals and objectives, plans and projects, and future funding and governance. RAC meetings are all publicly noticed and are frequently attended by members of the general public as well as the DWR regional service representative. This broad-based involvement by regional stakeholders has led to balanced input that reflects the wide array of water resources management perspectives throughout the region.

Most relevant to this plan are technical memorandums completed as part of the IRWMP which support MID's management practices regarding water conservation and conjunctive use, including groundwater recharge.

***Surface Water/Groundwater Model for the Merced Basin (Project start date approximately September 2013).***

MAGPI will start on developing a basin-wide water resources model with the help of a DWR grant covering around 50percent of the total cost. This stakeholder process will last approximately two years. Results from this exercise will increase the resolution of information MID and other agencies have about the Merced Groundwater Basin. The goal is to utilize the model as a tool to address future planning in the basin and identify best management practices and projects that can be feasibly implemented to increase water supply reliability.

### **2.3 Plan Adoption and Submittal (§10841)**

Upon adoption of the Plan, a copy of the adopted AWMP will be submitted to entities identified below (§10843 (a)&(b)):

- The Department (§10843 (b)(1)) (Electronic copies, preferably in Adobe™ pdf are acceptable)

- Any city, county, or city and county within which the agricultural water supplier extracts or provides water supplies (§10843 (b)(2))
- Any groundwater management entity within which jurisdiction the agricultural water supplier extracts or provides water supplies (§10843 (b)(3))
- Any urban water supplier within which jurisdiction the agricultural water supplier provides water supplies (§10843 (b)(4))
- Any city or county library within the jurisdiction the agricultural water supplier provides water supplies (§10843 (b)(5))
- The California State Library (§10843 (b)(6))
- Any local agency formation commission serving a county within which the agricultural water supplier provides water supplies (§10843 (b)(7))

*~End of Section~*



*Lake Yosemite*



## Section 3. Agricultural Water Supplier and Service Area (§10826 (a))

The MID Agricultural Water Management Plan has been prepared in accordance with Water Code Section §10826. The following sections are presented in a sequence stated in the Contents of Plans (§10826)

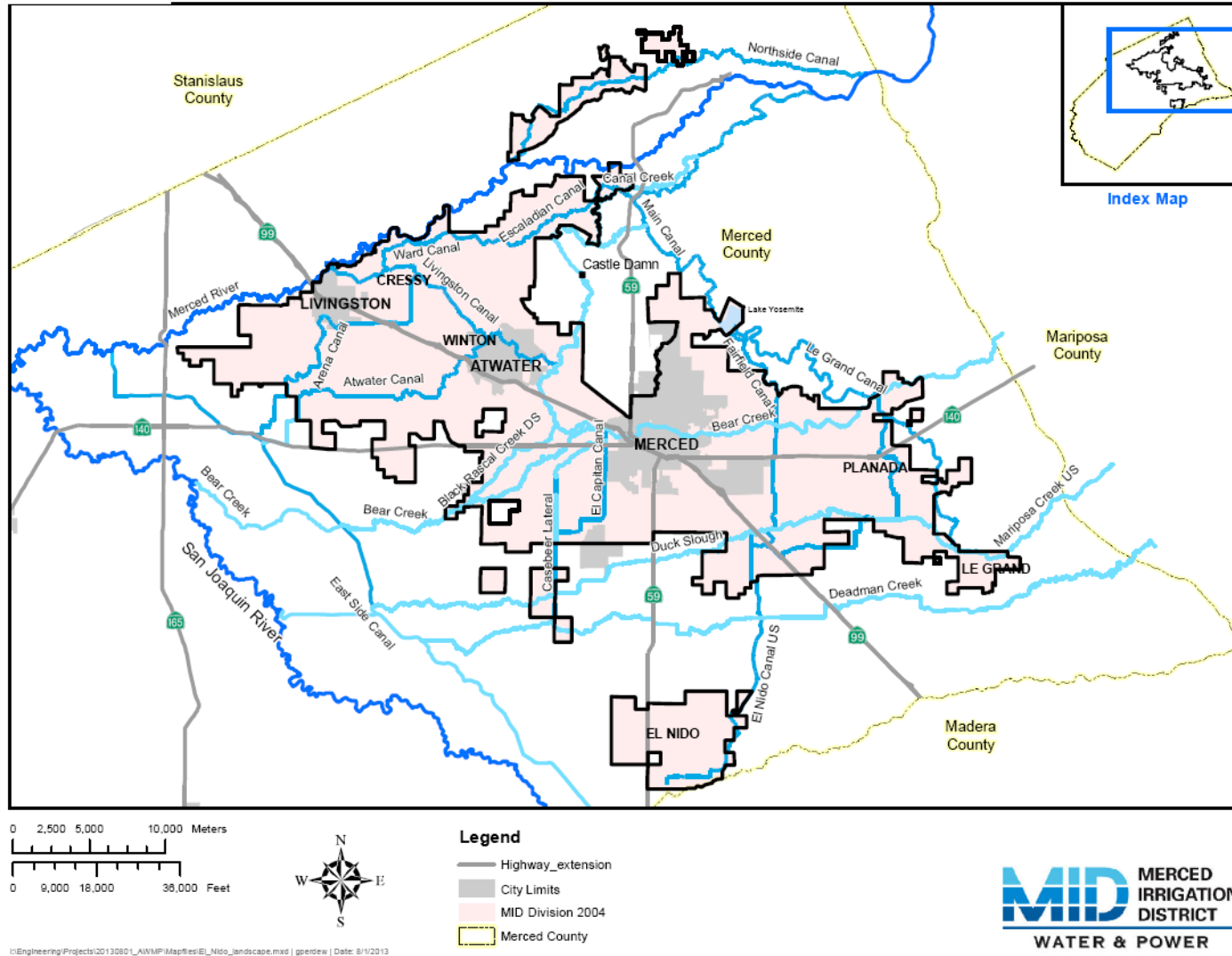
### 3.1 Size of Service Area (§10826 (a)(1))

The Merced Irrigation District became a legal entity on December 8, 1919. The District covers a service area of 164,317 gross acres, 131,950 acres of which are irrigable and approximately 100,000 acres of which are currently irrigated (2000-2008). Eight urban areas, including three incorporated cities, Merced, Atwater and Livingston, are all located within the boundaries of the MID. Table 3.1 provides information on the age and size of the MID with Figure 3.1 showing a map of the MID’s service area.

<b>Table 3.1 Water Supplier History and Size</b>	
Date of formation	1919
Source of Water at Time of Formation	Local Surface Water (Merced River/Local Streams)
Present Gross Acreage	164,317
Present Irrigable Acreage	131,950
Present Irrigated Acreage	100,237 <sup>1</sup>

<sup>1</sup> average irrigated acreage from 2000 through 2008

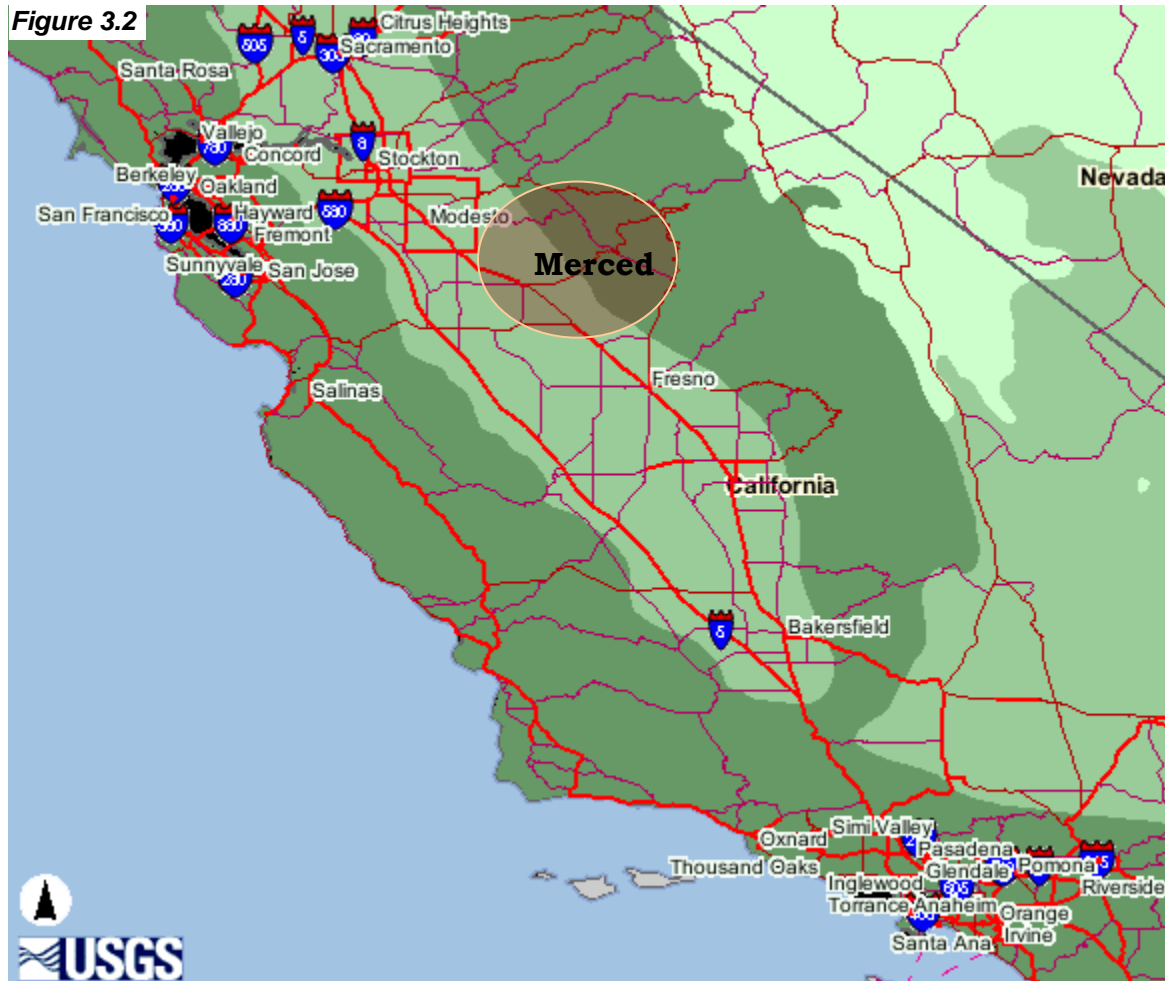
Figure 3.1



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### 3.2 Location of the Service Area and its Water Management Facilities (§10826 (a)(2).)

The MID lies on the eastern side of the San Joaquin Valley in eastern Merced County, approximately 120 miles south of Sacramento and 275 miles north of Los Angeles as shown in Figure 3.2.



The Merced River provides the principal renewable water supply for the District and the Merced Groundwater Basin. Water is diverted from the river into the District by the Northside Canal from a pool created by Merced Falls Dam and by the Main Canal from a pool created by the Crocker-Huffman Diversion Dam, a reinforced concrete structure completed in 1910. The Merced Falls Dam replaced an older wooden crib-type dam used to divert Merced River waters before 1873. The Crocker-Huffman Diversion Dam replaced a crib-type dam used to divert river water completed in 1870.

Lake McClure, the principal storage reservoir, is impounded by New Exchequer Dam, which is owned and operated by MID. New Exchequer Dam was completed in 1967, replacing the original dam, which was completed in 1926. Lake McClure’s capacity was expanded from 270,000 AF to 1,024,600 AF with the completion of New Exchequer Dam in 1967.

The MID distribution system includes 862 miles of conveyance facilities. See Table 3.2 for details.

The system was originally designed as a “flow-through” system, meaning that a substantial fraction of carriage water was diverted and routed through the system along with water for delivery to users. The extra water allowed users and operators to “turn on” and “turn off”, within certain limits, without advance notice, thereby providing a high degree of operational flexibility.

The MID distribution system includes portions of natural streams (or drains) that convey irrigation water during the irrigation season and flood flows during the off season. These reaches collect and enable reuse of canal operational discharges and return flows during the irrigation season. Recent emphasis has been placed on improving the distribution system to better integrate reuse into operations, leading to reduced flow-through requirements.

The District also owns 235 groundwater wells of which 198 wells are currently operational. Table 3.2 provides information on District wells and conveyance facilities.

The District possesses several smaller reservoirs that are used for regulating flows and balancing water supply with demand (Table 3.3). Lake McSwain is located on the Merced River and serves to re-regulate flow releases from Lake McClure and to help to ensure steady instream releases. Lake Yosemite, completed in 1888, is located north of Merced, along the Main Canal, and originally served as a forebay for piped surface water deliveries to the City of Merced utilizing the Main Canal, also completed in 1888. Those deliveries were discontinued in 1927, but the lake continues to serve as a Main Canal regulating reservoir and a popular recreational area for residents in Merced.

<b>Table 3.2 Water Conveyance and Delivery System</b>	
<b>System Used</b>	<b>Number of Miles</b>
Unlined canal	422
Natural Channels (creeks and sloughs)	121
Lined canal	97
Pipelines	177
Drains	45
<b>Total Mileage of System</b>	<b>862</b>
Wells	235
Delivery Gates	1,968

Bear Creek Pool is formed by Crocker Dam, which was originally constructed as a wood-crib dam in the late 1800s. It was later replaced by a reinforced concrete dam that captures runoff from the entire Bear Creek watershed, including Parkinson Creek, Fahrens Creek, Cottonwood Creek, Black Rascal Creek, Bear Creek, and Burns Creek. It was originally constructed as a direct diversion facility, with limited regulating capacity, but recent improvements have created approximately 180 AF of regulating storage there.

Castle Dam irrigation pool on Canal Creek was completed around 1998 by the Army Corps of Engineers as a multi-purpose flood control reservoir including an irrigation pool. The pool provides approximately 400 AF of regulating storage and has cut nearly 24 hours off the time required to initiate flow changes at the head of the Livingston Canal. Mariposa Creek Pool and El Nido Reservoir were similarly improved creating up to 50 and 200 AF of regulating capacity, respectively. The latest addition to MID’s regulating capacity is Livingston Automatic No. 2 operating storage, which was completed in 2005. It is MID’s only off-stream basin which can be completely bypassed without impacting operations. A summary of all the regulating pools in the system is listed Table 3.3, below.

<b>Table 3.3 Regulating Reservoirs</b>			
<b>Regulating Basins</b>	<b>Completed After 2002</b>	<b>Total Volume (AF)</b>	<b>Active Regulating Volume (AF)</b>
Lake Mc Swain		9,740	1,600
Lake Yosemite		7,425	1,000
Castle Dam Irrigation Pool		1,000	400
Bear Creek Pool (Crocker Dam)		1,000	180
El Nido Reservoir	√	200	200
Livingston Automatic No. 2	√	100	100
Mariposa Creek Pool (El Nido Dam)		55	55
Puglizevich Dam Pool		35	35
Livingston Canal Pool		20	20

Table 3.4 describes tailwater and operational discharge recovery mechanisms now in place within the District.

<b>Table 3.4 Tailwater/Operational Discharge Recovery System</b>	
<b>System</b>	<b>Description</b>
District-Operated Tailwater/ Operational Discharge Recovery	Most operational discharges are recaptured in creeks or interceptor canals where they are reused either within MID or downstream
Grower-Operated Tailwater/ Operational Discharge Recovery	Since the 1980s the District has had a moratorium on drainage discharge to canals. While a number of drains are grandfathered, the District is working to minimize the number of drains discharging into canals. Most of the farmers in the western portion of MID have no offsite drainage. Some farms in the eastern portion drain to natural sloughs.

MID charges volumetrically at the farm turnout, meeting SB X7-7 requirements. MID strives to provide its growers with as much flexibility as possible with regard to frequency, rate and duration of irrigation events.

MID uses different water ordering and delivery schedules, depending primarily on the operational capabilities of portions of the distribution system (Table 3.5). Most users are provided water under an arranged demand system, where the user places an order with the District and water is delivered later, typically within two to three days. In the last few years, the majority of orders have been filled within 24 hours. Where requested and determined to be practical, the District offers “on-demand” service, so that the water user can turn on and off without advance notice to the District. This typically is provided to drip and micro-spray users whose systems are equipped with cumulative volumetric meters, which draw directly from a main canal or from large laterals where the fluctuations in canal flow resulting from “on-demand” service can be re-regulated downstream. MID may mandate rotation on laterals with limited capacity to ensure sufficient supplies to all users.

<b>Type</b>	<b>Mark if Used</b>
On demand	<b>X</b>
Modified demand	<b>X</b>
Rotation	<b>X</b>
Other	<b>X</b>

An irrigation customer can call the office, send a fax during the working hours, use an Automated Voice Recognition System or the Web to place their delivery orders. The water account may be accessed through a Web connection and it can also provide history of deliveries and invoices. Since 2008, MID Distribution System Operators (DSOs) have been equipped with laptops that receive the water orders from MID headquarters over a wireless network into a water order software that keeps track of delivery orders. The DSOs also use a Supervisory Control and Data Acquisition (SCADA) system to monitor and manage water in their area with help from the Senior Distribution System Operators (SDSOs), who is in charge of a larger distribution area and the reservoirs serving their distribution area.

Table 3.6 lists agencies with whom MID coordinates in carrying out its operations and the nature of the restrictions that this coordination now imposes. It should be noted that some of these restrictions could place a significant challenge on irrigation operations.

<b>Table 3.6 Restrictions on Water Sources</b>		
<b>Restrictions</b>	<b>Name of Agency Imposing Restrictions</b>	<b>Operational Constraints</b>
Flood Control Space	U.S. Army Corps of Engineers	None
Minimum Reservoir Pool	FERC	Must use groundwater pumping
Power Generation Forecasting	PG&E/State Independent System Operator (Cal ISO)	Limits flexibility as diversion forecasts are set in advance
In-Stream Flow	FERC	Possible loss of diversion flows into the distribution system to satisfy in-stream flows
In-Stream Flow (Nov-Mar)	DWR (Davis-Grunsky)	
In-Stream Pulse Flow (October)	SWRCB (San Joaquin River Agreement)	
In-Stream Pulse Flow (Spring)	SWRCB (VAMP)	
Senior Water Rights on River	SWRCB Merced County Superior Court Adjudication(s)	Possible loss of diversion flows into the distribution system to satisfy adjudicated demands in the river
System Downstream Commitments	Stevinson Water District and Merced National Wildlife Refuge	Increases operational discharges as a result of guaranteeing minimum flows
In-System Water Entitlements	By adjudications or agreements	Impact canal capacities

Since the early 1930s, MID has provided water to lands within the former El Nido Irrigation District (ENID), when surface water supplies were adequate, utilizing the District’s pre-1914 water rights. In 2005, the ENID’s 9,923 acres was consolidated into the MID service area, and lands within the former ENID service area were classified as MID Class II users. As part of the consolidation, it was agreed that Class II water allocations would be 50 percent of the allocation (AF/AC) to Class I users, i.e., the MID service area prior to consolidation. As a result of the consolidation, MID storage and direct diversion licenses were amended to include a 12,500 AF pulse flow for fish attraction and spawning flows for fall run Chinook Salmon during the month of October. Since the ENID consolidation, there have been no other consolidations or annexations to the MID service area. Table 3.7 notes factors that may affect the size of the MID service area.

<b>Table 3.7 Changes to the Service Area</b>	
<b>Change to Service Area</b>	<b>Affect on the Water Supplier</b>
Increased service area size due to consolidation with El Nido Irrigation District and simultaneous urbanization within the existing boundaries of MID	12,500 AF additional release to Merced River in October

**3.3**

**Terrain and Soils (§10826 (a)(3))**

The irrigated land in MID is typically mildly sloped with a fall of about one foot per 1,000 feet. Most fields are surface irrigated with laser leveling employed to achieve and maintain uniform grades.

Pressurized systems are used in undulating areas that are not suited to land leveling, and, increasingly, as replacements for, or in conjunction with, surface irrigation systems on permanent crops.

The soils in the eastern part of MID are typically medium- to fine-textured, with the majority of fields using surface irrigation systems that generate little tailwater. Pastureland in MID tends to be located on slightly steeper ground, and there has been a gradual substitution of permanent crops (trees and vines) for crops such as pasture over the last thirty years or so. Soils in the western portion of the District are typically medium- to coarse-textured, with most having medium to rapid intake rates.

The spatial variation in soils from east to west has resulted in the majority of the orchard crops being located in the western portion of the District while the row crops still thrive in the eastern portion. Water conserving irrigation measures, such as micro sprinkler and drip systems, are concentrated in the western portion of the District, the area MID has traditionally relied on for groundwater extractions in years of surface water shortages.

Table 3.8 describes the influence of local topography on District operations.

<b>Table 3.8 Topographic Impacts</b>	
<b>Topography Characteristic</b>	<b>Impact on Water Operations</b>
Natural streams and sloughs	Mostly located in the eastern portion of the District. Integrated into MID’s water delivery and drainage system. Natural channels that are used as conveyances in their upstream reaches may serve as drains downstream of the delivery service area. Natural channels also convey stormwater during the non-irrigation season. Most creeks and sloughs are located in the eastern portion of the District.
Land slope	Does not constrain irrigation operations.

Table 3.9 describes the effects of local soils on District operations.

<b>Table 3.9 Soil Characteristic Impacts</b>	
<b>Soil Characteristic</b>	<b>Impact on Water Operations</b>
Eastern portion: typically clay based to loamy soils	Limited groundwater recharge; basin-check irrigation generates little tailwater.
Western portion: typically loamy to sandy soils	Moderate recharge rates make this area important to MID’s conjunctive management approach.

### **3.4 Climate (§10826 (a)(4))**

The average annual precipitation for the District is approximately 12 inches, coming primarily between November and March. In most years, this rainfall is sufficient to meet the water needs of winter annuals, pasture and winter cover crops in the orchards. There are generally no irrigation deliveries during this period unless a continuous dry period creates needed demand such as the case with the winter of 2000.



The District opted to make a two-week surface water deliveries during a normally off- irrigation season period.

Water is not delivered specifically for frost protection. However, during the off-season (November through mid-March), MID does make its deep groundwater wells available. Growers purchase flows at the MID well and incur all losses between the well and their delivery gates.

The characteristics of microclimates within the District do not range widely and, therefore, have little impact on District operations or on-farm water requirements. Table 3.10 describes some characteristics of the local climate.

<b>Table 3.10 Climate Characteristics</b>	
<b>Climate Characteristic</b>	<b>Value</b>
Average Annual Precipitation	12.29 inches
Minimum Mean Monthly Temperature	35.5 °F (December)
Maximum Mean Monthly Temperature	96.7 °F (July)

### **3.5 Operating Rules and Regulations (§10826 (a)(5))**

A copy of the Merced Irrigation District Rules and Regulations Governing Distribution of Water is included in Appendix A. These rules, updated occasionally at the direction of the Board, describe procedures for water ordering and operation of the MID water distribution system.

### **3.6 Water Delivery Measurements or Calculations (§10826 (a)(6))**

The following describes the frequency with which MID makes measurements, calibrates water measurement devices and performs scheduled maintenance on these devices. Also included below is an assessment of the estimated accuracies of the various measurement devices. See Appendix F, Water Measurement Documentation and Reporting for a more detailed Agricultural Water Measurement Regulation.

#### **Meter Gate Measurement Configurations**

Installations that allow for a vertical installation of a meter gate and a downstream measuring vent are considered to be turnouts with a meter gate measurement configuration. Meter gates, such as a standard Fresno Valve C101 gate, provide instantaneous flow readings based on a manufacturer specific rating table, the differential head across the gate and the gate opening.

There are various turnout types that contain meter gate measurement configurations, as follows:

**Upright Structures:** Typically measured once during an irrigation and as needed depending on changing conditions. The turnout is checked daily and cleared of debris as necessary when in use. Annual maintenance consists of checking that zero gate marks have not changed due to wear of valve stem threads or the face of the gate. Gates are repaired and calibrated when wear indicates it is necessary. The margin of error is estimated to be approximately 15 percent.

**Slant Structures:** Typically measured once during an irrigation and as needed depending on changing conditions. The turnout is checked daily and cleared of debris as necessary when in use. Annual maintenance consists of checking that zero gate marks have not changed due to wear of valve stem threads or the face of the gate. Gates are repaired and calibrated when wear indicates it

is necessary. A variety of methods are used to estimate flows through these turnout types. The manufacturer's rating table for these gates can only be used when they are fully open during irrigation, and even then they have a higher margin of error than vertically installed gated, depending on the site specific configuration.

**Concrete Boxes:** Typically measured once during an irrigation and as needed depending on changing conditions. The turnout is checked daily and cleared of debris as necessary when in use. Annual maintenance consists of checking that zero gate marks have not changed due to wear of valve stem threads or the face of the gate. Gates are repaired and calibrated when wear indicates it is necessary. Boxes with weirs that are fixed do not need calibration. The margin of error is estimated to be 15 percent.

**Other:** These include headwalls, standpipes and other miscellaneous structure types. Typically measured once during an irrigation and as needed depending on changing conditions. The turnout is checked daily and cleared of debris as necessary when in use. Annual maintenance consists of checking that zero gate marks have not changed due to wear of valve stem threads or the face of the gate. Gates are repaired and calibrated when wear indicates it is necessary. The margin of error is site specific and generally unknown.

### **Meter Measuring Configurations**

Flows to fields measured with a meter, such as the McCrometer Propeller Meter or other MID approved, factory calibrated meter, are considered meter measuring configurations. These configurations typically serve pressurized on-farm systems, although they can serve open flow systems if certain site specific conditions are met. MID approved meters come calibrated from the factory. The flows through the meters are periodically verified to conform to expected flows using an ultrasonic test meter. When necessary, the meter undergoes maintenance and is factory re-calibrated as required. The accuracy of the propeller meters, the most common meter in use, is  $\pm 2$  percent as specified by the manufacturer if properly installed and maintained. MID staff typically read turnouts with meter measurement configurations every one to two weeks.

Turnout types for meter measurement configurations can be similar to those for meter gate measurement configurations. In these cases, the frequency with which MID performs scheduled maintenance on the turnout structure is similar. Other accounts may be served directly from a booster pump or groundwater well. Each type of pump has periodic maintenance schedules, including daily, monthly and annual schedules.

Table 3.11 provides a summary of MID's turnout types, the measurement attributes of each and the on-farm irrigation system classification.

**Table 3.11, Turnout Inventory Results**

Measurement Configuration	Turnout Type	Total No. of Active Accounts (2011 Irrigation Season)	Combined Irrig. Systems	Gravity Irrig. System		Pressurized Irrig. Systems				Unspecified
			Flood and Drip	Flood	Furrow	Drip	Impact Sprinkler	Micro-Mist	Sprinkler	
Meter Gate	Concrete Box	186	2	153	5	3	16	6		1
	Slant Delivery Structure	334	2	229	27	7	51	12	4	2
	Upright Delivery Structure	556		357	108	7	61	14	2	7
	Other	152	1	95	13	3	29	8	1	2
	<b>Sub-Total</b>	<b>1228</b>	<b>4</b>	<b>739</b>	<b>140</b>	<b>17</b>	<b>128</b>	<b>32</b>	<b>6</b>	<b>10</b>
Meter	Concrete Box	75		9	2	3	2	5	1	53
	Slant Delivery Structure	106		6	1	5	1	12	1	80
	Upright Delivery Structure	173		22	6	4	10	13	1	117
	Other	198	1	28	15	4	12	12	2	124
	<b>Sub-Total</b>	<b>552</b>	<b>1</b>	<b>65</b>	<b>24</b>	<b>16</b>	<b>25</b>	<b>42</b>	<b>5</b>	<b>374</b>
TBD <sup>1</sup>	TBD	188	3	127	30	4	14	6	0	4
<b>Total</b>		<b>1968</b>	<b>5</b>	<b>804</b>	<b>164</b>	<b>33</b>	<b>153</b>	<b>74</b>	<b>11</b>	<b>384</b>

<sup>1</sup> Measurement Attributes and Turnout Types are currently being inventoried as part of the GIS mapping effort discussed herein.

### **3.7 Water Rate Schedules and Billing (§10826 (a)(7))**

MID adopted a volumetric rate for its water sales in 1993. MID sells water by the acre-foot, in increments of 0.1 AF. By this long standing adoption, MID meets SB X7-7 requirements.

MID's pricing policy is integrated with the District's conjunctive management strategy by offering a water rate per acre-foot for applied water and a standby charge per acre of irrigable land to encourage customers to rely on surface water when surface supplies are abundant. The price is designed to compete with the cost of groundwater pumping to prevent severe, irreversible groundwater overdraft. Growers who elect to purchase supplemental water made available through conjunctive groundwater pumping from the District will pay close to 300 percent the cost of surface water, a practice that growers only use during droughts. Most growers with permanent crops tend to have their own private wells.

MID's rate structure includes a \$24 per acre standby charge (2013) assessed against the gross acreage of all irrigable land regardless of the provision of surface water ( e.g. some areas receive groundwater only). In addition to the standby charge, accounts are charged a base rate of \$23.25 per acre-foot for water usage (2013). Therefore, the total charge for a typical seasonal irrigation delivery of three AF per acre is \$93.75. Municipal and industrial (M&I) customers are charged \$125 per acre-foot but are not assessed a standby charge. Both irrigation and M&I customers are billed monthly for service. Garden Heads are the term used for small hobby parcels. They generally receive very small flows that are usually based on estimated head pressure and gate size and opening. Garden Head users do not grow crops for commercial benefit. In the past, they paid a flat fee and did not need to place a water order for each irrigation. Beginning in 2012, Garden Heads have been required to place water orders and are charged volumetrically where facilities exist for such measurements and as needed by the DSOs.

### **3.8 Water Shortage Allocation Policies (§10826 (a)(8))**

MID's drought water management approach is encompassed by the broader practices dealing with conjunctive water management. The District has aggressively pursued expanded conjunctive water management capability so that it can meet the needs of MID water users, while also meeting growing environmental demands.

As an example, since the 1920s the District has constructed well fields to reduce the impact of shallow water tables at the time and to supplement surface water supplies during shortages. The District owns and operates more than 235 groundwater well locations, with 198 on standby at any time, which makes it one of the most extensive well fields owned by a single irrigation District in the San Joaquin Valley. In 2002 MID conducted a study to expand its well field in the southeast quadrant of the District comprising 25,000 Acres. The study recommended against it due to the relatively low yields and shallow groundwater aquifer which would not be able to support the required demand.

MID's conjunctive water management strategy assures that groundwater conditions will be managed so that supplies available to MID users in times of drought will be sufficient to meet its needs. As discussed, the foundation of MID's engagement in conjunctive use stems from the desire to do what it can, in collaboration with its regional partners, to ensure that the groundwater basin is managed in a sustainable fashion. One of the cornerstones of MID conjunctive use management is the fact that growers who can rely on MID during droughts are not compelled to install private wells on their properties. Owners of new wells tend to use them most years due to convenience, thereby impacting the groundwater and MID revenue which puts pressure on MID to raise its water rates. The result would be a downward spiral of higher water rates and more groundwater extraction in the basin. The result could lead to irreversible negative impacts on the groundwater basin and on the District at-large. An example of irreversible impact is the occurring land subsidence at the southwest quadrant of the Merced Groundwater Basin as a result of

excessive unyielding groundwater pumping, by growers that have limited or no access to surface water supply.

In addition to groundwater extraction in years of surface water shortage, the District establishes its available water supply at the beginning of the irrigation season. Typically, the water made available is based on estimated forecasted runoff, District in-stream requirements, historical water commitments (e.g. senior water right holders or adjudicated rights) in the Merced River or/and through its distribution system, system losses, and desired carryover storage in Lake McClure. During droughts, the set allocation could be insufficient for full irrigation for many crops. In 2008 growers were provided 2.5 AF/Acre for Class I users and 1.25AF/Acre for Class II users. These values are variable depending on many factors, and they are approved annually by the MID Board of Directors.

The District has a financial reserve policy that addresses financial shortages. MID has historically replenishing its financial reserve through water transfers from water storage.

As for the resource in years of surface water shortage, the District reduces the allocation to its growers proportioned to its Class I and Class II users. It also relies on its conjunctive use groundwater pumping activities to supplement the limited surface water supply, which helps to prevent growers from drilling wells during such years and further stressing the groundwater basin.

In 2008, The District brokered water to its customers from Stevinson Water District by purchasing around 7,000 AF of its committed 25,000 AF. However, such amount wouldn't bring meaningful relief district wide in the case of a severe drought(s).

In the case of severe droughts with a de minimis surface water supply, the District has to rely on its available local resources. The District is located in an area that cannot purchase water from other entities so the District's last resort is groundwater, hence its continuous effort to protect this valuable resource.

Facing a catastrophe in the winter of 1993 with Lake McClure having less than 50,000 AF in storage, the Board announced that there would not be an irrigation season for that year and water would only be delivered to save the permanent crops, which are mainly trees and vines. The lake was below its minimum pool of 115,000 AF and no surface water could have been diverted from storage.

Water supply options have not changed and the District will resort to a similar action should an extended drought impact water supply. During such a case, the District will rely on its financial reserves to survive the economic impact of droughts.

### **3.9 Policies Addressing Wasteful Use of Agricultural Water**

MID Rules and Regulation for the Distribution of Water addresses issues of wasteful water, see Appendix A.

*~End of Section~*



*Lake McClure*

## **SECTION 4. INVENTORY OF WATER SUPPLIES**

### **(§10826 (b))**

This section of the Water Management Plan describes the quality and quantity of water available to the MID from surface and groundwater sources. The section continues by describing water usage within the MID service area. The technical foundation of this section, and of the entire Water Management Plan, is the water balance analysis (2000-2008) that is summarized in Section 4 and presented in more detail in Appendix C.

#### **4.1 Surface Water Supply (§10826 (b)(1))**

The Merced River is the main source of MID's surface water supply. The District diverts direct flows and stored water impounded in Lake McClure by New Exchequer Dam on the Merced River. The District diverts water according to a series of pre- and post-1914 flow and storage water rights recognized by the State of California.

#### **4.2 Water Rights**

MID enjoys pre-1914 water rights on the Merced River, local reservoirs (e.g. Lake Yosemite which was completed in 1888) and creeks (e.g. Bear Creek) that are intertwined with its distribution system. In addition, MID holds six appropriative water right licenses on the Merced River issued by the State Water Resources Control Board, Division of Water Rights for the direct diversion and storage of Merced River water. Licenses 2685, 6047 and 11395 are for consumptive use purposes while Licenses 990, 2684 and 11396 are for power production. A summary of each of these licenses is contained in Appendix D. During the irrigation season, MID operates under its consumptive use licenses. The pre-1914 water rights and licenses for power use compliment the consumptive use rights, authorize use outside the irrigation season and add to MID's direct diversion rights. Under the licenses for consumptive use, MID is allowed to store up to 605,000 AF during October through June of any year and withdraw from storage up to 516,110 AF throughout any given year.

In 2005, the District acquired two licenses on Mariposa Creek, also contained in Appendix D, as part of its consolidation with El Nido Irrigation District. These licenses amount to a total of 10,066 AF with a maximum diversion flow rate of 100 cfs. The District acquired a smaller water right on Deadman Creek for 3.8 cfs of direct flow.

#### **4.3 Flow and Reservoir Requirements**

The District has also been issued a license by the Federal Energy Regulatory Commission (FERC), which provides a minimum in-stream flow requirement and a minimum pool requirement of 115,000 AF in Lake McClure. The license further provides that the District cooperate with the California Department of Fish and Game and the U.S. Fish and Wildlife Service to determine means of providing up to 15,000 AF of project water and return flow waters to the Merced National Wildlife Refuge. The Davis-Grunsky Agreement is a 1967 contract between the State of California and MID in which the State provided funding in the amount of \$8 million for the construction of the dam recreational and fish enhancement facilities with the provision that MID maintains continuous flow of 180 to 220 cfs in the river reach between Crocker-Huffman Dam and Shaffer Bridge from October 31 through March 31. This agreement expires in 2017.

The Army Corps of Engineers Water Control Manual for Lake McClure requires that the District reserve 350,000 AF of reservoir capacity for rain flood control purposes. This reserve must be maintained from November 1 through March 15. An additional 50,000 AF may be vacated, beginning March 1 for forecasted snowmelt runoff.

#### 4.4 Cowell Agreement

At the time of the construction of the original Exchequer Dam in the 1920s, a court action was brought against MID by riparian water rights holders along the Merced River downstream of the project. A Merced County Superior Court Adjudicated Settlement was signed on January 27, 1926, resolving these issues and setting minimum flow rates released to the Merced River by MID for diversion by the Cowell Agreement parties downstream of Crocker-Huffman Diversion Dam. Table 4.1 presents the schedule of flows required to satisfy the Cowell Agreement.

<b>Month</b>	<b>Flow (cfs)</b>	<b>Comment</b>
January	50	Only when available from the inflows to New Exchequer
February	50	Only when available from the inflows to New Exchequer
March	100	
April	175	
May	225	
June	250	Sustain 250 cfs until inflows to New Exchequer fall below 1,200 cfs, then sustain 225 cfs for 31 days, 175 cfs for 31 days, and 150 cfs for 30 days
July	225	See June requirement
August	175	See June requirement
September	150	See June requirement
October	50	Only when available from the inflows to New Exchequer
November	50	Only when available from the inflows to New Exchequer
December	50	Only when available from the inflows to New Exchequer

#### 4.5 Stevinson Entitlement

J. J. Stevinson Company is located southwest of MID and has adjudicated flow entitlements at MID’s westerly boundary in the amount of 24,600 AF per normal year. The flow entitlements are delivered through the MID distribution system from April through September, with flows that could vary between 30 and 100 cfs. If in any year the reservoir (i.e., McClure Lake) does not fill on or before June 15<sup>th</sup> to the amount of 289,000 AF, then the water deliveries to J. J. Stevinson Company shall be curtailed in the same proportion as MID curtailments.

Water from the Merced River is diverted into the MID delivery system at two locations. One diversion is from a pool created by the Merced Falls Dam into the Northside Canal and the second is from a pool created by the Crocker-Huffman Diversion Dam into the Main Canal.



## **4.6 Groundwater Supply (§10826 (b)(2))**

MID utilizes groundwater wells in two modes:

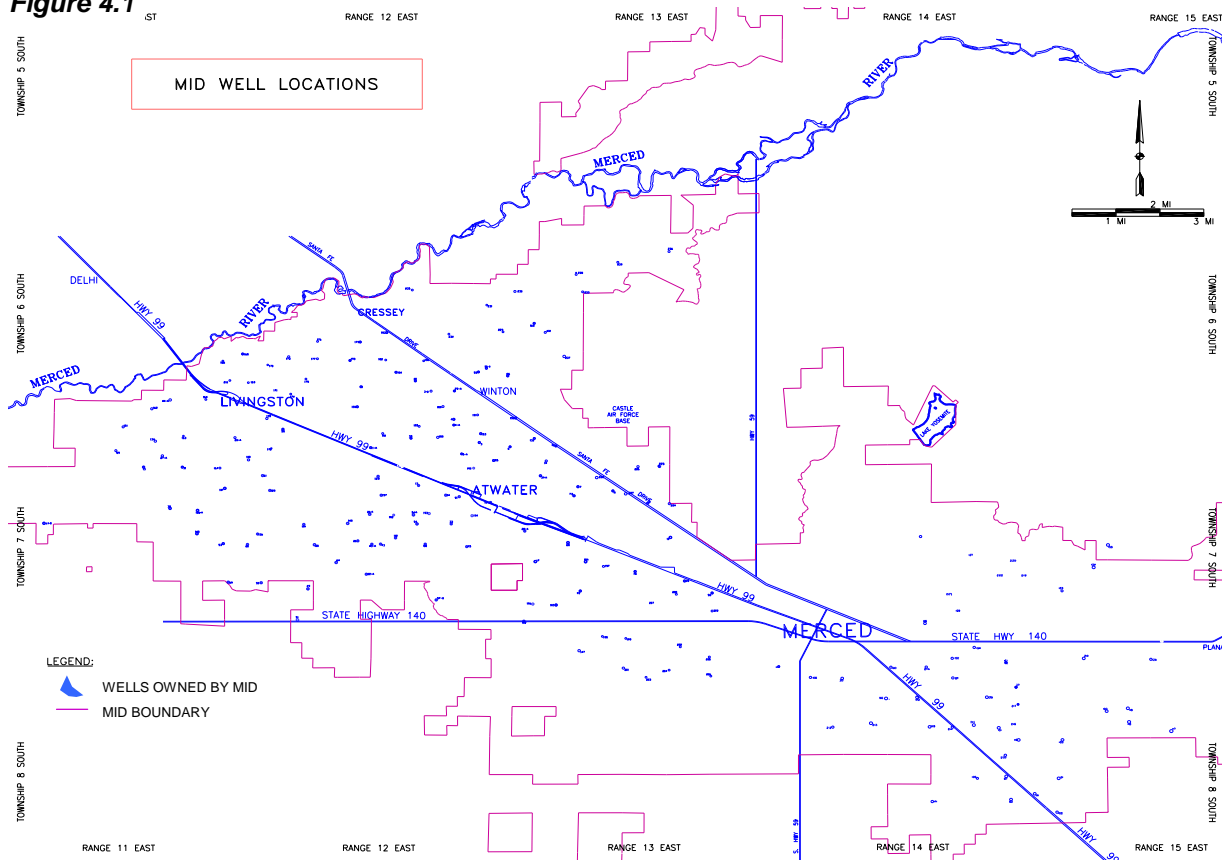
- 1- **Base Line Groundwater Pumping:** The District service area contains 1,764 acres of high grounds that the District serves with groundwater wells. These areas are served with groundwater in all water year types. On average, MID extracts approximately 8,000 AF annually to serve these areas. In 2011 MID reached a record low of 4,112 AF, mainly due to its conjunctive use SUGWOP program, one component of which includes replacing deep wells with booster pumps that can supply said high grounds with surface water. MID has completed multiple in-lieu recharge projects whereby surface water boosters reduced the acreage totally dependent on groundwater. These projects will be further discussed under the EWMPs.
- 2- **Conjunctive Use/ Groundwater Supplement:** The vast majority of MID wells are used conjunctively where they are on standby during year of adequate surface water supply. The wells utilized are made from two types of groundwater wells, the first are irrigation/drainage wells that are currently used for supply and the second types are Project wells which are further discussed below.

## **4.7 Groundwater Conditions**

Groundwater conditions in the Merced area are complex because of the significant effects of pumping and recharge associated with agricultural irrigation. The general direction of regional groundwater movement is from the northeast to the southwest. This fact, in combination with localized perched water caused by the clayey lenses, caused excessively high water tables soon after surface water was introduced into the region in the 1920s. The high water table, with standing water in many locations, proved detrimental to farming operations and occurred mostly in the southwestern quarter of the District.

MID constructed approximately 160 drainage and irrigation wells in the 1920s and 1930s. Initially most of these were intended to lower high water tables primarily in the Atwater and Livingston areas and, to a lesser extent, southwest of the City of Merced. Figure 4.1 shows the location of these wells. These wells were used selectively after the completion of New Exchequer Dam in 1967, only in areas where shallow water table affected agricultural practices and for water supply during droughts.

**Figure 4.1**



With the advent of low volume irrigation combined with severe droughts, many farmers within the District converted to groundwater usage for better compatibility with their irrigation system and/or because MID could not meet their demand schedules. In addition, vast acreage of range land and dry farming outside the District was transformed to irrigated agricultural depending, for the most part, on groundwater. The increased number of private wells and groundwater pumping in the basin reduced the groundwater table during the 1977 and the 1987-1992 droughts. Increasing groundwater usage outside the District has drawn down water tables more than 10 feet in most of the historically high water table areas.

After completion of New Exchequer Dam, 81 additional supply wells were constructed, bringing the total number of groundwater wells owned and operated by MID to 241 wells. Since the 1970s, some wells were abandoned, reducing the number of wells available to the District. The vast majority of the MID wells are left on standby to be operated for irrigation during years of surface water shortages. In fact, between 1993 and 2001, the supplemental groundwater supply wells were not used as a result of a continuous string of wet and above average years and only the high ground wells were used. Most wells range from 350 to 500 feet in depth and are constructed of 12 to 18-inch casing. Drainage well casings are typically continuously perforated, while irrigation wells are typically perforated at intervals. Approximately 10 percent of the drainage and irrigation wells have been deepened since their original construction.

The variability in surface and subsurface geologic conditions and the presence of groundwater contaminants in some areas complicate groundwater conditions in the MID. To track local conditions, the District systematically monitors perched and high water levels using monitoring wells constructed at section corners in ten drainage sub-areas throughout the District. Since 1982, water table depths monitored by these wells have ranged from 1 to 15 feet below the ground surface.

Average depth to groundwater has increased several feet over the period of record. Due to this general increase in water table depth, the District has had no need to operate drainage wells to control shallow water tables since the onset of the 1987-1992 drought.

Natural groundwater flow in the Merced Groundwater Basin is generally from northeast to southwest. However, cones of depression caused by pumping and groundwater mounds resulting from irrigation complicate the general flow pattern, causing the pattern to change over time. The response of the aquifers to changes in pumping and irrigation is relatively rapid leading to equally rapid shifts in flow direction.

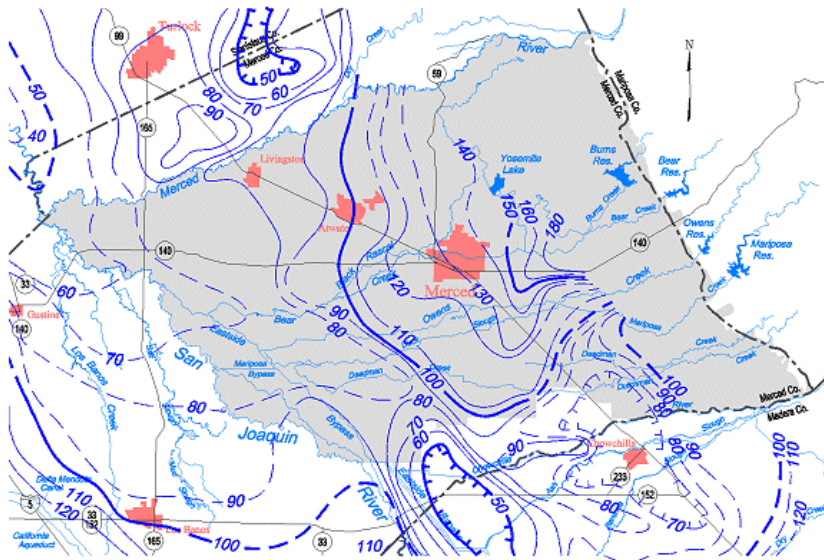
Figure 4.2 shows a map of the unconfined aquifer water levels prepared by the Department of Water Resources. This map indicates several major cones of depression further pronounced between 1995 and 2010. One cone is centered approximately 13 miles southeast of Merced in the Le Grand/Athlone Water District. A second major cone is centered about 13 miles southwest of Merced just north of the San Joaquin River. The third major cone is 17 miles northwest of the City of Merced and lies north of the District in the Turlock Groundwater Basin.

Figure 4.2

### Merced Groundwater Basin

Spring 1995, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles  
2 0 2 4 6 8 10

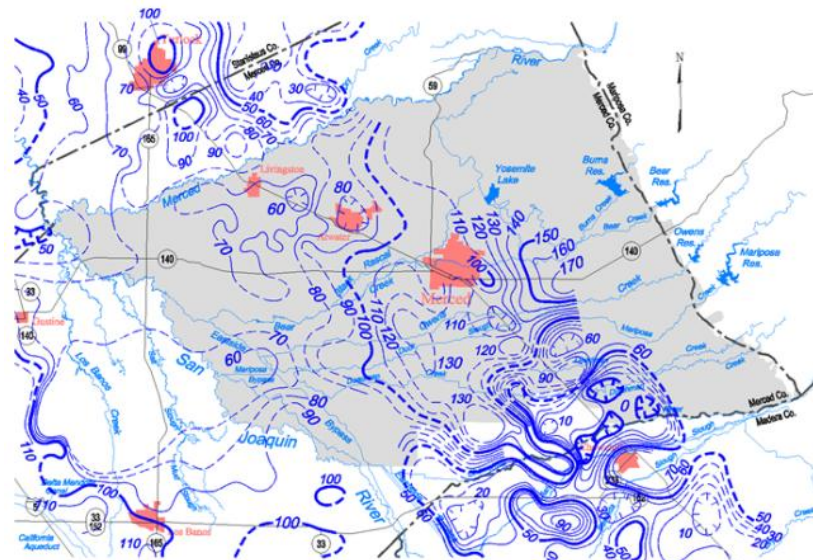


Contours are dashed where inferred. Contour interval is 10 feet.

### Merced Groundwater Basin

Spring 2010, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles  
2 0 2 4 6 8 10



Contours are dashed where inferred. Contour interval is 10 feet.

The groundwater elevations relative to the elevations of the major rivers and the interaction of cones of depression with the rivers suggest that some reaches of the rivers lose water to groundwater while others gain from groundwater discharge.

The groundwater elevation data appears to indicate that there is a trough in the water table elevations that follows the San Joaquin River. Consequently, groundwater inflow to the river and surrounding areas occurs from both sides of the San Joaquin Valley. This river and the surrounding areas are the primary groundwater discharge areas for the valley. There is also an extended cone of depression straddling the Chowchilla River west of the San Joaquin River. The cone of depression seems to have further developed subsidence in the Red Top area and groundwater recharge in that direction are not likely to impact river flows.

On the north side of the District, west of Highway 99, the lower reaches of the Merced River appear to be a groundwater discharge area. East of the Highway 99, the river may be acting as a constant head source and supplying water to a large cone of depression centered approximately 17 miles northwest of Merced. East of Oakdale Road, the river is higher than the groundwater and probably provides some recharge to the groundwater.

The vertical groundwater gradient, and hence the direction of vertical groundwater movement, is downwards, from the shallowest groundwater to the deeper aquifers. Consequently, degradation of shallow groundwater can potentially affect deeper water supply wells where this downward movement is significant and dilution and chemical/biological processes are insufficient to adequately reduce the concentrations of constituents of concern.

As described above, the direction of the groundwater flow, except in the vicinity of the Merced River, is from northeast to southwest on a line generally perpendicular to the San Joaquin River where a natural saline water sink occurs. Deep percolated water not extracted by groundwater wells tend to end at the sink. However, deep percolation around the District’s southwesterly boundary is required to stem the saline water wedge from migrating to the east, where the primary agricultural grounds in the District and urban centers tend to concentrate.

Table 4.2 contains information on the groundwater basin underlying MID. This information was taken from the DWR Bulletin 118-2003 description of the Merced Groundwater Basin. The storage estimate is based on data collected in 1995 by DWR.

<b>Groundwater Basin Name</b>	<b>District Footprint (acres)</b>	<b>Basin Area (Sq. Mi.)</b>	<b>Total Capacity (300 feet depth) (AF)</b>	<b>Specific Yield</b>
Merced	149,500	767	15,700,000	9 percent
Turlock	5,500	542	12,800,000	10.1 percent
Chowchilla	9,000	248	5,500,000	8.6 percent

MID makes no groundwater extraction from either Turlock or Chowchilla Groundwater Basin. However growers within the District may utilize their private wells on an as needed basis.

MID participated in preparation of the local AB 3030 Regional Groundwater Management Plan completed in December, 1997. In July 2008, MID, along with other members of MAGPI, prepared an update of the Merced Groundwater Management Plan, which included components of the new 2002 legislation of SB 1938 and SB 1672. This new updated plan is included as Appendix E.

Table 4.3 describes the destinations of deep percolation from MID lands.

<b>Table 4.3 Deep Percolation Characteristics</b>	
<b>Destination</b>	<b>Volume (AF)</b>
Flows to saline sink	Not Quantified
Unrecoverable flows to perched water table	None

Groundwater conditions and recharge are further addressed in the Merced IRWMP.

#### **4.8 Other Water Supplies (§10826 (b)(3))**

Currently, all of MID’s water supplies come from the surface and groundwater sources described above. However, MID is dedicated to pursuing efforts to help ensure that it continues to have a reliable and robust water supply well into the future.

One such effort includes negotiations with the City of Merced in regards to using recycled water as the City Waste Water Treatment Plan currently discharges tertiary treated water, a source that was not available at the time MID’s previous WMP was completed.

Furthermore, the District is in the process of acquiring US Congressional approval for FERC to consider increasing the storage volume of New Exchequer Dam reservoir by 70,000 AF.

The District continues to have interest in pursuing CALFED identified surface water reservoirs, such as the Montgomery Reservoir on Dry Creek.

#### **4.9 Source Water Quality Monitoring Practices (§10826 (b)(4))**

The surface water supply for the District rainfall and snowmelt from the Sierra Nevada Mountains, more specifically Yosemite National Park, and is of very high quality. Diverted water has an EC generally less than 20 µmhos/cm, with very low levels of nitrates and no detectable organics. This high quality water poses no restrictions for irrigation. MID has performed periodic water quality testing that dates to the 1980s, including testing within the Merced River, creeks utilized by the District, and active operational discharge locations. The District has made this information public through numerous submittals to the Central Valley Regional Water Quality Control Board under the Irrigated Land Regulatory Program. (ILRP). See further discussion below.

## **4.10 Surface Water Sampling**

Surface water sampling has become more regular and consistent. Beginning in 1999, MID started a new water quality sampling program to assess the water for agricultural suitability, known as the Ag Suitability Monitoring Program. Due to the consistent nature of the testing results, MID recently reduced sampling frequency to twice a year. Samples at diversion points are tested for EC, Ca, Mg, Na, Cl, CO<sub>3</sub>, HCO<sub>3</sub>, SO<sub>4</sub>, B, NO<sub>3</sub>, Fe, Mn, and pH. In addition, MID has started testing for Total Dissolved Solids (TDS), and Total Suspended Solids (TSS). Specific collection points are further sampled for Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO).

The sampling is not required under State or Federal programs, but was developed internally by MID as an added public benefit. The objective of the Ag Suitability Monitoring Program is to give growers a source to analyze the quality of irrigation water provided to them each year and to keep the District apprised of water quality variations, if any, throughout the system.

Growers may use this information to adjust their irrigation and develop crop management programs. This testing has evolved as a Quality Assurance/Quality Control program to assure the public that they are being provided with an adequate product. The sampling activities do not include the use of a water quality meter as in the MRP. Instead, the samples are delivered to a State certified laboratory for analysis. The sampling results have illustrated to growers the superiority of MID's surface water supply as compared to groundwater, particularly pertaining to PH balance, lower EC (TDS) and primary metals and minerals.

## **4.11 Groundwater Sampling**

Groundwater sampling includes selective groundwater wells that have suspected water quality problems. Samples are typically tested for EC, Ca, Mg, Na, Cl, CO<sub>3</sub>, HCO<sub>3</sub>, SO<sub>4</sub>, B, NO<sub>3</sub>, Fe, Mn, and pH. As expected, groundwater TDS and other mineral components vary by location. Generally speaking TDS tends to increase heading westerly with a range between 250 PPM to 600 PPM. All groundwater is suitable for agricultural use, although some crops are sensitive to certain minerals in the water. Almond trees are sensitive to carbonates and other salts, which impact yield and the health of the trees. This is one reason why some growers opted to return to surface water.

*~End of Section~*



*The McCoy Lateral*



## SECTION 5. WATER BALANCE

### 5.1 Water Uses Within the MID Service Area (§10826 (b)(5))

Because of the active conjunctive use management strategy pursued by MID, the analyses of water usage presented in this section are not based on a single representative year but on the period between January 2000 and December 2008. Basing the analyses on a number of years (period of analysis) enables the Water Management Plan to better illustrate the nature of MID’s conjunctive water management program. MID covers a gross area of 164,317 acres, with an average of 99,792 acres receiving District surface water during the period of analysis.

The following paragraphs describe various types of water use within the District.

#### 5.1.1 Agricultural (§10826 (b)(5) (A))

Table 5.1 lists the major crops grown in the MID service area and the average acreage of said crops over the period of analysis. Table 5.1 also presents average seasonal ET rates for these crops and typical planting and harvest dates.

Type of Crop	Average Acreage	Planting Month	Harvest Month	ETc (applied water, inches)	Effective Precipitation (inches)	Leaching Requirement	Average Crop Water Needs (inches)
Nut trees	29,771	Permanent	Permanent	35.3	4.5	Not required	39.8
Pasture	10,055	Permanent	Permanent	39.6	8.0	Not required	47.6
Alfalfa	8,615	Permanent	Permanent	41.5	5.3	Not required	46.8
Corn	12,543	May	October	24.3	3.3	Not required	27.6
Cotton	4,819	May	October	26.6	2.7	Not required	29.2
Tomatoes	5,745	April	September	23.2	5.2	Not required	28.4

Table 5.2 presents the number of acres that received MID surface water or/and groundwater during each year of the period of analysis, including Sphere of Influence (SOI) customers.

However, the numbers do not include acreages that have received flows for a number of irrigations in Le Grand Athlone Water District or Lone Tree Mutual Water Company as MID sells wholesale water to these entities, and they in turn distribute it to interested properties within their areas.

<b>Year</b>	<b>Irrigated Acres</b>
2000	97,197
2001	94,736
2002	96,927
2003	96,700
2004	109,469
2005	101,927
2006	95,359
2007	99,831
2008	105,935

Table 5.3 compares the average number of double-cropped acres reported within MID with the average total irrigated acreage for the same period.

The double cropping irrigated acreage has varied based on cropping, hydrology, and commodity prices. Double cropping is expected to be on the rise due to the increased value of most ag commodities.

<b>Average Cropped Acres</b>	100,237
<b>Double Cropping</b>	4,421

### **5.1.2 Environmental (§10826 (b)(5) (B))**

There are several requirements and voluntary agreements entered into by MID that include environmental flows. These requirements and agreements are described below.

#### **Measures in Current Federal Energy Regulatory Commission (FERC) License**

The existing FERC license includes 44 “active” articles. Articles relating to environmental flows are discussed herein.

**Article 40.** The Licensee shall provide minimum streamflows in the Merced River downstream from the project reservoirs in accordance with the following schedule:

- (a) Downstream from Exchequer Dam, a minimum flow of 25 cfs at all times.
- (b) At Shaffer Bridge downstream from Exchequer Afterbay Dam, a minimum streamflow shall be maintained as follows

<u>Period</u>	<u>Normal Year (cfs)</u>	<u>Dry Years (cfs)</u>
June 1 through Oct. 15	25	15
Oct. 16 through Oct. 31	75	60
Nov. 1 through Dec. 31	100	75
Jan. 1 through May 31	75	60

**Article 41.** The licensee shall, insofar as possible during the period November 1 through December 31, regulate the Merced River streamflow downstream from the Exchequer Afterbay development between 100 and 200 cfs except during dry years when the streamflow shall be maintained between 75 and 150 cfs. Streamflow shall be measured at Shaffer Bridge.

**Article 42.** The Licensee shall operate the power plants so as to avoid rapid fluctuation of the Merced River. At Crocker-Huffman diversion, the Licensee shall, insofar as possible, restrict the rate of change of release during any one-hour period to not more than double nor less than one-half the amount of release as the start of the change. The licensee shall during emergency periods, endeavor to make releases in a manner that will not be detrimental to fish.

**Article 43.** The Licensee shall make all releases at Exchequer Dam during the period, October 16 through December 31, from the outlets at or below elevation 485 feet insofar as physically possible.

**Article 44.** The Licensee shall make every reasonable effort to maintain the water surface elevation of Exchequer Reservoir [Lake McClure] as high as possible from April through October consistent with the primary purposes of the reservoir and shall maintain a minimum pool of not less than 115,000 AF in Exchequer Reservoir [Lake McClure] except for a drawdown as necessary to maintain minimum streamflow as required by Article 40.

**Article 45.** The Licensee shall cooperate with the Bureau of Sport Fisheries and Wildlife of the U.S. Fish and Wildlife Service to determine means of providing up to 15,000 AF of project water and return flow waters to the Merced National Wildlife Refuge.

**Davis-Grunsky Agreement**

Merced ID entered into an agreement, known as the Davis-Grunsky Agreement, with the State of California. Under the agreement, Merced ID provides a continuous flow of between 180 cfs and 220 cfs in the Merced River between the Crocker-Huffman Diversion Dam and Shaffer Bridge from November through March every year for environmental purposes.

The agreement expires on December 31, 2017.

**SWRCB Water Rights License (No Expiration Date)**

Pursuant to Merced ID’s consumptive water right licenses 2685, 6047, and 16186 (Applications 1224, 10572, and 11395, respectively), Merced ID is required to supplement flows in the Merced River in October by providing 12,500 AF of water in addition to the Project’s minimum flow requirement in that month. The license does not state how the flow is distributed (i.e., rate) or where the flow is measured. Historically, these supplemental flows have been made in accordance with related agreements discussed

below, and Merced ID anticipates continuing to schedule the fall supplemental flow in consultation with the California Department of Fish and Game (Cal Fish and Game).

**San Joaquin River Agreement (Expired December 31, 2011)**

Under the San Joaquin River Agreement, since 2000 Merced ID and others provided water to help support a scientific study that included meeting a pulse flow of up to 110,000 AF of supplemental water for a 31-day period in the San Joaquin River at Vernalis, California, during April and May for ecological resources as prescribed in the Vernalis Adaptive Management Plan (VAMP). The specific amount of the April/May supplemental flow provided each year was determined annually by the Hydrology Group of the San Joaquin River Technical Committee, which included technical representatives from the San Joaquin River Group Authority (SJRG), USDO, Bureau of Reclamation (BOR) and USFWS. Merced ID’s contributions to these flows are shown in Table 5.4 following.

Water allocation in acre-feet specified in the Division Agreement among water district members within the San Joaquin River Group Authority for use in the San Joaquin River Agreement’s April/May pulse flow.

<b>Table 5.4</b>					
<b>Water Allocation in AF</b>					
<b>Priority in Descending Order</b>	<b>First 50,000 (AF)</b>	<b>Next 23,000 (AF)</b>	<b>Next 17,000 (AF)</b>	<b>Next 20,000 (AF)</b>	<b>Total (AF)</b>
Merced ID	25,000	11,500	8,500	10,000	55,000
Oakdale ID/ South San Joaquin ID	10,000	4,600	3,400	4,000	22,000
Exchange Contractors	5,000	2,300	1,700	2,000	11,000
Modesto/Turlock ID	10,000	4,600	3,400	4,000	22,000

The agreement also included a fall flow of 12,500 AF from Merced ID, with the flow schedule developed in consultation with the BOR, USFWS and Cal Fish and Game. The fall flow has since been incorporated into Merced ID’s water rights as previously described in Section 4.2 and the requirement will continue irrespective of the San Joaquin River Agreement expiration. The agreement, as amended, expired on December 31, 2011.

**United States Bureau of Reclamation (USBR) Spring Flows Agreement**

MID entered into a two-year agreement with USBR for the release of flows to meet flow targets at Vernalis for environmental purposes for 2012, and 2013.

**Cal Fish and Game Memorandum of Understanding (Expired August 2011, with Some Caveats)**

In August 2002, Merced ID and Cal Fish and Game entered into a memorandum of understanding (MOU). Pursuant to the MOU, water right licenses 2685, 6047, and 16186 were amended in 2003 and require Merced ID to supplement flows in the Merced River in October by providing 12,500 AF of water in addition to the Project’s minimum flow requirement in that month. The supplemental October water provided for in the MOU overlapped with, and was not in addition to, the fall flow provided for in the San Joaquin River Agreement. The requirement to provide the 12,500 AF of supplemental October water survives the expiration of the MOU. As written, the MOU stipulated that Cal Fish and Game would provide the requested October schedule to Merced ID by August 15 of each year and the parties would

attempt to agree on the final schedule by September 15 of each year. If the parties could not agree on a schedule by September 15 of any year, then a default schedule would apply, as follows:

- October 1-15: 2,500 AF
- October 16-31: 5,000 AF
- October 1-31: 5,000 AF.
- The default is a level flow of 2,500 AF between October 10 and 15, inclusive, and 2,500 AF between October 16 and 20, inclusive.

The default schedule has been interpreted by Merced ID in Table 5.5 as follows:

<b>Period</b>	<b>Supplemental Flow (cfs)</b>	<b>Total (AF)</b>
October 1 - 9	84	1,500
October 10- 15	294	3,499
October 16 – 20	410	4,066
October 21 - 31	158	3,447

The measuring point for the flow was identified as the USGS gage at Shaffer Bridge. In practice, the default schedule has never been used. The fall flows have been governed by the San Joaquin River Agreement (described in Section 6.3.2) for the past 10 years (said agreement expired December 31, 2011), and will be governed by Merced ID’s water rights in the future.

**East Bear Creek Unit**

MID has delivered flows to the East Bear Creek Unit refuge, a division of the U.S. Fish and Wildlife Service’s San Luis Wildlife Refuge complex, since 2010 through water transfers. Flows are made available from various sources including Bear Creek, Crocker Dam, but are mostly from the reoperation of Lake Yosemite.

Tables 5.6a and 5.6b presents information on environmental uses of MID water in addition to the in-stream flow releases.

Environmental Resources	AF
FERC In-Stream	33,025 – 43,736
DWR (Davis-Grunsky)	53,912 – 65,892 (Nov-Mar)
SWRCB (VAMP – 10 Year) expired in 2011 <sup>1</sup> and replaced by separate transfers as agreed upon between parties	0 – 55,000 (Spring)
October Pulse Flow	12,500 (October)

<sup>1</sup> A new two-year spring pulse flow agreement with USBR is being implemented starting 2012 from April 15 to May 15 for a maximum release volume of 75,000 AF into the river.

<b>Table 5.6b</b>	
<b>Consumptive Environmental Water Uses</b>	
<b>Average Annual Volumes</b>	
Environmental Resources	AF
Merced National Wildlife Refuge	Up to 15,000 (Mar-Oct)
East Bear Creek Unit Wildlife Refuge <sup>1</sup>	Up to 7,363

<sup>1</sup> A one year transfer to Fish and Wildlife service between November 2012 and September 2013

### 5.1.3 Recreational (§10826 (b)(5) (C))

MID maintains recreational facilities as requirements of its existing FERC license, as well as a public resource on select locations unrelated to the Merced River Hydroelectric Project (the Project).

Project recreation facilities are located on the main stem of the Merced River at two Project reservoirs – Lake McClure and McSwain Reservoir. The Project consists of five developed recreation areas. Four of the recreation areas are located at Lake McClure, including McClure Point Recreation Area (RA), Barrett Cove RA, Horseshoe Bend RA, and Bagby RA. McSwain RA is the only recreation area located at McSwain Reservoir. Table 5.7 provides a brief summary of the developed recreation facilities at each of the Project reservoirs.

<b>Table 5.7</b>					
<b>Summary of the Merced River Hydroelectric Project Recreation Facilities</b>					
<b>Lake McClure Facilities</b>					
<b>Recreation Area</b>	<b>Facility</b>	<b>Number of Campsites</b>	<b>Number of Picnic Sites</b>	<b>Number of Parking Spaces</b>	<b>Number of Boat Ramps</b>
McClure Point	Campground	101	--	14	--
	Picnic Area	--	8	8	--
	Swim Beach	--	22	60	--
	Marina	--	--	50	--
	Boat Launch	--	--	140	1 (3 lanes)
Barrett Cove	Campground	275	--	39	--
	Swim Beach	--	13	30	--
	Boat Launch/Marina	--	6	267	2 (5 lanes)
	Overflow Parking	--	--	35	--
Horseshoe Bend	Campground	109	1	--	--
	Swim Beach	--	12	50	--
	Boat Launch	--	--	49	1 (2 lanes)
Bagby	Bagby Campground	30	--	221	--
	Sheperd's Point Primitive Area	15	--	--	--
	Boat Launch	--	--	31	1 (2 lanes)
<b>Total</b>	<b>15</b>	<b>530</b>	<b>62</b>	<b>994</b>	<b>5</b>
<b>Lake McSwain Facilities</b>					
<b>Facility</b>	<b>Number of Campsites</b>	<b>Number of Picnic Sites</b>	<b>Number of Parking Spaces</b>	<b>Number of Boat Ramps</b>	
Campground	112	1	28	--	
Picnic Area	--	12	52	--	
Group Picnic Area	--	1	55	--	
Swim Beach	--	6	15	--	
Informal Day Use Area	--	8	24	--	
Marina	--	--	20	--	
Boat Launch	--	--	89	--	1 (2 lanes)
<b>Total</b>	<b>112</b>	<b>28</b>	<b>283</b>		<b>1</b>

The District’s operations of Lake Yosemite as a regulating reservoir is influenced by recreational activities on the lake which includes, sailing, boating, fishing and swimming.

### 5.1.4 Municipal and Industrial (§10826 (b)(5) (D))

Merced ID makes three small diversions from Lake McClure, each related to water supply. The diversions are so minor that they do not affect Project operations, and Merced ID anticipates that the diversions will continue unchanged. These are:

- The Lake Don Pedro Community Service District (LDPCSD) withdraws from a location just north of Barrett Cove Marina up to about 5,000 AF of water annually for water supply. The LDPCSD’s intake is at elevation 700 ft.
- Less than 1,000 AF of water is withdrawn annually by the Merced ID recreation facilities at three locations along Lake McClure.
- The McClure Boat Club, a small development adjacent to the Project, diverts about 25 AF at a point near the development. The boat club withdraws water from a pump on a float that rises and falls with the reservoir elevation and has an intake 10 feet below the float.

The City of Merced received all its drinking water from Lake Yosemite until 1917. Since then most municipal consumers within the Merced Groundwater Basin have relied on groundwater as their source of supply.

As part of its conjunctive use program, the District supplies landscape and pond water to boat manufacturers and school districts who have supplemented groundwater supplies with surface water. The Cities of Merced is currently working with MID on providing surface water to landscape areas in public parks. Both Cities aim at reducing pressure on their municipal groundwater supply wells. The City of Merced is interested in meeting demand during summer, while the City of Livingston is also interested in reducing reliance on marginal water quality wells during the summer. MID intends to continue to seek out opportunities to expand its in-lieu groundwater recharge efforts within urban areas as feasible.

Urban areas occupy approximately 18,200 acres within the MID. The Merced Groundwater Basin, Groundwater Management Plan reported a total of approximately 50,250 AF of urban groundwater use in 2007. This total includes both groundwater pumped by urban utilities and groundwater produced by small private residential water systems, commercial businesses and industrial plants not served by the major utilities. Groundwater use is projected to grow despite effective water conservation efforts. Table 5.8 presents information on M&I usage of groundwater within the Merced Groundwater Basin.

Area	Volume Pumped AF
Black Rascal Water District, Le Grand and Planada CSD, City of Livingston, Meadowbrook, Winton Water and Sanitation District	8,325
City of Merced	27,750
City of Atwater	10,175
Unincorporated areas	4,000
<b>Total</b>	<b>50,250</b>

The 1996 municipal total of approximately 40,000 AF is compared to a municipal total of approximately 50,000 AF in 2007.

Urban water demands in the City of Merced form the largest single component of the municipal and industrial demand category. Historical data showed an overall trend of declining per capita water use. The

droughts of 1976-77, 1987-92, and 2007-2008 contributed to this downward trend, partly by creating public awareness of water shortages. However, whether residential users will continue these same consumption patterns in the future during non-drought periods is uncertain.

### 5.1.5 Groundwater Recharge (§10826 (b)(5) (E))

The MID water balance shows annual deep percolation from applied water on the grower’s fields and canal seepage (the main components of groundwater recharge) which varied between 72,000 and 135,000 AF during the water balance period between through 2000 and 2008, varying.

The fluctuation is dependent on hydrology, length of season, and irrigation methods. Historically, deep percolation climbed to approximately 152,000 AF during 1972, a wet year when flood irrigation was the norm, and dropped to 34,000 AF during 1992, the driest year on record. Deep percolation rates per acre are expected to continue to decrease due to the current trend where permanent crops are replacing row crops, as permanent crops typically apply low volume pressurized irrigation methods with lower percolation tendencies.

In dry years, the District relies on stored deep percolation and seepage water distribution system to supplement surface water deliveries. The District recognized the benefits it is providing to urban areas and in-District private well owners pumping recharged groundwater in all years. The MID does not currently have a comprehensive recharge program to manage groundwater recharge. However, a system of recharge facilities such as recharge basins may be employed by MID in the future to achieve targeted recharge quantities and groundwater levels. Such a program would be funded by all beneficiaries in the basin and is being considered by the Merced Area Groundwater Pool Interests, an association concerned with managing the Merced Groundwater basin. It is also the objective of the Regional Advisory Committee of the Merced Integrated Regional Water Management Plan that would be addressed by the governing body of the Merced IRWMP.

Nevertheless, the District has historically implemented in-lieu recharge practices in years of adequate surface water supplies, as part of its conjunctive use activities, and has expanded the recharge as feasible as shown in Table 5.9.

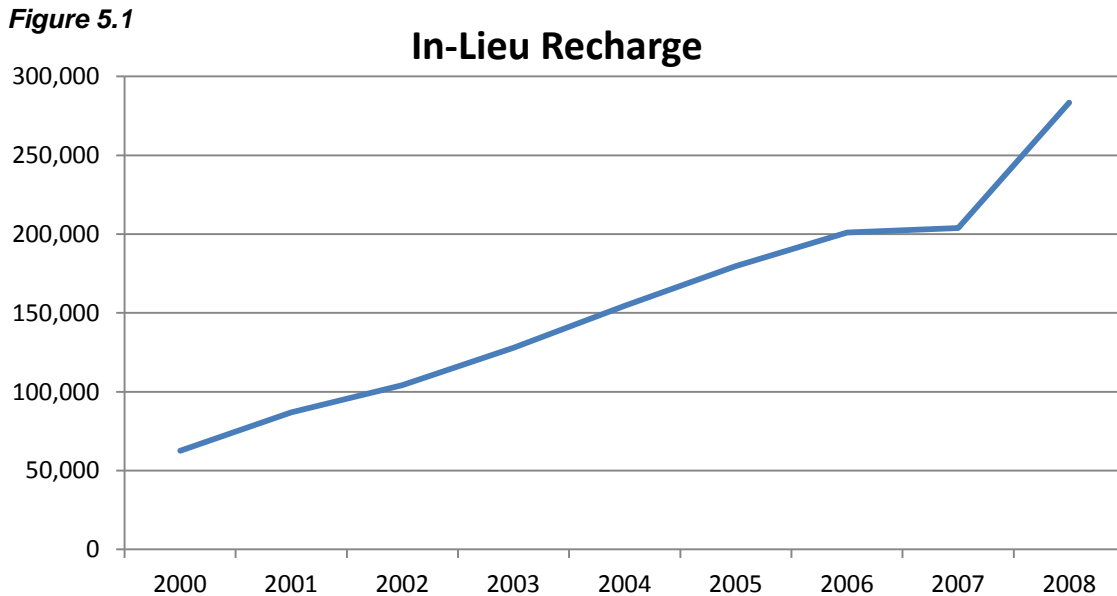
Environmental Resources	Drought	Average
Reduced Overall Usage of MID owned and operated Groundwater wells	0	11,000
Reduced Base Line Pumping – Low Head Boosters Serving High Grounds	0	1,700
Merced Highlands Pilot Project	0	1350
Merced Groundwater Conservation Incentive Program	0	4,365
Sphere of Influence Sales	0	15,400
<b>Total</b>		<b>32,115</b>

In addition to its in-lieu recharge efforts and its passive seepage programs, the District manages two recharge basins: one is on the northerly area of the District and the other is a historical basin close to the south end of the District, in El Nido. The northerly basin is MID Cressey Recharge Basin located north of the town on Winton. The project was completed in 2011 after 11 years of study which started in 2000 with seed funding from DWR. The basin receives water in years of adequate surface water supply.

As for the El Nido recharge basin, the basin receives flows under an existing license dedicated to recharge in the El Nido area in addition to the conditions bounding the Cressey Basin. Through various water



management practices and incentive programs, the District has cumulatively recharged close to 283,400 AF using in-lieu recharge programs between 2000 and 2008 as shown in Figure 5.1.



### 5.1.6 Transfers and Exchanges (§10826 (b)(5) (F))

Transfers are a management tool used by MID to maintain competitive water rates with groundwater pumping, fund capital improvement and replacement projects, conduct studies, and protect MID water rights.

Since October 31, 1967 the MID has engaged in various transfers. The first was a long term transfer with DWR under the Davis-Grunsky Contract which expires in December 31, 2017. The District would provide between 53,912 AF– 65,892 AF (Nov-Mar) of flows in a year for fishery purposes depending on the hydrology. The \$8.0 MM compensation was applied to establishing MID’s recreational areas at Lake McSwain and Lake McClure. In addition, the District engaged in a number of short-term transfers where the District has made water available, primarily to support environmental enhancement and study programs such as the Vernalis Adaptive Management Program (VAMP), the State’s Environmental Water Account and the Bureau of Reclamation’s Water Acquisition Program. MID made a number of transfers to the Environmental Water Account and East Bear Creek Unit, a local federal refuge. MID also engages in transfers from water storage to parcels within its Sphere of Influence in years of adequate surface water supply.

These and other short-term water transfers to agencies (e.g. irrigation districts) are part of MID’s strategic water resources planning. In addition to transfers and exchanges, water is delivered through the MID to a number of entitlement holders located downstream of the District. Table 5.10 provides information on transfers, exchanges and deliveries to downstream entitlements. In addition, in instances where natural watercourses have been incorporated into the MID distribution system, District water is supplied to satisfy riparian entitlements that have been established on these watercourses.

From What Agency	To What Agency	Type of Transfer or Exchange (Ag to M&I, M&I to Ag, or Ag to Ag)
MID	Stevinson	Entitlement conveyance
MID	Cowell Agreement Diverters	Adjudicated entitlement
MID	Various Riparians	Entitlement conveyance
MID	DWR	Davis-Grunsky Long-Term Transfer
MID	Merced National Wildlife Refuge	FERC Requirement
MID	VAMP	Term transfer- expired in 2011
MID	San Luis Water District	Short-term transfer
MID	Sphere of Influence Group	Short-term transfer
MID	Sphere of Influence	Short-term transfer
MID	Westlands Water District	Short-term transfer
MID	East Bear Creek Unit, Refuge	Short-term transfer
MID	Kern County Water Agency	Short-term transfer
MID	EWA	Short-term transfer

### 5.1.7 Other Water Uses (§10826 (b)(5) (G))

MID occasionally provides water for construction work within its service and the amounts don't normally exceed 25 AF on a busy season. The water is mostly used from groundwater as it is preferred being naturally clear of debris in nature.

## 5.2 Drainage from the MID Service Area (§10826 (b)(6)).

As previously discussed, MID's SUGWOP program has focused on networking canals so as to reduce the number of operational discharge sites. Most "spills" are discharged to another canal now, where they continue to be put to beneficial use in MID's service area or are used to meet downstream commitments. Drainage flows leaving the District without meeting a water commitment is considered a loss. The following is a list of the major drainage facilities:

- The Livingston Canal Spill and the Garibaldi Lateral Spill: Both of these facilities can discharge to the Merced River. MID has completed projects that drastically reduced flows through these spills and they are typically only used for storm water discharges or emergencies. Flows through these spills are considered a loss.
- Several other laterals can physically spill to the river, but due to their low capacity, typically do not have measurable or significant operational discharges.

- Bear Creek, Owens Creek, Duck Slough, Howard Lateral and McCoy Lateral are all facilities that can be utilized by the District to meet Stevinson’s commitment of 24,600 AF annually. MID maintain recorders on all these facilities that discharge to the East Side Canal.
- The Atwater Drain is a man-made facility that terminates at the East Side Canal, but is not equipped with a reliable recorder. Flows downstream from Highway 140 are considered a loss.
- Mariposa Creek/Duck Slough spills into the East Side Canal. The District has not utilized the creek to meet Stevinson commitment since the late 1930s. MID completed improvements in the 1990s that drastically reduced discharges to the creek. Discharges to the creek are currently considered a loss.
- Deadman Creek is used to meet MID’s 15,000 AF annual commitment to the Merced National Wildlife Refuge per MID’s existing FERC license. Flows are measured with a weir on the creek at the refuge’s eastern boundary.
- The Livingston Drain is a man-made facility that terminates in Bear Creek. Flows through the MID SCADA recorder on the drain are considered a loss, except during times where MID is delivering so a SOI grower.
- The Lingard “F,” El Nido Dam, El Nido Canal, El Nido “A” and El Nido “B” are smaller spills that are typically active in wet years.
- Other minor laterals spill in other locations that are mostly dry and dissipate over private property such as the Fesler Drain

All natural creeks mentioned above are intercepted by the East Side Canal but naturally terminate in the San Joaquin River. Natural waterways that serve as conveyances for deliveries within MID may also carry agricultural drainage, storm drainage and operational discharges. Waterways of this type are designated within the MID water balance as being parts of the MID delivery system to the point of their most downstream delivery. However, downstream of all MID delivery points, watercourses that receive drainage water are designated as drains.

## **5.2.1 Drainage System Water Quality**

### **MID’s Water Quality Monitoring Program**

A description of each component of the WQMP follows:

MID has participated in the Irrigated Lands Regulatory Program (ILRP) administered by the Central Valley Regional Water Quality Control Board (RWQCB) since the initiation of the program in 2003 with the issuance of Monitoring and Reporting Program Order No. R5-2003-0827 for individual dischargers under Resolution No. R5-2003-0105. The ILRP regulates discharge of irrigation return flows and storm water from those lands to surface waters. A majority of the irrigated acres in the central valley have regulatory coverage in the ILRP by participating in Water Quality Coalitions that are locally managed by agricultural interests. The Coalitions conduct an extensive amount of monitoring and work with growers to address identified water quality problems. Others participate as Individual Dischargers and perform their own water quality monitoring and reporting. MID participated as an Individual Discharger for the years reported herein.

According to the Order, Individual Dischargers were required to develop and implement a Monitoring and Reporting Program Plan (MRP Plan) to assess the impacts of waste in discharges from irrigated lands, and where necessary, to track progress of existing or new management practices implemented to improve the impact of these discharges on water quality and/or to protect waters of the state and its

beneficial uses. The reports required by this Order are required to evaluate impacts of waste discharges on Waters of the State and to determine compliance with the terms and conditions of the Waiver. MID prepared and submitted to the RWQCB for review and approval by the Executive Officer an MRP Plan that met the minimum conditions of the MRP.

In 2010, the RWQB conducted a review of the ILRP program and concluded that the data gathered over the last 6 years indicated that MID is a low threat discharger and does not appear to create water quality problems. Based on the review, the District was given the opportunity to determine future coverage under the ILRP and elected to join the East San Joaquin water quality coalition (ESJWQC). MID is no longer considered an Individual Discharger and will no longer be generating reports under the ILRP program. Rather, MID will be represented under the regional MRP of the ESJWQC.

In accordance with the IRLP, the MRP achieved the following objectives:

- Assessed the impacts of waste discharges from irrigated lands to surface water
- Established the effectiveness of management practices and strategies to reduce discharges of wastes that impact water quality
- Determined concentration and load of waste in these discharges to surface waters
- Evaluated compliance with existing narrative and numeric water quality objectives to determine if additional implementation of management practices is necessary to improve and/or protect water quality

### 5.3 Water Accounting (§10826 (b)(7))

#### 5.3.1 Quantification of MID Water Supplies-(§10826 (b)(7)(A))

##### *Surface Water Supplies*

Table 5.16 summarizes the monthly distribution of surface water diversion to MID’s irrigation conveyance systems over the period from 2000 through 2008. The total annual average is about 446,000 AF. As explained above, except for incidental runoff from local tributaries, all of the MID’s surface water supplies are released from Lake McClure.

<p align="center"><b>Table 5.16</b>  <b>Surface Water Supplies in TAF<sup>1</sup></b>  <b>2000 - 2008</b>  <b>Monthly Averages</b></p>												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Pre- and Post-1914 rights</b>	1	1	18	43	70	87	93	74	41	20	1.5	.4

<sup>1</sup> Period consists of mostly dry years

##### *Groundwater Supplies*

Annual volumes of groundwater pumped from MID and private wells for the period 2000 through 2008 are presented in Table 5.17. The private pumpage by MID customers are based on the results of the water balance which illustrates the variability of the water extracted in relation to hydrology. During the study period, the total volume estimated for annual pumpage by private customers ranged from zero to about

153,000 AF. Private well pumping is only calculated for active surface water fields that are supplemented with the grower’s groundwater well.

Month	Pumped by MID (AF)	Pumped within Service Area by Active MID Customers (AF)	Total (AF)
2000	9,042	0	9,042
2001	32,017	0	32,017
2002	17,062	0	17,062
2003	17,484	0	17,485
2004	13,839	29,081	42,920
2005	11,729	42,676	54,405
2006	10,612	26,346	36,958
2007	70,734	33,483	104,217
2008	91,000	153,252	253,085
<b>Average (2000-2008)</b>	31,373	31,648	63,021

***Effective Precipitation***

A computer program, the MID Root Zone model, was applied during development of the District’s water balance. This model was used to estimate effective rainfall (the volume of rainfall consumed by crops). Details of this model are described in Appendix B. Table 5.18 compares total annual rainfall with effective rainfall for the 9-year study period (2000-2008).

Year	Total Rainfall	Effective Rainfall	Percent Effective
2000	16.11	6.61	41
2001	13.76	4.27	31
2002	16.7	6.68	40
2003	9.17	4.68	51
2004	14.84	4.60	31
2005	16.15	5.01	31
2006	15.74	6.77	43
2007	6.97	4.18	60
2008	10.18	3.77	37
<b>Average (2000-2008)</b>	13.29	5.17	40.5

The Root Zone model estimates effective precipitation for each month of the period being simulated for 22 crops. For this reason, the averages presented in Table 3.14 are comprised of effective precipitation values that range widely in response to crop characteristics such as rooting depth and growing season as well as in response to climatic factors such as annual total rainfall and distribution of rainfall over the year. Average effective rainfall values for individual crops vary from percentages in the mid-20s for crops with short, mid-summer growing seasons to values approaching 70 percent for some deep-rooted permanent crops.

The average annual effective precipitation value of 40 percent computed using the Root Zone model compares well with that presented in Table 18 of the California Department of Water Resources Bulletin

*Effective Precipitation.*

1. Estimated groundwater extracted by non-MID parties within MID boundaries: The Merced Groundwater Basin Groundwater Management Plan (2008) identifies 50,250 AF of groundwater pumped by municipalities and individual domestic, commercial and industrial groundwater users in 2007 versus approximately 36,100 AF pumped in 1996. The projected urban population within eastern Merced County, the area covered by the Merced Water Supply Plan, is expected to grow from approximately 150,000 people in 1995 to just over 500,000 people in 2040, an average annual increase of approximately three percent. Because this expanded urban population would be served largely from groundwater, the anticipated increase in urban population is an index of anticipated growth in urban demand for groundwater. The water resources model expected to be launched by MAGPI will better quantify the amounts of private Ag pumping within MID.
2. Recycled water: Four wastewater sources exist in the vicinity of MID. A portion of the Wastewater from the City of Merced is applied on land adjacent to the city treatment plant. MID and the City are considering the use of recycled water by the District. The City of Livingston discharges their effluent downstream of MID lands and does not present opportunities for land application within the District. The City of Atwater has contracted with a private landowner for use of the city's entire waste stream. All of the above discharge to locations downstream from District lands or are committed to agricultural interest outside MID boundaries. The University of California has discussed with MID the possibility of utilizing wastewater generated by the new UC Merced campus which lies upslope from MID. Reuse is among the options being evaluated.
3. Other water uses: All surface and groundwater supplies to the MID have been described in the preceding paragraphs.

### **5.3.2 Tabulation of Water Uses (§10826 (b)(7)(B))**

Water uses in MID are tabulated in the water balance database developed for this Plan.

*Applied Water*

Estimated farm deliveries of District-supplied surface water over the period 2000 through 2008 have averaged 271,363 AF per year. Figure C-3 in Appendix C shows annual deliveries for this period.

*Consumptive Use*

The MID Root Zone model has been used to estimate consumptive use of applied water and of precipitation for the water balance. Evapotranspiration of applied water over the period 2000 through

2008 has averaged 238,000 AF per year. Figure C-5 in Appendix C shows average evapotranspiration of applied water for each year in this period.

***Seepage, Evaporation and Operational Discharges***

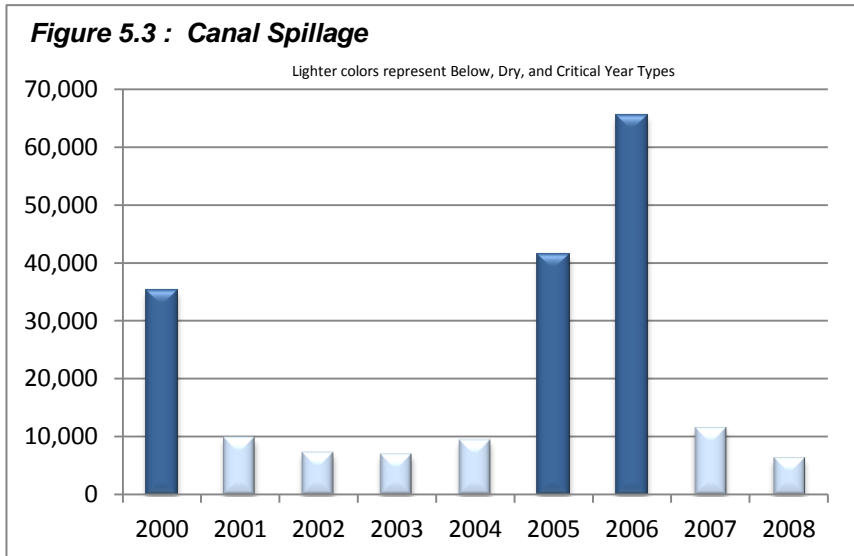
Seepage from MID canals is estimated to average 98,000 AF per year for the period between 2000-2008. Because much of the canal system is unlined, seepage tends to vary throughout the irrigation season with the seepage rate increasing with:

- a. Flow volume although seepage as a proportion of flow is greatest during months when little water is being conveyed.
- b. The length of the irrigation season.
- c. Soil formation.
- d. Time and amount of perception, a greater proportion tends to be absorbed from diverted flows during droughts.

Figure C-11 in Appendix C shows the range of annual seepage volumes estimated for the period 2000 through 2008.

Annual evaporation from MID canals is estimated to be 9,846 AF per year. Although this is a relatively small number, it, too, is sensitive to the length of the irrigation season.

Annual operational discharges during the irrigation season in the MID averages 21,600 AF per year over the period 2000 through 2008, a figure that includes both measured discharges and estimates of unmeasured operational discharges, and tributary inflows to the Stevinson Water District. This amount includes tributary flows from natural creeks that pass-through MID recorders as a result of storm events to Stevinson. Minimum canal spillage for the period was in 2008 (second critically dry year) at 6,332 AF. Figure 5.3 shows the distribution of average annual discharges over the period 2000 through 2008. As this figure illustrates, discharge values vary greatly from year to year. During droughts, discharges are significantly reduced. During wet years, MID maximizes its diversions from the Merced River for both increasing recharge opportunities, and reducing flood releases in the river. As a result, discharges tend to increase in these years, which a component of its conjunctive use program. In addition, the discharge estimates for the period from 2000 through 2002 indicate the impact commissioning of SUGWOP automation and control projects have on controlling discharges during non-drought conditions.



***Water Used for Leaching and Cultural Practices***

Because of the high quality of the surface water supply and because approximately 88 percent of applied water (surface deliveries, MID groundwater pumping and private groundwater pumping) comes from this

source, leaching is generally not a significant factor in irrigation management at MID. Water used for cultural purposes is included in the District’s accounting.

***Municipal and Industrial Water Use***

Municipalities and industries in the MID service area rely on groundwater except for a limited number of users who supplement groundwater supplies with MID surface water. M&I usage is not included in the water use accounting used to develop the MID water balance.

***Water Used for Environmental Purposes***

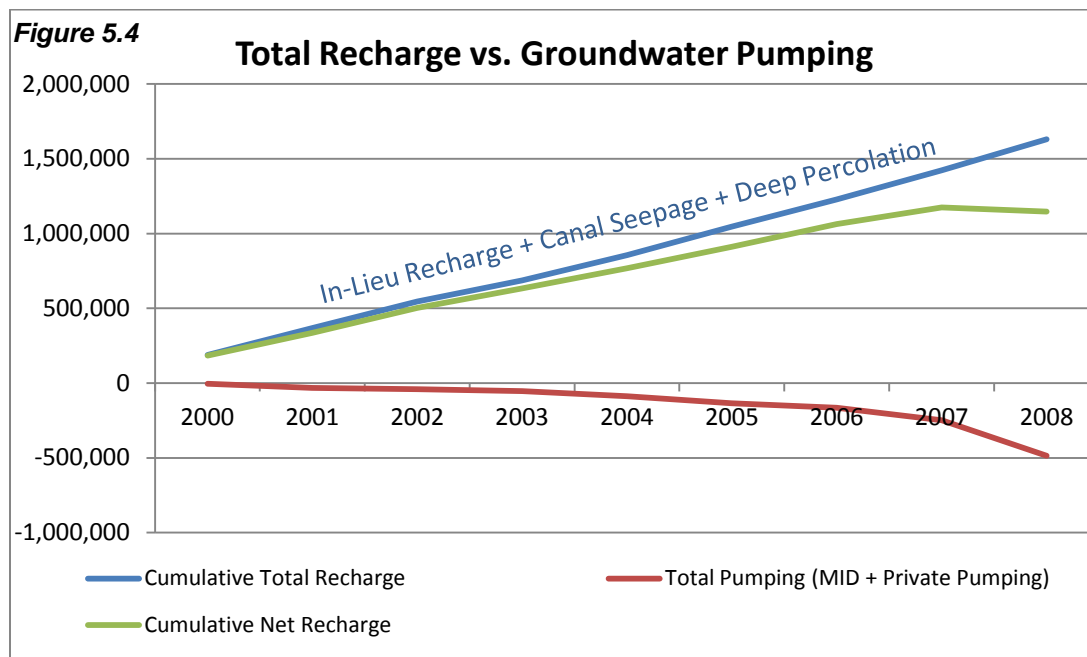
This has been discussed under Section §10826 (b)(5) (B).. -Water Uses within the MID Service Area includes the delivery of up to 15,000 AF to the Merced National Wildlife Refuge.

***Water Used for Recreational Purposes***

This has been discussed above under Section §10826 (b)(5)(C). - Water Uses Within the MID Service Area. As noted above, there is no explicit diversion or consumption of MID water for recreational purposes, and, hence, there is no need to include this use in the MID accounting framework.

***Groundwater Recharge and Conjunctive Use***

Groundwater recharge and conjunctive use are discussed earlier in this document. As noted in Section §10826 (b)(5).- Water Uses Within the MID Service Area, average annual deep percolation and canal seepage contributing to groundwater recharge are estimated to have been approximately 60,116 and 98,526 AF, respectively, over the period from 2000 through 2008 as shown in Figure 5.4. Similarly, in-lieu recharge efforts have yielded approximately 32,115 AF annually. Therefore, the total annual average recharge is around 190,000 AF.



***Water Exchanges or Transfers***

MID reoperated New Exchequer Dam reservoir through multiple water transfers since 1967. Between 2000 and 2008, MID transferred 102,614 AF on average annually, as part of negotiated settlements and studies benefitting fisheries. Except for 12,500 AF, the remaining amounts have sunsets in 2011 and



2017. In the same period, MID engaged in voluntary water transfers averaging 16,800 AF annually. MID continues to work with various agencies benefitting the environment in the Merced River while securing compensations that will be utilized by the District to support District modernization and water rights protection.

***Estimated Deep Percolation***

Deep percolation within the MID has been divided into deep percolation of applied water and deep percolation of precipitation. Annual deep percolation of precipitation is estimated to have averaged approximately 42,763 AF over the period 2000 through 2008. Deep percolation of applied water is discussed above under groundwater recharge and conjunctive use. Figure C-6 of Appendix C shows the annual distribution of this component over the water balance period.

***Flows to Saline Sink or Perched Water Table***

Some of MID’s water flows are believed to migrate to either saline sinks or non-recoverable perched water tables. Determining these values require a high resolution hydro geologic analysis, and are not included in this accounting. The soon to be launched, MAGPI Water Resources Model, will address these values

***Total Recycled Water***

This has been discussed above under Section §10826 (b)(7).-Water Accounting.

***Water Leaving the Water Supplier’s Service Area***

Water leaving the MID service area exits primarily via two pathways 1) operational discharge, drainage and entitlement flows which leave the District as streamflow; and 2) evaporation and evapotranspiration. These pathways have been discussed above. Groundwater flow across MID boundaries is considered negligible for the water balance. This assumption will be further evaluated during the development of the water resources model discussed in Section 1. resources model discussed in Section 1.

***Other***

All water uses that are accounted for by the MID have been presented in the above discussion.

**5.3.3 Overall Water Budget (§10826 (b)(7)(C))**

Water supply and water use data from the MID, CIMIS and other sources were used to develop a water balance that presents a quantitative history of District water use as well as a basis for improving water management. The balance facilitates identification of water conservation opportunities, provides a basis for assessing the magnitude of various opportunities and illustrates links among various balance components.

The water balance is based on the general equation:

$$(\text{sum of inflows}) - (\text{sum of outflows}) \pm (\text{sum of changes in storage}) = 0 \text{ (Eqn 1)}$$

However, not all of the inflows and outflows are measured or estimated precisely. Hence, a closure term is used in the balance to represent a term for which incomplete data are available. The closure term is expressed by the equation:

$$\text{closure} = [ (\text{sum of all measured or estimated inflows}) - (\text{sum of all measured or estimated outflows}) ]$$

$$\pm (\text{sum of all known or estimated changes in storage})] \quad (\text{Eqn 2})$$

It is important to recognize that the closure term contains the combination of all errors that may be present in the measured historical record and the estimated values. Random errors would tend to cancel out over time while systematic errors, such as an inaccurate rating of measurement devices, would tend to be cumulative.

The water balance has been developed using two computer applications tailored specifically for this purpose. One of the programs is the MID Root Zone model. This spreadsheet-based program operates on a monthly basis and computes the following components of the water balance for both precipitation and applied water:

- evaporation
- evapotranspiration
- deep percolation
- surface runoff

Inputs to the Root Zone model include:

- crop types
- crop coefficients
- crop acreage
- rooting depth
- soil water holding capacity.

Appendix B contains a more detailed description of the MID Root Zone model.

Measured data and estimates generated by the Root Zone model are used as inputs for a water use database, which is the core of the water balance. Information maintained in this database represents all values for inflows and outflows used to formulate the water balance. Appendix C describes the water balance in greater detail and presents results of the balance.

Tables 5.19 through 5.23 are summary tables based upon average values taken from the MID water balance. Table 5.19 presents the average annual volume of water delivered (applied water) to MID farms for the period of 2000-2003. This value includes groundwater and surface water deliveries from the MID distribution system, water from MID wells pumped directly to farms and private groundwater pumping. Again none of the values represent a given year, but an average spanning critically dry years to wet years with all the variations of length of season, groundwater pumping, cropping trends, and all related conjunctive use practices.

<b>Table 5.19 Applied Water</b>	
	<b>Volume Average Annual AF</b>
Applied Water	279,270

Table 5.20 describes on-farm use of applied water, pumped groundwater and precipitation that fell on MID farmland. This table notes destinations of applied water and precipitation that include crop water use, evaporation, and deep percolation.

<b>Table 5.20</b>	
<b>Quantification of On-farm Water Use</b>	
<b>Water Use</b>	<b>Volume(AF)</b>
<b>Crop Water Use</b>	
1 Crop evapotranspiration of applied surface and groundwater	237,838
2 Crop evapotranpiration of precipitation	40,788
3 Leaching	0
4 Evaporation losses (precipitation)	10,519
5 Uncollected runoff (precipitation)	10,519
6 Tailwater Return Flows	13,568
7 Cultural practices	0
<b>Conjunctive Use</b>	
8 Ground water recharge (applied surface and ground water)	60,116
9 Ground water recharge (precipitation)	42,763
<b>Other</b>	
<b>Subtotal</b> (calculated)	416,112

Table 5.21 quantifies average annual volumes of delivered MID surface and ground water, groundwater pumped by growers, and precipitation available to MID farms over the period from 2000 through 2008. The average annual groundwater that was pumped directly to the growers’ fields from MID wells amounted to 7,907 AF, while an average annual amount of 22,315 AF of well water was pumped to MID’s canal/distribution system for delivery.

<b>Table 5.21</b>	
<b>Quantification of Water Supplies Available On Farm</b>	
<b>Water Supplies</b>	<b>Volume (AF)</b>
1 Surface Water	263,456
2 Groundwater	63,021
3 Annual Precipitation	105,193
<b>Subtotal</b> (calculated)	431,670

<b>Table 5.22</b>	
<b>Quantification of District Water Use</b>	
<b>Water Use</b>	<b>Volume AF</b>
<b>District Water Use</b>	
1 Farm deliveries (surface and groundwater excluding private wells)	271,363
2 Unmeasured operational discharges and Stevinson inflow	21,884
3 Measured operational discharges	11,232
4 Downstream entitlement flows and water sales	74,712
5 Evaporation from canals	9,846
6 Seepage	98,526
<b>Subtotal</b> (calculated)	487,564

Table 5.22 presents a system-wide perspective of flow paths taken by water that has entered the MID canal distribution system excluding MID well water pumped and delivered directly to the growers’ fields from the period 2000-2008.

Table 5.23 presents average values for the period from 2000 to 2008 of sources of water supplying the MID’s canal distribution system excluding MID well water pumped and delivered directly to the growers’ fields.

<b>Water Supplies</b>		<b>Volume (AF)</b>
1	Surface water diversions	445,637
2	Ground water	22,315
3	Annual precipitation (to canals)	252
4	Tributary inflow	13,824
5	Water purchases	0
6	Transfers or Exchanges into District	0
7	Tailwater returned to distribution system	5,535
<b>Subtotal</b> (calculated)		<b>482,083</b>

Because operational discharges, drainage and flows leaving the District to meet downstream entitlements are commingled, it is not practical to give a representative value for surface drainage leaving the District. MID has very little acreage having tile drainage, therefore subsurface drainage flows are negligible.

#### **5.4 Water Supply Reliability (§10826 (b)(7))**

The reliability of MID’s water supplies, including both surface water and groundwater, is reflected in the consistency of supplies during the full 2000-2008 span of the water balance. The exception was 2008 which was the second of two critically dry years where MID Class I users received 2.5 AF per acre and Class II users received 1.25 AF per acre through a shorter irrigation season.

As a result of technological advances, higher commodity prices and groundwater quality concerns, the District is experiencing: increased cultivation of grazing lands, that is considered marginal lands of Soil Index = less than 50 and groundwater dependent parcels turning to surface water.

There are around 26,000 acres of land within the District that solely utilize private groundwater wells for irrigation. These are expected to convert to surface water due to deteriorating groundwater quality and/or concerns regarding dropping groundwater levels and the health of the aquifer.

So despite the overall lower per acre delivery, more acres are expected to return to surface water consumption, thereby tending to keep over all District diversions the same if not higher and possibly impacting the water supply reliability overtime.

*~End of Section~*



*Cressey Recharge Basin*

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## **SECTION 6: CLIMATE CHANGE (§10826 (c))**

Climate change is a pervasive global phenomenon, but the changes in climatic conditions and their impacts in the regional level are varied. Changes in climate can affect water supplies through modifications in the timing, amount, and form of precipitation, as well as water demands and the quality of surface runoff. These changes can affect all elements of water supply systems, from watersheds to reservoirs, conveyance systems, and groundwater basins.

Planning for and adapting to anticipated changes in climate will be essential to ensuring water supply reliability for all users and to protect sensitive infrastructure against more frequent and extreme precipitation events. This climate change section will address the impacts of those changes with regard to water resource management, assess the vulnerability of the region to anticipated climate change impacts, and provide responses and recommended adaptation strategies to mitigate the negative effects.

### **6.1 Statewide Historical Climatic Trends and Projections**

Indications of climate change have been observed over the last several decades throughout California. Statewide average temperatures have increased by about 1.7°F from 1895 to 2011, with the greatest warming in the Sierra Nevada (Moser et al. 2012). Although the State’s weather has followed the expected pattern of a largely Mediterranean climate throughout the past century, no consistent trend in the overall amount of precipitation has been detected, except that a larger proportion of total precipitation is falling as rain instead of snow (Moser et al. 2012).

Even though California’s average temperature has increased by 1°F in the last one hundred years, trends are not uniform across the state. The Central Valley has actually experienced a slight cooling trend in the summer, likely due to an increase in irrigation (CEC 2008). Higher elevations have experienced the highest temperature increases (DWR 2008). Many of the state’s rivers have seen increases in peak flows in the last 50 years (DWR 2008).

While historical trends in precipitation do not show a statistically significant change in average precipitation over the last century (DWR 2006), regional precipitation data show a trend of increasing annual precipitation in Northern California (DWR 2006) and decreasing annual precipitation throughout Southern California over the last 30 years (DWR 2008). A key change in precipitation patterns has been more winter precipitation falling as rain instead of snow (CNRA 2012), leading to increased streamflow in the winter and decreased streamflow in the spring and summer, when water demands are the greatest. This increased streamflow variability could lead to increased risks of flooding, levee failure, saline water intrusion and flood-or-drought-induced habitat destruction.

Multiple models have been developed and run to evaluate global and regional climate change impacts. Global Climate Models (GCMs) project that in the first 30 years of the 21<sup>st</sup> century, overall summertime temperatures in California will increase by 0.9 to 3.6°F (CAT 2009) and average temperatures will increase by 3.6 to 10.8°F by the end of this century (Cayan et al. 2006). Increases in temperature are not likely to be felt uniformly across California. Models generally project that warming will be greater in California in the summer than in the winter (CAT 2009) and inland areas will experience more extreme warming than coastal areas (CNRA 2009). These non-uniform warming trends are among the reasons that regional approaches to addressing climate change are important.

While temperature projections exhibit high levels of agreement across various models and emissions scenarios, projected changes in precipitation are more varied. Taken together, downscaled GCM results show little, if any, change in average precipitation for California before 2050 (DWR 2006), with a drying

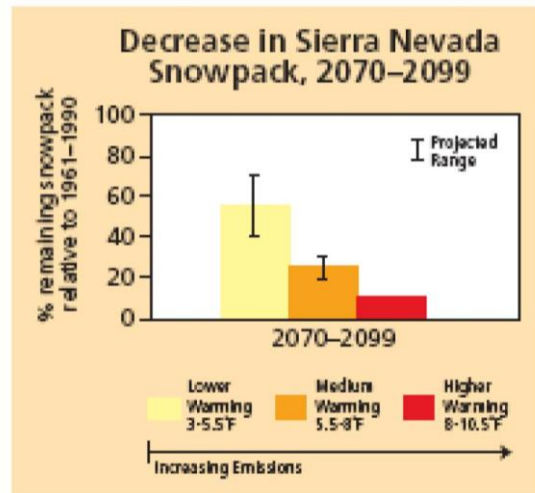
trend emerging after 2050 (BOR 2011, CCSP 2009). While little change in precipitation is projected by the GCMs as a group, individual GCM results are considerably varied. Climate projections therefore imply an increase in the uncertainty of future precipitation conditions.

## 6.2 Sea-level Rise, Snowpack Reduction, and Extreme Events

In the last century, the California coast has seen a sea level rise of seven inches (DWR 2008). The average April 1<sup>st</sup> snowpack in the Sierra Nevada region has decreased in the last half century (Howat and Tulaczyk 2005, CCSP 2008), and wildfires are becoming more frequent, longer, and more widespread (CCSP 2008).

As the climate warms, the Sierra Nevada’s snowpack (a primary storage mechanism for California’s water supply) is anticipated to continue to shrink. Based on simulations conducted to date, Sierra Nevada snowpack is projected to shrink by 30percent between 2070 and 2099, with drier, higher warming scenarios putting that number as high as 80percent (Kahrl and Roland-Holst 2008). Additionally, extreme events are expected to become more frequent, including wildfires, floods, droughts, and heat waves. In contrast, freezing spells are expected to decrease in frequency over most of California (CNRA 2009). While GCM projections may indicate little, if any, change in average precipitation moving into the future, extreme precipitation events are expected to become more commonplace (CBO 2009). The combination of drier and warmer weather compounds expected impacts on water supplies and ecosystems in the Southwestern United States (CCSP 2009) with wildfires expected to continue to increase in both frequency and severity (CCSP 2009).

**Figure 6.1: Projected Snowpack Changes in the Sierra Nevada**



Source: Hopmans et al. 2008

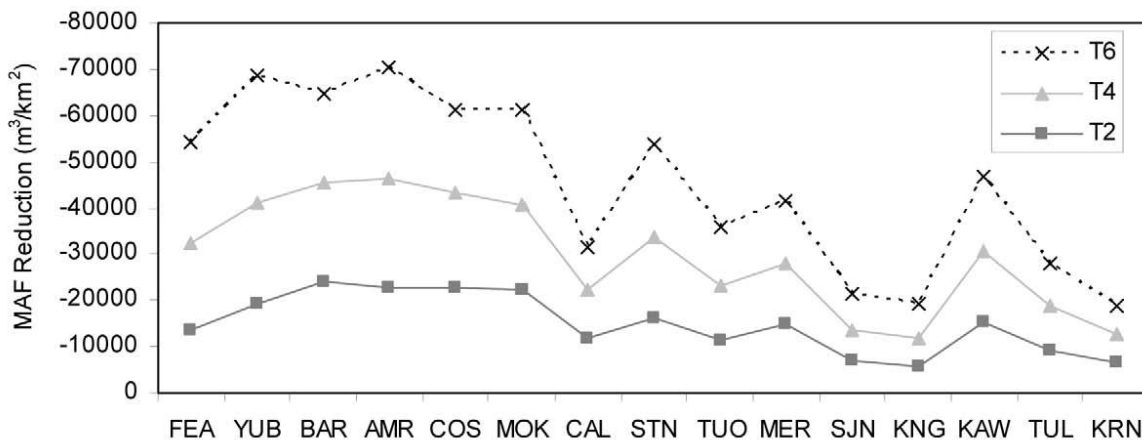
## 6.3 Regional Climate Change Projections and Impacts

The MID lies within the San Joaquin River Hydrologic Region and contains the San Joaquin River, Merced River, Bear Creek and Owens Creek. In general, regional climate change modeling simulations project temperature increases throughout California, with consistent spatial patterns. Anticipated temperature increases are expected to be less extreme along the southwest coast, with increasing warming to the north and northeast. There is significant uncertainty associated with future precipitation patterns and water supply projections Statewide. In general, changes in precipitation correlate with changes in water supply, with decreased precipitation correlating to decreased stream flows and decreased groundwater recharge. A study conducted by Null et al. of the University of California, Davis Center for

Watershed Sciences, published in 2010, evaluated the hydrologic response and watershed sensitivity to climate change for the Sierra Nevada watersheds, including that of the Merced River. This study used a climate-forced rainfall-runoff model to explicitly simulate intra-basin hydrologic dynamics and understand localized sensitivity to climate warming. Using the Stockholm Environmental Institute’s Water Evaluation and Planning System (WEAP21), the researchers simulated anticipated 2°C, 4°C and 6°C temperature increases and evaluated changes from baseline for three key parameters – mean annual flow, centroid timing, and low flow duration – to highlight relative differential responses across the Sierra Nevada watersheds and in relation to water resource development (water supply, hydropower and mountain meadow habitat, respectively).

Modeled changes to climate warming in the Merced River watershed resulted in reductions in mean annual flow (MAF). Specifically, there were approximately 30 TAF (3percent) , 60 TAF (6percent) and 80 TAF (8percent) decreases in mean annual flow on the Merced River based on an average annual natural flow of approximately 1M AF resulting from 2°C, 4°C and 6°C increases in air temperature, respectively. Relative to other Sierra watersheds, the Merced River experienced a moderate change in MAF due to climate change and was therefore considered to be less vulnerable to climate warming based on total water stored and changes in MAF than more northern watersheds (such as the American, Yuba, Bear, Mokelumne and Cosumnes Rivers).

**Figure 6.2: Reduction in Mean Annual Flow from Basecase by Watershed**

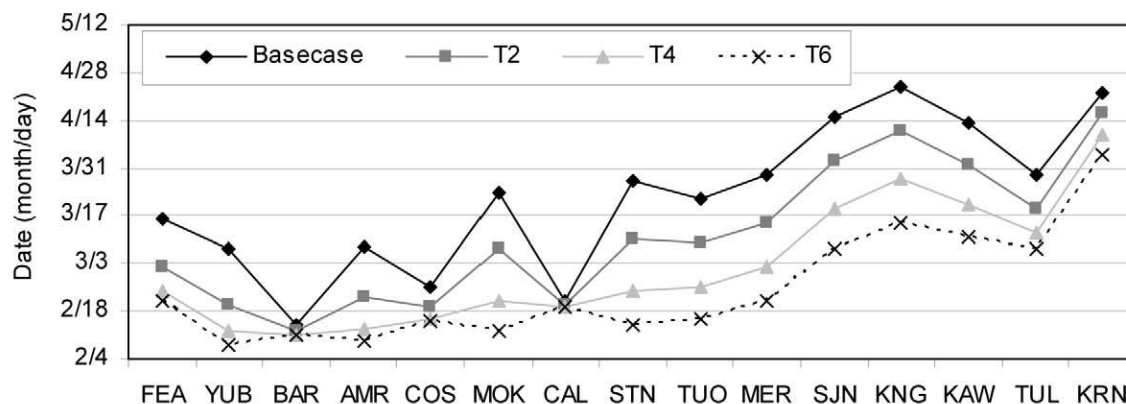


Notes: MER – Merced River watershed  
 Source: Null et al. 2010

The modeling also showed that runoff centroid timing (CT) was 2 weeks, 4 weeks, and 6 weeks earlier given the respective 2°C, 4°C and 6°C increases in air temperature. Change in seasonal runoff timing may affect flood protection, water storage and deliveries. Using online hydropower capacity as a measure of impact, the study identified watersheds vulnerable to CT shifts as they rely on hydropower generation and may face substantial changes in runoff timing with climate warming.



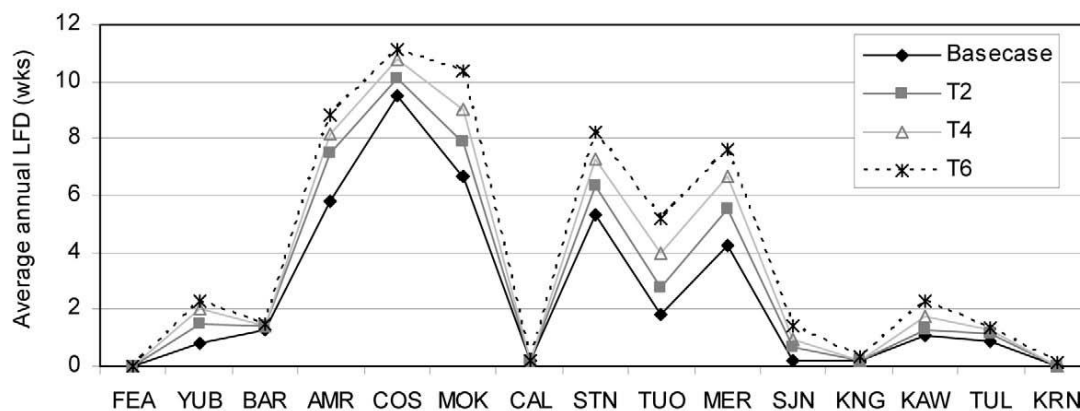
**Figure 6.3: Average Annual Centroid Timing by Watershed**



Notes: MER – Merced River watershed  
Source: Null et al. 2010

Finally, the study evaluated the average low flow duration (LFD) for the Sierra Nevada watersheds relative to climate change. For the Merced River, average low flow duration lasted 2, 3 and 4 weeks longer for the 2°C, 4°C and 6°C increases in air temperature, respectively. Merced River was considered vulnerable to LFD. Along with Yosemite and its meadows upstream, the Merced River could experience habitat loss as a result of climate change.

**Figure 6.4: Average Annual Low Flow Duration by Watershed**



Notes: MER – Merced River watershed  
Source: Null et al. 2010

### Water Resource Vulnerability

MID is the primary agricultural water user in the Merced River region. Water supplies include both groundwater and surface water, with groundwater coming from the Merced (predominantly), Turlock and Chowchilla Subbasins of the San Joaquin Valley Groundwater Basin and surface water being diverted primarily from the Merced, Chowchilla, and San Joaquin Rivers. Declining Sierra Nevada snowpack, earlier runoff, and reduced spring and summer streamflows will likely affect surface water supplies and shift reliance to groundwater resources, which are already overdrafted in many places. This will, in turn, affect critical natural resource issues in the region.

Other anticipated regional impacts resulting from climate change (increased air temperatures and variable precipitation) include changes to water quality; increased flooding, wildfires and heat waves. Earlier springtime runoff will increase the risk of winter flooding as capturing earlier runoff to compensate for future reductions in snowpack would take up a large fraction of the available flood protection space, forcing a choice between winter flood prevention and maintaining water storage for summer and fall dry-period use.

The identified vulnerabilities for the Merced region which are pertinent to the MID are summarized in Table 6.1 and further described in the following sections.

<b>Table 6.1</b>	
<b>Merced Region Vulnerabilities</b>	
Vulnerability	Description
Agricultural Water Demand	Vulnerable to increased agricultural demands due to increased temperatures and evapotranspiration rates, and more frequent/severe droughts.
Water Supply and Quality	Vulnerable to decreased snowpack in the Sierra Nevada, shifts in timing of seasonal runoff, increased demands exacerbating groundwater overdraft, degraded surface and groundwater quality resulting from lower flows, exaggerated overdraft conditions, a reduction of meadows which can provide contaminant reduction, and more frequent/severe droughts and storm events increasing turbidity in surface supplies.
Flood Management/Disaster	More severe/flashier storm events and earlier springtime runoff leading to increased flooding, and a reduction of meadows which help reduce floods in the winter. Less opportunities to capture for recharge.

## 6.4 Agricultural Water Demand

In general, irrigation water demand varies based on crops and climatic conditions, and may or may not increase under future climate change conditions. Groundwater pumping is anticipated to increase as more irrigators and agricultural water users turn to groundwater to meet crop water requirements and farming needs (depending on surface water availability). Groundwater salinity increases with decreasing precipitation because less water is available to recharge the groundwater as a result of flashier and more variable precipitation events (Schoups et al. 2005). The effects of increased air temperatures on agriculture will include faster plant development, shorter growing seasons, changes to reference evapotranspiration (ET) and possible heat stress for some crops. In addition, fruit crops are more climate-sensitive than other crop types and may require additional water as the climate warms. Therefore, more water may be necessary to maintain yield and quality in future years of apricot or peach crops, for example, in the Merced region.

If more water is required to maintain yield, and combined with potentially reduced supplies, the agricultural community may respond to these climate-induced changes primarily by increasing the acreage of land fallowing and retirement, augmenting crop water requirements by groundwater pumping, improving irrigation efficiency, and shifting to high-value and salt-tolerant crops (Hopmans et al. 2008). However, agricultural impacts resulting from climate changes are anticipated to be significant for the MID as Merced County ranks 5<sup>th</sup> in the state in agricultural production with a value of over \$2.7 billion (Kahrl and Roland-Holst 2008).

Groundwater modeling was completed which indicated that groundwater demands are highest during dry years, likely due to the fact that groundwater is primarily used for agricultural irrigation (MAGPI 2002). The seasonal variability of water demands is projected to increase with climate change as droughts become more common and severe (DWR 2008). Other seasonal uses such as landscape irrigation demands are also expected to increase as a result of climate change (DWR 2008 and CNRA 2009).

### ***Water Supply and Quality***

The MID's water supplies include groundwater and surface water from Merced River and local creeks and drainages. Additional water storage will be required to ensure water supply reliability due to the impact of early spring runoff and reduced mean flow. Without additional storage, it will be difficult to capture and retain the extra runoff for use after April 1<sup>st</sup> without reducing the amount of flood storage space left in reserve. Both the need for empty storage for flood protection and the need for carryover storage for drought protection reflect the uncertainty about future weather conditions and the level of regional risk aversion (Hayhoe et al. 2004). Another concern is MID's water rights on the Merced River which are effective only in certain time periods.

Decreased summertime flows will likely result in increased groundwater pumping (and potential overdraft conditions) due to increased groundwater to offset surface water shortages. Additionally, rising temperatures are projected to increase the frequency of heat waves, which could also lead to increased water use and further exacerbate low flow conditions (Hayhoe et al. 2004).

Finally, climate change impacts may affect water quality in a multitude of ways.

- Water quality can be impacted by both extreme increases and decreases in precipitation. Increases in storm event severity may result in increased turbidity in surface water supplies while decreases in summertime precipitation may leave contaminants more concentrated in streamflows (DWR, 2008) as well as increased dissolved concentrations of constituents in groundwater due to decreased groundwater percolation.
- Higher water temperatures may exacerbate reservoir water quality issues associated with reduced dissolved oxygen levels and increased algal blooms (DWR, 2008).

Declining Sierra Nevada snowpack, earlier runoff and reduced spring and summer stream flows will likely affect surface water supplies and shift reliance to groundwater resources, which are already overdrafted in many places.

### ***Groundwater Quality***

The MID service area overlies three groundwater subbasins within the San Joaquin Groundwater Basin including the Merced Subbasin in entirety, and portions of the Chowchilla and Turlock Subbasins. According to the 2008 Groundwater Management Plan (GWMP) Update (Amec 2008), groundwater elevations in the Merced Subbasin have been monitored by DWR, MID, and other entities since the 1950s. This monitoring data demonstrates that since 1980 average groundwater levels beneath the Merced Subbasin have declined approximately 14 feet, with most of this decline occurring between 1980 and 1996 (Amec 2008). As such, the Merced Subbasin is considered to be in a state of mild long-term groundwater level decline. In addition to dropping groundwater levels, the Merced Subbasin has high concentrations of total dissolved solids (TDS), generally at depths between 400 and 800 feet below the ground surface, that increase in concentration from east to west. The San Joaquin River acts as a natural saline barrier, so generally, TDS concentrations are greater on the west side of the River and less on the east side. Reduced streamflows in the River could reduce the effect of the natural barrier and allow for further migration of salinity in the groundwater basin. Additionally, climate change impacts may cause

increased evapotranspiration and longer growing seasons for permanent crops, further exacerbating groundwater overdraft and high salinity levels.

Portions of the groundwater subbasins are subject to high nitrate concentrations; elevated iron and manganese concentrations; and contamination with methyl tert-butyl ether (MTBE), 1,2-dibromo-3-chloropropane (DBCP) and other contaminants; which can impact the beneficial use of groundwater. Lastly, the variation in precipitation and streamflow in the future will influence how and when the groundwater subbasins are recharged.

### ***Surface Water Quality***

The Central Valley Regional Water Quality Control Board (RWQCB) compiled the 303(d) list of impaired water bodies within the Sacramento River and San Joaquin River Basins that suffer significant water quality impairments from a variety of pollutants and must be addressed through the development of Total Maximum Daily Loads (TMDLs). The Lower Merced River (from McSwain Reservoir to the San Joaquin River) is included on this list. Irrigated agriculture has been identified as a significant anthropogenic source of both nitrate and sediment loading in surface water bodies. Additional sources of sediment loading include erosion, mining, and grazing, among others. Current climate change scenarios project lower stream flows and higher agricultural water use that would pose significant challenges in implementing the defined TMDLs and meeting water quality goals.

Lake McClure and the Merced River are supplied primarily by snowmelt from the Sierra Nevada. Changing volumes of snowfall and snowpack in the Sierra Nevada and the changing seasonal melting patterns may require changes in dam operation. As the timing of snowmelt shifts in the spring, hydroelectric power generation may also shift to accommodate enhanced flood control operations. Additionally, increasing temperatures will also increase energy demands, especially during peak demand times (DWR 2008). As previously described, the modeling completed as described in the *Hydrologic Response and Watershed Sensitivity to Climate Warming in California's Sierra Nevada*, showed that runoff centroid timing (CT) on the Merced River was 2 weeks, 4 weeks, and 6 weeks earlier given the respective 2°C, 4°C, and 6°C increases in air temperature, respectively. Change in seasonal runoff timing may affect electrical generation capabilities, flood protection, water storage and deliveries. Hydropower is often generated during high demand periods, which may be compromised if facilities are forced to spill due to higher magnitude flows or to accommodate early arrival of flows (Null, et. al. 2010).

### ***Adaptation Strategies***

Global climate modeling carries a significant degree of uncertainty resulting from varying sensitivity to changes in atmospheric forces (e.g. CO<sub>2</sub>, aerosol compounds), unpredictable human responses, and incomplete knowledge about the underlying geophysical processes of global change. Even though current scenarios encompass the “best” and “worst” cases to the greatest degree possible based on current knowledge, significant uncertainty associated with future global GHG emission levels remains, especially as timescales approach the end of the century. The historical data for calibrating GCMs is not available worldwide, and is spatially biased towards developed nations.

Therefore, considering the great deal of uncertainty associated with climate change projections, a prudent approach to addressing climate change incorporates a combination of short-term and long-term adaptation strategies. Climate adaptation includes strategies (policies, programs or other actions) that prepare the District to effectively respond to the unavoidable negative climate impacts. These strategies are also identified in the *California Water Plan (CWP)* as resource management strategies (RMSs) for water management approaches in the region. The potential issues to consider are as follow:

- Reduce Water Demand

- Improve Operational Efficiency and Transfers
- Increase Water Supply
- Improve Water Quality
- Improve Flood Management
- Other Strategies

As described in the *Climate Change Handbook for Regional Planning* (CDM 2011), the key to climate change adaptation or mitigation is to be directed at overall system resiliency, which improves a system’s resilience to the uncertain conditions climate change could bring.

## 6.5 Reduce Water Demand

Reducing existing and future water demands can reduce pressure on water sources of limited supply and help adapt to the potential climate change impacts of less precipitation, shifting of springtime snowmelt, and overall uncertainty. Opportunities for increased water conservation and water use efficiency measures are discussed in other sections of this document. Performance metrics that could be used to measure the effectiveness of reduced water demand adaptation include average water demand reduction per year and peak water demand reduction per month (CDM 2011).

MID is already implementing many agricultural water use efficiency efforts. It has identified and is currently implementing efficient water management practices (EWMPs) as part of this Plan. Several EWMPs that include infrastructure upgrades and operational improvements reduce water demand and maintain productivity. The following are the two groupings of EWMPs that MID is considering implementing in the short-term:

- **Infrastructure Upgrade:** Evaporation loss from irrigation ditches and canals is a function of temperature and other climate variables. Depending on different emission scenarios, the operation of these facilities may be impacted by climate change, leading to increased water loss. One of the EWMPs is to convert irrigation canals and ditches to piping. This water conservation method prevents evaporative losses, which will only increase as temperatures rise. This approach could help the MID adapt to climate change by expanding water supplies and making existing water supplies less vulnerable to climate change impacts. Canal lining is identified as a less capital-intensive method to reduce seepage into the ground, although it does not reduce water evaporation and does reduce groundwater recharge that occurs as a result of this seepage. Canal automation can increase water supply reliability and flexibility to deliver water at the time, quantity, and duration required by the grower, and can facilitate conversion to more efficient irrigation methods such as micro-irrigation.
- **Water Management:** MID and its users will take advantage of new technologies and hardware to optimize management of water-related infrastructure for water conservation. Supervisory control and data acquisition (SCADA) systems enable water managers to collect data to a centralized location and operate automated canals to achieve desired water levels, pressures or flow rate, and also increase the efficiency in reservoir operation. In addition, automated control will free water system operators from manual operation and allow them to plan, coordinate system operations, and potentially reduce costs. Such systems improve communications and provide for flexible water delivery, distribution, measurement, and accounting. On-farm practices can also be improved. Furrow, basin, and border irrigation methods have been improved to ensure that watering meets crop water requirements while limiting runoff and deep percolation. Using organic or plastic mulch can reduce non-essential evaporation of applied water. Advanced

irrigation systems include GIS, GPS and satellite crop and soil moisture sensing systems and can all improve overall farm water management.

### ***Improve Operational Efficiency and Transfers***

Water supply system operations need to be optimized in order to maximize efficiency. Well-maintained conveyance infrastructure improves water supply reliability and enhances regional adaptability to climate change impacts. Addressing aging infrastructure, increasing existing capacity, in-system storage and/or adding new conveyance facilities can improve existing conveyance system and operational efficiency.

As a long-term approach through system reoperation, the New Exchequer Dam may be able to adapt to less reliable water supplies and/or increased water demands by maintaining conveyance infrastructure, as well as adapting to climate change impacts on hydropower production, flooding, habitat, and water quality. The approach is to model and determine the trade-offs associated with levels of encroachment in the flood pool or reservoir operation under new, adaptive rules.

MID is currently investigating and implementing long-term or short-term water transfers. Specifically, the City of Merced and MID are working to formalize the exchange of tertiary-treated wastewater effluent from the City of Merced for surface water from MID. This will help the region adapt to climate change by providing additional climate resilient water supplies. As such, transfers can improve supply reliability when other supplies are projected to have reduced reliability due to climate change impacts.

An example of a performance metrics to quantify this strategy includes amount of new supply created through regional water transfers (CDM 2011).

### ***Increase Water Supply***

As water demands increase due to longer growing seasons, higher temperatures, and longer droughts, and the future of existing water supplies sources becomes less certain, MID will need to enhance existing water supplies to meet demands. Increasing water supply can be accomplished through the implementation of conjunctive management of surface and groundwater supplies as well as through groundwater storage, recycled water use, and increased surface water storage, as appropriate. Diversifying the region's water supply portfolio and adding drought-resistant sources is an adaptation measure that will help address increased water demands and/or decreased supply reliability. Performance metrics for measuring the effectiveness of the increased water supply could include additional supply created, amount of potable water offset, and supply reliability (CDM 2011).

### ***Conjunctive Management and Surface and Groundwater Storage***

Merced Area Groundwater Pool Interests (MAGPI) has been implementing the Merced Groundwater Basin Groundwater Management Plan, which promotes conjunctive surface water and groundwater management to improve the long-term sustainability of the Merced Groundwater Basin. MID as the lead agency for MAGPI will continue to investigate conjunctive management to increase surface and groundwater use, improve groundwater quality, and adapt to climate change. Increased storage and conjunctive use may increase resilience to shifting runoff patterns, providing more storage for early runoff, reducing or eliminating the potential climate change impacts on flooding and hydropower production, and offsetting decreases in snowpack storage. This strategy is valuable as weather patterns change in frequency and timing and more extreme events occur. MAGPI is in the process of embarking on an integrated water resources modeling study with funding from the State that will provide MAGPI the modeling tools to better manage the basin conjunctively between surface water and groundwater supplies. The integrated model is capable of simulating the interactions between surface water and groundwater to determine the impacts of surface water supplies on groundwater supplies due to the effects of climate change.

Developing a project to provide additional local surface water storage is a possible adaptation strategy for climate change impacts on water supply and associated reliability. Storage provides a way of adjusting a water system to altered peak streamflow timing resulting from earlier snowpack melting. Additional storage capacity could also help to adapt to the anticipated increased precipitation variability. Increased surface storage could allow water managers to make real-time decisions that are not available otherwise. It would also facilitate water transfers between basins from upstream reservoirs to receiving regions that have additional storage for the transferred water. Added storage provides greater flexibility for capturing surface water runoff, managing supplies to meet seasonal water demands, helping manage floods from extreme storm events, and adapt to extreme weather conditions such as droughts.

As mentioned earlier sections, to facilitate the additional surface storage, the District is seeking US Congress approval through the Federal Energy Regulatory Commission (FERC) re-licensing process to consider increasing the maximum storage capacity of New Exchequer Dam reservoir up to 70,000 AF. This will be accomplished by raising the current New Exchequer spillway elevation by about 10 feet. The extra storage will be an appropriate volume of supplemental source of water to off-set the anticipated potential reduction in the Merced River annual natural flow that ranges from 30 to 80 TAF as reported in the climate change study. Again, the New Exchequer Dam FERC re-licensing program is currently re-examining the various environmental in-stream requirements of the Merced River in light of the effects of climate change so that there would not be unreasonable pressure on the river demands.

In addition to new potential storage, MID may seek developing water purchasing agreements to buy water from other agencies that own existing storage reservoirs with substantial water supplies. Rehabilitation and possible enlargement of existing dams and infrastructure will potentially improve the lack of reservoir storage capacity. The Merced Integrated Regional Water Resources Management Plan (IRWMP) has included various existing reservoir enlargement projects as well as new off-stream regulating reservoir as proposed by MID and others as potential projects to augment the water supply shortage issue.

Finally, implementing conjunctive management and groundwater storage can provide benefits similar to additional surface storage, in addition to increased water management flexibility while also reducing groundwater overdraft. There is the potential to bank water, flood flows, runoff, recycled water, and/or desalinated water for dry seasons in groundwater basins. Conjunctive management is highly dependent on how well surface water and groundwater are managed as a single source to adapt to the climate system.

### ***Recycled Water Use***

The California Recycled Water Policy, developed by the State Water Resource Control Board in 2009, includes a goal of substituting as much recycled water for potable water as possible by the year 2030. Recycled water is a sustainable, climate resilient local water resource that could significantly help to meet water management goals and objectives, and assist in meeting the seasonal water demands of agriculture. Water recycling also provides a local supply that generally uses less energy than other water supplies, helping to mitigate climate change impacts through associated GHG emissions. Beside to what is being negotiated between the City of Merced and MID as mentioned earlier, recycled water used for agricultural purposes and urban landscape irrigation, and expanded use will be encouraged and explored as opportunities arise.

### ***Improve Water Quality***

Groundwater remediation, matching water quality to use, pollution prevention, salt and salinity management, and urban runoff management can help improve water quality for all uses. These strategies may help MID to adapt water quality impacts from climate change on the district level. They may also contribute to providing additional supplies; for example, storm water capture and reuse would reduce

pollution and also provide a seasonal source of irrigation water for urban landscaping or groundwater recharge. Water quality performance metrics for this RMS could include stream temperature, dissolved oxygen content, and pollutant concentrations (CDM 2011).

### ***Pollution Prevention***

In recent years, as point sources of pollution have become regulated and controlled, “non-point source” (NPS) pollution has become a primary concern for water managers. NPS pollution is generated from land use activities associated with agricultural development, forestry practices, animal grazing, uncontrolled urban runoff from development activities, discharges from marinas and recreational boating activities, and other land uses that contribute pollution to adjacent surface and groundwater sources. The East San Joaquin Water Quality Coalition (ESJWQC), which MID is a member of, will continue to assess the level of surface water quality in the region and to monitor any changes that could occur due to the negatives effects of climate change.

More severe flooding patterns and frequencies due to climate changes will invariably contribute to higher debris flows and sedimentation loads. There are several multi-purpose storm water capture, recharge, and reuse projects that have been proposed in the Merced IRWMP by other agencies and MID to address this issue. These detention storage basin projects allow sediments and potential contaminants to settle out before entering the distribution system for usage. Protecting water supply sources will help to ensure that long-term sustainability of those supplies.

### ***Salt and Salinity Management***

Accumulation of salts in soil can impair crop productivity, making salinity management a critical concern for the District’s highly productive agricultural industry. Several potential benefits of establishing or improving salt and salinity management include protecting water resources and improving water supplies, securing, maintaining, expanding, and recovering usable water supplies, and avoiding future significant costs of treating water supplies and remediating soils. Salt and salinity management strategies identified by the *California Water Plan Update 2009* include:

- developing a regional salinity management plan, and interim and long-term salt storage, salt collection, and salt disposal management projects;
- monitoring to identify salinity sources, quantifying the level of threat, prioritizing necessary mitigation action, and working collaboratively with entities and authorities to take appropriate actions;
- reviewing existing policies to address salt management needs and ensure consistency with long-term sustainability; and
- collaborating with other interest groups to optimize resources and effectiveness;
- identifying environmentally acceptable and economically feasible methods for closing the loop on salt.

As part of the Merced IRWM planning process, MID and the region is developing information to support development of a salt and nutrient management plan. This will identify specific salt and salinity challenges within the region and strategies to help adapt to climate change by mitigating potential salinity increases associated with climate change.

### ***Forest Management***

Although MID does not have responsibility to manage the upland forested areas that drain to the Merced River watershed, protection of those lands is a vested interest of MID for ensuring high quality and quantity surface runoff supplies. Proper forest management would improve water quality and quantity,



help reduce wildfires, and improve ecosystem and habitat within the watershed. The University of California, Merced staff researchers and MID are currently collaborating in forest management studies that will hopefully improving water yield originating from the high mountain forested area. MID is also receiving a Flood-Coordinated Operation (FC-O) grant from the Department of Water Resources to install additional stream gages and precipitation stations upstream and within the boundary of the District to be used to better manage and forecast floods and to establish and confirm climate trends and evaluate hydroclimatic and geologic conditions. Another objective of the grant program is to improve flood forecasting by using forecasting tools such as a physically- based simulation model to operate the reservoir in real-time. With the help of a good forecasting tool, the impacts of climate change on river runoff and reservoir operations may be minimized. Water quality and sediment monitoring stations would allow quantification of the effects of climate change as well as forest management activities on surface water quality (CDM 2011).

***Other Strategies***

Additional conservation and demand reduction measures, such as crop idling, irrigated land retirement, and rain-fed agriculture could be implemented as adaptive management strategies.

*~End of Section~*



*New Exchequer Dam*

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## **SECTION 7. EFFICIENT WATER MANAGEMENT PRACTICES (EWMPs) (§10608.48)**

The purpose of this section is to identify EWMPs that will accomplish improved and more efficient water management.

Under the authority included under the California Water Code §10608.48(i)(1), the Department of Water Resources is required to adopt regulations that provide for a range of options that agricultural water suppliers may use or implement to comply with the measurement requirements in paragraph (1) of subdivision (b) of §10608.48. For reference, §10608.48(b) of the California Water Code states that:

*Agricultural water suppliers shall implement all of the following critical efficient management practices:*

- a. *Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph b.*
- b. *Adopt a pricing structure for water customers based at least in part on quantity delivered.*

### **7.1 Critical Efficient Water Management Practices (EWMPs) (§10608.48 (b))**

1. *Measure the volume of water delivered to customer with sufficient accuracy (§10608.48(b)(1))*

MID has been measuring the volume of water delivered to customers since 1993, when it adopted a volumetric rate for its water sales and charges for water by the acre-foot, in increments of 0.1 AF. With the exception of a few community laterals, all MID delivery points are measured. See Appendix F Water Measurement Documentation and Reporting, for a more detailed discussion of the various turnout types and their associated water measurement attributes as they relate to the Agricultural Water Measurement Regulation (Regulation).


- a. Collection of Water Measurement Data:
  - i. MID uses a state of the art, SQL based database application to manage its water measurement data for growers, including all water ordering, delivery and billing information by field.
  - ii. Growers are required to place a water order for planned irrigations. MID growers can place a water order by speaking with a Customer Service representative in person or on the phone, facsimile, an automated phone water ordering system, or through the mercedid.org web site. A grower would identify its Account Number (field), desired flow rate, time of start of delivery and duration, upon which the grower is provided a confirmation number for the request. MID Distribution System Operator (DSO) receives the request on a portable computer.
  - iii. Upon completion of the delivery, the flow, duration and subsequent volume, the DSO posts the information for billing.
- b. Frequency of Measurements:

Meter measurement configurations are typically read every one to two weeks. Meter gate measurement configurations are typically measured once during and irrigation and as needed depending on changing conditions.

c. Methods for Determining Irrigated Acres

Prior to the first irrigation, all MID customers have to submit an irrigation application which includes acreage, cropping, and method of irrigation. See Figure 7.1, Application for Irrigation Water. MID personnel further verify all data in the field and apply appropriate modifications to the account.

**Figure 7.1: Application for Water Application**



www.mercedid.org

## Application for Irrigation Water

Mailing Address: P.O. Box 2288  
Merced, CA 95344-0288  
Main Office: (209) 722-2720  
Automated: (800) 750-2720  
Main Office: 744 W. 20th Street,  
Merced, CA 95340

---

**Customer Information**

Joe Farmer  
99 Farmland Lane  
Merced, CA 95340

Customer #: 999999  
Contact Phone: (209) 999-9999

---

**Water Account Information**

Please verify information in each column below. If corrections are needed, line through incorrect information and write-in correct updates. If column is blank, please write-in information accordingly.

**IMPORTANT**  
If you have a tenant leasing your property and their name is not listed below in column 12, you will need to complete a new Landowner Tenant Agreement (LTA) and submit it to MID Customer Service. LTAs should be mailed to MID Customer Service at the address above or faxed to (209) 722-1457.

Water Account (1)	Section/Facility (2)	Total Irrigated Acres (3)	1st Crop (change to "Fallow" if using transfer water during curtailment year) (4)	Irrigation System (Sprinkler, drip, micro, flood, etc) (5)	Parcel APN (6)	Parcel Acres (7)	Requested AF (8)	Private Well Crop (9)	Private Well Acres (10)	Farming / Leasing (11)	Tenant information on File (12)
FA#	Fairfield B Side / Hartley Lateral	11.70	Walnuts	Sprinkler	999999999A	11.70				Farming	Joe Farmer

---

**Notes and Signature**

1. This application must be submitted prior to ordering/receiving irrigation water.
2. Applicant shall abide by all Merced Irrigation District (District) Rules and Regulations Governing the Distribution of Water (Rules and Regulations) as a condition to water service. Applicant's signature below confirms that Applicant has received and read the Rules and Regulations, or that Applicant has waived reading same. If Applicant has not received a copy of the Rules and Regulations, Applicant is aware they are available from the Customer Service Department and is responsible for obtaining a copy and abiding by same.
3. Applicant, by the filing of the Application, hereby assumes the responsibility for the proper disposition of drainage water resulting from the use of water applied for, and agrees to hold the District harmless from any responsibility arising out of any damage or claim of damage from surface or subsurface drainage resulting from the user of the water applied.
4. Water furnished by the District under this Application is not treated to make it safe for drinking or stock watering purposes.
5. The terms of the Application and all Rules and Regulations shall apply to any subsequent verbal request for water which may be accepted by the District within this irrigation season.

Signature of Applicant - #999999 - Joe Farmer

Date

d. Quality Control and Quality Assurances Procedures:

- i. MID DSOs are responsible for the delivery at every gate in the District. They determine set flows and measure volumes based on that.
- ii. A Senior Distribution System Operator checks the values and approves the final posting.

- iii. Upon the receipt of the posted values, Customer Service in turn checks the growers' accumulated deliveries since the start of the season and compares it to MID Board's set allocation, then provides the DSO with instructions as a grower approaches its maximum allotted volume.
- e. Measurement with compliance with §597.3(b), as outlined in Section §597.3(b)(2) and Section §597.4(b)(2) and Frequency.
  - i. Turnouts with meter gate measurement configurations are typically measured once during and irrigation and as needed depending on changing conditions.
  - ii. Turnouts with meter measurement configurations are typically read every one to two weeks.
  - iii. See Appendix F, Water Measurement Documentation and Reporting, for a more detailed discussion of the various turnout types and their associated water measurement attributes as they relate to the Agricultural Water Measurement Regulation.

**Figure 7.2: Fixed Orifice Plate**



2. Volumetric Pricing (§10608.48(b)(2))

- a. Since 1993, MID has charged its growers volumetrically, in increments of 0.1 Acre-foot. In March 2013, the MID Board of Directors approved a \$5/AF rate increase (in accordance with Proposition 218), resulting in the current water volumetric price equal to \$23.25 per AF. MID also charges a Standby Fee of \$24 per acre-foot. The Standby Fee is collected from all irrigable lands within the District regardless if they received deliveries from MID.
- b. MID’s rate for supplemental water made available through conjunctive groundwater pumping supply is currently \$73.25 per AF.
- c. MID’s water rate for urban landscaping and other similar raw water deliveries is currently \$125 per AF.

**Table 7.1 MID Efficient Water Management Practices**

**Critical EWMPs**

<b>Water Code Reference No.</b>	<b>EWMP</b>	<b>Implementation Status</b>	<b>Implementation</b>	<b>Planned Activities</b>
10608.48.b (1)	Measure the volume of water delivered to customers with sufficient accuracy	Implementing	See Appendix F, Water Measurement Documentation and Reporting	See Appendix F, Water Measurement Documentation and Reporting, for planned activities.
			See the above discussion in Section 2 and Section 6, and in Appendix F for MID practices and procedures as they relate to the Agricultural Water Measurement Regulation.	Continue to establish corrective measures and meet required accuracies.
10608.48.b (2)	Adopt a pricing structure based at least in part on quantity delivered	Implementing	MID Board adopts rate per AF for various uses in-District, including surface water deliveries to ag, urban, out-of-District, and supplemental water made available through conjunctive groundwater pumping.	Continue long standing volumetric pricing. Periodically review long term O&M and capital needs and ensure pricing is sufficient to properly maintain system, taking into account other revenue sources.

<b>Conditional EWMPs</b>				
<b>Water Code Reference No.</b>	<b>EWMP</b>	<b>Implementation Status</b>	<b>Implementation ,</b>	<b>Planned Activities</b>
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 applicable	Lands with exceptional high water duties or whose irrigation contributes to significant problem including drainage does not exist within MID.	Not Applicable
10608.48.c (2)	Facilitate use of available recycled water.	Implementing	MID is in discussion with the City of Merced regarding using portion of the City’s waste water effluent. Other effluent sources are not available, either because water is already committed to a third party or it is not tertiary treated.	Culminate discussions with the City of Merced.
10608.48.c (3)	Facilitate financing of capital improvements for on-farm irrigation systems	Implementing	<ul style="list-style-type: none"> <li>• MID Groundwater Incentive Program</li> <li>• MID Water Conservation Program</li> <li>• Technicians available to help growers</li> <li>• Educational workshops, newsletters and MID website.</li> <li>• Make presentations at the Farm Bureau, UC extension and other similar local activities</li> </ul>	Continue to implement

<p>10608.48.c (4)</p>	<p>Implement an incentive pricing structure that promotes one or more of the following goals identified in the CWC</p>	<p>Implementing</p>	<ul style="list-style-type: none"> <li>• In 2012, MID Board raised price for deliveries over 2.5AF/AC.</li> <li>• In 2013 MID Board raised rate by 27percent</li> <li>• MID has raised its rates by 69percent since 2006.</li> <li>• Conjunctive Use/Increase Groundwater Recharge - Water rate is generally close to cost of pumping groundwater, The rate encourages growers to use surface water or dry water depending on the surface water status.</li> <li>• Recharge- reasonable in-basin out-of-District water rate in years of available surface water supply.</li> </ul>	<p>The Water Resources Management Plan will address rates.</p>
<p>10608.48.c (5)</p>	<p>Expand line or pipe distribution systems, and construct regulating reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage</p>	<p>Implementing</p>	<ul style="list-style-type: none"> <li>• MID regularly adopts projects for pipelines and/or canal lining under its CIP or extra ordinary maintenance budget.</li> <li>• Pipelined approximately 13 miles of open laterals since 2002.</li> <li>• Capital projects over the last 3 years have combined to reduce or eliminate operational spills and seepage a total of 10,000 AF annually</li> <li>• District has a combined total of 3,590 AF in regulating reservoir space.</li> <li>• Has a number of regulating basins and added two more basins for a total of 300 AF since 2002.</li> </ul>	<p>MID’s Water Resources Management Plan will include a system evaluation and modernization plan, including regulating reservoirs where applicable. The plan will also address funding and prioritization.</p>



10608.48.c (6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits	Implemented	<ul style="list-style-type: none"> <li>• Around the clock water order service with operators, voice activated system, facsimile, or the web.</li> <li>• Custom delivery where each irrigation could differ in flow rate, duration, and start of irrigation.</li> <li>• Offers limited on-demand, constant flow, and arranged on-demand irrigation service.</li> <li>• Growers can query their delivered water online.</li> <li>• Flexible distribution system.</li> </ul>	MID will continue to improve flexibility to its water ordering.
10608.48.c (7)	Construct and operate supplier spill and tailwater recovery systems	Implementing	<ul style="list-style-type: none"> <li>• MID completed projects automating canals to effectively intercept flows from up-gradient laterals that otherwise would have otherwise ended in a natural streams.</li> <li>• Constructed canals and pipelines to move operational discharges to areas of water commitment, such as the Casebeer Extension to Merced National Wildlife Refuge.</li> <li>• Pipelined laterals and backed up flows away from traditional spill such as the recently completed Garibaldi Lateral Spill to Merced River.</li> </ul>	The District will continue to identify projects that would recover operational spill and tailwater. The Water Resources Management Plan will address these projects.

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10608.48.c (8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area	Implementing	<ul style="list-style-type: none"> <li>• Completed studies regarding expanding groundwater fields. Study recommendation did not recommend well construction.</li> <li>• MID Groundwater Conservation Incentive Program, growers revert to groundwater in years of surface water shortage.</li> <li>• In-Lieu Recharge: Reduce base line pumping by management actions, Highlands Pilot Project, Low Head Boosters replacing deep wells, increased system flexibility to compete with groundwater in non-dry years.</li> <li>• Construct Recharge basins which are left idle during droughts.</li> </ul>	MID's conjunctive use program is extensive and leading edge. MID will continue to expand all the components of its conjunctive use program.
10608.48.c (9)	Automate canal control structures	Implementing	<ul style="list-style-type: none"> <li>• Completed 85 projects automating control structures since 2002.</li> <li>• MID installed 23 SCADA site in 2002, which were expanded by 19 more sites since.</li> <li>• Tabled topped and pipelined canals</li> </ul>	Will continue to expand its control structure automation. Projects will be identified under the Water Resources Management Plan.
10608.48.c (10)	Facilitate or promote customer pump testing and evaluation	Implementing	<ul style="list-style-type: none"> <li>• MID senior Distribution System Operators are trained to perform pump tests.</li> <li>• Performed more than 500 pump tests since 2002.</li> <li>• Staff provides information and education to District's growers.</li> </ul>	Will continue to perform and promote pump testing.
10608.48.c (11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	Implementing	<ul style="list-style-type: none"> <li>• Hicham ElTal appointed as WC Coordinator effective-December 15, 1998.</li> </ul>	Complete

10608.48.c (12)	Provide for the availability of water management services to water users.	Implementing	<ul style="list-style-type: none"> <li>• MID operates and maintains a CIMIS station with a link on its website</li> <li>• MID has a full-time Engineering Technician dedicated to support growers.</li> <li>• Educate growers on how to order varied water orders to better manage their operation.</li> <li>• Provides growers with monthly bills.</li> <li>• On-line web page for growers to review their existing deliveries over all their individual fields and plan to stay within the water allocation for the season.</li> </ul>	Will continue to pursue
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.	Implementing	<p>MID owns its own storage at Lake McClure. Since the creation of the Independent System Operator (ISO), MID had to make diversions forecasts 48 hours in advance which tested all MID’s regulating systems. For the 2013 irrigation season, MID has dropped that to 24 hours through coordination with the Hydro personnel.</p> <p>MID has its own groundwater wells that are always on standby. The Water Operations Superintendent authorizes the DSOs the wells to be operated in a given period. DSOs are free to engage the authorized wells for the highest efficiency.</p>	MID will continue to increase its coordination with all parties towards maximum system flexibility
10608.48.c (14)	Evaluate and improve the efficiencies of the supplier’s pumps.	Implementing	The District Engineering Department and the Pump Department work on continually upgrading wells and boosters through system evaluations and pump	The District plans to install more than 150 motor savers within the next 5 years. Currently installing VFD’s on certain pumps.

			tests, see Table 5.2.	<p>The District plans to upgrade Booster Station #2</p> <p>The timing and financing of the upgrade will be addressed through the proposed Water Resources Management Plan.</p> <p>The District has plans to install motor savers on all its wells and boosters in addition to a major upgrade to its Booster Station #2 facilities which has a maximum combined capacity of 270 cfs.</p>
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## 7.2 Conditional Applicable Efficient Water Management Practices (§10608.48 (c))

Table 7.2 identifies current conditional applied EWMPs and their experienced benefits. A discussion of each follows the table.

<b>Table 7.2 Current Efficient Water Management Efforts</b>							
Conditional EWMP	(Check if results were experienced)						
Water Management Plan	Less Applied Water (AF)	Inc. System Eff.	Better Water Qual..	Inc. Yield	Inc. Crop Qual	Reduce Ops Costs	Other
EWMP 1 -Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Applicable						
EWMP 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.	Pending						
EWMP 3- Facilitate financing of capital improvements for on-farm irrigation systems	X			X	X	X	Less Weeds
EWMP 4 -Implement an incentive pricing structure that promotes one or more of the goals identified in the CWC	X						
EWMP 5- Expand line or pipe distribution systems, and construct regulating reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage		X	X	X	X	X	Saves Energy
EWMP 6 - Increase flexibility in water ordering by, and delivery to, water customers within operational limits	X			X	X		N/A
EWMP 7 - Construct and operate supplier spill and tailwater recovery systems		X	X				
EWMP 8 -Increase planned conjunctive use of surface water and groundwater within the supplier service area							Inc. Resource Reliability
EWMP 9 -Automate canal control structures		X	X	X		X	
EWMP 10 Facilitate or promote customer pump testing and evaluation	X						
EWMP 11 - Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	X	X	X	X	X	X	
EWMP 12 - Provide for the availability of water management services to water users.	X	X		X	X	X	

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EWMP 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.	X	X	X				
EWMP 14 - Evaluate and improve the efficiencies of the supplier's pumps.		X				X	

EWMP 1. Facilitate Alternative Land Use (§10608.48(c)(1))

Response: *Not Technically Feasible.*

Discussion: Lands with exceptionally high water duties or whose irrigation contributes to significant problems are not found within the District boundaries, nor within the District Sphere of Influence. Furthermore, MID's rules and regulations prohibit wasteful use of water, preventing exceptional water duties or significant problems from occurring.

Irrigated farming at MID is the primary land use. The District's water management policies allow farmers flexibility in selecting crops to maximize the benefits of this land use. Groundwater recharge from deep percolation contributes to the water supplies used by urban areas and low density rural human dwellings and, thereby, supports existing urban land uses.

EWMP 2. Facilitate Use of Available Recycled Water (§10608.48(c)(2))

Response: *Implementing*

Discussion: Most existing wastewater sources in the vicinity of MID are currently not acceptable for MID irrigation applications with the exception of the cities of Atwater and Merced. The City of Atwater has contracted with a private landowner for use of the City's entire waste stream. The City of Merced updated its Waste Water Treatment Plant in 2012 to produce tertiary treated effluent. The City already utilizes a portion of the effluent for an irrigation operation owned and managed by the City in addition to a mandated wetland application. MID is currently in discussion with the City to utilize uncommitted effluent for District's purposes.

MID use of the potentially received recycled water would be consistent with the Merced Groundwater Basin Groundwater Management Plan. Per the plan, recycled water should be applied to areas generally down gradient of the existing discharge for concerns regarding introducing pharmaceutical components in urban areas.

As for the city of Livingston, it utilizes percolation at its current WWTP with no available discharge. The District will continue to identify opportunities for use of recycled water that conform to regulatory standards.

EWMP 3. Facilitate Financial Assistance (on-farm capital improvements) (§10608.48(c)(3))

Response: *Implementing*

Discussion: MID currently has an active financing program to support on-farm improvements as part of MID's Groundwater Conservation Incentive Program which is consistent with the water management objectives of the District, namely conjunctive use. Growers receive up to \$200 per acre to apply towards on farm improvements needed to take surface water from the MID during

years of available surface water and utilize their groundwater wells during years of surface water shortages. The funds could be applied to filters, pumps, structures, valves and all other means needed to facilitate using surface. The program proved most beneficial for users utilizing flood irrigation from groundwater wells. The program assisted 540 acres since its inception in 1997.

MID's Water Conservation Program provides growers with a standard delivery gate if the parcel decided to return to surface water and had no delivery.

Furthermore, the District has an assigned Engineering technician who provides growers with professional recommendations in regards to on-farm improvements to their system as that may relate to MID operations. Growers benefit in the design and construction of their intakes, type of pump, screening, backflow, backflow prevention and filtration systems.

MID holds workshops partially sponsored by various local irrigation integrators for the education and benefit of MID growers.

#### EWMP 4. Incentive Pricing Structure (§10608.48(c)(4))

Response: *Implementing*

Discussion: MID is implementing incentives and pricing related to the components identified in the CWC.

##### A. More Efficient water use at the farm level (§10608.48(c)(4)(A))

MID has progressively increased water rate prices. Since 2002, MID water rates increased 69 percent from \$13.75/AF to \$23.25/AF in 2013. The Standby Fee of \$24/AF was not changed.

In 2013, the MID Board increased the price of supplemental water supplied made available through conjunctive groundwater by approximately 300 percent, from \$23.25/AF to \$73.25/AF.

MID charges for all water ordered. For example, if a grower requested during his water order to terminate his irrigation at a certain time but opted to turn off his pump prior to the agreed time, MID will charge him for all water ordered. However, MID will not charge the grower if he properly notified the DSO of his plan to end the irrigation early. The same applies for growers who start later than the requested time for delivery.

##### B. Conjunctive Use of Groundwater (§10608.48(c)(4)(B))

MID's pricing policy is integrated with the District's conjunctive management strategy. For example, the standby charge assessed across the District encourages growers to use surface water when it is available and conserves groundwater until it is needed. Also, the price per acre-foot is generally designed to compete with groundwater pumping costs, which is more readily suitable for low volume irrigation system for most crops. Background on the District's water pricing is presented above

MID's Groundwater Conservation Incentive Program provides growers a monetary incentive of up to \$200/AF to connect a parcel relying on groundwater to District Surface Water System. The program requires the purchase of a minimum of 3 AF/Acre in years of available

surface water supply for up to 8 years of commitment. Growers joining the program have to maintain their existing private well on standby. When the Board establishes allocations less than 3AF/Acre these growers are expected to use their private groundwater wells. MID provides all technical services including required agreements for this program at no cost to the grower. In addition, MID provides a flow meter with a totalizer to the grower above and beyond the monetary incentive.

C. Increase Groundwater Recharge (§10608.48(c)(4)(C))

MID allows a higher allocation during years of available surface water supply. In addition, MID allows growers to set their flow rate, duration, and time of irrigation for every water request.

MID has a strategy of water transfers within the groundwater basin designed at reoperating Lake McClure and promoting In-Lieu Recharge in the basin. Transfers to properties outside the District and within the Sphere of influence have been implemented since the 1980s. MID offers growers a reasonable water rate that is set annually by MID Board of Directors for its pre-1914 water deliveries. In 2010 the rate was at \$42/AF. In contrast, the District does not offer water in years of low surface water availability such as 2012 and 2013. This program provides for in-lieu recharge, as most growers within the SOI rely solely on groundwater when MID surface water is not available.

MID is also seeking, through an IRWMP implementation grant application to perform a Land Spreading Program for storm flows directed from Mariposa Creek.

D. Reduction in problem drainage (§10608.48(c)(4)(D))

Generally MID has no problem drainage within the MID as almost all growers, including the District, abide by the Irrigated Lands Regulatory Program. There are no tile drains. In addition MID does not allow drainage to its manmade system, and direct drainage to natural streams is intercepted by various District instream facilities for reregulation and reuse.

Furthermore, MID staff provides consultation to growers in regards to their tailwater recapture systems.

E. Improved Management of Environmental Resources (§10608.48(c)(4)(E))

Per MID Rule Book, MID can deny grower service in the case of causing harm to other land.

F. Effective management of all water resources through the year by adjusting seasonal pricing structures based on current conditions. (§10608.48(c)(4)(F))

As discussed in paragraphs A, B and C, the MID Board has changed pricing per conditions at hand. An example would be reasonably priced transfer water for out-of-District in-basin growers in years of available water supply in contrast to raising rates, as occurred in 2013, for supplemental water made available through conjunctive groundwater pumping.

In 2012, the MID Board raised the price by \$5/AF for water use above 2.5 AF/AC for the duration of the season to encourage growers' efficiency.



G. EWMP 5. Lining or Pipelining Distribution System and Construct Regulatory Reservoirs (§10608.48(c)(5))

Response: *Implementing*

Discussion: MID has a robust capital improvement plan combined with rules for encroachment by land development that maintains a steady increase in the footage of lined canals and pipelines. In addition, MID plans to increase the network of regulating reservoirs within its water distribution system.

MID has constructed pipelines to back up or reroute water in the system thereby eliminating or reducing historical operational discharges, and to allow for better service response time for dead-end, open laterals. Pipelining canals has also been practiced for safety purposes I terms of flood risk to urban residents, or when an agricultural area is urbanized. During the last decade, MID managed more than \$54 million of projects related to land development where the vast majority was dedicated to pipelining 13 miles of open channels. MID has completed more than 2.5 miles of pipelines designed to address a combination of the above purposes just in the past three years. MID has lined and relined more than 4 miles of canals in the last three years.

Since the early 1990s, the District has constructed, through automation or actual construction a number of regulating basins. As shown on Table 2.3, MID owns and operates nine regulating basins with a combined effective regulating total capacity of 3,590 AF. By automating outlets at local dams and check structures, MID converted static pools into regulating buffer reservoirs. Into this category falls Lake Yosemite, Crocker Dam, Puglizavech Dam, El Nido Dam, and Castle Dam. Also by automation, MID enhanced existing basins such as Livingston Canal Pool, and El Nido Reservoir.

Since 2002, MID increased its inventory of regulating basins by two with a combined capacity of 300 AF, namely The Livingston Automatic No. 2, and El Nido Reservoir. The District is in the process of designing and constructing a 100 AF off-canal regulating reservoir off the McCoy Lateral. In addition, the District is studying possible off-canal regulating reservoirs off the North Side Canal and the Casebeer Extension lateral. Beyond these projects MID has plans to increase the number of basins in the next few years based on a prioritization provided by the modernization components included in the aforementioned Water Resources Management Plan.

H. EWMP 6. Increased Flexibility to Water User (§10608.48(c)(6))

Response: *Implementing*

Discussion: MID offers the following water ordering and delivery options to customers as feasible:

- Full on-demand delivery in specific district system areas where approved farmers can draw water on demand without notification to the District;
- Arranged on-demand delivery where farmers place routine calls to notify the control center that they are taking delivery;
- Constant flow delivery to large farms that distribute the delivered water among farm fields which applies mostly to rice farming and large fields, and
- Normal service where farmers place orders for water. Under this option, delivery is guaranteed within four days and normally received within 24 hours. Between 75 and 80 percent of accounts fall under this option.

The above flexibilities have been curtailed during years of limited surface water supply as needed to optimize usage of the facility and reduce seepage. In addition to the different form of deliveries, MID offers growers flexibility in ordering water:

- MID grower may request different flow rates, duration of irrigation, and start of irrigation at every water order request. MID staff has to meet the request within 72 hours from the start of irrigation. MID staff prides itself on meeting most requests within 24 hours of the requested start of irrigation. Delivery timing may be impacted in droughts in an effort to increase overall system efficiency.
- Growers can interact with Customer Service’s personnel during work hours. In addition, growers can make orders 24-hours per day, seven days a week during the irrigation season via telephone (Interactive Voice Recognition, IVR), fax, and internet through a special web applications. MID has also provided a phone app for water ordering.
- Real-time computerized water ordering and delivery information that helps personnel track status of delivery by DSOs and their supervisors.
- Improvements to remove constraints in system capacity, and
- Improvements to in-canal storage facilities enabling them to operate as regulating reservoirs:

I. EWMP 7. Construct/Operate Tailwater and Spill Recovery Systems (§10608.48(c)(7))

Response: *Implementing*

Discussion: Most MID lands and laterals drain to local streams, which also serve as MID water conveyance facilities. Hence, a significant percentage of irrigation return flows and lateral operational discharges are automatically captured and re-regulated for supply. The Livingston Canal, Fairfield Canal, El Capitan Canal, and the Dean Canal/Casebeer system are totally automated and are designed to intercept operational discharges from laterals that terminate at these facilities. Changes include automating, improving, and possibly extending interceptor canals to reduce operational discharges and tailwater.

MID eliminated its historical dependence on major spills by automation and constructing facilities that move water to other facilities rather than natural streams to direct such flows to meet a downstream commitment. Examples include:

- The Hartley Lateral to El Capitan Canal pipeline and SCADA sites that eliminated spills to the Hartley Sough,
- Casebeer Lateral Extension eliminated dependence on the spill to Duck Slough and moved flows to Deadman Creek to meet the District’s commitment to the Merced National Wildlife Refuge.
- Automation and improvement completed to eliminate dependence on the Livingston Canal Spill.
- Connecting the Garibaldi Lateral “A” to the McCoy Lateral to eliminate dependence on the Garibaldi Spill.

MID continues to reduce operational discharges through projects identified in its five year capital budgets, and will be identified through the Water Resources Management Plan.

J. EWMP 8. Optimize Conjunctive Use (§10608.48(c)(8))

Response: *Implementing*

Discussion: MID has no alternative water supply sources other than its surface water and groundwater resources. During droughts, MID commissions its conjunctive groundwater pumps to supplement its surface water supply. The vast majority of these wells remain dormant during years of adequate surface water supply. Use varies between a peak of 52 percent of irrigation supply generated by groundwater during 1977, a severe drought year, to wet years when less than one percent of irrigation demand was met by groundwater such as 2011.

In 2002, the District completed a Prop 204 funded study to explore constructing a well field in the 25,000 acre southeast quadrant of its service area. The study recommended against development of a well field due to a limited aquifer, as based on geographic location and geologic conditions.

In addition to limited supplies in certain parts of the basin, consistent conversion of grazing lands to irrigated lands outside the District exacerbates groundwater supply conditions. The urban centers in the basin also expanded in the early 2000s replacing surface water usage (Irrigation) by groundwater usage (Urban) as all urban areas are dependent of groundwater. Groundwater levels continue to drop despite recharge through its distribution system and farm applications.

In response, the District has continued to expand its existing conjunctive use efforts by expanding its incentive for conjunctive use, in-lieu recharge efforts, and direct surface water recharge through recharge spreading basins.

Incentives for Conjunctive Use:

1. Groundwater Conservation Incentive Program:

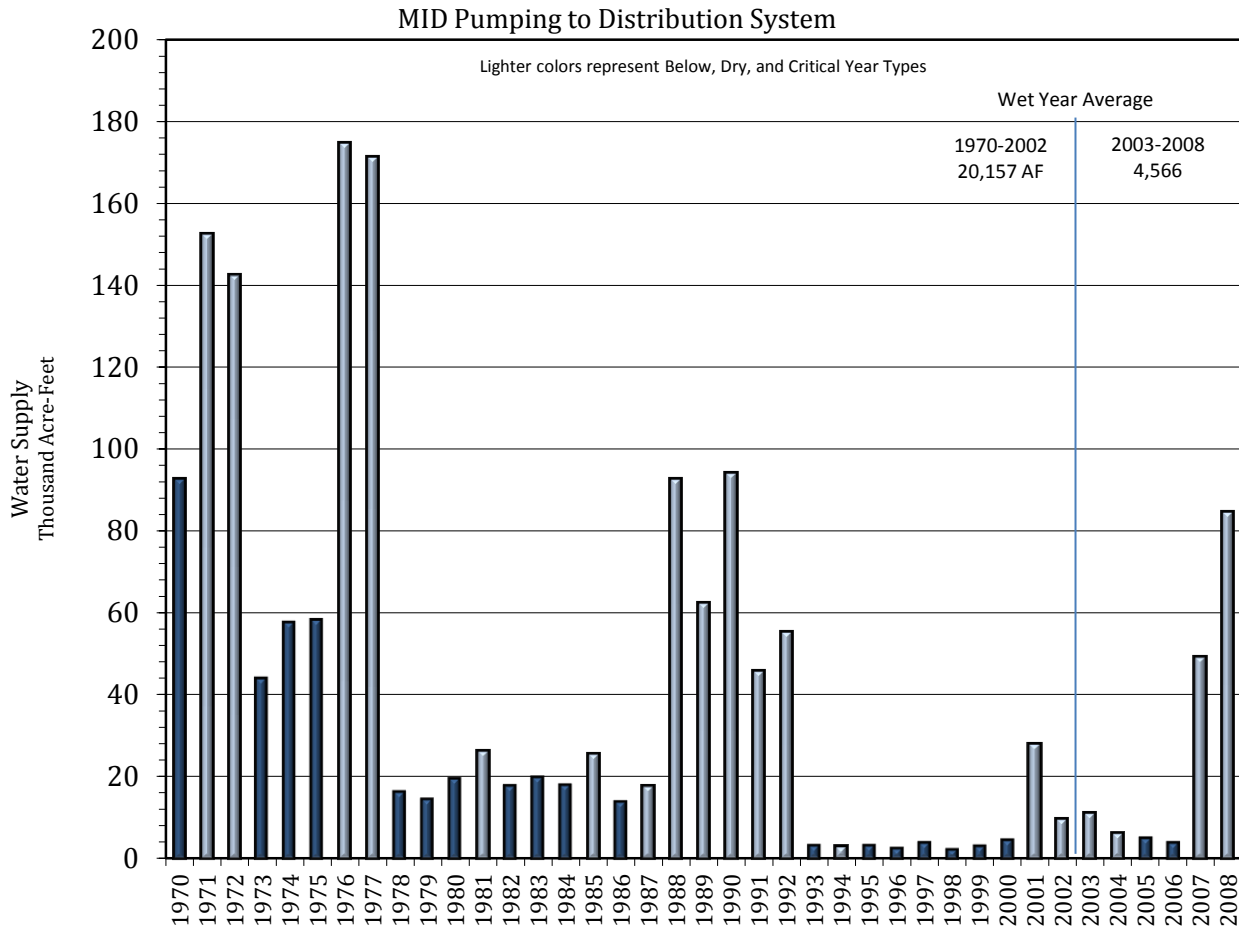
This program assists growers who use groundwater wells to convert to MID surface water conditioned on a commitment from the grower to purchase surface water for so many years. The incentive amount expands and contracts based on the years of commitment which maxes at eight years. However, years of surface water shortages do not count as the grower is expected to return to groundwater pumping. The program started in 1997 and since then:

- a) Total acres joined: 5,472 acres
  - b) Groundwater saved per year 16,146 AF
  - c) Total GW saved since the inception of the program: 117,800 AF
2. Pricing incent as discussed in Incentive Pricing Structure, Conjunctive Use of Groundwater (§10608.48(c)(4)(B))

In-Lieu Recharge

1. Reduction in Base-Line Pumping: MID reduced its based-line groundwater pumping in years of adequate surface water supply by 11,000 AF annually, as seen in Figure 7.2. MID average annual base-line pumping prior to the late 1980s drought was around 19,000 AF. MID reduced annual groundwater pumping by directing the DSOs not to use groundwater wells in years of adequate surface water supply, except to service highground areas that cannot be serviced by the gravity system.

**Figure 7.2: MID Pumping to Distribution System**



2. Highlands Pilot Project: Similar to the incentive program, except MID did not only replace surface water with groundwater in years of adequate surface supply, but also provides pressurized filtered water at the farm since 1996. The average usage has been 1,300 AF annually.
3. Low Head Boosters Serving High Ground Areas: The base-line pumping is mainly generated from wells serving high grounds that cannot receive gravity water from surrounding canals. MID installed a number of low head boosters where water is pumped to these high ground islands in years of adequate surface water supply. Currently, the overall in-lieu recharge volume is around 4,000 AF annually.
4. Encouraged reducing private groundwater pumping by increasing the flexibility of the system. By allowing changing water orders and delivering flows as close to the time requested, growers tended to use less groundwater in years of available water supply.

Recharge Basins: MID applies water to the basins in years of available surface water supply. No recharge is applied during years of surface water shortages, except when intercepting runoff generated from local precipitation. MID did not deliver water to recharge basins in 2012 and 2013 due to the hydrology.

1. Cressey Recharge Basin: The basin yield can be as high as 21 AF per day or 4,500 AF during the irrigation season .

2. El Nido Recharge Basin: The basin could receive water year round. On average, the basin could receive 800 AF outside the proper irrigation season and 2,950 AF during the irrigation season for a total of 3,750 AF annually.

Activity	Average
Reduced Overall Usage of MID owned and operated Groundwater wells	11,000
Reduced Base Line Pumping – Low Head Boosters Serving High Grounds	1,700
Merced Highlands Pilot Project	1,350
Merced Groundwater Conservation Incentive Program	4,365
Sphere of Influence Sales	15,400
Cressey Recharge Basin	4,500
El Nido Recharge Basin	3,750
Total	40,365

The District has participated in development of a regional AB 3030 Groundwater Management Plan. Local groundwater management objectives include maintenance of average groundwater levels at elevations similar to those observed in 1999, reduction of groundwater pumping during years when surface water is abundant and allowing use of groundwater during dry years adequate to meet local demands. These objectives are becoming harder to meet with the rise in agricultural development outside the District and urban expansion both totally dependent on groundwater. Ongoing regulatory proceedings that threaten to take additional surface water for instream purposes also threatens MID’s conjunctive use activities.

MID is actively pursuing grants under the IRWM funding for in-lieu recharge projects by intercepting excess flood flows in coordination with other entities in the basin.

K. EWMP 9. Automate Canal Control Devices (§10608.48(c)(9))

Response: *Implemented.*

Discussion: MID applies automation to all new improvements. For example, new projects are automated by table topping facilities (level top canals) constructing of pipeline or the installation of long crested weirs. In addition, MID has installed numerous automated gates at head of laterals and check structures.

Since 2002 MID has installed automation features as shown on Table 7.4.

Automation Feature	Applied Control	No. of Gates Installed
ITRC Flap Gate	Level	20
Langmann Gate	Level	3
Lopac Gate	Level	16
Rubicon Flume Gate	Level/Flow	13
Rubicon Slip Gate	Level/Flow	2
Downward Opening Weir Gate	Level	9
Long Crested Weirs	Level	22

Expansion of SCADA Facilities

The District completed the first phase of its SCADA system in the summer of 1997. The system serves to monitor and control facilities to better manage flows and water levels that support each of the system and operation improvements described above. In addition to the above capabilities, SCADA may be utilized to maintain minimum District compliance flows in the Merced River, to monitor storm runoff in creeks and canals, and to obtain information useful to MID and growers via the local CIMIS station. It is expected that eventually, every major discharge point in the District will have a SCADA station. By 2002, MID had installed 23 SCADA sites, since then the District installed 19 additional sites.

MID now has SCADA facilities operating with 24-hr attendance. DSO and managers have real time access to SCADA through portable computers that can be operated from vehicles in the field.

The District is pursuing local automation on most control structures whenever feasible. MID has plans to complete three more sites in 2013-2014.

L. EWMP 10. Facilitate or promote customer pump testing and evaluation (§10608.48 (c)(10)).

Response: *Implementing*

Discussion: The MID has a staff in the Engineering and Water Operations departments o manages the pump testing in MID. Table 7.5 lists the number of pumps tested in the years between 2002 and 2013.

Year	MID			Private		
	Wells	Boosters	Total	Wells	Boosters	Total
2002	11	2	13	2	1	3
2003	58	29	87	0	0	0
2004	1	2	3	0	0	0
2005	36	21	57	0	0	0
2006	19	11	30	0	0	0
2007	68	6	74	4	0	4
2008	1	0	1	1	0	1
2009	0	0	0	8	0	8
2010	0	0	0	4	0	4
2011	0	25	25	0	0	0
2012	12	16	28	0	36	36
2013	119	5	124	0	4	4

MID provides support to MID growers by promoting pump testing and undertaking workshops attended by local professionals.

M. EWMP 11. Designate a water conservation coordinator (§10608.48 (c)(11)).

Response: *Implementing*

Discussion: Hicham EITal P.E. was appointed as Water Conservation Coordinator on December 15, 1998. His current position is Deputy General Manager for Water Supply/Rights

N. EWMP 12 Provide for Availability of Water Management Services (§10608.48 (c)(12))

Response: *Implementing*

Discussion: MID supports CIMIS Station No. 148 and provides links to CIMIS data over the MID website. The District also supports a full-time Engineering Technician who is dedicated to support growers' irrigation needs.

As part of its water management services, the District provides delivery rates and times that are flexible and responsive to customer orders. The District also provides customers with monthly bills reporting water usage. A web page allows a grower to trace the more recently posted consumption for all of its water accounts (fields).

MID staff attends workshop and coordinates with the UC Extension regarding growers' education.

O. EWMP 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. (§10608.48 (c)(13))

MID owns its own storage at Lake McClure. Since the creation of the Independent System Operator (ISO), MID had to make diversions forecasts 48 hours in advance which tested MID's regulating systems. For the 2013 irrigation season, MID has dropped that to 24 hours through coordination with the Hydro personnel.

As for the groundwater supply, MID has its own battery of conjunctive groundwater wells that are always on standby. The Water Operations Superintendent authorizes the wells to be operated, when DSOs are then free to engage them for the highest efficiency.

P. EWMP 14 Evaluate and improve the efficiencies of the supplier's pumps. (§10608.48 (c)(14)).

The District Engineering Department and the Pump Department work on continually upgrading wells and boosters through system evaluations and pump tests, see Table 5.2.

The District has plans to install motor savers on all its wells and boosters in addition to a major upgrade to its Booster No. 1 facilities, including the installation of a VFD, which has a maximum combined capacity of 270 cfs.

Q. On-farm irrigation and drainage system evaluations (§10608.48)

*~End of Section~*



*The El Capitan Canal*



## **APPENDICES**

*APPENDIX A: RULES FOR DISTRIBUTION AND USE OF WATER*

*APPENDIX B: MERCED IRRIGATION DISTRICT ROOT ZONE MODEL*

*APPENDIX C: MERCED IRRIGATION DISTRICT INTERPRETIVE SUMMARY OF THE ANNUAL WATER BALANCE*

*APPENDIX D: MERCED IRRIGATION DISTRICT LICENSES FOR DIVERSIONS AND USE OF WATER (WATER RIGHTS)*

*APPENDIX E: MERCED GROUNDWATER BASIN GROUNDWATER MANAGEMENT PLAN UPDATE*

*APPENDIX F: WATER MEASUREMENT DOCUMENTATION AND REPORTING*

*APPENDIX E: OTHER DOCUMENTATION*

- Public Notice
- Board Resolution – Plan Adoption

*APPENDIX H: DISTRICT MAP*

**APPENDIX A**  
**RULES FOR DISTRIBUTION AND USE OF WATER**

The MID Rules and Regulations Governing the Distribution of Water is available on the MID website at <http://www.mercedid.org/default/assets/File/WaterRules.pdf> or available on hard copy at the MID Main office, 744 W. 20<sup>th</sup> Street, Merced.

**APPENDIX B**  
**MERCED IRRIGATION DISTRICT ROOT ZONE MODEL**

## **Introduction**

The Root Zone model is a root zone water balance developed to provide specific information required for the Water Management Plan. The balance uses data on reference ET, precipitation, soils, crop type and acreage, rooting depth and other parameters described in the following text to track moisture through the root zone. Outputs relevant to the Water Management Plan include:

- effective precipitation,
- consumptive use of precipitation
- consumptive use of applied water
- evaporation of precipitation
- evaporation of applied water
- deep percolation of precipitation
- deep percolation of applied water
- uncollected surface runoff of precipitation, and
- uncollected surface runoff of applied water.

The following sections of this appendix give a detailed description of computations used in computing these parameters.

## **2. Root Zone Water Balance Overview**

The root zone water balance calculates the volume of water consumed to meet crop evapotranspiration requirements and apportions this consumption between precipitation and applied water. In addition, the water balance estimates the demand for applied water, the volumes of precipitation and applied water that are stored in the root zone and later consumed, and the volumes of precipitation and applied water that run off or are lost to deep percolation.

Calculations for the Root Zone Water Balance are performed for each month and crop/land use type. The water balance outputs results for each land use type including unmanaged crop/land uses, canal evaporation, and all other (irrigated and sustained) crop/land use types.

The only initial condition required by the water balance is the amount of precipitation and applied water stored in the root zone. These values are specified for the first month of simulation and computed for each successive month.

## **3. Model Description**

### **3.1 Input Data**

The input data used by the root zone water balance were developed using the best available sources and necessary assumptions. All of the input data reside on a separate page in the spreadsheet program and are organized in a pseudo-database format to facilitate easy inspection and alteration. The primary input values include:

- Irrigation performance fractions by land use
- Historical land uses
  
- Crop coefficients by land use and month
- Precipitation and reference ET by month
- Root zone storage parameters:
  - Initial precipitation stored in root zone
  - Initial applied water stored in root zone
  - Maximum and minimum root zone storage capacity
- Surface water availability by crop/ land use type (SWcrop) and month (SWmonth)
- Precipitation losses

Sample data input tables are included at the back of this appendix.

The root zone water balance routine stores 18 variables to track the water balance on a monthly time step and to partition components of the water balance between precipitation and applied water. The eighteen variables are described below in Table 1. In addition, other variables are used in computations within the root zone module but are not passed to the main module.

<b>Table 1. Definitions of Stored Variables</b>			
<b>Variable Name</b>	<b>Description</b>	<b>Units</b>	<b>Current Value</b>
ETo	Reference et	inches	
pr	Precipitation	inches	
urpr1F	Precipitation runoff factor	--	.1
elprF	Precipitation evaporation factor	--	.2
dpprF	Precipitation deep percolation factor	--	1.0
awgF	Applied groundwater	--	
stoAWmaxF	Maximum portion of available root zone storage filled by applied water	--	.75
SWmonth	Monthly surface water availability flag (1: available; 0: not available)	--	
etawF	Fraction of applied water that is evapotranspired	--	.9
dpawF	Fraction of applied water that is deep percolated	--	.05
urawF	Fraction of applied water that results in uncollected runoff	--	.05
Swcrop	Flag for irrigated land use	--	
etF	ET reduction factor (for sensitivity analysis)	--	
Kc	Monthly crop coefficient	--	
stoMax	Maximum available root zone storage	inches	
stoMin	Minimum available root zone storage	inches	
sto0pr	Initial precipitation stored in root zone	inches	
sto0aw	Initial applied water stored in root zone	inches	

### 3.2 Computation of Effective Precipitation

The water balance distributes monthly precipitation to evaporation, runoff, crop consumptive demand, and deep percolation in a step-wise process. At each step, the program checks to see if there is remaining precipitation to distribute. For this reason, the module begins by estimating infiltrated precipitation. This is done by first multiplying monthly precipitation by the precipitation evaporation factor to account for rainfall that is evaporated directly (Eq. 1) and by the precipitation runoff factor to account for uncollected runoff (Eq. 2). Based on this allocation to evaporation and runoff, infiltrated precipitation is defined as total precipitation minus direct evaporation and uncollected runoff (Eq. 3).

$$elpr = pr * elprF \quad (\text{Eq. 1})$$

$$urpr1 = pr * urpr1F \quad (\text{Eq. 2})$$

$$pr\_1 = pr - elpr - urpr1 \quad (\text{Eq. 3})$$

where:  $elpr$  = evaporation from precipitation  
 $pr$  = monthly precipitation  
 $elprF$  = precipitation evaporation factor  
 $urpr1$  = uncollected runoff from precipitation  
 $pr\_1$  = infiltrated precipitation

### 3.3 Consumptive Demand and Root Zone Storage

Consumptive demand is estimated by multiplying reference ET by the monthly crop coefficient and by the ET reduction factor (used only in sensitivity analyses) (Eq. 4).

$$ETc = ETo * Kc * etF \quad (\text{Eq. 4})$$

where:  $ETc$  = consumptive demand  
 $Kc$  = monthly crop coefficient  
 $ETo$  = reference ET  
 $etF$  = ET reduction factor

Total root zone storage capacity is computed as the difference between the maximum and the minimum available storage depths (Eq. 5). These depths are computed for each crop/ land use type based upon estimated rooting depths, moisture holding capacities of local soils and estimates of the maximum depletion of soil moisture allowable before calling for irrigation water. Available root zone storage is the total storage capacity minus initial storage of precipitation and applied water (Eq. 6).

$$stoTotal = stoMax - stoMin \quad (\text{Eq. 5})$$

$$rm = stoTotal - sto0pr - sto0aw \quad (\text{Eq. 6})$$

where:  $stoTotal$  = total root zone storage capacity  
 $stoMax$  = Maximum available root zone storage  
 $stoMin$  = Minimum available root zone storage  
 $rm$  = available root zone storage  
 $sto0pr$  = initial root zone storage of precipitation  
 $sto0aw$  = initial root zone storage of applied water

### 3.4 Water Use Conditions

After the root zone water balance distributes precipitation, it uses the following steps to determine the source of consumed water. The conditions referred to below are show on Figure 1 and are described in more detail later in this section.

Step 1: Check if ETc has been completely satisfied by precipitation. If it has this signals use of Condition 1.

Step 2: If precipitation for the given month has not completely satisfied ETc, then the water balance extracts stored water from the root zone limited by the minimum available root zone storage. Water stored in the root zone is comprised of precipitation and applied water from previous months, which are extracted in proportion to their respective volumes. This corresponds to Conditions 2a and 2b.

Step 3: If the extracted root zone water does not completely satisfy ETc, then the water balance computes the ET demand for applied water under Condition 3.

Step 4: Condition 3 also tracks the root zone water balance in situations where the land use is not irrigated or the availability of applied water is restricted. In these conditions, the consumption of applied water is less than the demand and monthly consumptive use is suppressed.

Step 5: In Condition 3, the volume and destination of applied water are computed using crop-specific weighted average irrigation performance values.

Detailed descriptions of each of the water use conditions used in the root zone module are presented below.

#### 3.4.1 Condition 1

In Condition 1 consumptive demand is less than effective precipitation. Under this condition, evapotranspiration of precipitation is set equal to consumptive demand and excess precipitation is calculated as effective precipitation minus consumptive demand.

Because all consumptive demand is met by precipitation falling within the month, the portion of ET demand met by other potential sources is set to zero (Eqs. 7, 8 and 9). In particular,

$$etaw = 0 \quad (Eq. 7)$$

$$etrzpr = 0 \quad (Eq. 8)$$

$$etrzaw = 0. \quad (Eq. 9)$$

where:  $etaw$  = ET of applied water  
 $etrzpr$  = ET of precipitation stored in the root zone  
 $etrzaw$  = ET of applied water stored in the root zone

As applied water is not needed to meet consumptive demand, the contribution of applied water to root zone storage is zero (Eq. 10). As a result, root zone storage of applied water at the end of the month equals that at the beginning of the month (Eq. 11).

$$rzaw = 0 \quad (Eq. 10)$$

$$sto1aw = sto0aw \quad (Eq. 11)$$

whererzaw = applied water stored in the root zone during the month

sto1aw = applied water stored in the root zone at the end of the month  
 sto0aw = applied water stored in the root zone at the beginning of the month

After satisfying consumptive demand, remaining precipitation (Eq. 12) is distributed to root zone storage as follows.

In conditions where available storage capacity in the root zone is greater than excess precipitation, all of the excess precipitation goes to root zone storage. Under this condition, the volume of precipitation stored in the root zone at the end of the month equals the amount stored at the beginning of the month plus the excess in precipitation (Eq. 13). Deep percolation of precipitation and uncollected runoff of effective precipitation both equal zero. (Eqs. 14 and 15).

$$pr\_2 = pr\_1 - ETc \quad (Eq. 12)$$

$$sto1pr = sto0pr + pr\_2 \quad (Eq. 13)$$

$$dppr = 0 \quad (Eq. 14)$$

$$urpr2 = 0 \quad (Eq. 15)$$

where:  $pr\_2$  = residual infiltrated precipitation after accounting for ET

$sto1pr$  = end of month root zone storage of precipitation

$sto0pr$  = beginning of month root zone storage of precipitation

$dppr$  = deep percolation of effective precipitation

$urpr2$  = uncollected runoff of effective precipitation

### 3.4.2 Condition 2a

Condition 2a is similar to Condition 1 with the exception that in Condition 2a available storage in the root zone is less than residual effective precipitation ( $pr\_2$ ).

In this instance, excess precipitation is first allocated to available root zone storage (Eq. 16). The remaining precipitation ( $pr\_3$ ) is then allocated to deep percolation using the deep percolation precipitation factor (Eq. 17). Any precipitation still in excess is assigned to uncollected runoff (Eq. 18)).

$$pr\_3 = pr\_2 - rm \quad (Eq. 16)$$

$$dppr = pr\_3 * dpprF \quad (Eq. 17)$$

$$urpr2 = pr\_3 - dppr \quad (Eq. 18)$$

where  $pr\_3$  = infiltrated precipitation after satisfying ET and available root zone capacity

$dpprF$  = deep percolation of precipitation factor (this factor is now 1 so all excess precipitation is distributed to deep percolation)

Under Condition 2a the root zone is filled so stored precipitation at the end of the month equals stored precipitation at the beginning of the month plus available root zone storage (Eq. 19).

$$sto1pr = sto0pr + rm \quad (Eq. 19)$$

### 3.4.3 Condition 2b

Condition 2b occurs when consumptive demand is greater than effective precipitation but can be satisfied by the sum of effective precipitation and total available root zone storage. The

paths followed by various fractions of precipitation and stored water for this condition are described in the following.

The first step is to reduce consumptive demand by effective rainfall (Eq. 20). This residual demand is apportioned between initial stored precipitation and initial stored applied water. ET of stored precipitation equals residual demand times stored precipitation divided by total initial storage (Eq. 21). Similarly, ET of stored applied water equals residual demand times stored applied water divided by total initial storage (Eq. 22).

$$ET_x = ET_c - et_{pr} \quad (\text{Eq. 20})$$

$$etr_{zpr} = ET_x * sto_{0pr} / (sto_{0pr} + sto_{0aw}) \quad (\text{Eq. 21})$$

$$etr_{zaw} = ET_x * sto_{0aw} / (sto_{0pr} + sto_{0aw}) \quad (\text{Eq. 22})$$

where:  $ET_x$  = residual consumptive demand  
 $etr_{zpr}$  = ET of stored precipitation  
 $etr_{zaw}$  = ET of stored applied water

In this Condition, because all consumptive demand is met either through precipitation or through stored soil moisture, end of month storage of precipitation equals initial storage of precipitation minus evapotranspired stored precipitation (Eq. 23). Likewise, end of month storage of applied water equals initial storage of applied water minus evapotranspired applied water (Eq. 24).

As no water has been applied, evapotranspiration of applied water is set to zero (Eq. 25)

$$Sto_{1pr} = sto_{0pr} - et_{zpr} \quad (\text{Eq. 23})$$

$$sto_{1aw} = sto_{0aw} - et_{zaw} \quad (\text{Eq. 24})$$

$$et_{aw} = 0 \quad (\text{Eq. 25})$$

### 3.4.4 Condition 3

If consumptive demand is greater than the combination of effective precipitation and total available stored moisture, then the remaining consumptive demand is met through water applied during the month. In this Condition all effective precipitation is accounted for as evapotranspiration as is all initial storage of precipitation and of applied water. The consumptive demand required of applied water is the difference between consumptive demand after accounting for precipitation ( $ET_x$ ) and the portion of this demand satisfied by precipitation and storage (Eq. 26).

$$et_{awreq} = ET_x - et_{zpr} - et_{zaw} \quad (\text{Eq. 26})$$

where:  $et_{awreq}$  = consumptive demand for applied water

If the crop/ land use type is one that generates consumptive demand but is not irrigated, then regardless of the time of year, no water is available to meet the demand for applied water and the water availability factor is set to zero (Eq. 27).

$$\text{If } SW_{crop} = 0 \text{ then } SW_{month} = 0 \quad (\text{Eq. 27})$$

where:  $SW_{crop}$  = monthly crop/ land use type irrigation demand factor

$SW_{month}$  = monthly surface water availability factor

Values of  $SW_{crop}$  were developed in conjunction with the definitions of crop/land use types to represent whether their respective water consumption is supported by surface water.



Irrigated crops have SWcrop values of 1 while land uses such as fallow and unsustained riparian have values of 0 as shown below in Table 2.

Values of SWmonth were developed for each month by inspecting the average monthly diversion as a percentage of average monthly ETo. When this percentage was close to 0 (less than 25 percent), the corresponding value of SWmonth was set to 0. When the percentage was close to or greater than 100 (greater than 70 percent), the corresponding value of SWmonth was set to 1.0. All other values of SWmonth (with percentages between 25 and 70 percent) were set to 0.5.

The consumptive demand that can be met by applied water equals the demand for applied water times the applied water availability factor (Eq. 28)

$$etaw = SWmonth * etawreq \quad (Eq. 28)$$

If, due to constrained water supply or type of land use, the availability of applied water is restricted, the difference between the demand for applied water and the actual consumption of applied water becomes the consumptive use suppression (Eq. 29).

$$etawsprs = etawreq - etaw \quad (Eq. 29)$$

where:  $etawsprs =$  consumptive use suppression

As root zone stored water is exhausted before a demand is placed upon applied water, some of the applied water is assigned to root zone replenishment. The quantity required is the product of the total root zone storage capacity and a factor representing the maximum portion of available root zone storage that can be filled by applied water (Eq. 30). This equation insures that the demand for applied water to replenish the root zone can be less than the total root zone deficit.

$$rzawreq = stoTotal * stoAWmaxF \quad (Eq. 30)$$

where  $rzawreq =$  root zone applied water storage requirement  
 $stoAWmaxF =$  maximum portion of available root zone storage capacity filled by applied water (this factor is now 75 percent)

The quantity of applied water actually distributed to root zone replenishment is adjusted using the applied water availability factor. This eliminates root zone replenishment for land uses that are not irrigated and reduces replenishment in instances when availability of applied water is limited (Eq. 31).

$$rzaw = SWmonth * rzawreq \quad (Eq. 31)$$

Because all effective and stored precipitation has gone to meet consumptive demands, end of month storage of precipitation is set to zero (Eq. 32). On the other hand, applied water stored in the root zone at the beginning of the month, has been at least partially replenished (Eq. 33).

$$sto1pr = 0 \quad (Eq. 32)$$

$$sto1aw = rzaw \quad (Eq. 33)$$

<b>Table 2</b>	
<b>Surface Water Availability Indices by Crop/Land Use Type</b>	
<b>Crop/Land Use Type</b>	<b>SWcrop</b>
Canal Evaporation	1
Canal Riparian	1
Fallow	0
Farmsteads	1
Hay	1
Sustained Lakes/Marshes	1
Irrigated Pasture	1
Unsustained Lakes/Marshes	0
Unsustained Riparian	0
Onions	1
Potatoes	1
Silage	1
Spring Grain	1
Sugar Beets	1
Urban	1
Vegetables	1
Winter Grain	1

The proportion of applied water assigned to evaporation is computed from the proportions explicitly assigned to evapotranspiration, unrecovered runoff and deep percolation (Eq. 34).

$$elawF = 1 - etawF - urawF - dpawF \quad (\text{Eq. 34})$$

where:  $elawF$  = applied water evaporation fraction  
 $etawF$  = applied water ET fraction  
 $urawF$  = applied water uncollected runoff fraction  
 $dpawF$  = applied water deep percolation fraction

Total applied water equals the consumptive demand met by applied water plus the root zone replenishment from applied water divided by the applied water ET fraction (Eq. 35).

$$aw = (etaw + rzaw)/etawF \quad (\text{Eq. 35})$$

Uncollected runoff from precipitation equals uncollected runoff computed in determining effective precipitation plus uncollected runoff that may be generated by rainfall in excess of consumptive demand (Eq. 36).

$$urpr = urpr1 + urpr2 \quad (\text{Eq. 36})$$

Applied groundwater equals applied water times the applied groundwater factor (Eq. 37).

$$awg = aw * awgF \quad (\text{Eq. 37})$$

where:  $awg$  = applied groundwater  
 $awgF$  = fraction of applied water met by groundwater

Applied surface water equals total applied water minus applied groundwater (Eq. 38).

$$aws = aw - awg \quad (\text{Eq. 38})$$

where:  $aws$  = applied surface water

Deep percolation of applied water equals applied water time the deep percolation factor (Eq. 39).

$$dpaw = aw * dpawF \quad (\text{Eq. 39})$$

where:  $dpaw$  = deep percolation of applied groundwater  
 $dpawF$  = deep percolation of applied groundwater fraction

Uncollected runoff of applied water equals applied water times the uncollected runoff factor (Eq. 40).

$$uraw = aw * urawF \quad (\text{Eq. 40})$$

where:  $uraw$  = uncollected runoff of applied runoff  
 $urawF$  = uncollected runoff of applied water fraction

Evaporative loss of applied water equals applied water times the evaporative loss factor (Eq. 41).

$$elaw = aw * elawF \quad (\text{Eq. 41})$$

where:  $elaw$  = evaporative loss of applied water  
 $elawF$  = evaporative loss of applied water fraction

At the end of each month's computation the module checks the water balance (Eq. 42).

$$\text{balance} = pr + aws + awg - etpr - etrzpr - etaw - etrzaw - dppr - dpaw - urpr - uraw - elpr - elaw - stor1pr - stor1aw + sto0pr + sto0aw \quad (\text{Eq. 42})$$

Figure 1 presents examples that illustrate that the water balance may or may not distribute precipitation to deep percolation and root zone storage depending on monthly values of precipitation, ETc, and available root zone storage (at the beginning of the month).

## 4. Output

The primary values computed by the root zone water balance include:

- ET, deep percolation, uncollected runoff, and evaporation losses of precipitation and applied water
- Consumptive losses various crop/ land use types
- Total applied water demands

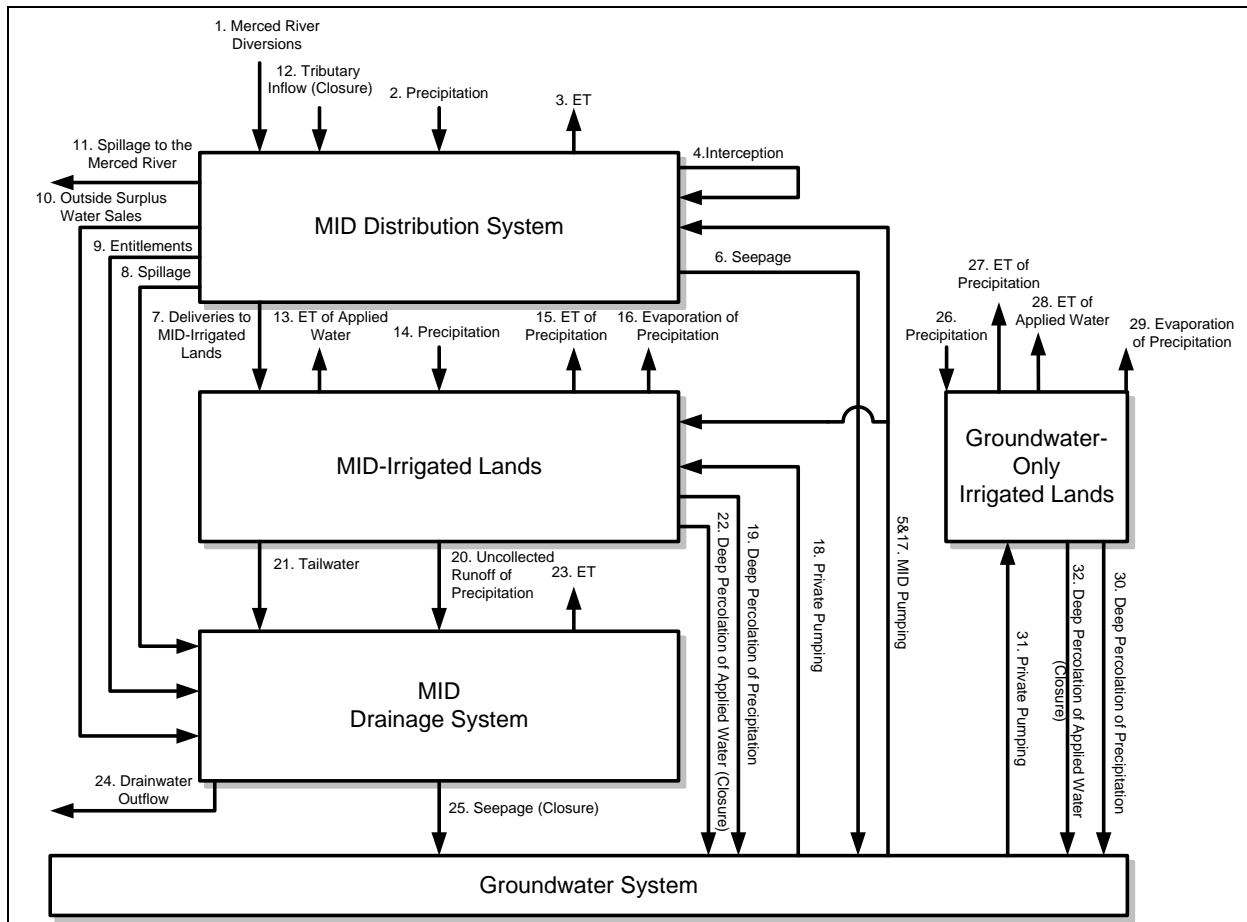
These can be computed as unit values (inches) or as volumes (thousand AF).

**APPENDIX C  
MERCED IRRIGATION DISTRICT  
INTERPRETIVE SUMMARY OF THE ANNUAL WATER BALANCE**

**Overview**

Monthly water data for the years 1970 through 1999 was prepared for Merced Irrigation District to support development of the District’s original Water Management Plan. For this Water Management Plan update, the water balance was completed for 2000 through 2008. Therefore, throughout this index “historical” values are confined to the water balance period. For both the original water balance and this update, the analysis accounts for Merced River diversions, precipitation and tributary inflows affecting MID’s distribution and drainage systems, *during the irrigation season*. The water balance features three pools (or accounting centers); namely, MID Distribution System, MID Surface Water Irrigated Lands, and MID Drainage System. A fourth pool, Groundwater Only Irrigated Lands is also included to account for water use on lands using groundwater only. Exchanges between all four pools and the underlying Groundwater System are included (Figure C-1).

**Figure C-1. Merced Irrigation District Water Balance Schematic**



## MID’s Conjunctive Water Use Program

MID and its customers use surface water and groundwater supplies in a conjunctive manner. The normal operating objective is to maximize surface water use subject to availability in order to preserve groundwater for use in years when surface supplies are limited. Thus, the proportions of surface water use and groundwater use vary from year to year depending primarily on surface water availability and to some extent on cropping patterns and weather conditions. This variability was evident in the original water balance, but the results were not analyzed with respect to year type. In this water balance update, results have been analyzed with respect to year type according to the San Joaquin Valley Water Year Hydrologic Classification. Specifically, the tables and graphs in this document present values for two year types, with Wet and Above Average years classified as “Wet”, and Critically Dry, Dry, and Below Average years classified as “Dry”.

In 1993, MID initiated an improvement program to reduce spillage, thereby reducing Merced River diversions and increasing supplies available for other uses. Through this program, MID provides water to the Vernalis Adaptive Management Program (VAMP). Because the changes in MID water management from 1970 through 1999 are described in the 2003 water plan, this description focuses on the more recent time period following the initiation of this improvement program, specifically, 1995 through 2008. Over this recent 9 year period, three years are classified as wet and six years as dry according to the conventions described above.

Average wet-year and dry-year values for selected water balance flow paths are summarized in Table C-1 for purposes of revealing the nature of MID’s conjunctive water use. In addition to actual averages, the table displays the expected relationship between wet-year and dry-year averages, with “+” indicating the value is expected to be higher and “-“ indicating that the value is expected to be lower relative to the other year type.

**Table C-1. Expected relationship between average flow path values in wet and dry years compared to actual average values in thousands of AF, 2000 through 2008.**

Flow Path	Expected Relationship Between Wet-Year and Dry-Year Values <sup>a</sup>		Actual Averages in Thousands of AF	
	Wet	Dry	Wet	Dry
Merced River Diversions	+	-	479	437
MID Pumping to Distribution System	-	+	5	29
Deliveries to MID - Irrigated Lands	=	=	254	275
MID Pumping to Irrigated Lands	-	+	9	7
Private Pumping	-	+	23	35
Total Applied Water	=	=	286	317
Seepage (Canal System)	=	=	104	96
Deep Percolation	+	-	57	61

<sup>a</sup>“+” denotes a higher expected value for the flow path in the indicated year type relative to the other year type; “-“ denotes a lower expected value relative to the other year type.

Annual Merced River Diversions, the main source of MID’s surface water supplies, should be higher in wet years compared to dry years. In fact, wet year Merced River Diversions have averaged 50,000 AF more in wet years, 479,000 compared to 429,000 AF. MID pumps groundwater to the Distribution System and directly to irrigated lands; these flow paths are referred to as MID Pumping to the Distribution System and MID pumping to Irrigated Lands, respectively. In dry years, increased

groundwater pumping is expected to replace the surface water that is not available. MID Pumping to Distribution System averaged 27,000 AF more in dry years (31,000 AF compared to 4,000 AF in wet years). In contrast, MID Pumping to Irrigated Lands averaged about the same in both wet and dry years, 9,000 and 7,000 AF, respectively. This is because MID Pumping to Irrigated Lands is to irrigated service areas without access to surface water, so about the same volume must be pumped in wet years as in dry years, depending mainly on cropping patterns, weather conditions and irrigation practices.

The objective of conjunctive water management is to provide reliable water supplies over time so that agricultural production is not affected by wet and dry cycles. This requires the Deliveries to MID – Irrigated Lands to be about the same in all years. In dry years, the Deliveries to MID - Irrigated Lands are 24,000 AF greater, 287,000 compared to 263,000 AF. The increased delivery volume in dry years is a reflection of increased demand for applied water due to reduced soil water storage from precipitation and possibly greater demand due to warmer weather.

Private Conjunctive Groundwater Pumping is expected to be greater in dry years compared to wet years, as growers strive to meet crop needs when MID surface water supplies are not adequate. The water balance computation resulted in a dry year average of 12,000 AF greater than the wet year average.

Total Applied Water equals the total of Deliveries to MID-Irrigated Lands, MID Pumping to Irrigated Lands and Private Pumping. Similar to Deliveries to MID-Irrigated Lands, it is expected to be about the same in dry and wet years and differs from. In dry years, Total Applied Water is 31,000 AF more than in wet years.

Seepage from the Canal System is expected to be about the same in both dry and wet years as the irrigation season length historically has not changed, unless, in an extremely dry year, it is cut short due to unavailability of surface water. Seepage averaged nearly the same volume, with the dry year average found to be just 7,500 AF less than the wet year average.

Deep Percolation needs to be higher in the wet years to recharge the water taken out of groundwater storage during the dry years. In wet years, the Deep Percolation average was 4,000 AF greater than the dry year average.

During an average wet year, 92 percent of the District's water supply comes from surface water sources compared to 85 percent from surface water in an average dry year. The remainder of the supply comes from groundwater. As previously noted, proportions of groundwater and surface water supplies change in response to different hydrologic conditions. For example,

In the following paragraphs, the primary flow paths are discussed for MID Surface Water Irrigated Lands and MID Distribution System pools. MID Surface Water Irrigated Lands Pool is discussed first because it reflects changing on-farm conditions and water demands over the period. These trends must be understood before looking at MID Distribution System Pool, which reflects District-level operations. This is preceded by a discussion of MID Irrigated Lands, which provides an overview of land use trends in MID.

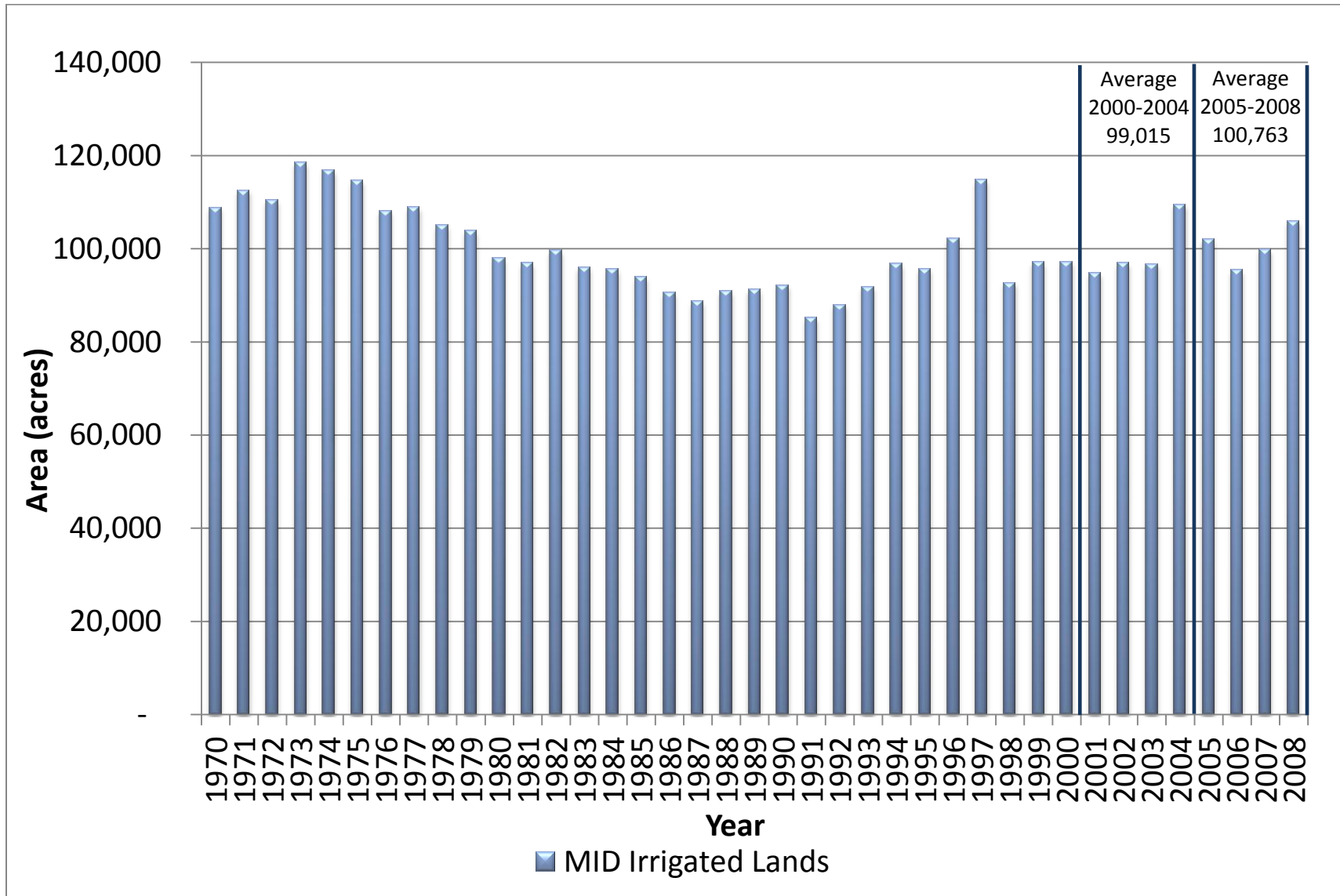
## **MID Irrigated Area**

Although this discussion focuses on the 2000 through 2008 period, MID's irrigated area over the last 40 years is described here so that recent changes in irrigated area are better understood.

MID's irrigated area gradually declined from 1973 through 1991 (Figure C-2), due primarily to displacement of agriculture by municipal and industrial development. In addition, beginning in 1978, increases in the cost of MID service resulting from Proposition 13 caused some growers to convert from MID service to private groundwater use. Thus, while the total irrigated area in the District was declining,

the area receiving surface water was declining even faster. This had the effect of constraining the District's ability to manage surface and groundwater supplies conjunctively, at a time when more aggressive conjunctive management was clearly needed.

**Figure C-2. Merced Irrigation District Irrigated Acreage (1970-2008)**





To restore and eventually expand conjunctive water management options, the District initiated efforts to win back surface water users, through water pricing incentives, service improvements, and other means. These efforts began to pay off in 1991, when MID irrigated area began to expand.

The current total irrigable area in MID is about 131,950 acres according to MID standby fees accounting. Over recent years (2000 through 2008), the area receiving MID surface water has averaged about 99,800 acres while the area within irrigable area not receiving surface water from MID was 27,000 acres. The area receiving MID water averaged slightly more in dry years, 101,000 acres compared to 98,000 in wet years.

The spike in irrigated area that occurred in 1997 (see Figure C-2) reveals an interesting aspect regarding MID's customer base and potential future water demands. Water users in MID have the option of placing their accounts into an "inactive" category if they decide not to use MID service. For example, if a parcel is fallowed, or is cropped and relies on precipitation or private groundwater, the owner may elect to register the parcel as inactive (with respect to use of MID service), thereby reducing MID charges. It is believed that the spike in 1997 resulted from unusually dry late-winter and spring conditions, which caused growers who ordinarily would not have subscribed to MID service to use MID water. The significance of this with respect to MID's water management is that there are lands within the District that presently do not typically use surface water, but could become regular users by reactivating these accounts.

## **MID Surface Water Irrigated Lands Pool**

An annual summary of all the inflows and outflows to the Irrigation Lands Pool is presented in Table C-2. Years classified as wet years are highlighted in yellow. Flow paths are grouped as inflows and outflows and the consumptive use fraction is provided. A footnote briefly describes the source of the data for each flow path. At the bottom of the table, general statistics are provided including wet and dry year averages. Annual water deliveries from MID Distribution System to District Lands reflect the natural variability in water supply and demand over the period of analysis (Figure C-3).

MID water sales averaged about 271,000 AF for 2000-2008. Average dry year sales averaged about 25,000 AF more than average wet year sales, 280,000 compared to 255,000 AF. The goal of various incentives and service improvements is to restore and maintain average in-District water sales of 300,000 AF or more. This target is based on the results of modeling conducted for the Merced Water Supply Plan, which indicated that average surface water sales of this magnitude would help to achieve stable groundwater levels, reducing the need for expensive active recharge facilities. This goal was achieved 2002 through 2004, but with the exception of 2007, water sales have been less than 300,000 AF in recent years.

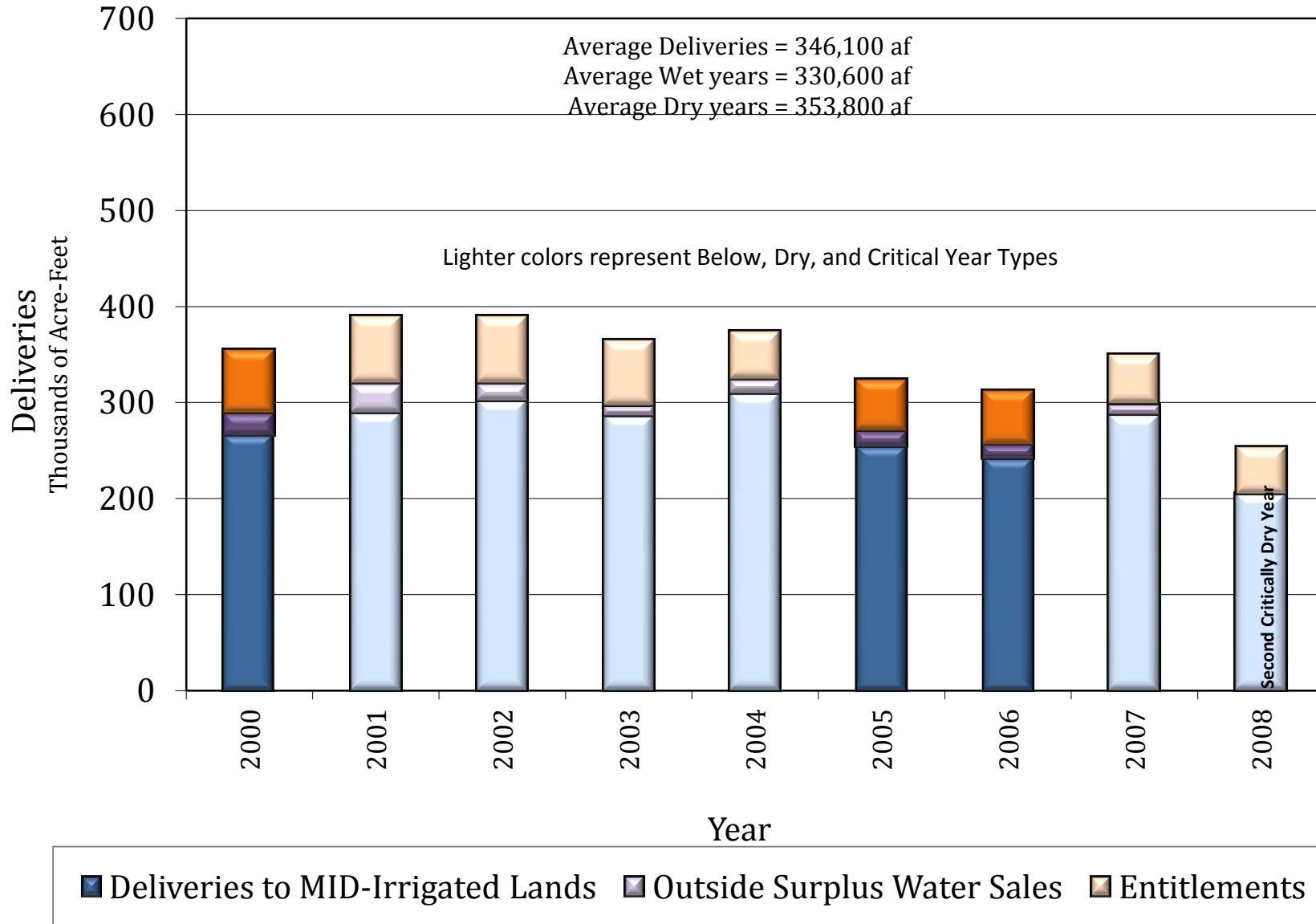
Supplemental private groundwater pumping by growers using MID surface water estimates are based on the consumptive use fraction derived from analysis of water delivery records from the year 2000 to parcels identified as using only surface water from District Deliveries. This analysis indicated an average consumptive use fraction of 77 percent for the sample parcels. The consumptive use fraction is computed as the Evapotranspiration of Applied Water divided by applied water. As expected, historical Private Pumping (of groundwater) tends to be higher in drought years (e.g., 2008) when MID water supplies were limited (Figure C-4).

**Table C-2. Merced Irrigation District Irrigation Season Irrigated Lands Water Balance (1995-2008)**

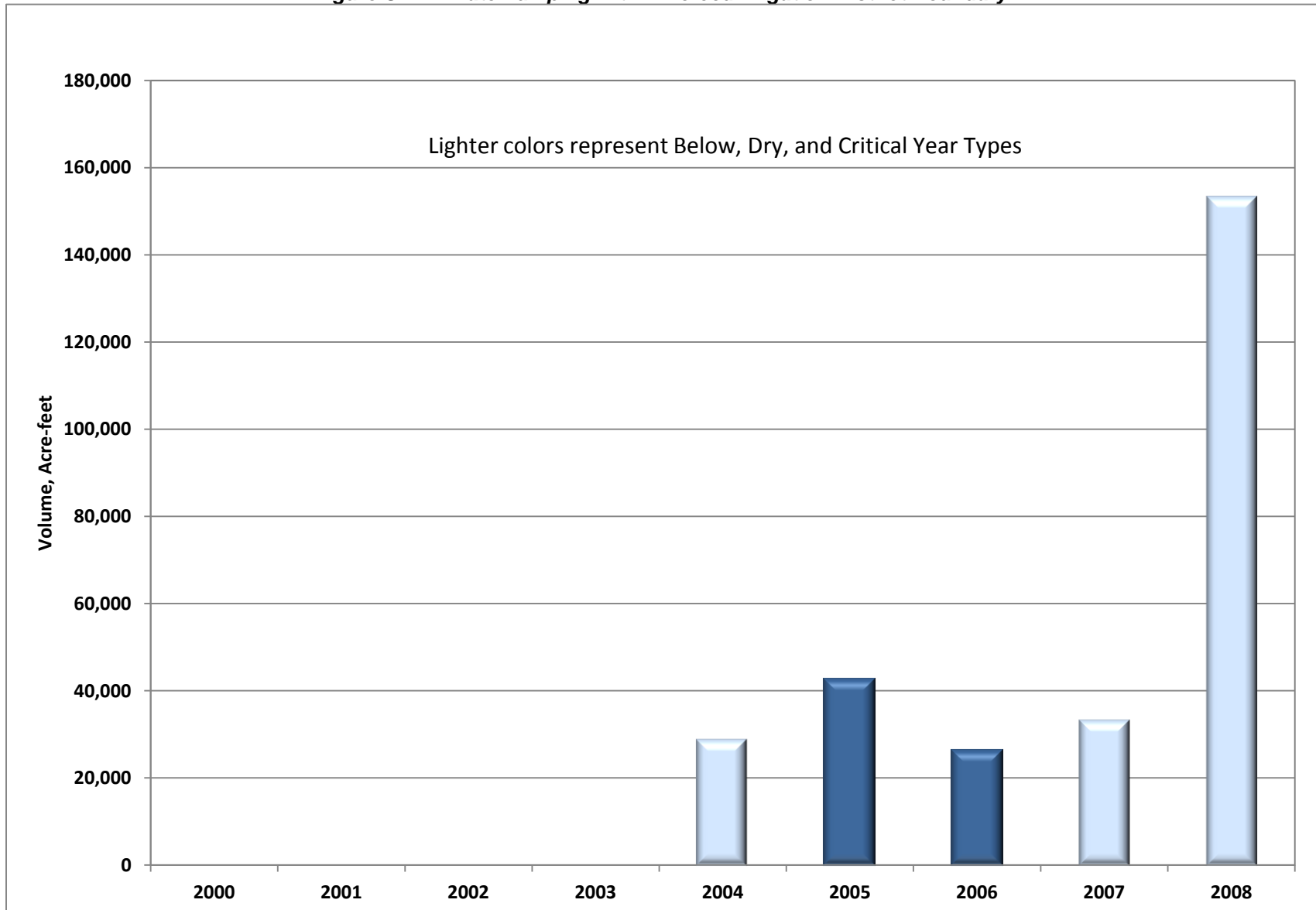
# of Days	Year Type	Year	Inflows				Outflows						Consumptive Use <sup>9</sup>	
			Deliveries to MID - Irrigated Lands <sup>1</sup>	MID Pumping to Irrigated Lands <sup>2</sup>	Precipitation <sup>3</sup>	Private Pumping <sup>4</sup>	Evapotranspiration of Applied Water <sup>5</sup>	Evapotranspiration of Precipitation <sup>6</sup>	Deep Percolation of Precipitation <sup>6</sup>	Deep Percolation of Applied Water <sup>7</sup>	Evaporation of Precipitation <sup>6</sup>	Uncollected Runoff of Precipitation <sup>6</sup>		Tailwater <sup>8</sup>
219	Above	2000	266,163	13,133	130,487	0	203,533	53,533	47,739	65,573	13,049	13,049	13,308	73%
224	Critical	2001	289,572	8,929	108,631	0	230,997	34,149	48,105	57,676	10,863	10,863	14,479	77%
230	Dry	2002	302,047	7,905	88,234	0	230,035	35,060	34,194	66,147	8,823	8,823	15,102	74%
238	Below	2003	286,184	6,646	73,895	0	223,721	37,499	23,801	52,616	7,389	7,389	14,309	76%
227	Dry	2004	309,639	7,968	135,377	29,081	268,370	42,503	68,073	60,561	13,538	13,538	15,482	77%
227	Wet	2005	254,271	6,646	137,177	42,676	235,010	42,820	64,684	58,106	13,718	13,718	12,714	77%
238	Wet	2006	242,142	6,646	125,079	26,346	212,981	53,885	47,819	48,406	12,508	12,508	12,107	77%
212	Critical	2007	287,282	6,646	57,985	33,483	253,448	34,833	11,027	60,127	5,799	5,799	14,364	77%
193	Critical	2008	204,969	6,646	89,869	153,252	282,442	32,810	39,425	71,836	8,987	8,987	10,248	77%
Average			251,094	7,618	107,851	44,090	234,680	40,963	44,809	56,076	10,785	10,785	12,555	78%
Maximum			309,639	13,133	166,842	153,252	316,384	53,885	85,983	71,836	16,684	16,684	15,482	83%
Minimum			160,672	5,324	57,985	0	179,734	28,506	11,027	34,250	5,799	5,799	8,034	73%
Wet and Above Year Type Average			250,649	7,746	126,230	37,221	227,428	44,405	56,971	55,263	12,623	12,623	12,532	77%
Below, Dry, and Critical Year Type Average			251,494	7,503	91,311	50,271	241,207	37,865	33,863	56,807	9,131	9,131	12,575	78%

1. Deliveries from District Records minus MID Pumping to Irrigated Lands
2. Summarized from High Grounds Pumping.xls and Daily Pumping.xls files received from District
3. Merced NDCD Precipitation Multiplied by MID Irrigated Land Area
4. Evapotranspiration of Applied Water divided by an assumed efficiency minus Deliveries to MID - Irrigated Lands minus MID Pumping to Irrigation Lands (negative results are set to zero)
5. RZ reduced by 7%
6. RZ reduced by 7%
7. Irrigated Land Closure Term
8. 5% of Deliveries to MID -Irrigated Lands
9. Evapotranspiration of Applied Water divided by Deliveries to MID -Irrigated Lands plus MID Pumping to Irrigated Lands plus Private Pumping

**Figure C-3. Merced Irrigation District Deliveries to Irrigated Lands, Outside Surplus Water Sales and Entitlements**



**Figure C-4. Private Pumping within Merced Irrigation District Boundary**



ET of Applied Water is the largest outflow from the Irrigated Lands pool (Figure C-5). Its variability from year to year reflects the variability in climatic conditions, effective precipitation and cropping patterns. Average dry years have 32,000 AF more ET of Applied Water; 249,000 AF compared to 217,000 AF. As expected, given that there is no trend in irrigated acreage, this parameter displays no trend from 2000 through 2008.

Deep Percolation of Applied Water is the second largest outflow from the Irrigated Lands pool (Figure C-6). It is calculated as a closure term by subtracting all the outflows from all the inflows. All the measurement and estimation inaccuracies in all flow paths are expressed in the closure term often leading to large annual variability. Deep Percolation of Applied Water averages about 4,000 AF more in dry years. This result, although a bit counter intuitive, is due to the greater deliveries in dry years and the same consumptive use fraction being used in all years. Deep Percolation of Precipitation averages nearly 16,000 AF higher in wet years. Combining Deep Percolation from Precipitation with Deep Percolation from Applied Water indicates about 12,000 AF more average Deep Percolation in wet years.

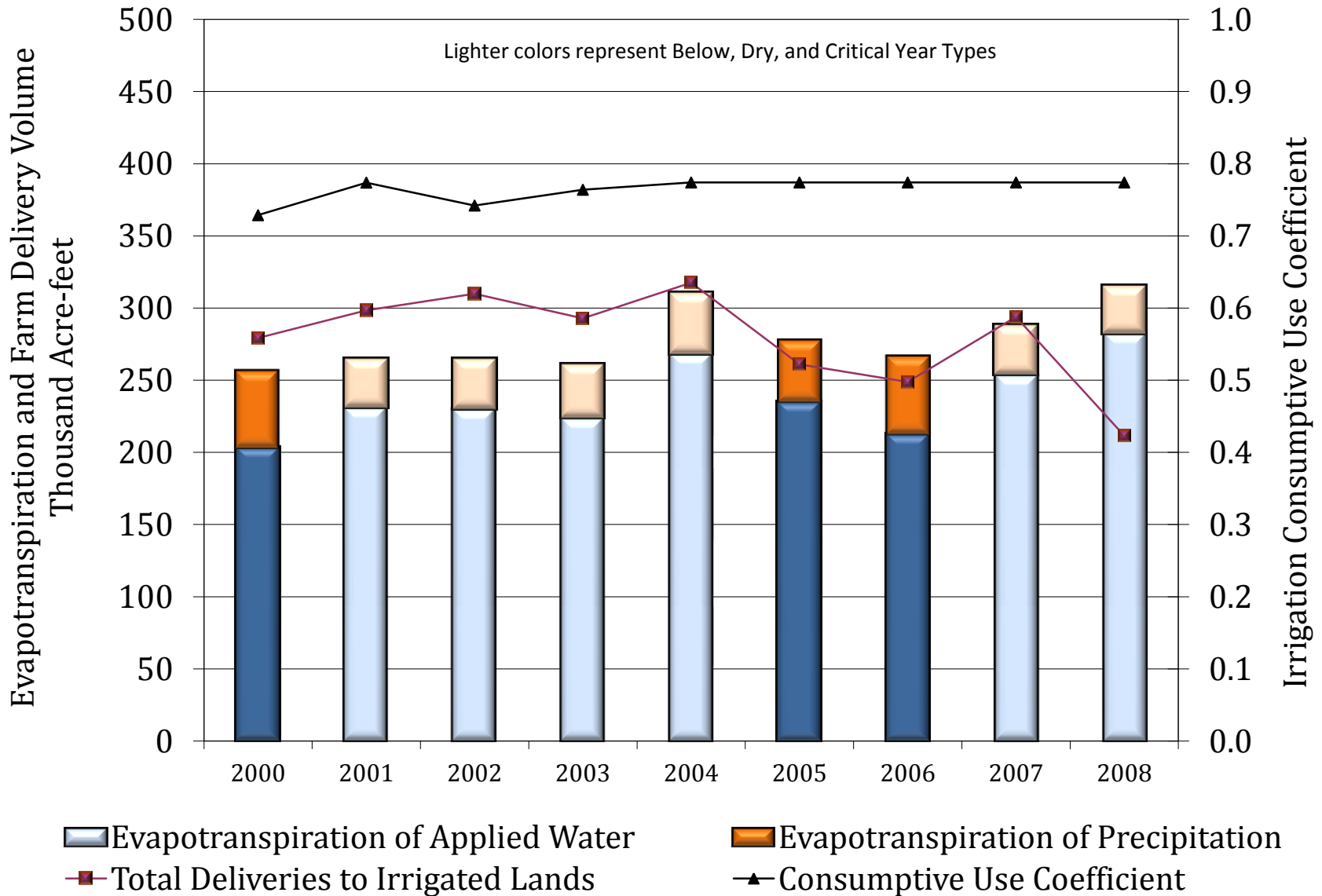
## **MID Distribution System Pool**

An annual summary of the Distribution System Pool is presented in Table C-3. Years classified as wet years are highlighted in yellow. All flow paths to the Distribution System Pool are included and grouped as inflows and outflows. General statistics for all years and averages for wet and dry years are provided at the bottom of the table, followed by footnotes describing the basis for each flow path. The largest inflow to MID Distribution System is Merced River Diversions (Figure C-7). Annual diversions have ranged from nearly 500,000 AF in 2005 and 2006 to a low of about 300,000 in 2008, reflecting the natural variability in Merced River surface water supplies available to the District, and revealing the importance of conjunctive water management in meeting District and other water demands. The average annual diversion over the period has been about 445,600 AF with wet years averaging 50,000 AF more than dry years (479,000 to 429,000 AF). However, during the last stretch of above average years, diversions were higher due to high irrigated area and MID's attempt to maximize in-lieu recharge.

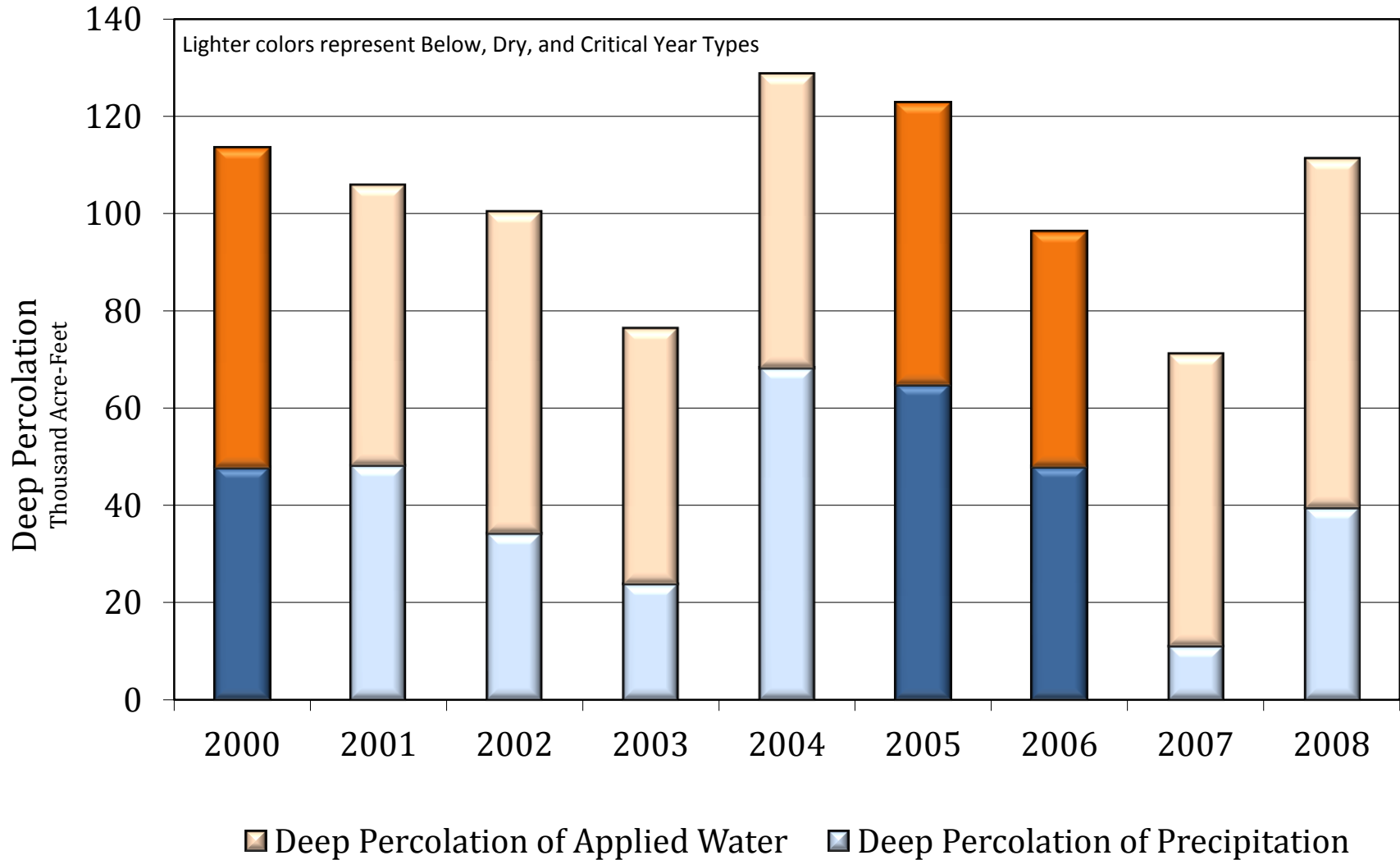
MID pumps groundwater into its distribution system (MID Pumping to Distribution System) to supplement Merced River Diversions, and at times to provide operational benefits such as increasing system responsiveness or overcoming capacity bottlenecks. The variability in annual MID Pumping over the period reflects the nature of MID's conjunctive water management program (Figure C-7). Pumping during the wet years averaged approximately 4,500 AF annually.

In dry years, MID Pumping to Distribution System, at just over 32,000, is about 27,000 AF more compared to wet years.

**Figure C-5. Evapotranspiration, Deliveries, and Consumptive Use**



**Figure C-6. Deep Percolation**



**Table C-3. Merced Irrigation District Irrigation Season Distribution System Water Balance (1995-2008)**

# of Days	Year Type	Year	Inflows					Outflows								Conveyance Efficiency <sup>13</sup>	Unmeasured Spillage <sup>14</sup>	Measured Spillage <sup>15</sup>	Tributary Inflow Reregulated <sup>16</sup>	Canal Spillage <sup>17</sup>
			Merced River Diversions <sup>1</sup>	MID Pumping to Distribution System <sup>2</sup>	Tailwater Interception <sup>3</sup>	Precip <sup>4</sup>	Tributary Inflow <sup>5</sup>	Deliveries to MID - Irrigated Lands <sup>6</sup>	Outside Surplus Water Sales <sup>7</sup>	Entitlements <sup>7</sup>	Seepage <sup>8</sup>	Evaporation <sup>9</sup>	Spillage to Merced River <sup>10</sup>	Spillage to Drains <sup>11</sup>	Unmeasured Spillage & Trib In Avail to Stevinson <sup>12</sup>					
219	Above	2000	483,391	4,647	7,985	470	14151	266,163	22,959	66,227	96,248	9,665	11,221	5,935	32,226	70%	18075	17,156	0	35,231
224	Critical	2001	465,222	27,604	0	132	16133	289,572	30,646	69,502	85,609	9,886	4,917	4,864	14,095	77%	0	9,781	2,038	9,781
230	Dry	2002	470,156	9,453	9,061	134	7385	302,047	18,250	69,482	86,536	10,150	3,369	3,890	2,465	79%	0	7,259	4,920	7,259
238	Below	2003	431,926	10,839	8,586	222	7342	286,184	10,313	68,351	72,009	10,503	2,620	4,360	4,574	80%	0	6,980	2,768	6,980
227	Dry	2004	463,744	5,872	9,289	307	5398	309,639	14,612	50,517	85,093	10,018	2,870	4,632	7,228	77%	1830	7,502	0	9,332
227	Wet	2005	468,724	5,083	7,628	339	23377	254,271	16,806	52,594	106,674	10,018	6,727	7,611	50,450	64%	27073	14,338	0	41,411
238	Wet	2006	484,759	3,967	7,264	552	33402	242,142	14,677	56,063	107,676	10,503	9,420	10,954	78,508	59%	45106	20,374	0	65,480
212	Critical	2007	430,739	48,972	0	105	9606	287,282	10,325	51,640	112,044	9,356	4,158	7,209	7,408	71%	0	11,367	2,198	11,367
193	Critical	2008	312,072	84,401	0	6	7627	204,969	0	49,446	134,842	8,517	1,782	4,550	0	63%	0	6,332	7,627	6,332
Average			471,989	14,050	6,001	234	16,381	251,094	12,309	56,038	102,998	9,730	8,132	5,367	30,880	65%	16015	13,499	1,736	29,514
Maximum			571,438	84,401	9,289	594	33,402	309,639	30,646	69,502	148,314	10,680	18,379	10,954	106,369	80%	81113	25,760	7,627	102,156
Minimum			312,072	2,232	0	6	5,398	160,672	0	19,423	72,009	7,679	1,782	1,000	0	47%	0	3,568	0	3,568
Wet and Above Year Type Average			500,429	3,587	7,519	321	23,010	250,649	15,356	59,651	125,780	9,979	12,561	6,979	54,151	61%	31489	19,540	588	51,030
Below, Dry, and Critical Year Type Average			439,994	25,821	4,292	155	8,805	251,494	9,568	52,786	117,000	9,506	4,145	3,916	9,935	68%	2089	8,061	2,770	10,150

1. North Side Canal at Head + Main Canal at Head (dist002)
2. C:\Active Projects\1018.07 - MID\wb2008\MIDPumping\MID\_Pumping\_Definal.xls
3. If Critical year then 0 else Deliveries to MID - Irrigated Lands X 3%
4. query:dist\_001
5. Army Corps of Engineers Flood Control Dams outflows
6. (Deliveries from District Records - MID Pumping to Irrigated Lands)
7. OWS and Entitlements
8. Canal Water Balance Closure
9. Number of Days X 44 AF/day
10. 3 sites: Garibaldi Lateral, Livingston Lateral Spill, and North Side Canal Spill (dist003)
11. 5 sites: 1900 Lateral Spill, McGilvray Lateral Automatic, McGilvray Lateral Spill, Middle Dallas Lateral spill, Tin Flume Spill (dist007)
12. See stev worksheet



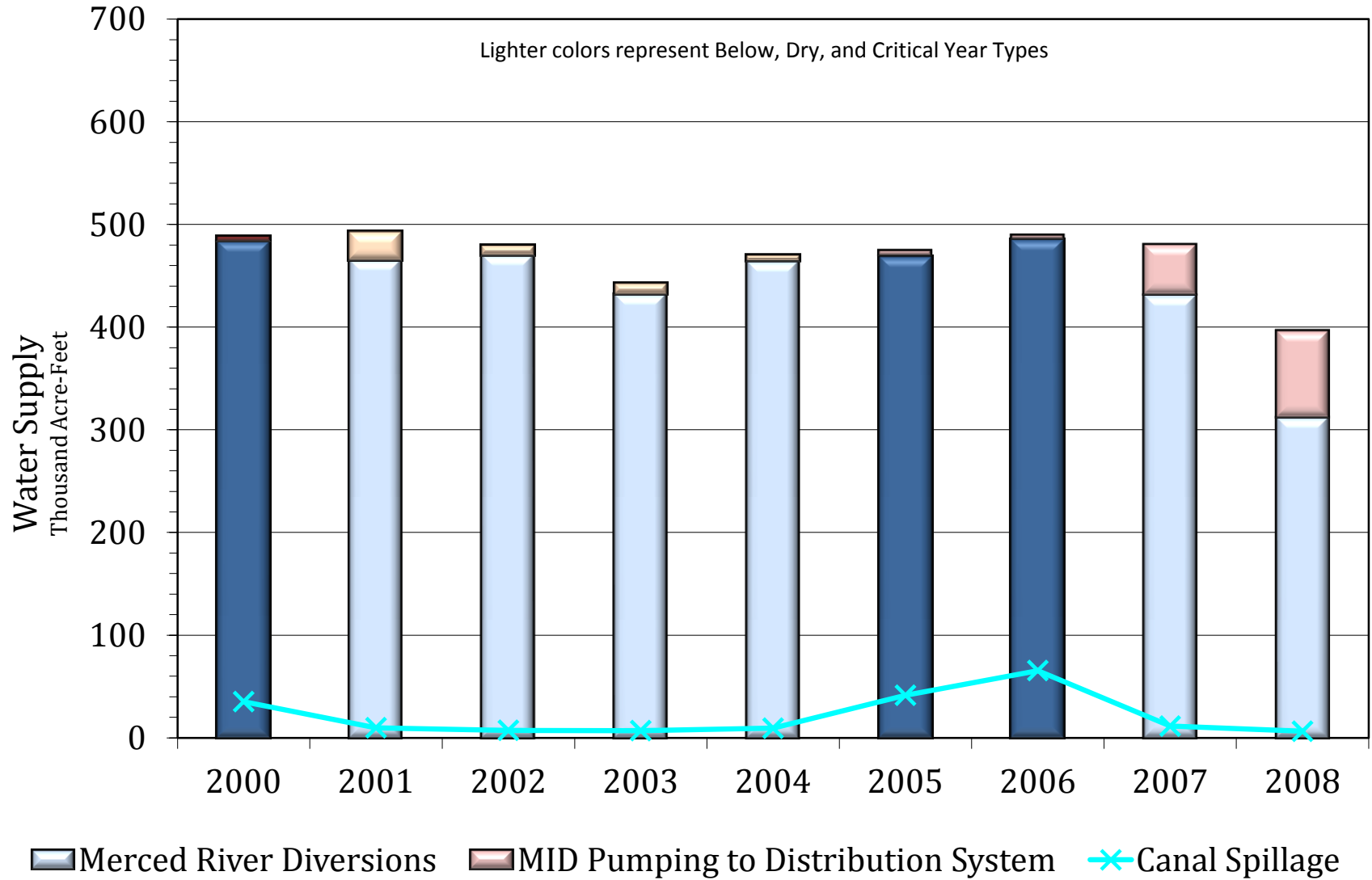
13. (Deliveries + Outside Water Sales + Entitlements)/ (Sum of Inflows)

14. If Unmeasured Spillage&Trib In Avail to Stevinson - Tributary Inflow

15. Spillage to Merced River + Spillage to Drains

16. If Tributary Inflow -Unmeasured Spillage&Trib In Avail to Stevinson <0 then 0 else Tributary Inflow - Unmeasured Spillage& Trib In Avail to Stevinson

**Figure C-7. Merced Irrigation District Pumping to Distribution System, River Diversions, and Canal Spillage**



As previously discussed in the Plan, the MID distribution system incorporates a number of natural streams that serve primarily as conveyance channels during the irrigation season and as drainage/storm event control channels during the non-irrigation season. Some of these streams have appreciable drainage areas that generate substantial runoff volumes. Most of this runoff occurs during the non-irrigation season; however, some runoff occurs during the irrigation season, and may contribute to the water supply available for delivery to users. To the extent that tributary inflow exceeds user demand, it simply flows through the system and nominally registers as spillage, but should not be attributed to MID operations. Tributary inflow has ranged from 5,000 AF to 33,000 AF with an average of 13,256 AF per year during the irrigation season (Figure C-8).

In addition to water demands by MID users, MID delivers water to satisfy other entitlements, and for sale to irrigators located outside of the District (Figure C-9). The entitlements include deliveries to Stevinson Water District (formerly Stevinson Corporation), riparian users along the Merced River and the Merced National Wildlife Refuge. Historically, these obligations have totaled to approximately 38,000 AF, subject to reductions in dry years. Beginning in 1996 when the first deliveries were made to the Refuge, total entitlements have been between 55,000 and 69,000 AF annually. Average entitlements are 2,000 AF less in the dry years.

Outside water sales are subject to water availability from year to year, and therefore vary more radically as compared to water entitlements. Outside sales have been as low as zero in the drought year of 2008, and as high as 30,000 AF in the wet year of 2001. Outside sales have been made to El Nido Irrigation District for many years, and, more recently, to Le Grand-Athlone Water District (beginning in 1994) and to other water users in MID's sphere of influence (beginning in 1973). Outside water sales only average about 4,000 AF less in dry years compared to wet years.

Surface water outflows from the District, above the flows needed to satisfy entitlements and outside water sales, vary radically from year to year depending on hydrologic conditions and related system operation procedures (Figure C-10). These outflows are nominally referred to as District "spillage"; however, in most years, they should not be construed as an indicator of operations effectiveness, since tributary inflow from upslope watersheds is passed through the District and contributes substantially to spillage. However, the District does measure spills to certain drains and to the Merced River (Figure C-10).

**Figure C-8. Tributary Inflow**

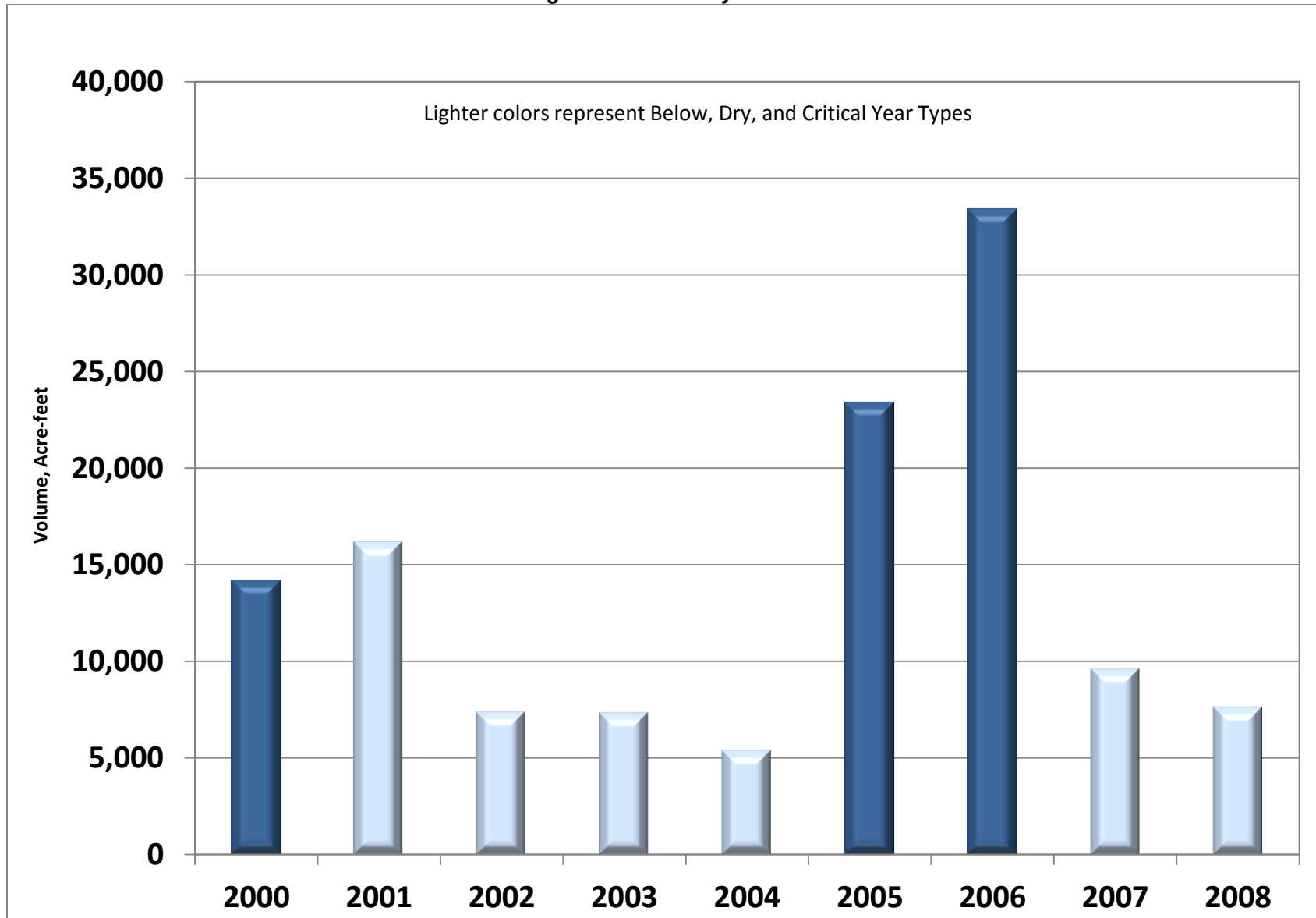
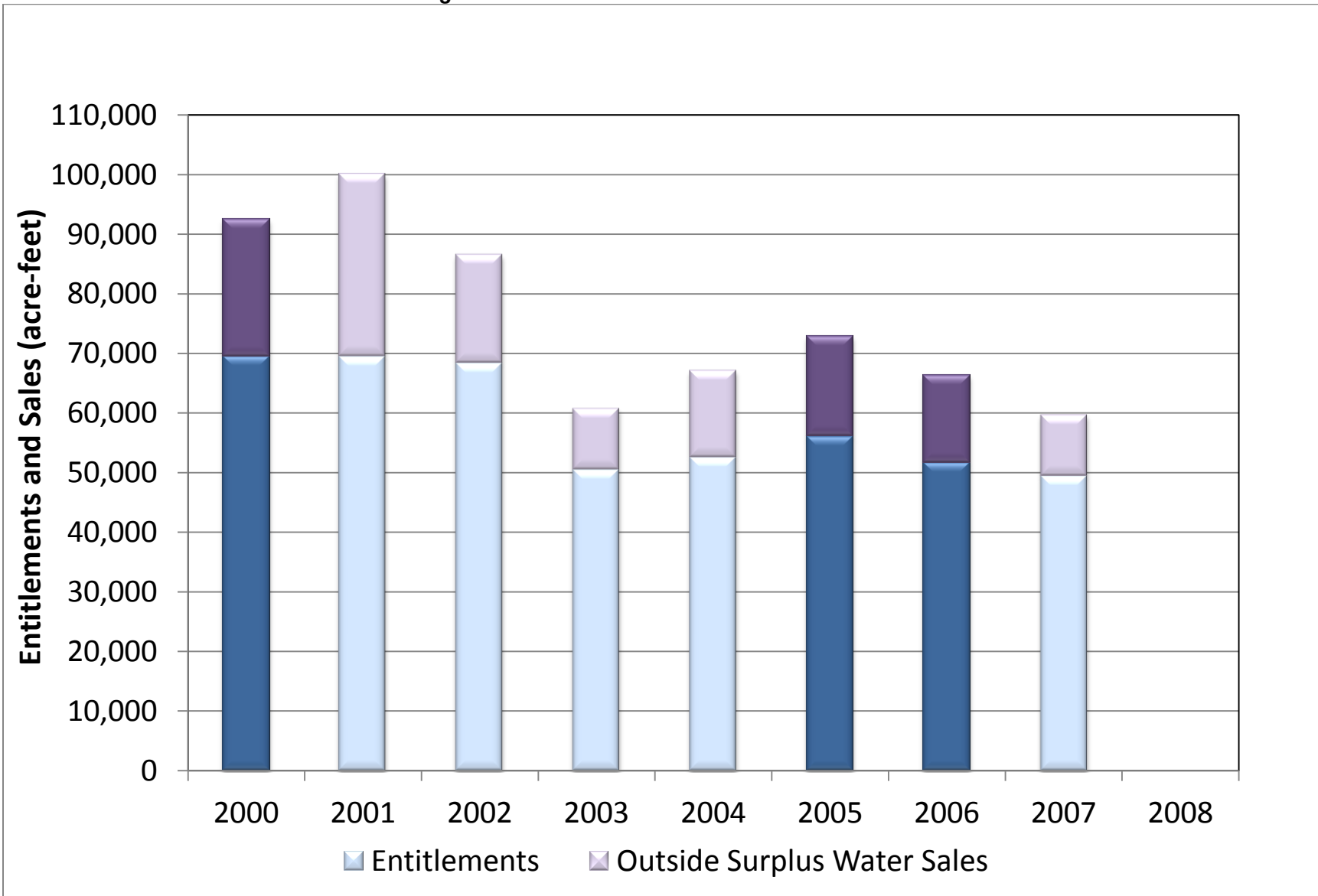
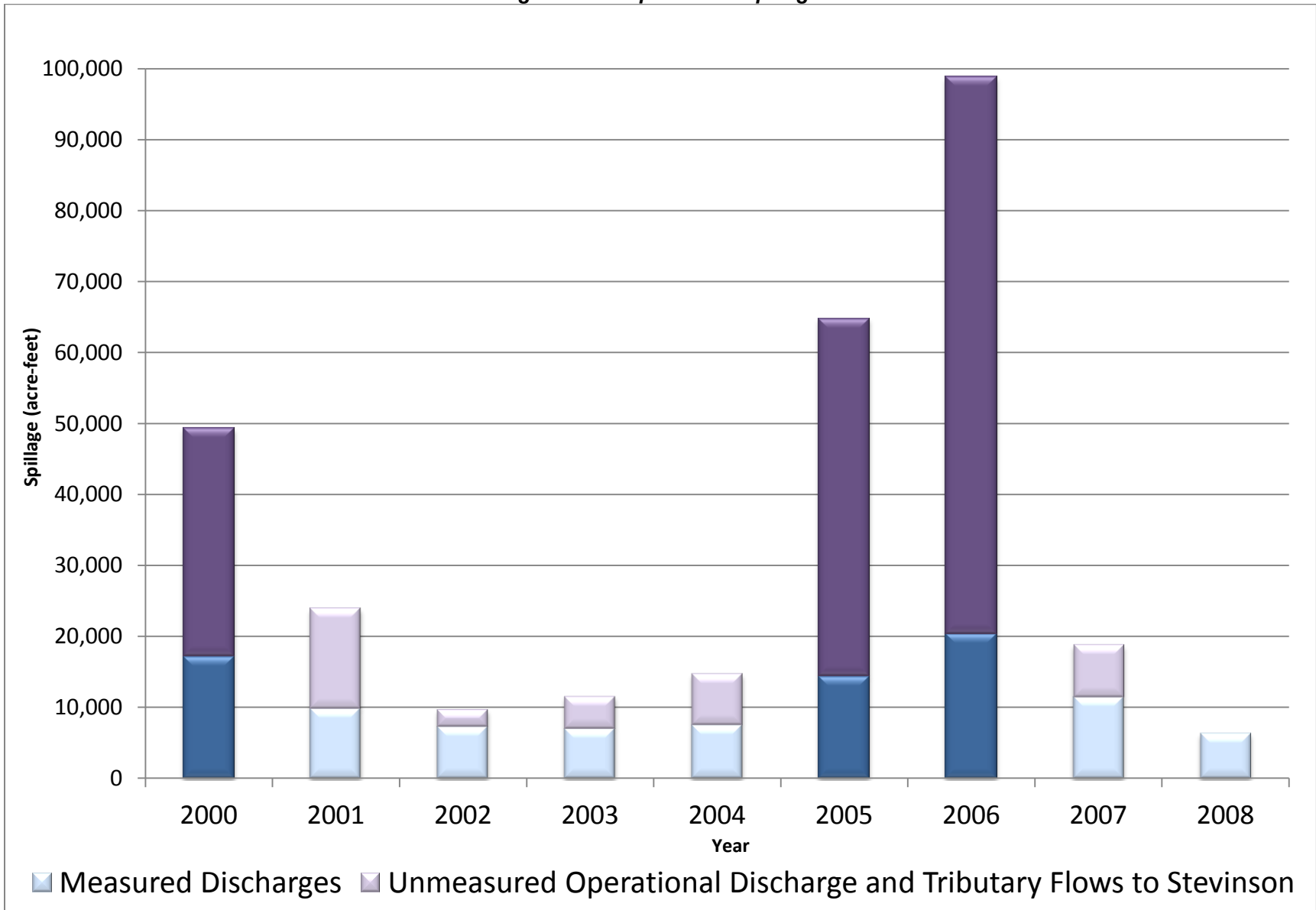


Figure C-9. Entitlements and Outside Water Sales



**Figure C-10. Operational Spillage**



In normal and better water supply years, these measured flows average just over 17,000 AF and are typically in the range of 15,000 to 20,000 AF, and in dry years drop to between 6,00 to 12,000 averaging about 8,000 AF. Unmeasured Spillage and Tributary Inflow Available to Stevinson averages about 54,000 AF in wet years compared to about 6,000 AF in dry years.

Seepage from MID canals has historically ranged between roughly 72,000 and 135,000 AF, depending primarily on the length of the irrigation season (Figure C-11). The length of season, in turn, reflects annual water supply conditions, with the season generally lengthened as water supply conditions improve. In dry years, seepage averages less than 7,500 AF more than in wet seasons.

An annual net recharge volume (Figure 12) attributable to MID's operations can be calculated as the total of Deep Percolation of Applied Water, Deep Percolation of Precipitation (agriculture land use is conducive to recharge of groundwater from rainfall) and seepage minus the total District and private groundwater pumping with the District boundaries. The average net recharge was found to be 169,000 AF.

**Figure C-11. Distribution System Seepage**

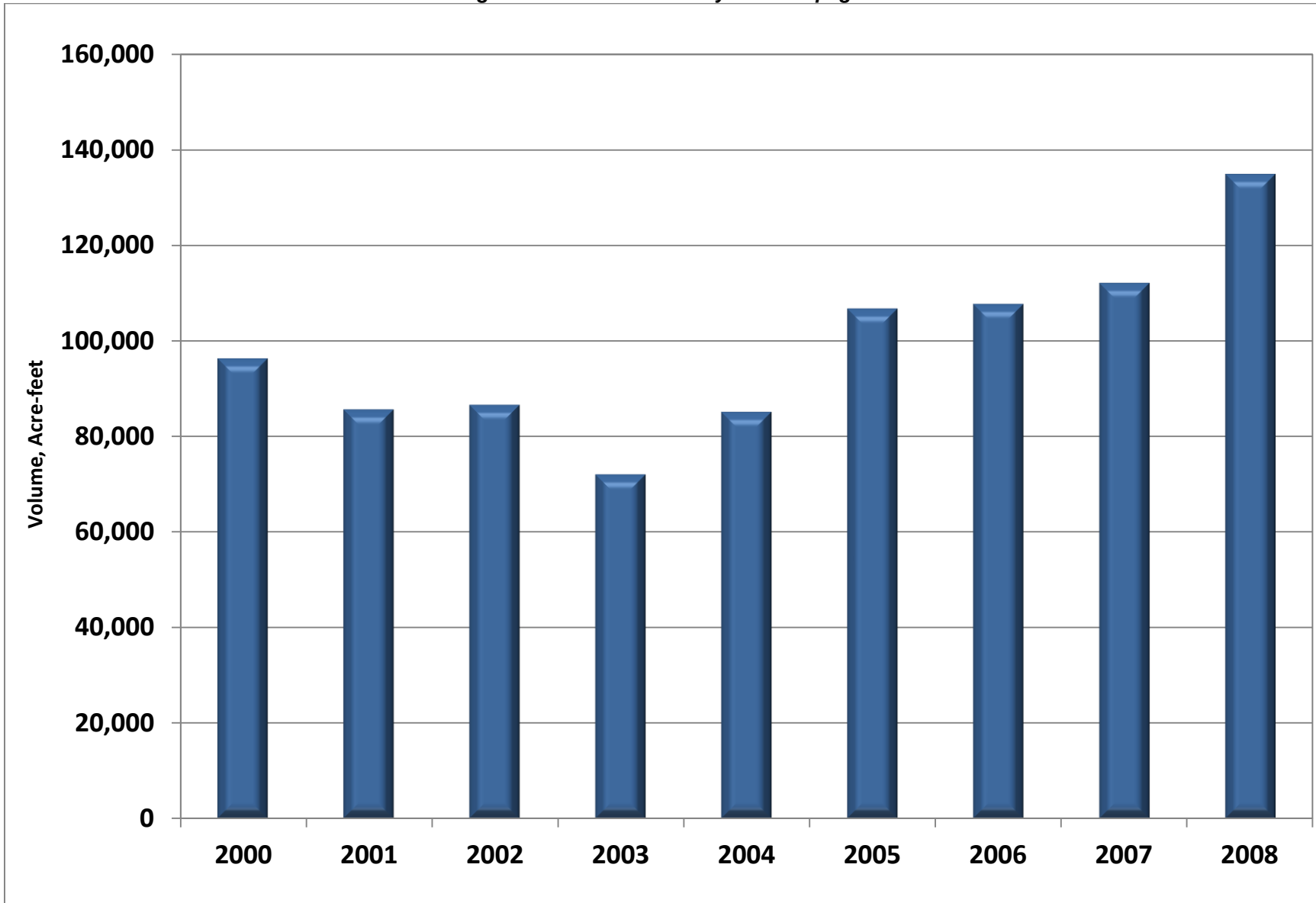
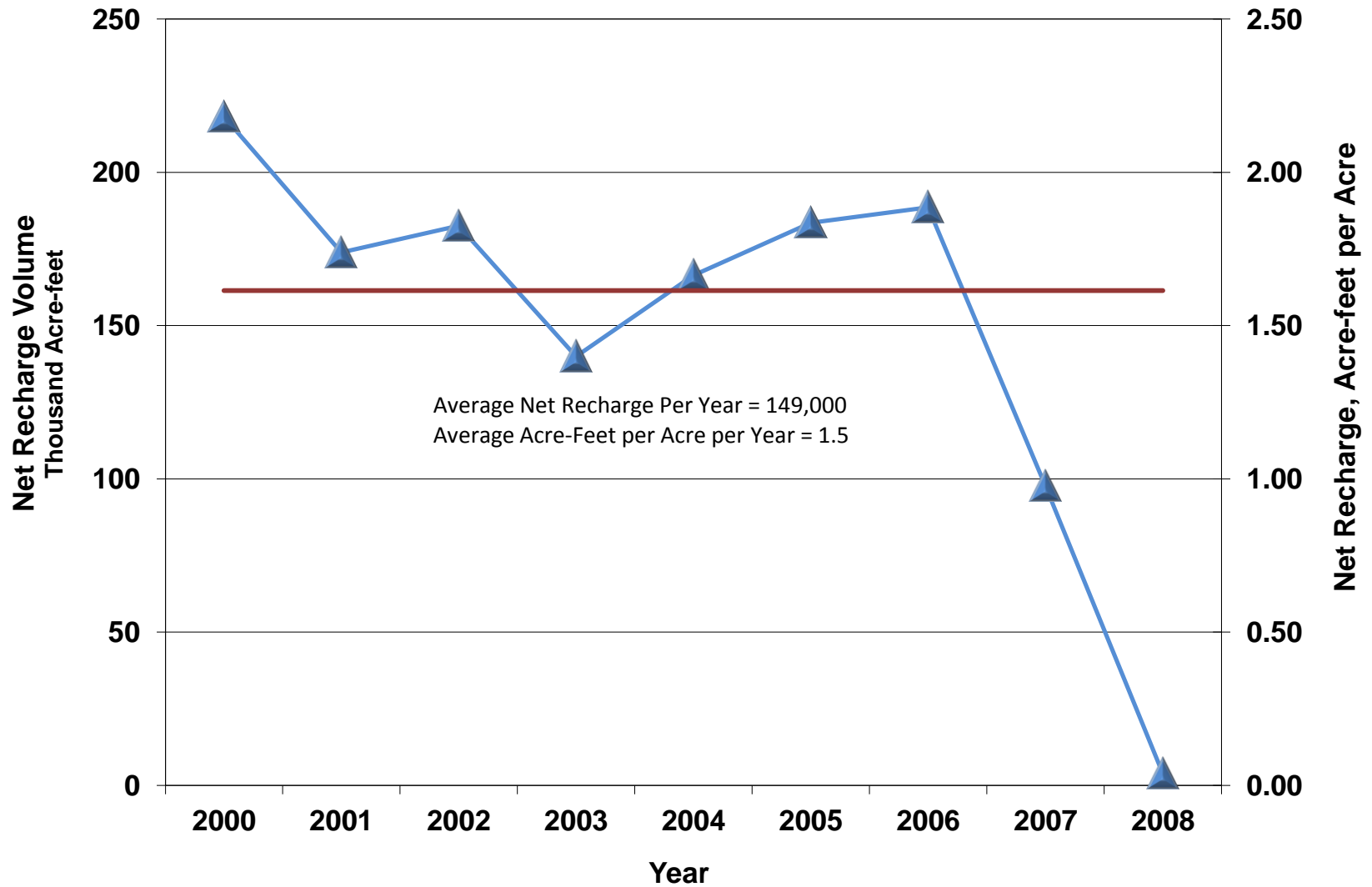




Figure C-12. Annual Net Recharge Volume



**APPENDIX D**  
**MERCED IRRIGATION DISTRICT**  
**DEPARTMENT OF WATER RESOURCES**  
**LICENSES FOR DIVERSION AND USE OF WATER**

*1- Application No. 1221*

*Permit No. 912*

*License No. 990*

Date of Priority: March 26, 1919 (Pursuant to Order Amending License dated June 10, 1946.

Source: Merced River in Mariposa County tributary to San Joaquin River.

Point of Diversion: South Thirty Eight Degrees West, Three Thousand Eight Hundred (3,800) feet from the northeast corner of Section 13, T4S, R15E, MDB&M, being within the NW1/4 of SE1/4 of said Section 13.

Point of Rediversion: NW1/4 of SE1/4 of Section 13, T4S, R15E, MDB&M.

Season of Diversion: January 1 to December 31.

Maximum Annual Use: One Thousand Two Hundred (1200) cubic feet per second.

Purpose of Use: Power.

Place of Use: Power use at Exchequer Power House within the NW1/4 of SE1/4 of Section 13, T4S, R15E.MDB&M.

*2- Application No. 1222*

*Permit No. 913*

*License No.2684*

Date of Priority: March 26, 1919.

Source: Merced River in Mariposa County tributary to San Joaquin River.

Point of Diversion: South thirty eight degrees, no minutes West (S 38 00' W) thirty-eight hundred (3800) feet from the NE corner of Section 13, T4S, R15E, MDB&M., being within the NW1/4 of SE1/4 of said Section 13.

Point of Rediversion: NW1/4 of SE1/4 of Section 13.

Season of Diversion: January 1 to December 31.

Storage Collection Season: October 1 to July1.

Storage Capacity: 272,800 AF in Lake McClure.

Maximum Annual Use: Three hundred sixty two (362) cubic feet per second by direct diversion and two hundred seventy two thousand eight hundred (272,800) AF by storage.

Purpose of Use: Power.

Place of Use: Power use at Exchequer Power House within the NW1/4 of SE1/4 of Section 13, T4S, R15E., MDB&M.

**3- Application No. 1224**

**Permit No. 914**

**License No. 2685**

Date of Priority: March 26, 1919.

Source: Merced River in Mariposa and Merced Counties tributary of San Joaquin River.

Point of Diversion #1: South thirty-eight degrees, no minutes West (S 38 00' W) thirty-eight hundred (3800) feet from the NE corner of Sec. 13, T4S, R15E, MDB&M., being within the NW1/4 of SE1/4 of said Section 13 in Mariposa County.

Point of Diversion #2: (Northside Canal). North sixty eight degrees, no minutes West (N 68 00' W) twenty seven hundred fifty (2750) feet from the SE corner of Sec. 4, T5S, R15E, MDB&M, being within the SW1/4 of SE1/4 of said Section 4 in Merced County.

Point of Diversion #3: (Main Canal) North forty seven degrees, thirty minutes East (N 47 30'E) twenty-eight hundred thirty (2830) feet from the SW corner of Sec. 7, T5S, R15E., MDB&M, being within the NE1/4 of SW1/4 of said Section 7 in Merced County.

Points of Rediversion: Same as points of diversions nos. 1, 2 and 3 above.

Season of Diversion: March 1 to October 31 and throughout the remainder of the year as required by domestic purposes. In case of rotation, the equivalent of the continuous flow allowance for any thirty day period may be diverted in a shorter time if there is no interference with other vested rights.

Storage Collection Season: October 1 to July 1.

Storage Capacity: 266,400 AF in Lake McClure.

Maximum Annual Use: Fifteen hundred (1500) cubic feet per second and two hundred sixty six thousand four hundred (266,400) AF by storage in Lake McClure. The maximum combined storage under Application 1222, License 2684, and Application 1224, License 2685 shall not exceed two hundred seventy two thousand eight hundred (272,800) AF per annum.

Purpose of Use: Irrigation and domestic.

Place of Use: 164,395 gross acreage within the boundaries of Merced Irrigation District as shown on map of the District filed with the Division of Water Resources December 11, 1942.

**4- Application No. 10572**

**Permit No. 6808**

**License No. 6047\***

Date of Priority: December 11, 1942.

Source: Merced River in Merced County tributary to San Joaquin River.

Point of Diversion #1: At Merced Falls Dam: North sixty eight degrees no minutes west (N 6800' W) two thousand eight hundred thirty (2830) feet from SW corner of Section 7, T5S, R15E, MDB&M, being within the NE1/4 of SW 1/4 of said Section 7.

Point of Diversion #2: At Crocker Dam: North forty seven degrees thirty minutes east (N 4730' E) two thousand eight hundred thirty (2830) feet from SW corner of Section 7, T5S, R15E, MDB&M, being within NE1/4 of SW1/4 of said Section 7.

Season of Diversion: March 30 to August 1. The equivalent of such continuous flow allowance for any thirty day period may be diverted in a shorter time if there is no interference with other vested rights.

Maximum Annual Use: Two hundred fifty seven (257) cubic feet per second. Simultaneous diversions under this license and License 2685 issued under Application 1224 and appropriate rights purchased from Crocker-Huffman Land Company shall not exceed 1757 cubic feet per second.

Purpose of Use: Irrigation.

Place of Use: Within Merced Irrigation District and comprising 143,075 net acres within 164,395 gross acres as shown on map filed with the State Water Rights Board.

**5- Application No. 16186**

**Permit No. 12825**

**License No. 11395\***

Date of Priority: December 23, 1954.

Source: Merced River in Mariposa County tributary to San Joaquin River.

Point of Diversion #1: New Exchequer Dam (Lake McClure) – North 42 11' 03" West 3,089.69 feet from SE corner of Section 13, T4S, R15E, MDB&M, being within NW1/4 of SE1/4 of said Section 13.

Point of Diversion #2: McSwain Dam – North 80 36'38" West 2,275.01 feet from SE corner of Section 3, T5S, R15E, MDB&M, being within SW1/4 of SE1/4 of said Section 3.

Point of Rediversion #1: McSwain Dam – North 80 36'38" West 2,275.01 feet from SE corner of Section 3, T5S, R15E, MDB&M, being within SW1/4 of SE1/4 of said Section 3.

Point of Rediversion #2: Merced Falls Diversion Dam for Northside Canal – North 67 00' 00" West 2,760 feet from SE corner of Section 4, T5S, R15E, MDB&M, being within SW1/4 of SE1/4 of said Section 4.

Point of Rediversion #3: Crocker-Huffman diversion dam for Main Canal, Trout Farm and Salmon Spawning Channel – South 24 00' 00" East 2,700 feet from NW corner of Section 7, T5S, R15E, MDB&M, being within SW1/4 of NW1/4 of said Section 7.

Storage Collection Season: October 1 to July 1.

Maximum Annual Use: Six hundred five thousand (605,000) AF per annum storage. The maximum withdrawal from the reservoirs under this license, Licenses 2684 and 2685 (Applications 1222 and 1224) and any license issued pursuant to Application 16187 shall not exceed 516,110 AF.

Purpose of Use: Irrigation, domestic, recreation, fish and wildlife protection and enhancement and fish culture.

Place of Use: Irrigation of 131,953 acres within a gross area of 154,394 acres within the boundaries of the Merced Irrigation District and 55 acre golf course within the service area of Sierra Highlands Water Company.

Domestic use of homesites within the service area of Sierra Highlands Water Company and at homesites and recreation facilities adjacent to Lake McSwain and Lake McClure including McClure point, McClure Boat Club and Barrett Cove.

Fish culture at Merced Irrigation District’s spawning channel and at a privately operated trout farm.

Recreational use and wildlife protection and enhancement in and around Lake McClure and Lake McSwain.

Future Appropriations: The license is subject to depletion of stream flow in quantities set forth in the subparagraphs (A), (B) and (C) below, by future appropriations of water for reasonable beneficial use within Mariposa County, provided such future appropriations shall be initiated and consummated pursuant to law.

(A) From South Fork Merced River a maximum of 500 cubic feet per second of water not to exceed a total of 112,000 AF annually by direct diversion to beneficial use and/or by diversion to storage to be later applied to beneficial use; provided that such future appropriation shall not be made prior to July 1, 2014, which is the date of maturity of bonds by which the licensee has financed the project under this license and license issued on Application 16187, unless the person or agency making such future appropriation shall compensate the Merced Irrigation District for the loss of power revenue resulting during said period from said appropriation.

(B) From Maxwell Creek a maximum of 34,000 AF of water in any consecutive ten year period and a maximum of 4,000 AF of water in any one year to be directly diverted to beneficial use and/or diverted to storage to be later applied to beneficial use.

(C) From Bean Creek a maximum of 10,000 AF of water in any consecutive ten year period and a maximum of 1,200 AF of water in any one year to be directly diverted to beneficial use and/or diverted to storage to be later applied to beneficial use.

Special Conditions: This license is subject to the terms of provisions 1, 2, 3, and 4 of the stipulation and agreement between Merced Irrigation District and California Department of Fish and Game dated October 8, 1959.

***6- Application No. 16187***

***Permit No. 12826***

***License No. 11396\****

Date of Priority: December 23, 1954.

Source: Merced River in Mariposa County tributary to San Joaquin River.

Point of Diversion #1: New Exchequer Dam – North 42 11’03” West 3,089.69 feet from SE corner of Section 13, T4S, R15E, MDB&M, being within NW1/4 of SE1/4 of said Section 13.

Point of Diversion #2: McSwain Dam – North 80 36’38” West 2,275.01 feet from SE corner of Section 3, T5S, R15E, MDB&M, being within SW1/4 of SE1/4 of said Section 3.

Point of Rediversion: McSwain Dam – North 80 36’38” West 2,275.01 feet from SE corner of Section 3, T5S, R15E, MDB&M, being within SW1/4 of SE1/4 of said Section 3.

Season of Diversion: January 1 to December 31.

Storage Collection Season: October 1 to July 1.

Storage Capacity: 1,024,600 AF in Lake McClure 9,730 AF in Lake McSwain

Maximum Annual Use: One thousand seven hundred thirty six (1,736) c/f/s by direct diversion; six hundred five thousand (605,000) AF by storage. The total amount of water taken from the source (combined direct diversion plus collection to storage, both power plants and both reservoirs) under this license, licenses 990, 2684 and 2685 (Applications 1221, 1222 and 1224) and any license issued pursuant to Permit 12825 (Application 16186) shall not exceed 1,778,800 AF per year. The total amount of water to be placed to beneficial use (combined direct diversion plus withdrawal from storage, both power plants and both reservoirs) under this license, licenses 990, 2684, and 2685 (Applications 1221, 1222, and 1224) and any license issued pursuant to Permit 12825 (Application 16186) shall not exceed 1,609,100 AF per year.

Purpose of Use: Power.

Place of Use: At Exchequer Power Plant within NW1/4 of SE1/4 of Section 113, T4S, R15E, MDB&M, and at McSwain Power Plant within SW1/4 and SE1/4 of Section 3, T5S, R15E, MDB&M as shown on map filed with State Water Resources Control Board.

Future Appropriations: The license is subject to depletion of stream flow in quantities set forth in the subparagraphs (A), (B) and (C) below, by future appropriations of water for reasonable beneficial use within Mariposa County, provided such future appropriations shall be initiated and consummated pursuant to law.

(A) From South Fork Merced River a maximum of 500 cubic feet per second of water not to exceed a total of 112,000 AF annually by direct diversion to beneficial use and/or by diversion to storage to be later applied to beneficial use; provided that such future appropriation shall not be made prior to July 1, 2014, which is the date of maturity of bonds by which the licensee has financed the project under this license and license issued on Application 16187, unless the person or agency making such future appropriation shall compensate the Merced Irrigation District for the loss of power revenue resulting during said period from said appropriation.

(B) From Maxwell Creek a maximum of 34,000 AF of water in any consecutive ten year period and a maximum of 4,000 AF of water in any one year to be directly diverted to beneficial use and/or diverted to storage to be later applied to beneficial use.

(C) From Bean Creek a maximum of 10,000 AF of water in any consecutive ten year period and a maximum of 1,200 AF of water in any one year to be directly diverted to beneficial use and/or diverted to storage to be later applied to beneficial use.

Special Conditions: This license is subject to the terms of provisions 1, 2, 3, and 4 of the stipulation and agreement between Merced Irrigation District and California Department of Fish and Game dated October 8, 1959.

**7- Application No.6807**

**Permit No. 5732**

**License No. 5227**

Date of Priority: September 27, 1930.

Source: Creek in Merced County Tributary to San Joaquin River.

Point of Diversion: Within the SE1/4 of SW1/4 of Section 26, T8S, R14E, MDB&M.

Season of Diversion: November 1 to April 15.

Maximum Annual Use: Three and eight-tenths (3.8) cubic feet per second.

Purpose of Use: Irrigation and Domestic.

Place of Use: 9498.6 acres within T9S, R13E, and R14E, MDB&M as shown on map filed State Water Rights Board, being within the boundaries of former El Nido Irrigation District.

**8- Application No.8238**

**Permit No. 4893**

**License No. 6032**

Date of Priority: February 11, 1935.

Source: Duck Slough in Merced County tributary to Bear Creek thence San Joaquin River.

Point of Diversion: SW1/4 of NW1/4 of Section 11, T8S, R14E, MDB&M.

Season of Diversion: November 1 to April 15.

Maximum Annual Use: Five Thousand Sixty-Six (5066) AF per annum by underground storage.

Purpose of Use: Irrigation and Domestic.

Place of Use: 9418.6 acres within T9S, R13E, and R14E, MDB&M as shown on map filed State Water Rights Board, being within the boundaries of former El Nido Irrigation District.

**9- Application No. 18744**

**Permit No. 13088**

**License No. 9429**

Date of Priority: June 8, 1959

Source: Duck Slough in Merced County tributary to Deadman Creek thence Deep Slough thence Bravel Slough.

Point of Diversion: SW1/4 of NW1/4 of Section 11, T8S, R14E, MDB&M.

Season of Diversion: November 1 to April 15.

Maximum Annual Use: Five Thousand (5,000) AF per annum by underground storage at a maximum rate of 100 cubic feet per second and subsequently extracted and placed to beneficial use. The maximum withdrawal in any one year shall not exceed 5,000 AF.

Purpose of Use: Irrigation and Domestic.

Place of Use: 8,600 acres net within a gross area of 9,418.6 acres within the Boundaries of the El Nido Irrigation District, including portions of T9S, R13E, and R14E, MDB&M, as shown on map filed with State Water Resources Control Board.

\*Denotes current license



**APPENDIX E**  
**MERCED GROUNDWATER BASIN GROUNDWATER**  
**MANAGEMENT PLAN UPDATE, 2008**

The Merced Groundwater Basin –Groundwater Management Plan Update is available on the MAGPI website at: [http://magpi-gw.org/GWMP\\_Update.html](http://magpi-gw.org/GWMP_Update.html) or available on hard copy at the MID Library located at the MID Main office, 744 W. 20<sup>th</sup> Street, Merced.

**APPENDIX F**  
**WATER MEASUREMENT DOCUMENTATION AND REPORTING**

## **CCR §597.4(e) Reporting in Agricultural Water Management Plans**

The California Water Code, CWC §10608.48 (b) (1) stipulates that Agricultural water suppliers shall: “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).” The intent of this section is to document the progress that the Merced Irrigation District has made towards compliance with the Agricultural Water Measurement Regulation (Regulation), contained in CCR §597.4(a)(1).

MID is currently performing the SB X7-7 required evaluation of the delivery structures, or turnouts, throughout its system. In support of this evaluation, MID has embarked on an aggressive GIS based inventory, survey and classification of its turnouts and is concurrently pilot testing various flow measurement devices at representative sites within the District. These efforts will allow it to establish a comprehensive, planned and economical corrective action plan to bring non-compliant turnouts into compliance.

MID has concurrently begun a master water management planning effort consisting of a long range capital improvement plan, centered on system modernization, conservation, efficiency and other drivers. Once finalized, the above discussed corrective action plan will be incorporated into this master water management plan, providing for a prioritized financing and phasing plan to assist the district in meeting compliance with the Regulation.

A more detailed discussion of the Regulation compliant delivery structure evaluation follows.

## **Analysis and Evaluation of Existing Flow Measuring Devices (CCR §597.4(a)(1))**

### **General**

This evaluation of existing flow measuring devices includes an inventory and attribute classification of delivery structures (or turnouts), protocols for field-testing of flow meter measurement certification, status of SB X7-7 flow measurement compliance, and water measurement corrective action plan.

Prior to performing an evaluation, it is important to understand and categorize the various infrastructure and operational components that impact measurement at the turnout. Major components include on farm irrigation systems, turnout types and measurement configurations, each discussed in more detail below.

### **On Farm Irrigation Systems**

On farm irrigation systems can be generally classified into three categories:

1. Open Flow systems
2. Pressurized Systems
3. Combined systems

Open flow systems are typically associated with flood or furrow irrigation methods, while pressurized systems are typically associated with sprinkler systems, micromist systems, impact sprinklers, etc.

Combined systems utilize both open and pressurized irrigation methods for various reasons. For example, some fields use an open system for the first irrigation and use pressurized systems for the remainder of irrigations.

## **Delivery Structure (Turnout) Types**

Generally speaking, there are three primary types of turnouts in MID: 1) open or closed (pressurized) concrete boxes; 2) slant delivery structures; and 3) upright structures. Some turnouts consist of a booster pump system or a groundwater well system. There are also a number of as yet unclassified turnouts. These are typically associated with garden head accounts (small hobby farms less than 5 acres). Flow through each primary type of turnout is typically controlled with a meter gate (such as a standard Fresno Valve C101 gate), while delivery flows through booster pump and groundwater well turnouts are typically controlled with meter gates, gate valves, butterfly valves and other methods, depending on the specific installation configuration. Photos of the three typical primary types of turnouts are shown below in Figures F-1 – F-3, while a typical booster pump turnout system is shown in Figure F-4.

**Figure F-1 Typical Upright Structure with Meter Gate**



**Figure F-2 Typical Slant Structure with Meter Gate**



**Figure F-3 Typical Open Concrete Box Structure with Meter Gate**



**Figure F-4 Typical Booster Pump Installation**



## **Flow Rate Measurement Configurations within MID**

One turnout can deliver water to one or more farms, or accounts (MID water accounting terminology for an individual field). Similarly, one account can have multiple turnouts.

The flow rate for turnouts serving pressurized irrigation systems are typically measured with a meter. There are a small amount of turnouts to open flow systems that are measured with an instantaneous and volumetric meter (meters). These locations are rare and require certain uncommon downstream configurations. MID staff regularly reads meter installations to determine the flow volumes in AF for billing purposes (CCR §597.3(a)). In practice, the DSO enters the current meter read into the database, which subtracts the previous meter read and calculates AF for billing purposes. For the purposes of the Regulation analyses, all turnouts that have meters were included with the closed-pipe metering devices, whether associated with an open or pressurized on-farm irrigation system.

The flow rate for turnouts serving fields irrigated via open flow methods are typically measured with the use of a meter gate and measuring well or similar control and measurement device installed within a box or upright structure. Other turnout types include headwalls, standpipes and other miscellaneous structures that allow for a vertical installation and measuring well. These are measured by MID staff as instantaneous flows. The volumetric totals for the deliveries and billing charges are then calculated based on the flow rate multiplied by time. In practice, the DSO enters the flow rate, start time and end time, as well as the time and value of any flow changes, into the database, which performs the acre-foot calculation for billing purposes.

Open flow measurements for a slant structure without a meter are estimated from a combination of available tools. Slant gates are not rated to measure flow accurately, although MID has established flow rates for gates when fully open. Nevertheless, flows at turnouts with a slant structure are reasonably estimated based on various available data, such as measuring flow in grower ditches (not always applicable), crop-soil science relationships and estimated ETC values, measuring the flow upstream and downstream of the turnout (where possible), estimating flows based on the specifications and quantity of sprinkler heads or other distribution devices, using the meter gate table to provide an estimated flow when fully open, etc.

The typical field conveyance setup in MID downstream of open flow turnouts is underground piping rather than on-farm open ditches. This type of pipe system setup makes it difficult to verify the accuracy of the flow rates measured by the various delivery gate structures at the canal or calibrate them since there is no cost effective way to perform another independent flow measurement in the system for comparison. For flows conveyed on farm via an open service ditch, independent flow measurement may be possible. Even with these systems though, fluctuating downstream water levels (which is common) could impact the consistency of instantaneous measurements.

Booster pumps and groundwater wells providing deliveries are typically installed with a meter.

## **Turnout Inventory**

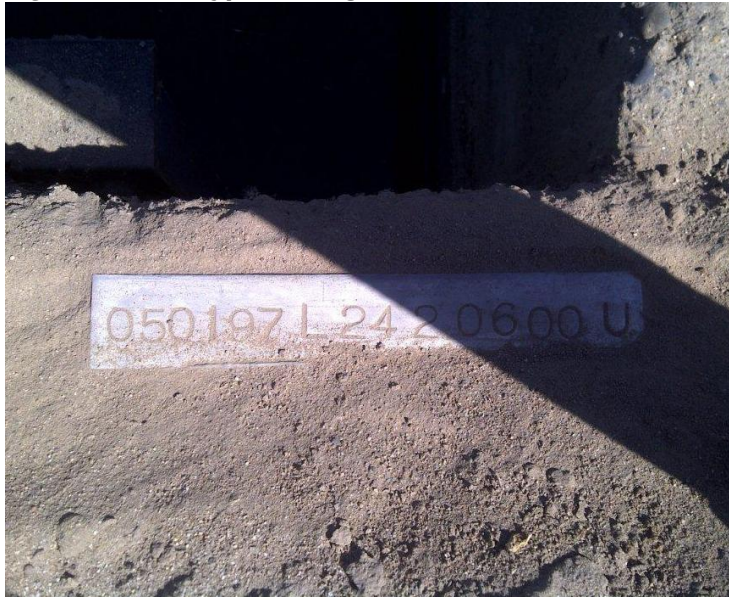
### **Approach and Methodology**

2011 was used as representative of the District’s average delivery gate activities. An inventory of all delivery gates active during the 2011 irrigation season (i.e., operated and served water in 2011) was performed. The analysis was based on the District’s water ordering and billing database (database). This database contains a list of all active delivery structures (or turnouts) and documents whether the turnout includes a meter. The database also contains a “tag ID” for most turnouts. The “tag ID” is a coded identifier describing various attributes of a structure. MID had previously inventoried and identified all delivery structures and documented the structures attributes on a physical stamp affixed to the structure. This information has since been incorporated into its database.

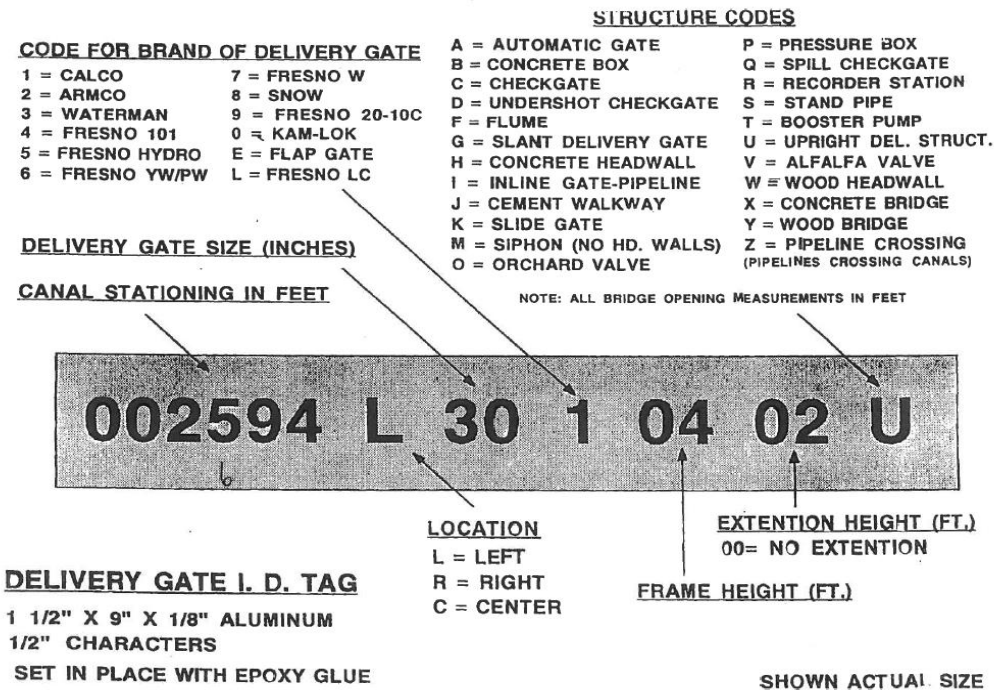
The nomenclature on each structure I.D. tag specifies the brand, type and size of meter gate, as well as the approximate location of the structure (stationing along the canal). An actual photo of a typical structure I.D. tag and the various parameters contained in the structure I.D. tag are described in Figures F-5a and F-5b, respectively.

Note that the “tag ID” inventory occurred several years ago and turnouts installed or replaced since that inventory do not have “tag IDs,” i.e., do not have readily available attributes. These turnouts are being addressed via the aforementioned GIS inventory effort. In order to bring its databases up to date, even those structures whose attributes were previously documented via the “tag IDs” are being verified in this effort.

**Figure F-5a Typical “tag ID” Installation**



**Figure F-5b Tag ID Nomenclature Description**



## Inventory Results and Summary

The results of the turnout inventory are presented in Table F-1, Turnout Inventory Results, below.

**Table F-1 Turnout Inventory Results**

Measurement Config	Turnout Type	Total No. of Active Accounts (2011 Irrigation Season)	Combined Irrig. Systems	Gravity Irrig. System		Pressurized Irrig. Systems			Unspecified	
			Flood and Drip	Flood	Furrow	Drip	Impact Sprinkler	Micro-Mist		Sprinkler
Meter Gate	Concrete Box	186	2	153	5	3	16	6		1
	Slant Delivery Structure	334	2	229	27	7	51	12	4	2
	Upright Delivery Structure	556		357	108	7	61	14	2	7
	Other	152	1	95	13	3	29	8	1	2
	<b>Sub-Total</b>	<b>1228</b>	<b>4</b>	<b>739</b>	<b>140</b>	<b>17</b>	<b>128</b>	<b>32</b>	<b>6</b>	<b>10</b>
Meter	Concrete Box	75		9	2	3	2	5	1	53
	Slant Delivery Structure	106		6	1	5	1	12	1	80
	Upright Delivery Structure	173		22	6	4	10	13	1	117
	Other	198	1	28	15	4	12	12	2	124
	<b>Sub-Total</b>	<b>552</b>	<b>1</b>	<b>65</b>	<b>24</b>	<b>16</b>	<b>25</b>	<b>42</b>	<b>5</b>	<b>374</b>
TBD <sup>1</sup>	TBD	188	3	127	30	4	14	6	0	4
<b>Total</b>		<b>1968</b>	<b>5</b>	<b>804</b>	<b>164</b>	<b>33</b>	<b>153</b>	<b>74</b>	<b>11</b>	<b>384</b>

<sup>1</sup> These accounts consists of a turnout without a "tag ID" and do not have a meter. Measurement Attributes and Turnout Types are currently being inventoried as part of the GIS mapping effort discussed herein.

As shown, out of a total of 1,968 accounts served in 2011, 1,228 accounts (62 percent of total accounts) have meter gate measurement configurations, while 552 accounts (28 percent of total accounts) are served by turnouts with a meter measurement configuration. There are 188 accounts with an unclassified turnout type and measurement configuration, or about 10 percent of the total number of accounts.

## Inventory Results

### *Meter Gate Measurement Configuration*

Of the 1,228 accounts with a meter gate measurement configurations, 894 accounts (73 percent) have been tentatively classified as measurable, although this number is expected to decrease once the ongoing evaluation and corrective action plan is complete. The tentative classification is based on the fact that the delivery structure consists of either a concrete box, upright structure, or other non-slant delivery structure and contains a meter gate and a measuring well or similar ratable control gate.

The remaining 334 accounts (27 percent) with a meter gate measurement configuration and turnout consisting of a slant structure are deemed non-compliant with the Regulation.



Based on the inventory data, it appears that there are 225 accounts that could potentially be converted to a meter measurement configuration, based on the On-Farm Delivery classification of “Pressure System”. These accounts are currently being evaluated in the GIS inventory and classification effort.

***Meter Measurement Configuration***

There are 552 accounts (28 percent) that have a meter measurement configuration and are tentatively classified as measurable.

***TBD Measurement Configuration***

There are 188 accounts with an unclassified measurement configuration and turnout type. As previously discussed, these turnouts are being addressed via the aforementioned GIS inventory and classification effort. Once complete, compliance with the Regulation will be determined.

**Inventory Summary**

There are 1,446 accounts (73 percent of the total accounts) that can be tested to verify if they comply with the SB X7-7 measurement regulations. Of these, 894 accounts (62 percent) have a meter gate measurement configurations while the remaining 552 accounts (38 percent) are meter measurement configurations.

There are 334 accounts (27 percent) that are deemed non-compliant with the Regulation.

There are 188 accounts (10 percent) where additional attribute data must be obtained prior to determining if they can be tested or if they can be deemed non-compliant. This is currently being conducted within the GIS inventory and classification effort.

## **Protocols for Field-Testing of Flow Meter Measurement Certification (CCR §597.4(a)(1)(A))**

### **Field Testing Study Plan**

#### **Protocols**

CCR §597.3(a) states that existing measurement devices shall be certified to an accuracy within  $\pm 12$  percent by volume. New or replacement measurement devices shall be certified to an accuracy within  $\pm 5$  percent by volume in the laboratory if using a laboratory certification or  $\pm 10$  percent by volume in the field if using a non-laboratory certification.

For field-testing flow measuring devices, CCR §597.4(b)(1-2) require that the sampling size should not be less than 10 percent of each existing device type and more than 25 percent of the samples shall meet the accuracy criteria of  $\pm 12$  percent.

As stated above, there are 1,446 accounts (73 percent of the total accounts) that can be tested to verify if they comply with the SB X7-7 measurement regulations. Of these, 894 accounts (62 percent) have a meter gate measurement configurations while the remaining 552 accounts (38 percent) are meter measurement configurations. MID's planned approach to complete the required evaluations for all accounts is discussed below.

#### **Sampling Procedure**

There are a wide range of field sizes within MID, thus, a random sample set based on a percentage of each device type may only represent a small portion of total water delivered to the District. To correct this delivery volume bias, a sampling procedure based on device type and acreage rather, rather than just the device type was adopted.

The total acreage served by meter measurement configurations and the total acreage served by meter gate measurement configurations will be determined. Based on this determination, a minimum number of meter and meter gate configurations will be evaluated that provide service to at least 10 percent of the acreage served by each measurement configuration (meter or meter gate).

Accounts served by meter configurations total approximately 33,800 acres of irrigated crops. Based on the required sampling protocols, the amount of meters needing testing should cover at least 10 percent of the total acreage served, or 3,380 acres.

Accounts served by meter gate configurations total approximately 66,755 acres of irrigated crops. Based on the required sampling protocols, the amount of meters needing testing should cover at least 10 percent of the total acreage served, or 6,675 acres.

## **Field-Testing Procedures**

Field testing procedures for meter configurations will differ from those for meter gate configurations. The field testing procedure for each configuration is discussed below.

### ***Meter Measurement Configurations***

The field-testing protocols that MID used to certify the volumetric flow accuracies of the installed field meters are partially based on the sampling technique described on pages 7-12 of a publication entitled “SB X7-7 Compliance for Agricultural Irrigation Districts, “Draft” prepared by Irrigation Training & Research Center (Charles Burt and Evan Geer, July 2012). This draft report is included in Attachment I.

### ***Reference Device***

The GE (General Electric) Panametrics TransPort PT878 Ultrasonic Flowmeter (reference device) was utilized as a reference measurement instrument to certify the volumetric accuracies of meter measurement configurations. This is a clamp-on unit that has a flow accuracy of  $\pm 1$  to 2 percent for a pipe inside diameter (I.D.) greater than 6-inches and  $\pm 2$  to 5 percent for a pipe I.D. less than 6-inches. The GE PT878 has been used by MID staff for several years to perform pump tests for MID’s groundwater supply wells.

### ***Installation and Procedure***

The measurement configuration being verified, as well as the reference device installation, will be photographed for future reference.

In order to meet the specified accuracy, the reference device must be placed with a minimum straight run of pipe upstream and downstream of the reference device installation, per the manufacturer’s recommendation. This is typically 10 pipe diameters upstream of the reference device and 5 pipe diameters downstream. However, such distances are sometimes difficult to achieve in the field, due to the varied configuration of downstream pressure systems.

The reference device should be located upstream of the meter being subject to verification.

Reference measurements should range from 5 to 10 minutes, depending on the rate of flow. If the flow rate is small, a longer time is needed to allow the totalizer of the meter being verified to have sufficient revolutions/cycles in the totalizer readout.

Begin and end totalizer reads from the meter being verified and accumulated flow volume measurements from the reference device will be documented for comparison.

### ***QA/QC Procedures***

A field training session was held for MID staff performing field testing. The training was held on August 23, 2012 and conducted by David Palmer, GE Technical Sales Manager. In addition to the training, all field testing is performed under the direction and supervision of a licensed professional engineer. Other similar reference devices may be used in the future. If so, similar manufacturer training will occur.

Diagnostic data from the reference device will be reviewed and documented to ensure that it is working properly during the field testing. Sound speed is a diagnostic criteria that indicates how well the meter is functioning. Errors in sound speeds ranged from -0.1 percent to 2.93 percent. If the sound speed value measured with the reference device is within  $\pm 5$  percent of expected theoretical value at a specific

measured water temperature, then the instrument’s timing measurement is working properly, which is the primary principle the ultrasonic meter is based on.

**Typical Setup**

Two representative examples of a field testing setup are shown in Figure F-6 – Figure F-9.

**Figure F-6 Testing a McCrometer propeller meter near a filtration station using PT878.**



**Figure F-7 Close-up of a McCrometer**



**saddle propeller meter  
Figure F-8 Testing of a Water Specialties saddle propeller meter using PT878 with a stand pipe configuration.**



**Figure F-9 Close-up of a Water Specialties propeller meter.**

### ***Meter Gate Measurement Configurations***

As previously discussed, there are a wide variety of meter gate configurations within MID. Hence, a standardized evaluation methodology cannot be developed. Each site must be individually inspected and an evaluation plan prepared for that specific site. As other similar sites are evaluated, the same plan will be used for each. Once complete, the field testing procedures for all tested turnouts will be documented.

## **Results**

### ***Meter Measurement Configurations***

Field testing was performed between August 2012 and October 2012. Meters evaluated were located downstream of the MID turnouts and were typically just upstream of the grower's filtration system. The meters selected for testing are owned by the growers and are either manufactured by Water Specialties or McCrometer.

MID staff tested a total of 27 meters. These meters service approximately 5,000 acres, which exceeds the minimum requirement of 3,380 acres, hence complies with the sampling protocols discussed above.

A summary of the meter measurement configuration evaluation is presented in Table x, below. The table includes the turnout, acreage served by the turnout, the sound speed of the reference device during each field test, the volume, in AF, measured by both the meter being evaluated and the reference device, the calculated flow rate and the determined accuracy of each turnout measurement configuration.

**Table F-2 Summary data for flow meter testing and accuracy verification.**

Turnout No.	Field Size (ac)	Date	Sound Speed % Error	Test Duration (min)	Field Meter	PT878 Meter	Flow Rate (cfs)	% Accuracy
					Accum. Flow Volume (AF)	Accum. Flow Volume (AF)		
1	234.00	8/23/2012	0.04%	10.00	0.02	0.0256	1.859	-21.88%
2	156.80	8/24/2012	-0.10%	10.72	0.03	0.0268	1.816	11.94%
3	315.70	8/27/2012	-0.06%	5.00	0.044	0.0419	6.084	5.01%
4	203.20	8/27/2012	-0.10%	5.00	0.023	0.0246	3.572	-6.50%
5	296.60	8/27/2012	-0.10%	5.00	0.015	0.0169	2.454	-11.24%
6	336.00	8/30/2012	0.06%	5.80	0.04	0.0287	3.592	39.37%
7	150.00	9/5/2012	1.92%	7.30	0.03	0.0332	3.302	-9.64%
8	160.00	9/5/2012	0.88%	6.50	0.03	0.0261	2.915	14.94%
9	188.30	9/5/2012	0.90%	5.13	0.03	0.0307	4.342	-2.28%
10	176.00	9/5/2012	0.77%	5.00	0.018	0.0171	2.483	5.26%
11	321.00	9/6/2012	0.37%	6.20	0.04	0.0408	4.777	-1.96%
12	317.60	9/7/2012	0.59%	6.03	0.03	0.0271	3.261	10.70%
13	160.20	9/7/2012	0.59%	10.42	0.03	0.0251	1.749	19.52%
14	147.70	9/7/2012	1.59%	4.98	0.02	0.0179	2.609	11.73%
15	115.70	9/12/2012	-0.88%	8.70	0.03	0.023	1.919	30.43%
16	315.71	9/12/2012	-0.43%	5.00	0.03	0.0297	4.312	1.01%
17	244.80	9/13/2012	0.86%	5.00	0.017	0.0157	2.280	8.28%
18	175.94	9/17/2012	1.54%	5.00	0.031	0.0298	4.327	4.03%
19	78.20	9/19/2012	0.31%	7.64	0.03	0.0235	2.233	27.66%
20	65.60	9/19/2012	0.25%	5.00	0.013	0.0128	1.859	1.56%
21	133.01	9/27/2012	1.00%	5.00	0.008	0.0075	1.089	6.67%
22	105.70	9/28/2012	0.45%	5.00	0.02	0.0229	3.325	-12.66%
23	111.80	9/28/2012	2.93%	5.00	0.021	0.0211	3.064	-0.47%
24	117.00	10/2/2012	1.08%	10.42	0.01	0.0124	0.864	-19.35%
25	103.80	10/2/2012	1.46%	5.00	0.036	0.0383	5.561	-6.01%
26	103.80	10/2/2012	1.75%	5.00	0.04	0.0385	5.590	3.90%
27	161.18	10/3/2012	0.65%	5.00	0.025	0.0248	3.6009	0.81%

**Note:** The green shaded rows are meters that do not comply to the ±12% accuracy criteria.

As shown, the results of the sound speed of each field test verify that the accuracy of the reference device was within ±5 percent of the sound speed criteria, indicating the reference devices were performing adequately.

The volumetric flow accuracies of the evaluated turnouts range from -22 percent to 39 percent. Seven evaluated turnouts, which serve about 1,200 acres, do not meet the ±12 percent volumetric flow accuracy criteria of the SB X7-7. This equates to about 24 percent of the total sample set acreage. Pursuant to CCR §597.3(b)(2), the threshold percentage criteria for not meeting the ±12 percent flow accuracy requirement must be equal or below 25 percent of the sample set. Therefore, MID’s test results have satisfied the flow accuracy criteria of the Regulation for turnouts with meter measurement configurations.

## **Status of SB X7-7 Flow Measurement Compliance (CCR §597.4(e)(4))**

MID has completed compliance investigations for turnouts with a meter measurement configuration and has concluded that the flow accuracy criteria of the Regulation for turnouts with meter measurement configurations have been met.

For accounts with a meter gate configuration, MID has begun exploratory evaluations of select accounts in conjunction with its pilot testing of various flows measurement devices. Accounts have been selected based on known measurement configuration issues. Once the pilot testing is complete, MID will begin a systematic evaluation of all accounts with meter gate configurations. It is expected that this effort will prove more difficult due to the wide variety of upstream and downstream conditions associated with meter gate configurations.

The 334 accounts (27 percent of the total number of accounts) that are deemed non-compliant with the Regulation will be addressed in the corrective action plan.

The 188 accounts (10 percent of the total accounts) where additional attribute data must be obtained are currently being addressed in MID's GIS inventory and classification effort. Once this effort is complete, these accounts will be evaluated for compliance with the Regulation similar to the above.

## **Water Measurement Corrective Action Plan (CCR §597.4(e)(4))**

MID has two primary measurement configurations: meter configurations and meter gate configurations. Meter configurations have been deemed compliant with the Regulation and no corrective actions are required.

Once the necessary data is collected on the 188 accounts that require additional attribute data (see above discussion), these accounts will be categorized as including turnouts with meter measurement configurations or with meter gate configurations.

Following this data effort, field testing of meter gate configurations will be performed. Once complete, compliance with the flow accuracy criteria of the Regulation will be determined. Due to the number of slant structures and the fact that MID has determined that these structures do not meet the required measurement criteria, MID is anticipating that corrective action measures may be required to bring meter gate configurations into compliance.

## **Draft Corrective Action Plan**

In preparation for developing a final corrective action plan, MID has been pilot testing various measurement devices and evaluating necessary infrastructure changes (turnout types) that will allow MID to ensure its meter gate configurations are compliant with the Regulation. A discussion of this effort follows.

Meter measurement configurations have been shown to be accurate and cost effective, contingent on the proper upstream and downstream conditions. Similar configurations will be evaluated for current non-compliant meter gate configurations when conditions are favorable (i.e., pressurized on farm systems, open systems where upstream and downstream hydraulic conditions allow for such installations).

Another approach is to evaluate the existing meter gate structures to see if it will be cost-effective to calibrate these standard gates to improve flow measurement accuracies by updating the discharge curves. Strategies will be developed to field-test these gate structures since their flows are a challenge to verify as mentioned earlier. Additional water level sensor devices may need to be installed at these gates to record and monitor upstream and downstream water level fluctuations.

New measuring structures may need to be designed and constructed to replace or modify existing non-compliant turnouts. These structures will have standardized specifications and calibrations to provide accurate discharge rates for various flow conditions. A description of devices currently being pilot tested by MID follows.

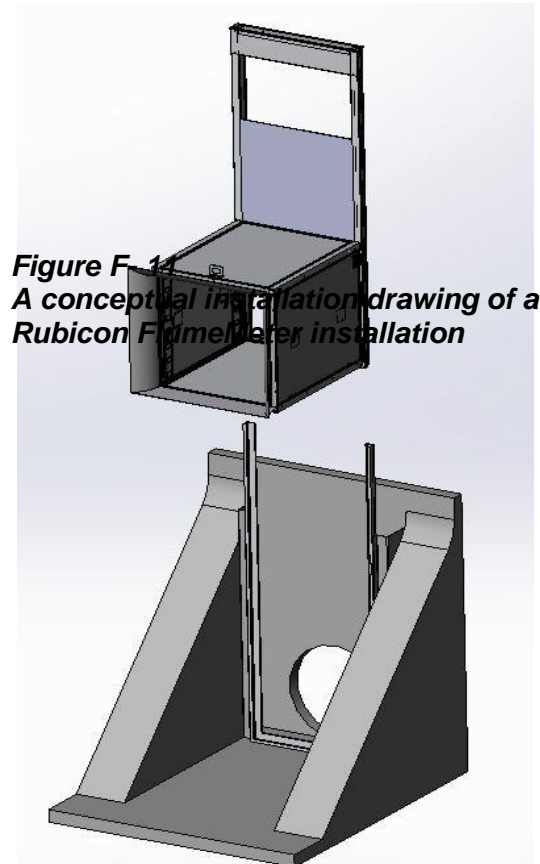
### Constant-Head Orifice (CHO)

The Constant-Head Orifice (CHO) turnout is one viable option. This measurement configuration is being evaluated for MID by Dr. Charles Burt of the Irrigation Training & Research Center (ITRC) and includes an adjustable orifice installed upstream of existing meter gates. It includes instrumentation and sensors that can continuously measure water depths in the upstream and downstream of the orifice plate, resulting in a continuous flow reading and volumetric measurement. It may require structural modifications to some turnout to be effective. Depending on the installation configuration, it is assumed that these devices could obtain an average accuracy

**Figure F-10 Typical Installation of a Constant-Head Orifice (CHO) Measurement Configuration**



of  $\pm 3$  percent. An example of a CHO turnout is shown in Figure F-10.



**Figure F-11**  
**A conceptual installation drawing of a Rubicon Flume Meter installation**

### Rubicon Sonaray Flume Meter

The Rubicon Sonaray FlumeMeter with ultrasonic transit time measurement technology may be used to



measure flow over time in either partial or full pipe flow conditions. It may also be retrofitted to an existing standard delivery gate structure once the existing gate is removed.

The Sonary transit time measurement technology has been proven in the field for several years now. It is designed to measure flow to within  $\pm 1$  percent. A prototype of this current configuration is being field tested in Turlock and Oakdale Irrigation Districts for turnouts.

MID has installed one on the head of a small sub-lateral for testing and other purposes. See Figure F-11 for a descriptive figure of said meter.

### **McCrometer “Trash-Shedding” Reverse-Facing Propeller Meter**

The McCrometer “trash-shedding” reverse-facing propeller meters for pipe and open flow are designed to shed debris while in operation. They come with a standard instantaneous flow rate indicator and flow volume totalizer. They are specified to measure flow at  $\pm 2$  percent under standard conditions. The saddle-type McCrometer can easily be installed in a pressurized pipeline downstream of a delivery gate. However, for the open flow meter, an open concrete box structure will need to be provided to install the meter. Debris in the canals often get caught or stuck in the conventional propeller meters if the water is not screened well. The reverse-facing propeller meters are designed to improve on the trash issue. See Figures F-12 and F-13 for more information regarding these meters.

***Figure F-12 McCrometer bolt-on saddle reverse-helix propeller meter.***



**MODEL M0300SW**

**CONFIGURATION SHEET  
REVERSE BOLT-ON SADDLE  
SURFACE WATER FLOWMETER**

**DESCRIPTION**

The M0300SW is a bolt-on reverse-helix\* propeller meter designed to shed debris often associated with surface water applications. The M0300SW is designed with the meter body turned 180 degrees from normal, a propeller installed nose-first on the bearing shaft, and a reverse flow style bearing assembly. This configuration allows the ell to curve with the flow, allowing grass or other debris to shed off with ease. The assembly design also reduces the ability of sand and silt to accumulate in the bearing.

The M0300SW features a fabricated stainless steel saddle with McCrometer's unique drive and register design. The stainless steel saddle eliminates the fatigue-related breakage common to cast iron and aluminum saddles and provides unsurpassed corrosion protection. Fabricated stainless steel construction offers the additional advantage of being flexible enough to conform to out-of-true pipe. The Model M0300SW is manufactured to comply with applicable provisions of American Water Works Association Standard No. C704-02 for propeller-type flowmeters. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

The impellers are manufactured of high-impact plastic, capable of retaining their shape and accuracy over the life of the meter. Each impeller is individually calibrated


at the factory to accommodate the use of any standard McCrometer register, and since no change gears are used, the M0300SW can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The shielded bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

The instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective vinyl liner. The register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

**INSTALLATION**


Standard installation is horizontal mount. If the meter is to be mounted in the vertical position, please advise the factory. A straight run of full pipe the length of eight pipe diameters upstream and five diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least three pipe diameters upstream and two diameters downstream of the meter.

\* 4" meters use a forward helix propeller with a reverse register.



Typical face plate

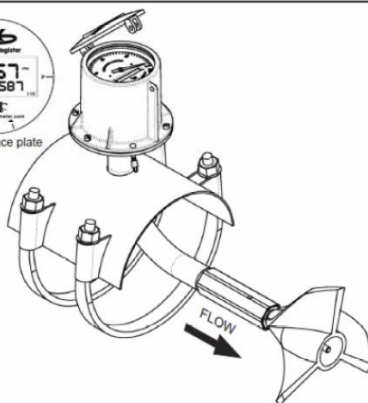
The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available.



Typical face plate

**APPLICATIONS**

- Surface Water
- Water Containing Trash
- Sand Producing Wells
- Irrigation District Turnouts



**Figure F-13 Standard McCrometer open flow propeller meter, which can also be fitted with a reverse-helix propeller.**



**CONFIGURATION SHEET  
OPEN FLOWMETER**

**MODEL M1700**

**DESCRIPTION**

Model M1700 Open Flowmeters are designed to measure the flow in canal outlets, discharge and inlet pipes, irrigation turnouts and other similar installations. The M1700 series meets or exceeds the American Water Works Association Standard C704-02. Constructed of stainless steel, the meter incorporates bronze mounting brackets that permit simple installation and removal. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

Impellers are manufactured of high-impact plastic, designed to retain both shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of standard McCrometer registers, and since no change gears are necessary, the M1700 can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The sealed bearing design limits the entry of

materials and fluids into the bearing chamber providing maximum bearing protection.

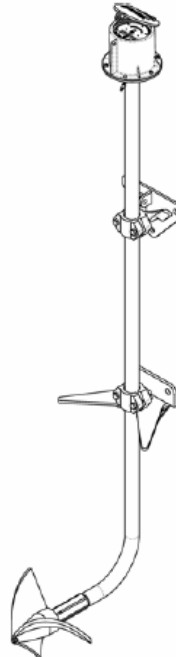
An instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective, self-lubricating vinyl liner. The die-cast aluminum register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

**INSTALLATION**

The M1700 must be mounted on a headwall, standpipe or other suitable structure so that the propeller is located in the center of the discharge or inlet pipe. A straight run of full pipe the length of ten pipe diameters upstream and two diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least five pipe diameters upstream of the meter. Please specify the inside diameter of the pipe when ordering.



The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available. Typical face plates.



**APPLICATIONS**

The McCrometer propeller meter is the most widely used flowmeter for municipal water and wastewater applications as well as agricultural and turf irrigation measurements. Typical applications include:

- Water and wastewater management
- Canal laterals
- Gravity turnouts from underground pipelines
- Sprinkler irrigation systems
- Golf course and park water management

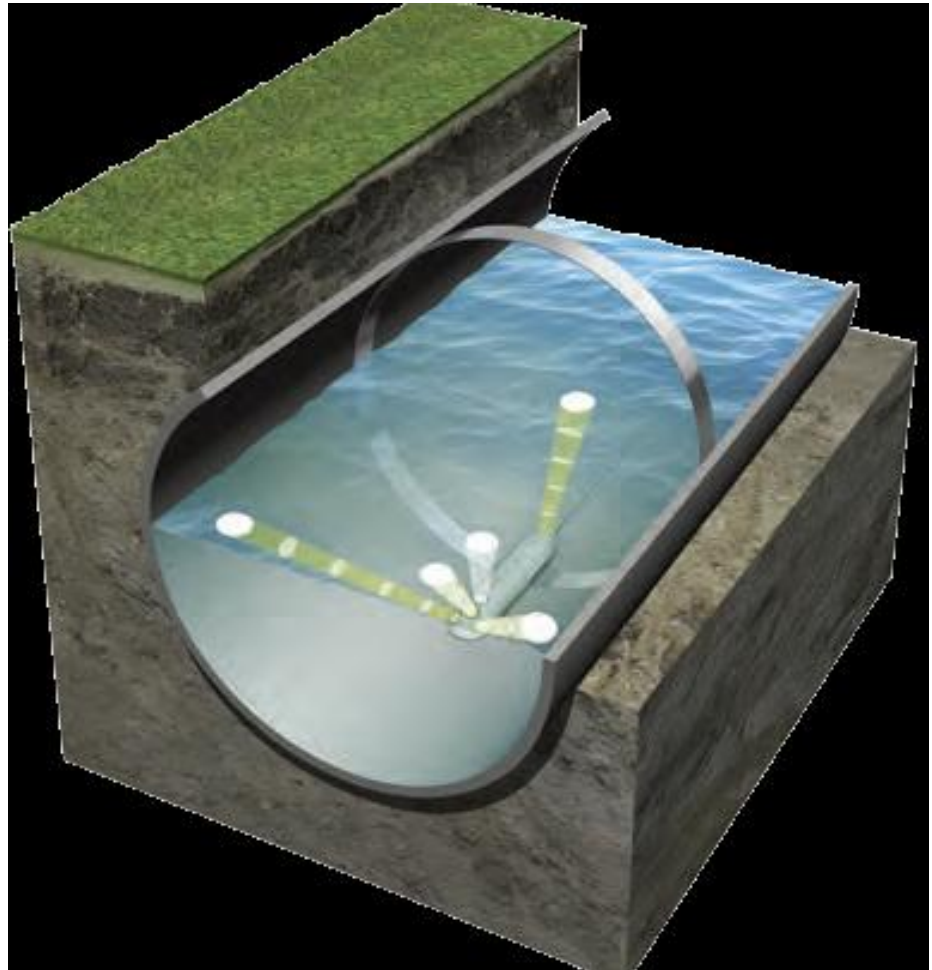
**SonTek IQ-Pipe**

**Figure F-14 SonTek IQ-Pipe instrument sensor**

The SonTek IQ-Pipe may be bottom or top mounted to measure flow volume accurately in either full or partially full pipe. It uses acoustic Doppler technology to compute flow velocity to within  $\pm 1$  percent accuracy. See Figure F-14 for a descriptive figure of this meter.

There are various other manufacturers that are promoting or currently field testing various high precision insertion type magnetic meters that are battery operated and may be mounted on a saddle for ease of installation and operation. MID has joined up with

McCrometer to test its newly developed battery operated insertion magnetic meter this winter (2013/2014). McCormeter is also working on expanding this series beyond 12-inch pipe diameter to 18-inch pipe diameter.



## **Schedule, Budget, and Finance**

### **Schedule**

- 2013** Continue pilot testing of measurement devices and configurations  
Begin field testing of turnouts with meter gate measurement configurations.
- 2014** Complete pilot testing of measurement devices and configurations  
Complete field testing of turnouts with meter gate measurement configurations  
Perform compliance evaluation for meter gate measurement configurations
- 2015** Finalize Corrective Action Plan  
Begin Implementation of Final Corrective Action Plan
- 2016 and beyond**  
Continue Implementation of Final Corrective Action Plan

### **Budget and Finance**

MID has not yet determined the method of financing necessary improvements to comply with SB X7-7. The District's policy regarding this will be determined in the aforementioned master water management planning effort. Options being considered include:

1. MID to purchase, install and construct necessary improvements
  - a. Build into long term capital plan (including plan funding mechanisms)
  - b. Provide a surcharge on grower's bills to pay for required improvements
2. Growers must perform such improvements at no cost to the District as a condition of service
3. MID provide financing for growers to perform necessary improvements

The final corrective action plan will also be incorporated into said MID master planning effort, providing for a prioritized financing and phasing plan to make the necessary turnout improvements (infrastructure and device purchase and installations) ensuring the District's compliance with SB X7-7.

## ATTACHMENT 1

Excerpts from the document: “SB X7-7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts” prepared by Irrigation Training & Research Center (Charles Burt and Evan Geer, July 2012)

SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts  
www.itrc.org/reports/sbx7/sbx7.pdf ITRC Report No. R 12-002  
SBx7 Compliance for Agricultural Irrigation Districts

### SELECTION OF A REPRESENTATIVE SAMPLE FOR VERIFICATION OF ACCURACY

California Legislature SBx7 requires flow measurement devices to be within a required level of accuracy. For existing flow measurement devices, the acceptable error for volumetric flow measurement is  $\pm 12\%$  as stated in §597.3(a)(1). Initial certification of existing devices requires a random and statistically representative sample set or an accepted statistical methodology as described in §597.4(a)(1) and §597.4(b)(1). This document defines a statistical methodology that can be used to provide good information that meets both the intent of SBx7 and the needs of the irrigation districts.

#### ***Background***

##### **Representative Sample**

Irrigation districts have turnouts with flow measurement devices that supply water to areas with correspondingly varying annual delivered volumes. The selection process defined below is intended to define how to select a representative sample set of flow measurement devices for verification of volumetric measurement quality in the district as whole.

In an irrigation district with a wide range of acreages downstream of flow measurement devices, a simple random selection of measurement devices would statistically over-emphasize the importance of small delivery points. The sampling may only represent a very small percentage of all the water delivered in the district. The volume delivered through a turnout is related to the size of the area irrigated. Therefore, it is better to weigh the importance of each measurement device according to the area it services, rather than weighing all turnouts equally. Thus, the sample of flow measurement devices to be tested will be constructed using a *probability-proportional-to-size (PPS)* sampling method so that the likelihood of inspection for a given flow measurement device will be proportional to the acreage served by that device.

##### **Considerations for Availability**

Ideally, all the devices would be randomly selected by the PPS sampling process mentioned above, and then the selected devices would be evaluated for accuracy. However, only some percentage of the turnouts will be operating at a given time. Therefore, if a turnout is selected in a purely random manner, the customer served by that turnout may not be ready to irrigate, prohibiting evaluation of the flow measurement device at that turnout. It is also clear that even if farmers are scheduled to receive water from a turnout on a specific date/time, they do not always irrigate on that schedule; this makes advance and careful scheduling of field evaluations problematic.

A solution to this is to use *opportunity sampling* in combination with *sampling quotas*. An opportunity sample is composed of samples taken as they are available or convenient. Since device availability will be an issue, devices should be inspected when they are available.

**Point #1:** To ensure that the data set is representative of the district’s overall volumetric flow measurement, a minimum of 10% of the district’s service area (or volume) should be represented by the combined service acreage for the turnouts in the sample set.

**Point #2:** To meet the SBx7 requirements, the minimum sample size of 5 and maximum of 100 for a particular device type should be evaluated.

**Point #3:** Two scenarios for sampling are described in this document:  
- Advance Probability-Proportional-To-Size (PPS) Sampling  
- Opportunity Sampling with a consideration of PPS

***Scenario 1: Acreage-Based Sampling Using Probability-Proportional-to-Size (PPS)***

Scenario 1 is the ideal situation, where at any given time all turnouts will be available for inspection.

**Background**

***Representative Sample Selection***

Flow measurement devices in a district will be assigned a number *range* based on the acreage (or known annual volume) that the devices serve (e.g., a turnout servicing 10 acres may be assigned 10 numbers such as 61-70). This numbering will have a logical sequencing that is appropriate for the given district. A random number generator will then be used to select a device from the developed sequence. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensure that the random sample will be statistically representative of the overall accuracy of flow measurement within the district.

***Random Selection Process***

A random number generator will be used to select a device to be tested. If the number produced by the random number generator is within the range assigned to a device, then that device will be tested. Once a device has been tested, its range will no longer be considered in the selection process, and numbers randomly generated in its range will be ignored. This procedure will be improved from the example given in §597.4(b)(1), in that devices providing at least 10% of the district volume or acreage (rather 10% of the devices) will be tested, with a minimum of 5 devices, and not to exceed 100 individual devices of a certain type.

***Device Types***

It is important to take note of device types for this legislation. If 25% of existing devices (as estimated from the properly selected sample) of a particular type are not in compliance with  $\pm 12\%$  accuracy requirements, the district must develop a plan to test another sample of measurement devices of this type as stated in §597.4(b)(2). This document interprets the intent of the legislation as applying to 25% of water delivered, rather than 25% of existing devices. For illustration, in the extreme case of a district with the following:

- 100 garden plots of 0.25 acres each, each with a measurement device (25 acres total)
- 50 larger fields of 80 acres each, each with a measurement device (4000 acres total)

Certainly, careful irrigation water management would not focus on the large number of very small plots that represent less than 1% of the total acreage. This document therefore assumes that the proper interpretation is to focus on reasonable measurement of at least 25% of sample water volume, rather than 25% of the sample devices.

**Step 1: Assign Sequence Range Numbers to Each Turnout**

Table 1 describes a sample scenario and shows a sequence range of number assignments for each turnout. The district in the sample scenario has one lateral with 10 turnouts serving a varying array of acreage.

**Table 1. Example of assigning sequence range numbers**

Turnout #	Acreage Served	Sequence Range	
		From	To
1	10	1	10
2	10	11	20
3	15	21	35
4	15	36	50
5	2	51	52
6	2	53	54
7	5	55	59
8	5	60	64
9	50	65	114
10	50	115	164
Total		164	

*Note that the final sequence number should be equal to the total acreage*

Each turnout is assigned sequence range numbers based on their acreage. Turnout 1 is assigned the sequence range from 1 to 10 because it has 10 acres, and Turnout 2 is similarly assigned 11 to 20. Turnout 3 is assigned a longer sequence range, from 21 to 35, because it has 15 acres. Turnouts are continued to be assigned sequence range numbers in this fashion. As a result of this sequence range numbering, each turnout will represent a portion of the total 164 acres.

**Step 2: Use a Random Number Generator to Select Turnouts**

Use a random number generator to choose a number between 1 and the total acreage of the district. A random number generator can be a software program or simply pulling numbers out of a hat. In the example above the random number generator would pick a number between 1 and 164. If the number produced by the random number generator is between the sequence range numbers assigned to a device, then that device will be tested.

Repeat this process until devices representing 10% of the acreage served (or volume delivered) have been selected with a minimum of 5 and a maximum of 100 per device type.

Continuing with the example data set above, assume that the first numbers selected by the random number generator were: 17, 24, 157, 156, 53, 42, 41, 36, 2, 12, and 52.

Eliminate duplicate turnouts, starting from the first random number.

With this random selection of numbers, the following turnouts are selected:

- 2 (selected by number 17; 12 is a duplicate)
- 3 (selected by number 24)
- 10 (selected by number 157; 156 is a duplicate)
- 6 (selected by number 53)
- 4 (selected by number 41; 41 and 36 are duplicates)

This provides the minimum number of 5 turnouts. Now, the acreage must be checked to verify that the selection represents more than 10% of the acreage (or volume).



**Table 2. Example of randomly selected sample set**

*Green rows indicate the selected devices for the sample set*

Turnout #	Acreage Served		Sequence Range	
	Acres	% of Total	From	To
1	10	6%	1	10
2	10	6%	11	20
3	15	9%	21	35
4	15	9%	36	50
5	2	1%	51	52
6	2	1%	53	54
7	5	3%	55	59
8	5	3%	60	64
9	50	30%	65	114
10	50	30%	115	164
Total	164	100%		

The five turnout samples represent 55% of the total acreage.

Therefore, this sample set meets the criteria of:

- greater than or equal to 10% of the acreage, and
- a minimum of 5 turnouts of a particular type - assuming all are the same device.

Note: If there is more than one device, this process would be repeated *by device*. The final criteria to be met are:

- Including all device sample sets, at least 10% of the district acreage (or volume) must be accounted for.
- A minimum of 5 turnouts of a particular device, for each device.
- No more than 100 of any particular device.

**Step 3: Evaluate Selected Turnouts and Record Data**

Once the turnouts have been selected, evaluate each flow measurement device for accuracy. Record gate type, total acreage serviced by the device, and measured accuracy. This data will need to be retained for ten years or two Agricultural Water Management Plan Cycles as per 597.4(c).

To continue the example, Table 3 shows how data should be recorded for the example district. For simplicity, it is assumed that all devices are meter gates.

**Table 3. Sample data collection for selected turnouts**

*Red rows indicate devices that do not meet the required standard*

Turnout #	Device Type	Acreage Served	Flow Accuracy Error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
<i>Total acreage sampled:</i>		92	

**Step 4: Determination of Compliance**

SBx7 requires an annual volumetric accuracy of within 12% on existing devices. Table 3 addresses flow rate accuracy, not volumetric accuracy.

If 25% or more of the sampled area for a particular device type exceeds the 12% annual volumetric allowable error, then a second round of testing must be conducted. This second round of testing should be conducted in the same manner as the first, but only for the device type(s) that did not meet the required accuracy standard.

*Compliance of this particular example.* Table 3 is repeated below for illustration.

**Table 3. Sample data collection for selected turnouts**

*Red rows indicate devices that do not meet the required standard*

Turnout #	Device Type	Acreage Served	Flow Accuracy error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
<i>Total acreage sampled:</i>		<b>92</b>	

Assuming that the minimum required flow rate accuracy is 10.7% (using the example), then only one turnout measurement device does not meet the requirement. No re-testing is needed, because:

1. Ninety-two acres were tested out of the total 164 acres. This is much greater than the 10% sample size required.
2. Five devices were sampled, which meets the minimum because all devices are of the same basic design.
3. The one device with greater than 10.7% error only represents 10 acres, which is 11% of the acreage sampled. This is below the allowable 25%.

**Scenario 2: Limited Availability of Turnouts and Opportunity Sampling**

Turnouts may not be available for inspection due to fluctuations in irrigation scheduling. Therefore, opportunity sample can be used to select devices to be evaluated. As opposed to the PPS random sample set, this sample will be based on availability and service size rather than a weighted random sampling.

**Background**

**Representative Sample Selection**

To ensure the sample is representative of the district as a whole, evaluators need to ensure that the area serviced by the devices evaluated is at least 10% of the district’s entire area. Furthermore, when given a choice between devices of equal convenience, devices servicing a larger acreage should be given priority for inspection. Additionally, a minimum of 5 devices must be inspected. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensure that the opportunity sample will be statistically representative of the overall accuracy of flow measurement within the district.

**Selection Process**

Devices will be selected as they are available to be tested. Priority for evaluation will be given to devices that service greater acreage. Once a device has been tested, it will no longer be considered in the selection process. A minimum of 5 devices will be tested, and all evaluated devices (summation of all types) will service a combined 10% of the district’s total area (or delivered volume), not to exceed 100 individual devices of a certain type.

**Step 1: Choose a Currently Available Turnout**

Select a turnout that is available for testing based on the size of the turnout, giving priority to turnouts that serve greater acreage. Do not test the same device more than once. Table 4 shows an example of the selection process for two days. On the first day Turnout 10 serves the largest acreage out of the available turnouts. On day two, Turnout 5 is chosen because it serves the largest area and has not yet been tested. The district in this example has one canal lateral with 10 turnouts, and the turnouts have limited availability for testing.

**Table 4. Device selection on two separate days**

*Green rows indicate the selected turnout. Grey rows indicate a turnout that has been tested.*

Day 1			Day 2		
Turnout #	Currently Available	Acreage Served	Turnout #	Currently Available	Acreage Served
1	yes	10	1	no	10
2	yes	10	2	yes	10
3	no	9	3	no	9
4	yes	7	4	yes	7
5	no	30	5	yes	30
6	no	1	6	no	1
7	yes	1	7	yes	1
8	yes	2	8	yes	2
9	no	50	9	no	50
10	yes	50	10	yes	50

Continue testing devices until the following criteria have been met:

- o At least 10% of the total district acreage is serviced by the devices tested
- o At least 5 devices have been tested
- o Test no more than 100 devices of a particular type

**Steps 2-4 : Follow the Previous Scenario Instructions**

**APPENDIX G  
OTHER DOCUMENTATION**

**Public Notice**

Notice of Public Hearing

Notice is hereby given that the Merced Irrigation District (MID) will hold a public hearing  
Tuesday, September 3, 2013 at 10:00 AM  
at the City of Merced Civic Center  
678 W. 18<sup>th</sup> Street  
Merced, CA

Regarding Merced Irrigation District  
2013 Agricultural Water Management Plan (AWMP)

Agricultural water agencies in California are required to prepare Agricultural Water Management Plans. To meet the new requirement, MID will be considering revisions to the voluntary prepared AWMP. The AWMP includes a discussion of MID and its irrigation facility, water supply and demand, and various programs, policies, and efficient water management practices being implemented now or planned into the future. The MID Board of Directors will hold a hearing to consider public comments on the proposed revisions to MID's AWMP

A draft of the AWMP may be reviewed after August 9, 2013 at the MID offices (744 W. 20<sup>th</sup> Street, Merced CA), the Merced Public Library (2100 O Street, Merced, CA), or the MID website ([www.mercedid.org](http://www.mercedid.org)). Written comments, submitted prior to the hearing, should be directed to:

Hicham Eltal  
Merced Irrigation District  
P.O. Box 2288  
Merced, CA 95344

Or, for any questions please contact Hicham Eltal at (209)722-5761 Ext 154

Comments may also be provided at the hearing.

Merced Sun-Star, Merced, Calif.

Tuesday, July 30, 2013 **B7**

Notice of Public Hearing  
Notice is hereby given that the Merced Irrigation District (MID) will hold a public hearing Tuesday, September 3, 2013 at 10:00 AM at the City of Merced Civic Center 678 W. 18th St Regarding Merced Irrigation District 2013 Agricultural Water Management Plan (AWMP) Agricultural water agencies in California are required to prepare Agricultural Water Manage Plans. To meet the new requirement, MID will be considering revisions to its voluntarily prepared AWMP. The AWMP includes a discussion of MID and its irrigation facilities, water supply and demand, and various programs, policies, and efficient water management practices being implemented now or planned into the future. The MID Board of Directors will hold a hearing to consider public comments on the proposed revisions to MID's AWMP. A draft of the AWMO may be reviewed after August 6, 2013 at the MID offices (744 W. 20 St., Merced Ca), the Merced Public Library (2100 O St., Merced, Ca), or the MID website ([www.mercedid.org](http://www.mercedid.org)). Written comments, submitted prior to the hearing, should be directed

to:  
Hicham Eltal  
Merced Irrigation District  
P.O. Box 2288  
Merced, Ca 95344  
Or, for any questions please contact Hicham Eltal at (209)722-5761 Ext 154  
SS-152782 7/30, 8/6/13

## MID Board Resolution of Plan Adoption

### MERCED IRRIGATION DISTRICT RESOLUTION NO. 2013-25

**RESOLUTION ADOPTING THE MERCED IRRIGATION DISTRICT AGRICULTURAL WATER MANAGEMENT PLAN, AMENDING AND SUPERSEDING THE DISTRICT'S EXISTING AGRICULTURAL WATER MANAGEMENT PLAN, AND ADOPTING NOTICE OF EXEMPTION RELATING THERETO**

**WHEREAS**, the Board of Directors of the Merced Irrigation District adopted its existing Agricultural Water Management Plan in July 1999 pursuant to the Water Code Section 10900 et. seq.; and

**WHEREAS**, staff has prepared an update to the Agricultural Water Management Plan, pursuant to Water Code Section 10800, et. seq., Section 10900 and Section 10608.48, including recent modifications effective November 2009, attached hereto as Attachment 'A', incorporated herein; and

**WHEREAS**, the California Water Code, as amended by Senate Bill X7-7 in 2009, requires agricultural water suppliers to prepare and adopt Agricultural Water Management Plans; and

**WHEREAS**, the District has held a properly noticed public hearing to receive comments on the adoption of the proposed revisions to the Agricultural Water Management Plan as required by Sections 10821 and 10841 of the Water Code and Section 6066 of the Government Code; and

**WHEREAS**, the California Environmental Quality Act (CEQA) and the Water Code exempts certain projects from the environmental review process, including Agricultural Water Management Plans created pursuant to Water Code requirements, which are exempt from compliance with CEQA pursuant to applicable provisions of state law including Water Code §§10851 and the general exemption provided for under the CEQA Guidelines §15061; and

**WHEREAS**, staff has conducted a review of the Agricultural Water Management Plan and CEQA and has presented that review to the Board, including reporting to the Board that complying with SBX7-7 AWMP reporting and evaluation requirements will result in the fiscal impact of approximately \$110,000 annually, equivalent to one (1) full time position equivalent.


**NOW, THEREFORE, BE IT HEREBY RESOLVED THAT:**

1. The recitals hereto are true and correct, and are incorporated herein.
2. The Merced Irrigation District Agricultural Water Management Plan as presented and prepared in accordance with Senate Bill x7-7, attached hereto as Attachment 'A', is adopted and supersedes all previous agricultural water management plans.
3. The Board determines that the Agricultural Water Management Plan referenced herein is exempt from compliance with CEQA pursuant to applicable provisions of state law including Water Code §§10851 and the general exemption provided for under the CEQA Guidelines §15061. The Board authorizes the General Manager or General Counsel to sign and file a Notice of Exemption if said officers deem it appropriate or desirable.
4. The General Manager or his designee is directed to submit copies of the Agricultural Water Management Plan, no later than 30 days from this date, to the various agencies and entities as specified in California Water Code Section 10843.

5. The Agricultural Water Management Plan shall be posted on the Merced Irrigation District web site, and made available for public review, no later than 30 days from this date.

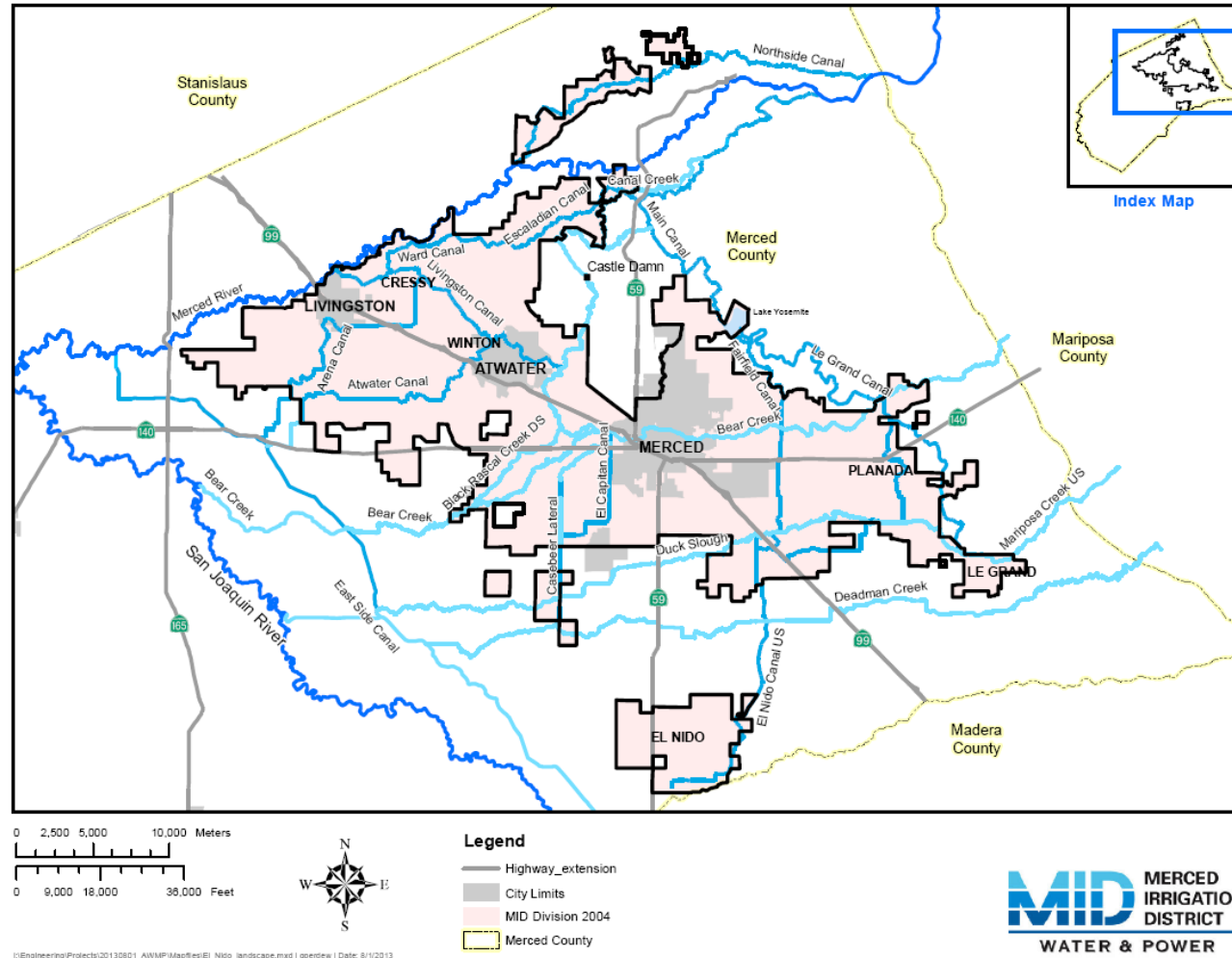
**PASSED AND ADOPTED** by the Board of Directors of Merced Irrigation District this 3<sup>rd</sup> day of September, 2013, by the following vote:

Ayes:	Directors:	Koehn, Long, Pellissier
Noes:	Directors:	Gonzalves, Pimentel
Abstain:	Directors:	None
Absent:	Directors:	None

  
\_\_\_\_\_  
Tim Pellissier  
President  
Merced Irrigation District

  
\_\_\_\_\_  
David Long  
Vice President/Secretary  
Merced Irrigation District

## APPENDIX H DISTRICT MAP





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