



**MERCED GROUNDWATER BASIN
GROUNDWATER MANAGEMENT
PLAN UPDATE
MERCED COUNTY, CA**

Submitted to:

Merced Area Groundwater Pool Interests, Merced, CA

Submitted by:

AMEC Geomatrix, Inc., Fresno, CA



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Project No. 13651.001

AMEC Geomatrix



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This report was prepared by the staff of AMEC Geomatrix, Inc., under the supervision of the Engineer(s) and/or Geologist(s) whose seal(s) and signature(s) appear hereon.

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A handwritten signature in black ink that reads "David M. Bean".

David M. Bean, PG, CHg
Principal Hydrogeologist

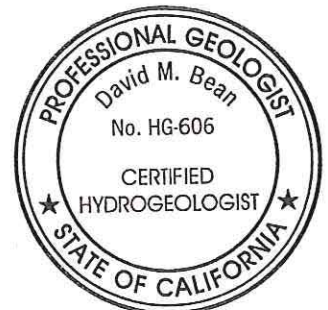


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List of Acronyms

°C	temperature degrees Celsius
°F	temperature degrees Fahrenheit
1,2 DCA	1,2-dichloroethane
1,2,3-TCP	1,2,3-trichloropropane
AB	California Assembly Bill
ac-ft	acre-feet
ac-ft/d	acre-feet per day
ac-ft/y	acre-feet per year
bgs	below ground surface
BMO	Basin Management Objective
BShs	Koppen climate classification - Mediterranean Steppe
Csa	Koppen climate classification - Hot Mediterranean
CWC	California Water Code
DBCP	dibromochloropropane
DOHS	Department of Health Services
DPH	California Department of Public Health
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
EDB	ethylene dibromide
EPA	United States Environmental Protection Agency
et. Seq.	and subsequent (Latin)
GMO	genetically modified organism
gpm	gallon per minute
GWMP	Groundwater Management Plan
IGSM	Integrated surface water / groundwater model
IWRIS	integrated water resources information system database
JPA	Joint Powers Authority
MAGPI	Merced Area Groundwater Pool Interests
MCDEH	Merced County Division of Environmental Health
MCL	maximum contaminant level
mg/L	milligrams per liter (also part per million)
MGWB	Merced Groundwater Basin
MID	Merced Irrigation District
MOU	Memorandum of Understanding
MTBE	methyl-tertiary-butyl-ether
PCE	perchloroethylene
ppm	parts per million
RWQCB	California Regional Water Quality Control Board
SB	California Senate Bill
SPI	Standardized Precipitation Index
SWRCB	California State Water Resources Control Board
TCE	trichloroethylene
TDS	total dissolved solids
TWG	Technical Working Group
UC Merced	University of California - Merced Campus
µg/L	micrograms per liter (also parts per billion)
USDA	United States Department of Agriculture
USGS	United States Geological Survey

List of Acronyms (continued)

UST	underground storage tank
VOC	volatile organic compound
WPA	wellhead protection area
WWP	wellhead protection program

**MERCED GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN**
Merced Area Groundwater Pool Interests
Merced County, California

1.0 INTRODUCTION

The Groundwater Management Act, California Water Code (CWC) Section 10753 et. seq., originally enacted as Assembly Bill (AB) 3030, was passed by the State legislature during the 1992 session and became law on January 1, 1993. AB 3030 identifies groundwater as a valuable resource that should be managed to ensure both its safe production and its quality. It also encourages local agencies to work cooperatively to manage groundwater resources within their jurisdiction.

Groundwater management encompasses the planned and coordinated monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of long-term sustainability of the resource (DWR, 2003). Groundwater management includes a number of integrated actions, both natural processes and managed activities, which relate to groundwater recharge and discharge. Those actions include a range of options to increase water supply reliability to achieve the long-term sustainability of groundwater resources. A groundwater management plan (GWMP) provides the framework to implement a groundwater management strategy for an area, basin, or a portion of a groundwater basin. In this case, the GWMP addresses the Merced Groundwater Basin (MGWB) which is located in the eastern half of Merced County, California (Figure 1).

1.1 PURPOSE OF THE GROUNDWATER MANAGEMENT PLAN

The purpose of the GWMP is to identify and implement a number of actions using modern technology and sound science to preserve and/or increase the quantity of groundwater resources in the MGWB to ensure adequate groundwater resources for future generations. The GWMP is a living document; progress in implementing the plan will be periodically reviewed with the current understanding of groundwater levels, quality, and trends. The GWMP is a guideline for the community to use for sustainable development of groundwater resources. It is intended to be consistent with Federal, State, and County regulations; however it is not intended to replace or ensure compliance with local General Plans or the California Environmental Quality Act. The burden of proving proposed project compatibilities with applicable plans and regulations is fully borne by the lead agencies.

1.2 PREVIOUS GROUNDWATER MANAGEMENT PLAN

The Merced Irrigation District (MID) and the City of Merced prepared a final draft GWMP in 1997 to comply with legislative requirements of AB 3030. In December 1997, water purveyors within the MGWB signed a Memorandum of Understanding (MOU) creating an association identified as the Merced Area Groundwater Pool Interests (MAGPI) (Appendix A). MAGPI adopted the GWMP in December 1997. The 1997 GWMP served as the initial framework for management of groundwater resources within the MGWB.

In 2002, State Senate Bills (SB) 1938 (Groundwater Management Planning Act of 2002) and SB 1672 (Integrated Regional Water Management Planning Act of 2002) were signed into law. These bills required various changes and additions to existing basin-wide groundwater management plans. The most significant changes were the adoption of an integrated approach to basin-wide groundwater management, the development of management objectives, and a basin-wide monitoring program by stakeholders. The California Department of Water Resources (DWR) outlined the new requirements of SB 1938 in Appendix C of the 2003 update to Bulletin 118 "California's Groundwater" and suggested additional components that should be included in a GWMP.

1.3 GROUNDWATER MANAGEMENT PLAN UPDATE

This document supersedes the 1997 GWMP and incorporates new components and updates existing components to address the legislative requirements of SB 1938 and SB 1672. This update incorporates data collected since 1997 and reflects analyses performed subsequent to preparation of the 1997 GWMP. In addition, the components suggested in Bulletin 118 have been added and the existing AB 3030 components were also updated to reflect: 1) expansion of the number of MAGPI members (i.e., Lone Tree Mutual Water Company), 2) revised characterization and understanding of the basin hydrogeology, 3) the addition of new monitoring data, 4) new or revised groundwater monitoring procedures, 5) changes to the basin management objectives, and 6) changes in groundwater management practices and philosophy.

The lead agencies for this GWMP update are the City of Merced and MID on behalf of MAGPI. The GWMP has been prepared with assistance from a Technical Working Group (TWG) consisting of members of MAGPI (Stevenson Water Company, Meadowbrook Water Company, the City of Merced, MID, Winton Water & Sanitation District, Le Grand-Athlone Water District, and Merced County Department of Health Services [DOHS]), non-MAGPI agencies (East Merced Resource Conservation District, DWR, San Joaquin Raptor Rescue Center), consulting engineers and hydrogeologists (Davids Engineering and AMEC Geomatrix, Inc.), and members of the general public.

A summary of the components of a GWMP required by applicable legislation (AB 3030, SB 1938, and SB 1672) and suggested in Bulletin 118 is included in Table 1. As shown, the GWMP addresses these items:

- the twelve required components of AB 3030 that describe technical issues that should be addressed in the GWMP to manage the basin optimally and protect against adverse conditions;
- the seven components of SB 1938 that are required for agencies to be eligible for funds administered by DWR for construction of groundwater projects;
- the five required components of SB 1672 that promote integrated regional groundwater management; and
- the seven voluntary components of Bulletin 118 that link Basin Management Objectives (BMOs) to specific actions within the GWMP.

These items are addressed throughout this GWMP. The GWMP consists of the following sections:

Section 1 Introduction – This section describes the legislative framework for the GWMP and the basis of the update.

Section 2 Groundwater Planning Process – This section describes the steps and procedures that were conducted to draft, review, and finalize this GWMP. Records of public participation, input received from the TWG, and the timeline of all events relating to the GWMP update process are included in this section.

Section 3 Existing Groundwater Basin Conditions – This section describes the current hydrogeologic conditions and issues related to the MGWB. It includes discussions of the MGWB boundaries, local hydrogeology and groundwater levels, existing water supplies and groundwater extractions, and groundwater quality.

Section 4 Water Resources Setting – This section describes existing surface water and groundwater supplies and municipal, industrial, and agricultural water demands within the MGWB.

Section 5 Basin Management Goals and Objectives – This section presents MAGPI's strategy for managing the MGWB in terms of states goals and associated BMOs. The goals are broad principals, and the BMOs are quantifiable or verifiable actions for achieving the goals.

Section 6 Groundwater Management Plan Elements – This section details the specific projects, programs, and policies that will be implemented to manage the MGWB; some new, and others existing.

Section 7 Groundwater Management Plan Implementation – This section outlines a schedule for implementation and assessment of this GWMP.

Section 8 References – This section provides a list of documents utilized to prepare this GWMP.

2.0 GROUNDWATER MANAGEMENT PLANNING PROCESS

Groundwater management is the planned and coordinated monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of achieving long-term sustainability of the resource (DWR, 2003). A GWMP is a document that provides a framework to implement a groundwater management strategy for an area, basin, or a portion of a groundwater basin. This GWMP presents the approach to implement a series of integrated water management actions to secure a sustainable source of groundwater in the MGWB.

The DWR has divided the state into 10 hydrologic regions, which have been further divided into basins and subbasins. As described in the 2003 update to Bulletin 118 "California's Groundwater," the MGWB is a subbasin within San Joaquin Valley Groundwater Basin of the San Joaquin River Hydrologic Region (Figure 2).

2.1 BASIN BOUNDARIES AND ASSEMBLY BILL 3030 STUDY AREA

The MGWB is located in the San Joaquin Valley, which is surrounded by the Coast Range on the west, the San Emigdio and Tehachapi Mountains on the south, the Sierra Nevada on the east, and the Sacramento-San Joaquin Delta (Delta) and Sacramento Valley on the north. The northern portion of the San Joaquin Valley drains toward the Delta by the San Joaquin River and its tributaries, including the Fresno, Merced, Tuolumne, and Stanislaus rivers. The southern portion of the valley is internally drained by the Kings, Kaweah, Tule, and Kern rivers that flow into the Tulare drainage basin including the beds of the former Tulare, Buena Vista, and Kern lakes (DWR, 2003).

The MGWB lies on the eastern side of the San Joaquin Valley, entirely within Merced County and is generally described as the eastern half of Merced County (Figure 3). For the purposes of this GWMP, the MGWB includes lands south of the Merced River between the San Joaquin River on the west and the crystalline basement rock of the Sierra Nevada foothills on the east. The MGWB boundary on the south stretches westerly along the Madera-Merced County line (Chowchilla River) to the northern boundary of the Sierra Water District, which is followed westerly to the San Joaquin River. Although this modified study area is about 54 square miles larger than the MGWB as described in Bulletin 118, it is more consistent with natural hydraulic boundaries surrounding the basin.

2.2 GROUNDWATER MANAGEMENT WITHIN THE MERCED GROUNDWATER BASIN

During 1997, several agencies within the groundwater basin adopted Resolutions of Intention to Adopt a Groundwater Management Plan pursuant to Water Code Section 10753 et seq. In addition, these agencies formed MAGPI for the purpose of developing a basin-wide groundwater management plan to guide the management of the groundwater resources in the MGWB.

The 1997 GWMP was the result of the planning effort of the City of Merced and MID on behalf of MAGPI. In June 2001, the DWR and MAGPI entered into a MOU to work cooperatively to promote conjunctive use of surface and groundwater projects within the MGWB. Since 2001, MID (on behalf of MAGPI) has implemented a number of in-lieu recharge programs to reduce groundwater pumping and decrease stress on the aquifer. Other activities completed by MAGPI include:

- Southeast Quadrant Data Assessment (2002; DWR funding), which described the regional hydrogeologic setting of Eastern Merced County, compiled available water resources data, and developed a data management plan for MAGPI members.
- Conjunctive Use Site Assessment (2003; DWR funding), which compared and evaluated alternative artificial recharge sites.
- Cressey Pilot Recharge Basin (ongoing; MID funding), which is providing promising results with respect to infiltration rates for spreading basins.
- Public Involvement (ongoing; DWR funding), which is aimed at improving coordination among MAGPI members and between MAGPI and other entities in the MGWB.
- Stream and Groundwater Monitoring (ongoing; AB 3030 funding), which is aimed at defining stream-aquifer interaction along Bear Creek in the vicinity of Merced.

2.2.1 Agencies/Water Purveyors within the Merced Groundwater Basin

There are numerous agencies that lie either wholly or partly within the MGWB and therefore are eligible to participate in an AB 3030 GWMP. These agencies include the:

- City of Atwater
- Black Rascal Water District
- East Side Water District
- Le Grand Community Service District
- Le Grand-Athlone Water District
- City of Livingston
- Lone Tree Mutual Water Company
- Meadowbrook Water Company
- City of Merced
- Merced County Environmental Health Department

- Merced Irrigation District
- Merquin County Water District
- Planada Community Service District
- Stevinson Water District
- Turner Island Water District
- Winton Water and Sanitary District

2.2.2 Merced Area Groundwater Pool Interests

The signatory agencies to the MAGPI MOU are shown on Figure 4. These agencies, which cover most of the MGWB, agree that the groundwater and surface water resources within the MGWB are vitally important resources in that they:

- Satisfy environmental, agricultural, domestic, municipal, industrial, and other water needs and
- maintain the economic viability and prosperity of eastern Merced County.

Eastern Merced County is a vital agricultural area with increasing importance in industry and education. Because of increasing demands for California's finite water resources, it is critical that those people and agencies making use of the region's limited water supplies do so in an efficient and knowledgeable manner to preserve the resources for all elements of a robust regional economy. The MAGPI parties acknowledge that long-term groundwater level declines due to pumping can diminish water quality and quantity; cause land subsidence; increase water costs; and eventually restrict economic development.

2.2.3 Public Participation

An extensive public involvement process was conducted to provide for broad input to development of the GWMP update, including formal public hearings conducted according to AB 3030 requirements, MAGPI board meetings, and formation of an ad hoc technical working group that represented selected MAGPI members and other interested members of the public. A chronology of the various activities carried out to support the update process is provided below:

- On January 16, 2008, the MAGPI Board published a notice informing the public of the intention of the MAPGI to hold a public hearing to determine whether to adopt a resolution to prepare the groundwater management plan update. These notices are included in Appendix B.
- The MAGPI Board, in a regularly scheduled meeting on January 30, 2008, held a hearing (after publication of notice) on whether to adopt a resolution of intent to prepare a GWMP Update. In this hearing, the public was invited to comment on

whether the agency should adopt the resolution and on the planning process. The public was informed on how to provide comments to the agency.

- At the conclusion of the hearing, the MAGPI Board adopted a resolution of intent to draft the GWMP update. The MAGPI Board also directed the staff to participate with members of MAGPI and the public to form a TWG to act as an advisory committee of stakeholders in development of the GWMP update.
- From February through May, the TWG met approximately monthly to review and comment on sections of the Draft GWMP. Notice of the TWG meetings were sent via e-mail to TWG members and the MAGPI Board. The Draft sections of the GWMP were published on the MAGPI website as they were prepared, and available for public review. The TWG meetings were open to the public.
- On May 31, 2008, the MAGPI Board published a notice informing the public of the intention of MAPGI to hold a public hearing to receive input from the public leading to adoption of the Draft GWMP, which would amend and supersede the existing plan adopted by the member agencies of MAGPI on December 29, 1997. These notices are included in Appendix B.
- The MAGPI Board, in a regularly scheduled meeting on June 16, 2008, held a hearing (after publication of notice) to present the Draft GWMP update to the Board and public and solicit public comment on the Draft. In this hearing, the MAGPI Board voted to keep the hearing open until July 1, 2008 and invited the public to provide written comments on the Draft GWMP (available on the MAGPI website since June 2, 2008) by July 1, 2008. The public was informed on how to provide comments to MAGPI.
- The MAGPI Board, on July 30, 2008, passed a resolution adopting the Draft GWMP update, superseding the December 29, 1997 plan.

3.0 EXISTING GROUNDWATER BASIN CONDITIONS

This section addresses the current hydrogeologic conditions and issues related to the MGWB. It includes discussions of the physical setting, local geology, local hydrogeology and groundwater levels, existing water supplies and groundwater extractions, and groundwater quality.

3.1 PHYSICAL SETTING

The MGWB is located in the San Joaquin Valley is a broad structural trough approximately 200 miles long and up to 70 miles wide. It is filled with up to 32,000 feet of marine and continental sediments deposited during periodic inundation by the Pacific Ocean and by erosion of the surrounding mountains. Continental deposits shed from the surrounding mountains form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough. This depositional axis is below and slightly west of the series of rivers, lakes, sloughs, and marshes that mark the current and historic axis of the surface drainage of the San Joaquin Valley (DWR, 2003).

The physiographic units in the MGWB area include the Sierra Nevada, dissected uplands, low alluvial plains and fans, river flood plains and channels, and overflow lands (Page and Balding, 1973). These physiographic units are presented on Figure 5. The Sierra Nevada unit, which can be found along the eastern border of the MGWB, consists of metamorphic and granitic mountains that have deep river-cut canyons and highly dissected foothills.

The dissected uplands unit has a width ranging between 5 and 18 miles and covers a significant portion of the MGWB. Local relief may be up to 200 feet. Within the uplands the Merced River has developed two terraces and a broad flood plain while the Chowchilla River is only slightly entrenched into the upland surface.

The low alluvial plains and fans unit, which consists primarily of coalescing alluvial fans, has a width ranging between 14 and 20 miles and covers a significant portion of the MGWB. Local relief may be up to 10 feet. Between Atwater and Turlock, northwest trending sand dunes underlie the surface of the plains and fans.

The river flood plains and channels unit flank the channels of the major rivers including the Merced and Chowchilla Rivers. In the dissected uplands unit, the flood plain of the Merced River ranges in width between 0.25 and 1 mile. In the Cressey area, natural levees are present. Near the valley trough, the Merced River flood plain becomes indistinguishable from the surrounding alluvial plains. The Chowchilla River, which is entrenched about 40 feet near where it leaves the Sierra Nevada, has developed a thin flood plain through the dissected uplands. The river has deposited natural levees throughout the low alluvial plains and fans unit.

The MGWB and San Joaquin Valley are classified as having a hot Mediterranean (Koppen climate classification *Csa*) to Mediterranean steppe (*BShs*) climate (McKnight & Hess, 2000). It is typically hot and dry during the summer and cool and damp in winter, leading to frequent ground fog known regionally as tule fog. Summer temperatures reach into the mid to upper

90s (degrees Fahrenheit [°F], 30s in degrees Celsius [°C]), and occasional heat waves might bring temperatures well over 100°F (38°C) with some locations topping out at around 115°F (46°C). Average precipitation ranges between 10 and 13 inches per year, increasing with elevation. Winter and spring comprise the rainy season, although during the late summer, southeasterly winds aloft can bring thunderstorms of tropical origin, mainly in the southern half of the San Joaquin Valley.

3.2 GEOLOGY

The MGWB is underlain by consolidated rocks, unconsolidated deposits, and shallow surface soils (Figure 6). The consolidated rocks, from bottom to top, include the Sierra Nevada basement complex, lone Formation and other sedimentary rocks, the Valley Springs Formation, and the Mehrten Formation (Page and Balding, 1973). The unconsolidated deposits include continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood-basin deposits. The surface soils consist of 18 soil associations based on physiographic sections. The geology and soils are described in the following sections.

3.2.1 Consolidated Rock

The consolidated rocks include the Sierra Nevada basement complex, lone Formation and other sedimentary rocks, the Valley Springs Formation, and the Mehrten Formation.

The Sierra Nevada bedrock complex consists largely of metasedimentary and metavolcanic rock of pre-Tertiary age (Page and Balding, 1973). These rocks occur as foothill ridges along the eastern edge of the MGWB. Where the basement complex occurs near the surface, fracture sets and joints within the bedrock complex may contain sufficient groundwater for domestic or stock supplies.

The Eocene lone Formation unconformably overlies the Sierra Nevada bedrock complex and is composed of marine to non-marine clay, sand, sandstone, and conglomerate (Figure 6). These rocks occur as foothill ridges along the eastern edge of the MGWB. The lone is characterized by a white sandy clay (kaolinite) at its base and beds of conglomerate and yellow, red, and gray sandstone in its upper parts. In localized areas near the Sierra Nevada foothills, the formation contains fresh water; however, well yields are highly variable.

The Miocene Valley Springs Formation overlies the lone Formation and is composed of a fluvial sequence of rhyolitic ash, sandy clay, and siliceous gravel in a clay matrix. These rocks occur as foothill ridges along the eastern edge of the MGWB (Figure 6). Because of the abundant ash and clay matrix, the Valley Springs has a relatively low groundwater yield, sufficient for domestic or stock supplies, but generally insufficient for irrigation.

The Miocene/Pliocene Mehrten Formation overlies the Valley Springs Formation and is composed of fluvial deposits of sandstone, breccia, conglomerate, tuff, siltstone and claystone. It contains a large amount of andesitic material, making it easy to distinguish. The Mehrten outcrops over a large area in eastern MGWB (Figure 6). It forms an important aquifer in the MGWB with relatively high yields.

3.2.2 Unconsolidated Deposits

The unconsolidated deposits, from bottom to top, include continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood-basin deposits. The Pliocene/Pleistocene continental deposits consist of a heterogeneous mixture of poorly sorted gravel, sand, silt and clay derived primarily from the Sierra Nevada. The sediments, which are found throughout the MGWB, dip gently to the southwest and have variable thickness up to 700 feet. The continental deposits have relatively large yields to wells and are an important part of the aquifer system.

The lacustrine and marsh deposits consist of two beds: the Corcoran Clay Member of the Pleistocene Tulare Formation and a shallow clay bed of Holocene age (Page, 1977). The Corcoran Clay is a bed of laterally extensive reduced (blue/grey) silt and clay that underlies about 770 square miles in the southeast portion of the MGWB (Figure 7). The Corcoran Clay is a significant confining layer up to 60 feet thick. The shallow clay bed of Holocene age is composed of oxidized (brown/red) sandy clay and clay with silica cemented intervals (hardpan). It is found throughout most of the MGWB at a shallow depth (~ 35 feet).

The older alluvium consists of a heterogeneous mixture of poorly sorted gravel, sand, silt and clay up to 400 feet thick derived primarily from the Sierra Nevada. The sediments, which are found throughout the MGWB, were deposited as a series of interbedded coarse-grained and fine-grained layers and form a leaky-aquifer system.

The flood-plain deposits consist of intercalated lenses of reduced to oxidized fine sand, silt, and clay. These deposits are found in the southwestern portion of the MGWB and generally are less than 30 feet thick (Figure 6).

The younger alluvium consists of well sorted gravel and sand derived primarily from the Sierra Nevada. The younger alluvium is found in a narrow band along the stream channels throughout the MGWB (Page and Balding, 1973).

3.2.3 Surface Soils

The United States Department of Agriculture (USDA) Soil Conservation Service conducted a soil survey in Merced County and identified more than 200 unique soil types within the MGWB

(USDA, 1962). These soil types can be grouped into 18 soil associations based on physiography and permeability (Figures 8 and 9).

3.3 HYDROGEOLOGY

This section provides a summary of the local hydrogeology, groundwater levels and trends, existing water supplies and groundwater extractions, and groundwater quality.

3.3.1 Occurrence of Groundwater

The base of fresh water in the MGWB is approximately 1,200 feet below ground surface (bgs, Page, 1977). Five aquifer systems have been identified in the MGWB including a fractured bedrock aquifer, the Mehrten Formation, a confined aquifer, an intermediate "leaky" aquifer, and a shallow unconfined aquifer. These are discussed below.

Fractured Bedrock - Along the eastern edge of the MGWB wells have been completed within the Valley Springs and Lone Formations (Page & Balding, 1973, Page, 1977). These wells appear to be completed in fractured bedrock with limited and variable yields. Because of the limited extent (and poor yields) of the fractured bedrock aquifer, the fractured aquifer is not a significant source of water in the MGWB.

The Mehrten Formation - The Mehrten Formation outcrops over a large area in the MGWB. Many water supply wells in the eastern portion of the MGWB penetrate the formation and it is a significant source of groundwater. Where the Mehrten occurs beneath the Corcoran Clay, it is considered a confined aquifer. Where the Mehrten does not underlie the Corcoran Clay, there is insufficient data to determine the degree of confinement of the formation.

Confined Aquifer - The confined aquifer occurs in older alluvium (and Mehrten Formation) deposits that underlie the Corcoran Clay (Figure 7). Many water supply wells in the western portion of the MGWB penetrate the Corcoran Clay into the confined aquifer and it is a significant source of groundwater.

Intermediate Leaky-Aquifer - The intermediate aquifer occurs in older alluvium deposits that overlie the Corcoran Clay or are east of the Corcoran Clay (Figure 7). Where the Corcoran Clay is absent the intermediate aquifer extends to the Mehrten Formation. In the eastern portion of the MGWB the intermediate aquifer consists of a series of interbedded coarse-grained (gravel and sand) layers separated by fine-grained (silt and clay) layers. The fine grained layers inhibit, but do not prevent vertical groundwater flow between layers and thus form a leaky-aquifer system. Many water supply wells in the MGWB are completed in the intermediate leaky-aquifer and it is a significant source of groundwater.

The Intermediate leaky-aquifer is the most extensively developed aquifer in MGWB. Measured well yields within the MGWB (Page & Balding, 1973) range from 670 to 4000 gallons per minute (gpm). Estimates of specific capacity of supply wells throughout the MGWB range from about 20 to 40 gallons per minute per foot of drawdown and indicate that the specific capacity increases from east to west (Figure 10).

Shallow Unconfined Aquifer – The shallow unconfined aquifer occurs in older and younger alluvium deposited above the shallow clay bed. Because of its shallow depth, few water supply wells are completed in the shallow unconfined aquifer. Where water levels in the intermediate leaky aquifer fall below the base of the shallow clay bed, groundwater in the intermediate aquifer becomes unconfined and water in the overlying shallow aquifer becomes perched.

3.3.2 Groundwater Levels and Historical Trends

Groundwater elevations in water supply and monitoring wells have been monitored by DWR, MID, and other entities since the 1950s. DWR monitors more than 305 wells on a semi-annual basis throughout the MGWB. MID currently measures static regional groundwater levels monthly in a total of 290 active wells within its service area (Figure 11). In addition, MID monitors shallow monitoring wells, which are located at the section corners, to evaluate localized areas of high groundwater (near ground surface) or perched groundwater table conditions. The municipalities within the MGWB also monitor groundwater levels frequently in their water supply wells. The City of Merced monitors water levels in more than 120 monitoring wells on a quarterly basis.

To simplify evaluation of the available groundwater level data in the MGWB, 34 monitoring wells (about 10 percent) with at least 30 years of history from 1970 to present were selected from the available data set. These wells are located relatively uniformly throughout the MGWB (Figure 12). Long-term hydrographs prepared for these wells show that throughout most of the MGWB, groundwater elevations are declining with time (Figure 13). Since 1980, average groundwater levels beneath the MGWB have decline approximately 14 feet (Figure 14). Most of this decline occurred between 1980 and 1996. The notable exception is beneath the El Nido area, where groundwater levels have shown a substantial increase since 1980 in response to increased delivery of surface water by MID. Individual hydrographs for the 34 selected wells are presented in Appendix C.

3.3.3 Groundwater Flow Directions

Groundwater conditions within the MGWB vary based on location. On the regional scale, groundwater flow beneath the MGWB is generally from northeast to southwest, from the foothill recharge areas toward the valley trough and the San Joaquin River. Locally, the

groundwater flow direction varies with time in response to local groundwater pumping and irrigation recharge. The response of the aquifers to changes in pumping and irrigation is relatively rapid, and localized flow directions are affected by these changes.

DWR routinely publishes potentiometric surface maps of the unconfined aquifer groundwater elevation in the San Joaquin Valley. The 1996 map indicates several major cones of depression in the potentiometric surface centered approximately on Chowchilla and El Nido (Figure 15). The DWR map for 2006 shows a highly convoluted potentiometric surface due to numerous localized pumping centers beneath Chowchilla, Merced, and Livingston (Figure 16).

The groundwater elevation data from the 34 selected monitoring wells were used to prepare simplified potentiometric surface maps on an annual basis (Appendix D). As shown on Figures 17 and 18, these maps show the same general features in the potentiometric surface as the DWR maps (Figures 15 and 16), but is more easily interpreted.

3.3.4 Groundwater Recharge and Discharge Areas

The groundwater elevations relative to the elevations of the major rivers and the interaction of the cones of depression with the rivers suggest that some reaches of the rivers lose water to groundwater while others gain water from groundwater discharge. Comparison of Chowchilla River elevations with groundwater levels indicates that the river is higher than the groundwater. Consequently, the river probably contributes some recharge to groundwater along the reach south of the study area. The pumping depressions near the Chowchilla River do not appear to be affected by the presence of the river.

The groundwater elevation data indicate that there is groundwater discharge along the San Joaquin River. There is a trough in the water table elevations that follow the San Joaquin River. Groundwater inflow to the river and surrounding areas occurs from both sides of the San Joaquin Valley. This river and the surrounding areas are the primary groundwater discharge area for the valley.

On the north side of the MGWB west of State Highway 99, the lower reaches of the Merced River appear to be a groundwater discharge area. East of the highway, the river may be acting as a constant head source and supplying water to the large cone of depression centered approximately 17 miles northwest of Merced, east of Oakdale Road (Township 5 South, Range 12 East, Section 36), the river is higher than the groundwater and probably provides some recharge to the groundwater.

3.3.5 Vertical Groundwater Gradients and Shallow Groundwater

The vertical groundwater gradient, and hence the direction of vertical groundwater flow, is downward from the shallowest groundwater to the deeper aquifers (Elliott, 1984).

Consequently, degradation of shallow groundwater can potentially affect deeper water supply wells where downward flow is significant and where dilution and chemical/biological processes are insufficient to adequately reduce the concentrations of constituents of concern.

The area of the MGWB located generally between the cities of Atwater and Livingston, south of State Highway 99 and north of State Highway 140, has historically experienced localized high groundwater levels. Groundwater levels have varied from year to year and over the course of an irrigation season as a result of pumping, precipitation and applied irrigation water. If left uncontrolled, groundwater levels of less than six feet bgs would not be uncommon, resulting in potentially adverse impacts to local crop production.

To minimize these potentially adverse impacts, the MID provided groundwater control (referred to as "drainage pumping") in areas where groundwater levels were within six feet of the ground surface. Ninety-five wells specifically designed and located for drainage purposes were used for drainage pumping. This localized high groundwater condition within MID has declined steadily over the last 10 years. As a result, many of the drainage wells are now used exclusively for irrigation purposes during periods when insufficient surface water is available. Water pumped from these wells is typically discharged into the MID water distribution system where it is used, as much as possible, for irrigation purposes.

3.3.6 Subsidence

Subsidence of the land surface is not known to be occurring in the MGWB although subsidence has been detected in the vicinity of Los Banos within the Delta-Mendota Groundwater Basin west of the San Joaquin River (Merced County General Plan, 2000). In the Le Grand area, the ground surface around two wells is reported to have fallen a few feet, leaving the well heads above ground surface (Kole Upton, personnel communication). Although this subsidence appears to have occurred beneath a relatively small area and is not known to be occurring presently, it demonstrates that there is potential for subsidence in the MGWB if groundwater levels are not sustained. Monitoring of subsidence is not occurring in the MGWB at this time.

3.4 GROUNDWATER QUALITY

Many constituents, both man-made and naturally occurring, are present in the groundwater supply within the MGWB. The constituents identified in this section either currently impact groundwater usage within the basin or have the potential to impact groundwater usage in the future.

3.4.1 Salinity

Variability in soil conditions, soil type, geologic structure, irrigation practices, and irrigation water quality result in wide variability of the quality of groundwater, especially in the upper water-bearing zone. Because of these influences, groundwater salinity is generally lowest in the easterly portion of the MGWB and in the adjoining MID. Salinity increases westward toward the San Joaquin River and southward toward the Chowchilla River (Figure 19).

Salinity levels within the MGWB range from 90 to greater than 1,250 milligrams per liter (mg/L) as measured by total dissolved solids (TDS). TDS in groundwater in the eastern two-thirds of the Basin is generally less than 500 parts per million (ppm). TDS in groundwater increases westward and southwestward towards the San Joaquin River and southward towards the Chowchilla River. In these areas, high TDS water is found in wells deeper than 350 feet. Better quality groundwater (less than 1,000 ppm) in these areas is found at shallower depths.

Groundwater with high TDS concentrations in the MGWB is principally the result of the migration of a deep saline water body which originates in regionally deposited marine sedimentary rocks that underlie the San Joaquin Valley. The depth of this saline water body within the MGWB boundaries is very shallow compared to other parts of the San Joaquin Valley.

Groundwater with high concentrations of total dissolved solids is present beneath the entire MGWB at depths from about 400 feet in the west to over 800 feet in the east. The shallowest high TDS groundwater occurs in zones five to six miles wide adjacent and parallel to the San Joaquin River and the lower part of the Merced River west of Hilmar, where high TDS groundwater is upwelling.

Under natural pressure, the saline groundwater body is migrating upward. Brines move up through permeable sedimentary rocks and also through wells, faults and fractures. The chemistry of groundwater in the MGWB indicates that mixing is occurring between the shallow fresh groundwater and the brines, which produces the high TDS groundwater observed. Pumping of deep wells in the western and southern parts of the MGWB may be causing these saline brines to upwell and mix with fresh water aquifers more rapidly than under natural conditions.

The Corcoran Clay has provided a natural impediment to the migration of high TDS groundwater from the confined aquifer into the unconfined aquifer. High permeability pathways through the clay from the confined to the unconfined aquifer may be created by wells perforated in both the unconfined and confined aquifers.

3.4.2 Nitrates

Nitrate occurs from both natural and man-made sources and is widespread in groundwater in many parts of the San Joaquin Valley. High concentrations of nitrate in groundwater are primarily a concern for potable water supplies. The Meadowbrook Water Company has one well (of four) that, based on a 10-year trend analysis, is expected to reach the maximum contaminant level (MCL) in 10 to 12 years. The Planada Community Services District has two wells (of five) that are at or near the MCL. The MCL for nitrate in public drinking water supplies is 45 mg/L (as nitrate).

Nitrate in irrigation water is not a major concern for many crops, because it acts as fertilizer. However, permanent crop production, including grape vineyards, may be adversely affected by excess nitrate concentrations. High nitrate concentrations, typically found in shallower groundwater zones, has been attributed to various sources such as agricultural fertilizers, sewer effluent, septic tank effluent, and animal wastes.

3.4.3 Iron and Manganese

Groundwater in some areas within the MGWB has elevated iron and manganese concentrations. For example, manganese is found near the Merced Airport at relatively shallow depths. Generally "reducing conditions" (a lack of oxygen) may lead to elevated iron and manganese concentrations in groundwater. Also, shallow groundwater near streams often has high manganese and sometimes high iron concentrations.

3.4.4 Arsenic

Arsenic concentrations in water from public water supply wells in the MGWB are below the current MCL of 0.010 mg/L. The United States Environmental Protection Agency (EPA) is currently evaluating the MCL for arsenic, which if lowered significantly could have a decided impact on groundwater usage and cost within the MGWB.

3.4.5 Radionuclides

Radionuclides are primarily from natural sources and can affect drinking water supplies. Sampling in the MGWB for radiological constituents has generally been limited to public water systems. The MCL for gross alpha is 15 picocuries per liter, and the MCL for uranium has recently been increased from 5 to 20 picocuries per liter.

The EPA has discussed establishing a standard for radon in drinking water. Depending on how low this standard is set, the natural activity of radon in groundwater could be a significant concern in the future.

3.4.6 Bacteria

Bacteriological quality in the MGWB is generally acceptable in deep groundwater aquifers. Bacteriological quality of groundwater pumped by individual wells cannot be generalized and depends on many factors pertaining to the well and surrounding conditions. Inadequately constructed and improperly located, destroyed, or abandoned water wells may contribute to bacteriological contamination of groundwater. Some of the factors that may influence contamination of water wells include location with respect to sources of contamination, inadequate construction features, general deterioration, and/or inadequate maintenance of wells, and improper use of water wells for disposal of wastes.

Bacteriological contamination of groundwater is a health concern because groundwater is used for drinking water. State DOHS standards require periodic sampling and testing for pathogenic microorganisms. The minimum number of tests depends on the number of service connections in the system.

3.4.7 Petroleum Hydrocarbons

A number of unauthorized releases from underground storage tanks (USTs) have occurred in the MGWB. The State Water Resources Control Board and Merced County Division of Environmental Health (MCDEH) are involved in monitoring and regulating the cleanup of sites involving many volatile organic compounds (VOCs) and UST spills (Figure 20). Most of these cases are very localized in nature in terms of groundwater impacts, and public water supply wells are not known to have been affected. MCDEH has a contract with the State Water Resources Control Board to provide mitigation services for the definition and cleanup of releases resulting from underground storage tanks. Benzene, toluene, xylenes, methyl-tertiary-butyl-ether (MTBE), and 1,2-dichloroethane (1,2 DCA) are the constituents of concern in groundwater.

MTBE, a mandatory gasoline additive designed to reduce air emissions, has been detected in various locations, primarily shallow monitoring wells. MTBE is highly mobile and highly soluble in water, but it does not degrade naturally like other petroleum product constituents. MTBE is also resistant to the biological treatment methods commonly used to clean up hydrocarbon spills. The incidence of MTBE may be more common than many realize because it does not show up in the commonly used EPA test methods; however, it can be detected by EPA analytical methods 502.2 or 602.

3.4.8 Pesticides

Pesticide contamination is primarily the result of the widespread use of the agricultural nematicide dibromochloropropane (DBCP) on croplands for several decades before it was banned in 1977. DBCP in the groundwater is usually associated with vineyards or orchards

where the pesticide was used. DBCP is a carcinogen at very low concentrations in water, and is a concern for potable water supplies. It moves freely with the groundwater and persists for long periods. The MCL for DBCP is 0.2 micrograms per Liter ($\mu\text{g/L}$). DBCP has been found in public water supply wells in the Merced area at levels either at or below the MCL. For public water purveyors, the frequency of monitoring for DBCP, where it has been detected, is set by DOHS. Also, 1,2,3-trichloropropane (1,2,3-TCP), a common cleaning and degreasing solvent also used in the application of soil fumigants, has been detected in shallow groundwater in the Livingston area. The MCL for 1,2,3-TCP is 0.005 $\mu\text{g/L}$.

Another nematicide that has been detected in the MGWB is ethylene dibromide (EDB). Used primarily on vineyards, EDB was banned in the early 1980s, but it has been detected in at least one public water supply well and several domestic wells in the Atwater/Livingston area.

Pesticide and fertilizer formulators and distributor sites often have releases resulting from spills, residual materials, wash racks, etc. Sites with known releases, whether they impact groundwater or not, are monitored by the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB). Sites with known releases in the MGWB are shown on Figure 20.

3.4.9 Trichloroethylene

The VOC trichloroethylene (TCE) is a nonflammable, colorless liquid with a sweet odor and is used as a solvent for dyes, rug cleaners, as well as a degreaser for metal parts. Improper storage and disposal have made TCE a major contaminant of groundwater supplies in California. The California Drinking Water Action Level of 5 parts per billion (ppb; 5 ppb is equivalent to 5 $\mu\text{g/L}$) for TCE is based upon what is considered a negligible risk level for cancer (i.e. if one million people drank about 2 liters of water containing TCE at 5 $\mu\text{g/L}$ every day over a 70-year lifetime, there would be no more than one additional case of cancer in the million people exposed).

Two locations in the MGWB, the Castle Airport Aviation and Development Center and the Merced's Eastern Industrial Park have known TCE plumes and have remediation activities in progress (Figure 20). At Castle Airport, a former United States Air Force Base, approximately 13,065 cubic yards of soil were removed and disposed of offsite. Twenty-three soil vapor extraction systems have removed 831,110 pounds of VOCs from the soil. Groundwater extraction systems were installed on and off base to protect nearby municipal wells and to remove the contaminants from the groundwater. As of 2007, 13.6 billion gallons of contaminated groundwater have been extracted and treated. All remediation has been completed or there are treatment systems in place and operating properly. (DTSC, 2007).

At the Merced Eastern Industrial Park, on-site and off-site groundwater extraction systems were installed. In addition, an impacted City of Merced supply well was replaced at an upgradient location. As of 2007, 7.2 billion gallons of contaminated groundwater have been extracted and treated, removing approximately 19,000 pounds of TCE. All groundwater remediation is completed or there are treatment systems in place and operating properly. (RWQCB, 2007).

3.4.10 Perchloroethylene

The VOC perchloroethylene (PCE) has been detected at sporadically in some of the MGWB's public water supply wells. Industrial wastes and dry cleaners are a recognized source of PCE in groundwater in many municipal areas, including the City of Merced (Figure 20). Beginning in the 1986, PCE was detected in three of the City of Merced's wells. As a result of the PCE contamination, three wells were replaced in the late 1980s and one well was rebuilt to seal off PCE contaminated aquifers. Five additional City of Merced wells are known to be at risk. Intensive monitoring and studies continue in an effort to manage the PCE problem in Merced. Improper use, improper storage, and accidental spills have resulted in unauthorized releases of PCE to groundwater.

3.4.11. Other Trace Organics

Other trace organic compounds have been detected in the MGWB including, but not limited to, carbon tetrachloride and hydrocarbon-based products. Improper use, improper storage, and accidental spills have resulted in unauthorized releases of these substances to groundwater.

Carbon tetrachloride is often attributed to auto repair shops, which have historically used it as a solvent or degreaser. There are no records of carbon tetrachloride being found in concentrations above the MCL of 0.5 µg/l in public water supply wells within the MGWB.

3.4.12. Emerging Contaminants

Many chemical and microbial constituents that have not historically been considered as contaminants are occasionally detected in groundwater. These newly recognized (or emerging) contaminants are commonly derived from municipal, agricultural, and industrial wastewater sources and pathways. These newly recognized contaminants are dispersed to the environment from domestic, commercial, and industrial uses of common household products and include such things as caffeine, artificial sweeteners, pharmaceuticals, cleaning products, etc. Residual waste products of genetically modified organisms (GMOs) are also of potential concern. A recently completed survey for pharmaceuticals at dairies in the MGWB by the UC Davis and the USGS resulted in a few detections of pharmaceuticals in shallow groundwater (Watanabe, Harter, and Bergamaschi, 2007).

4.0 WATER RESOURCES SETTING

The following sections describe the water resources setting in the MGWB, including review of water supply and demands within the MGWB and an evaluation of the sustainability of the water supply.

4.1 WATER SUPPLY

Water supplies within the MGWB consist of infiltration of precipitation, tributary inflow (surface water resulting from run-off of precipitation), surface water imported from the Merced River, and water stored in the subsurface as groundwater.

4.1.1 Precipitation

Precipitation is an important source of groundwater recharge in the MGWB. The average annual water year (July through June) precipitation in the MGWB is 12.25 inches (Figure 21) based on more than 100-years of monthly precipitation records from 1897 through 2006 collected by MID and its predecessors. Precipitation is highly seasonal with over 90 percent of precipitation occurring between the months of October and April (Figure 22).

Many quantitative measures of drought have been developed in the United States. One such index, the Standardized Precipitation Index (SPI), is useful for describing the many scales of drought. The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index value is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI can be computed for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term (1 to 2 months) and long-term (12 to 24 months) drought.

A SPI chart for the a 12-month interval representing a water year (July through June) for the 1897 to 2006 period indicates that the MGWB is likely to receive less than average annual precipitation approximately 52 percent of the time and greater than average annual precipitation approximately 47 percent of the time (Figure 23). Using an SPI value of +/- 1.0, the MGWB is likely to receive average annual precipitation approximately 68 percent of the time, experience drought conditions about 15 percent of the time, and experience wet conditions about 16 percent of the time,

A cumulative precipitation departure curve shows that precipitation in the MGWB during the past 100 years has generally been less than the annual average with several extended

periods of drought (Figure 24). Only three intervals had extended periods with above average precipitation.

An isoheytal map of the MGWB and watersheds that are tributary to the MGWB shows that annual average precipitation increases rapidly with increasing elevation (Figure 25). Much of the precipitation accumulates as snow pack in the higher elevations, which melts and runs off during the spring and early summer months.

4.1.2 Surface Water

The Merced River is the principal renewable surface water supply in the MGWB. The Merced River is impounded by New Exchequer Dam, forming Lake McClure. Lake McClure has a storage capacity of over 1 million acre-feet (ac-ft), and is used for flood control and storage of irrigation water. Under agreement with the United States Corp of Engineers, each spring the storage pool in Lake McClure is reduced to a maximum of 675,000 ac-ft for flood control purposes.

Since 1994, storage in Lake McClure has ranged from about 98,300 to 1,022,000 ac-ft and averaged about 610,400 ac-ft (Figure 26). Since 1994, inflow into Lake McClure has ranged between zero and about 133,000 ac-ft per day (ac-ft/d) and averaged about 2,560 ac-ft/d. Outflow has ranged between zero and about negative 23,400 ac-ft/d and averaged about negative 2,325 ac-ft/d. The maximum instantaneous release recorded was negative 95,000 cubic feet per second (negative 188,340 ac-ft/d) in January 1997 (MID, 2007).

Water is diverted from the Merced River into the MID distribution system through the Northside Canal from the Merced Falls Dam and through the Main Canal from the Crocker-Huffman Diversion Dam. Between 1994 and 2007, MID diversions have ranged between 430,600 and 571,400 ac-ft/y and averaged about 499,400 ac-ft/y (Figure 27).

Other sources of surface water within the MGWB include permanent and ephemeral streams including Bear Creek, Black Rascal Creek, Burns Creek, Canal Creek, Cottonwood Creek, Deadman Creek, Dutchman Creek, Fahrens Creek, Little Dutchman Creek, Mariposa Creek and Owens Creek. Gauging stations located at flood control structures on several of these creeks (Burns, Bear, Mariposa, and Owens) indicate that since 1993, annual outflow from the creeks has ranged between 15,000 and 238,700 ac-ft/y and averaged about 94,000 ac-ft/y (Figure 28). DWR has estimated that approximately half, or about 47,000 ac-ft/y of this water infiltrates and recharges groundwater (DWR, 2003).

4.1.3 Groundwater

The 2003 DWR Bulletin 118 indicates that the MGWB has a surface area of about 491,000 acres or about 767 square miles. The MGWB, as defined in this GWMP (Section 2.1) has a surface area of about 525,000 acres or about 821 square miles. DWR estimated the total storage capacity of the MGWB as of 1995 assuming an average specific yield of 9.0 percent. Based on 1995 water levels, DWR estimated the available groundwater in storage beneath the MGWB to be approximately 15.7 million ac-ft to a depth of 300 feet and 42.2 million ac-ft to the base of fresh water.

The potentiometric surface maps in Appendix D were used to estimate the change in groundwater storage over time. Between 1995 and 2007, the average decline in groundwater levels beneath the MGWB was approximately 3.7 feet (Figure 29). Based on an average specific yield of 9.0 percent, this is equivalent to decrease in storage of approximately 117,200 ac-ft. A plot of the annual change in storage from 1980 to 2007 shows that the MGWB experiences periods of long-term groundwater level decline and subsequent recovery (Figure 30). As of 2007, the MGWB is in a state of mild groundwater level decline with a cumulative decrease in storage of approximately 720,000 ac-ft from 1980 to 2007.

4.1.4 Reclamation

Waste water reclamation plants are operated by the municipalities to treat and discharge effluent back into the MGWB. For example, the City of Merced discharges a total of about 8,700 ac-ft/y of treated effluent (City of Merced, 2008). Approximately 900 ac-ft/y of treated effluent is discharged to about 600 acres of City owned cropland and reused. Another 1,400 ac-ft/y of treated effluent is discharged to about 385 acres of wetlands. The remaining treated wastewater (approximately 6,400 ac-ft/y) is discharged to the Hartley Slough where it is utilized for agricultural and environmental purposes within and downstream of the MGWB.

The Cities of Atwater and Winton treat and discharge approximately 4,500 acft/y of municipal and industrial effluent. This treated water is reclaimed for agricultural purposes. The Cities of Le Grand, Livingston, and Planada treat and discharge approximately 6,000 ac-ft/y of effluent.

4.2 LAND AND WATER USE/DEMAND

Water demand within the MGWB consists primarily of agriculture, municipal, industrial, and environmental uses. These are described in the following Sections.

4.2.1 Agricultural

Most water within the MGWB continues to be utilized for agricultural purposes. Based on cropping patterns (DWR, 1995, 2002) and published crop demands (DWR, 1986), agricultural

demand 1995 was estimated to be 1.45 million ac-ft/y (Figure 31). Agricultural demand decreased in 2002 to an estimated 1.28 million ac-ft/y (Figure 32).

Agricultural demand within the MGWB is typically met with a combination of surface water and groundwater. MID provides surface water to neighboring water districts for agricultural application including average deliveries of about 26,400 ac-ft/y to the Stevinson Water District, 5,300 ac-ft/y to LeGrand Athlone Water District, and about 14,000 ac-ft/y to adjoining lands within the MID sphere of influence. Prior to incorporation into MID in 2004, the El Nido Water District received deliveries of about 15,000 ac-ft/y from MID. The remaining agricultural demand outside of MID (approximately 595,000 ac-ft/y) is met with groundwater solely.

Within the boundaries of MID, between 1994 and 2007, agricultural demand has ranged between 218,000 and 313,000 ac-ft/y and averaged approximately 275,000 ac-ft/y on approximately 110,000 irrigated acres (MID, 2007). To meet this demand, MID provides approximately 500,000 ac-ft/y of surface water from the Merced River and about 13,000 ac-ft/y of groundwater for irrigation in a typical year. Conveyance losses, most of which recharges the aquifer, account for approximately 80,000 to 110,000 ac-ft/y of water.

4.2.2 Municipal and Industrial

All municipal water purveyors within the MGWB rely solely on groundwater for water supply including the Cities of Atwater, Livingston, and Merced, the Black Rascal Mutual Water Company, the Le Grand and Planada Community Service Districts, the Meadowbrook Water Company, and the Winton Water and Sanitary District. Since 1996, total pumping by these municipal purveyors increased from approximately 36,100 ac-ft in 1996 to 46,250 ac-ft in 2007 (Figure 33). An estimated 4,000 ac-ft/y was produced in 2007 by small private residential water systems, commercial businesses, and industrial plants not served by the major municipal purveyors (MID, 2007).

Most of the municipal pumping is concentrated along the State Highway 99 corridor in the cities of Atwater and Merced. These two municipalities account for approximately 82 percent of municipal pumping with the City of Merced accounting for about 60 percent. Municipal water use varies seasonally with most of the municipal water demand occurring in the summer months (Figure 34).

4.2.3 Environmental

Water demand for environmental purposes is growing within the MGWB. Approximately 15,000 ac-ft/y are used at the Merced National Wildlife Refuge. Since 2000, Merced River releases by MID for the Vernalis Adaptive Management Plan to facilitate the migration of juvenile Chinook salmon have been approximately 60,000 ac-ft/y. During 2002 and again in

2007, MID released approximately 25,000 acre-feet of surface water from the Merced River to the Environmental Water Account for protection and restoration of at-risk fish species listed under the Federal and California Endangered Species Acts. MID pumped an equal amount of groundwater to replace the surface water supply to growers within the District.

4.3 GROUNDWATER YIELD AND SUSTAINABILITY

Safe yield or sustainable groundwater yield of an aquifer is defined as the amount of water that can be withdrawn annually without producing a permanent, undesired result, such as long-term groundwater level declines, groundwater quality degradation, and declines in river levels or discharge rates to wetlands resulting from increased pumping of the groundwater basin. An understanding of the sustainable groundwater yield of an aquifer, based on water availability, begins with understanding the hydrologic budget of the MGWB. A hydrologic budget is a mass balance expression that quantifies water inflow to and outflow from the MGWB.

Groundwater cannot be pumped in large quantities from the MGWB without experiencing impacts such as localized long-term groundwater level declines, which can create water quality degradation and increase pumping costs. It is not atypical in the San Joaquin Valley to have varying levels of water supply to different areas within a groundwater basin. This is the condition within the MGWB where the absence of surface supplies on the east side and southwest portions of the MGWB has resulted in concentrated pumping to support irrigated agriculture. Various methods of reducing long-term groundwater level declines to the Basin are discussed in Section 5.0 of this GWMP.

The simplified potentiometric surface maps (Appendix D) were used to estimate the change in MGWB storage on an annual basis, assuming a specific yield of 9.0 percent (Figure 30). As shown on Figure 30, there was a significant decrease in storage during the drought from 1986 through 1992 followed by a partial recovery from 1993 through 1999. As of 2007, the MGWB is in a state of mild long-term groundwater level decline, with a cumulative decrease in storage of approximately 720,000 ac-ft from 1980 to 2007, or about 26,000 ac-ft/y on average.

In response to the declining groundwater levels, MID implemented a series of programs in the 1990s to recharge the Merced subbasin aquifer system through in-lieu and direct recharge. MID has installed low-head booster pumps on several canals to provide surface water to higher lands and reducing annual pumping from about 24,000 ac-ft/yr to about 8,000 ac-ft/yr, resulting in an annual in-lieu recharge of about 16,000 ac-ft/yr. MID also implemented a program to provide more responsive service (delivery with 24 hours of demand) to its customers, which has reduced supplemental private pumping from an annual average of 42,000 ac-ft/yr to about 10,000 ac-ft/yr and resulted in an annual in-lieu recharge of about 32,000 ac-ft/yr. MID implemented a groundwater conservation incentive program, which has

resulted in the shifting of about 3,000 acres of groundwater irrigated land to surface water irrigation and resulted in the annual in-lieu recharge of about 9,000 ac-ft/yr. MID implemented the Highlands Pilot In-Lieu Recharge Project, which provides surface water to 450 acres of lands previously irrigated by groundwater only, thus replacing 12 wells and resulting in the annual in-lieu recharge of about 1,500 ac-ft/yr. MID also implemented a pilot direct recharge project at Cressey Basin, which has the potential to recharge up to 10,000 ac-ft/yr when surface water is available. In total, MID has implemented various recharge and conservation projects which combined provide an annual in-lieu recharge of about 60,000 ac-ft/yr and have resulted in the cumulative in-lieu recharge of about 300,000 ac-ft since 2001. Despite these efforts, the overall MGWB is in a state of mild long-term groundwater level decline (i.e. overdraft).

5.0 BASIN MANAGEMENT GOALS AND OBJECTIVES

MAGPI desires to identify, formulate, and implement sound groundwater management practices in order to maintain the available groundwater resources to meet the beneficial uses and needs of the MGWB. For the purposes of this groundwater management plan, Basin Management Goals (Goals) are statements of broad principles that express the desired state of the MGWB. BMOs are specific actions that are verifiable or quantifiable to achieve the Goals. Four groundwater management Goals have been established (no priority is implied). For each groundwater management goal, specific basin management objectives have been developed.

Goal 1 – Protect and maintain groundwater quality within the MGWB to satisfy current and future beneficial use.

BMOs

- 1.1 Monitor and evaluate groundwater quality within the MGWB.
- 1.2 Develop a high resolution numerical model of the groundwater system in the MGWB.

Goal 2 – Maintain groundwater quantities and eliminate conditions of long-term over draft in the MGWB to ensure water supply reliability to meet current and future beneficial use.

BMOs

- 2.1 Monitor groundwater elevations and evaluate the quantity of the MGWB's existing groundwater supplies.
- 2.2 Determine the MGWB's need for additional or improved water extraction, storage, conveyance, conservation, reuse, and intentional recharge facilities.

- 2.3 Promote in-lieu recharge of groundwater through conjunctive use of surface water.
- 2.4 Avoid subsidence through monitoring and prevention of overdraft.

Goal 3 – Protect and maintain groundwater recharge areas within the MGWB.

BMOs

- 3.1 Identify and evaluate natural recharge areas and potential intentional recharge areas within the MGWB.
- 3.2 Implement projects to intentionally recharge available surface water when surplus to needs.

Goal 4 – Manage the MGWB with local control.

BMOs

- 4.1 Provide information and guidance for the management, preservation, protection, and enhancement of the MGWB.
- 4.2 Assert local control of the region's groundwater resources.
- 4.3 Promote coordinated planning to make the best use of available water resources to meet the needs of all water users reliably and sustainably, and service territories in the mutual best interests of the inhabitants and resources of the MGWB.
- 4.4 Update the groundwater management plan for the MGWB periodically.

6.0 GROUNDWATER MANAGEMENT PLAN ELEMENTS

This section identifies the different groundwater management plan components that are included in this GWMP. The GWMP addresses these items:

- the twelve required components of AB 3030 that describe technical issues that should be addressed in GWMPs to manage the basin optimally and protect against adverse conditions;
- the seven components of SB 1938 that are required for agencies to be eligible for funds administered by DWR for construction groundwater projects;
- the five required components of SB 1672 that promote integrated regional groundwater management; and
- the seven voluntary components of Bulletin 118 that link BMOs to specific actions within the GWMP.

The correlation of the GWMP BMOs with the GWMP elements are presented in Table 2 and discussed in the following sections.

6.1 ELEMENT 1 – CONTROL OF SALINE WATER INTRUSION

Saline water can slowly degrade groundwater quality, limiting its range of potential beneficial use. Six potential sources of saline intrusion in the MGWB include:

- increase in salt content from dissolved materials (not a significant source of salts although some site-specific problems may exist),
- lateral or upward migration of saline water (not a significant source of salts, although there is some potential eastward migration of saline water from the Delta-Mendota Groundwater Basin),
- downward seepage of sewage, agricultural, or industrial waste (potential wide-spread problem associated with municipal waste water treatment plants, application of fertilizers, and dairies),
- downward seepage of mineralized surface water (potentially a wide-spread problem from infiltration of irrigation water containing salts), and
- seawater intrusion (not a potential risk in MGWB).

A program to minimize water quality degradation from saline water intrusion would include the following elements:

- Establish a network of monitoring wells completed to various depths throughout the management area using the existing monitoring well network.
- Monitor water quality periodically for salinity, nitrates, boron or other constituents of concern. Incorporate data from RWQCB, DTSC, DWR, and USGS, as appropriate.
- Identify and monitor areas where the groundwater flow patterns suggest a high probability of water quality degradation.
- Identify zones of marginal water quality that can be used in conjunction with surface water to increase the water supply for agricultural purposes and reduce migration of saline water into zones containing potable groundwater.
- Identify water management strategies that may be employed to minimize degradation.

Saline intrusion is not known to be a significant problem at this time; however, there is a potential for it to develop. For example, there is some evidence of migration of shallow saline water from west to east in the Stevinson area. At this time, the GWMP will emphasize groundwater monitoring. Groundwater monitoring, which is performed through existing activities of the individual parties of the GWMP, will allow the evaluation of saline water intrusion. If water quality changes begin to occur related to saline intrusion, the cause will be investigated and remedial actions will be considered to reverse the trend.

6.2 ELEMENT 2 – IDENTIFICATION AND MANAGEMENT OF WELLHEAD PROTECTION AREAS AND RECHARGE AREAS

The Federal Wellhead Protection Program (WPP) was established in 1986 by the Safe Drinking Water Act Amendments (Section 1428). The purpose of the WPP is to protect groundwater resources of public drinking water supplies from contamination to minimize the need for costly treatment to meet drinking water standards. The WPP is a preventative approach to protecting groundwater quality. Under the Act, the states are required to develop and EPA-approved WPP. To date, California does not have a formal state-mandated WPP program, but instead relies on public agencies to plan and implement programs under AB 3030. Merced County has developed and adopted a comprehensive countywide WPP (Appendix E).

The Merced County WPP for public water supply wells in the MGWB contains the following basic plan elements:

- Identification and description of all public water supply wells in the MGWB.
- Delineation of the wellhead protection area (WPA) for each well based on groundwater quality and flow information developed under Element 1 – Control of Saline Water Intrusion and Element 7 – Monitoring and Controlling Groundwater Levels, Quality, and Storage of this groundwater management plan.
- Identification of potential sources of contaminants within each WPA.
- Establishment of land use ordinances to preclude or control future land uses within each WPA that have the potential for groundwater contamination.
- Development of site specific well construction and abandonment programs to minimize contaminate migration (see Elements 4 and 9).
- Development of a contingency plan to implement if a WPA becomes contaminated.

A formal recharge area protection program for the MGWB does not exist at this time. Protection of recharge areas in the MGWB is realized by controlling or regulating surface contaminants before they migrate into the groundwater. This migration occurs either by percolation or via wells that have not been properly constructed or destroyed. The RWQCB, DTSC, and MCDEH regulate waste disposal.

To protected recharge areas, each MAGPI agency should provide assistance to the RWQCB, DTSC, and MCDEH by identifying areas that are most susceptible to groundwater contamination. Areas with good recharge potential should also be protected from development so that they may continue to be utilized for artificial and/or natural recharge. In addition, MAGPI agencies should closely review the applications for Waste Discharge Permits,

Tentative Waste Discharge Permits, and other environmental documents for facilities within and adjoining their boundaries with waste disposal systems that have the potential to degrade groundwater quality. Such waste disposal systems include disposal of dairy wastes, industrial wastes, sewage treatment plant effluent, and solid waste. Environmental documents and permits should be reviewed such that appropriate monitoring and mitigation measures are developed to preclude the possibility of migration of pollutants from disposal sites. Each participating agency should be observant for existing and proposed land use activities that have the potential to degrade groundwater quality so that appropriate action can be taken.

6.3 ELEMENT 3 – REGULATING CONTAMINANT MIGRATION IN GROUNDWATER

Section 10753.7c of the CWC addresses groundwater contaminants, which may originate from a number of sources such as leaking USTs or from the application, storage, and disposal of petroleum products, solvents, pesticides, fertilizers, sewage effluent, and other chemical used by businesses and in industry. These groundwater contaminants are distinguished from saline intrusion, which is addressed in Element 1 – Control of Saline Water Intrusion.

Agencies involved in mitigating groundwater contamination generally include the RWQCB, DTSC, EPA, and MCDEH. The MAGPI participant's role in protecting groundwater from contamination includes supporting each agency's efforts in monitoring and cleaning up point-source contamination sites. The RWQCB holds the primary responsibility for enforcing water quality regulations. The MCDEH oversees soil and groundwater cleanup activities associated with leaking USTs and sites. In addition, MAGPI participants should assist in understanding the hydrogeology of the MGWB, the vertical and lateral flow directions, and groundwater quality based on the groundwater monitoring activities carried out by each participating agency. Each participating agency should make the appropriate regulating agency aware of changes in groundwater quality, which may indicate that point source contamination is occurring.

6.4 ELEMENT 4 – ADMINISTRATION OF WELL ABANDONMENT AND WELL DESTRUCTION PROGRAMS

State regulations require that all unused or inactive wells be properly maintained (DWR bulletins 74-81 and 74-90) or destroyed (California Health and Safety Code Section 24400). Wells that are not properly maintained or destroyed may contribute to groundwater contamination as pollutants enter the well from the ground surface, as the well establishes vertical communication and allows poor quality water and pollutants to move from one aquifer to another, or if the well is used for illegal waste disposal.

It is the responsibility of the property owner or lessee to properly destroy their wells. Permits are required from the applicable County and/or City for destruction of wells within their

jurisdictions (See Elements 2 and 9). DWR bulletins 74-81 and 74-90 (Water Well Standards) provide the minimum standards for the destruction of wells, and Sections 13700 through 13806 of the CWC require proper destruction of wells. These standards apply to all water wells, cathodic protection wells, and monitoring wells. If a local agency does not have its own well standards, it must enforce the State Water Resources Control Board's Model Well Ordinance (Resolution 89-98). Local agency requirements may exceed California standards. For public supply wells, the DOHS may prescribe additional requirements.

Each participating MAGPI agency will continue to rely on administration of the well abandonment and destruction program by the permitting agencies. Each participating MAGPI agency's role in well abandonment and destruction should be to provide available groundwater data, assist in identifying locations of operating and abandoned wells, and provide support for a public awareness/outreach program to advise well owners why proper wells destruction is important for protection of water quality.

6.5 ELEMENT 5 – MITIGATION OF GROUNDWATER OVERDRAFT

Long-term uncontrolled groundwater level declines (overdraft) occur when the groundwater discharge rate exceeds the long-term recharge rate. Long-term groundwater level declines may result in land subsidence, degradation of groundwater quality, well dewatering, increased pumping costs, and other undesirable conditions.

At various locals within the MGWB, the amount of pumping has exceeded the recharge creating localized conditions of long-term groundwater level decline. As described in Sections 3.3.2 and 3.3.3, in general, groundwater elevations throughout the MGWB have declined approximately 14 feet since 1980 (Figure 13). Potentiometric surface maps of the unconfined aquifer indicate several major cones of depression in the potentiometric surface centered approximately on Chowchilla, El Nido, and Livingston (Figures 15 through 18).

In response to the declining groundwater levels, MID implemented a series of programs in the 1990s to recharge the Merced subbasin aquifer system through in-lieu and direct recharge. These programs are described in Section 4.4. These various recharge and conservation programs provide an annual in-lieu recharge of about 60,000 ac-ft/yr and have resulted in the cumulative in-lieu recharge of about 300,000 ac-ft since 2001. Despite these efforts, the overall MGWB is in a state of mild overdraft.

To avoid the negative impacts of groundwater long-term groundwater level decline, methods to recharge areas of decline need to be identified, evaluated, and implemented if they are economically and environmentally feasible. Restrictions on pumping should not be relied upon to mitigate long-term groundwater level decline until all possible and reasonable means of

recharge have been shown to be not viable. A conjunctive use program is one of the most cost effective ways to achieve aquifer recharge within the basin. Conjunctive use of surface water and groundwater is discussed in more detail in Element 8 – Facilitating Conjunctive Use Operations.

6.6 ELEMENT 6 – REPLENISHMENT OF GROUNDWATER EXTRACTED BY PRODUCERS

Groundwater replenishment may occur as:

- In-lieu recharge where surface water is substituted for groundwater supplies;
- natural percolation of surface water through the soil into the groundwater basin;
- intentional percolation of surface water in recharge basins that are created and maintained to maximize percolation; and
- injection of surface water or groundwater into the groundwater basin through injection wells.

Most groundwater recharge in the MGWB occurs from the application of irrigation water that is diverted from the Merced River. As the water is transported and distributed to the fields, seepage from canals and ditches percolates through the soil and recharges the groundwater basin. Annual seepage to groundwater is estimated by MID to be between 80,000 and 130,000 ac-ft/yr (Section 4.2.1). As irrigation water is applied to crops, a portion percolates past the root zone and continues downward also recharging the groundwater basin. This is most prevalent with the flood irrigation technique. As irrigation efficiency is increased through the adoption of advanced irrigation techniques like drip and micro sprinkler systems, applied water and deep percolation will decrease.

To increase groundwater replenishment, additional surface water must be recharged to the basin either by in-lieu or by direct recharge. During wet years, recharge of available surface water should be maximized. Through implementation of Element 8 – Facilitating Conjunctive Use Operations, MAGPI will be exploring methods of replenishing depleted groundwater supplies and optimizing use of available aquifer storage.

6.7 ELEMENT 7 – MONITORING AND CONTROLLING GROUNDWATER LEVELS, QUALITY, AND STORAGE

The purposes of a groundwater level and groundwater quality monitoring program are to identify areas of long-term groundwater level decline and provide information that will allow evaluation of the changes in groundwater quality and storage. Groundwater level monitoring is essential to understanding the impacts on the aquifer resulting from changes in water supply conditions and groundwater pumping activities. Such monitoring is also necessary for

administering any conjunctive water use program. Groundwater quality monitoring is essential to detect any adverse impacts on groundwater supply and to identify steps to protect groundwater quality in the MGWB.

Several participating local agencies (MID, the City of Merced, MCDEH) within the MGWB have established groundwater monitoring programs. The MID, for example, has recorded water levels in a network of shallow groundwater monitoring wells since 1942 and has recorded beginning and end-of-season water levels in its production wells since 1959. In addition, the cities are required to routinely test the groundwater quality in their supply wells. The MCDEH also maintains a groundwater monitoring program for individual domestic wells. These existing monitoring programs should be coordinated and expanded to develop a comprehensive basin-wide groundwater monitoring program.

Monitoring well networks should be established to monitor water levels both in the unconfined aquifer above and the confined aquifer below the Corcoran Clay where present. Water levels in the confined aquifer should be compared to water levels in the unconfined aquifer to evaluate the hydraulic gradient between the two zones. The hydraulic gradient is an important element in understanding how pumping affects the movement of water between the two aquifers. An adequate monitoring network should include representative wells that tap the two aquifers.

Basic elements should include:

- expanding the current network of monitoring wells to cover the entire basin;
- compiling the necessary data on the monitoring wells (e.g. location, depth, lithologic log, electric log, and casing and ground surface elevation);
- establishing the frequency of water level and quality monitoring;
- preparing an inventory of active wells and determining annual pumping amounts;
- developing a standardized data collection method;
- tabulating data and preparing groundwater maps; and
- interpreting and disseminating results.

Considering the substantial cost of implementing a comprehensive groundwater monitoring program, monitoring will largely continue to be accomplished through the existing, ongoing monitoring activities of the participating agencies. Each year, monitoring data collected by the individual agencies will be pooled and a report of groundwater conditions in the MGWB shall

be prepared. The report will address groundwater production, groundwater levels and storage changes, groundwater inflow and outflow, groundwater quality and other topics that are deemed appropriate.

To supplement the pooled effort, MAGPI participating agencies will implement routine groundwater monitoring in selected wells throughout the MGWB to collect water level data and groundwater quality samples on a consistent basis. This MGWB groundwater monitoring program is described in Section 6.13.

The MAGPI participating agencies have agreed that a numerical model of the MGWB will be useful as a means of consolidating available hydrologic and geologic data and preparing estimates of groundwater flow conditions. To that end, MAGPI has initiated a contract to prepare an integrated surface water/groundwater model (IGSM) of the MGWB. This work is anticipated to be completed within two years.

6.8 ELEMENT 8 – FACILITATING CONJUNCTIVE USE OPERATIONS

DWR Bulletin 118 defines the conjunctive operation of a groundwater basin as the "...operation of a groundwater basin in coordination with a surface water reservoir system. The basin is intentionally recharged in years of above average precipitation so groundwater can be extracted in years of below average precipitation when surface water supplies are below normal." Operation of a conjunctive use program requires the following features, all of which are present in the MGWB:

- a source of surface water during years with above normal precipitation and streamflow;
- conveyance facilities to import water;
- recharge facilities;
- usable storage capacity in the aquifer;
- extraction facilities; and
- distribution facilities for surface water and groundwater.

Conjunctive use of groundwater and surface water in a basin typically occurs when the surface water supply to the basin varies from year to year and basin water demand is relatively constant. In some years, the surface water supply is greater than the basin water demand; in other years, the surface water supply is less than the basin water demand. In the years of plentiful supply, surface water is utilized to recharge the groundwater aquifer. Recharge can occur either directly by surface recharge or injection well or by using surface water in-lieu of

groundwater when it is available. In effect, the groundwater basin is utilized as a storage reservoir and water is placed in the reservoir during wet years and withdrawn from the reservoir in dry years. This description (i.e. in-lieu recharge) generally portrays conditions in the MGWB.

In the MID portion of the MGWB, groundwater and surface water have historically been used conjunctively on an intentional but informal basis. For example, in view of the important part that canal seepage plays in recharging the MGWB aquifers, MID has elected not to line the vast majority of its canal system. Additionally, MID has implemented the in-lieu recharge project described previously. However, there has been no formalized plan for artificial recharge nor have recharge or extracted volumes been systematically inventoried.

During 2006, MID conducted a pilot recharge test of a small recharge basin north of Winton (Section 4.3). The results of this pilot test were promising, and this facility has been identified as a potential recharge project by MAGPI. Another potential recharge area has been identified in the El Nido area (Section 3.3.2). This area has been identified as a potential pilot recharge test project by MAGPI. MAGPI also intends to pursue cooperative arrangements with State and local agencies for the purpose of expanding the MGWB's conjunctive use capabilities.

6.9 ELEMENT 9 – WELL CONSTRUCTION

Improperly constructed wells can result in poor yields and may contribute to groundwater contamination by creating pathways for pollutants to enter the aquifer from surface drainage or by causing mixing of waters between aquifers of differing quality. CWC Sections 13700 through 13806 require proper construction of wells. DWR bulletins 74-81 and 74-90 specify minimum well construction standards that are adopted by local permitting authorities.

The Cities and County within the MGWB are responsible for adopting and enforcing well construction standards. Merced County and the City of Merced have adopted standards that are more strict than the minimum DWR standards. Permits are required from the applicable County and/or City for construction of a new well or to modify an existing well within their jurisdictions (See Elements 2 and 4). Well Driller's Reports must be filed with the DWR and Merced County. MCDEH is responsible for enforcing standards for construction and destruction of wells and for issuing drinking water permits for small public water systems; therefore, they maintains records on wells and groundwater. Since 1988, MCDEH has required at all new domestic wells be tested for bacteria, DBCP, EDB, and general minerals prior to issuing a use permit for the well.

The MAGPI participating agencies can augment efforts by the County and Cities by providing information on water levels and groundwater quality. These data can be used to identify

locations susceptible to intermingling of aquifer zones of varying water quality and to establish specifications for well construction and destruction to optimize well water quality and minimize mixing of water in these zones.

6.10 ELEMENT 10 – CONSTRUCTION AND OPERATION OF RECHARGE, STORAGE, CONSERVATION, WATER RECYCLING, AND EXTRACTION PROJECTS

MAGPI member agencies share the responsibility for development and operation of recharge, storage, conservation, water recycling, and extraction processes. The role of MAGPI is to promote cooperation and sharing of information among the agencies sponsoring water management projects and other member agencies. To the extent feasible, MAGPI will also support measures to coordinate development and optimize operation of facilities to improve basin-wide effectiveness and efficiency of water management. Participating agencies will take the following actions:

- Encourage sharing of information on project planning, design, and operation among member agencies.
- Promote a coordinated approach toward development and operation to lower costs and increase benefits of water management efforts.
- Identify and promote projects and programs that will contribute to water conservation, recycling, storage, and recharge within the MGWB.

In the future, MAGPI intends to form a joint powers authority (JPA) and undertake a significant recharge project as outlined in the 1995 and 2000 Merced Water Supply Plans. Potential projects to contribute to water conservation, recycling, storage, and groundwater recharge could include:

- using use non-potable surface water (secondary water) for in-lieu of potable groundwater to irrigate public lands;
- using reclaimed wastewater for agricultural or landscape irrigation purposes, taking care to not adversely impact recharge areas;
- expanding surface water distribution facilities to increase the use of surface water in areas not currently serviced;
- constructing recharge facilities in areas of long-term groundwater decline (i.e. Cressey Basin and El Nido area);
- adding wetland buffer zones around drainages and recharges areas to promote infiltration rather than run-off; and
- constructing additional surface water storage facilities to increase surface water availability.

6.11 ELEMENT 11 – DEVELOPMENT OF RELATIONSHIPS WITH LOCAL, STATE, AND FEDERAL AGENCIES

Each MAGPI participant recognizes the benefit of close coordination between their efforts and work performed by various local, state, and federal agencies to monitor and protect groundwater in the MGWB. Some of these agencies include the DTSC, DWR, RWQCB, MCDEH, EPA, and USGS. The role that each of these agencies plays in the MGWB is described below.

- DTSC – under California EPA, is responsible for regulating hazardous waste facilities and overseeing cleanup of hazardous waste site in California. This includes oversight of the cleanup of contaminated soils, surface water, and groundwater.
- DWR – is responsible for managing the water resources of California in cooperation with other agencies, to benefit the State's people, and to protect, restore, and enhance the natural and human environments. Also to develop and assess strategies for managing the State's water resources, including supporting local planning and integrated regional water management through technical and financial assistance.
- RWQCB, under the SWRCB, has a responsibility to protect the waters of the state by reviewing projects and issuing waste discharge permits, as necessary, for disposal activities that threaten both surface and groundwater supplies. They are also responsible for oversight of the cleanup of contaminated water.
- MCDEH monitors the installation and destruction of wells to protect the groundwater from degradation caused by improper procedures. They also oversee the cleanup of contamination from leaking underground storage tanks.
- Federal regulations for the protection of groundwater are developed through the EPA, which looks to the states for implementation. The USGS provides technical studies and reports and maintains a database of surface and groundwater quality.

It is important for MAGPI agencies to establish and maintain an effective working relationship with local, state, and federal agencies. The CWC requires local agencies implementing an AB 3030 GWMP within the same groundwater basin to meet annually to coordinate groundwater management activities. MAGPI meets on a semi-annual basis to discuss the status of the MGWB and review implementation of the groundwater management plan.

6.12 ELEMENT 12 – REVIEW OF LAND USE PLANS AND COORDINATION WITH LAND USE PLANNING AGENCIES

In California, land use planning decisions are generally made by City or County government agencies, special districts (i.e. school districts, UC Merced, MID, etc.). Each MAGPI participating agency should review proposed development plans and associated environmental documentation to assess the potential groundwater impacts of land use

changes. Planning departments should refer development proposals to MCDEH for direction on potential impacts, studies, and mitigation. Each MAGPI participating agency should review initial studies, proposed negative declarations, draft environmental impact reports, and provide comments as appropriate to ensure that potential threats to groundwater can be addressed and avoided. In cases where the proposed land use involves disposal of wastes, storage of hazardous materials, or handling of petroleum products, solvents, or chemicals such as pesticides and fertilizers, each participating agency should coordinate with the appropriate state regulatory agencies to ensure that compliance with regulations for containment and disposal of wastes is obtained. During periodic land use plan preparation and updates, the county and cities in the MGWB should consult with the appropriate participating agency to avail themselves of the latest information on groundwater conditions that may be affected by the proposed activities, so that necessary mitigation measures can be included in the plans.

6.13 ELEMENT 13 – MERCED GROUNDWATER BASIN GROUNDWATER MONITORING PROGRAM

A GWMP should be capable of assessing the status of the basin and responses in the basin to future management activities. The groundwater monitoring program for the MGWB will consist of measuring groundwater levels and collecting groundwater quality data from selected wells within the MGWB on a consistent basis using the same protocols.

As previously mentioned, the groundwater levels in water supply and monitoring wells have been measured by DWR, MID, and other entities since the 1950s. To simplify evaluation of the groundwater level within the MGWB, MAGPI proposes to monitor groundwater levels in a select group of wells that are located relatively uniformly throughout the MGWB. Groundwater levels in each well will be monitored at minimum each spring and each fall during a short time period using a standard protocol. It is MAGPI's intent that these wells will be maintained as a consistent long-term network that represents overall groundwater elevation conditions in the MGWB. The approximate well locations for the proposed network are shown on Figure 35.

MAGPI has applied for grants to install pressure transducers and automated data logging equipment in approximately 40 monitoring wells (i.e. the proposed monitoring well network). The purpose of these data loggers is to allow for the continuous monitoring of water levels in the selected wells on an hourly basis so that the dynamic hydraulics of the basin can be evaluated and to provide a contemporaneous record of water levels for mapping purposes. The monitoring data may also be used to help calibrate a proposed IGSM model of the MGWB.

MID, the City of Merced, MCDEH, small water distribution systems, and mutual water companies public supply wells are monitored as required by the California Department of Public Health (DPH) under California Code of Regulations Title 22 (which includes organic

compounds, inorganic compounds, metals, microbial, and radiological analytes). The MCDEH has also monitored 18 domestic wells within Merced County (9 well within the MGWB) for general minerals, inorganics, DBCP, and EDB since 1988. These comprehensive programs will be supplemented with groundwater quality data collected from up to 20 selected water supply (i.e. agricultural) wells that are not already part of these programs. Groundwater samples will be collected on a 5-year frequency and analyzed for agricultural suitability including general minerals, nitrate, and arsenic. These data will be used to evaluate the groundwater geochemistry and monitor long-term changes in groundwater quality.

Water level and quality data collected by the various member agencies as part of the groundwater monitoring program will be uploaded into a centralized repository for storage and analysis. Data will also be uploaded in to the DWR integrated water resources information system (IWRIS). Data will be made available to member agencies and the public using an internet website including the links to the DWR IWRIS.

Subsidence is not known to be occurring in the MGWB at this time. MAGPI will seek funding to evaluate subsidence in the MGWB in the future.

6.14 ELEMENT 14 – ADOPTION OF MONITORING PROTOCOLS

To improve the comparability, reliability, and accuracy of groundwater elevation data collected by MAGPI member agencies, the member agencies will adopt a standard protocol for collection of water level data. The protocol is presented in Appendix F. To collect comparable, reliable, and accurate groundwater quality data from agricultural wells to be sampled for general minerals and nitrate, a standard protocol will be used for collecting groundwater samples. The protocol is presented in Appendix F. The MGWB groundwater monitoring program described in Section 6.13 will be performed in accordance with these same protocols.

7.0 GROUNDWATER MANAGEMENT PLAN IMPLEMENTATION

The following sections discuss the implementation of the groundwater management plan and metrics to evaluate the effectiveness of the implementation. References are provided where appropriate.

7.1 INTEGRATION OF WATER RESOURCES MANAGEMENT ACTIVITIES

Integration of groundwater resources management activities was accomplished through the creation of MAGPI (see Section 2.2; Section 7.3).

7.2 REGIONAL PLANNING AND MANAGEMENT

Regional planning and management was accomplished through the preparation of the GWMP. Implementation of regional groundwater management planning within the MGWB began with the 1997 GWMP, which served as the initial framework for management of groundwater resources within the MGWB, and will continue with this update to the GWMP. Other regional planning and management activities completed include the:

- 2003 Water Management Plan,
- 2005 Merced Water Supply Plan Update, and
- 2005 City of Merced Urban Water Management Plan

7.3 FORMATION OF A REGIONAL MANAGEMENT GROUP

MAGPI acts as the regional management planning group and its responsibilities are to:

- coordinate public awareness and participation in groundwater management planning,
- provide interagency coordination,
- develop regional priorities,
- assure that the BMOs are pursued in a reasonable and timely manner,
- prepare and assure the accuracy of an annual report associated with GWMP implementation,
- evaluate and modify the GWMP as needed to address issues within the MGWB,
- update the GWMP as necessary based on the state of the basin or to reflect changes in State law or in local conditions/programs, and
- coordinate with the storm water monitoring group.

MAGPI will meet at least semi-annually, at which time it will review the report on the status of the basin, review progress made to meet the basin management goals and objectives, discuss any work planned for the upcoming year, and consider any proposed amendments to the GWMP. It will be the responsibility of individual MAGPI members to complete activities or projects within their jurisdictions. Implementation of the GWMP does not preclude any agency from pursuing programs or projects related to groundwater management either independently or in cooperation with other agencies. In the future, MAGPI should form a JPA to facilitate regional planning and management of water resources within the MGWB.

7.4 PUBLIC INVOLVEMENT

MAGPI has developed a website (<http://magpi-gw.org>) to disseminate information about MAGPI and MAGPI activities. The website provides the public with access to MAGPI governing board meeting agendas and minutes, and electronic copies of various public documents concerning water resources in the MGWB. MAGPI will hold public meetings to inform the public on the progress of the groundwater management plan. MAGPI will also form, as necessary, ad hoc committees of technical and interested public (like the GWMP TWG) to assist MAGPI in review and/or implementation of elements of the GWMP.

7.5 DEVELOPMENT OF LOCAL, REGIONAL, AND STATEWIDE PRIORITIES

Local Priorities

Development of local priorities is the responsibility of each agency participating in the GWMP; however, the overriding local priority for implementation of the GWMP is satisfying regional and local water management objectives as identified in the BMOs. Through their involvement in MAGPI and the adoption of the BMP, participating agencies have demonstrated their conviction that the most effective approach to local water management is through regional actions.

Regional Priorities

The GWMP is an effort that recognizes that the most effective approach to managing the resources of the MGWB is an integrated plan that enlists the cooperation of the agencies whose political boundaries match the physical boundaries of the basin. The GWMP includes a number of BMOs (Section 5.0) that have been agreed upon by the MAGPI member agencies to promote wise management of regional groundwater resources.

Statewide Priorities

Implementation of the GWMP will enable MAGPI member agencies to respond to a range of statewide water management initiatives. Completion and adoption of the GWMP will allow participating agencies to satisfy one of the key prerequisites for grant funding through Chapter 8 of Proposition 50, the Integrated Regional Water Management Grant Program. The GWMP also places specific groundwater and surface water management projects in the context of an integrated regional water management strategy, which leads to a more comprehensive management of water supplies in a framework for compliance with state and federal water quality standards. By promoting effective water use within the MGWB, implementation of the GWMP will:

- increase California's water supply reliability;
- reduce conflict among water users;

- contribute to meeting water quality objectives; and
- assist in the implementation of the RWQCB's Watershed Management Initiative.

7.6 GROUNDWATER MANAGEMENT PLAN IMPLEMENTATION REPORT

Periodically, MAGPI will prepare a GWMP implementation report which will summarize groundwater conditions within the MGWB, groundwater management activities; success in meeting the BMOs, and any proposed changes to plan components. This report will document conditions in the MGWB and GWMP activities completed since the previous update including a summary of:

- monitoring results, including historical trends;
- actual management actions;
- whether management actions are achieving progress in meeting management objectives, as supported by monitoring results;
- proposed management actions; and
- plan component changes, including addition or modification of management objectives.

7.7 PERIODIC EVALUATION OF GROUNDWATER MANAGEMENT PLAN

MAGPI will meet at least semi-annually, at which time it will review the status of the basin, review progress made to meet the basin management goals and objectives, discuss any work planned for the upcoming year, and consider any proposed amendments to the GWMP. The periodic evaluation of the GWMP will serve as a tool for MAGPI to organize its many activities to implement the plan, act as a driving force for plan implementation, and help interested parties understand the progress made by MAGPI in managing the groundwater resources of the MGWB.

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