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List of Abbreviations

af	acre-feet
Agreement	Agreement for Mendota Pool Transfer Pumping Project (2001)
Agreement No. 2	Agreement for Mendota Pool Transfer Pumping Project (2011)
Bank	Meyers Water Bank
bgs	below ground surface
Chowchilla Bypass	Chowchilla Bypass Canal
CCC	Columbia Canal Company
CCID	Central California Irrigation District
cfs	cubic feet per second
CGH	Coelho/Gardner/Hansen (currently Vista Verde Farms)
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
°C	degrees Celsius
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
EC	electrical conductivity
EIS	Environmental Impact Statement
FCWD	Firebaugh Canal Water District
feet msl	feet from mean sea level
FWD	Farmers Water District
GPS	Global Positioning System
GSPs	Groundwater sustainability plans
JID	James Irrigation District
KDSA	Kenneth D. Schmidt & Associates
LSCE	Luhdorff & Scalmanini Consulting Engineers
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter at 25 °C
mg/L	milligrams per liter
MPG	Mendota Pool Group
MW	Monitor well
MWA	Mendota Wildlife Area
NLF	Newhall Land and Farming
PBO	Plate Boundary Observatory
PFC	Paramount Farming Company
PW	Production well
SGMA	Sustainable Groundwater Management Act
SLCC	San Luis Canal Company

SLDMWA	San Luis and Delta-Mendota Water Authority
SJR	San Joaquin River
SJREC	San Joaquin River Exchange Contractors Water Authority
SJRRP	San Joaquin River Restoration Program
TDS	total dissolved solids
TID	Tranquility Irrigation District
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WO	Wonderful Orchards
WQO	Water Quality Objective
WWD	Westlands Water District

1 INTRODUCTION

This annual report was prepared on behalf of the Mendota Pool Group (MPG) in compliance with the *Agreement No. 2 for Mendota Pool Transfer Pumping Project* (Agreement No. 2), the annual extension of Agreement No. 2, and the Environmental Impact Statement (EIS) entitled *Mendota Pool 10-Year Exchange Agreements* (U.S. Bureau of Reclamation [USBR], 2005a). The purpose of this report is to identify effects of transfer pumping on non-MPG wells and water resources in the area around the City of Mendota in Fresno and Madera Counties, California (**Figure 1-1**). Data collected as part of the 2017 MPG monitoring program are presented in this report and discussed in the context of the historical data record. The MPG did not pump for transfer in 2017; all water pumped by the MPG was used on adjacent lands.

The original study area was established in 1999 and encompassed the vicinity around the Mendota Pool south of Avenue 5 and west of the Chowchilla Bypass Canal (Chowchilla Bypass). All wells owned by the MPG are located within the original study area along (and mostly west of) the Fresno Slough branch of the Mendota Pool, between the Firebaugh Intake Canal and Whitesbridge Road, and south of the San Joaquin River (SJR) branch of the Pool in Farmers Water District (FWD). The original study area was expanded in 2001 to include a radius of at least six miles from the approximate center of the MPG wells in FWD. The locations of the active MPG wells that were pumped for adjacent and overlying use in 2017 are shown on **Figure 1-2**. Locations of known production wells that currently exist in the original study area and the portion of the current study area east of the Chowchilla Bypass are shown on **Figure 1-3**. Known monitor well locations in the original and current study area are shown on **Figure 1-4**. **Figure 1-5** is a larger scale well location map of the central portion of the Study Area east of the Fresno Slough and north of Whitesbridge Road to provide greater detail on the locations of both production and monitor wells in this area. The evaluation of water-level impacts was extended to the northern and eastern portions of the current study area, and the evaluation of surface-water quality impacts was extended to the southern portion of the current study area (study area), which includes the northern portion of the Mendota Wildlife Area (MWA). Other analyses of pumping impacts, such as groundwater quality and subsidence, remained focused on the original study area.

Some of the water pumped by the MPG wells is used to irrigate “adjacent” lands (defined as overlying lands and lands near the Mendota Pool that are irrigated with groundwater using the Pool as a conveyance to transport groundwater). The MPG has also pumped water for transfer (21 of the last 28 years), and the majority of this water was exchanged with USBR and used to irrigate lands owned by MPG members in Westlands Water District (WWD) and San Luis Water District. The MPG did not pump for transfer in 2017; all water pumped by the MPG was used on adjacent lands.

1.1 Background

MPG transfer pumping began in 1989 to make up for some of the cutbacks in deliveries of Central Valley Project (CVP) and State Water Project surface water during the drought in the late 1980s. The period of greatest MPG transfer pumping was 1991 and 1992. There was very little MPG transfer pumping in the calendar years from 1995 to 1999, except for a four-month period in 1997.

A pilot pumping and monitoring program was undertaken in 1999 to determine the impacts of MPG transfer pumping on water users within the San Joaquin River Exchange Contractors Water Authority (SJREC) and Newhall Land and Farming Company (NLF) service areas. NLF's New Columbia Ranch (**Figure 1-3**) was purchased by Paramount Farming Company (PFC) of Bakersfield on December 1, 2005 and the PFC name changed to Wonderful Orchards (WO) on June 1, 2015. The pilot pumping and monitoring program was developed and jointly evaluated by Luhdorff & Scalmanini Consulting Engineers (LSCE) of Woodland, consultants to the MPG, and Kenneth D. Schmidt & Associates (KDSA) of Fresno, consultants to the SJREC and WO (previously Paramount Farms and NLF). Extensive monitoring of pumpage, water levels, water quality, and compaction was initiated in 1999 and continues to the present. The impacts observed during the 1999 program were presented in the Phase I report entitled *Results of 1999 Test Pumping Program for Mendota Pool Group Wells* (KDSA and LSCE, 2000a).

A similar transfer-pumping program to 1999 was conducted in 2000, and the results were summarized in *Mendota Pool Group Pumping and Monitoring Program: 2000 Annual Report* (LSCE and KDSA, 2001). The data collected during the 1999 and 2000 pumping programs were used to evaluate the long-term impacts of MPG transfer pumping on the SJREC and NLF service areas and to develop mitigation measures to address potentially significant impacts. The impacts and recommended mitigation measures were documented in the Phase II report entitled *Long-Term Impacts of Transfer Pumping by the Mendota Pool Group* (KDSA and LSCE, 2000b). This report also included criteria for an agreement between the MPG, the SJREC, and NLF on a 10-year MPG pumping program. This agreement, entitled *Agreement for Mendota Pool Transfer Pumping Project* (Agreement), was signed by all parties in May 2001, with an effective date of January 1, 2001 to December 2010. Annual MPG transfer pumping of up to 31,600 acre-feet (af) in six "normal" years and up to 40,000 af in two "dry" years for a total of 269,600 af was permitted under the terms of this agreement. Two out of the 10 years were to be classified as "wet" years in which no transfer pumping would occur. The Agreement included requirements for a detailed monitoring program and other provisions to ensure that MPG transfer pumping would not cause significant increases in surface-water salinity, depth to water, or land subsidence.

The 2001 transfer-pumping program was the first conducted under the provisions of the Agreement. The most significant change to the pumping program for 2001 was that deep-zone transfer pumping was minimized between July 1 and September 15, to minimize drawdowns in other wells during the summer. The 2001 MPG transfer pumpage was approximately 27,400 af and an additional 13,300 af were pumped by the MPG to irrigate adjacent lands. Annual reports were required under the terms of the Agreement and the 2001 annual report was entitled *Mendota Pool Group Pumping and Monitoring Program: 2001 Annual Report* (LSCE and KDSA, 2002).

The 2002 transfer-pumping program was the second conducted under the provisions of the Agreement. The most significant change to the pumping program for 2002 was that both shallow and deep transfer pumping were reduced from the 2001 levels, due primarily to incomplete water-level recovery that was observed in many shallow and deep zone wells at the end of 2001. Transfer pumping in 2002 was conducted between May 1 and September 30. The total volume of MPG transfer pumpage in 2002 was

about 12,500 af and MPG pumpage for adjacent use was about 15,900 af. The 2002 annual report was entitled *Mendota Pool Group Pumping and Monitoring Program: 2002 Annual Report* (LSCE and KDSA, 2003).

The MPG classified 2003 as a “wet” year, and no transfer pumping was conducted. MPG pumping in 2003 was limited to approximately 14,200 af for adjacent use. The results of the 2003 monitoring program are summarized in an annual report entitled *Mendota Pool Group Pumping and Monitoring Program: 2003 Annual Report* (LSCE and KDSA, 2004). In addition to conducting monitoring activities in 2003, consultants to the MPG prepared an EIS to allow the MPG to obtain exchange agreements with USBR for a 10-year transfer pumping program (effective 2005 through 2014). The Draft EIS was released in May 2003, and the Final EIS was approved in March 2005 (USBR, 2005a). The Record of Decision for the project was signed on March 30, 2005 (USBR, 2005b).

The MPG also classified 2004 and 2005 as “wet” years, and no transfer pumping was conducted. MPG pumping in 2004 was limited to about 12,900 af for adjacent use. The results of the 2004 monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2004 Annual Report* (LSCE and KDSA, 2005). MPG pumping in 2005 was limited to about 10,000 af for adjacent use. The results of the 2005 monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2005 Annual Report* (LSCE and KDSA, 2006). NLF’s New Columbia Ranch (**Figure 1-3**) was purchased by PFC on December 1, 2005 and the PFC name changed to WO on June 1, 2015).

The MPG classified 2006 as a “normal” year and planned to pump about 23,000 af for transfer, along with about 14,000 af for adjacent use. However, due to the extended period of San Joaquin and Kings River flood releases, which continued until mid-July, the planned transfer pumping program did not occur, and pumpage for adjacent use was limited to about 6,400 af. The results of the 2006 monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2006 Annual Report* (LSCE and KDSA, 2007).

The 2007 transfer pumping program was the third conducted under the provisions of the Agreement. Transfer pumping was conducted between April 1 and November 30. The total volume of MPG transfer pumpage in 2007 was about 22,560 af, and MPG pumpage for adjacent use was about 15,500 af. The results of the 2007 monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2007 Annual Report* (LSCE and KDSA, 2008).

The 2008 transfer pumping program was the fourth conducted under the provisions of the Agreement. As in 2007, transfer pumping was conducted between April 1 and November 30. The total volume of MPG transfer pumpage in 2008 was about 24,000 af and MPG pumpage for adjacent use was about 11,800 af. The results of the 2008 monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2008 Annual Report* (LSCE and KDSA, 2009).

The 2009 transfer pumping program was the fifth conducted under the provisions of the Agreement. Transfer pumping was conducted between March 9 and November 24. The total volume of MPG

transfer pumpage in 2009 was 23,811 af; and an additional 2,981 af were pumped for transfer by Don Peracchi, a non-MPG member in FWD. The total pumpage for adjacent use by the MPG and Peracchi was about 10,900 af. The results of the 2009 monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2009 Annual Report* (LSCE and KDSA, 2010).

The 2010 transfer pumping program was the sixth and final to be conducted under the provisions of the original Agreement. Transfer pumping was conducted between March 15 and November 30. The MPG and Peracchi planned to pump a total of 26,890 af for transfer and 10,131 af for adjacent use in 2010. The actual pumping program was greatly reduced due to wet conditions and the availability of CVP and other surface water in 2010. The total volume of transfer pumpage in 2010 was 11,102 af by the MPG and 763 af by Peracchi. Pumpage for adjacent use by both parties was 8,071 af. The results of the 2010 pumping and monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2010 Annual Report* (LSCE and KDSA, 2011).

The original Agreement ended on December 31, 2010. Over the ten-year period of the Agreement, the MPG and Peracchi pumped a total of 125,142 af for transfer. This represents an average of 20,857 af per year over the six years that transfer pumping was conducted. Pumpage for adjacent use by the MPG and Peracchi totaled 118,221 af and averaged 11,822 af per year during this period. A second agreement between the Exchange Contractors, WO, and the MPG was finalized in 2011 with an effective date on January 1, 2011. The term of Agreement No. 2 was four-years (2011 through 2014). The end of Agreement No. 2 was intended to coincide with the 2005 EIS end of term (2014). Annual MPG transfer pumping of up to 25,000 af was permitted under the terms of this agreement with a maximum of 12,000 af from the deep zone.

Beginning in 2011, there was a four-year extension of the original Agreement (Agreement No. 2). The MPG initially classified 2011 as a “normal” and proposed to pump about 21,400 af by the MPG and 1,300 af by Peracchi for transfer. Pumping for adjacent use was planned to be 10,600 af by both parties. However, due to the extended period of San Joaquin and Kings River flood releases, which continued until mid-June, the planned transfer pumping program did not occur, and the total pumpage for adjacent use was limited to about 8,600 af. The results of the 2011 monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2011 Annual Report* (LSCE and KDSA, 2012).

The 2012 transfer pumping program was the first to be conducted under Agreement No. 2. The MPG classified 2012 as a “normal” year, and transfer pumping was conducted between March 1 and October 16. The total volume of MPG transfer pumpage in 2012 was about 22,500 af by the MPG and 2,400 af by Peracchi, for a total of about 24,900 af. Pumpage for adjacent use by both parties totaled about 14,300 af. The results of the 2012 pumping and monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2012 Annual Report* (LSCE and KDSA, 2013). The 2013 transfer pumping program was the second to be conducted under Agreement No. 2. The MPG classified 2013 as a “normal” year, and transfer pumping was conducted between March 1 and November 12. The total volume of MPG transfer pumpage in 2013 was about 19,200 af by the MPG and

3,200 af by Peracchi, for a total of about 22,400 af. Pumpage for adjacent use by both parties totaled 12,100 af. The results of the 2013 pumping and monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2013 Annual Report* (LSCE and KDSA, 2014).

The 2014 transfer pumping program was the third and final program to be conducted under the provisions of Agreement No. 2. The MPG classified 2014 as a “normal” year (in compliance with the EIS, 2005), and transfer pumping was conducted between March and November. The planned pumping program for both the MPG and Peracchi totaled about 23,400 af of transfer pumping and 13,400 af of pumping for adjacent use. The actual transfer pumpage in 2014 was about 20,600 af by the MPG and 2,500 af by Peracchi, for a total of about 23,100 af. Pumpage for adjacent use by both parties totaled about 9,200 af. The results of the 2014 pumping and monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2014 Annual Report* (LSCE and KDSA, 2015).

The Agreement No. 2 ended on December 31, 2014. Over the four-year period of the Agreement, the MPG and Peracchi pumped a total of 70,428 af for transfer compared to the 80,000 af maximum allowed during the term of this agreement. This represents an average of 23,475 af per year over the three years that groundwater pumping for transfer was conducted. Pumpage for adjacent use by the MPG and Peracchi totaled 44,183 af and averaged 11,046 af per year during this period. An annual extension of Agreement No. 2 between the Exchange Contractors, WO, USBR, and the MPG was agreed to following the end of the Agreement No. 2 term. This extension, to be revisited on an annual basis between the MPG, the Exchange Contractors, WO, and the USBR was developed to continue the MPG exchange program until the EIS/EIR is finalized and adopted by WWD and the USBR. Once the EIS/EIR is finalized, the terms of the MPG transfer program will comply with the description of the approved project as described in the EIR/EIS. In the meantime, the annual extension of Agreement No. 2 permits annual MPG transfer pumping of up to 25,000 af with a maximum of 12,000 af from the deep zone.

The 2015 transfer pumping program was conducted under the annual extension of Agreement No. 2. The MPG classified 2015 as a “normal” year (as required by the EIS, 2005), and transfer pumping was conducted between March 1 and November 17. The planned pumping program for both the MPG and Peracchi totaled about 23,300 af of transfer pumping and 10,500 af of pumping for adjacent use. The actual transfer pumpage in 2015 was about 18,300 af by the MPG and 2,800 af by Peracchi, for a total of about 21,100 af. Pumpage for adjacent use by both parties totaled about 10,300 af. The results of the 2015 pumping and monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2015 Annual Report* (LSCE and KDSA, 2016).

The 2016 transfer pumping program was conducted under the annual extension of Agreement No. 2. The MPG classified 2016 as a “normal” year (as required by the EIS, 2005), and transfer pumping was conducted between March 1 and November 22. The planned pumping program for both the MPG and Peracchi totaled about 24,160 af of transfer pumping and 12,000 af of pumping for adjacent use. The actual amount of groundwater pumped for transfer in 2016 was less than planned at about 19,800 af by

the MPG and 2,500 af by Peracchi, for a total of about 22,300 af. Pumpage for adjacent use by both parties totaled about 9,400 af. In late November, the Mendota Pool was drained to allow for the Mendota Dam to be inspected. The results of the 2016 pumping and monitoring program are summarized in a report entitled *Mendota Pool Group Pumping and Monitoring Program: 2016 Annual Report* (LSCE and KDSA, 2017).

The MPG classified 2017 as a “wet” year and proposed to pump about 14,876 af by the MPG and Peracchi for transfer. Pumping for adjacent use was planned to be 5,376 af by both parties. However, due to the extended period of San Joaquin and Kings River flood releases, which continued until July, the planned transfer pumping program did not occur, and the total pumpage for adjacent use was limited to about 4,412 af. The results of the 2017 monitoring program are summarized in this report.

2 MONITORING PROGRAM

The monitoring program conducted in 2017 (**Table 2-1**) followed the monitoring program set forth in the EIS (2005) and is comparable in its scope to the monitoring program conducted in 2016 with a few exceptions (e.g., no surface-water quality or sediment quality sampling) due to the MPG not pumping for transfer. During years when transfer pumping occurs, the monitoring program specifies data collection for the following seven types of data:

- 1) Pumpage
- 2) Water Levels
- 3) Groundwater Quality
- 4) Surface-Water Flow
- 5) Surface-Water Quality (MPG sampling only in years of transfer pumping)
- 6) Sediment Quality (only in years of transfer pumping)
- 7) Compaction

For 2017, the monitoring program excluded sampling for surface water quality and sediment quality due to the absence of transfer pumping. In addition, monitoring of groundwater quality, normally conducted in May, was limited due to the lack of MPG wells that were pumping groundwater. The monitoring program includes wells owned and/or operated by many entities, including the MPG. Thus, although the MPG collects a large amount of the necessary data, it relies on the cooperation of numerous participants in order to fully accomplish the monitoring program objectives. Recognizing that there are different participants in the program, four levels of participation were defined in the EIS to characterize the roles and responsibilities of the various entities:

Level I This level is comprised of the MPG members and encompasses the monitoring activities where the MPG has control over (1) the data being collected, (2) the data quality objectives, and (3) the monitoring frequency. This includes groundwater level (water level) and quality monitoring in wells owned by the MPG and the collection of surface-water and sediment samples from the Mendota Pool. In addition, monitoring of the Fordel extensometer was conducted by the MPG from 1999 through 2014. Since 2015, the MPG has allowed the United States Geological Survey (USGS) to assume maintenance and monitoring of the Fordel extensometer. Monitoring efforts of the Level I participants are coordinated through the MPG agent and consultants to the MPG.

Level II This level originally consisted of the SJREC and NLF, which were the signatories of the Agreement along with the MPG. As the current owner of the New Columbia Ranch, WO (formerly PFC) replaced NLF as one of the participants in the Agreement and was a signatory of Agreement No. 2 and the annual extensions of Agreement No. 2. The SJREC and WO have participated in the monitoring program under the terms of all agreements. The SJREC consists of four entities: Central California Irrigation District (CCID), Columbia Canal Company (CCC), Firebaugh Canal Water District (FCWD), and San Luis Canal Company (SLCC). These entities and the WO are responsible for collection and analysis of groundwater-quality samples from wells in their respective service areas and surface-water quality samples from their canal intakes. The SJREC maintains continuous recorders to monitor electrical

conductivity (EC) at its canal intakes. CCID monitored compaction and water levels at the Yearout Ranch extensometer from 1999 to 2014. Since 2015, the USGS has monitored the Yearout Ranch extensometers as part of the San Joaquin Valley Land Subsidence Monitoring Network. CCID, CCC, and WO also provide monthly pumpage data for their wells. These entities grant the MPG access to specific wells, primarily for water-level monitoring purposes. CCID, CCC, and WO also conduct groundwater-level monitoring in a number of their own wells. The monitoring objectives and frequency can be coordinated between the MPG and these entities.

Level III This level of participation applies to the various public agencies, including the San Luis and Delta-Mendota Water Authority (SLDMWA), USBR, the City of Mendota, the USGS (with the exception of the compaction data monitoring described above), and the California Department of Water Resources (DWR), that conduct monitoring programs as part of their regular duties. These agencies generally provide data to the MPG upon request. The data collected, objectives, and monitoring frequencies are set by the respective agencies relative to their requirements. The MPG has no control over monitoring conducted or overseen by these agencies.

Level IV This level includes all other entities in the area not included in the preceding three levels. This includes water districts such as WWD, James Irrigation District (JID), Tranquillity Irrigation District (TID), and Aliso Water District, and private entities such as Meyers Water Bank (Bank), Meyers Farming (the former Spreckels Sugar Co.), Covanta Mendota (formerly Mendota Biomass), and Locke Ranch. Participation by these entities in the MPG monitoring program is voluntary. The MPG has regularly requested data from these entities with varying success, and, this year the WWD, the former Spreckels Sugar Co. (downloaded from the California State Water Resources Control Board's data management system [GeoTracker]), Locke Ranch (via CCID), JID and TID (flow data via SLDMWA), and Aliso Water District (water levels collected by MPG and Aliso Water District) provided data. In certain cases, the MPG has been granted access to non-MPG properties to measure water levels in or collect water-quality samples from specific wells. When samples are collected by the MPG, the MPG would specify the data to be collected and the data quality objectives. The monitoring frequency at these properties depends in part on when access is granted. Otherwise, the MPG has no control over the data collected, data quality objectives, or monitoring frequencies.

2.1 Pumpage

Groundwater pumped from the MPG wells along the Fresno Slough branch of the Mendota Pool is metered at the discharge points where groundwater enters the Pool. The majority of these wells are metered individually, but a number of shallow zone wells are manifolded together, and the meter reading is a composite value (e.g., the Five Star and Coelho West wells). The SLDMWA typically reads the meters on a weekly basis during the irrigation season and less frequently during the rest of the year. Wells in FWD are metered individually with the pumpage monitored on a monthly frequency by FWD. The discharge from the FWD wells are also manifolded together into five metered discharge locations into the SJR. The MPG maintains records to determine whether water from its wells is being pumped for transfer or adjacent use. A total of 19 MPG wells were pumped for adjacent use in 2017 and are shown on **Figure 1-2**.

Level II participants (e.g., WO, CCID, and CCC) provided monthly pumpage for wells within their service areas (CCC did not pump for irrigation, only for pump tests in 2017). SLCC has no wells within the study area. FCWD operated wells within the study area prior to the early 1990s and after 2008 and SLDMWA provided monthly pumpage data for the period 2008 through 2017. These wells reportedly pump groundwater from the deep zone, however, we have been unable to obtain well completion reports to verify the zone of completion. Groundwater level measurements have only been provided for one of FCWD's wells and no groundwater quality data are available. Monthly pumpage for all the WO wells is based on flow meter readings.

The City of Mendota is the only Level III entity that operates water supply wells within the study area. Metered pumpage data for its municipal water supply wells (well Nos. 7, 8, and 9) were supplied on a monthly basis for 2010, 2014, 2016, and 2017. Pumpage data for 2011 through 2013 and 2015 were not provided. The pumpage for 2011 through 2013 was assumed to be similar to 2010 amounts while 2015 pumpage was assumed to be similar to 2014 levels. Six wells (M-1 through M-6) operated by the City of Mendota (formerly operated by Fordel, Inc.) are metered nearly weekly by the SLDMWA.

Pumpage for level IV participants was provided for 2017 by Locke Ranch via CCID and Meyers Farming. Meyers Farming (the former Spreckels Sugar Co.) 2017 annual pumpage was not available however meter readings from May 12, 2016 and April 25, 2017 (taken during monitoring events) and was used in its place. Covanta Mendota suspended operations in January 2015 and remained closed through December 2017. Pumpage east of the Chowchilla Bypass was estimated based on most recent (e.g., 2009 and 2011) DWR land use maps and is discussed in Chapter 3.

2.2 Water Levels

The primary purpose of the groundwater-level monitoring program is to generate the data necessary to evaluate the effects of MPG transfer pumping on water levels. Water-level measurements have been taken in a large network of wells in the Mendota area since 1999. The wells in the monitoring network include water supply wells and monitor wells that are classified as either shallow (completed above the A-clay or its equivalent depth, i.e., generally less than 130 feet in depth, depending on location) or deep (completed below the A-clay or its equivalent depth but above the Corcoran Clay, which is at an average depth of about 400 feet). Some wells in FWD and WO that were classified as deep zone wells in the past are actually composite wells (completed both above and below the Corcoran Clay) due to a small portion of the wells perforated interval located below the Corcoran Clay and were reclassified in 2014. Four monitor wells, including one USGS well west of the Fresno Slough, one USBR well at the confluence of the DMC and the Fresno Slough, and two WO wells north of the SJR, are completed only in the lower aquifer below the Corcoran Clay.

Wells included in the water-level monitoring network are listed in **Table 2-2**, along with the entity responsible for monitoring each well, the participation level, and the monitoring frequency. In 2017, the MPG conducted seven rounds (January, February, May, August, September, October, and December) of water-level measurements in 59 wells, and compiled groundwater-level measurements provided by entities such as WO, CCID, CCC, WWD, USGS, and USBR. Well locations are shown on **Figure 2-1**. In

addition to the collection of manual water-level measurements, the MPG operates electronic equipment collecting daily water-level information in USGS monitor well 31J3 (near the Fordel extensometer). CCID installed electronic water-level recording equipment in the Yearout Ranch extensometer, but this equipment failed in 2004 and was replaced in 2012. Only manual measurements are available for the intervening years. The USGS took over monitoring and maintenance of the Yearout Ranch extensometer in 2015, but the water-level recording equipment became lodged in the well and, consequently, manual water-level measurements will only be available in the future unless a separate observation well for water level monitoring is constructed nearby.

2.3 Groundwater Quality

The purpose of the groundwater-quality monitoring program is to generate the data necessary to evaluate changes in groundwater quality that may be caused by MPG transfer pumping and to forecast potential surface-water quality impacts in the Mendota Pool. For these purposes, the MPG collects annual samples from its operational production wells along the Fresno Slough branch of the Pool and in FWD (**Table 2-3**). Since 2017 was a “wet” year and groundwater pumping was reduced, a groundwater sample was only able to be collected in FWD-R-7. Groundwater quality was reported in several non-MPG wells within the study area during 2017. Wells in which groundwater quality data were reported in 2017, MPG and non-MPG, are shown on **Figure 2-2**. These samples were analyzed for EC and total dissolved solids (TDS) or general minerals and trace elements, depending on the sampling schedule.

Water-quality data from signatories (e.g., WO, CCID, and CCC) to Agreement No. 2 and the annual extension of Agreement No. 2 were supplied as available. Water-quality data were also obtained from non-MPG members: The City of Mendota (available from California Department of Public Health) and the former Spreckels Sugar Co. (available from the California State Water Resources Control Board GeoTracker online link to data for regulated facilities). Meyers Farming now owns the former Spreckels’ property and wells, and it has a separate groundwater monitoring program specified by the Central Valley Regional Water Quality Control Board (CVRWQCB).

2.4 Surface-Water Flow (Water Budget)

The SLDMWA assumed operation of the Mendota Pool from USBR in October 1996. Since then, the SLDMWA has responded to delivery requests and monitored inflows, diversions (outflows), and the stage height in the Pool. Some inflows are monitored on a daily basis (e.g., inflow from the Delta-Mendota Canal [DMC], the SJR just west of the Chowchilla Bypass, and the Kings River via the James Bypass). Inflow to the Pool from the SJR is estimated daily by the SLDMWA based on data from the Chowchilla Bypass gage. Pumpage to the Pool is monitored on a weekly basis during the irrigation season and less frequently during the rest of the year. Based on the inflow and outflow components, including delivery requests, the SLDMWA monitors and forecasts the direction of flow in the Fresno Slough branch of the Mendota Pool. This information is needed to monitor the occurrence of water-quality degradation at the SJREC’s canal intakes caused by MPG transfer pumping and other non-MPG entities. The SLDMWA has agreed to notify the MPG whenever a north flow event is expected to occur.

During most of the year, the flow direction in the Fresno Slough branch of the Mendota Pool is to the south. Northerly flow is typically observed as a result of major upstream flood releases to the Kings River and the Fresno Slough and when the Pool is being drained in preparation for winter maintenance work on or inspection of the Mendota Dam as occurred in late November 2016 through mid-January 2017. During such times, the MPG does not conduct transfer pumping.

Data provided by the SLDMWA are used by the MPG to prepare a monthly water budget for the Fresno Slough Branch of the Pool south of the Firebaugh Intake Canal. Water delivery demands by entities located along this portion of the Mendota Pool account for approximately 10 to 15 percent of the total DMC deliveries (most of the DMC deliveries are diverted into the SJREC's canal intakes in the northern portion of the Pool). The MPG's water budget accounts for all known and measured inflows from and diversions to these entities, evaporation and seepage losses, and the change in storage (as calculated from SLDMWA's stage height measurements). The water budget is used to calculate the monthly amount of inflow from the DMC that reaches the southern portion of the Pool. This quantity is used in combination with water quality information for the DMC and MPG wells to devise MPG pumping programs to meet strict water-quality constraints. However, since 2017 was a wet year with no MPG water transfers, a 2017 pumping program was not implemented.

2.5 Surface-Water Quality

The primary purpose of the surface-water quality monitoring network (**Table 2-4**) is to allow the MPG to detect any potential exceedances of water-quality objectives at key locations in the Pool and adjust the pumping program accordingly. During transfer pumping years, the MPG monitoring program is supplemented by data obtained from the SJREC and USBR. During non-transfer pumping years (such as 2011 and 2017), most of the surface water quality data are collected by these entities. The SJREC operates continuous EC recorders at its four canal intakes that divert water from the Pool, i.e., the Columbia Canal, CCID Main Canal, CCID Outside Canal, and Firebaugh Intake Canal, and retrieves grab samples from these locations (**Figure 2-3**) monthly during the irrigation season. These samples are analyzed for EC, boron, and selenium. Data obtained from USBR include daily high, low, and average EC values based on electronic transducer data from the DMC at Bass Avenue (Check 21), and daily selenium concentrations from samples retrieved via auto-sampling equipment at Check 21. USBR also collects manual grab samples from the DMC (Check 21), CCID Main Canal, and the CCID Outside Canal on a monthly basis and they are analyzed for EC and selenium.

2.6 Sediment Quality

A sediment quality monitoring program was initiated in 2001 at the request of the U.S. Fish and Wildlife Service (USFWS). Most of the eight sediment sampling stations (**Figure 2-4**) are co-located with surface-water sampling locations. Its objectives are to provide baseline characterization of metal concentrations in Pool sediments and to allow identification of temporal and spatial trends in sediment quality. Sediment samples were collected in 2001, 2002, 2007, 2009, 2010, and 2012 through 2016. Sediment sampling was not conducted during years when the MPG did not pump for transfer (2003-2006, 2008, 2011, and 2017).

2.7 **Compaction and Land Subsidence**

Continuous compaction data are collected from two extensometers in the Mendota area to evaluate compliance with the subsidence criterion specified in the original Agreement, Agreement No. 2, and the annual extension of Agreement No. 2. The MPG installed the Fordel extensometer west of the Fresno Slough in 1999. The Yearout Ranch extensometer, located east of the Slough, was installed by DWR in 1965 and was monitored by CCID from 1999 to 2014, at which time the USGS incorporated the Yearout Ranch and Fordel extensometers into their San Joaquin Valley Land Subsidence Monitoring Network. The 2017 and early 2018 data from these extensometers are evaluated in this report in the context of the period of record. Both extensometers monitor compaction above the Corcoran Clay, the top of which was encountered at depths of 418 and 428 feet at the Fordel and Yearout Ranch sites, respectively.

Since 2004, total compaction (including compaction occurring in and below the Corcoran Clay) has been measured at a Global Positioning System (GPS) monitoring station located on land owned by Meyers Farms southeast of Mendota and west of the Fresno Slough (**Figure 2-1**). This GPS station is part of a network of similar stations that have been installed throughout the western United States by the Plate Boundary Observatory (PBO), which is a division of UNAVCO. Data at the Mendota PBO station (No. P304) began to be collected on April 28, 2004, and the data are uploaded daily to the UNAVCO website.

3 PUMPAGE

This section includes a summary of the 2017 pumpage from agricultural, municipal, and industrial wells in the study area compiled from various sources as described in Chapter 2. In general, pumpage records based on monthly flow meter readings are deemed most accurate, i.e., records from MPG members, CCID, CCC, WO, FCWD (provided by SLDMWA), and City of Mendota. 2017 annual pumpage amounts for Locke Ranch were provided by CCID and estimated annual pumpage for the former Spreckels Sugar Co. wells is based on semi-annual meter readings. Pumpage east of the Chowchilla Bypass was based on estimates described below. Covanta Mendota closed permanently in January 2015. Pumpage from private domestic wells was not included because it is considered negligible compared to agricultural and municipal pumping.

3.1 Mendota Pool Group Pumping

The MPG developed a preliminary transfer pumping program for 2017, however, it was not implemented due to flows in the James Bypass that were expected to occur until July 2017 and CVP allocations to WWD. As a result, the 2017 MPG pumpage was limited to pumping for irrigation of adjacent and overlying lands. The MPG operated a total of 19 wells in 2017. Those wells are identified as “active” on **Table 3-1** and included 6 shallow zone wells, 12 deep zone wells, and 1 composite well. **Table 3-1** includes construction information (where available) and approximate discharge capacities for each MPG well (including wells not operated in 2017).

Pumping for irrigation of overlying and adjacent lands occurred from March through December and totaled 4,412 af (**Table 3-2**) for both the MPG and non-MPG use by Peracchi (964 af less than planned) (**Table 3-3**). With no transfer pumping, the total amount of groundwater pumped by the MPG was the same as the amount pumped for adjacent use.

As shown in **Table 3-3**, MPG wells located along the Fresno Slough branch of the Mendota Pool contributed approximately 38% of the pumpage for adjacent use (1,674 af). Wells located in FWD (west and south of the SJR, including Baker Farming, Panoche Creek Farms [also known as Panoche Creek Trust], and the FWD R-wells) pumped 2,738 af of groundwater for adjacent use (including use by Peracchi).

The annual extension of Settlement Agreement No. 2 limits transfer pumping (deep and shallow wells) to 25,000 af per year. The single year limit was not exceeded in 2017 (total transfer pumpage was 0 af). Adjacent pumping in the annual extension of Settlement Agreement No. 2 is set at 12,000 af per year. In 2017, the total adjacent pumpage was 4,412 af.

Table 3-4 shows MPG pumpage by aquifer zone (shallow versus deep) beginning in 1997; this breakdown was not available prior to 1997. Deep zone wells are generally completed below the A-clay and above the Corcoran Clay, i.e., primarily in the 200 to 400 foot depth range. However, one FWD well (R-9) is a composite well completed in the deep zone and partially below the Corcoran Clay. R-8, R-10, and R-11 were also composite wells until the lower aquifer perforations were sealed off over the past three years. Well R-9 is projected to be unusable in the near future due to impacts resulting from SJRRP

restoration flows. As a result, the status of sealing the perforations in this well below the Corcoran Clay will be determined pending the impacts that the SJRRP has on this area of FWD.

Deep zone MPG wells did not pump for transfer in 2017 (**Table 3-4**). Deep zone MPG wells pumped 3,200 af for adjacent use in 2017, which was 1,359 af less than the preliminary program.

Shallow zone wells in the Mendota area are defined as those completed above the A-clay or its equivalent depth, i.e., less than 130 feet deep. Shallow-zone transfer pumpage in 2017 did not occur. Shallow-zone adjacent pumpage in 2017 totaled 1,212 af, which is 395 a more than the preliminary pumping program, but far below the preliminary estimate for shallow zone wells and the allowed 12,000 af of adjacent pumping under the annual extension of Agreement No. 2. Well-by-well MPG pumpage in 2017 is presented in **Appendix A**.

3.2 Non-MPG Pumping

Non-MPG pumpage in the study area west of the Chowchilla Bypass was estimated to be about 12,000 af in 2017 (**Table 3-5**). Pumping was greatest in the WO service area (about 8,000 af), which was lower than WO pumpage in 2016 (**Table 3-6**). Non-MPG pumpage in the study area west of the Chowchilla Bypass has been highly variable, ranging from almost 52,000 to 58,500 af during 2001-2003, increasing to about 67,000 af in 2004, ranging from about 23,000 to 37,000 af during 2005-2010, decreasing to about 18,000 af in 2011, increasing to a range of about 47,000 to 57,000 af from 2012 through 2015, then decreasing in 2016 and 2017. The variability has been due to a number of factors including changes in cropping patterns and crop maturity along with availability of imported surface water supplies.

In the past, all of WO's pumpage was classified as occurring above the Corcoran Clay because estimates were not available of the contribution from the lower aquifer in WO's composite wells. Logs are not available for all WO wells, but at least 11 wells have been identified as composite wells as shown on **Figure 1-3**. An estimate of WO's pumpage from the lower aquifer was calculated for 2017 using the same methodology used in estimating lower aquifer pumping in the FWD composite well. Pumpage below the Corcoran Clay was estimated at about 400 af, which is about 5% of total WO pumpage (8,200 af).

Pumpage by other entities included about 200 af from CCC wells, 100 af from CCID wells, 1,900 af by the City of Mendota, 100 af by Locke Ranch (**Table 3-6**). Pumpage from grower wells within the FCWD service area were not available for 2017. Some water is still pumped for irrigation purposes at Meyers Farming (the former Spreckels Sugar Co.) and the volume pumped in 2017 was estimated (1,100 af) using semiannual meter readings by well.

The Meyers Water Bank did not extract from the shallow zone in 2017 but about 10,400 af was recharged. As of the end of 2017, about 75,500 af has been recharged to the shallow zone and 30,300 af has been extracted (data from Meyers Farms Water Bank). The Bank is required to leave five percent of the total recharge in the aquifer (2,290 AF), which means 43,000 af of available water is stored in the Bank.

Pumpage data are not available for wells east of the Chowchilla Bypass, and an estimate for 2017 is based on 2012 amounts. These pumpage estimates were based on crop demand calculated as a function of irrigated acreage, land use (2011 Madera County and 2009 Fresno County land use maps), irrigation efficiency, surface water deliveries, and precipitation. The total pumpage above and below the Corcoran Clay in the portion of the study area east of the Chowchilla Bypass was estimated to be 105,000 af, which includes about 67,000 af in Aliso Water District and undistricted portions of Madera County and 38,000 af in the undistricted portion of Fresno County east of FWD and Meyers Farming (the former Spreckels Sugar Co.). The total non-MPG pumpage above and below the Corcoran Clay in the study area was estimated to be about 116,600 af in 2017. It is expected that with the implementation of the Sustainable Groundwater Management Act (SGMA) in the future that these estimates of groundwater pumpage east of the Chowchilla Bypass will be refined and available for public review once SGMA-required groundwater sustainability plans (GSPs) are prepared and submitted to DWR by January 2020.

4 WATER LEVELS

4.1 Groundwater Elevation Contour Maps

Three groundwater elevation contour maps were prepared for both the shallow and deep zones. Contour maps for both zones were based on water levels measured mostly in November 2016 through February 2017, July through September 2017, and December 2017 to January 2018 (**Figures 4-1** through **4-6**). Groundwater elevations on the contour maps are shown as feet from mean sea level (feet msl) based on the North American Vertical Datum of 1988 (NAVD 88).

4.1.1 Shallow Zone

Water elevation contours in the shallow zone above the A-Clay in the Winter of 2016/2017 (November 2016 through February 2017, with the exception of the USGS wells measured October 12, 2016) are shown on **Figure 4-1**. Water elevations ranged from about 190 feet msl in the southwestern corner of the study area to about 70 feet msl in the northeast. Southwest of the City of Mendota, the direction of groundwater flow was to the east-northeast toward the Fresno Slough. There was a cone of depression near the Fresno Slough from Jack's Resort and northward, due to MPG pumping in 2016. Water levels in this area were lowest in the vicinity of Meyers Farming well MS-4 west of the Pool. There was a groundwater ridge beneath the SJR and a portion of the SJR branch of the Mendota Pool north and northwest of FWD, and groundwater flowed away from the River to both the northeast and southwest. There appears to be a hydraulic connection between river water and groundwater in this reach (the SJR was flowing in all of 2017). A second cone of depression was located beneath the north part of the study area, west of the Bypass. Water elevations were lowest at WO well 3431-91 in the northern portion of WO's New Columbia Ranch. In the vicinity of the Bank, there was a mound, due to recharge from the ponds.

Figure 4-2 shows water elevations in the Summer of 2017 (July 3 to September 25, 2017, with the exception of the USGS wells measured October 5, 2017 and two SJRRP wells measured October 24, 2017). This contour map shows that groundwater flow was away from the SJR in both directions (losing conditions) in the reach upstream of Mendota Dam. North of Mendota Dam, water levels were low enough that there appeared to be no direct hydraulic connection between river water and groundwater, and the direction of groundwater flow was to the northeast beneath the SJR. A groundwater mound was present around the Meyers Water Bank recharge ponds (source: GeoTracker Spreckels Sugar plant semi-annual groundwater report). The shape of the other contours shown on this map are similar to the November 2016 to February 2017 contour map (**Figure 4-1**). During the summer months, there was a cone of depression west of the Fresno Slough branch of the Pool due to MPG pumping. Except for this, groundwater flow directions were towards Madera County except for a small area south of the San Joaquin River.

Shallow-zone water elevations in the Winter of 2017/2018 (December 2017 to January 2018) are shown on **Figure 4-3**. Groundwater flow directions were similar to those shown on **Figure 4-2**. Groundwater elevations beneath the MPG well field west of the Fresno Slough were approximately 10 ft higher

compared to Winter 2016/2017 (**Figure 4-1**) and there was flow away from the SJR and a portion of the northern branch of the Mendota Pool upstream of the Mendota Dam. Overall, water level elevations in December 2017 to January 2018 were slightly higher than those in Summer 2017, indicating that water levels recovered from seasonal low levels in the Summer. Also, the cone of depression due to MPG pumping in the Summer (**Figure 4-2**) was not as evident in the Winter (**Figure 4-3**).

4.1.2 Deep Zone

Water elevations in the deep zone vary with well depth. For example, water levels in the upper portion of the deep zone often are higher compared to water levels from wells completed in the lower portion of the deep zone. This can be observed in the comparison of monitor wells at both USBR 19R and the USGS 31J site (**Figure 4-7**) where the difference in water levels between the upper and lower portions of the deep aquifer zones can be as much as 35 feet in summer and can be up to 16 feet different in winter. Therefore, these variations need to be accounted for when interpreting groundwater elevation contours and flow directions.

Water level elevation contours in the deep zone during Winter 2016/2017 (December 2016 to February 2017, one exception is the USGS-10A4 measured October 12, 2017) are shown on **Figure 4-4**. Most of the wells used to create this contour map are perforated below the A-Clay or its equivalent depth and above the Corcoran Clay. However, it was necessary to use data from composite wells to fill in data gaps and extrapolate water level contours in some areas such as part of the Aliso Water District. Water level elevations ranged from over 160 feet msl on the western edge of the study area to about 30 feet msl in a cone of depression located east of the Chowchilla Bypass. Groundwater flow directions were generally toward the cone of depressions near Avenue 7 east of the Chowchilla Bypass. The cone of depression coincides with an area with no surface water supplies.

Water elevation contours in the deep zone during the Summer/Fall of 2017 (July 10 to September 26, 2017) are shown on **Figure 4-5**. Compared to the Winter 2016/2017 period, groundwater elevations were lower in most areas, which is expected due to water level declines associated with groundwater pumping. There was a groundwater depression near Avenue 7 and also a slight depression around FWD (south of SJR). A small groundwater mound in the southeastern portion of WO caused groundwater to flow northeast and south towards the depressions under Aliso Water District and Farmers Water District respectively. This was probably due to flow in the Bypass in 2017.

Water elevation contours in the deep zone during the Winter 2017/2018 period (November 2017 through February 2018) are shown on **Figure 4-6**. Comparison of this contour map with that for the Summer/Fall of 2017 shows significant water-level recovery after the end of the 2017 irrigation season, and groundwater elevations were much higher than in the summer beneath the Aliso Water District, FWD, and the MPG well field west of the Fresno Slough. Water elevations ranged from about 143 feet msl (CCID-38A) north of the City of Mendota to about 30 feet msl (Alis-DP2 and Alis-DP-4) in the cone of depression east of the Chowchilla Bypass, and the overall direction of groundwater flow continued to be toward this cone of depression.

4.2 Water-Level Hydrographs

Short-term water-level hydrographs (defined as the last five years, January 2013 to February 2018) for all wells in the MPG monitoring program are included in **Appendix B**; and long-term hydrographs, which contain all available data for each well that has a dataset that extends back in time prior to January 2013 are included in **Appendix C**. Hydrographs for the San Joaquin River Restoration Program (SJRRP) monitor wells in the Mendota area are included in **Appendix D**. Water levels measured in shallow and deep zone wells are summarized below. Water-level changes in 2017 are shown in **Table 4-1** (shallow zone) and **Table 4-2** (deep zone). Water level measurements in Meyers Farming (former Spreckels Sugar Co.) monitor wells are usually taken in May and October. These dates do not provide an accurate representation of full drawdown (usually in July through September) and recovery (usually in January or February) and, therefore those data are not used for comparison purposes. These tables show the “maximum drawdown” (the difference between the static, non-pumping water level at the beginning of the year and the deepest static level during the irrigation season), “recovery” (the difference between the drawdown during the irrigation season and the recovery at the end of the year or early the following year), and “residual drawdown” (the difference between the beginning and end of the year water levels). As discussed below, water levels in most wells in the study area were higher at the end of 2017 than at the beginning of the year. The maximum drawdown and recovery water levels are not based on pumping water levels. **Figure 4-7** shows hydrographs for two multiple completion monitor wells. The “19R” wells are located at the confluence of the DMC and Fresno Slough (**Figure 1-4**) and the USGS wells are located on the eastern edge of the town of Mendota. These are unique in the area because they each monitor four different zones (e.g., shallow zone, upper deep zone, lower deep zone, and lower aquifer).

4.2.1 Shallow Zone (above the A Clay)

Annual Residual Changes in Water Levels

Water level response in 17 shallow-zone wells were evaluated to assess residual change over the past two Winter/Spring periods (**Table 4-1**). These wells were selected out of the 63 shallow zone wells listed in Table 2-2 that are monitored on a bi-monthly or more frequent basis with the exception of very shallow wells generally less than 30 feet deep (e.g., SJRRP and some WO wells) and dry wells (e.g., WO MW12, and -14). The residual change was calculated by comparing the change in water levels from the 2016/2017 Winter/Spring period to the 2017/2018 Winter/Spring period. Water levels rose over this period in all 17 wells. These water-level changes varied by location (**Table 4-1**). All eight shallow zone wells west of the Fresno Slough showed annual rises in water levels with a maximum of 14.13 feet at well MS-4. Water levels for shallow zone wells located east of the Fresno Slough at the former Spreckels site (MW-1, 3, 13, and 18) were downloaded from the GeoTracker website that posts semi-annual monitoring reports that include spring and fall measurements. The spring measurements are collected in late April or May, which is when water levels have already begun to decline due to irrigation pumping and fall measurements are taken in October when water levels have generally begun to recover. As a result, using the semi-annual water level data for the former Spreckels does not produce representative residual drawdown and recovery data.

North of the SJR in the CCC and WO area, all nine wells showed rises in water levels ranging from 2.47 feet (MW-3) to 30.96 feet (MW-4).

Long Term Changes in Water Levels

Long term changes in shallow zone water levels vary in the study area (**Figure 4-8**). Historical water levels west of the Fresno Slough at USGS monitor well T13S/R15E-31J4, located west of the Mendota Airport, have ranged from a high of 16 feet below ground surface (bgs) in 1986 to a low of 69 feet bgs in 1994. The water levels have generally responded to variations in climatic conditions and MPG pumpage, with the lowest water levels observed during the early 1990s and during the fall of 2015 and 2016. The highest water levels were observed during wet periods and minimal MPG pumpage such as the mid to late 1980s and 2006.

Water levels in the shallow zone in the northern half of the MPG well field west of the Fresno Slough as represented by well TLF-7s (**Figure 4-8**), generally were high in 2006, 2010/2011, and 2017 (during the wet periods and minimal MPG pumping). The lowest water levels occurred at the height of the recent drought in 2015/2016 with levels about 20 to 25 feet lower than the wet periods. In the southern portion of the MPG well field west of the Fresno Slough, near Jacks Resort the water levels in Five Star well FS-5, have risen from a low of 62 feet bgs in 2002 to a high of 13 feet bgs in 2007. Since 2007, water levels have undergone two separate periods of decline (2007 to 2010 and 2012 to 2016) with a recovery occurring from 2010 to 2012 and in 2017. Some of the periods of recovery may have been due to recharge by the Bank, as discussed below, and the deepest levels were associated with MPG pumping.

East of the Fresno Slough, water levels at shallow monitor wells in the western portion of Meyers Farming (the former Spreckels Sugar Co.) declined significantly between 1986 and 1993 due primarily to MPG pumping. Water levels recovered between 1993 and 2007, with the greatest rise occurring between 2003 and 2007. Rising water levels during this period were due to a combination of reduced MPG pumping near the Fresno Slough and recharge by the Bank that began in Spring 2002, which is located east of the Slough in the western portion of Meyers Farming property. By January 2007, water levels had recovered to mid-1980s levels. During 2007-2009, water levels declined due to MPG pumping and extraction from the Bank. Water levels rose significantly in 2010 and 2011 due to reduced MPG pumping and additional Bank recharge. Water levels were generally stable in 2012 and declined in shallow zone wells (MW-1 and MW-3) in 2013 through 2015. From 2015 to 2017, monitor wells closest to the Meyers Farms recharge ponds had the largest rise in water levels (e.g., MW-3 had about 27 feet and MW-1 had about 24 feet) and two others further away showed about a 16-foot rise (MW- 13 and MW-18).

At Meyers Farming MW-3 (**Figure 4-8**), the lowest water level was measured in 2015 at about 52 feet bgs in the Fall, similar to the depth to water measured in the well in 1995 (about 50 feet bgs). Much of the water-level rises during 2002-2007, 2010-2012, and 2016/2017 are attributed to recharge from the Bank and reductions in pumping from the MPG of varying degrees. The water level declines in 2007 to 2009 and 2013 to 2015 was due to MPG pumping, and extraction from the Bank.

Water levels in the Meyers Farming monitor well MW-32 (**Figure 4-8**), located east of San Mateo Avenue, are primarily influenced by recharge from the SJR as are SJRRP wells (09-56 and 09-57). Water levels in Meyers Farming MW-32 have fluctuated within a 20-foot range since 1999. Since 2012, there were two measurements per year compared to more frequent measurements prior to that time. The shallowest water levels were measured in Spring 2013 at about 32 feet bgs. Between 2013 and 2017, spring water levels declined about 13 feet. Other than Meyers Farms, the only significant shallow zone pumpage is for MPG wells along the Fresno Slough.

North of the SJR, water levels in the easternmost shallow WO monitor well 3730-91 (MW-2, **Figure 4-8**) shows the most response to recharge from the SJR. 3730-91 is located near the River and the Chowchilla Bypass and is too far east to be influenced by seepage from the Pool. Water levels in 3730-91 declined by 25 feet or more during periods of little or no SJR flow (2001-2004 and 2007-2009). Water levels rose by a similar amount during high flow periods (2005-2006 and 2010-2011). The 2010-2011 water-level rise was due primarily to interim releases from Friant Dam for the SJRRP. These flows continued in 2012 through 2013, and water levels in 3730-91 remained relatively high, at about 20 feet bgs. However, in 2014, flows in the SJR were highly variable through the year and during 2015 and 2016, SJR flows were limited to only a few months. These reductions in SJR flows resulted in water level declines of about 15 feet in 2015 and the first half of 2016. Water levels then recovered about 17 feet by mid-2017 to about 17 feet bgs due to SJR flood releases.

Water levels in shallow zone monitor wells near the SJR branch of the Pool, including WO well 3730-93 (MW-3, **Figure 4-8**) and the CCC Lopes-Observation well (**Appendix C**), are influenced by year-round seepage from the Pool. As a result, these wells show much smaller seasonal and year-to-year fluctuations than wells located more distant from the Pool. From 2012 to 2015, water levels in 3730-93 declined almost 10 feet to about 28 feet, bgs. This overall decline is likely a result of many factors predominantly dry climatic conditions since 2000. In 2017, water levels rose approximately 4 feet. This rise is likely due to reduced pumpage.

In the northern portion of the study area, water levels in WO wells 2480-93 and 3431-91 are influenced by pumping of deeper groundwater and declined from 2000 to 2005 and 2007 to 2010. Water levels in 2480-93 are also strongly influenced by flows in the Chowchilla Bypass and rose during 2005-2006 and in 2011 due to recharge from the Chowchilla Bypass and a nearby intentional recharge facility operated by WO. Water levels in 2480-93 rose by about 45 feet in 2011 but declined by about 50 feet from January 2012 to August 2014, when the well went dry and stayed dry through December 2016. In 2017, water levels increased from 75 feet bgs in February to 41 feet bgs in March and then fluctuated between 38 to 58 feet bgs the rest of the year. Compared to 2480-93, water levels in wells to the northwest (3431-91, 2480-96, 3561-93, and 3561-92) have shown smaller year-to-year fluctuations in response to nearby pumping and recharge from the Chowchilla Bypass. 3431-91 (**Figure 4-8**) water levels rose by about nine feet in 2011 and declined by a total of about 34 feet between 2011 and August 2016. Since August 2016, water levels have risen approximately 20 feet.

4.2.2 Deep Zone

This section describes water levels in deep zone wells completed below the A Clay or equivalent depth and above the Corcoran Clay and composite wells completed above and below the Corcoran Clay. Water levels in the 63 of the 64 deep-zone and composite wells rose in 2017 (**Table 4-2**). All seven deep zone wells east of the Pool had water level rises that ranged from 2.9 to 11.5 feet from winter 2016/2017 to winter 2017/2018. All ten deep wells monitored west of the Pool also experienced recoveries in water levels between winter 2016/2017 and winter 2017/2018. North of the Pool and west of the SJR, all ten CCID wells experienced water level recoveries over the past year. These ranged from 2.1 to 14.9 feet.

Deep zone and composite non-MPG wells north of the SJR had residual rises in water levels that ranged from 1.42 feet to 39.27 feet. Water levels rose in all of the 29 WO wells (up to about 39 feet) and increased approximately 8 feet in three of the four CCC wells during 2017. East of the Chowchilla Bypass Canal residual changes in water levels ranged from a decline of 0.05 feet to a rise of about 8 feet.

Long Term Changes in Water Levels

Long-term water-level trends vary by location (**Figure 4-9**). North and northwest of the City of Mendota, hydrographs of the CCID wells (**Appendix C**) show water levels that decline during dry periods to 25 to 70 feet bgs, followed by water level recoveries during wet periods to 5 to 10 feet bgs. Water levels have been measured since 1985 at the cluster of USGS monitor wells west of the Mendota Airport. The water levels in the USGS deep zone monitor well (31J5) with similar perforations to the CCID wells, has declined up to 130 feet bgs during dry periods and periods of MPG pumpage followed by full recovery to 20 to 30 feet bgs during wet periods and minimal MPG pumpage. Water levels in the deep zone well rose during 2003-2006, declined during 2007-2009, rose during 2010-2011, declined in 2012-2016, and stabilized to above 40 feet bgs in winter 2017/2018.

East of the Fresno Slough, water levels in the deep Meyers Farming monitor wells have declined to 50 to 95 feet bgs during dry periods and MPG pumpage since 1985, followed by water level recoveries to 20 to 30 feet bgs in wet periods and minimal MPG pumpage. Water levels rose in the deep zone Meyers Farming monitor wells from 1994 through 2006, with the largest rise occurring in wells near the Bank during 2003 to 2006. Water levels at Meyers Farming MW-11 rose by about 14 feet from 1994 to 2003 and by an additional 20 feet from 2003 to January 2007. Water levels at MW-11 (**Figure 4-9**), which is screened in the upper portion of the deep zone, declined by about 20 feet during 2007-2009 due primarily to MPG pumping and Bank recovery well pumping. The seasonal drawdown was relatively large in 2009, which was the year of greatest recovery pumping from the Bank. The seasonal drawdown was much smaller in 2010, and water levels were about 13 feet higher at the end of the year. The end-of-year water levels in MW-11 were stable from 2011 to 2013. Water levels declined from January 2013 to January 2016 by 35 feet, due to pumping by the MPG and the Bank. Only spring and fall water levels are available from the GeoTracker website for Meyers Farming wells after 2014 and, as explained above, residual drawdown (or rise) cannot be determined with the available data, however, spring water levels rose by about 27 feet from 2016 to 2017.

The hydrograph of Meyers Farming MW-14 (**Figure 4-9**), which is closer to the Fresno Slough than MW-11 and is screened in the upper portion of the deep zone, has had similar trends to MW-11, but showed more drawdown due to MPG transfer pumping during the 1990s. This well is east of the Pool but relatively close to some MPG wells. Recharge by the Bank has less influence on water levels at MW-14, because this well is farther from the Bank. Only spring and fall water levels are available from the GeoTracker website for this well after 2011 and residual drawdown (or rise) cannot be determined.

North of Meyers Farming site, the FWD wells have experienced a downward trend in water levels, ranging from 100 to over 160 feet bgs during dry periods and seasonally during irrigation periods since 1985, followed by recoveries to water levels ranging from 20 to 50 feet bgs during wet periods. These wells had declining water levels during 1998-2004, rising levels during 2005-2006, declining levels during 2007-2009, generally rising levels during 2010-2012, declining levels during 2013 to 2015, and rising levels in 2016 to 2017. FWD residual rise in 2017 ranged from 2.90 feet in EL-1 to 11.49 ft in well R-7 (**Table 4-2**). FWD wells generally have large seasonal drawdowns, and in 2017 they ranged from 18 feet to 48 feet, with the largest in FWD R-8 (**Table 4-2**). These trends are primarily related to pumpage patterns for the FWD wells, the confined nature of the deep zone, and other deep zone pumping in the area.

North of the SJR, hydrographs for WO and CCC (district and grower) deep zone wells also showed water-level declines from the late 1990s through 2004, followed by rising water levels during 2005-2006, declining levels during 2007-2009, followed by rising water levels from 2010-2011, and a decline from 2012 through January 2016. From January 2017 to January 2018 water levels rose in all WO and CCC district and grower deep-zone wells (**Table 4-2**). In the southern WO wells (3730-65 [W-53], 2630-61 [W-78], and 3730-62 [W-94]), maximum seasonal drawdowns ranged from 17 to 49 feet in 2017, and residual rises ranged from about nine to 16 feet. Water levels in these wells near the SJR declined from about 35 to 40 feet from 1999 to 2016, an average of about two feet per year (about half the rate as seen in the northern wells from 1999 to 2016 as described below). Water levels rose 8 to 15 feet in these wells by January 2018. Maximum seasonal changes were smaller in two northeastern (3311-62 [W-8] and 3591-66 [W-11]) WO wells (**Table 4-2**), ranging from about four feet to a rise of 26 feet; residual rises ranged from about 16 to 39 feet. Water levels have been measured at these two wells in the northeast area since at least the 1950s and have declined about 110 feet since that time, or nearly an average of two feet per year. However, from 1999 to 2016 water levels in these wells declined an average of four feet per year, about double the decline in wells further south. Water levels increased about 20 and 40 feet, respectively, between winter 2016/2017 and winter 2017/2018. Water levels in these wells have been influenced by pumping that changes significantly from year to year in nearby areas where surface water supplies are not available. Water level rises can be associated with recharge from Eastside Bypass and Lone Willow Slough.

Water levels are measured currently by the MPG in four wells in Aliso Water District (18H1, 19K1, 31G1 (DP2), and 31A (DP4)). These wells are located in the historically overdrafted western part of Madera County east of the Chowchilla Bypass. Most wells in the Aliso Water District are composite wells, except to the south, near the SJR. One well (Woolf Enterprises No. 18H1) has a period of record starting in

1950 and shows a long-term water-level decline of about 90 feet. Since 2005, water levels in wells measured in Aliso Water District have either been fairly stable or have declined about 10 to 40 feet. In 2017, the three northern wells showed a range of residual water level change that ranged from a rise of 7.61 feet (18H1) to a decline of 0.05 feet (DP-4). Residual change in the southernmost well (19K1) was a rise of 4.41 feet. Water levels in the south part of Aliso Water District (18H1 and 19K1) are influenced significantly by recharge from SJR seepage, as evidenced by relatively shallow depths to water (80 to 110 feet bgs) as compared to wells (DP2 and DP4) located in the northern portion of the district (about 150 feet bgs). Wells in the south part of the District have had lower rates of water level decline than in wells located farther north. Another factor is that some wells near the river only tap the deep zone, whereas wells farther north are composite wells.

4.2.3 Lower Aquifer

This section describes water levels in four lower aquifer wells completed below the Corcoran Clay. These wells include the deepest USGS monitor well in the cluster located near the City of Mendota (T13S/R15E-31J6), a USBR well located near the junction of the DMC and Mendota Pool (USBR-19R2), and two WO monitor wells (2480-91 [MW-6] and 2480-94 [MW-8]). In 2017, these four wells experienced residual water level rises ranging from about 10 to 41 feet.

Water levels in the 31J6 (**Figure 4-9**) have declined about 65 feet since 1999. Water levels declined about 35 feet between 1999 and 2003, due primarily to pumping below the Corcoran Clay both southwest and northeast of the Mendota area. Reduced pumping from the lower aquifer in subsequent years in the area west of Mendota resulted in about 25 feet of water-level rise during 2004-2006. Water levels declined during 2007-2009, and there were residual drawdowns of approximately 20 feet at the end of each year. The depth to water in Well 31J6 reached a new historical low at that time of about 160 feet bgs in September 2009. The USGS installed a pressure transducer in August 2010 to collect daily water-level data from 31J6 as part of a re-activation of land subsidence studies in this portion of the San Joaquin Valley. In 2010 and 2011, there was very little seasonal drawdown in this well, and water levels were higher at the end of each year. Water levels declined by over 70 feet from February 2012 to 2016. During this period, the depth to water reached a new historical low of about 215 feet bgs in August 2016. The depth to water in the lower aquifer at this location was significantly lower (e.g., about 110 feet at the end of 2017) than in the two overlying USGS deep zone wells (USGS 31J3 and 31J5) about 45 feet bgs), which indicates a large downward head gradient between the aquifers above and below the Corcoran Clay in this part of the study area. Water levels recovered approximately 41 feet between January 2017 and February 2018. The USBR drilled three monitor wells in 2011 at the confluence of the DMC and the Fresno Slough and the lower aquifer well (19R2) water levels declined by over 50 feet from February 2012 to January 2017 (**Figure 4-7**), and the depth to water was over 162 feet in January 2017. Water levels recovered approximately 41 feet (to 136.38 feet bgs) between January 2017 and January 2018 (**Table 4-2**).

The two deep WO monitor wells were constructed in 2010 and water-level measurements began in 2011. These wells experienced about five feet of seasonal drawdown in 2017. Water levels in these wells (over 114 feet bgs) at the end of 2017, were significantly deeper than in deep zone wells (e.g.,

MW-9 is approximately 63 feet bgs) in WO, which indicates a downward gradient from the deep zone to the lower aquifer at WO, similar in nature, but of less magnitude than in the area west of the Fresno Slough at the USGS monitor wells. Groundwater elevations in MW-6 and MW-8 at the end of 2017 were over 30 feet higher than in USGS monitor well 31J6 (153.70 feet bgs) west of the Fresno Slough and over 15 feet higher than USBR 19R2 (139.15 feet bgs). This indicates that the direction of groundwater flow in the lower aquifer is to the southwest, which is the opposite of that in the deep zone above the Corcoran Clay.

5 GROUNDWATER QUALITY

Groundwater quality in the Mendota area is highly variable, with the poorest water quality generally in the western portion of the study area and the best water quality in the eastern area and near the SJR. The primary water-quality concern is high salinity, which is partly due to natural factors but also due to deep percolation of applied irrigation water in some areas and altered groundwater flow directions. Localized degradation due to percolated wastewater has also occurred in certain areas. Except for locations that benefit from recharge from the River or the Pool, groundwater in the shallow zone generally has higher salinity than groundwater in the deep zone above the Corcoran Clay. The lowest TDS concentrations in groundwater in the study area typically occur in shallow and deep zone wells located east of Mendota Dam near the Mendota Pool and the SJR, including some of the FWD, CCC, and WO wells. Groundwater in the lower aquifer in most of the Mendota area is not used because of high salinity.

Groundwater-quality degradation has occurred for decades in the western portion of the study area due to a regional northeasterly movement of a “front” of saline groundwater, which is present primarily west of the Fresno Slough and the SJR. This poor-quality groundwater, located above the Corcoran Clay, flows into the Mendota area due to a pumping depression in western Madera County. In addition to the regional influences of groundwater pumping on saline water migration, groundwater pumping near the saline front produces a localized increase in the steepness of the gradient and accelerates the movement of the saline water toward the pumping wells.

Historical and recent groundwater-quality data are shown in **Appendix E**. **Table E-1** contains data for shallow-zone wells, **Table E-2** contains data for wells below the A clay, and **Table E-3** contains data for the Meyers Farming and the Bank shallow and deep zone wells. Hydrographs of EC data from individual wells are provided in **Appendix F** and EC hydrographs for representative shallow and deep zone wells are shown on **Figures 5-1** and **5-2**, respectively. **Figure 2-2** shows the location of the wells included in the 2017 groundwater quality monitoring network. Less water-quality sampling was conducted in 2017 compared to prior years because fewer wells were operating. No sampling was conducted in MPG wells with the exception of FWD-7.

5.1 Salinity in the Shallow Zone

Recent EC and TDS data (2013 to 2017) for shallow zone wells in the monitoring program are summarized in **Table 5-1**. These parameters are highlighted in the following discussion because they represent groundwater salinity. **Figure 5-1** presents historical EC trends for nine shallow wells across the study area. Concentrations of major inorganic constituents, shown in **Appendix E** tables, were reviewed for this report and are generally consistent with the EC and TDS data. For example, a well with elevated salinity usually has higher concentrations of most of the major inorganic constituents. **Figure 1-4** shows monitor wells with known locations and historical water quality data reported in **Table 5-1** and **Appendices E** and **F**.

5.1.1 West of Fresno Slough

The salinity data for shallow zone MPG wells located west of the Fresno Slough exhibit different trends: most wells show degradation and some show relatively stable salinity. The shallow Terra Linda wells located in the northern and central portion of this area generally have lower salinity water than other wells located to the south (**Figure 5-1**). Historical data are available for 18 shallow Terra Linda wells (**Appendix E-1**), and the initial samples for 12 of these wells were collected in 2001. These wells were not sampled in 2017, but the most recent EC concentrations (2016) in nine of the 18 wells that were sampled ranged from 638 to 1,460 micromhos per centimeter at 25 degrees Celsius [$\mu\text{mhos/cm}$]. Six wells sampled in 2016 had more than two years of data; three wells have experienced increasing salinity as measured by EC (greater than 200 $\mu\text{mhos/cm}$) and three wells show relatively stable salinity (**Appendix F**).

In the central portion of the MPG's Fresno Slough well field, salinity in the shallow zone generally increases from north to south. Wells that are located farther west (closer to the saline front) also have higher salinities than more easterly wells. TDS concentrations in shallow MPG wells are highest at the Vista Verde Farms (formerly Coelho/Gardner/Hansen, CGH wells) in the south-central portion of the well field. These wells were not sampled in 2017, but the most recent TDS concentrations in water from the two shallow CGH wells that were sampled in 2016 ranged from 840 to 1,270 mg/L. EC hydrographs are included in **Appendix F** for 12 shallow CGH wells. Salinity at these wells has been highly variable, but both of the two shallow zone wells sampled in 2016, experienced increases in salinity. Several of the CGH wells have been dropped from the MPG transfer program because the TDS concentrations exceeded 2,000 mg/L (**Table 3-1**).

In the southern portion of the MPG well field along the Fresno Slough, Meyers Farm wells MS-6 and MS-7 were not sampled in 2017 but had TDS concentrations of 3,140 and 2,170 mg/L, respectively, in 2015 (**Table 5-1**). The salinity at these wells has been variable, but there was an overall decrease from 2004 to 2007 followed by an increase in 2012 through 2015 (**Appendix F**). The EC increased from 2002 to 2015 in these wells by about 1,000 micromhos per centimeter at 25 degrees Celsius ($\mu\text{mhos/cm}$) in MS-6 and 400 $\mu\text{mhos/cm}$ in MS-7. These variations were influenced by Bank operations.

The Five Star (also known as: Casaca Vineyards, Solo Mio Farms, and Daddy's Pride Farming) wells are the southernmost MPG wells west of the Fresno Slough. These wells were not sampled in 2017 but the most recent TDS concentrations ranged from 540 mg/L to 1,960 mg/L. The initial samples from these wells were collected in 1993 (two wells), 1999 (one well), and 2001 (seven wells). Since sampling began, four wells show generally stable salinity and six wells show an increase in salinity (from 300 to 1,000 $\mu\text{mhos/cm}$). FS-8 (**Figure 5-1**) shows an increase in EC from 2014 to 2016 (2,000 to 2,710 $\mu\text{mhos/cm}$). It is difficult to identify salinity trends for some of these wells because the data are highly variable.

The shallow USGS monitor well (31J4) west of the Mendota Airport was sampled in 2017 and it had the highest salinity (TDS concentration of 6,190 mg/L) of any shallow zone well in the study area that was sampled in 2017. The TDS concentration in 2017 at this location was slightly less than the concentration in 2016, however, TDS concentrations have overall increased (**Table E-1**) since 1985 when the TDS

concentration was 1,960 mg/L. The long-term upward trend is due to the easterly migration of the saline front as explained above.

5.1.2 East of Fresno Slough

East of the Fresno Slough, groundwater quality in and near the western portion of Meyers Farming has been variable due to the combined effects of degradation caused by Spreckels' historical wastewater disposal practices, altered groundwater flow directions, and more recent water-quality improvements due to recharge of surface water at the Bank (**Figure 5-1**).

Like the Five Star wells, water quality at the Coelho West shallow MPG wells near Jack's Resort have experienced variable TDS concentrations. In 2016, well CW-6 replaced well CW-1. Wells CW-2 through CW-6 were not sampled in 2017, but the 2016 TDS concentrations ranged from 740 mg/L at CW-2 to 1,280 mg/L at CW-5. Over the period of record, three of the northern wells (CW-3, CW-4, and CW-5) have experienced degradation, apparently due to Spreckels' wastewater that was used to irrigate an adjacent pasture, and locally altered groundwater flow directions due to MPG pumping. Groundwater salinity has improved at CW-4 and CW-5 from 2007 to 2013 due to surface water recharged by the Bank. There was an increase in salinity at CW-4 and CW-5 in 2014 and 2015 (**Appendix F**), possibly due to the lack of significant Bank recharge compared to previously.

A number of the Meyers Farming monitor wells have experienced long-term groundwater-quality degradation due to Spreckels' historical wastewater disposal practices or improvements in water quality due to recharge by the Bank. Water quality data for Meyers Farming (former Spreckels Sugar Co.) wells was downloaded from the California State Water Resources Control Board's data management system (GeoTracker) and the TDS concentrations of samples collected from shallow monitor wells in Spring 2017 ranged from 160 mg/L (MW-13) to 4,600 mg/L (MW-19). MW-3 is a good example of this variability due to its central location between the former Steffens' ponds and the Bank's recharge ponds (**Figure 1-5**). TDS concentrations at this well increased from 735 mg/L in 1988 to 1,800 mg/L in 2003. Since 2003, the TDS concentration has declined significantly and was 960 mg/L in April 2017 (**Table E-3**).

Meyers Farming MW-1 is located (**Figure 5-1**) between the Coelho West wells and former Spreckels' pasture that had previously been irrigated with factory wastewater. Shallow groundwater salinity beneath these pasture areas was high, because salts in the wastewater used for irrigation were further concentrated by evapotranspiration. MW-1 was historically downgradient from seepage from the Fresno Slough branch of the Mendota Pool, due to a northeasterly direction of groundwater flow. The TDS concentration at MW-1 was relatively stable at about 900 to 1,000 mg/L from 1982 until the MPG wells near Whitesbridge Ave started pumping in 1990; this created a southwesterly direction of groundwater flow during pumping periods, which allowed higher salinity groundwater to flow to MW-1. The TDS concentration at MW-1 rose sharply to about 2,600 mg/L in 1994 and more gradually to over 3,000 mg/L in 2006. Groundwater recharged by the Bank reached this well in 2007, and the TDS concentration in water from MW-1 had decreased to 370 mg/L (620 μ mhos/cm EC, **Figure 5-1**) by 2013. In 2014 and 2015, TDS concentrations increased to 1,900 mg/L, probably associated with increased withdrawals from the bank. Some recharge reportedly occurred in 2015 through 2017 but amounts

were not provided. The TDS concentrations in water from MW-1 decreased in spring 2017 to 940 mg/L (1,520 μ mhos/cm EC, **Figure 5-1**).

The nine Bank monitor wells (MF-1 through MF-9) east of the Fresno Slough have a shorter period of record but show substantial water-quality improvement due to their proximity to the Bank. Since Bank recharge began in 2002, TDS concentrations have decreased by up to 2,200 mg/L (e.g., MF-7) at these monitor wells (**Table E-3**).

Spring 2017 water-quality data for shallow monitor wells in the central and eastern portions of the Meyers Farming property show that TDS concentrations continue to be highest in the central area due to the previous percolation of Steffens' wastewater, which was a byproduct of the process used to produce molasses at the former Spreckels' plant until 1994. TDS concentrations near the center of the Steffens' plume have decreased in recent years, due to cessation of percolation of Steffens wastewater and as water recharged by the Bank migrated to the east. In spring 2017, TDS concentrations were highest at Meyers Farming MW-19 (4,600 mg/L), MW-15 (3,600 mg/L), and MW-16 (2,600 mg/L) (**Figure 1-5**). The RWQCB issued a Cleanup and Abatement Order(R5-2018-0033) on April 6, 2018 for "Southern Minnesota Beet Sugar Cooperative, Spreckels Sugar Company, Inc. and Meyers Farming, LLC Former Spreckels Mendota Facility, Fresno County". As part of this order an investigative work plan was required to address the extent of groundwater degradation. After the extent has been determined, a groundwater cleanup plan is to be prepared.

TDS concentrations have decreased considerably west and north of the former Steffens' ponds due to recharge of good quality surface water at the Bank into the shallow zone. For example, the TDS concentration at MW-13, which is adjacent to a Bank recharge pond, decreased from about 1,800 mg/L in 2005 to 160 mg/L in the spring of 2017 (**Appendix E-3**). TDS concentrations have also been decreasing at MW-18, which is located near the center of the former Steffens' ponds. The TDS concentration decreased from about 4,000 mg/L in 2006 to 910 mg/L in spring 2017, however, since 2012 TDS concentrations have fluctuated between 720 to 1,400 mg/L.

The Steffens' plume appears to be migrating to the northeast in the shallow zone, as indicated by increasing TDS concentrations at most of the shallow monitor wells east and northeast of the former Steffens' ponds. For example, MW-6 (**Figure 5-1**) located northeast of the former Steffens' ponds, has EC increasing from 1985 to 1996 and from 2001 to 2016.

The groundwater salinity is lower in monitor wells in the eastern portion of the Meyers Farming property (east of San Mateo Avenue), farther away from historical waste disposal areas. A contributing factor for the low salinity levels is recharge from the SJR. However, the Steffens' plume has affected the western and central portion of this area, and the maximum TDS concentration in shallow monitor wells east of San Mateo Avenue was 1,500 mg/L at MW-28 in spring 2017. At MW-30, which is located farther east, TDS concentrations increased from 160 mg/L in 1991 to 550 mg/L in spring 2017. MW-32 is apparently the only shallow monitor well not affected by the plume, and the TDS concentration was 190 mg/L in spring 2017.

5.1.3 North of San Joaquin River

There are four shallow WO monitor wells north of the SJR included in the monitoring program with salinity results in 2017. Monitor wells 3730-91 [MW-2] and 3730-93 [MW-3] are located near the River, and 2480-93 [MW-4] and 3431-91 [MW-5] are located about two and three miles north of MW-3, respectively. Water quality at these monitor wells has been highly variable, and some large year-to-year changes during 2004-2006 may have been due to the duration of purging prior to sample collection rather than reflecting actual changes in groundwater quality. Most of the samples collected from these wells were not analyzed for TDS; therefore, the salinity is discussed in terms of EC.

The salinity has decreased considerably at 3730-91 [MW-2] due to recharge from the SJR (**Figure 5-1**). The EC at this location decreased from 1,090 $\mu\text{mhos/cm}$ in 2002 to 280 $\mu\text{mhos/cm}$ in 2017. At 3730-93 [MW-3], the 2017 EC value (410 $\mu\text{mhos/cm}$) was lower than the high values reported in 2004 and spring 2006 (640 $\mu\text{mhos/cm}$).

Additionally, three very shallow (each 12 feet deep) WO monitor wells (MW-3921-91, 92, 93) located less than 1 mile west of MW-3 (**Figure 1-4**), have salinity results in 2011 and 2012 that range from 2,710 to 5,640 $\mu\text{mhos/cm}$. The reason for these high values is unknown but may be due to historical land use practices on the overlying fields and due to evaporation of shallow groundwater. These results are not compared to WO shallow monitor wells MW-2 through MW-5, due to the difference in depth zones monitored (e.g., MW-3921-91, 92, 93 monitor above 12 feet bgs and MW-2 through MW-5 monitor between 35 and 80 feet bgs).

Compared to MW-2 and MW-3 the salinity has historically been significantly greater and more variable farther north at 2480-93 [MW-4] and 3431-91 [MW-5]. Except during periods of flow in the Chowchilla Bypass, the predominant source of recharge to shallow groundwater in the vicinity of these monitor wells has been deep percolation of irrigation water, except for a recharge project near 2480-93 [MW-4]. In years prior to 2011, all of the EC measurements at 2480-93 [MW-4] exceeded 1,200 $\mu\text{mhos/cm}$, with the highest values reported in Spring 2005 and Spring 2006 (2,650 and 2,490 $\mu\text{mhos/cm}$, respectively). The EC decreased to 220 to 400 $\mu\text{mhos/cm}$ from 2011 to 2013 and 2017 (2014 through 2016 data are not available, the well was dry) due to recharge from the Chowchilla Bypass and a water recharge project conducted by WO. Similarly, the historical EC measurements for MW-5 (**Figure 5-1**) were highest (about 1,950 $\mu\text{mhos/cm}$) in spring 2005 and 2006. The salinity has declined considerably since that time, and the EC stabilized from 2012 to 2017 at around 1,350 $\mu\text{mhos/cm}$. The reason for the 2005 to 2006 temporary increase has not been determined.

5.2 Salinity in the Deep Zone

Recent EC and TDS data (2013-2017) for deep zone wells are summarized in **Table 5-2**. All of the water-quality data for the deep zone wells are shown in tables in **Appendix E**, and plots of EC measurements at individual wells are provided in **Appendix F**. Representative EC hydrographs for the deep zone are illustrated in **Figure 5-2**.

5.2.1 Northwestern Area

The CCID wells northwest of the City of Mendota have some of the longest periods of record of groundwater quality in the study area, with salinity records that date back to the 1960s at several wells. Salinity increases were observed at wells Nos. 32, 34, 35, and 49 during or before 1970 (**Figure 1-3**). Wells Nos. 34 and 49, were located northwest of well No. 32C along the Outside Canal, experienced sharp salinity increases in the 1960s and 1970s due to easterly movement of the saline front and have been abandoned. The increase in salinity in these wells has primarily been in response to horizontal migration of the saline front due to the altered regional groundwater flow direction (influenced by pumping in western Madera County). The largest increase in EC was about 1,500 $\mu\text{mhos/cm}$ at CCID well No. 28 (and its replacements), over a period of about 40 years (**Appendix F**). Periodic low electrical conductivities are associated with high stream flow in the SJR. The increases in EC over time have averaged about 37 $\mu\text{mhos/cm}$ per year.

Seven CCID wells were sampled in 2017, and five of these wells had salinity increases (greater than 200 micromhos per centimeter) over the period of record. One well's EC concentration remained stable and one well's concentration decreased. TDS concentrations at the CCID wells sampled in 2017 ranged from 390 to 1,400 mg/L.

5.2.2 West of Fresno Slough

The City of Mendota's older municipal wells located along Bass Avenue have been replaced by three wells (Nos. 7, 8, and 9) on the B&B Ranch east of the Fresno Slough (read discussion below), and salinity analyses (TDS or EC) for the old wells were discontinued in 2003. The City has operated the former Fordel wells south of Bass Avenue since 2004 but has not provided sampling results for the program.

One of the two deep zone USGS monitor wells (31J5), west of the Mendota Airport, was sampled in 2017 and it had the highest salinity (TDS concentration of 4,660 mg/L) of any deep well in the study area in 2017. ECs at this location were relatively stable (around 10,000 micromhos) from 1999 to 2010 and ranged between 7,000 to 10,000 micromhos from 2012 to 2017 (**Figure 5-2**).

None of the deep Terra Linda wells were sampled in 2017, but the most recent (2016) TDS concentrations ranged from 840 mg/L at TLF-12d to 1,940 mg/L at TLF-5d. Since the initial samples collected in 1999 or 2000 from the five deep zone Terra Linda wells, TDS concentrations have increased at all these wells except TLF-18d (though this well has not been sampled since 2012). Salinity has also increased farther south at the one CGH deep zone well, but the TDS concentration at CGH-7 has been variable: in 2012 (960 mg/L) was lower than in 2008 and 2009; the well was not sampled in 2013 or 2014; and the concentration increased to 2,140 mg/L in 2016.

5.2.3 East of Fresno Slough

Deep zone wells that were sampled in this area in 2017 include the three City of Mendota municipal wells on the B&B Ranch and 14 Meyers Farming monitor (MW) and production (PW) wells. Salinity in water from the City of Mendota wells has remained relatively low and stable since these wells were first

sampled in 2001. The TDS concentrations in samples from the City of Mendota wells ranged from 380 to 520 mg/L in 2017.

None of the deep FWD (R, Baker, and PFC wells) were sampled in 2017, but the most recent (2016) TDS concentrations ranged from 310 mg/L at BF-3 to 790 mg/L at R-11. One exception to this was R-7 that had a TDS concentration of 150 mg/L. Figure 5-2, which includes an EC hydrograph for R-7, indicates that the value (EC of about 300 umhos) was the lowest on record. Salinity has been stable at most of these wells. However, the three southernmost wells (R-1, R-3, and R-11) are the most vulnerable to northerly movement of poor-quality groundwater from the Steffens' plume and R-11 has had the greatest increase in TDS. TDS concentrations at R-11 have increased from 300 to 400 mg/L TDS in the early 2000s to the high 700 mg/L in 2016 (**Table 5-2, Table E-2**). The increase in EC in well R-11 is illustrated in **Figure 5-2**.

Groundwater quality records for 14 deep Meyers Farming wells were downloaded from the California State Water Resources Control Board's data management system (GeoTracker) for 2017. There was a steady increase in EC from 1985 to 2017 in water from some wells (MW-10, 11, and PW-10, 11, 12). Meyers Farming production wells PW-6, PW-7, PW-9, PW-10, PW-11, and PW-12 were sampled in 2017. Although the Spreckels' factory closed at the end of 2008, some of these wells are being pumped by Meyers Farming for irrigation use. Water-quality degradation has occurred at most of the former Spreckels' production wells, and the wells with the poorest water quality (PW-1, PW-2, PW-3, PW-4, PW-5, and PW-8) have been abandoned. In the north-central portion of the Meyers Farming site, the degradation is believed to be due to the downward of percolated Steffens' wastewater from the shallow zone to the deep zone and, partly due to the high salinity of the degraded groundwater above the A-clay. This degraded groundwater in the deep zone has moved to the north. PW-9, located just west of San Mateo Avenue, has experienced the greatest salinity increase of the production wells that are still in service. The TDS concentration at PW-9 (**Table E-3**) was about 400 mg/L in 1988 and ranged from 540 to 1,700 mg/L from 2014 to 2017. The Meyers Farming wells located east of San Mateo Avenue have the lowest salinity, but the TDS concentration in PW-11, located east of PW-9, increased from the initial value of 200 mg/L in 2002 to 410 mg/L in 2017, indicating that the Steffens' plume was spreading to the east in this area. There has been continued migration of the plume to nearby FWD supply wells.

5.2.4 North of San Joaquin River

North of the SJR, EC concentrations in the WO and CCC wells have been variable. Some of the large year-to-year changes during 2003-2006 may have been due to sampling procedures, rather than actual changes in groundwater quality.

All but three of the twenty-two WO wells listed on the Groundwater Quality Monitoring Network (**Table 2-3**) tapping the deep zone were sampled in 2017. For the five wells with TDS reported, the results ranged from a low of 318 mg/L in well 2630-61 (W-78) and a high of 927 in well 2480-66 (W-42). The salinity of water from most of these wells has generally been stable since the mid-1990s, but gradual salinity increases have occurred at the northern wells (e.g., No. 3431-61 [W-32] and No. 3311-61

[W-89]). The salinity is lower and has been stable in wells near the SJR in the southeastern portion of WO (**Figure 5-2**), for example at well 3703-62.

Water from CCC district and grower wells has not been analyzed for TDS concentrations, so the salinity is discussed in terms of EC. Fifteen CCC district and grower wells in the portion of the CCC service area shown on **Figure 1-3** were sampled in 2017. Many of these wells are located near the SJR north of Mendota Dam and one (Cardella-Lopes (Lopes-1) experienced an increase in EC from 2011 (about 900 $\mu\text{mhos/cm}$) to 2017 (about 1,860 $\mu\text{mhos/cm}$). Groundwater salinity is generally acceptable for irrigation of most crops in this area. 2017 ECs ranged from about 570 to 2,020 $\mu\text{mhos/cm}$ (in wells Elrod-3 and Agriland-2). There is an area of elevated salinity approximately two miles east of the River in the northern portion of the CCC service area shown on **Figure 1-3**. The Agriland-1 (formerly Diepersloot-1) and Agriland-2 (formerly Diepersloot-2) wells in this area had ECs of about 1,670 to 2,020 $\mu\text{mhos/cm}$ in 2017. The salinity has been highly variable at the Elrod-1 well, which is also located in this area. The EC at the Elrod-1 well has ranged from 550 to 2,730 $\mu\text{mhos/cm}$ and was 1,510 $\mu\text{mhos/cm}$ in 2017.

5.3 Trace Elements

Samples from the MPG wells and a number of other wells in the study area are typically analyzed for boron and eight trace elements: arsenic, barium, copper, iron, manganese, molybdenum, selenium, and zinc. The concentrations of these constituents have generally been low in both shallow and deep zone production wells in the Mendota area, except for elevated concentrations of manganese, primarily in the shallow zone (**Appendix E, Tables E-1, E-2, and E-3**). Data on manganese, arsenic, barium, copper, iron, molybdenum, and zinc are limited in some areas, because samples from many irrigation wells have not been analyzed for these trace elements. Arsenic and selenium concentrations in groundwater discharged to the Pool from MPG wells along the Fresno Slough and have typically been below the reporting limits of 2 and 0.4 micrograms per liter ($\mu\text{g/L}$), respectively. As discussed in Chapter 6, water quality objectives (WQOs) established by the CVRWQCB for inland surface waters are 10 $\mu\text{g/L}$ for arsenic and 2 $\mu\text{g/L}$ for selenium.

The MPG wells were not sampled in 2017, but the most recent (2016) selenium concentrations were all $<0.4 \mu\text{g/L}$. The once exception to this was FWD Well R-7. The well was sampled for selenium in 2017 with a result of $<0.4 \mu\text{g/L}$ (**Appendix E**). Several WO wells were sampled for selenium in 2017 with results ranging from <0.4 to $1.53 \mu\text{g/L}$. In 2013, a different analytical laboratory was used for selenium analyses and 18 out of the 47 wells sampled returned results that exceeded the $2 \mu\text{g/L}$ WQO for selenium. Most of these wells had never had values over the reporting limit of $0.4 \mu\text{g/L}$ which suggests a laboratory error. To confirm the expected laboratory error, split samples (identical groundwater samples) were collected from 17 of the 18 wells (one well was not pumping and unable to be sampled) in Spring 2014. These were sent to two new laboratories (Caltest and South Dakota Agricultural Laboratories), both of which had an analytical methodology that provides lower selenium detection limits ($0.06 \mu\text{g/L}$ and $0.1 \mu\text{g/L}$, respectively) than the laboratory used in 2013. Selenium was not detected in any of the 17 samples from either lab. One exception to this was water from Well SC-4B, which has $0.20 \mu\text{g/L}$ from Caltest and $<0.4 \mu\text{g/L}$ from SDAL, both well below the selenium WQO of $2 \mu\text{g/L}$. The verification sampling of the 17 wells confirmed selenium concentrations below the $2.0 \mu\text{g/L}$ WQO.

Boron concentrations in most wells in the Mendota area have also been low (typically below 0.5 mg/L) with the exception of wells impacted by the saline front (shallow zone wells USGS 31J4, MS-6, MS-7, S-2, S-3, CGH-1B, CGH-3, and CGH-11 and deep zone wells to the west USGS 31J5, CCID 12C, 23B, and 28C). The CVRWQCB's WQO for boron is 0.8 mg/L. MPG wells that are likely to be impacted by Steffens wastewater from the former Spreckels' factory (Coelho West CW-3, CW-4, CW-5, and FWD R-1, R-3, R-11, **Figure 1-5**), are analyzed for barium, which was present at elevated concentrations in non-carbonated Steffens wastewater from the former Spreckels factory. These MPG wells were not sampled in 2017, but the 2016 barium concentrations in two wells slightly exceeded the WQO (0.31mg/L in CW-3 and 0.12 mg/L in CW-4). The CVRWQCB's WQO for barium is 0.1 mg/L for surface water (California maximum contaminant level for drinking water is 1 mg/L).

Molybdenum concentrations in groundwater are much more variable, and concentrations in MPG wells tend to be higher in the central and southern portion of the well field along the Fresno Slough. The molybdenum concentration measured in the one MPG well sampled (FWD-R-7) in 2017 was 3 µg/L. The CVRWQCB's WQO for molybdenum is 20 µg/L.

5.4 Summary

5.4.1 Shallow Zone Wells

In 2017, TDS concentrations in shallow zone wells in the Mendota area varied widely, from about 160 mg/L near the Meyers Farm Water Bank (MF-1) to over 6,000 mg/L west of the Fresno Slough at the USGS shallow zone well (31J4). Many wells show large salinity fluctuations from year to year, and salinity is sometimes higher in the summer and fall than in the spring. Groundwater salinity appears to have been generally stable in the northern (TLF-8s and 13s) part of the MPG well field west of the Fresno Slough, but salinity increases have continued at some of the MPG wells in the central portion of the well field. A number of Terra Linda, CGH, and Meyers Farms wells in this area have experienced high or increasing salinity over time due to easterly movement of the saline front, which has been aggravated by MPG pumping. TDS concentration in water from the southern (Five Star wells) portion of the MPG well field west of the Fresno Slough have been variable but stable until several years ago. However, in the past few years, salinity has increased in water from six out of the 10 wells.

Data and information on Bank recharge and discharge operations have been obtained in recent years from SLDMWA reporting and USBR (email communication with Erma Leal). The operation of the Bank east of the Fresno Slough, in the western portion of the former Spreckels Sugar Co. property, has resulted in salinity decreases near the recharge ponds due to recharge of low salinity surface water. In the central portion of the former Spreckels' property, however, shallow groundwater remains degraded due to historical wastewater disposal practices. This degraded groundwater has generally moved in a northeasterly direction, and this movement has been exacerbated by recharge from the Meyers Farms Water Bank.

In the WO's NCR salinity in water from shallow monitor wells in the vicinity of the SJR (3730-91 [MW-2] and 3730-93 [MW-3]) has been lower historically than shallow zone wells located farther north (2480-93

[MW-4] and 3431-91 [MW-5]), due to seepage of low salinity stream flow from the River. Water from one of the northern WO monitor wells (2480-93 [MW-4]), which is located near one of WO's recharge ponds, experienced a large salinity decrease in 2010 as a result of recharge operations and from 2011 to 2013 had a similar salinity to values for the southern monitor wells. From 2014 to 2016, shallow water levels dropped and the well went dry, however, in 2017 water levels recovered and EC was reported at 220 umhos/cm.

5.4.2 Deep Zone Wells

The CCID wells have some of the longest periods of record showing water-quality changes in the Mendota area, with salinity data going back to the 1960s at several wells. Nine CCID wells are still operating in the study area, and seven of these have experienced long-term historical water-quality degradation, due to the migration of poor-quality groundwater from the west and southwest.

Many deep MPG wells west of the Fresno Slough have experienced degradation due to easterly movement of the saline front, which has increased in this area due to MPG pumping. The MPG operated three of the five deep Terra Linda wells west of the Fresno Slough in 2017 for adjacent water use. Four of the five deep Terra Linda wells (TLF-5d, 6d, 12d, and 14d) have experienced salinity (TDS) increases ranging from about 400 to 1,100 mg/L since the initial sampling in 1999 through 2016. Salinity has been stable (2007 to 2012) in water from the other well (TLF-18d).

East of the Fresno Slough, most wells in or near FWD have low and stable salinity due to recharge from the River and the Pool. In the central portion of the former Spreckels Sugar Co. property, degraded shallow groundwater has moved downward to the deep zone and north into FWD. Three FWD wells (R-1, R-3, and R-11) have been affected by the northerly movement of the Steffens' plume.

North of the SJR, groundwater salinity is generally low and stable in the southern portion of the WO and the CCC service areas, but salinity has increased in water from most wells in the northern portion of the WO (e.g., W-32 and W-89). The salinity of water from CCC district and grower wells, generally, did not show an increasing trend through 2017.

6 SURFACE-WATER FLOW DIRECTION AND QUALITY

Prior to the completion of Friant Dam in 1942, the flow direction in the SJR branch of the Mendota Pool was to the west. Since the construction of Friant Dam, however, flow in the River between Gravelly Ford and the Pool during the irrigation season has been minimal during most years. The flow direction in the SJR branch of the Pool has generally been to the east between the DMC and the Columbia Canal intake. Westerly flow occurred in some years as a result of upstream flood releases from Friant Dam and became more common due to the SJRRP. In 2017, westerly flows occurred from early January to mid-July as a result of flood releases and continued through the rest of the year from SJRRP restoration flows.

The Fresno Slough is a tributary of the SJR, and the natural direction of flow in the Slough is to the north. Since the construction of the DMC, the Mendota Pool has become a regulated water conveyance facility, and the flow direction has normally been to the south during most of the year. The amount of flow depends primarily on the inflow from the DMC and diversions to the SJREC in the northern portion of the Pool and to JID, TID, the MWA, and WWD in the southern portion of the Pool (**Figure 6-1**). Northerly flow still occurs in some years as a result of flood releases to the Kings River (which occurred in the first half of 2017). Northerly flow also temporarily occurs if the Pool is being drained in preparation for maintenance work on Mendota Dam (which occurred in late November 2016 through mid-January 2017). The MPG does not pump for transfer during these periods. It is also possible for a northerly flow to occur as a result of MPG transfer pumping, if diversions in the southern portion of the Pool are insufficient to offset the inflow from the MPG wells along the Slough. However, an agreement has been developed to limit the northerly flow, due to water quality considerations at the SJRECWA intakes from the pool.

6.1 Water Budget Analysis

The calculation of a water budget is an accounting process which evaluates the inflows, outflows, and change in storage during a given time period. Data provided by the SLDMWA (including inflows, diversions, and stage height measurements) have been used by the MPG since 1999 to prepare a monthly water budget for the southern portion of the Fresno Slough Branch of the Pool, i.e., south of transect A-A', which is located between the southernmost SJREC canal intake (the Firebaugh Intake Canal) and the Fordel wells (now operated by the City of Mendota) (see **Figure 6-1**). The water budget also accounts for additional outflow components, such as evaporation and seepage losses.

The net evaporation is calculated as the difference between evaporation and precipitation as obtained from a CIMIS weather station in Firebaugh, applied to the surface area of the southern portion of the Pool. This area is estimated at 1,087 acres based on aerial photographs taken for the Army Corps of Engineers in August 1998. The seepage loss from the Mendota Pool was estimated based on the decline in stage measured at Mendota Dam over a 44-hour period from November 25 to 27, 1999 after DMC inflows were suspended in preparation for draining the Pool. The total seepage loss for the southern portion of the Pool during this period was estimated to be 40 cubic feet per second (cfs) (KDSA and LSCE, 2000a). The seepage rate is assumed to be constant throughout the year, except when the Pool is

drained. The monthly change in storage is calculated by taking the SLDMWA Mendota Pool stage height measurement from the end of the month and subtracting it from the first of the month measurement and multiplying by the southern Pool area. The water budget is used to calculate the monthly amount of inflow from the DMC and the SJR that reaches the southern portion of the Pool, i.e., south of transect A-A'. The basic equation for a water budget is as follows:

$$\text{Inflow} - \text{Outflow} = \text{Change in Storage } (\Delta S) \quad (1)$$

To calculate the unknown inflow or outflow across the transect line, the equation is rewritten as

$$(\text{Inflow}_{\text{meas}} + \text{Inflow}_{\text{calc}}) - (\text{Outflow}_{\text{meas}} + \text{Outflow}_{\text{calc}}) = \Delta S \quad (2)$$

Rearranging terms yields

$$\text{Inflow}_{\text{meas}} - \text{Outflow}_{\text{meas}} - \Delta S = \text{Outflow}_{\text{calc}} - \text{Inflow}_{\text{calc}} \quad (3)$$

or

$$\text{Inflow}_{\text{meas}} - \text{Outflow}_{\text{meas}} - \Delta S = \text{Net Flow}_{\text{calc}} \quad (4)$$

Rearranging terms to accommodate the conceptual design of the water budget for the southern area yields

$$\text{Outflow}_{\text{meas}} - \text{Inflow}_{\text{meas}} + \Delta S = - (\text{Net Flow}_{\text{calc}}) \quad (5)$$

Finally, to be consistent with previous reports, the minus sign on the right side of the equation was dropped so that flow to the south would be indicated by positive values.

6.1.1 2017 Water Budget

A large snow pack in the winter of 2016 and 2017 resulted in unusual flow conditions in the Pool, with northerly flow occurring during the first part of the year. The Kings River flowed to the Fresno Slough via the James Bypass from February to August, resulting in large northerly flows during these months. As shown in **Table 6-1**, the average net flow across transect A-A' was to the north during this period and ranged from a high of 3,338 cfs in April to a low of 73 cfs in February.

As shown in **Table 6-1**, the flow direction in the Fresno Slough was southerly in January and from September through December, and ranged from a high of 248 cfs in September to a low of 110 cfs in December. For the year, the average flow was to the north at 673 cfs.

6.2 Surface-Water Quality

Surface-water quality data are available from seven continuous recorders and 10 grab sample locations in the Pool (**Figure 2-3** and **Table 2-4**). USBR operates continuous EC and selenium recorders at the DMC terminus (Check 21), and the SJREC operates continuous EC recorders at four canal intakes in the northern portion of the Pool (Columbia Canal, CCID Main Canal, CCID Outside Canal, and Firebaugh

Intake Canal). The MPG operates a continuous EC recorder at the MWA. Grab samples are collected monthly during the irrigation season and analyzed for EC, boron, and selenium. Grab samples are collected by USBR at the DMC terminus and by the SJREC at Mendota Dam and its canal intakes in the Pool. During transfer pumping years, the MPG collects grab samples from 10 locations in the Pool. The MPG does not collect grab samples during non-transfer pumping years such as 2017. The grab sample results obtained from all sources from 1999 through 2017 are compiled in their entirety in **Appendix G**. **Appendix H** lists the daily average EC values for the DMC and the SJREC's canal intakes in 2017.

6.2.1 Salinity

The salinity of the water delivered to the Pool via the DMC is subject to large daily and seasonal fluctuations. Daily fluctuations are due to tidal effects in the Sacramento-San Joaquin Delta, and seasonal fluctuations are due to factors such as discharge of higher salinity drain water to the DMC in the spring and volume of water discharged into the Pool and flowing to the south to the MWA. EC values based on continuous recorder and grab sample results are shown on **Figures 6-2 to 6-5**. The Columbia Canal Company water quality equipment is installed when the CCC begins taking deliveries in the first of the year and is removed when the canal is dry at the end of the year. In 2017, the installation was delayed until April, one month after CCC began taking deliveries due to a staff transition at SJRECWA. Historically, the highest EC values in the DMC have occurred in the spring, due in part to inflow of agricultural drainage water from sumps along the DMC upstream of the Pool. The EC is usually lowest during the summer months. A slightly different pattern was observed in 2017 (**Figure 6-2**). EC values were highly variable from April through May with values reaching a high in late May (a daily average value of 430 $\mu\text{mhos/cm}$) and a low in mid-May (a daily average value of 51 $\mu\text{mhos/cm}$). The lowest sustained ECs (daily averages of less than 100 $\mu\text{mhos/cm}$) occurred from mid-June through mid-July, and then gradually increased throughout the rest of the year. The daily average exceeded 500 $\mu\text{mhos/cm}$ on December 31. On an annual basis, the daily average 2017 EC level in the DMC was about 196 $\mu\text{mhos/cm}$. These levels were lower than those in 2014, 2015, and 2016 which averaged about 755, 790, and 590 $\mu\text{mhos/cm}$, respectively.

The daily average EC values at the SJREC's canal intakes in 2017 was not as well correlated with the DMC data as in most years (**Figures 6-3 and 6-4**). The EC at the Columbia Canal intake (**Figure 6-4**) was lower than that of the DMC during the period of record for 2017, due to inflow of low salinity water from the SJR. The ECs at the CCID Outside Canal and Firebaugh Intake Canal were elevated in early February. The daily average EC values at three of the SJREC's canal intakes (CCID Outside Canal, Firebaugh Intake Canal, and CCID Main Canal), was lower than the DMC during March through early-July due to Kings River inflow. The EC at these canal intakes tracked the DMC closely the rest of the year, except for the CCID Main Canal, that was lower than the DMC in December.

The annual approval of the MPG transfer program states that the EC measured at the SJREC canal intakes should not exceed that of the DMC by 90 $\mu\text{mhos/cm}$ or more for longer than three consecutive days. If such exceedances occur, the MPG is required to temporarily suspend transfer pumping upon notification by the SJREC. Although there was no transfer pumping in 2017, there were two exceedances at the CCID Outside Canal around the first of December lasting one day each and eight exceedances at

the Firebaugh Intake Canal from April 30th through May 5th and two days the first of December. The MPG discharged into the pool in the month of December, but it is unclear if this pumping coincided with the exceedances. The cause of the April and May exceedances are unknown because the MPG did not discharge to the pool for transfer or adjacent use during this time. Highlighted cells in **Table H-1** in **Appendix H** are values exceeding the DMC by 90 $\mu\text{mhos/cm}$ or more.

The average EC measured at the MWA in the southern portion of the pool was 218 $\mu\text{mhos/cm}$ in 2017. As shown in **Figure 6-5**, very low EC values were recorded during the period of Kings River inflows (February to mid-July) when the EC was mostly below 100 $\mu\text{mhos/cm}$. The highest EC measurement was recorded in mid-December (about 575 $\mu\text{mhos/cm}$). The MPG made 12 field EC measurements from the MWA in 2017 (**Figure 6-5**). The MPG did not collect grab samples from the MWA or elsewhere in the southern portion of the Pool in 2017.

6.2.2 Trace Elements

The surface-water grab sample results for eight trace elements are shown in **Table G-1** in **Appendix G**. The data for four key trace elements (arsenic, boron, molybdenum, and selenium) are summarized in **Table 6-2**, but sampling for these constituents was limited to boron and selenium in 2017, a no transfer year.

Five samples from the DMC and SJREC canal intakes were analyzed for boron in 2017. Boron concentrations at the DMC terminus (Check 21) ranged from non-detect (0.03 mg/L) to 0.06 mg/L, with a median of 0.06 mg/L in 2017. The median boron concentrations at the other sampling locations were similar, ranging from non-detect (<0.025 mg/L) to 0.07 mg/L.

An automated sampler retrieves samples from the DMC terminus on an hourly basis, and daily composites of these samples are analyzed for selenium at USBR's laboratory. A total of 333 daily samples were analyzed for selenium in 2017, and 242 of these were non-detect (<0.4). Selenium concentrations in the remaining 91 samples ranged from 0.42 to 4.74 $\mu\text{g/L}$. Samples exceeded the WQO 23 times between late February and late May apparently due to drainwater pumped into the DMC upstream of the Pool. Selenium concentrations in grab samples retrieved monthly from the DMC terminus by USBR in 2017 ranged from <0.4 to 3.52 $\mu\text{g/L}$. Grab samples exceeded the WQO on two occasions in March and May. These results can be seen in **Figure 6-6**.

A total of five to 16 grab samples were collected from each of the four SJREC canal intakes, and all of the selenium results were non-detect (e.g., <0.4 and <1 $\mu\text{g/L}$).

As noted in Chapter 5, the WQOs established by the CVRWQCB for inland surface waters are 10 $\mu\text{g/L}$ for arsenic, 0.8 mg/L for boron, 19 $\mu\text{g/L}$ for molybdenum, and 2 $\mu\text{g/L}$ for selenium (**Table 6-3**). The WQOs for boron were not exceeded in any of the 2017 surface-water samples. The WQOs for selenium were exceeded in two of the grab samples from the DMC in 2017 but were not exceeded in any of the samples from the SJREC canal intakes apparently due to the mixing of DMC water with that from the Kings River and San Joaquin River.

CDFW has developed specific target WQOs for the MWA. The WQO for selenium was unchanged at 2 µg/L, but the WQOs for the other constituents were lower than the CVRWQCB criteria: 5 µg/L for arsenic, 0.3 mg/L for boron, and 10 µg/L for molybdenum. Compliance with these WQOs in 2017 is unknown because no grab samples were collected from the MWA.

6.3 Sediment Sampling Results

As described in Chapter 2, a sediment-monitoring program in the Pool was initiated in 2001 at the request of USFWS. Sediment sampling is conducted by the MPG during transfer pumping years but was not conducted in 2017. Most of the eight sediment sampling stations (**Figure 2-4**) are co-located with surface-water sampling locations. These locations allow for the estimation of metals introduced by inflow from the SJR, the DMC, the James Bypass, and the MPG wells and allow assessment of spatial distribution of the selected parameters.

6.4 Summary

The SJR flowed into the pool most of 2017 due to Friant Dam flood releases and the SJRRP. Results from the 2017 water budget indicate the Kings River flowed to the Pool via the James Bypass from February to August, resulting in a large northerly flow in the Fresno Slough during these months. The highest monthly average flow to the north across transect A-A' was about 3,300 cfs in April. The highest monthly average flow to the south across transect A-A' was about 267 cfs in January. For the entire year, the monthly average flow was about 675 cfs in a northerly direction.

The DMC delivers water to the Pool and, historically, the greatest daily fluctuations in salinity occur in winter and spring and lower salinity has been measured in summer months. These patterns were observed in 2017, with the highest ECs (a daily average of about 500 µmhos/cm) occurring in late December and the lowest ECs (a daily average of about 60 µmhos/cm) occurring in late June.

The salinity at the SJREC's canal intakes was slightly lower than the DMC concentrations during much of 2017 due to the SJR and Kings River inflows. The EC at the Columbia Canal intake was lower than that of the DMC during the entire year due to inflow of water from the SJR. The EC at the CCID Outside Canal and the Firebaugh Intake Canal was elevated at the start of the north flow event in February. The EC at these canal intakes was low or tracked the DMC until mid-July, then they tracked the DMC closely during the remainder of the year.

The EC at the CCID Outside Canal and the Firebaugh Intake Canal exceeded that of the DMC by more than the limit specified in Agreement No. 2 (90 µmhos/cm) on 10 days in 2017. Although there was no transfer pumping in 2017, there were two exceedances at the CCID Outside Canal around the first of December lasting one day each and eight exceedances at the Firebaugh Intake Canal from April 30th through May 5th and two days the first of December.

Surface-water grab samples from the Mendota Pool and co-located sediment samples were not required in 2017, a no transfer year. However, surface water samples were collected by USBR and SJREC in the northern and central portions of the Pool at six locations and analyzed for two trace elements (boron

and selenium). Boron concentrations were low at all locations in 2017 but selenium concentrations were elevated at the DMC terminus in the first half of the year (**Figure 6-6**). The cause of the elevated selenium concentrations has not been investigated. Selenium concentrations were low (less than 1 µg/L) at the SJREC canal intakes. No samples were collected from the MWA or other locations in the southern portion of the pool. Sediment sampling was also not conducted in 2017.

7 SUBSURFACE COMPACTION AND LAND SUBSIDENCE

Subsurface compaction data are collected from two extensometers in the Mendota area (**Figure 2-1**) to evaluate compliance with the subsidence criteria specified in the original agreement, Agreement No. 2, the annual extension of Agreement No. 2, and the 2005 EIS. The original settlement agreement and Agreement No. 2 state that MPG transfer pumping cannot cause more than an average of 0.005 feet of subsidence per year at the Yearout Ranch extensometer. The 2005 EIS also applies this criterion to the Fordel extensometer.

The Fordel extensometer was installed by the MPG in 1999 at a site approximately one mile west of the Fresno Slough located near the cluster of USGS and USBR monitor wells west of the Mendota Airport. The Yearout Ranch extensometer was installed by DWR in 1965 and is located about two miles north of Whitesbridge Ave. near San Mateo Avenue, northeast of the former Spreckels Sugar Co. Mendota factory. DWR collected historical compaction and water-level data at this site from 1966 to 1982. Data collection was reinitiated by CCID in 1999, and CCID monitored the extensometer until April 2015, at which time the USGS incorporated the Yearout Ranch and Fordel extensometers into their San Joaquin Valley Land Subsidence Monitoring Network. The historical data record was analyzed to calculate the relationship between drawdown and inelastic compaction at the Yearout Ranch location (KDSA and LSCE, 2000b), and reexamined based on more recent data (LSCE and KDSA, 2003).

The two extensometers monitor the compaction of sediments between the ground surface and the top of the Corcoran Clay, which was identified prior to construction of the extensometers at depths of 418 and 428 feet at the Fordel and Yearout Ranch sites, respectively. All measurements are reported in reference to an arbitrarily chosen reference datum. The reference datum was chosen to be the measurement of maximum recovery after the 1999 irrigation season, which occurred in March 2000. These measurements were assigned a zero value, and all subsequent measurements are reported relative to that period.

For each year, the total compaction is calculated as the difference between the measurement of greatest compaction, which typically occurs in the summer, coinciding with the lowest water levels and the preceding measurement of least compaction (typically a winter or spring measurement coinciding with high water levels). The total compaction is comprised of elastic and inelastic components. Elastic compaction occurs relatively instantaneously in response to water-level declines in the aquifer and is followed by expansion (i.e., elastic rebound) as water levels recover. If the compaction during the irrigation season is greater than the expansion during the subsequent winter/spring when water levels recover, this difference is considered to represent the inelastic compaction. At the end of each year, the amount of permanent land subsidence occurring at each site due to compaction above the Corcoran Clay is indicated by the inelastic compaction.

The annual inelastic compaction was initially considered to be non-reversible. However, as discussed below, data collected from the extensometers during years of rising water levels show that some or all of the compaction originally considered to be inelastic was eventually reversible. This means that truly

inelastic compaction can only be determined over a multi-year period, rather than the current annual criteria as required by the agreements.

7.1 Fordel Extensometer

Table 7-1 and **Figure 7-1** show cumulative compaction at the Fordel extensometer and water levels at nearby USGS monitor well T13S/R15E-31J3 (31J3) for 1999-2017. Monitor well 31J3 is perforated just above the Corcoran Clay from 400 to 410 feet in depth, and water levels are monitored daily by a pressure transducer installed in the well and checked monthly with manual field measurements using an electric sounder monthly. The shallowest and deepest depths to water during 2017 (**Table 7-1**) were recorded on March 14, 2017 (45.60 feet bgs) and August 17, 2017 (54.20 feet bgs), respectively, indicating a drawdown of 8.6 feet. The shallowest water level following the 2017 irrigation season was recorded on January 23, 2018 (37.23 feet), indicating 16.97 feet of recovery. As a result, the January 2018 water level was 8.37 feet higher than in March 2017. Over the last five years (January 2013 to January 2018) the shallowest winter water levels in 31J3 rose about 0.8 feet. From January 2012 to January 2016, the shallowest water levels declined about 17 feet followed by about 11 feet of recovery from January 2016 to January 2018.

Compaction at the Fordel extensometer is monitored hourly with electronic equipment (available online: http://nwis.waterdata.usgs.gov/nwis/dv?site_no=364518120222401) and monthly with manual dial indicator readings. The seasonal compaction in 2017 was 0.003 feet. As of February 7, 2018, the elastic rebound was 0.011 feet. This meant that there was no inelastic compaction in 2017, and the net expansion was 0.009 feet. Since January 2016 when rain events made extensometer measurements unreliable, the dial indicator readings were used. However, dial indicator readings are only taken once per month and do not capture the maximum rebound resulting in conservative estimates of elastic rebound and inelastic subsidence. The cumulative inelastic compaction at the Fordel site during the 18-year period beginning in March 2000 and ending January 2018 was 0.038 feet. This amounts to an average inelastic compaction of about 0.002 feet per year, which is less than the “do not exceed” amount (average 0.005 feet per year) specified in the 2005 EIS.

7.2 Yearout Ranch Extensometer

Table 7-1 and **Figure 7-2** show water levels and cumulative compaction measured at the Yearout Ranch extensometer, which is also completed as a monitor well with a perforated interval of 373 to 433 feet bgs. Since 2000, daily automated water-level measurements were made in this well until the transducer failed in 2004, and a new transducer was installed with readings beginning November 2012. During the interim period, water-level data were limited to manual measurements made every one to two months. Due to the much lower frequency of manual measurements, the full seasonal water-level fluctuations were not determined during that time. From November 2012 to February 4, 2016 the transducer was operational, but after February 4, 2016, the transducer became lodged in the hole. Since that time, only manual water level measurements are available for this site. Based on the manual measurements, there was approximately 50.12 feet of water level drawdown and 56.53 feet of recovery (**Table 7-1**) between

March 2017 and February 2018. These water levels were about six feet higher at the end of the year, compared to at the beginning of the year.

The compaction at this location was monitored with an automated sensor and data logger on a daily basis until December 2007. The automated equipment experienced intermittent problems, and periodic manual dial indicator readings were used along with occasional direct rod surveys to correct the daily data. The automated equipment was removed at the end of 2007, and daily readings were only available for a few months in early 2009. A new sensor and data logger were installed in August 2012, but the daily data did not match the dial indicator readings. The data logger was sent back to the manufacturer for calibration adjustments in September and October 2012. In 2012, dial indicator readings were made at least once a month, and direct rod surveys were conducted in August 2012 and February 2013. However, the dial indicator readings and direct rod survey data were inconsistent and could not be reconciled. As a result, compaction could not be calculated for the Yearout Ranch extensometer in 2012. On April 25th, 2013, a direct rod survey was conducted that was used to set the dial indicator and extensometer. The dial indicator and data logger tracked well from April 25th to December 2013. However, the datalogger failed to record from January to May 6th, 2014, when the maximum elastic rebound usually occurs, making the estimates of elastic, inelastic, and cumulative inelastic compaction incomplete. Also, data logger readings were uncertain after May 2014, when the Stevens Shaft Recorder malfunctioned, and only direct rod survey readings were used for compaction calculations in 2014 and early 2015 (when the new plunger style potentiometer was installed). The winter 2015/2016 potentiometer readings were not reliable and again the direct rod measurements were used to provide a conservative estimate of compaction. A plunger-style potentiometer (Penny and Giles HLP190) was installed in March 2016 and connected to a CR10X datalogger along with a 3" dial gage. This has improved data quality at the site.

As shown in **Table 7-1**, the seasonal compaction measured in 2017 was 0.051 feet. As of February 4, 2018, the elastic (rebound) was 0.059. This meant that there was no inelastic compaction in 2017, and the net expansion was 0.008 feet. Between 2000 and 2017 total seasonal compaction at the Yearout Ranch extensometer ranged from 0.051 to 0.112 feet, and the elastic rebound ranged from 0.058 to 0.098 feet at the end of each year. The annual inelastic compaction ranged from -0.008 to 0.034 feet. The cumulative inelastic compaction at the Yearout Ranch site during the 18-year period from March 2000 to February 2018 was estimated at 0.199 feet. This results in an average annual inelastic compaction of about 0.011 feet (about 0.13 inch) per year.

As shown in **Table 7-2**, none of the drawdown at the Yearout extensometer was caused by MPG transfer pumping. As a result, the cumulative amount of compaction attributable to MPG transfer pumping since monitoring began (0.068 feet) is the same as was determined through 2016. The remaining inelastic compaction cause by other pumping is 0.131 feet. This corresponds to an average annual inelastic compaction of 0.004 feet, which is less than the "do not exceed" annual average of 0.005 feet of subsidence at the Yearout Extensometer due to MPG transfer pumping specified in the annual extension of Agreement No. 2.

7.3 Other Land Subsidence Data

In addition to the two extensometers in the Mendota area, a Plate Boundary Observation site with GPS (P304) was installed in 2004 on land owned by Meyers Farms southeast of Mendota and west of the Fresno Slough (**Figure 2-1**). A large network of these stations has been installed throughout the western United States in recent years by PBO, which is a division of UNAVCO. PBO's primary focus is monitoring plate tectonics, but data from the high-definition GPS recorders are also useful for monitoring subsidence. The GPS stations monitor the total displacement of the ground surface, which shows how much cumulative compaction is occurring in all depth zones and aquifers, including the Corcoran Clay and underlying clays in the lower aquifer. Unlike the extensometers, which monitor compaction within a specific depth interval (i.e. between the ground surface and the bottom of the extensometer), the GPS data provide a measure of the total land subsidence, from the compaction of all the deposits. Data from each of the GPS stations are uploaded daily to the UNAVCO website.

Measurements at the Mendota PBO station began on April 28, 2004, and these data are plotted on **Figure 7-3** along with compaction data from the Fordel extensometer for comparison. Since the start of the monitoring period at P304, there has been about 0.72 feet of total inelastic compaction at this site, which is over 20 times more than was measured at the Fordel extensometer over the same period. Most of the inelastic compaction is indicated to be occurring in and below the Corcoran Clay. A hydrograph of water levels below the Corcoran Clay at USGS monitor well T13S/R15E-31J6 is shown on the bottom of **Figure 7-3**. This well is located west of the Mendota Airport near the Fordel extensometer and has a perforated interval of 480-490 feet. During 2007-2009, when the hydraulic head in the upper part of the lower aquifer declined by about 70 feet, there was 0.22 feet of inelastic compaction. Also, from 2012 through 2016, there was over 90 feet of head decline in monitor well 31J6, and the inelastic compaction at the Mendota PBO station was 0.5 feet. From the beginning of 2017 to the beginning of 2018, water levels rose by approximately 41 feet, and compaction rebounded by approximately 0.018 feet. 2017 saw the greatest rebound in water levels and compaction since 2011.

There is little pumpage from the lower aquifer (below the Corcoran Clay) near the City of Mendota. There is one composite wells in FWD and 11 composite wells in NCR, but most of the perforated intervals of these wells are above the Corcoran Clay. Inelastic compaction occurring in and below the Corcoran Clay in the Mendota area is believed to be caused primarily by regional pumping from the lower aquifer in the area southwest of Mendota and in Madera County.

8 SUMMARY

Data collected in accordance with the 2017 MPG monitoring program are summarized in this annual report. The MPG classified 2017 as a wet year and there was no transfer pumping under the annual extension of Agreement No. 2 for 2017.

8.1 Pumpage

MPG did not conduct a transfer pumping program in 2017. Pumpage by the MPG and non-MPG use by Peracchi for irrigation of overlying and adjacent lands occurred from March through December and totaled 4,412 af (964 af less than planned).

Non-MPG pumpage west of the Chowchilla Bypass was estimated to be about 11,600 af in 2017. This included about 8,200 af pumped in the WO NCR service area, about 200 af in the CCC service area, about 100 af pumped in CCID, about 1,900 af in the City of Mendota, about 100 af pumped by Locke Ranch wells, no pumpage by FCWD area, and about 1,100 af in the Meyers Farming area. Non-MPG pumpage east of the Chowchilla Bypass was first estimated for 2012 and this estimate is used for 2017. The total pumpage east of the Chowchilla Bypass was estimated to be 105,000 af within the study area, which includes about 67,000 af in Aliso Water District and undistricted portions of Madera County and 38,000 af in the undistricted portion of Fresno County east of FWD and Meyers Farming. The total non-MPG pumpage occurs mostly above the Corcoran Clay in the study area and was estimated to be about 116,600 af in 2017. These estimates may be high for 2017 due to the wet conditions and the resulting availability of surface water.

8.2 Water Levels

Water levels in some wells tapping strata above the Corcoran Clay west of the Chowchilla Bypass have been relatively stable over the period of record, but there are notable short-term fluctuations, including water level declines during the drought years. The principal exceptions are wells with very long periods of records such as wells in the northern and eastern portions of WO which have shown long-term water-level declines since the records began.

Water levels in the study area have experienced significant fluctuations during the past decade. Water levels rose considerably in almost all shallow and deep zone wells in 2005 and 2006, due to recharge from flood releases to the SJR and the Chowchilla Bypass and reduced pumping by the MPG and other entities in the study area. After two years of rising water levels, most wells experienced water-level declines during the 2007-2009 period, but water levels were more stable during 2010-2012. In 2013 through 2015, seasonal drawdowns were larger than previous years, and water levels in most wells did not recover after the irrigation season.

Water levels in the majority of both shallow and deep zone wells in the MPG well field west of the Fresno Slough remained stable or continued to rise from 2016 to 2017 following declining water levels in 2013 mid 2016. East of the Fresno Slough, water level information for Meyers Farm Water Bank and Meyers Farming (the former Spreckels Sugar Co.) monitor well data generally showed rising water

levels. North of Meyers Farming, water levels in FWD wells rose from two to twelve feet in the seven wells with water level data in 2017.

North of the SJR, water levels in monitor wells rose in 2017. Water levels in shallow monitor wells near the SJR rose approximately four to twelve feet. Water levels in deeper monitor wells located in the northern portion of the study area, away from the SJR, rose more than fourteen feet in 2017.

8.3 Groundwater Quality

TDS concentrations in shallow and deep zone wells in the Mendota area vary widely, from less than 200 mg/L near the Meyers Farm Water Bank (MF-1) to over 6,000 mg/L west of the Fresno Slough (USGS 31J4). The CCID deep zone wells have the longest period of record showing water quality changes in the Mendota area, with salinity data (measured as EC) going back to the 1960s at several wells. Degradation was observed at several CCID wells due to easterly movement of the saline front. The largest increase in EC was about 1,500 $\mu\text{mhos/cm}$ at CCID well No. 28 (and its replacement), over a period of about 40 years. (**Appendix F**). The increase in EC over time have averaged about 37 $\mu\text{mhos/cm}$ per year.

MPG shallow and deep zone wells west of the Fresno Slough continue to experience degradation due to easterly movement of the saline front, which has increased due to MPG transfer pumping. This is especially true for the CGH wells in the central portion of the well field west of the Slough. In contrast, groundwater salinity appears to be generally stable or decreasing at the majority of wells in the northern portion of the MPG well field along the Fresno Slough. In years prior to 2014, southern wells (e.g., Five Star wells) had low and stable salinity attributed in part to the Bank, which has recharged relatively low salinity surface water in the shallow zone. However, from 2014 to 2016 (wells were not sampled in 2017), six of these wells showed increasing salinity.

The operation of the Bank has resulted in substantial water quality improvements in the western portion of the Meyers Farming property. In the central and north portions of the Meyers Farming property, however, shallow groundwater remains degraded due to historical wastewater disposal practices. Substantial degradation has continued at Meyers Farming supply wells along the north boundary of the former Spreckels property. Since the factory closed, degraded groundwater has moved downward to the deep zone and has moved farther north to the southernmost FWD wells. FWD wells R-1, R-3 and R-11 have shown the most increase (EC greater than 1,000 $\mu\text{mhos/cm}$) in salinity, but most other FWD wells farther north exhibit low salinity and stable groundwater quality.

North of the SJR, the salinity at most wells in the WO and CCC service areas has generally been stable and the groundwater has been acceptable for irrigation. Although many of the WO and CCC wells have experienced year-to-year salinity fluctuations, the salinity of samples collected in 2017, with a few exceptions, was similar to that of the mid-1990s in this area. Gradual salinity increases have occurred at the northern deep wells (W-32 and W-89), but EC has been lower and stable near the SJR.

8.4 Surface-Water Flow and Quality

In 2017, there were San Joaquin flood releases from late January through July, and SJRRP restoration flows for the remainder of the year. Kings river flood releases to the Fresno Slough also occurred from February through August. The average flow direction in the Fresno Slough branch of the pool was to the north from February through August with flows ranging from 73 cfs to 3,338 cfs. In January and from September through December, flow was to the south, ranging from 110 to 248 cfs. For the entire year, the average flow to the north was 673 cfs.

The salinity in the DMC entering the Pool was much lower in 2017 than in 2014 through 2016 when higher levels were experienced. The EC at the Columbia Canal intake was lower than the DMC during the majority of the year due to inflow of low salinity water from the SJR. The salinity at the CCID Outside Canal and Firebaugh Intake Canal tracked that of the DMC very closely for most of the year with the exception of February when the two intakes had temporary elevated EC values.

The 2017 salinity was lower in the southern portion of the Pool compared to during 2014 through 2016, primarily due to low salinity inflows from low the Kings River.

Surface-water quality data for two key trace elements (boron and selenium) were available from the Mendota Pool in 2017. None of the samples exceeded the WQO for boron but selenium concentrations were elevated at the DMC terminus in the first half of the year.

Sediment sampling was not conducted in 2017 since transfer pumping did not occur. Analysis of historical surface water and sediment sample results do not indicate any influence of MPG operations on sediment quality.

8.5 Compaction

There was no inelastic compaction above the Corcoran Clay at the Fordel extensometer in 2017. The extensometer data show a net expansion of 0.009 feet during the year, and the cumulative inelastic compaction during the 18-year period beginning in March 2000 was 0.038 feet. This amounts to an average inelastic compaction of about 0.002 feet per year.

There was no inelastic compaction above the Corcoran Clay at the Yearout Ranch extensometer. The extensometer data show a net expansion of 0.008 feet in 2017. The cumulative inelastic compaction since March 2000 was 0.199 feet. This amounts to an average inelastic compaction of about 0.011 feet per year. The cumulative inelastic compaction caused by MPG transfer pumping since 2000 is estimated to be 0.068 feet, which corresponds to an average annual inelastic compaction of 0.004 feet per year. This is less than the limit on average annual compaction of 0.005 feet at the Yearout Extensometer due to MPG transfer pumping specified in Agreement No. 2 and the annual Agreement extension. Transfer pumping by the MPG from below the Corcoran Clay has been included in the total amount of MPG pumping considered in this evaluation.

Total land subsidence in the area is monitored by PBO using high-definition GPS equipment on the Meyers Farms property south of the City of Mendota. Since data collection began in April 2004, there

has been about 0.72 feet of land subsidence at this site, which is over 20 times more than the compaction that was measured at the Fordel extensometer during the same period. The inelastic compaction has primarily occurred in and below the Corcoran Clay due to pumping of deep wells in the areas southwest and northeast of Mendota.

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