Groundwater Management Plan for the Southern Agencies in the Delta-Mendota Canal Service Area

San Luis & Delta-Mendota Water Authority

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Introduction

The growing demand for cost-effective water resources in an ever-changing environment compels the responsible agencies to enhance resource management and to promote long-term sustainability of water resources to meet the needs of their users. The proper management of water resources requires knowledge of the storage, distribution, depletion, and replenishment of the resource as well as the various local and regional geologic and hydrologic factors. Without such knowledge, the effect of current and future activities on the water resources cannot be adequately predicted.

To aid in managing the groundwater component of these water resources, a Groundwater Management Plan (GMP) for the Southern Agencies (SA) of the Delta Mendota Canal (DMC) service area was developed on behalf of San Luis & Delta Mendota Water Authority (SLDMWA). The GMP-SA characterizes the groundwater basin, summarizes the existing groundwater management activities in the Groundwater Management Area (GMA), develops the relative elements of the GMP, identifies management objectives, and provides project recommendations for implementation. It is intended to establish the framework for collecting the necessary groundwater monitoring data needed to assess the impacts of the various activities that affect the groundwater basin and manage the resource such that sustained use of groundwater can be optimized without adverse impacts to the water quality and yield.

This GMP-SA has been updated to reflect the understanding of current conditions within the GMA, and incorporate the appropriate management goals and components necessary to address recent changes that have occurred in regulations, Participating Agencies' (PAs) policies, and groundwater conditions since the last update. Under this plan the PAs, including SLDMWA, will assume a more active role managing regional groundwater resources within the basin. This GMP-SA is intended to set the framework for managing and monitoring groundwater resources in the GMA-SA. As part of this update to the GMP-SA, SLDMWA will be assuming the role as the entity responsible for the groundwater monitoring function within the GMA-SA on behalf of the PAs, in conformance with Senate Bill SBx7-6. The groundwater monitoring function will be a cooperative effort of the PAs and SLDMWA under SLDMWA's administration.

1.1 Water Resources within the GMA-SA

To supply water to meet the various users' demands within the GMA-SA, several water sources are utilized. Water supplies within the SA service area are primarily obtained from two sources:

1. Groundwater, which supports municipal, industrial, rural domestic, and agricultural production needs.

2. Imported surface water diverted from the Sacramento River-San Joaquin River Delta (Delta) and conveyed through the DMC and the San Luis Canal (SLC) under the Central

Valley Project (CVP). The DMC and SLC provide water for urban use in the community of Santa Nella located within the San Luis Water District and for agricultural production.

Other sources of water supplies occur within the GMA-SA, such as direct precipitation and local stream flows, but these meet a relatively small portion of agricultural water demand and a minor recharge source for groundwater.

As political and environmental conditions change, so does the availability of supplies from these various sources. During drought, the water supply available from the CVP can be limited. In addition, CVP water supplies delivered south of the Delta can be limited in an effort to protect endangered species that depend on favorable water conditions within the Delta. During periods when CVP surface water supplies are limited, many water users who would normally depend on the CVP supplies increase groundwater pumping to augment supplies to meet their water demands.

In some locations, water users, in particular domestic water users that rely on groundwater, have experienced water quality deterioration over time, while regulations governing water quality have become stricter. This combination has made it increasingly difficult for these water users to find groundwater supplies meeting the domestic water quality standards (CCR Title 22, Div. 4, Ch. 15) and has raised serious concerns about the sustainability of groundwater resources to meet domestic demands without treatment.

1.2 Regulatory Basis

The regulatory basis for the establishment of GMPs began with the passage of the Groundwater Management Act. In 1992, Assembly Bill 3030 (AB 3030), the Groundwater Management Act, was enacted to amend the California (State) Water Code, Sections 10750 through 10756. It established provisions to allow local water agencies to develop and implement a groundwater management plan (AB3030 GMP) in groundwater basins defined in the California Department of Water Resources (DWR) Bulletin 118. Twelve technical components are identified in the Water Code that may be included in an AB3030 GMP. The twelve components consist of the following:

a. The control of saline water intrusion;

b. Identification and management of wellhead protection areas and recharge areas;

c. Regulation of the migration of contaminated groundwater;

d. The administration of a well abandonment and well destruction program;

e. Mitigation of conditions of overdraft;

f. Replenishment of groundwater extracted by water producers;

g. Monitoring of groundwater levels and storage;

h. Facilitating conjunctive use operations;

i. Identification of well construction policies;

j. The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling and extraction projects;

k. The development of relationships with state and federal regulatory agencies; and

l. The review of land use plans and coordination with land use planning agencies to assess activities which create a reasonable risk of groundwater contamination.

An AB3030 GMP can be developed only after a public hearing and adoption of a resolution of intention to adopt a groundwater management plan. The procedures for adopting an AB3030 GMP are clearly defined in the Water Code. Once adopted, rules and regulations must be enacted to implement the AB3030 GMP programs.

Based on the provisions of AB3030, the PAs entered into an agreement with the SLDMWA to jointly fund the preparation of a coordinated regional AB3030 GMP for the SA as part of their ongoing efforts to manage their limited water resources in the region. Since then, the GMP-SA has continued to be updated routinely to reflect changing conditions within the SA service area and the law. Since its establishment, the GMP-SA has provided a mechanism to bridge gaps and interface between local PAs' programs to support comprehensive regional water resources management in the GMA-SA.

Since 1992 a number of other changes to the Water Code have occurred that have triggered the need for an update of the GMA-SA. In 2002, Senate Bill SB 1938 was enacted to amend the Water Code Section 10750 *et. seq.* to require that AB3030 GMPs contain specific elements and documented public review, if local agencies desire to remain eligible for water grants and/or loans administered by the State (Water Funds). (DWR, 2010a). It also allows for additional elements to be considered in an AB3030 GMP that were not previously allowed under the provisions of AB3030. In order to remain eligible for Water Funds, an agency preparing the AB3030 GMP must include the following:

a. Documentation that a written statement was provided to the public: “describing the manner in which interested parties may participate in developing the groundwater management plan”, Section 10753.4;

b. A plan to: “involve other agencies that enables the local agency to work cooperatively with other public entities whose service areas or boundaries overlie the groundwater basin”;

c. A map showing the area of the groundwater basin, as defined by Bulletin 118, with the area of the local agency subject to the plan as well as the boundaries of the other local entities that overlie the basin in which the agency is developing the AB3030 GMP;

d. Management objectives for the groundwater basin subject to the AB3030 GMP;

e. Components relating to the monitoring and management of the groundwater levels, groundwater quality, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping; and

f. Monitoring protocols for the components described above (Water Code 10753.7 (a)(4)).

The GMP-SA is a living document that evolves to address changes that impact groundwater management in the GMA. In 2008, the GMP-SA was updated as part of the ongoing efforts by the SLDMWA and the PAs to assist in managing the limited water resources in conformance with SB1938 and AB3030.

Recent amendments to the Water Code Section 10920 et seq., enacted through the passage of Senate Bill SBx7-6 in 2009, have established further requirements related to groundwater management that have led to this current update to the GMP-SA. SBx7-6 mandates that prescribed entities with authority to assume groundwater monitoring functions (entities) do so, coordinate monitoring efforts with DWR, and convey the information regularly to DWR if they seek to remain eligible for Water Funds (California, 2009). SBX7-6 mandates that (DWR, 2010b):

- Local entities may assume responsibility for monitoring and reporting groundwater elevations;
- DWR work cooperatively with local monitoring entities to achieve monitoring programs that demonstrate seasonal and long-term trends in groundwater elevations;
- DWR accept and review prospective monitoring entity submittals, then determine the designated monitoring entity, notify the monitoring entity and make that information available to the public;
- DWR perform groundwater elevation monitoring in basins where no local party has agreed to perform the monitoring functions; and
- If local entities do not volunteer to perform the groundwater monitoring functions, and DWR assumes those functions, then those entities become ineligible for water grants or loans from the state.

This current update of the GMP-SA addresses these new regulatory requirements set forth in SBx7-6. The GMP-SA designates the local entity that assumes responsibility for groundwater monitoring, and sets forth the framework that will form the basis for a groundwater monitoring program.

This GMP-SA is compliant with AB 359.

1.3 Setting

In general, this GMP-SA is meant to promote the sustainability of groundwater resources within the GMA-SA. However, as the individual PAs may have different ambitions they may seek to attain through groundwater management, it would be very difficult to develop or implement highly-specific or locally-specialized groundwater management programs that suit all of the needs of the individual PAs. Rather, at this regional scale, it is more efficient and specific programs would be better focused if they were undertaken by each individual PA or group of PAs depending on their specific local needs. The GMP-SA has been prepared to facilitate coordinated regional management of groundwater resources within the GMA-SA and may not address all of the more specialized or localized groundwater resource management needs that could occur. It is intended that the GMP-SA afford the PAs the operational flexibility to address their own individual or local group needs without being bound by specific programs that are irrelevant to their operations, counterproductive to the cost-effective implementation of local groundwater best management practices, or not mandatory for the regional program. Thus, it is anticipated that in some cases the individual PAs may also seek to prepare their own local GMP to augment this regional plan and address specific local needs beyond the more general scope of the GMP-SA. The GMP-SA provides the regional framework for:

- Gathering the groundwater data needed to assess the regional impacts of activities that affect the groundwater resources within the GMA-SA;
- Establishing standards amongst the PAs that promote consistency in management and monitoring practices that provide regional benefits throughout the GMA-SA;
- Interaction of the PAs for regular early collaborations to discuss and resolve concerns that may arise from groundwater monitoring assessments and projections; and
- Providing general guidance for programs to promote focused groundwater management practices and resource sustainability throughout the GMA-SA for the benefit of the PAs.

Since this is a regional plan, each PA would need to independently adopt the whole plan or portions thereof. Through the appropriate execution of this GMP-SA and sincere efforts of the PAs, it is anticipated that the sustained use of groundwater within the GMA-SA will be better optimized without adverse impacts to the water quality and yield. Regional sustainability of the groundwater resources throughout the GMA-SA is the basic goal of this program.

In the past, the PAs within the GMA-SA have engaged in transfers of water supplies to qualified recipients. Under this plan, the PAs will continue to reserve their operational flexibility to engage in such water transfers. However, prior to undertaking any water transfer program, the PAs will evaluate any adverse economic or environmental impacts of the program. The evaluation may include, but is not limited to, an assessment of management practices, groundwater storage capacity, and conjunctive use with surface water supplies. These programs may be undertaken to assist other areas in need of water, and to provide benefit to the PAs and their consumers, as long as such programs do not:

- Exceed the safe annual yield of the aquifer;
- Result in conditions of overdraft or otherwise fail to comply with provisions of California Water Code Section 1745.10;
- Result in uncompensated adverse impacts upon landowners affected by the program.

Section 2
The Groundwater Management Area

The GMA-SA lies within Merced and Fresno Counties in the San Joaquin Valley of California. The DWR divides California into 10 hydrologic regions (HRs), which generally correspond to the State's major drainage areas, and subbasins within each HR that are defined based on both political and hydrologic considerations for groundwater management (DWR, 2003). The GMA-SA lies mostly within the Delta-Mendota (5.22-07) Basin of the San Joaquin River HR, with some southwestern portions of the GMA-SA extending into the Westside Subbasin (5.22-09) of the Tulare Lake HR. The boundaries of the HRs and the GMA-SA are shown in Figure 1. The groundwater subbasins as described in the DWR Bulletin 118 Update 2003; the relative location of the GMA-SA boundaries within the subbasins are depicted in Figure 2. The GMA-SA is generally bounded:

- On the north by Del Puerto Water District (DPWD), and Central California Water District (CCID) extending as far north as Fahey Road near SR-33 in Merced County.
- On the south it is bounded by Westlands Water District (Westlands WD) extending as far south as the alignment for West Jensen Avenue near Interstate 5 in Fresno County.
- On the west it extends beyond Interstate 5 to near the base of the Coast Ranges.
- On the east it is bounded by the CCID extending generally towards the Outside Canal and the former Broadview Water District (BWD) which is now part of Westlands WD.

The GMA-SA encompasses approximately 125,000 acres. Figure 3 shows the boundaries of the GMA-SA.

The GMA-SA encompasses the following agricultural water supply districts: Pacheco Water District (PWD), Panoche Water District (PNWD), Eagle Field Water District (EFWD), Oro Loma Water District (OLWD), Widren Water District (WWD), Mercy Springs Water District (MSWD), and San Luis Water District (SLWD). The community of Santa Nella as well as several unincorporated communities exist within the GMP-SA. The Santa Nella County Water District (SNCWD) is not participating in this GMP-SA at this time. Most of the area contained in the SNCWD is also within the SLWD. A list of the current PAs involved in the GMP-SA is shown in Table 1 below.

Table 1
List of Agencies Participating in the Groundwater Management Plan

- San Luis & Delta-Mendota Water Authority (SLDMWA)

Water or Irrigation Districts:

- Pacheco Water District (PWD)
- Panoche Water District (PNWD)
- Eagle Field Water District(EFWD)
- Oro Loma Water District (OLWD)
- Widren Water District (WWD)
- Mercy Springs Water District (MSWD)
- San Luis Water District (SLWD)

Section 3
Characteristics of the GMA

3.1 Land Use and Groundwater Beneficial Use

Most of the land in the San Joaquin Valley is utilized for agricultural crop production. Major agricultural activities include the operation of dairies, and the production of cotton, tomatoes, beans, alfalfa, corn, wheat, grapes, walnuts, almonds and citrus. A number of small rural communities, as well as some large municipalities exist within the San Joaquin Valley. The largest of these communities, Fresno, has a population of nearly a half of a million people. The majority of communities have populations of less than 100,000 people, and many have less than 10,000. Other notable large municipalities in the San Joaquin Valley include Stockton, Modesto, and Bakersfield. The southern end of the San Joaquin Valley also has a large oil production industry, and numerous oil/gas fields are located throughout the San Joaquin Valley.

Within the GMA-SA, the majority of the current land use is agricultural, with irrigated crops, dairies and rangeland. No municipalities lie within the GMA-SA. However, the municipalities of Los Banos, Dos Palos, Firebaugh, and Mendota lie within a few miles of the GMA-SA, as well as a number of unincorporated communities. Major Federal and State water conveyance systems, the SLC and the DMC lie within portions of the GMA-SA.

The beneficial uses of groundwater in the GMA-SA are predominantly for agriculture and related industry, domestic potable water and other small community municipal uses. For agricultural applications within much of the GMA-SA, groundwater is used conjunctively to supplement surface water supplies that support the water needs in the GMA-SA. However, groundwater is the primary source for domestic use, as well as large areas of agriculture, within the GMA-SA. The SNCWD relies primarily on imported CVP water which is supplemented with groundwater use.

3.2 Topography and Structure

The San Joaquin Valley is the southern portion of the Great Valley Geomorphic Province in central California. The San Joaquin Valley is a structural trough up to 200 miles long and 45 to 70 miles wide. It conjoins the northern portion of the Great Valley Geomorphic Province, the Sacramento Valley, at the Delta, the confluence of the Sacramento and San Joaquin Rivers. The Great Valley opens to the San Francisco Bay west of the Delta.

The San Joaquin Valley is bounded by the Sierra Nevada Mountains to the east, the Coast Range Mountains to the west, and the Tehachapi Mountains to the south. It is a broad, fault bounded, northwest trending, asymmetric topographic and structural trough, with axis of the valley offset nearer the western margin. The topographic slope along the axis declines gently, generally towards the north-northwest.

Within the GMA-SA, the land surface generally slopes easterly to northeasterly from the base of the Coast Range Mountains, near the western boundary, towards the trough of the valley and the San Joaquin River, along the eastern boundary. Small ephemeral streams drain from the Coast Range Mountains typically trending northeasterly toward the trough of the valley. The natural land surface is relatively flat to slightly undulating. However, agricultural practices have modified many topographic features to provide suitable conditions for crop production. The land surface elevation in the GMA-SA ranges from about 600-feet above mean sea level in the southwest to about 150-feet above mean sea level in the north. Major man-made features include Interstate Highway 5, the SLC, the DMC, and a number of smaller canals and channels used for water supply distribution and drainage.

3.3 Climate

The San Joaquin Valley has a more continental climate than much of the more populous coastal areas, with relatively warm summers and cooler winters. The mean annual high temperatures in the valley range from about 73^{o} Fahrenheit (°F) to 79^{o}F, and the mean annual lows range from about 48^{o}F to 50^{o}F.

Due to some rain shadow effects from the Coast Range Mountains and the lower elevations of the valley floor, the valley experiences relatively little rainfall, typically less than 12 inches. Some areas of the southern San Joaquin Valley experience desert conditions due to the very low seasonal precipitation. Rainfall occurs typically between late fall and early spring, with dry summers. Mean annual rainfall amounts range from 5 to 13 inches per year on the valley floor.

The range of typical climatic conditions experienced within the GMA-SA can vary. Three weather stations, with long documented histories, have been chosen as representative to demonstrate the range of climatic conditions across the GMA-SA.

The City of Los Banos (Los Banos) lies within 10 miles of much of the northern portions of the GMA-SA, east of the furthest northern boundary of the GMA-SA, and northwest of the furthest eastern boundary. The Little Panoche Detention Dam is located within 10 miles west of the furthest southwestern corner of the GMA-SA. The City of Mendota lies less than 10 miles southeast of the furthest eastern boundary of the GMA-SA. The recent climatic history recorded for each location is presented below:

- Los Banos:

  During the period of record, 1906 to 2010, the average annual temperature was 62.2^{o}F, the average monthly high temperature of 96.5^{o}F was in July, and the average monthly low temperature of 36.3^{o}F was in December (WRCC, 2011a). Los Banos averages about 97 days per year above 90^{o}F, and 29 days below 32^{o}F. The hottest day on record was 116^{o}F on July 30, 1931, and the coldest was 14^{o}F occurring twice on January 11, 1949 and December 22, 1990.

  Between 1906 and 2010, the average annual rainfall was 9.21 inches. The highest annual rainfall recorded was 21.08 inches in 1998, and the lowest annual rainfall was 4.61 inches in 1947. The maximum rainfall recorded over a 24-hour period was 2.25 inches on

September 30, 1983. Annually, Los Banos experiences, on average, about 46 days with precipitation greater than 0.01 inches, 25 days with precipitation greater than 0.10 inches, 5 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

- Little Panoche Detention Dam:

  During the period of record, 1968 to 1975, the average monthly high temperature of 95.1^{o}F was in July, and the average monthly low temperature of 36.1^{o}F was in December (WRCC, 2011b) Little Panoche Detention Dam averages about 85 days per year with high temperatures above 90^{o}F, and 24 days per year with low temperatures below 32^{o}F. The hottest day on record was 111^{o}F on July 16, 1972, and the coldest was 21^{o}F on December 21, 1968.

  The average annual rainfall during the period of record was 7.37 inches. The highest annual rainfall recorded was 10.01 inches in 1969, and the lowest annual rainfall was 5.15 inches in 1971. The maximum rainfall recorded over a 24-hour period was 1.71 inches on February 2, 1971. On average, annually, Little Panoche Detention Dam experienced about 50 days with precipitation greater than 0.01 inches, 21 days with precipitation greater than 0.10 inches, 3 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

- Mendota Dam:

  No temperature measurements were collected during the period of record, 1948 to 1984, (WRCC, 2011c).

  The average annual rainfall during the period of record was 7.98 inches. The highest annual rainfall recorded was 12.49 inches in 1958, and the lowest annual rainfall was 3.80 inches in 1953. The maximum rainfall recorded over a 24-hour period was 1.66 inches on December 16, 1962. On average, annually, Mendota experiences about 41 days with precipitation greater than 0.01 inches, 23 days with precipitation greater than 0.10 inches, 4 days with precipitation greater than 0.50 inches, and less than 1 day with precipitation greater than 1.0 inch.

Table 2
Summary of Climatic Data for Los Banos, Little Panoche Detention Dam, and Mendota Dam

		Los Banos	Little Panoche	Mendota
Peak Month Average High-Temperature	^{o}F	96.5	95.1	--
Peak Month Average Low Temperature	^{o}F	36.3	36.1	--
Hottest Recorded High Temperature	^{o}F	116	111	--
Coldest Recorded Low Temperature	^{o}F	14	21	--
Average Number of Days Above $90^{o}F$		97	84.5	--
Average number of Days Below $32^{o}F$		29	0.1	--
Average Annual Rainfall	Inch	9.2	7.4	8.0
Highest Annual Rainfall	Inch	21.1	10.0	12.5
Lowest Annual Rainfall	Inch	4.6	5.2	3.8
Maximum 24-hour Rainfall	Inch	2.3	1.7	1.6

Based on the climatic data, the GMA-SA lies within a semi-arid hot climate regime. The northern end of the GMA-SA receives on average about 15 percent to 25 percent more rainfall annually than the southern end, with the eastern side receiving nearly 10 percent more rainfall than the western. The relatively low annual rainfall and difference in rainfall between the east and west of the GMA-SA are in large part due to the rain shadow effect of the Coast Range Mountains west of the GMA-SA. The amount of rainfall received is insufficient for production of most crops in the GMA-SA requiring the importation of CVP water to sustain the irrigated agriculture.

3.4 Geology

The geologic materials that fill the San Joaquin Valley are comprised of mostly unconsolidated alluvial and lacustrine sediments, Holocene to Jurassic in age, derived from parent materials of the Coast Ranges and the Sierra Nevada Mountains. These sediments overlie older marine sediments. The valley fill reaches a thickness of about 15,000 feet in the south part with the base of fresh water at a maximum depth of about 4,700 feet (Page, 1986). 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 to slightly west of the series of rivers, lakes, sloughs, and marshes, which mark the current and historic axis of surface drainage in the San Joaquin Valley (DWR, 2003). Major faults run parallel to the western boundary of the GMA, along the east side of the Coast Range Mountains. In particular, the

Ortigalita fault lies about 5 to 10 miles west of the western boundary of the GMA-SA. The Calaveras/San Andreas Fault system lies about 25 miles west of the GMA-SA.

The water bearing geologic formations within the GMA-SA typically are comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include the Tulare Formation, older alluvium, flood basin deposits, terrace deposits, and younger alluvium. The cumulative thickness of these deposits ranges from a few hundred feet near the Coast Range foothills west of the GMA-SA to about 3,000 feet along the trough of the valley east of the GMA-SA (DWR, 2003).

The Tulare Formation is composed of beds, lenses, and tongues of clay, sand, and gravel that have been alternately deposited in oxidizing and reducing environments (Hotchkiss, 1972). The Tulare Formation dips eastward from the Coast Ranges in the west towards the trough of the valley. The total thickness of the Tulare Formation can range up to greater than 1,400 feet (DWR, 2006). The E-Clay or Corcoran Clay occurs near the top of the Tulare Formation and is a regionally contiguous low permeability layer comprised of lacustrine deposits of fine grained material. The E-Clay layer functions as an aquitard separating the unconfined fresh water aquifer from the confined freshwater aquifer of the lower Tulare formation. Other contiguous, though less extensive, low permeability lacustrine layers also occur above the E-Clay layer in some areas. These layers are designated the A-Clay and the C-Clay, and occur nearer the trough of the valley.

3.4.1 Confined Aquifer

The confined aquifer zone underlying the Corcoran Clay stratum extends downward from the base of the clay to the base of fresh water (Page, 1971). Sierran Sand and Coast Ranges alluvium interfinger in a similar fashion as those of the semi-confined zone above, except that Sierran sediments extend further to the west in the confined zone (Dubrovsky et al., 1991).

3.4.2 Corcoran Clay Layer

The Pleistocene layer within the Tulare formation known as the Corcoran Clay layer, or E-Clay, is continuous across much of the San Joaquin Valley, near the trough of the valley. This layer is comprised of fine-grained lacustrine and marsh deposits that divide the aquifer system vertically into an upper zone and a lower zone (Davis and DeWiest, 1966). Because of this, the underlying aquifer is typically designated the confined aquifer or zone in the regions where the Corcoran Clay occurs, and the overlying aquifer is designated as the semiconfined or unconfined aquifer or zone. The Corcoran Clay underlies the basin at depths ranging from about 100 to 500 feet and acts as a confining bed (DWR, 2003). In some locations near the western edge of the GMA-SA the Corcoran-Clay is at the surface and exposed.

The unconsolidated sediments of the valley floor taper toward the Coast Ranges, and the Corcoran Clay becomes discontinuous along the west margin of the San Joaquin Valley, near the western limits of the GMA-SA. Other, less-extensive, younger, continuous fine-grained lacustrine layers also exist at depths shallower than the Corcoran Clay. However, these other lacustrine layers near the trough of the valley do not appear to extend into the GMA-SA.

Terrace deposits of Pleistocene age lie along the western edge of the GMA-SA near the margins of the San Joaquin Valley up to several feet higher than present streambeds. They are composed of yellow, tan, and light-to-dark brown silt, sand, and gravel with a matrix that varies from sand to clay (Hotchkiss, 1971). The water table generally lies below the bottom of the terrace deposits. However, the relatively large grain size of the terrace deposits suggests their value as possible recharge sites.

3.4.3 Semiconfined Aquifer

In the area of the GMA-SA, overlying the Corcoran Clay is the semiconfined zone. It is comprised of sediments derived from the Coast Ranges on the west interfingered to the east with sediments derived from the Sierra Nevada. These sediments comprise the older alluvium, younger alluvium and terrace deposit layers. The Coast Ranges and Sierran sediments differ in their hydrogeologic characteristics. The Coast Range sediments consist of beds, lenses, and tongues of clay, sand, and gravel, and form most of the sedimentary material deposited west of the San Joaquin River (Hotchkiss, 1972). Although there are no distinct continuous aquifers or aquitards within the Coast Range alluvium, the term “semiconfined” is used to emphasize the cumulative effect of the vertically distributed fine-grained materials. The Sierran sediment that interfingers with the Coast Range alluvium is well sorted, medium to coarse-grained micaceous sand derived from the Sierra Nevada. The uppermost expression of the interface between the Coast Ranges and Sierran deposits is close to the eastern boundary of the GMA-SA.

Across much of the San Joaquin Basin, a layer of older alluvium consisting of loosely to moderately compacted sand, silt and gravel deposited in alluvial fans during the Pliocene and Pleistocene ages overlies the Tulare Formation. The older alluvium is widely exposed between the Coast Range foothills and the Delta. The thickness of the older alluvium is up to about 150 feet. It is moderately to locally highly permeable.

A layer of younger alluvium overlies the layer of older alluvium. This layer includes sediments deposited in the channels of active streams as well as overbank deposits and terraces of those streams. They consist of unconsolidated silt, fine to medium grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and, where saturated, yield significant quantities of water to wells. Further terrace deposits of Pleistocene age lie up to several feet higher than present streambeds. They are composed of yellow, tan, and light-to-dark brown silt, sand, and gravel with a matrix that varies from sand to clay (Hotchkiss, 1972). The water table generally lies below the bottom of the terrace deposits.

3.4.4 Subsidence

Land subsidence up to about 16 feet has occurred in the southern portion of the basin due to artesian head decline (DWR, 2006). For some areas in the southern portion of the GMA-SA the USGS had determined land subsidence up to approximately 24 feet had occurred between 1926 and 1970 (Ireland, 1984). In the past SLDMWA, in conjunction with CCID and other agencies, have measured land subsidence at a variety of fixed locations in order to better understand the relationship of deep groundwater pumping and land subsidence. At one of these locations, near Russell Avenue and Check 18 along the DMC, an approximate subsidence of the fixed structure of nearly 0.1 feet was measured between February and August 2008. Past land subsidence has resulted in the loss of capacity of canals which traverse along the eastern margin of the GMA-SA.

3.5 Hydrology

The following sections discuss the surface and groundwater hydrology of the area. Hydrologically, the GMA-SA has inflow from outside bringing water supplies into the area.

Sources of inflow into the GMA-SA include:

- Imported CVP surface water supply delivered via the DMC and the SLC
- ephemeral streams conveying storm runoff from the east side of the Coast Range Mountains,
- subsurface groundwater flowing in from the southwest,
- and precipitation.

Sources of outflow from the GMA-SA include:

- Storm water runoff,
- subsurface groundwater flow moving towards the trough of the valley and exiting the GMA-SA,
- crop and phreatophyte evapotranspiration,
- surface waters conveyed out of the GMA-SA by canals and drainage ways,
- shallow groundwater collected and conveyed out of the GMA-SA by drainage ways to the San Joaquin River,
- and evaporation.

3.5.1 Surface Hydrology

Streams that drain into the northern two-thirds of the San Joaquin Valley, flowing from the Sierra Nevada and Coast Range mountains, empty into the San Joaquin River and flow northward to join the Delta. Historically, the rivers and streams in the southern one-third of the San Joaquin Valley had no natural drainage connecting to the ocean, but rather drained into Tulare and Buena Vista Lakes. Seasonal flooding would occur along these rivers and streams in spring as rainfall and snowmelt from the mountains drained to the valley floor. A number of dams placed along the major watercourses, particularly in the Sierra Nevada Mountains, have alleviated most of the flooding. The majority of the runoff that drains into the San Joaquin River basin is derived from the rainfall and snowmelt from the western side of the Sierra Nevada Mountains. The rivers and streams typically drain southwest to west out of the Sierra Nevada Mountains, turning north at the trough of the valley floor, where they join the San Joaquin River.

The ephemeral streams of the eastern side of the Coast Range Mountains typically drain east to northeast out of the mountains towards the trough of the valley floor. Many of these streams only flow during torrential winter storms and for very short periods following. In the past, many of these ephemeral streams would drain out onto the valley into wetlands and infiltrate before reaching the San Joaquin River. This infiltrated water would supply base flow for the San Joaquin River and recharge groundwater. Many of these ephemeral streams have been transected by canals and highways, their drainage courses diverted, and agriculture reclaimed and drained much of the wetlands and lakes. Much of the surface hydrology of the San Joaquin Valley is controlled by man-made structures and practices. Surface waters in the San Joaquin Valley are frequently conveyed into and out of the valley by a network of large canals that supply users' needs in areas far from the natural source. Large man-made reservoirs are used to retain and store runoff from the mountains, the water being conveyed to local and remote locations.

Consistent with most of the San Joaquin Valley, within the GMA-SA, much of the surface hydrology is governed by the man-made structures, agricultural practices, and urbanization. A notable few ephemeral streams convey water into the GMA-SA from the east side of the Coast Range Mountains. These streams include:

- San Luis Creek (severed by San Luis Reservoir),
- Los Banos Creek (regulated by Los Banos Creek Detention Dam),
- Salt Creek,
- Ortigalita Creek,
- Laguna Seca Creek,
- Little Panoche Creek,
- and numerous smaller creeks and drainages.

Some areas along the south central to eastern side of the GMA-SA are relatively flat, and groundwater can be seasonally shallow. These conditions may create seasonal wetlands where the drainage has not been modified. The San Joaquin River flows near the southeastern boundary of the GMA-SA.

Besides the natural water conveyance systems, major canals convey CVP water from the Delta and through the GMA-SA. These canals include the SLC and the DMC. Smaller canals and pipeline networks convey the surface water throughout the GMA-SA.

3.5.2 Subsurface Hydrology and Hydrogeology

The GMA-SA lies within the Delta Mendota groundwater subbasin (5-22-07) mapped by the California Department of Water Resources (DWR, 2003). The aquifers of the GMA-SA consist of unconsolidated sediments derived primarily from the Coast Ranges. Groundwater occurs in three water-bearing zones (DWR, 1981). Much of the GMA-SA is underlain by the Pleistocene Corcoran Clay Member of the Tulare Formation, which is a lacustrine deposit that divides the aquifer system vertically into an upper semiconfined zone and a lower confined zone (Davis and

DeWiest, 1966). The unconsolidated sediments taper towards the Coast Ranges and the Corcoran Clay crops out sporadically on the west margin of the valley.

In the semiconfined zone, the sediments consist of beds, lenses, and tongues of clay, sand, and gravel, and form most of the sedimentary material deposited west of the San Joaquin River (Hotchkiss, 1972). Although there are no distinct continuous aquifers or aquitards within the alluvium, the term “semiconfined” is used to emphasize the cumulative effect of the vertically distributed fine-grained materials. The confined zone underlies the confining Corcoran Clay stratum and is similar to the semiconfined zone in texture and composition. It extends downward from the base of the Corcoran Clay to the base of fresh water mapped by Page (Page, 1971). The estimated specific yield of the Delta Mendota subbasin was estimated to be 11.8 percent (DWR, 2006).

The surface represented by the static groundwater elevation in wells that tap an unconfined zone is defined as the water table. The imaginary surface represented by the static groundwater elevation in wells that tap semiconfined or confined aquifers is defined as the potentiometric surface. The potentiometric surface in a confined aquifer represents the water pressure underlying a confining layer, or aquitard, and not the actual elevation at which groundwater from that layer occurs. The static groundwater elevation in wells completed to shallower depths may not be the same as in deeper wells. This is due to numerous fine-grained beds of variable thickness that exist in the semiconfined zone, and the fine-grained aquitards, e.g. Corcoran Clay, that overlie the confined zone, as discussed above. These fine-grained sediments restrict the vertical movement of water.

The horizontal groundwater flow direction in the semiconfined zone is northeast, towards the San Joaquin River from the Coast Ranges, typically causing subsurface outflow across the defined GMA-SA boundary. In the confined zone beneath the Corcoran Clay, water tends to move southwesterly into the GMA-SA.

Imported agricultural water supplies in the GMA-SA provides most of the recharge water of the upper semiconfined zone through seepage losses occurring in irrigation water conveyance channels and by deep percolation of applied water. Other sources of recharge include seepage from creeks and rainfall. Recharge to the lower confined zone occurs primarily by infiltration downward from the unconfined zone through the Corcoran Clay and inflow from the west. Groundwater pumping from below the Corcoran Clay in the GMA-SA is likely to increase percolation through the clay layer. Groundwater pumping in the northern and southern portions of the GMA-SA occurs primarily from above the Corcoran Clay. In the central portion of the GMA-SA, pumping is primarily from below the Corcoran Clay.

Groundwater levels in much of the GMP-SA are managed by the collection and removal of shallow groundwater which is accomplished through the installation of subsurface drainage systems. These systems typically consist of a series of collector drains, termed tile drains, installed in the field which collect the shallow drainage water and deliver the water to a drainage pump station, the tile drainage sump. Pumps installed in the sump lift the water into regional drainage collection and disposal systems. As result of this groundwater level management, groundwater levels are maintained at selected levels below the crop root zones and there is a continual withdrawal of water from the shallow zone of the semiconfined aquifer. Groundwater pumping for water supply purposes occurs when surface water supplies are limited due to the marginal to poor quality of the groundwater. Pumping for water supply purposes cannot occur to balance aquifer inflow and outflow due to the need to maintain a salt balance in the crop root zone which is accomplished through the use of the tile drainage systems. Water contained in groundwater storage therefore does reflect the difference in water supply and water demand in the GMP-SA.

3.5.3 Groundwater Quality

The chemical analyses of samples from wells screened in the semiconfined and/or the confined zones in a narrow band along the DMC were reported in the previous Groundwater Management Plan (Stoddard, 1996). The analysis appears to indicate that groundwater quality in these aquifers is highly variable and is affected by different agricultural and natural sources of recharge, and the sources and geochemical nature of the sediments. The distribution of various constituents in the two zones shows little similarity.

The 1994 DMC water quality analyses indicate that in the deeper semiconfined zones of the northern part of the GMA-SA, total dissolved solids (TDS) concentrations range from 560 to 1,300 mg/L, boron concentrations range from 0.5 to 2.1 mg/L, sulfate concentrations range from 65 to 230 mg/L, and the selenium concentrations were below the detection limit of 1 μg/L. In the southern part of the GMA-SA, the concentrations of these constituents are relatively high. TDS concentrations range between 1,200 and 1,800 mg/L, boron concentrations range between 1.1 and 3.1 mg/L, sulfate concentrations range between 460 and 1,200 mg/L, and selenium concentrations range from less than detectable to 5 μg/L.

In the confined zone of the central part of the GMA-SA, TDS concentrations range between 1,000 and 1,800 mg/L, boron concentrations range from 1.90 to 3.85 mg/L, sulfate concentrations range from 470 to 720 mg/L, and selenium concentrations range from less than detectable to 6 μg/L. Groundwater quality data in both the semiconfined zone and the confined zone in the GMA-SA are sparse; therefore, a definitive groundwater quality picture of the portions of the GMA-SA away from the DMC is lacking. Groundwater quality of the semiconfined and the confined zones in these areas can be expected to vary from the concentration ranges given above due to variations in the geochemical nature of sediments and different agricultural practices. The lack of current groundwater quality information available in the GMA-SA demonstrates the need to establish a groundwater quality monitoring program.

3.5.4 Shallow Groundwater

Shallow groundwater is characterized as an area where the water table is within 20 feet of the ground surface at any time during the year. Shallow groundwater frequently occurs within the south-eastern portions of the GMA-SA. Because inadequate drainage accumulates salts within a rising groundwater table, the San Joaquin Valley Drainage Program identifies and separates shallow groundwater into two problem areas, 1) a "present problem area" is defined as a location where the water table is within 5 feet of the ground surface and, 2) a "potential problem area" indicates the water table is between 5 and 20 feet below the ground surface.

In the past, the San Joaquin District of the California Department of Water Resources (DWR-SJ) has sampled several drainage sumps and monitoring wells scattered throughout the west side of the San Joaquin Valley. One of the parameters measured is the Electrical Conductivity (EC) sometimes referred to as Specific Electrical Conductivity or Specific Conductance. EC is a measure of the ability to conduct an electrical current through a given solution and is used as an indirect indicator of the total salt content in water at a specific site. The more salts in the water, the better the conductivity. The strength of the electrical current is dependent upon the temperature of the solution and type and concentration of ions within the solution. EC and TDS, in conjunction with other parameters such as Sodium Absorption Ratio (SAR), and total hardness, are used to determine the suitability of water for agriculture. DWR-SJ prepares maps that show the special variation in conductivity based on the measurements at the time of the sampling event.

In accordance with PNWD's Water Conservation Plan (Stoddard, 2008), PNWD collects samples from four drainage points. The quality of this drainage water may be used as an indicator of the quality of the seasonally shallow, "perched", groundwater that is encountered is the south-eastern portion of the GMA-SA. A summary of the results for some key analyses in drainage water is presented below in Table 3.

Table 3
Chemical Analysis of Selected Constituents in Drainage Water

Sampling Location Designation	Sampling Date	Upper Zone EC (µmhos/cm)	Boron (mg/L)	Selenium (µg/L)
DP-30	10/15/2008	5,300	10	63
	10/06/2009	4,500	8.6	58
	10/06/2010	5,100	9.2	64.3
	04/12/2011	4,490	8.2	48.6
DP-31	10/15/2008	9,100	17	510
	10/06/2009	9,500	18	530
	10/06/2010	8,830	13.9	400
	04/12/2011	8,380	14.2	345
DP-40	10/15/2008	7,900	10	470
	10/06/2009	8,200	14	580
	10/06/2010	8,950	13.2	643
	04/12/2011	8,230	12.0	460
DP-41	10/15/2008	8,700	15	810
	10/06/2009	8,600	14	580
	10/06/2010	8,550	12.9	567
	04/12/2011	8,150	11.2	413

The U.S. Environmental Protection Agency (EPA) suggested criterion for boron concentration in water used for long-term irrigation of sensitive crops is 0.75 mg/L. Boron in this perched water greatly exceeds the EPA suggested maximum limit for Boron. The concentrations of Selenium greatly exceed the current Primary Drinking Water Standards Maximum Contaminant Limit (MCL) of 50 μg/L and 2 μg/L MCL for the channels in the Grassland watershed. In addition, the very high electrical conductivities indicate a high concentration of soluble salts in the water (Table 3).

The recent sample results suggest that this captured perched water has no beneficial uses for potable or agricultural applications, and very limited use for industrial applications. Capture of this perched water, which might otherwise percolate, through the extensive tile drain systems may aid in preventing long term degradation of the deeper aquifers, and protect the water resources and welfare of the community.

3.5.5 Unconfined and Semi-Confined Aquifer Groundwater

USBR conducts sampling and analysis of water being pumped into the DMC by local well owners. USBR is in the process of preparing a Quality Assurance Program Plan (QAPP) to more comprehensively specify the sampling and testing procedures and standards for water being pumped into the DMC, the frequency of sampling, and events that triggers sampling. Currently, they typically collect water quality samples from each candidate well and include them in a weekly batch of samples for analytical testing. If the sample being analyzed meets the current selenium standard for discharging into the DMC, the well water is then tested for additional constituents specified in the Water Quality Monitoring Program, Water Quality Standards for Acceptance of Groundwater into the Lower Delta-Mendota Canal (WQS) (USBR, 2011). The water quality standards utilized include the following constituents and MCLs:

- Bicarbonate (61 mg/L),
- Boron (0.7 mg/L),
- Calcium (80 mg/L),
- Chloride (40 mg/L),
- Chromium, total (50 μg/L),
- Magnesium (16 mg/L),
- Mercury (2 μg/L),
- Molybdenum (10 μg/L),
- Nickel (100 μg/L),
- Nitrates (45 mg/L),
- Nitrites (1 mg/L),
- pH (5.0 to 7.0),
- Potassium (4.5 mg/L),
- SAR (<2),
- Selenium (2 μg/L),
- Sodium (69 mg/L),
- Specific Conductance (1,230 μS/cm),
- Sulfate (50 mg/L),
- TDS (800 mg/L),
- Chlorpyrifos (0.025 μg/L), and
- Diazinon (0.16 μg/L).

A summary of the results for some key analytes is presented below in Table 4.

Table 4
Chemical Analysis of Selected Constituents in Groundwater

DMC Mile Post	Well Depth (feet)	Sampling Date	EC (µmhos/cm)	TDS	Nitrate	Boron	Arsenic	Selenium
			Lower Zones	-------------------(mg/L)	----------------		----------(µg/L)	---------
69.30				**O'Niell Forebay**				
78.31L	49	04/21/2008	1,400	890	--	0.79	--	<2.0
78.31L	49	11/12/2009	1,300	820	37	0.87	--	<1.0
79.13R	112	07/14/2008	1,300	760	17	0.82	6.6	11
79.13L	na	03/19/2008	--	--	--	<0.005	<5.0	--
79.13L	na	01/24/2011	830	510	14	0.60	--	1.3
79.60L	83	01/24/2011	1,100	660	25	0.64	--	1.9
80.03L	80	11/12/2009	1,600	980	75	1.0	--	<1.0
80.03R	144	05/26/2009	1,000	510	26	0.81	--	<1.0
80.03R	144	11/12/2009	800	470	13	0.84	--	<1.0
81.08R	na	07/14/2008	2,500	1,700	90	--	6.3	22
83.90L	na	09/04/2009	1,400	820	28	0.93	--	1.4
84.38				**Mercey Springs Road**				
90.60L	na	06/16/2008	1,800	1,200	<1.0	2.9	--	<2.0
90.91L	na	08/08/2008	2,500	1,600	20	3.3	--	5.1
91.15L	na	08/08/2008	--	1,500	<1.0	3.9	--	<2.0
91.80L	na	06/16/2008	2,400	1,500	<1.0	3.6	--	<2.0
91.80L	na	06/18/2008	2,200	--	10	3.0	5.0	<2.0
92.14L	na	06/11/2008	1,900	1,200	--	3.0	--	<2.0
92.72L	na	06/19/2008	2,200	1,400	<1.0	2.3	9.2	<2.0
97.68				**Russell Avenue**				
98.74L	114	02/18/2009	2,000	1,500	<1.0	2.6	--	<2.0
98.74L	114	11/12/2009	1,800	1,400	<1.0	2.6	--	<1.0
99.24L	96	11/12/2009	2,000	1,500	<1.0	2.4	--	<1.0

During 2008 to 2011, results of water quality analyses of deep water samples from pumping wells in the Northwestern part of the SA-GMA, west of the Mercey Springs Road crossing showed:

- EC ranged from 800 to 2,500 µhos/cm,
- TDS concentrations range from 510 to 1,700 mg/L,
- Nitrate concentrations range from 13 to 90 mg/L,
- Boron concentrations range from below a detection limit of 0.005 to 1.0 mg/L,
- Arsenic concentrations range from below a detection limit of 5 to 6.6 µg/L,
- and Selenium concentrations range from below a detection limit of 1.0 to 22 µg/L.

Results of water quality analyses from the North Central part of the SA-GMA, between the Mercey Springs Road crossing and the Russell Avenue crossing, showed:

- EC ranged from 1,800 to 2,500 µhos/cm,
- TDS ranged from 1,200 to 1,600 mg/L,
- Nitrate ranged from below a detection limit of 1.0 to 20 mg/L,

- Boron ranged from 2.3 to 3.9 mg/L,
- Arsenic concentrations range from 5 to 9.2 μg/L,
- and Selenium ranged from below detection limits of 2.0 to 5.1 μg/L.

Results of water quality analyses from the Southeastern part of the GMA, east of the Russell Avenue, crossing showed:

- EC ranged from 1,800 to 2,000 μhos/cm,
- TDS range from 1,400 to 1,500 mg/L,
- Boron range from 2.4 to 2.6 mg/L,
- Nitrate was below the detection limit of 1.0 mg/L,
- and Selenium was below the detection limits, which were 1.0 and 2.0 μg/L, respectively.

In general the wells sample results appear to indicate TDS, SEC, Boron and Selenium concentrations increasing east of Mercey Springs Road. While Nitrate concentrations appear to decrease east of Mercey Springs Road.

3.5.6 Arsenic

Recently, the California Drinking Water Standard Maximum Contaminant Level (California MCL) for arsenic was lowered from 50 μg/L to 10 μg/L. This change became effective for all states as of January 23, 2006, and California's revised Arsenic MCL of 0.010 mg/L (equivalent to 10 micrograms per liter, µg/L) became effective on November 28, 2008 (DPH, 2008). Currently, the California standard is consistent with the federal standard. Arsenic is typically derived by dissolution of igneous parent materials, and released from iron and manganese oxides when pH declines. Analysis for Arsenic in the shallow groundwater bearing zone was conducted on samples collected from only four drains east of Russell Avenue. Of the 16 drain samples analyzed, all greatly exceeded the California MCL, ranging from 48.6 to 810 μg/L. Analysis for Arsenic in the lower groundwater bearing zones was conducted on only a limited number of well samples collected from the west of Russell Avenue. Of the five well samples analyzed none exceeded the California MCL for Arsenic, with Arsenic concentrations ranging from 5 to 9.2 μg/L

3.5.7 Selenium

The Selenium concentration in shallow drainage water from within the GMA-SA exceeds the California Drinking Water MCL in all sample locations except one from DP-30 (Table 3). None of the 17 deeper zone water well samples analyzed exceeded the California Drinking Water MCL for Selenium. Only two of the samples analyzed exceeded the 2 μg/L MCL for Selenium. In general, Selenium concentrations in the water well samples appear to increase in the eastern portion of the GMA-SA.

3.5.8 Nitrate

Both the California Drinking Water and the WQS MCL for Nitrate are 45 mg/L. Nitrate concentrations are monitored only in the lower zone. Nitrate concentrations appear to decline progressively from west to east across the GMA-SA, with the highest concentrations occurring in the western portion of the GMA-SA and the lowest in the eastern portions. Nitrate concentrations in the lower zone well water samples collected from the western portions of the GMA-SA ranged from 13 to 90 mg/L. Two of the nine well samples collected from west of Mercey Springs Road exceeded the MCL for Nitrate. Only two of the six samples from the central portion, between Russell Avenue and Mercey Springs, were reported to have nitrate concentrations above the detection limit of 1.0 mg/L. None of the samples in the eastern portion, east of Russell Avenue, were reported to have nitrate concentrations above the detection limit. None of the nine samples collected from east of Mercey Springs Road exceeded the MCL.

3.5.9 Boron

Boron is an essential micronutrient for plant growth. However, at relatively low concentrations it can become toxic to plants. A small number of very sensitive crops, such as lemons, can show toxicity responses to Boron in soil-water at concentrations lower than 0.5 mg/L (Ayers, 1994; CFA, 1985). Sensitive crops show a toxic response at concentrations ranging between 0.5 and 0.75 mg/L. In comparison, a few very tolerant crops, such as cotton, can tolerate concentrations of Boron in excess of 6 mg/L. The suggested limit for Boron in water used for long-term irrigation is less than the toxicity limit for the crop. For Boron-sensitive crops this limit should less than 0.75 mg/L. For drinking water, the State of California does not set a MCL for Boron (DPH, 2011). It does, however, set a Notification Level (NL) of 1 mg/L, and a recommended Response Level (RL) of 10 times the Notification Level. State law (Health & Safety Code §116455) requires timely notification of the local governing bodies by drinking water systems whenever a notification level is exceeded in drinking water that is provided to consumers. The California Department of Public Health (DPH) recommends that the drinking water system take the source out of service if the RL is exceeded. The WQS MCL for Boron is 0.7 mg/L.

The Boron concentrations appear to increase progressively from west to east across the GMA-SA, with the highest concentrations occurring in the eastern portion of the GMA-SA and the lowest in the western portions. The Boron concentration in shallow drainage water from within the GMA-SA greatly exceeds the WQS MCL, ranging from 8.2 to 18 mg/L. Additionally, the Boron concentrations in the shallow drainage water exceed the NL and in some cases the RL for drinking water. For crop applications, the Boron concentrations in the shallow drainage water exceed the toxicity limits for most crops, except the few that are very tolerant. None of the 17 lower zone water well samples exceed the California RL, ranging from below the detection limit of 0.005 to 3.9 mg/L. Seven of the 10 lower zone water well samples from west of Mercey Springs Road exceed WQS MCL and the Boron-sensitive crop toxicity limits, and there was no exceedance of the California NL. All of the samples from east of Mercey Springs Road exceeded the WQS MCL, the California NL, and the Boron-sensitive crop toxicity limits. All samples from east of Mercey Springs Road exceed a 2.0 mg/L upper limit for moderately sensitive crops.

3.5.10 Salinity

Salinity of water can be evaluated through two forms of measurement, d TDS and the EC. While high levels of salinity can be toxic to both plants and animals (including humans), water generally becomes distasteful at much lower concentrations. On this basis of taste, California requires the recommended MCL for TDS of 500 mg/L with an upper MCL 1,000 mg/L, and a recommended MCL for EC of 900 μs/cm with an upper MCL 1600 μs/cm. California regulations state that constituent concentrations lower than the Recommended MCL are desirable for a higher degree of consumer acceptance, but constituent concentrations may range to the upper MCL if it is neither reasonable nor feasible to provide more suitable waters. The WQS MCL is 1,230 μs/cm for EC and 800 mg/L for TDS.

The Food and Agriculture Organization of the United Nations (FAO) recommends the following general guidelines for irrigation water quality with respect to salinity (Ayers, 1994). With regard to salinity as measured by EC, the following general guidelines are recommended:

- below 700 μs/cm no restriction need be considered on the use for irrigation of crops,
- between 700 and 3,000 μs/cm slight to moderate restrictions need to be considered, as some crops may not tolerate the higher salinity,
- greater than 3,000 μs/cm severe restrictions as most crops cannot tolerate these salinity levels.

With regard to salinity as measured by TDS, the following general guidelines are recommended:

- below 450 mg/L no restriction need be considered on the use for irrigation of crops,
- between 450 to 2,000 mg/L slight to moderate restrictions need to be considered,
- greater than 2,000 mg/L severe restrictions need to be considered.

However, these guidelines are just a generalized management tool and are not applicable as standards for all agricultural uses. Different crops respond differently to various levels of salinity with some being more tolerant than others to salinity, e.g. cotton.

The EC of the upper zone water samples from the south-eastern portion of the GMA-SA exceeds the California Upper MCL, the WQS MCL, and the FAO recommended limit for severe restriction on the use for agriculture, ranging from 4,490 to 8,950 μs/cm. The TDS of the shallow drainage water was not reported.

The EC of the lower zone well water samples ranged from 800 to 2,500 μs/cm west of Mercey Springs Road, and 1,800 to 2,500 μs/cm east of Mercey Springs Road. The TDS content of the lower zone well water samples ranged from 510 to 1,700 mg/L west of Mercey Springs Road, and 1,200 to 1,600 mg/L east of Mercey Springs Road. The EC and TDS of all samples from within the GMA-SA exceeded the FAO recommended limit for slight to moderate restriction on the use for agriculture.

Of the EC testing West of Mercey Springs Road, 80 percent of the samples exceeded the California recommended MCL, 60 percent exceeded the WQS MCL, and 20 percent exceeded the California upper MCL. Of the TDS testing West of Mercey Springs Road, 90 percent of the samples exceeded the California recommended MCL, 50 percent exceeded the WQS MCL, and 20 percent exceeded the California upper MCL. The EC and TDS for all samples east of Mercey Springs Road exceeded the California upper MCL, the WQS MCL, and the recommended limit for slight to moderate restriction on the use for agriculture. Based on these sample results, there is an apparent trend towards salinity progressively increasing eastwards across the southern portion of the GMA.

None of the samples of the lower zone within the GMA-SA exceed the FAO suggested limits for severe restriction on the use for agriculture. However, more restrictive practices, such as salt tolerant crops and salt management, may need to be employed on use for crop applications towards the easterly end of the GMA.

Because of the high variability of groundwater quality in the GMA-SA, focused groundwater supply investigations are necessary to determine if groundwater is suitable for an intended use. Additionally, management practices must be designed and implemented to maintain or improve groundwater quality to meet the differing needs of the users within the GMA-SA.

Section 4
Management Objectives

As it was stated before, typically, this regional program will rely on the PAs to develop the specific program components to meet management objectives that address local groundwater concerns while considering regional interests.

There are general objectives that should be considered for management of groundwater resources within the GMA-SA:

- Assure an affordable groundwater supply for the long term needs of the users.
- Prevent long-term depletion of groundwater resources and maintain adequate groundwater supplies for all users.
- Maintain groundwater quality to meet the long-term needs of users.
- Attempt to reduce or prevent inelastic land subsidence due to groundwater overdraft.
- Maintain general continuity between groundwater management practices and activities undertaken by the PAs.

Section 5
Program Components Relating to Management

During recent years, there have been several groundwater management activities undertaken by various agencies and individuals in the GMA-SA to protect the groundwater resources. These activities are described in the previous Groundwater Management Plan for the Southern Agencies (Stoddard, 1996).

In 1996, the PAs included in the Southern Subbasin Groundwater Management Area under the leadership of the SLDMWA, developed the Southern Agencies Groundwater Management Plan (SAGMP) under AB 3030 (Stoddard, 1996). The implementation of this plan provided the means for collection of the monitoring data necessary to assess the impact of activities that affect the groundwater basin such that sustained use of groundwater could be optimized without adverse impacts to the water quality and yield.

The passage of SB 1938 requires a GMP to include components relating to the management of groundwater levels, groundwater quality, inelastic land surface subsidence and changes in surface flow and water quality that directly affect groundwater levels or quality, or are caused by groundwater pumping.

In addition, SBx7-6 requires that prescribed entities assume groundwater monitoring functions, coordinate monitoring efforts with DWR, and convey the information regularly to DWR. Conformance with SBx7-6 will require more rigorous planning and management of these monitoring programs to be undertaken within the GMA-SA for the PAs to remain eligible for Water Funds.

Establishing effective working relationships with the various state agencies and federal agencies is essential for water resources management to be efficient and effective. The PAs value the information and guidance provided by these agencies. The PAs should collaborate with the appropriate state and federal agencies in well data collection, studies and findings, and in establishing effective communication and data transfer strategies.

The following sections discuss how these components are included in the GMP-SA, identify elements to be included in potential programs, and briefly describe the related activities within the GMA-SA.

5.1 Components Relating to Groundwater Level Management

Groundwater level management is becoming more critical to protect against future problems related to groundwater overdraft. Overdraft is the condition of a groundwater basin in which the amount of water withdrawn by pumping over the long term exceeds the amount of water that recharges the basin (DWR, 2003). Overdraft can lead to shortages in supplies, increased extraction costs, land subsidence, water quality degradation, and environmental impacts. With increasing demands for water supply, the ability to accurately quantify and manage groundwater resources is imperative to maintaining a sustainable resource.

5.1.1 Reduction of Groundwater Use by Development of New Surface Water Supplies

Agencies buy water from out-of-basin sellers to supplement their supplies.

Activities within the GMA-SA:

In order to reduce the demand for groundwater supplies SLDMWA has undertaken long term, multiple year agreements for water transfers into the GMA-SA from agencies outside the GMA-SA. These agreements involve agencies such as the Yuba County Water Authority, Placer County Water Authority, Merced Irrigation District, Patterson Irrigation District, Banta-Carbona Irrigation District, and the San Joaquin River Exchange Contractors. The water acquired is allocated to agencies in the GMA-SA on an as needed basis as available.

5.1.2 Increase Use of Available Surface Water Supplies

There can be in-basin water transfers and purchases from agencies to others with limited surface water rights and groundwater resources.

Activities within the GMA-SA:

No water transfers within the GMA-SA have been undertaken as demand always exceeds the surface supplies available to each agency.

5.1.3 Development of Overdraft Mitigation Programs

According to the DWR definition, overdraft occurs when continuation of present water management practices would probably result in significant adverse overdraft related impact upon environmental, social, or economic conditions at a local, regional, or state level. Long-term depletion of storage can cause several problems, including land subsidence, degradation of groundwater quality, and increased pumping costs.

Although overdraft of the entire basin is not occurring, conditions of localized overdraft could happen, since areas of extraction do not typically coincide with areas of recharge. One portion of the GMA can experience an increase in groundwater storage while another shows a continual decrease. Such localized overdraft can cause the same adverse impact as basin-wide overdraft, except on a smaller scale. Monitoring of groundwater levels and water quality is necessary to identify areas where localized overdraft is occurring, and to evaluate its effect. The monitoring will allow the overdraft to be quantified, which is needed to evaluate means to control or reverse the overdraft. Curtailing local overdraft usually requires increasing or redistribution of basin surface water supplies and/or reducing the amount of groundwater pumped.

The prerequisite to implementation of an overdraft mitigation program is to monitor groundwater levels. Once groundwater trends are known, a responsive overdraft investigation program should be developed around the following components:

- Identify areas of overdraft.
- Determine the potential for significant adverse impact due to the overdraft.
- Formulate a plan to mitigate the impact and a strategy for plan implementation.

Activities within the GMA-SA:

a. Activities in the GMA to address overdraft mitigation programs include those programs described in 5.1.1 and 5.1.2 above.

b. SLDMWA through USBR has contracted the USGS to modify the USGS Central Valley Hydrologic Model (CVHM) to provide a potential for increased resolution in the model within the GMA-SA, as well as other areas serviced by SLDMWA. It is intended that this higher resolution CVHM will be accessible to PAs to employ in evaluating the potential for changing groundwater conditions under selected water management schemes.

c. The SLWD in cooperation with the Central California Irrigation District, the USBR and the City of Los Banos monitor water supply, water use and groundwater pumping for export in the area southwest of the city including a portion of the GMA-SA. Decisions are made regarding the amount of export pumping which may be allowed based the groundwater storage to avoid overdraft of the underlying groundwater basin.

5.1.4 Development of Conjunctive Use Programs and Projects

Conjunctive use of groundwater and surface water typically occurs when the surface water supply varies from year to year and is insufficient at times to meet an area's demand. In some years, the surface water supply is greater than the water demand; and in other years, the surface water supply cannot meet the entire water demand. In the years when water is plentiful, water available above the demand is utilized to recharge the groundwater aquifer. Recharge can occur either directly by operation of recharge facilities or injection wells, or indirectly, by applying surface water where available to areas to avoid the pumping and use of groundwater. In effect, the groundwater basin is utilized as a storage reservoir, and water is placed in the reservoir during wet periods and withdrawn from the reservoir during dry periods.

There are opportunities for conjunctive use in the study area that could increase overall water supply yield; however, each must be evaluated in terms of available water supply, basin geology, available storage capacity, pumping zones, and recharge potential to determine yield, costs, and potential adverse impacts. In the GMA-SA, pumping takes place from both the semiconfined zone and the confined zone, while unoccupied aquifer storage is currently available only in the unconfined zone. Based on the basin characteristics, water supply sources, and current groundwater usage, potential conjunctive use opportunities should focus on the following:

- Identifying areas of local overdraft and evaluating the viability of a recharge program using direct recharge.
- Evaluating the availability of additional surface water supplies, which could be utilized in conjunctive use programs either directly or via exchange of CVP supplies.
- Optimizing the overall groundwater yields during dry periods through sound basin management.

In the GMA-SA due to the highly variable surface water supply, conjunctive use of surface water and groundwater is a common practice.. When full CVP water supplies are being received, relatively little pumping occurs and groundwater recharge occurs through seepage and deep percolation of surface water. During water short periods, water is withdrawn from the aquifer to make up for the deficits in surface water supply. In a large portion of the southern portion of the GMA-SA, groundwater is of marginal quality and must be blended with surface water to render the groundwater a usable supply. The resulting delivered water quality thus varies with the availability of surface water. During extreme CVP water supply shortages, other surface water supplies are procured such that the blended supply will be of adequate quality to meet the water supply needs and allow more groundwater to be pumped. Historically, natural recharge mechanisms have sufficed to provide the needed recharge. Land application of captured subsurface drainage water provides local recharge as well as drainage water disposal. Groundwater quality is monitored to as part of the drainage water program.

<u>Activities within the GMA-SA</u>:

a. The PWD and the SLWD maintain Warren Act contracts to allow pumping of groundwater meeting the water quality standards into the DMC when surface water supplies are insufficient to meet demand so that the groundwater can be conjunctively used with surface water supplies. Some of the wells are also used to manage water table levels in the local area.

b. The PWD the SLWD and some of the landowners own deep wells tied into the districts' and private surface water distribution systems. When surface water supplies are insufficient to meet demand, the groundwater is used conjunctively used with surface water supplies.

c. DWR has implemented, through its Conjunctive Water Management Program (CWMP), several integrated programs to improve the management of groundwater resources in California. The program emphasis is on forming partnerships with local agencies and stakeholders to share technical data and costs for planning and developing locally controlled and managed conjunctive water use projects.

5.1.5 Development of Agricultural and Urban Incentive Based Conservation and Demand Management Programs

Reduction of demand, either urban or agricultural, should be an important component of the long-term planning and management of water resources. It reduces the need for new water supply projects, often at relatively low cost, and makes prudent use of the available supplies.

The experience of active urban water conservation programs in California is that the potential for water savings are initially about 10 to 20 percent of the volume of water used. Such programs typically include distribution system leak-reduction programs, household metering, tiered pricing to discourage high use, education of children and the public and market-enforced transition to water-saving household plumbing devices.

The greatest potential for agricultural water conservation relies mainly on the use of more efficient irrigation technologies and irrigation scheduling based on crop water needs. Increasing irrigation efficiency decreases the amount of water that is lost to the system or leaves the site through surface water runoff or deep percolation.

The Reclamation Reform Act of 1982 and the more recently enacted Central Valley Improvement Act of 1992 (CVPIA) required water service contractors (including all the GMP-SA PAs) to prepare and implement Water Management Plans. The PAs have been involved in comprehensive demand management plans for almost thirty years.

In November 2009, SBx7-7 was enacted. It requires all water suppliers to increase water use efficiency and utilize a single standardized water use reporting form, which would be used by both urban and agricultural water agencies. Agricultural water suppliers must prepare and adopt agricultural water management plans by December 31, 2012, updating those plans by December 31, 2015 and every 5 years thereafter. In addition, on or before July 31, 2012, agricultural water suppliers shall:

- Measure the volume of water delivered to customers. The Department of Water Resources shall adopt regulations that provide for a range of options that agricultural water suppliers may use to comply with the measurement requirement.
- Adopt a pricing structure for water customers based at least in part on quantity delivered.
- Implement additional efficient management practices.

Agencies that fail to comply with SBx7-7 would be ineligible for State Water funds.

<u>Activities within the GMA-SA</u>:

The PAs that utilize agricultural water supplies of CVP water have completed agricultural Water Management Plans and periodically update the plans pursuant to the CVPIA. In these plans, water conservation practices have been identified and instituted to maximize beneficial use of the water supply. Practices include better irrigation management, physical improvements, and institutional adjustments. Irrigation management practices include on-farm water management and district water accounting, use of efficient irrigation methods, and on-farm irrigation system evaluations. Physical improvements include lining of canals, replacement of unlined ditches with pipeline conveyance systems and improvement of on-farm irrigation and drainage technology. Institutional adjustments include improvements in communication and cooperative work among districts, water users, and state and federal agencies, increased conjunctive use of groundwater and surface water, and facilitating the financing of on-farm capital improvements. Other practices that have been instituted include installation of flow measuring devices, modification of distribution facilities to increase the flexibility of water deliveries, and changes in the water fee structure to provide incentive for more efficient use of water. The Water

Management Plans have helped the districts identify and implement policies and projects for better irrigation water utilization.

5.1.6 Replenishment of Groundwater Extracted by Water Producers

The hydrologic balance included in the previous GMP-SA, suggests that lowering the groundwater levels increases sustainable yield, since subsurface outflow is reduced which counteracts the water extracted. More data and analysis are needed to confirm this finding and to determine the level of pumping that can be sustained without overdraft. However, localized conditions could develop due to changes in surface water delivery, concentrated groundwater pumping, and water quality changes. The natural response of the aquifer to limited increases in pumping can provide for some replenishment.

Where there is overdraft potential, additional surface supplies are sought to reduce the need for groundwater pumping thereby providing "in-lieu" recharge.

Activities within the GMA:

In order to reduce the demand for groundwater supplies SLDMWA has undertaken long term, multiple year agreements for water transfers into the GMA-SA from agencies outside the GMA-SA. These agreements involve agencies such as the Yuba County Water Authority, Placer County Water Authority, Merced Irrigation District, Patterson Irrigation District, Banta-Carbona Irrigation District, and the San Joaquin River Exchange Contractors. The water acquired is allocated to agencies in the GMA-SA on an as needed basis as available.

5.2 Components Relating to Groundwater Quality Management

Groundwater quality management is critical to protect against the degradation that could adversely impact beneficial uses of available groundwater resources. Municipal, agricultural, and industrial activities can all increase the risk of polluting groundwater resources. Pollutants from these activities can find their way into the local aquifers degrading the water quality such that it becomes unusable for some beneficial uses without substantial treatment, and cost. Some sources of pollution are natural. Through disruption in the existing barriers these low quality resources can intrude into higher quality groundwater resources, degrading the groundwater quality. Other sources are derived from anthropogenic applications and byproducts of human activities and waste. Degradation of groundwater resources can lead to expensive water treatment or loss of beneficial uses. The beneficial uses of groundwater resources may be sustained through proper monitoring and management of the resources and potential sources of degradation.

5.2.1 Regulation of the Migration of Contaminated Groundwater

Contaminants addressed in this section are those that result from improper application, storage or disposal of petroleum products, solvents, pesticides, fertilizers and other chemicals used by industry, and are distinguished from salinity degradation. The SLDMWA's role in protecting groundwater from contamination by point sources will be supporting the Regional Water Quality Control Board (RWQCB), whose primary responsibility is enforcing water quality regulations, in the respective counties. The SLDMWA will help develop a better understanding of the regional hydrogeology of the GMA-SA, the vertical and lateral groundwater flow directions, and groundwater quality based on the various groundwater monitoring activities supporting this program. The SLDMWA shall make the PAs aware of changes in groundwater quality, which may indicate that new sources of contamination or changes in existing plumes of contamination are occurring.

<u>Activities within the GMA-SA</u>:

a. Both Merced County Division of Environmental Health (MCEHD) and the Fresno County Division of Environmental Health (FCEHD) permit and inspect well installations, including the installation of appropriate well seals, and abandonments to minimize the potential for the wells to adversely impact groundwater.

b. The Underground Storage Tanks (UST) programs have been developed and implemented by both MCEHD and FCEHD to protect public health and the environment from exposure to hazardous materials releases from USTs. The primary focus is on protection of groundwater from contamination. Activities include inspection and permitting of the, monitoring, repair, installation and removal of USTs.

c. The California Department of Public Health (DPH) regularly collects data and monitors public drinking water supplies as part of the State Drinking Water Program. Data are maintained in a database and utilized to develop reports and source water assessments.

d. The State Water Resources Control Board (SWRCB) developed a UST program which purpose is to protect public health and safety and the environment from releases of petroleum and other hazardous substances from tanks. By 2005, there were approximately 2,650 open UST cases in the Central Valley Region. There are four program elements: leak prevention program (requirements for tank installation, construction, testing, leak detection, spill containment and overfill protection), cleanup of leaking tanks, enforcement, and tank tester licensing. In addition, there is a database and geographic information system (GIS), Geo Tracker, which provides online access to environmental data (http://www.geotracker.waterboards.ca.gov/). It tracks regulatory data about underground fuel tanks and public drinking water wells, as well as other types of sites, such as above ground storage tanks and site cleanup cases (SWRCB, 2006).

e. Under the Pesticide Contamination Prevention act of 1985, the California Department of Pesticide Regulation (DPR) maintains a Ground Water Protection Program (DPR, 2011). Through the Ground Water Protection Program DPR evaluates risk and monitors for pesticide contamination in groundwater, identifies sensitive areas, and develops mitigation measures to prevent further contamination. DPR adopts regulations to protect groundwater as part of the Ground Water Protection Program.

5.2.2 Development of Saline Water Intrusion Control Programs

Groundwater quality within an aquifer can be permanently degraded if saline groundwater migrates into the aquifer. Such degradation has the potential to render the groundwater unsuitable for some uses, particularly potable water use, if not treated. Desalination treatment systems are very expensive. In the GMA-SA, saline water intrusion does not occur from an ocean or saltwater body; instead, it results from: naturally occurring salts present in the soil, salts imported with surface water, and other activities on the land surface.

When water is applied for irrigation purposes, plants consume the water for plant growth leaving excess salts in the soil profile. Water is applied to crops in amounts in excess of the crop consumptive use requirement, so there is sufficient water to migrate downward and carry these salts beyond the crop root zone. This water also carries naturally occurring salts that are dissolved from the soil profile. Chemical fertilizers used in agricultural production and percolation of effluent from waste treatment facilities also contributes salts to the groundwater basin.

Due to the nature of the processes, shallower groundwater is the first to degrade and a vertical water quality gradient is established, with the poorer quality water in the upper shallow zones and the better quality water in the deeper zones. In much of the GMA-SA, downward vertical movement of groundwater is inhibited by intervening clay layers and subsurface drainage systems have been installed to manage groundwater levels. These drainage systems capture much of the salts imported with the surface water.

To maximize the sustainability and beneficial use of groundwater, knowledge of the various water quality zones and groundwater flow patterns is necessary. Once this information is gained, groundwater management techniques can be evaluated to protect zones of high water quality so that the beneficial use of these supplies can continue. A program to minimize water quality deterioration due to saline water intrusion should contain the following elements:

- Analysis of groundwater data obtained from different agencies.
- Identify areas where water quality monitoring and the groundwater flow patterns suggest a high probability of water quality degradation.
- Identify zones of marginal quality water, which can be used in conjunction by blending with surface water to increase water supply to reduce migration of saline water.
- Identify water management measures that may be employed to minimize the degradation.
- Cooperate in programs aimed at providing a way to export salts out of the GMA-SA via some type of drainage program to export salts to provide a balance with imported salts.

Activities within the GMA-SA:

Subsurface drainage water is collected in a large portion of the GMA-SA and either discharged to the San Joaquin River under a Waste Discharge Permit issued the SLDMWA or used to irrigate salt tolerant crops in a designated drainage water reuse area. The discharge aids in salt management and the collection and reuse concentrates the salts collected in the drained acreage for intense management. Currently, these concentrated salts are stored in the shallow groundwater under the reuse area. The drainage management plan calls for ultimately treating this water to remove the salts which would render the water useable for salt sensitive crops and would substantially reduce the salt loading the groundwater below the GMA-SA.

5.2.3 Identification and Management of Wellhead Protection Areas and Recharge Areas

The Federal Wellhead Protection Program established by Section 1428 of the Safe Drinking Water Act (SDWA) Amendments of 1986 was designed to protect groundwater resources of public drinking water from contamination and to minimize the need for costly treatment to meet drinking water standards. A Wellhead Protection Area, as defined by the 1986 Amendments, is *"the surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water or well field."* In 1996, Congress reauthorized SDWA and amended it to require each state to develop and implement a Source Water Assessment Program.

In response to the 1996 re-authorization of the SDWA, Section 11672.60 was amended to the California Health and Safety Code. Section 11672.60 requires the Department of Health Services (DHS, the precursor to DPH) to develop and implement a program to protect sources of drinking water, specifying that the program must include both a source water assessment program and a wellhead protection program. In conformance with the legal mandate, the California's Drinking Water Source Assessment and Protection (DWSAP) program was developed (DPH, 1999). The DWSAP program addresses both groundwater and surface water sources.

In November 1999, the United States Environmental Protection Agency (USEPA) gave final approval of the DWSAP program as California's Source Water Assessment and Protection program. The DPH Division of Drinking Water and Environmental Management is the lead agency for development of the DWSAP program and its implementation. California did not develop a separate Wellhead Protection program, thus the groundwater portion of the DWSAP serves as the State's Wellhead Protection program. In January 1999, USEPA approved the DWSAP as California's wellhead protection program.

According to the California Water Plan Update 2009 (DWR, 2009), recharge area protection includes keeping groundwater recharge areas from being paved over or otherwise developed and guarding the recharge areas so they do not become contaminated. Protection of recharge areas, whether natural or man-made, is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. Existing and potential recharge areas must be protected so that they remain functional and they are not contaminated with chemical or microbial constituents. Zoning can play a major role in recharge area protection by regulating land-use practices so that existing recharge sites are retained as recharge areas.

In the GMA-SA, an important source of groundwater recharge is derived from percolation of surface (mainly applied irrigation) water. In some cases pollutants associated with the percolating water can be transported from the surface into the underlying aquifer. The discharge of wastewater to land or surface water conveyance systems could, if improperly managed, pose a risk of polluting groundwater resources. To protect recharge areas, the PAs should review applications for Waste Discharge Permits within and adjoining their boundaries that have the potential to degrade groundwater. Such waste disposal systems include disposal of dairy wastes, disposal of industrial wastes, sewage treatment plant effluent disposal, and solid waste disposal. Environmental documents and permits for such facilities should be closely reviewed such that appropriate monitoring and mitigation measures are developed to preclude the possibility of migration of pollutants. PAs should be watchful for existing and proposed land use activities that have the potential to degrade groundwater, so that appropriate action can be taken.

Activities within the GMA-SA:

Through programs administered by a variety of State agencies, the State of California regulates waste disposal. The PAs will rely on continued regulation by the State; however, the PAs will work with the State agencies to identify areas that are threatened or are more susceptible to groundwater contamination.

5.2.4 Administration of Well Abandonment and Well Destruction Program

State regulations require that all unused wells be properly abandoned or destroyed so that they do not act as conduits for mixing of groundwater of differing quality. Non-pumped wells are a much greater threat than pumped wells, since pumping normally quickly removes contaminants that may have migrated during idle periods. In gravel packed wells, the gravel pack as well as the casing itself can act as a conduit for mixing and potential contamination.

Permits are required from the applicable county or city for abandonment of wells within their jurisdiction. For public water supply wells, additional requirements may be prescribed by the DPH. Permit fees are normally required.

Activities within the GMA-SA:

The PAs rely on continued administration of the well abandonment and destruction program by the permitting agencies. The PAs' role in well abandonment and destruction is to provide available groundwater data, assist in identifying locations of operating and abandoned wells, and advise well owners why proper well destruction is important for protection of water quality.

5.2.5 Well Construction

Improperly constructed wells can establish pathways for pollutants to enter from surface drainage and can cause mixing of water between aquifers of differing quality. Sections 13700 through 13806 of the California Water Code require proper construction of wells. The standards of well construction are specified in DWR Bulletins 74-81 and 74-90 (DWR, 1981 and DWR, 1991).

The counties within the GMA-SA have the fiduciary responsibility to enforce well construction standards within their jurisdictions. Well construction permits are required to drill a new well or to modify an existing well. Well Driller's Reports must be filed with the DWR and the respective counties.

Typically, it is the responsibility of the respective environmental health divisions of Fresno and Merced Counties to permit and enforce standards for construction and abandonment of wells, and for issuance of drinking water permits for small community water supply systems within their respective jurisdictions. The counties maintain records on these permitted wells. These data are publicly available and should be collected to incorporate into regional monitoring, and may be supplemented with data on water levels and groundwater quality collected by other agencies to identify locations susceptible to intermixing of aquifer zones of varying water quality. The information should be used to establish specifications for well construction and destruction to optimize well water quality and minimize mixing of water between zones of varying water quality.

A better understanding of the subsurface geology and water quality is needed to define the confining beds between aquifer zones of differing water quality. Site-specific hydrogeologic investigations should be conducted to support well designs and should be submitted with the proposed well designs to obtain the well drilling permit.

<u>Activities within the GMA-SA</u>:

Merced and Fresno Counties have adopted the DWR well construction standards. The authority over well construction remains with the respective counties. The PAs should request that the counties supply them with copies of well permits, logs, and studies to assist in their groundwater management activities.

5.2.6 Review of Land Use Plans to Assess Risk of Groundwater Contamination

Land use planning is used by the counties for regulation of land uses within their boundary or sphere of influence to create a quality of life and to achieve compatibility between human activities and the environment. It is a very effective method to mitigate impacts of changes in land use on groundwater quantity and quality.

Policies set forth in county general plans, city general plans, and community specific plans that affect groundwater may include:

- Regulating growth in groundwater recharge areas to protect water quality;
- Regulating development to improve water quality from storm water runoff and improve groundwater recharge opportunities;
- Monitoring water quality and groundwater levels;
- Providing planning for proper disposal of solid waste, sanitary waste, storm runoff, and hazardous wastes generated by communities and industry;
- Restrictions to projected growth based on water consumption relative to available water supplies; and
- Mitigating the impacts of reduction in surface water supply resulting from conversion of land from agricultural use to urban use.

To achieve the common goals between the various land use plans and this GMP-SA, close coordination between agencies is needed. During periodic land use plan preparation and updates, counties should consult with the appropriate PAs to avail themselves of the latest information on hydrogeologic conditions that may be affected by proposed activities, so that appropriate mitigation measures can be included in the plans to avoid significant adverse impacts to local water resources. Proposed land use plans and supporting environmental documentation should be reviewed and commented upon by the PAs.

Activities within the GMA-SA:

The PAs monitor activities within the GMA-SA as well as use permit activity in the two counties. When current or planned activities may pose a threat to the underlying groundwater, the PAs shall cooperate with the appropriate county departments to develop measures to avoid or mitigate potential water quality impacts. The PAs will provide available, geological, hydrological and groundwater level and quality data to the counties to assist in evaluation of project impacts.

5.2.7 Construction and Operation of Groundwater Management Facilities

Groundwater management plans can include projects that protect the quality of groundwater and assure that the quantity of groundwater in storage is managed to meet long-term demand. The facilities that can aid in efficient management of groundwater resources include groundwater contamination clean-up projects, groundwater recharge projects, water recycling projects, and groundwater extraction projects. As knowledge is gained through implementation of the GMP-SA components, specific projects may be identified and evaluated. The individual PAs are responsible for the development and implementation of those projects.

Activities within the GMA-SA:

Currently, the PWD and the SLWD as well as some of the landowners own and operate deep wells to conjunctively use groundwater with surface water to enable the groundwater to be used and managed for water supply. The districts are continually exploring ways to utilize the groundwater resource in a responsible manner to meet their water needs. These facilities allow the PAs to pump and transfer groundwater from areas of good water quality from areas where less impact from pumping occurs to areas where the water is needed. SLDMWA is developing a basin-wide groundwater monitoring plan that will include a groundwater monitoring network that will be developed following approval by DWR.

5.3 Components Relating to Inelastic Land Surface Subsidence

Reducing the amount of groundwater in storage by pumping can cause the dewatering of fine-grained geological formations, potentially resulting in land subsidence and a reduction in the storage capacity of the aquifer.

The management of land subsidence would include monitoring and prevention programs. Management of land surface subsidence should contain the following elements:

- Establish a subsidence monitoring program. Benchmarks should be established at well locations, so it would be possible to relate the subsidence to groundwater extraction.
- Identify areas where monitoring suggest land subsidence is occurring.
- Identify and employ pumping schemes that may be employed to avoid inelastic subsidence.

Activities within the GMA-SA:

a. The SLDMWA periodically performs level surveys to monitor for subsidence it the southern portion of the GMA-SA.

b. As part of the groundwater management, pumping of groundwater is regulated to avoid subsidence. For example, pumping from the confined aquifer in the western portion of the southern portion of the GMA-SA was curtailed since it has shown to be an area subject to inelastic subsidence.

c. Components Relating to Surface Water Quality and Flow

5.4 Components Relating to Surface Water Quality and Flow

SB 1938 requires the inclusion of components relating to the management of changes in surface flow and water quality that directly affect groundwater levels or quality, or are caused by groundwater pumping. Specific actions may include:

- Use of surface water supplies when available in a recharge program or conjunctive use program that is sensitive to downstream users and the environment;
- Avoidance or mitigation of projects that detrimentally affect surface water quality and flow;
- Increase understanding of the interaction between surface water quality and groundwater quality through the GMA-SA monitoring programs.

Activities within the GMA-SA:

a. The current and planned actions within the GMA-SA related to recharge and conjunctive use are detailed in previous sections. As discussed above, shallow, perched, poor quality groundwater occurs in the southern portion of the GMA-SA, and in many locations subsurface drainage systems are utilized to manage the groundwater levels to avoid impact to crop production.

b. In accordance with their conservation plans, the PAs endeavor to construct and maintain canals in a manner that effectively reduces seepage losses. Additionally, they provide best management practice guidance and financial assistance for growers to install efficient irrigations and tailwater recovery systems.

Section 6
Groundwater Monitoring Programs and Plans

6.1 Groundwater Monitoring Programs

The purposes of a groundwater monitoring program are to identify areas of overdraft, provide information that will allow computation of changes in groundwater storage to evaluate net recharge or depletion, and identify the areas and extent of water quality degradation for potential mitigation. Groundwater level monitoring is essential to understand the impact on aquifer storage due to changes in water inflow and outflow components and in pumping activities. Mapping of groundwater levels depicts the direction of groundwater movement and the hydraulic gradient necessary for quantifying groundwater inflow and outflow to the GMA-SA. Monitoring and mapping should be done independently in the unconfined and confined zones.

On behalf of the PAs, SLDMWA plans to take on the role as the groundwater Monitoring Entity within the GMA-SA, in accordance with the requirements set forth in SBx7-6. As of January 2011, SLDMWA notified DWR that they are planning to assume the responsibility for the groundwater Monitoring Function within the GMA-SA. Additionally, SLDMWA is preparing a groundwater monitoring plan, assuming this role as an Umbrella Monitoring Entity in a collaborative effort with USBR and the PAs. This plan will describe a proposed groundwater monitoring program in detail. It is anticipated that this plan will be submitted to DWR by the summer of 2011 for review and approval, and Monitoring Functions within the GMA-SA undertaken by the PAs with SLDMWA as the lead entity on or before January 2012. The proposed monitoring program would rely on the collaboration with the PAs to perform any necessary measurements and collect groundwater elevation data for regular submittals to DWR, at a minimum annually. As an Umbrella Monitoring Entity, SLDMWA will collect and compile the data gathered by the PAs for submittal to DWR. The proposed groundwater monitoring plan will describe:

- A program for collaborating with and coordinating the efforts amongst the PAs to monitor groundwater within the GMA-SA;
- Standard procedures and methods for the measurement and collection, quality assurance, and documentation of field data;
- A DWR approved monitoring network comprised of monitoring wells selected to be representative of the groundwater conditions throughout the GMA-SA, including a map of the proposed monitoring locations;
- A monitoring schedule that is coordinated amongst the PAs and approved by DWR that facilitates evaluation of seasonal and long-term trends in groundwater levels;

- Standard protocols for the gathering and coordination of data from the PAs and other agencies, as applicable, like DWR, USGS, DPH, Fresno County, and Merced County; and,
- Standard protocols for data transmittal from the SLDMWA to DWR.

As part of this groundwater monitoring plan, groundwater levels and groundwater quality data will be reviewed by the PAs. The SLDMWA in collaboration with the PAs would decide if additional monitoring is necessary to supplement information for areas where existing data may indicate possible overdraft or water quality issues developing. Some details regarding the sources of groundwater data from within the GMA-SA are identified below.

DWR

In the past, DWR measured groundwater levels in wells and maintained a database of the groundwater measurements statewide. Currently, DWR maintains publicly available statewide groundwater level data at the Department's Groundwater Level Database website (http://www.water.ca.gov/waterdatalibrary/). This site provides a graphical interface that allows selection of individual wells from a local area map. Data can also be retrieved by specifying the groundwater basin or township of interest. A selected well will return a groundwater level hydrograph and data table including the depth to water below reference point, elevation of water surface and depth to water below land surface. This site currently maintains groundwater level information for nearly 18,000 wells within the San Joaquin District boundary and about 60,000 wells statewide.

With the passage of SBx7-6, DWR will be relying on local entities to take on the responsibility of measuring groundwater levels within basins in conformance with a DWR approved monitoring plan and schedule, and submitting the data to DWR. The data will be uploaded to a DWR database in conformance with DWR protocols. Therefore, the number of groundwater monitoring locations, and continuity with previous locations may change as the monitoring responsibility transitions from DWR to local monitoring entities, and new monitoring networks and schedules are established. Information regarding the SBx7-6 requirements may be obtained through the DWR at the California Statewide Groundwater Elevation Monitoring (CASGEM) website (http://www.water.ca.gov/groundwater/casgem/).

USGS

The USGS maintains the Ground-Water Data for the Nation database, which contains groundwater site inventory, groundwater level data, and water quality data (http://waterdata.usgs.gov/nwis/gw). The groundwater site inventory consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States. Available site descriptive information includes well location information such as latitude and longitude, well depth, and aquifer. The USGS annually monitors groundwater levels in thousands of wells in the United States. Groundwater level data are collected and stored either as discrete groundwater level measurements or as continuous record. The data available for the GMA-SA is not updated.

USGS, in concert with other State and Federal agencies, developed and maintains a hydrologic model of the Central Valley of California. The CVHM is a MODFLOW model developed from a comprehensive geospatial database of numerous features of the heterogeneous Central Valley aquifer system. According to USGS, CVHM will be operated by USGS and made available for use by water managers and other agencies. It was designed to help resource agencies assess, understand and address the many issues affecting the use of surface water and groundwater supplies in the Central Valley. It is intended to aid water managers by simulating a number of water-management scenarios and assess possible changes in both groundwater and surface water supplies on a regional scale. CVHM generally has a resolution of about 1 mile spacing between nodes. However, at the request of SLDMWA through USBR, CVHM resolution is being increased by USGS to approximately ¼ mile spacing between nodes within the areas serviced by SLDMWA, including the GMA-SA. This improvement to the CVHM, within the SLDMWA Service Area, was requested to aid in modeling of potential subsidence from water withdrawal, and to assist PAs with alternatives impact analysis for local project decision-making through groundwater modeling. The model can take into account a number of hydrologic factors including the conversion of farmland to urban use, groundwater recharge and extractions, and the effects of climate change. Limitations on the application of CVHM due to scale used in calibration may be encountered in some smaller applications by water managers. Upon request, USGS can incorporate additional data into the CVHM to refine the input parameters and calibration, thus providing improved accuracy and precision, within a specified region. Information regarding the CHVM may be obtained through USGS (Contact: Claudia Faunt, Phone: 619-225-6142; ccfaunt@usgs.gov).

SWRCB – USGS – Lawrence Livermore National Laboratory (LLNL)

The SWRCB is collaborating with the USGS and the LLNL to implement the Groundwater Ambient Monitoring and Assessment Program (GAMA). The GAMA Program is a statewide comprehensive groundwater quality monitoring program, developed in response to the Groundwater Quality Monitoring Act of 2001 (Water Code Sec.10780-10782.3). The goals are to improve statewide groundwater monitoring, and facilitate the availability of information about groundwater quality to the public. The data collected will provide an indication of potential water quality problems. It will also be used to identify the natural and human factors affecting groundwater quality. Prior to 2003, the GAMA Program conducted the California Aquifer Susceptibility (CAS) Assessment. The CAS Assessment addressed the relative susceptibility to contamination of public wells. This effort was the foundation for the GAMA Program. The GAMA Program also addresses the quality of private/domestic drinking water wells through the Voluntary Domestic Well Assessment Project.

As part of the GAMA Program, the groundwater basins in California were ranked in groups of sampling priority on the basis of the number of public wells, groundwater usage, and potential sources of groundwater contamination in each basin. Three types of water quality assessments were conducted for each unit:

1. The assessment of current groundwater quality.

2. The detection of changes in water quality.

3. The assessment of natural and human factors that affect groundwater quality.

To efficiently facilitate a statewide, comprehensive program, uniform and consistent study-design and data-collection protocols were applied to the entire state.

There are currently four active components of the GAMA Project:

1. GeoTracker GAMA: GeoTracker GAMA is a program to develop and implement a user-friendly internet accessible to georeferenced groundwater database. Data are searchable by text or through an interactive map for groundwater constituents, location and other parameters. The database includes over 150,000 sampling locations. GeoTracker GAMA provides tools to integrate, standardize, and analyze data from several datasets, including data from:

    - California State Water Resources Control Board (SWRCB),
    - California Regional Water Quality Control Boards (RWQCB),
    - California Department of Public Health (DPH),
    - California Department of Pesticide Regulation (DPR),
    - California Department of Water Resources (DWR),
    - United States Geological Survey (USGS),
    - and Lawrence Livermore National Laboratory (LLNL).

    More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/geotracker_gama.shtml#).

2. Priority Basin Project: The GAMA Priority Basin Project assesses groundwater quality in key groundwater basins in the State. Groundwater is monitored for hundreds of chemicals at low detection limits, including emerging contaminants such as pharmaceuticals and personal care products. The GAMA Priority Basins consist of 116 of the 472 DWR defined groundwater basins in the State. The GAMA Priority Basin Project is grouped into 36 groundwater basin groups called “study units”. Each study unit is sampled for common contaminants regulated by the DPH, and also for unregulated chemicals. Some of the chemical constituents that are sampled by the GAMA Priority Basin Project include: volatile organic compounds (VOCs); pesticides; stable isotopes of oxygen, hydrogen, and carbon; emerging contaminants; trace metals; radioactivity; general ions; nutrients; and bacteria. Monitoring and assessments for priority groundwater basins is on-going and will be completed every ten years, with trend monitoring every 3 years. Initial testing of and reporting on the groundwater quality is being conducted currently. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/priority_basin_projects.shtml).

3. Domestic Well Project: The GAMA Domestic Well Project collects and tests samples from private domestic water supply wells, whose owners have volunteered for the program, for commonly detected chemicals. Domestic well water is for private use and consumption. Its quality is not regulated by the State. The results of the testing for each

well are shared with the well owner, and used to evaluate the quality of groundwater used by private well owners. The Domestic Well Project has sampled five County Focus Areas in California as of 2009: Yuba, El Dorado, Tehama, Tulare, and San Diego. None of which lie within the GMA-SA. In general, the Domestic Well Project tests for constituents that are a common concern in potable water: bacteria, general minerals, general chemical parameters, inorganics chemicals and nutrients, and organics chemicals. The results are compared to DPH drinking water standards. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/domestic_well.shtml).

4. Special Studies Project: The GAMA Special Studies Project consist of a number of studies undertaken by LLNL, to look at various relationships between land uses, management practices, and other activities and the effects these activities have on local groundwater resources. LLNL has conducted several groundwater special studies. Of which, Seven projects have been completed; five reports have been published with numerous scientific papers and presentation. The studies completed consist of the following:

    - The fate & transport of nitrate sources from dairies
    - Nitrate management plan studies for the Llagas Basin (Gilroy), and Chico Basins
    - The fate and transport of nitrate sources and occurrence, and its relation to land usage (fertilizer, wastewater, and/or agricultural)
    - Nitrate sources and occurrence in Orange County
    - Nitrate sources and occurrence in Livermore
    - Wastewater indicator study
    - A wastewater indicator study on how septic systems affect shallow groundwater
    - A wastewater indicator study of areas irrigated by recycled water in Gilroy and Livermore.

    The Special Studies still in progress address groundwater recharge, changes in chemistry of groundwater recharged by surface waters, and development of a field deployable apparatus for extraction and collection of dissolved gasses from groundwater samples. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/special_studies.shtml).

    - The GMA-SA lies within the Delta Mendota Subbasin, which lies within the Western San Joaquin Valley Study Unit. The initial sampling and testing of groundwater from wells located in the Western San Joaquin Valley Study Unit is currently being completed and the findings are scheduled to be published in the summer 2011 (Contact: jshelton@usgs.gov). More information about this program and the status of the research is available through SWRCB or USGS (http://www.waterboards.ca.gov/gama/ or http://ca.water.usgs.gov/gama/).

DPH - Division of Drinking Water and Environmental Management

Every public water system in the State has to have the analyzing laboratory enter the results of all chemical monitoring to the Drinking Water Program, a water quality monitoring database. A CD containing the database can be purchased from the Monitoring and Evaluation Unit (Contact: Steve Book, Phone: 916-449-5566; sbook@dhs.ca.gov). For security reasons, DPH does not provide the coordinates of each well included in the database. However, a lot of general location information is easy to deduce from names of the water systems.

SLDMWA

The PAs cooperatively developed a comprehensive groundwater level and quality monitoring plan for the GMA (Stoddard & Associates, 1999). Currently, only the groundwater levels are monitored twice a year in accordance to the groundwater monitoring plan. Other elements of the plan have not yet been implemented, though implementation of additional elements will occur in the future as the groundwater monitoring plan is approved by DWR. (Contact: Joe Martin, Phone: 209-832-6241; joe.martin@sldmwa.org.)

Water quality data is collected during years when diminished surface water supplies are available and groundwater is being pumped into the canal system for recovery later in the year. (Contact: Chris Eacock, Phone: 559-709-0557).

Merced County

Groundwater quality information available for the Public Water System is maintained on a database by the California Department of Public Health, Drinking Water Program, for District 11. At this time, there is no groundwater level information available. (Contact: Carl Carlucci, Phone: 559-447-3300).

Fresno County

Groundwater quality information available for the Public Water System is maintained on a database by the California Department of Public Health, Drinking Water Program, for District 23. At this time, there is no groundwater level information available. (Contact: Betsy Lichti, Phone: 559-447-3300).

Panoche Water District

The PWD maintains a database of groundwater information available from a number of wells, which are routinely monitored, within the Panoche, Pacheco, Widren, Eagle Field, Oro Loma, and Mercey Springs Water Districts. An appointment is necessary to review the available information. (Contact: Juan Cadena, Phone: 209-364-6136, Email: jcadena@panochewd.org).

6.2 Monitoring Plans

SB 1938 requires the adoption of monitoring protocols designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin. The monitoring protocols shall be designed to generate information that promotes efficient and effective groundwater management.

For the GMP-SA, monitoring protocols will be defined based on goals of particular programs. As part of the requirements of SB 1938, the PAs must adopt monitoring protocols to measure changes in water levels and quality, subsidence where subsidence has been identified as a potential problem, and flow and quality of surface water directly influenced by groundwater.

Under the requirements of SBx7-6, the SLDMWA will be applying to DWR as the Monitoring entity for the GMA-SA on behalf of the PAs. As an Umbrella Monitoring Entity in the GMA-SA, SLDMWA is responsible for coordinating the activities of the PAs with regard to groundwater monitoring, including development of schedules, approved monitoring network, and standardized collection techniques for groundwater level monitoring, groundwater quality sample collection, preparation, documentation, laboratory procedures and methods, and data validation and transfer procedures. All of these elements are described in the recent Groundwater Monitoring Plan prepared by SLDMWA. The Groundwater Monitoring Plan should be adopted by the PAs, and then approved by DWR by the summer of 2011, and implemented before the end of 2011. SLDMWA, through consultation with the PAs, will describe in the Groundwater Monitoring Plan the framework for analysis of data and dissemination of the results in conformance with DWR data transfer protocols. There are currently six proposed elements, or plans, considered for the Groundwater Monitoring Program.

Data Collection

This proposed element will describe a data collection plan to ensure that data is collected in a consistent manner that produces meaningful data for reporting. To this end, this element will include procedures associated with the data collection process, such as the protocol for sampling and/or measuring point location, frequency of sampling/measuring, what entity performs the sampling/measuring, quality assurance, quality control, documentation requirements, well owner notification procedures and parameters to be monitored. This element will also include a description of procedures for obtaining access permission from well and/or land owners, for documenting special access requirements, for marking and identifying monitoring points, and for obtaining and documenting site conditions and survey information regarding the monitoring points.

Groundwater Elevation Monitoring

This proposed element will describe a groundwater elevation monitoring plan to provide accurate and dependable groundwater well depth-to-water field measurements that are the basis for evaluating the long-term trends in the change in groundwater levels and quantity within the GMA-SA. This element will include procedures and schedules for conducting groundwater level measurements to determine groundwater elevations. A schedule for conducting measurements will be included and will be based on sampling periods most likely to be representative of long-term groundwater conditions, anticipated to likely occur in spring and fall of each year based on current understanding of regional conditions. In addition, groundwater level information will also be regularly collected from continuously monitoring instrumentation affixed to a number of groundwater monitoring points throughout the GMA-SA. Groundwater level data will be incorporated into the SLDMWA database in accordance with data collection protocol and uploaded to the DWR web-based database at least once a year in accordance with DWR protocol.

Groundwater Quality Monitoring

This proposed element will describe a groundwater quality monitoring plan to track various groundwater constituents of concern that may demonstrate long-term trends in water quality that may adversely impact the beneficial uses of groundwater within the GMA-SA and to allow early detection of potential trends as they develop so that timely remedial actions may be undertaken. Water quality testing will be conducted routinely on wells within the GMA-SA discharging to the DMC. Additionally, water quality testing will be conducted on some USGS wells. Groundwater quality data will be incorporated into the SLDMWA database in accordance with data collection protocol and uploaded to the DWR web-based database at least once a year in accordance with DWR protocol.

Groundwater Extraction Monitoring

This proposed element will describe a plan for documenting the amount and location of groundwater extracted from within the GMA-SA to aid in evaluating groundwater conditions. Groundwater pumping will be measured at a number of wells within the GMA-SA affixed with meters, many of which are currently measured for discharge to DMC under Warren Act Contract. Groundwater extraction data will be incorporated into the SLDMWA database in accordance with data collection protocol and may be uploaded to the DWR web-based database at least once a year in accordance with any applicable DWR protocol.

Land Subsidence Monitoring

This proposed element describes a plan to measure existing land subsidence and to predict the potential for further subsidence. Continuously operating subsidence monitoring stations have previously been installed within the GMA-SA, which will be utilized to measure subsidence. Tentatively, it has been proposed that data will be collected monthly. Subsidence monitoring data will be incorporated into the SLDMWA database in accordance with data collection protocol and may be uploaded to the DWR web-based database at least once a year in accordance with any applicable DWR protocol.

Reporting

This proposed element describes a plan for reporting the results of the monitoring program. As the Umbrella Monitoring Entity representing the PAs, SLDMWA will undertake the responsibility of coordinating the collection and compilation of all applicable groundwater well data within the GMA-SA, and regularly submit the data, at a minimum annually, to the DWR in conformance with the CASGEM protocol. Additionally, it is anticipated that as part of the program, an annual Groundwater Monitoring Report will be prepared that summarizes the water quality, water level, water extraction and subsidence data collected throughout the year. It is anticipated that this report will provide summary information including maps, figures, charts, and tables to characterize water quality, water level and subsidence trends occurring within the GMA-SA. Finally, in accordance with agreements with USGS, SLDMWA will submit data reports on a regular basis to USGS for incorporation into the USGS Central Valley Groundwater Study, and the groundwater flow and land-subsidence model that is currently being developed within the SLDMWA boundaries.

Section 7
Implementation of the Groundwater Management Plan

The GMP-SA implementation involves development of programs through cooperative efforts of the PAs. Implementation of some aspects of the plan may require considerable expenditures and formulas must be developed to allocate costs amongst the PAs. Implementation of regional groundwater management plans are ultimately less costly than implementation of plans by individual agencies, but the implementation strategy is complicated since the PAs have varied reliance on the groundwater resource. The priorities for implementation of the various elements of the GMP-SA will vary from PA to PA. The potential benefits of regional planning within a common groundwater basin or subbasin far outweigh the difficulties of plan implementation. The cooperation of agencies increases the opportunities for water resource management.

In the GMA-SA, the PAs can be generally separated into four categories:

1. Urban water users that currently rely exclusively or primarily on groundwater.

2. Agricultural water users who rely solely on groundwater for water supply.

3. Agricultural water users that rely on surface water and use groundwater for supplemental supply.

4. Agricultural water users with sufficient surface water supply, with groundwater used only for incidental purposes.

Depending on the category, a PA will be willing to invest an appropriate amount of time, effort, and financial resources into groundwater management and make the investment in those management elements that affect it the most. It cannot be expected that all agencies will invest equally in all the elements of the GMP-SA. Hence, an implementation strategy must provide flexibility in the level of agency participation in each element of the plan. For instance, urban agencies and agricultural agencies that rely solely on groundwater supplies may be much more prone to invest in controlling saline water intrusion and localized overdraft; whereas, urban agencies may be the only ones interested in wellhead protection or controlling migration of contaminated groundwater. Participating in conjunctive use operations is obviously desirable for those PAs with water supply deficits, but may also be attractive to those with surplus surface supplies that can be used for recharge purposes.

With consideration given to the reliance upon groundwater by the PAs and the varying importance of the groundwater management elements, the recommended implementation strategy is as follows:

- After public review and consideration of comments received, the final plan should be adopted by each agency.
- The SLDMWA will coordinate plan implementation among the PAs.
- A plan implementation committee made up of representatives of the PAs will meet at least twice a year to review groundwater information and developing trends; to review and consider regional groundwater policies and propose new policies as necessary; to review particular projects being implemented or proposed by the PAs and their potential impacts; and to coordinate policies and projects under the GMP-SA. The findings of the groundwater monitoring program would be reviewed with the group at these meetings.
- With consideration given to the identified problem areas, the committee shall establish a priority list for management actions.
- Management activity groups will be formed, as needed, of those participating agencies interested in implementing certain elements of the groundwater management plan to identify specific management actions, develop budgets, and apportion costs.
- Once a year, the PAs would submit a report to the SLDMWA summarizing their programs under each plan component for consideration by the PAs and for coordination purposes.
- An annual summary would be prepared to report the current state of the basin and describe the management activity that has taken place for each plan element. It would be used to keep PAs and the SLDMWA abreast of the group's activities.
- At least once a year the PAs will meet to discuss budgetary issues for implementing agreed upon groundwater management programs within the GMA-SA.

This GMP-SA is a living document and as such is expected to adapt as more information becomes available through the various programs instituted within the GMA-SA, as conditions change, and as the needs of the PAs evolve. Thus, this implementation strategy is expected to be refined as necessary by the management committee.

Section 8
Groundwater Aquifer Recharge Summary

The groundwater aquifer within the boundaries of the management area is made up of an upper aquifer and a lower aquifer. The Pleistocene Corcoran Clay layer of the Tulare Formation divides the groundwater flow system into an upper semi-confined zone and a lower confined zone. A description of the recharge processes for each aquifer is provided below.

8.1 Upper Aquifer Recharge (Figure 4)

The upper aquifer is recharged through unlined surface water channels and basins, including natural bodies of water such as the Los Banos Creek and the Little Panoche Creek which transverse the management area. Irrigation ditches and drainage ditches also provide a source of groundwater recharge for the upper aquifer. Additionally all agricultural lands irrigated with surface water provide a source of recharge to the upper aquifer. Rainfall also provides recharge to the upper aquifer. The Primary Recharge Areas are along the natural tributaries. The soil profile in and around the Los Banos and Panoche Creeks contain poorly graded soils providing some of the best recharge characteristics in the area.

8.2 Lower Aquifer Recharge (Figure 5)

Recharge in the lower aquifer consists of two processes. First, infiltration from the upper aquifer into the lower aquifer provides a source of recharge. Second, groundwater in the lower confined zone flows into the lower aquifer from adjacent and surrounding aquifers. Typically groundwater flows southwest from the upper groundwater boundary into the lower aquifer within the management area.

8.3 Recharge Project(s)

Los Banos Creek Diversion and Recharge Project - Los Banos Creek is an intermittent creek that begins in the Diablo Range in San Benito County and flows north then eastward into western Merced County where it is dammed at the Los Banos Detention Dam. As a flood control facility, the dam is subject to operation criteria of the United States Army Corps of Engineers (Corps). As part of its operations, flood control releases from the reservoir are made according to flood control criteria specified by the Corps between September 20th and March 15th. A substantial portion of the riparian lands are not fully able to use the intermittent high flows released into Los Banos Creek during flood control operations of Los Banos Creek Detention Dam because there are no pumps or diversion facilities sized for proper management of these types of flows which may last only several days. The Los Banos Creek Diversion project would control flood flows to maximize recharge in the Los Banos Creek. The project would divert portions of the flood flow into existing conveyance systems for controlled use on riparian lands. The project is expected to provide an annual average of 2,000 acre-ft additional recharge to the Los Banos Creek Groundwater Basin. This project is expected to be completed in 2015.

Section 9
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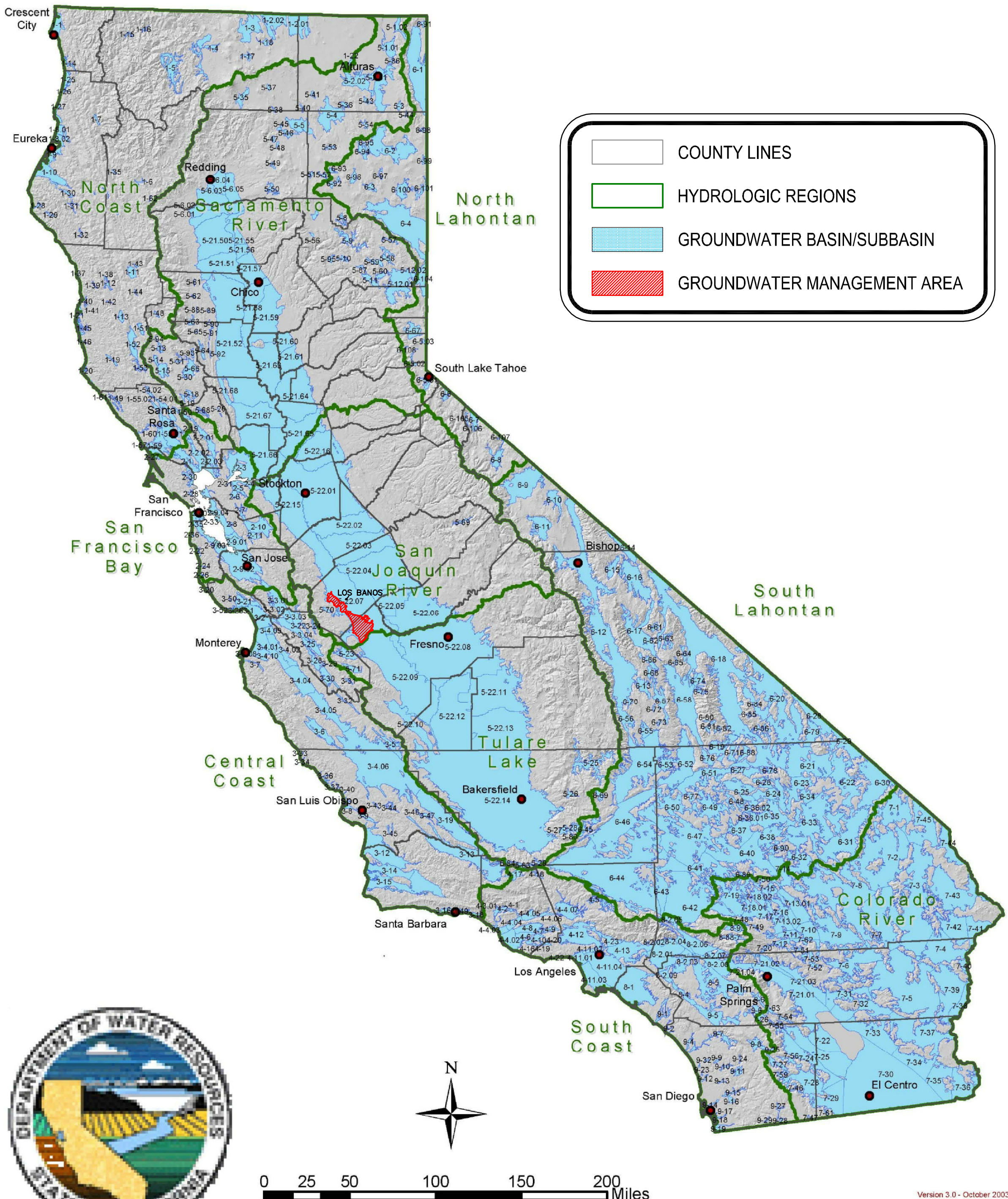
FIGURES

Groundwater Basins in California



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SAN LUIS DELTA MENDOTA WATER AUTHORITY	AECOM PROJECT NO.	FIGURE
HYDROLOGIC REGIONS, CALIFORNIA	60213885	1

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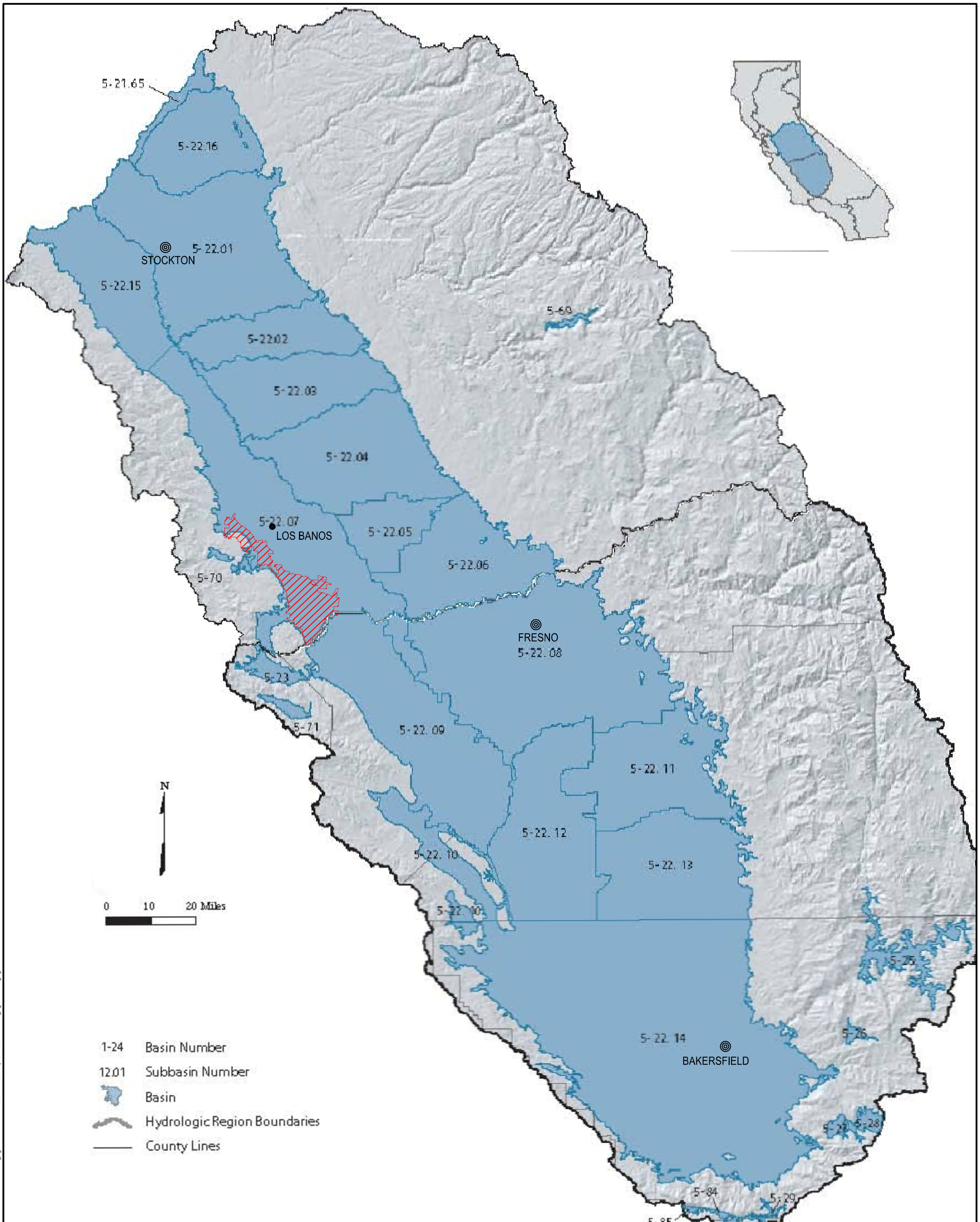

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SUB-BASINS OF THE SAN JOAQUIN RIVER & TULARE LAKE HYDROLOGIC REGION

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FIGURE 2

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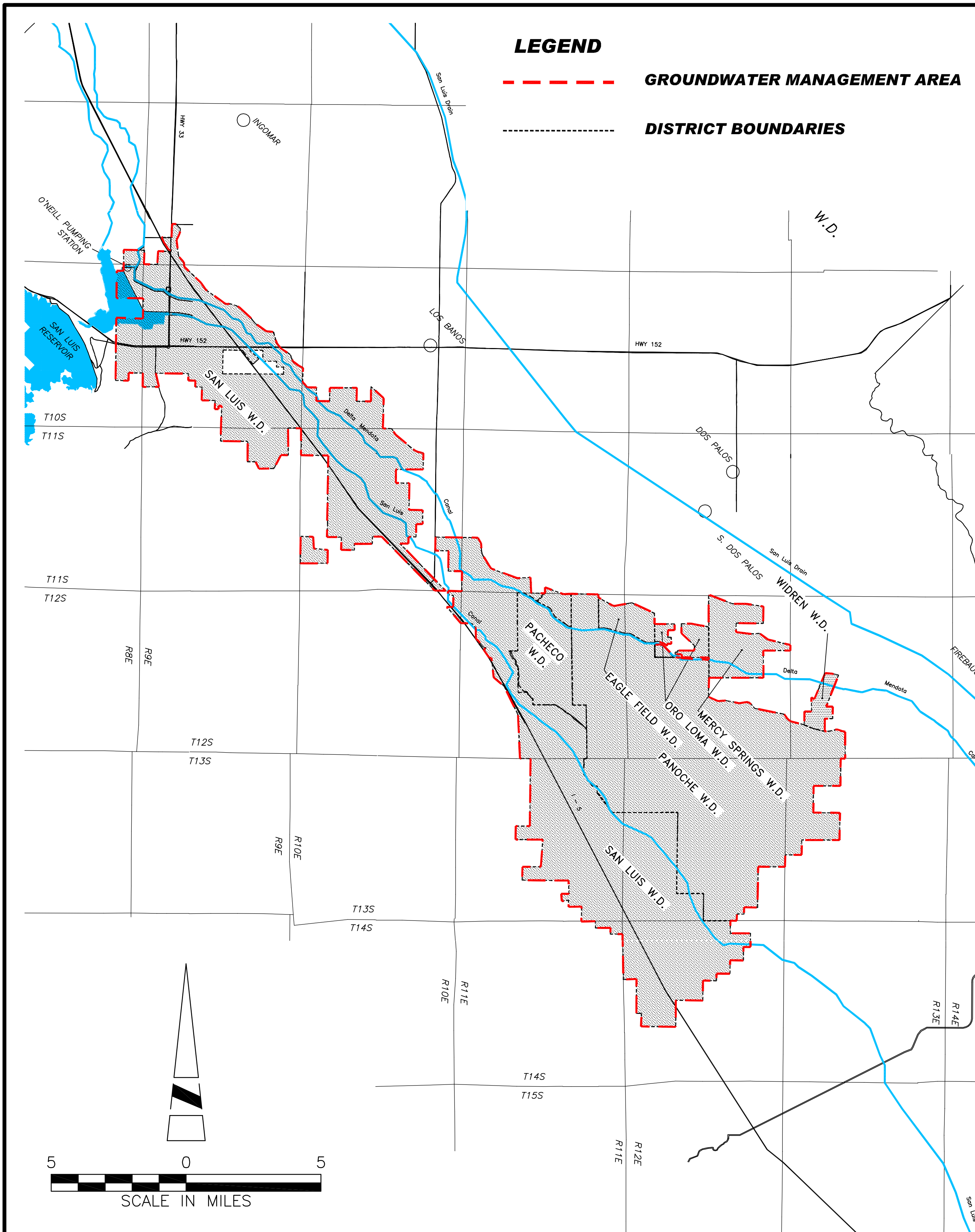

AECOM AECOM USA, Inc. 1120 W. I St. LOS BANOS, CA. 93635, SUITE "C" T 209-826-5155 F 209-826-3307 www.aecom.com	SAN LUIS DELTA MENDOTA WATER AUTHORITY BOUNDARY OF THE GROUNDWATER MANAGEMENT AREA	AECOM PROJECT NO. 60213885	FIGURE 3

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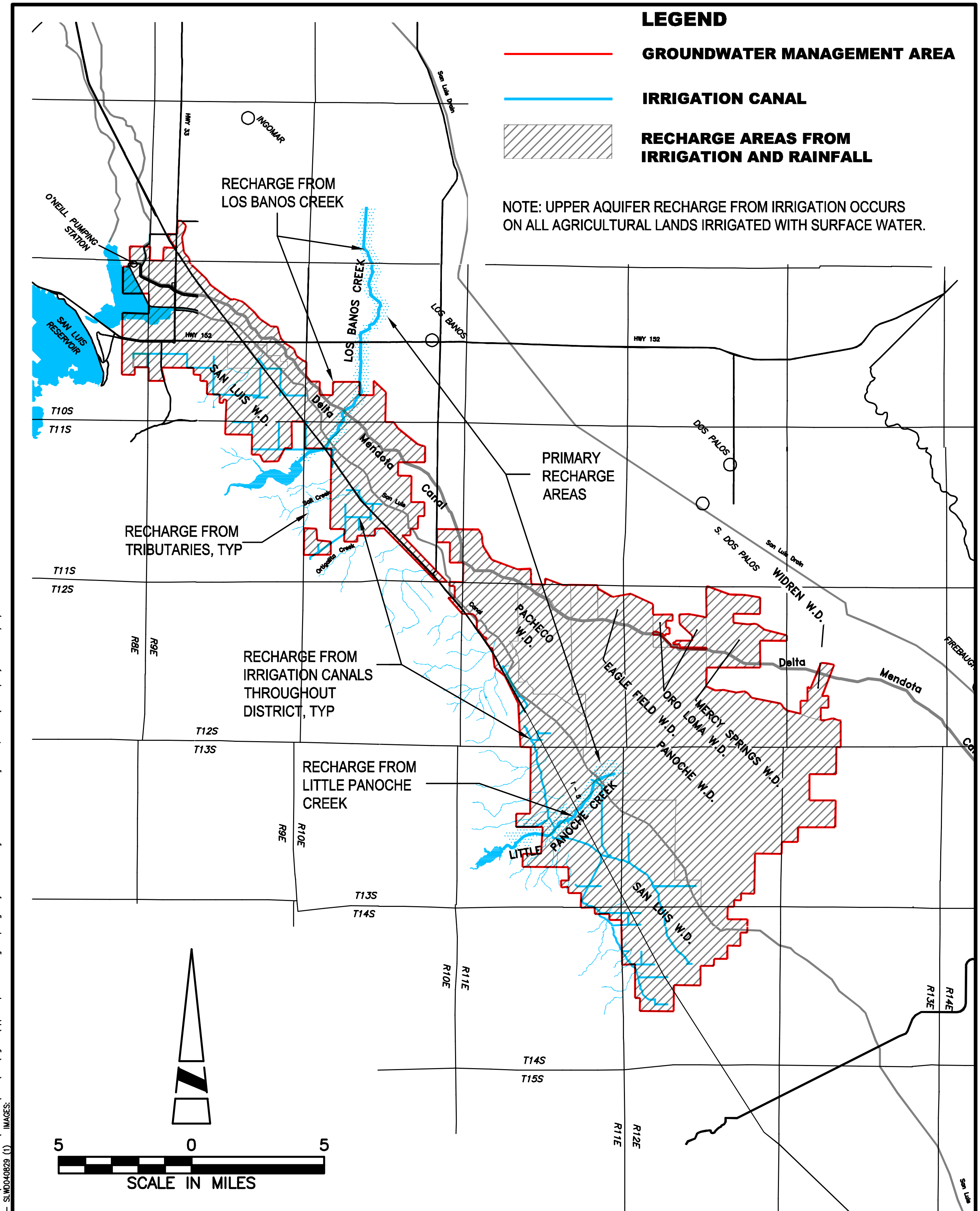

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SAN LUIS DELTA MENDOTA WATER AUTHORITY

UPPER AQUIFER RECHARGE AREA MAP

AECOM PROJECT NO.
60213885/
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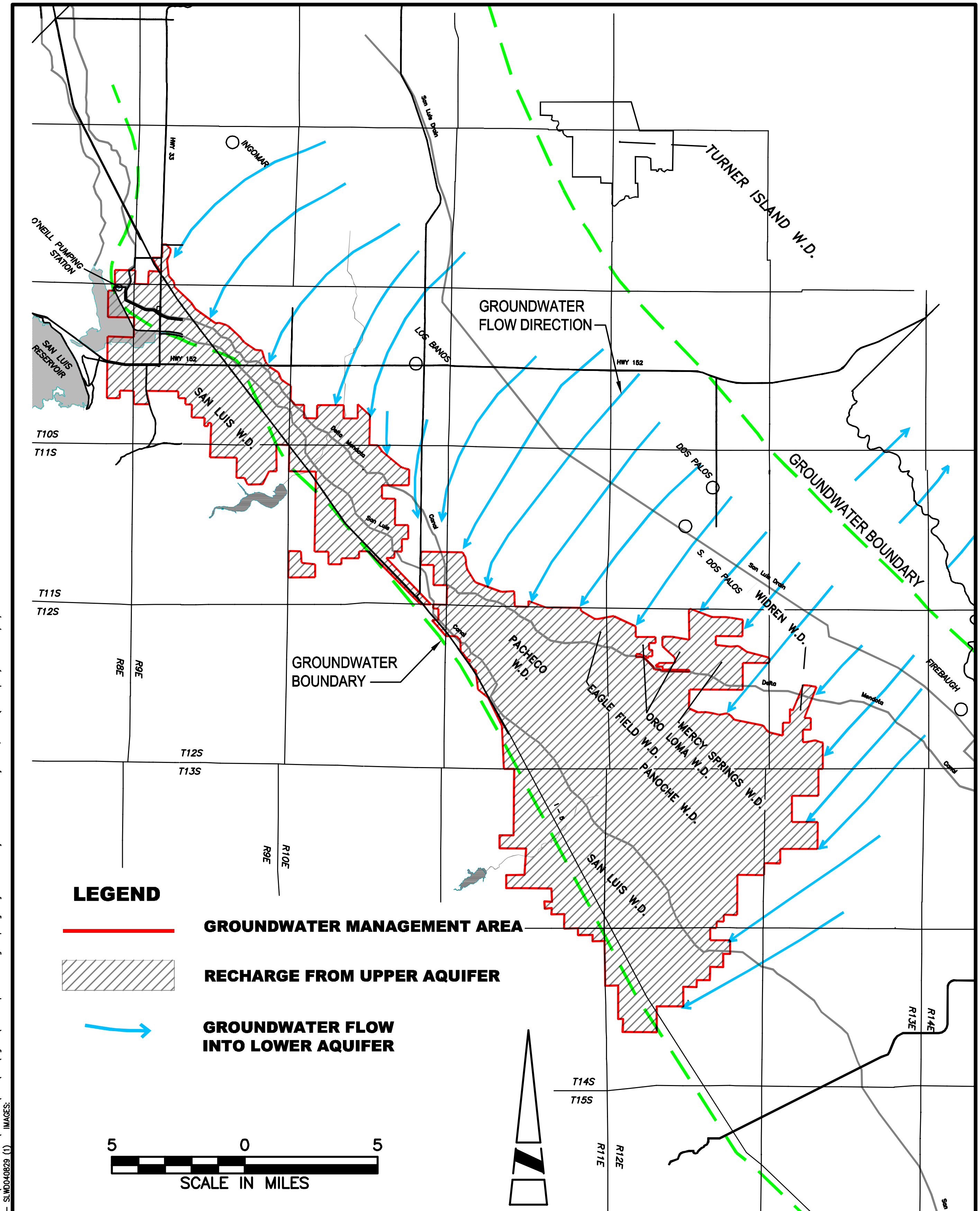
FIGURE 4



DWG: V:\SLDMWA\South GWMP Update 2011\400-Technical\406-Civil\0001\CAD\Figures\Lower Aquifer Recharge Map.dwg Layout Name: Layout3 - Plotted by: Gress, Aaron (Christopher) Date: 12/19/2014 - 8:29 AM
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AECOM AECOM USA, Inc. 1360 E SPRUCE AVE, SUITE 101 FRESNO, CA 93720 T 559-448-8222 F 559-448-8233 www.aecom.com	SAN LUIS DELTA MENDOTA WATER AUTHORITY LOWER AQUIFER RECHARGE AREA MAP	AECOM PROJECT NO. 60213885/ 60337459	FIGURE 5