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

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Section 1 Introduction

The Groundwater Management Act, Assembly Bill 3030 (AB 3030), signed into law in 1992, establishes provisions to allow local water agencies to develop and implement groundwater management plans. The Act provides a systematic procedure for existing local agencies to develop these plans. Amendments to the Water Code Section 10750 et seq., enacted in 2002 through the passage of Senate Bill 1938 (SB 1938) (Stats 2002, Ch 603), require AB 3030 groundwater management plans to contain specific plan components in order to receive state funding for water projects.

The Groundwater Management Plan for the Southern Agencies in the Delta-Mendota Canal Service Area (GMP) is part of the ongoing efforts by the San Luis and Delta-Mendota Water Authority (SLDMWA) and their Participating Agencies (PAs) to manage their limited water resources in the region. It will benefit the residents of the Groundwater Management Area (GMA) that rely on the groundwater resource as a part of their water supply. This GMP provides a mechanism to bridge gaps in and interface between local PAs' programs to support comprehensive regional water resources management in the GMA.

The PAs of the SLDMWA, located in the southern Delta-Mendota Canal (DMC) service area, entered into an agreement under the SLDMWA umbrella to jointly fund the preparation of a coordinated regional plan.

The water needed for agricultural, municipal, and industrial uses within the GMA is obtained from two sources:

1. Imported surface water diverted from the Sacramento/San Joaquin Delta and conveyed through the DMC under the Central Valley Project (CVP), and the California Aqueduct (CA) under the State Water Project (SWP). The DMC and CA provide water for urban use in communities, such as Santa Nella, and for agricultural production.

2. Groundwater, which is used for municipal and industrial purposes, for rural domestic needs, and for agricultural production where the surface water supplies are either not readily available or are insufficient to meet the demand.

In recent years, surface water supplies diverted south from the Sacramento-San Joaquin Delta have been greatly reduced by legal decisions that restrict water exportation to protect endangered species habitat within the Delta. Additionally, during drought conditions CVP supplies are further reduced. Due to these reductions in CVP surface water supplies, many water users must increase groundwater pumping to augment their supplies to meet demands.

Communities that rely on groundwater for their water supply have experienced water quality deterioration over time, while regulations governing domestic water quality have become stricter. This combination has made it increasingly difficult for these communities to find viable groundwater supplies, and has raised serious concerns about the sustainability of groundwater resources to meet domestic demands without expensive treatment.

Proper management of groundwater requires knowledge of the storage, distribution, depletion, and replenishment of the groundwater resource as well as various other local and regional geologic and hydrologic factors. Without such knowledge, the effect of current and future activities on groundwater resources cannot be adequately predicted.

SLDMWA would be responsible under this plan to monitor the regional groundwater conditions within the basin, although water level and water quality monitoring would be conducted by other agencies (the PAs, California Department of Water Resources (DWR), United States Geological Survey (USGS), Counties and Cities). SLDMWA would collect these data from the various agencies in order to evaluate the general condition of the groundwater basin, and to evaluate and promote projects that appear to provide effective and efficient utilization and protection of groundwater resources.

As the PAs have different factors that they must consider with regard to groundwater management, it is very difficult to develop or implement a single set of groundwater management programs that suit the needs of the group as a whole. Rather, it is more efficient, and programs would be better focused, if they were undertaken by each individual agency or group of agencies depending on their specific needs. The PAs can also prepare their own GMP. This regional plan has been prepared to facilitate coordinated regional management of groundwater resources. Each PA will independently adopt the whole plan or portions of it. Implementation of this GMP will provide the means for collection of the necessary groundwater monitoring data needed to assess the impacts of activities that affect the groundwater basin such that sustained use of groundwater can be optimized without adverse impacts to the water quality and yield. Sustainability is the basic goal of groundwater management.

The PAs within the GMA have been involved in and will continue to reserve operational flexibility to engage in transfers of water supplies to qualified purchasers should the circumstances occur where shortages of water have the potential to create hardship in other areas of the region or state that have access to federal water project facilities, and the PAs may have a water supply surplus that can help alleviate the hardship. Prior to undertaking any water transfer program, the PAs will evaluate the economic and environmental impacts of the program. The evaluation may include, but is not limited to, an assessment of water management practices, groundwater storage capacity, and conjunctive use with surface water supplies. These transfer programs may be undertaken to assist other areas in need of water and to benefit the PAs and their consumers, as long as such programs do not:

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

This plan characterizes the groundwater basin, summarizes the existing groundwater management activities in the GMA, identifies management objectives, develops the relative elements of the GMP, and provides recommendations for project implementation.

Section 2
The Groundwater Management Area

The DWR Bulletin 118 Update 2003, for planning purposes, divides California into 10 hydrologic regions (HRs) that generally correspond to the State's major drainage areas (DWR, 2003). HR boundaries are shown in Figure 1. The San Joaquin River HR is further divided into subbasins largely based on political considerations for groundwater management purposes (Figure 2). The area included in this GMP comprises portions of the Delta-Mendota Subbasin of the San Joaquin River HR and the Westside Subbasin of the Tulare Lake HR, and lies within Merced and Fresno Counties. In the north the GMA is bounded by Santa Nella County Water District, Del Puerto Water District, and Central California Water District extending as far north as Fahey Road near SR-33 in Merced County. In the south it is bounded by Westlands Water District extending as far south as the alignment for West Jensen Avenue near Interstate 5 in Fresno County. In the west it is extends beyond Interstate 5 to near the base of the Coast Ranges. In the east it is bounded by the Central California Irrigation District and Firebaugh Canal Water District extending generally towards the Outside Canal. The GMA encompasses approximately 125,000 acres. Figure 3 shows the boundaries of the GMA.

The GMA includes the following agricultural water supply districts: Pacheco Water District, Panoche Water District, Eagle Field Water District, Oro Loma Water District, Widren Water District Mercy Springs Water District, Broadview Water District and San Luis Water District. The GMA also contains portions of the community of Santa Nella as well as several unincorporated communities. Santa Nella County Water District is not participating in this GMP at this time.

A list of the current PAs involved in the GMP is given in Table 1.

Table 1
List of Agencies Participating in the Groundwater Management

Water District:

- Pacheco Water District
- Panoche Water District
- Eagle Field Water District
- Oro Loma Water District
- Widren Water District
- Mercey Springs Water District
- Broadview Water district
- San Luis Water District

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, alfalfa, corn, grapes, walnuts, almonds and oranges. A number of small rural communities, as well as some large municipalities exist within the San Joaquin Valley. The largest of these communities is Fresno, which has a population of nearly a half of a million people. The majority of the 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 through out the San Joaquin Valley.

Within the GMA, the majority of the current land use is agricultural, with irrigated crops, dairies and rangeland. No municipalities lie within the GMA. However, the municipalities of Los Banos, Dos Palos, Firebaugh, and Mendota lie within a few miles of the GMA, as well as a number of unincorporated communities. One unincorporated community lies within the GMA, the community of Santa Nella at the northern end of the GMA. Major Federal and State water conveyance systems, the California Aqueduct (CA) and the Delta-Mendota Canal (DMC), lie within the GMA.

The beneficial uses of groundwater in the GMA are predominantly for agriculture and related industry, and domestic potable water. Groundwater is generally used conjunctively to supplement surface water supplies that support the water needs in the GMA.

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 confluence of the Sacramento and San Joaquin Rivers ("the Delta"). The Great Valley opens to the San Francisco Bay west of this 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, 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 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 California Aqueduct, the DMC, and a number of smaller canals 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° Fahrenheit (°f) to 79°f, and the mean annual lows range from about 48°f to 50°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 13 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 can vary. Three representative weather stations, with long documented histories, have been chosen to demonstrate the range of climatic conditions within the GMA. The City of Los Banos (Los Banos) lies within less than 10 miles of much of the northern portions of the GMA, east of the furthest northern boundary of GMA 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. The City of Mendota lies within less than 10 miles southeast of the furthest eastern boundary of the GMA. The recent climatic history recorded for each location is presented below:

- Los Banos:

  Between 1948 and 2005, the average monthly high temperature of 96.2 °f was in July, and the average monthly low temperature of 36.1°f was in December (WRCC, 2006a). Los Banos averages about 96 days per year with high temperatures above 90°f, and 28 days per year with low temperatures below 32°f. The hottest day on record was 114°f on June 30, 1950, and the coldest was 14°f on January 11, 1949.

  The average annual rainfall was 9.43 inches. The highest annual rainfall was 21.80 inches in 1998, and the lowest annual rainfall was 5.24 inches in 1989. The maximum-recorded rainfall over a 24-hour period was 2.25 inches on September 30, 1983. Annually, Los Banos experiences, on average, about 48 days with precipitation greater than 0.01 inches, 26 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°f was in July, and the average monthly low temperature of 36.1°f was in December (WRCC, 2006b). Little Panoche Detention Dam averages about 85 days per year with high temperatures above 90°f, and 24 days per year with low temperatures below 32°f. The hottest day on record was 111°f on July 16, 1972, and the coldest was 21°f on December 21, 1968.

The average annual rainfall was 7.37 inches. The highest annual rainfall was 10.01 inches in 1969, and the lowest annual rainfall was 5.15 inches in 1971. The maximum recorded rainfall 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, 2006c).

The average annual rainfall was 7.98 inches. The highest annual rainfall was 12.49 inches in 1958, and the lowest annual rainfall was 3.80 inches in 1953. The maximum recorded rainfall 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 Detention Dam	Mendota Dam
Peak Month Average High-Temperature	°f	96.2	95.1	--
Peak Month Average Low Temperature	°f	36.1	36.1	--
Hottest Recorded High Temperature	°f	114	111	--
Coldest Recorded Low Temperature	°f	14	21	--
Average Number of Days Above 90°f		96	84.5	--
Average number of Days Below 32°f		28	0.1	--
Average Annual Rainfall	Inch	9.43	7.37	7.98
Highest Annual Rainfall	Inch	21.80	10.01	12.49
Lowest Annual Rainfall	Inch	5.24	5.15	3.80
Maximum 24-hour Rainfall	Inch	2.25	1.71	1.66

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 Range and the Sierra Nevada Mountains, these sediments are overlying older marine sediments. The Valley fill reaches a thickness of about 28,000-feet in the southwestern corner (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. The Calaveras/San Andreas Fault system lies about 25 miles west of the GMA.

The water bearing geologic formations within the GMA 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 to about 3,000 feet along the trough of the valley east of the GMA (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 Range in the west towards the trough of the valley. The Tulare Formation can range up to greater than 1,400 feet in total thickness (DWR, 2006). The E-Clay or Corcoran Clay occurs within 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 of upper layer of the Tulare formation 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 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 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 the impacts of 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.

3.4.2 Confining Layers

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 member of the formation 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 the E-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. Other, less-extensive, younger, continuous fine-grained lacustrine layers also exist at depths shallower than the Corcoran Clay. However, these other lacustrine layers do not appear to extend into the GMA.

Terrace deposits of Pleistocene age lie along the western edge of the GMA 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, 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.

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 Confined Aquifer

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

3.5 Hydrology

The following sections discuss the surface and groundwater hydrology of the area. Hydrologically, the GMA has inflow from outside bringing water supplies into the area. Inflows include diversions into the GMA from the San Joaquin River, the streams and channels conveying storm runoff from the east side of the Coast Range Mountains, the network of canals conveying surface water south from the Delta, subsurface groundwater flowing in from the southwest, and precipitation. Outflows from the GMA include surface runoff to the San Joaquin River, groundwater flow moving towards the trough of the valley and exiting the GMA, groundwater discharged to the San Joaquin River system, evaporation, canals and drainage ways conveying water outside the GMA, and crop and phreatophyte evapotranspiration.

3.5.1 Surface Hydrology

Streams flowing from the Sierra Nevada and Coast Range mountains drain into the northern two-thirds of the San Joaquin Valley, empty into the San Joaquin River and drain 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 the flooding. The majority of the runoff that drains into the San Joaquin River is derived from the rainfall and snowmelt from the western side of the Sierra Nevada Mountains. These rivers typically drain southwest to west out of the Sierra Nevada Mountains, turning north at the trough of the valley floor, where the San Joaquin River is located.

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 and temporary surface water being conveyed to other locations.

Consistent with most of the San Joaquin Valley, within the GMA, 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 from the east side of the Coast Range Mountains. These streams include: San Luis Creek, Los Banos Creek, Salt Creek, Ortigalita Creek, Laguna Seca Creek, Little Panoche Creek, and numerous smaller creeks and drainage. Some areas along the south central to eastern side of the GMA 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.

Besides the natural water conveyance systems, some major canals convey water from the Delta, to and through the GMA. These canals include the California Aqueduct and the DMC. Other smaller canals in the network convey surface water supplies to the users and drain runoff from areas within the GMA. The DMC is a major water supply source to the GMA.

3.5.2 Subsurface Hydrology and Hydrogeology

The GMA 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 consist of unconsolidated sediments derived primarily from the Coast Ranges. Groundwater occurs in three water-bearing zones (DWR, 1981). Much of the GMA 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 elevation to which water rises in a well that taps a semiconfined zone is the water table. The elevation of the water table represented by the static groundwater levels in wells completed to shallower depths may not be the same as the static levels in deeper wells. This is due to numerous fine-grained beds of variable thickness that exist in the semiconfined zone, as discussed above. These fine-grained sediments restrict the vertical movement of water. The elevation to which water rises in a well that taps a confined aquifer is its potentiometric surface. The potentiometric surface in a confined aquifer is an imaginary surface representing the confined aquifer pressure.

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 boundary. In the confined zone beneath the Corcoran Clay, water tends to move southwesterly into the GMA.

Historically, irrigation of lands in the GMA accounts for most of the recharge of the 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 canals and creeks. Occasional recharge may enter the GMA from the Coast Ranges to the west, but is not well quantified. Recharge to the lower confined zone occurs primarily from leakage from the unconfined zone through the Corcoran Clay and a variable amount of inflow from the east. Groundwater pumping from below the Corcoran Clay increases the leakage through the clay layer and subsurface inflow. Groundwater pumping in the northern and southern portions of the GMA occurs primarily from above the Corcoran Clay. In the central portion of the GMA, pumping is primarily from below the Corcoran Clay.

For comparison, Figures 4, 5, 6 and 7 show lines of equal elevation of groundwater for selected wells during the spring of 1996, 2000, 2004, and 2008. The direction of groundwater flow throughout the study area is generally northeast towards the San Joaquin River.

As a part of this planning effort, changes in groundwater levels were examined between Spring 1996 and Spring 2008. In general groundwater levels have appeared to fluctuate repeatedly between 1996 and 2008, though the average groundwater depth across much of the GMA appears to be about the same over the entire period. Periodic groundwater depressions were observed occurring between 1996 and 2008 along the DMC in the San Luis Water District southwest of the City of Los Banos, and between the northern end of the Pacheco Water District and Widren Water District. Periodic groundwater mounds consistently appear to occur near SR-33 and I-5 east of the San Luis Reservoir during the period from 1996 through 2008. The influence of pumping throughout the GMA and groundwater recharge in the vicinity of the San Luis Reservoir are observable throughout the period of 1996 through 2008 (Figures 4, 5, 6 and 7).

From 1996 through 2000, the groundwater levels appeared to generally rise slightly throughout most of the GMA (Figure 8). However, in the southern portions of San Luis Water District extending across the central portions of Panoche Water District towards Widren Water District, and the eastern portions of Broadview Water District water levels appear to have declined. Some of the change in water levels observed appear to be related to pumping depressions encountered during the Spring 1996. These depressions were located near the San Luis Canal northwest of the Mercey Springs Road bridge, south of the DMC near the boundary of the Panoche and Pacheco water districts, and further southwest into the Panoche Water District near the boundary between Range 11E and 12E.

The general trend in groundwater levels appears to have reversed across much of the GMA between the 2000 and 2004, except in the northern portions of San Luis Water District north of the San Luis Canal and Forebay, and portions of the district southwest of Los Banos (Figure 9). It is notable that more pumping depressions are observable in central Panoche Water District northwest to the border of Panoche and Pacheco water districts. Additionally, there is a notable depression occurring in the southwest corner of Broadview Water District near Panoche Water District, and along the Delta Mendota Canal between Pacheco and Widren water districts

The general pattern appears to have reversed again across much of the GMA between 2004 and 2008. Groundwater levels appear to have generally declined over that period (Figure 10), except along the western boundary of the southern portions of San Luis Water District extending across the central portions of Panoche Water District towards Widren Water District, and the eastern portions of Broadview Water District where water levels appear to have risen. The depression located in the southwest corner of Broadview Water District near Panoche Water District continued to be observed and has declined further. The groundwater levels in the northern end of San Luis Water District appear to have declined substantially between 2004 and 2008.

3.6 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 irrigation and natural sources of recharge, and the 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 semiconfined zone of the northern part of the GMA, 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 semiconfined zone of the southern part of the GMA, 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, 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 are sparse; therefore, a definitive groundwater quality picture of the portions of the GMA 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 demonstrates the need to establish a groundwater quality monitoring program in the GMA.

3.6.1 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. Within the eastern portions of the GMA, shallow groundwater frequently occurs within 20 feet below the ground surface. 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.

The San Joaquin District of the California Department of Water Resources (DWR-SJ) samples 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. Electrical Conductivity (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 ion within the solution. EC and Total Dissolved Solids (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 Panoche Water and Drainage District's (PWDD) Water Conservation Plan (Stoddard, 2008), PWDD 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 along the eastern side of the GMA. A summary of the results for some key analysis in drainage water is presented below in Table 3.

Table 3
Chemical Analysis of Selected Constituents in Drainage Water

State Well No.	Sampling Date	EC (µmhos/cm)	Boron (mg/L)	Selenium (µg/L)
DP-30	10/15/2008	5300	10	63
DP-31	10/15/2008	9100	17	510
DP-40	10/15/2008	7900	10	470
DP-41	10/15/2008	8700	15	810

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. In addition, the very high electrical conductivities suggest a high concentration of soluble salts in the water.

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.

3.6.2 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 Standards (WQS) (USBR, 2008). The water quality standards utilized include the following constituents and MCLs:

- Boron (700 µg/L),
- Chromium, total (50 µg/L)

- Mercury (2 µg/L)
- Molybdenum (10 µg/L)
- Nickel (100 µg/L)
- Nitrates (45 µg/L)
- Selenium (2 µg/L)
- Specific Conductance (1,230 µS/cm)
- Total Dissolved Solids (800 mg/L)
- Chlorpyrifos (0.025 µg/L)
- 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

			Lower Zones				
State Well No.	**Sampling Date**	**EC (µmhos/cm)**	**TDS**	**Nitrate**	**Boron**	**Arsenic**	**Selenium**
			(mg/L)			(µg/L)	
	8/28/2008	557	317	--	0.4	--	0.2
	4/21/2008	1300	760	--	0.8	--	1.2
	3/19/2008	1000	640	18	0.7	--	0.7
	3/18/2008	1000	630	32	0.6	--	0.5
	1/11/2008	1200	830	--	0.8	–	2.0
	9/21/2007	2800	580	--	4.3	–	9.0
	6/16/2008	1800	1200	<1.0	2.9	--	0.5
	8/8/2008	2500	1500	20	2.3	--	5.1
	8/8/2008	–	1500	<1.0	3.6	--	0.2
	6/16/2008	2200	1500	<1.0	3.0	–	0.5
	6/18/2008	2200	--	10	3.0	5.0	--
	6/11/2008	1900	1300	--	3.2	--	0.2
	6/19/2008	1900	--	<1.0	2.7	9.2	–
	6/16/2008	800	470	10	2.6	--	--
	6/18/2008	1900	--	<1.0	2.4	10.0	--
	6/19/2008	2300	--	<1.0	2.4	20.0	--
	6/16/2008	1900	1300	5.1	2.2	--	0.2
	7/24/1997	2100	1200	--	3.4	--	14.0
	6/16/2008	1800	1300	<1.0	2.5	--	1.3
	8/8/2008	--	1400	<1.0	--	--	2.0
	6/11/2007	2800	2300	--	2.4	--	--
	8/28/2008	625	353	--	--	--	--

During 2007 to 2008, results of water quality analyses of deep water samples from pumping wells in the Northwestern part of the GMA, north of the Mercey Springs Road crossing, showed:

- Specific Electrical Conductivity (SEC) ranged from 557 to 2,800 µmhos/cm,

- Total Dissolved Solids (TDS) concentrations range from 317 to 830 mg/L,

- Boron concentrations range from 0.4 to 4.3 mg/L,

- Nitrate concentrations range from 18 to 32 mg/L,
- and Selenium concentrations range from below detection limits of 0.4 to 9.1 µg/L.

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

- SEC ranged from 1,800 to 2,500 µmhos/cm,
- TDS ranged from 470 to 1,500 mg/L,
- Boron ranged from 2.2 to 3.6 mg/L,
- Nitrate ranged from below detection limits of 1.0 to 20 mg/L,
- and Selenium ranged from below detection limits of 0.2 to 14.0 µg/L.

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

- SEC ranged from 1,800 to 2,800 µmhos/cm,
- TDS range from 1,400 to 2,300 mg/L,
- Boron range from 2.4 to 2.5 mg/L,
- Nitrate was below detection limits of 1.0 mg/L,
- and Selenium was 2.0 µg/L.

In general the sample results appear to indicate TDS, SEC, Boron, and Selenium concentrations increasing towards the eastern end of the GMA. Total Dissolved Solids and Boron in samples collected east of Mercey Springs Road appears to consistently be above the WQS MCLs. Selenium appears to occur intermittently throughout the GMA at levels above the WQS MCL. Nitrate appears to occur intermittently throughout the GMA, but at levels below the WQS MCL.

Recently, the federal primary drinking water standard 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 (DHS, 2006). 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. Testing of water quality analysis samples for Arsenic was conducted on only a limited number of samples collected from the North Central GMA, west of Russell Avenue, Arsenic ranged from 5 to 20 µg/L. Of the 4 samples analyzed for arsenic, one was above the MCL and one was at the MCL.

The current MCL for Selenium in drinking water is 50 µg/L. The MCL for Nitrate in drinking water is 45 mg/L. None of the samples analyzed exceeded the MCL for Selenium or Nitrate.

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

Section 4
Management Objectives

As it was stated before, typically, this regional program will rely on the PAs to develop the specific programs and projects 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:

- 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.
- Attempt to maintain general continuity with past and current 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 to protect the groundwater resources. Previous activities within the GMA 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 necessary monitoring data needed 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.

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, identify elements to be included in potential programs, and briefly describe the related activities within the GMA.

5.1 Components Relating to Groundwater Level Management

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.

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

In order to reduce the demand for groundwater supplies SLDMWA has undertaken long term, multiple year, agreements for water transfers from agencies outside the GMA. 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 on an as needed basis as available.

5.1.2 Increase Use of Available Surface Water Supplies

There are some in-basin water transfers and purchases from agencies to others with limited water rights overlying areas having more depressed groundwater levels.

Activities within the GMA:

No water transfers within the GMA 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 impacts 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 does not appear to be occurring, conditions of localized overdraft may occur, 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 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:

The programs described in 5.1.1 and 5.1.2 above.

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 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, pumping takes place primarily from the confined zone, while unoccupied aquifer storage is 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 recent history in the GMA, conjunctive use has been practiced in an unmanaged fashion. When full CVP water supplies are being received, relatively little pumping occurs. During the water short periods of 1976-1977 and 1986-1992, water was withdrawn from the aquifer to make up for the deficits in surface water supply.

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

a. No efforts have been considered to develop or implement a conjunctive use program within the GMA. The groundwater in the GMA is generally of poor quality for beneficial use as agricultural and potable water supplies, in particular the very shallow, very poor, perched groundwater encounter in much of the GMA. Additionally, perched groundwater must typically be removed to properly utilize the land for agriculture. It is recognized that pumping primarily from the deeper confined aquifer may have the advantage of potentially increasing the depth to the shallow groundwater. However, it also risks further degrading the deeper water.

b. 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 assists in making 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. 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 to groundwater.

From the hydrologic system perspective, the water conservation efforts must be planned locally, taking into account groundwater levels, groundwater quality, and groundwater supply.

Activities within the GMA:

a. Many of the PAs have completed agricultural water conservation plans and periodically update the plans pursuant to the Central Valley Project Improvement Act. 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 conservation plans have helped the districts identify the opportunities for better irrigation water utilization.

5.1.6 Replenishment of Groundwater Extracted by Water Producers

The hydrologic balance included in the previous GMP, suggests that lowering the groundwater levels increases sustainable yield, since subsurface outflow is reduced which counteracts the water extracted. More data and analysis is needed to confirm this finding and to determine the level of pumping that can be sustained without overdraft. As urban areas develop and there is a corresponding shift from surface water use to groundwater use, groundwater use increases and aquifer recharge decreases. Judging by the water resources balance, the GMA should be able to absorb the increased extraction to supply urban demand and maintain a balance notwithstanding large changes in surface water delivery, the potential for localized overdraft caused by concentrated pumping, and water quality limitations. It appears that the natural response of the aquifer to limited increases in pumping will provide for replenishment.

5.2 Components Relating to Groundwater Quality Management

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, the vertical and lateral groundwater flow directions, and groundwater quality based on the various groundwater monitoring activities supporting this program. The PAs shall make the appropriate regulatory agencies 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:</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 regularly collects data and monitors public drinking water supplies as part of the State Drinking Water Program. Data is 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 purposes are 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 (SWRCB, 2009). 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.

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, 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. Without a means to remove the accumulated salts, the salts remain in the basin and ultimately increase the salinity of the groundwater.

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 zones and the better quality water in the deeper zones. In the GMA, the best quality water typically occurs in the confined zone just below the Corcoran Clay.

While it is recognized that there is the potential for groundwater quality degradation to be slowly occurring due to the regional downward movement of surface salts, upwelling of deep saline groundwater may also be occurring. Both downward and upward migration may be accelerated due to increased groundwater pumping. During the 1976-1977 and 1986-1992 drought periods there were substantial increases in groundwater pumping that may have caused further water quality degradation (Stoddard, 1996).

To maximize the sustainability of the groundwater basin, 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 uses are protected. 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 via some type of drainage program to export salts to provide a balance with imported salts.

Activities within the GMA: currently there are no related programs within the GMA.

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."*

The California's Drinking Water Source Assessment and Protection (DWSAP) Program has been prepared in response to the 1996 reauthorization of the federal SDWA, which included an amendment requiring states to develop a program to assess sources of drinking water and encourages states to establish protection programs. The Department of Health Services (DHS) Division of Drinking Water and Environmental Management is the lead agency for development of the DWSAP Program and its implementation. Since California has not developed a wellhead protection program, the groundwater portion of the DWSAP will serve as the State's wellhead protection program (DHS, 1999).

According to the California Water Plan Update 2005 (DWR, 2005), 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 the primary source of recharge is from percolation of excess irrigation water. Incidental recharge sources include seepage losses from canals and ditches and from the westside streams that flow intermittently during the rainfall season. 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 for such facilities and Tentative Waste Discharge Permits issued by the RWQCB should be closely reviewed such that appropriate monitoring and mitigation measures are developed to preclude the possibility of migration of pollutants from the disposal sites. PAs should be on the lookout 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: Through programs administered by RWQCB, the California Integrated Waste Management Board (CIWMB) and the Department of Toxic Substances Control, the State of California regulates waste disposal. The PAs will rely on continued regulation by the State; however, the PAs will assist the State by identifying areas that are threatened or are the most 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 DHS. Permit fees are normally required.

Activities within the GMA: 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 and cities within the GMA have the fiduciary responsibility to enforce well construction standards. 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.

The environmental health divisions of the respective counties maintain records on wells and groundwater quality because of their responsibility to enforce standards for construction and abandonment of wells, and for issuance of drinking water permits for small community water supply systems. These data are publicly available and should be collected to incorporate into regional monitoring. It should 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.

Activities within the GMA: Merced and Fresno Counties have adopted the DWR standards. The authority over well construction remains with the respective counties and cities. 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 counties and cities for regulation of land uses within their boundary or sphere of influence to create a quality of life and to achieve compatibility between man's 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.
- Monitoring water quality and groundwater levels.
- Providing planning for proper disposal of solid waste, sanitary waste and storm runoff, and hazardous wastes generated by the community.
- Matching projected growth in water consumption to available water supplies.
- 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, close coordination between agencies is needed. During periodic land use plan preparation and updates, cities or 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 the groundwater basin. Proposed land use plans and supporting environmental documentation should be reviewed and commented upon by the PAs.

5.2.7 Construction and Operation of Groundwater Management Facilities

Groundwater management plans can include projects that protect the quality of groundwater and assures 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 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:

Currently, the Panoche Water and Drainage District and the San Luis Water District both are contemplating the development of a variety of well facilities to pump groundwater into their surface water distribution systems. These facilities might potentially allow the PAs to pump groundwater and transfer water from areas where less impact from dry period pumping has occurred to areas where there is demand. Thus offsetting groundwater pumping in seasonally overdrafted areas.

5.3 Components Relating to Inelastic Land Surface Subsidence

Reducing the amount of groundwater in storage by pumping could 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 the land subsidence should 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.
- Identify management measures that may be employed to minimize the subsidence.

Activities within the GMA:

No management activities have been undertaken by SLDMWA to control or mitigate subsidence caused by deep groundwater pumping in the GMA beyond occasional measurement of benchmarks and level loops to monitor local impacts of land subsidence.

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 monitoring programs.

Activities within the GMA:

The current and planned actions within the GMA related to recharge and conjunctive use are detailed in previous sections. As discussed above, shallow, perched, very poor quality groundwater occurs across much of the GMA, and in many locations must be drained to utilize the overlying lands for crop production. 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 Program and Monitoring Protocols

6.1 Groundwater Monitoring Program

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 determine 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. Monitoring and mapping should be done independently in the unconfined and confined zones.

The monitoring program for this plan would rely on data collected by agencies like DWR, USGS, DHS, SLDMWA, PAs, Counties, and local Water Districts. Groundwater levels and groundwater quality data would be reviewed individually or as a group during the PAs meetings, and the PAs would decide if additional monitoring programs are necessary to supplement information for areas where existing data indicates possible overdraft or water quality issues.

The agencies that collect groundwater data for this area are the following:

- DWR

  The DWR measures groundwater levels in monitoring wells, and develops databases for groundwater levels. Statewide groundwater level data are available for download at the Department's Groundwater Level Database website (http://wdl.water.ca.gov/). 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 maintains groundwater level information for nearly 18,000 wells within the San Joaquin District boundary and about 60,000 wells statewide.

  Additionally, DWR conducts regular groundwater measurements of monitoring wells established along the alignment of the San Luis Canal. Information may be obtain from the San Luis Division of DWR.

- USGS

  The USGS Ground-Water Data for the Nation database (http://waterdata.usgs.gov/nwis/gw) contains groundwater site inventory, groundwater level data, and water quality data. 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 this GMA is not updated.

- 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). Statewide, the GAMA Program was 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 early 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.

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 will be conducted for each unit:

a. The assessment of current groundwater quality.

b. The detection of changes in water quality.

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

To facilitate a statewide, comprehensive groundwater quality-monitoring and assessment program most efficiently, uniform and consistent study-design and data-collection protocols are being applied to the entire state. The GAMA Program monitors groundwater for a broad suite of chemicals at very low detection limits, including exotic chemicals such as wastewater chemicals and pharmaceuticals. Monitoring and assessments for priority groundwater basins are to be completed every ten years, with trend monitoring every 3 years. Sampling for the GAMA Program is currently scheduled for the Western San Joaquin Valley Unit to begin sometime in 2009. More information about this program and the status of the research is available at http://www.swrcb.ca.gov/gama/ or http://ca.water.usgs.gov/gama/.

- DHS - Division of Drinking Water and Environmental Management

Every public water system in the State has to have the analyzing laboratory enter the results of 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, DHS does not provide the coordinates of each well included in the database. However, a lot of general vicinity locational information is easy to deduce from names of the water systems.

- SLDMWA

  Currently, only the groundwater levels are monitored regularly within the GMA by the various PAs. (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 Panoche Water District maintains a database of groundwater information available from a number of wells, which are routinely monitored seasonally, 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).

- Westlands Water District

  The Westland Water District maintains a database of groundwater information available from a number of wells, which are routinely monitored seasonally, within the Broadview Water District. An appointment is necessary to review the available information. (Contact: Dennis R. Loyd , Phone: 209-241-6245, Email: dloyd@westlandswater.org).

6.2 Monitoring Protocols

SB 1938 requires the adoption of monitoring protocols in order to collect the groundwater data in a systematic and consistent manner. For this GMP, monitoring protocols would be defined based on goals of particular programs. Under the auspices of the GMP, SLDMWA has the responsibility of monitoring of groundwater within the GMA. To meet this responsibility SLDMWA conducts monitoring activities, coordinates efforts with PAs, and gathers information from PAs and other agencies. Some of the efforts that SLDMWA is in the process of coordinating with PAs throughout the GMA includes the development of standardized collection techniques for groundwater level monitoring, groundwater quality sample collection, preparation, chain-of-custody, laboratory procedures and methods, and data validation procedures in an established QA/QC program for the PAs. SLDMWA, through consultation with the PAs, will develop a framework for analysis of data and dissemination of the results.

Section 7 Implementation of the Groundwater Management Plan

GMP 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 is 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 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, the PAs can be generally separated into four categories:

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

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

c. Agricultural water users that rely on groundwater for supplemental supply.

d. 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 dollars in 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. 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:

a. After public review and consideration of comments received, the final plan should be adopted by each agency.

b. The SLDMWA will coordinate plan implementation among the PAs.

c. A plan implementation committee made up of representatives of each PA will meet twice a year to review particular projects being implemented or considered by the PAs, and coordinate these projects under the regional GMP. The groundwater level and quality data, collected and analyzed, would be reviewed with the group at these meetings.

d. With consideration given to the identified problem areas, the committee shall establish a priority list for management actions.

e. Management activity groups will be formed of those participating agencies interested in implementing certain elements of the groundwater management plan to identify specific management actions, develop budgets, and apportion costs.

f. Once a year, the PAs would submit a report to the SLDMWA summarizing their programs under each plan component for consideration by the SLDMWA and for coordination purposes.

g. 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.

This implementation strategy is expected to be refined as necessary by the management committee.

Section 8
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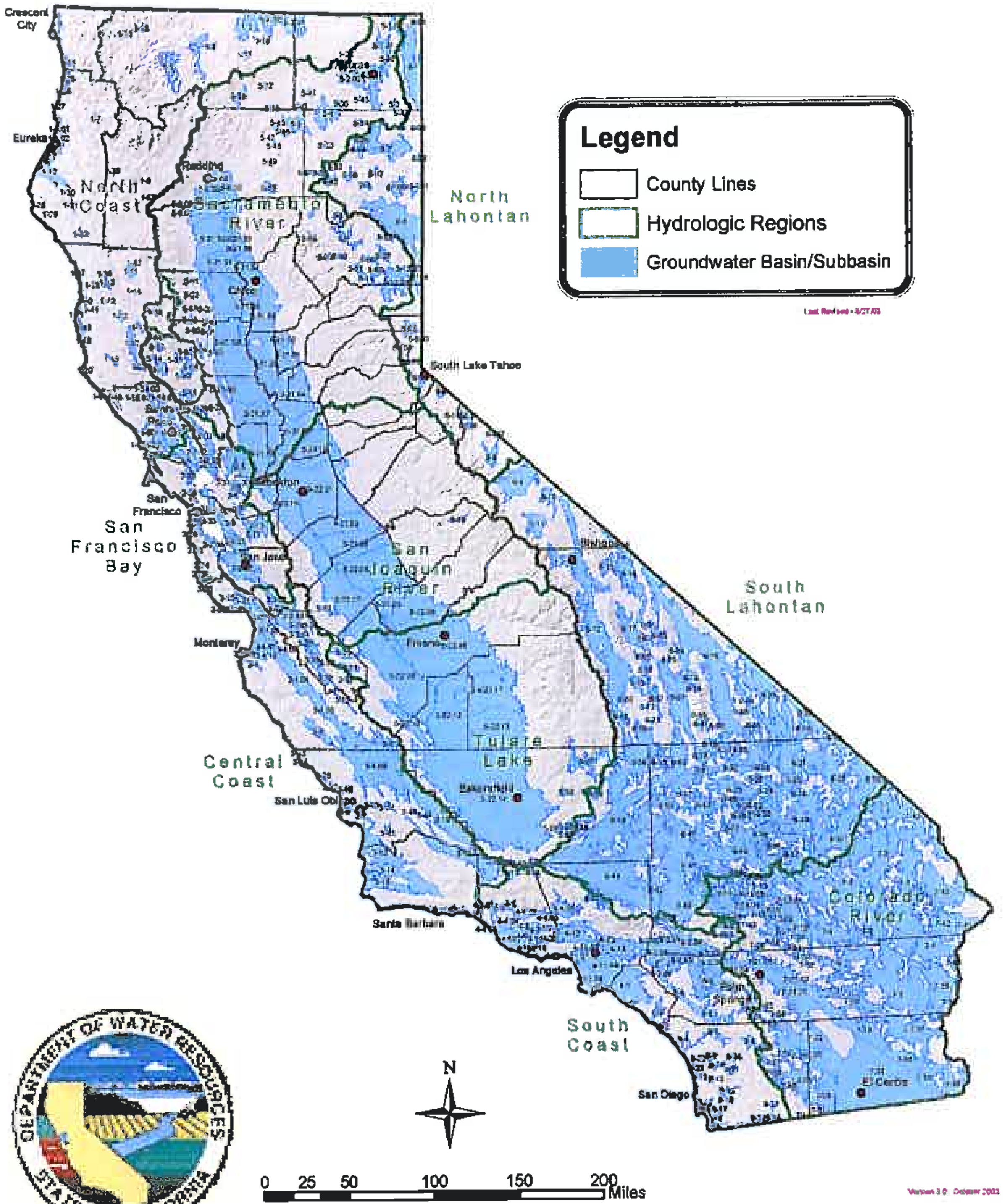
Groundwater Basins in California



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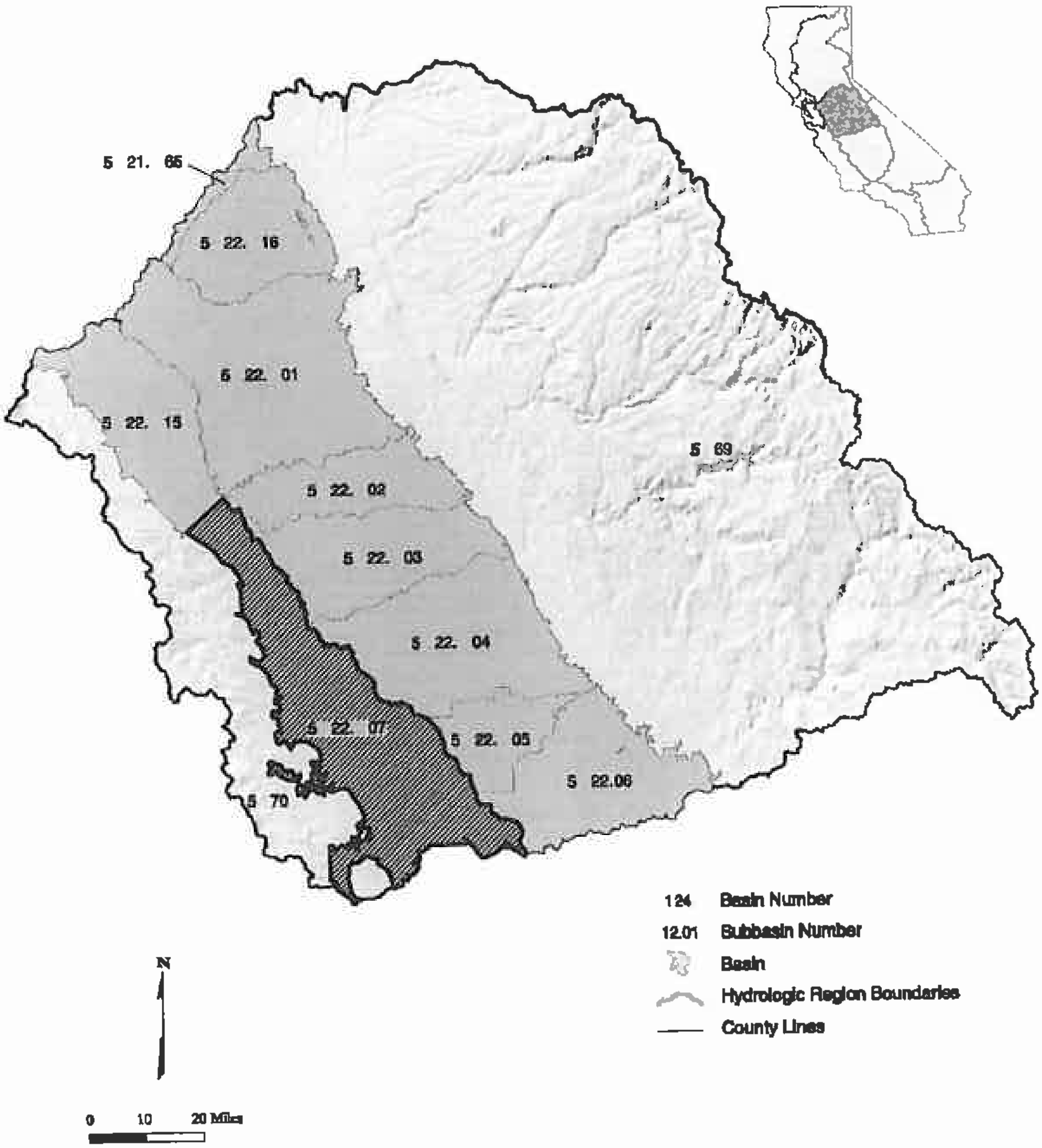

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SUB-BASINS OF THE SAN JOAQUIN RIVER HYDROLOGIC REGION

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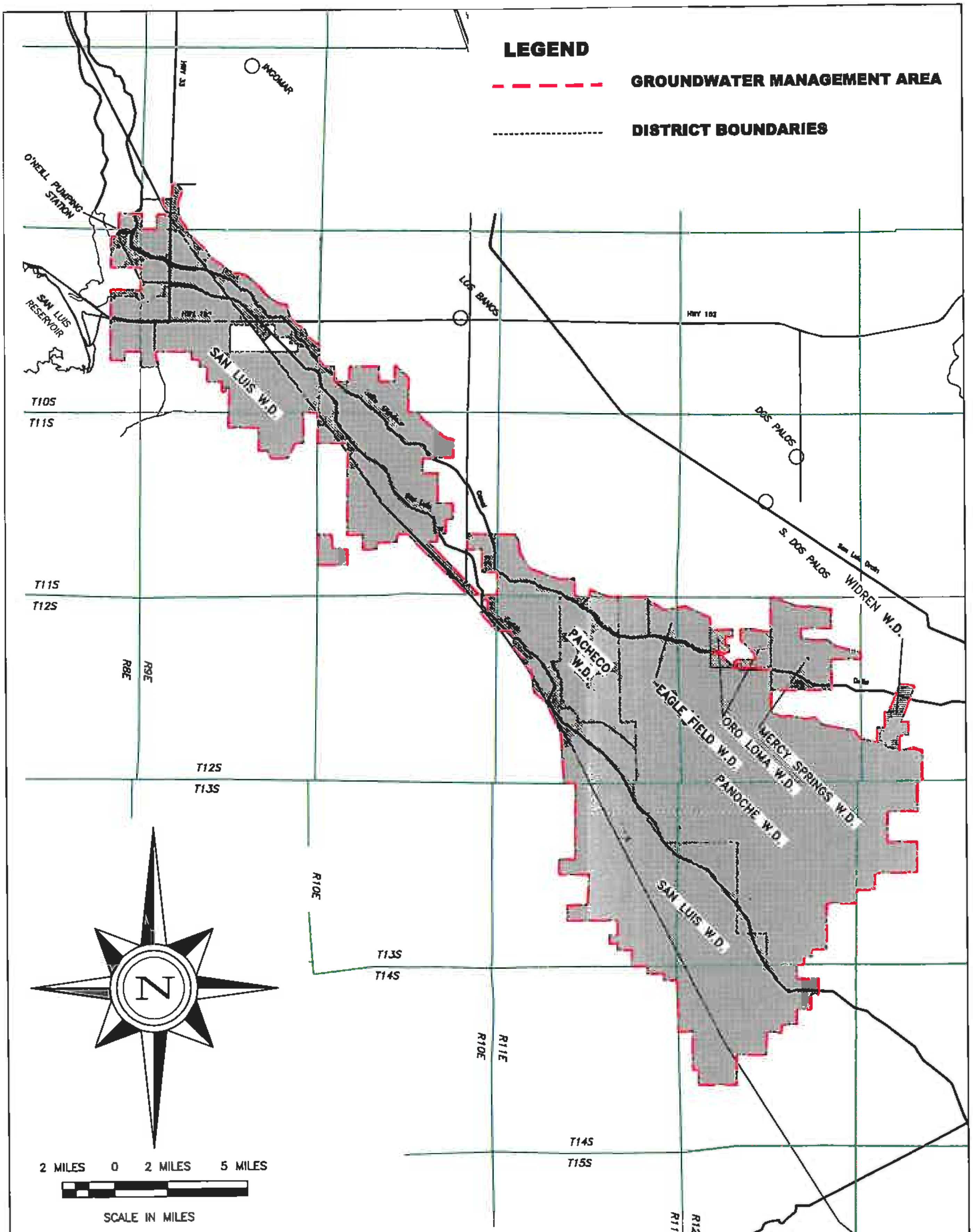
FIGURE 2



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BOUNDARY OF THE GROUNDWATER MANAGEMENT PLAN

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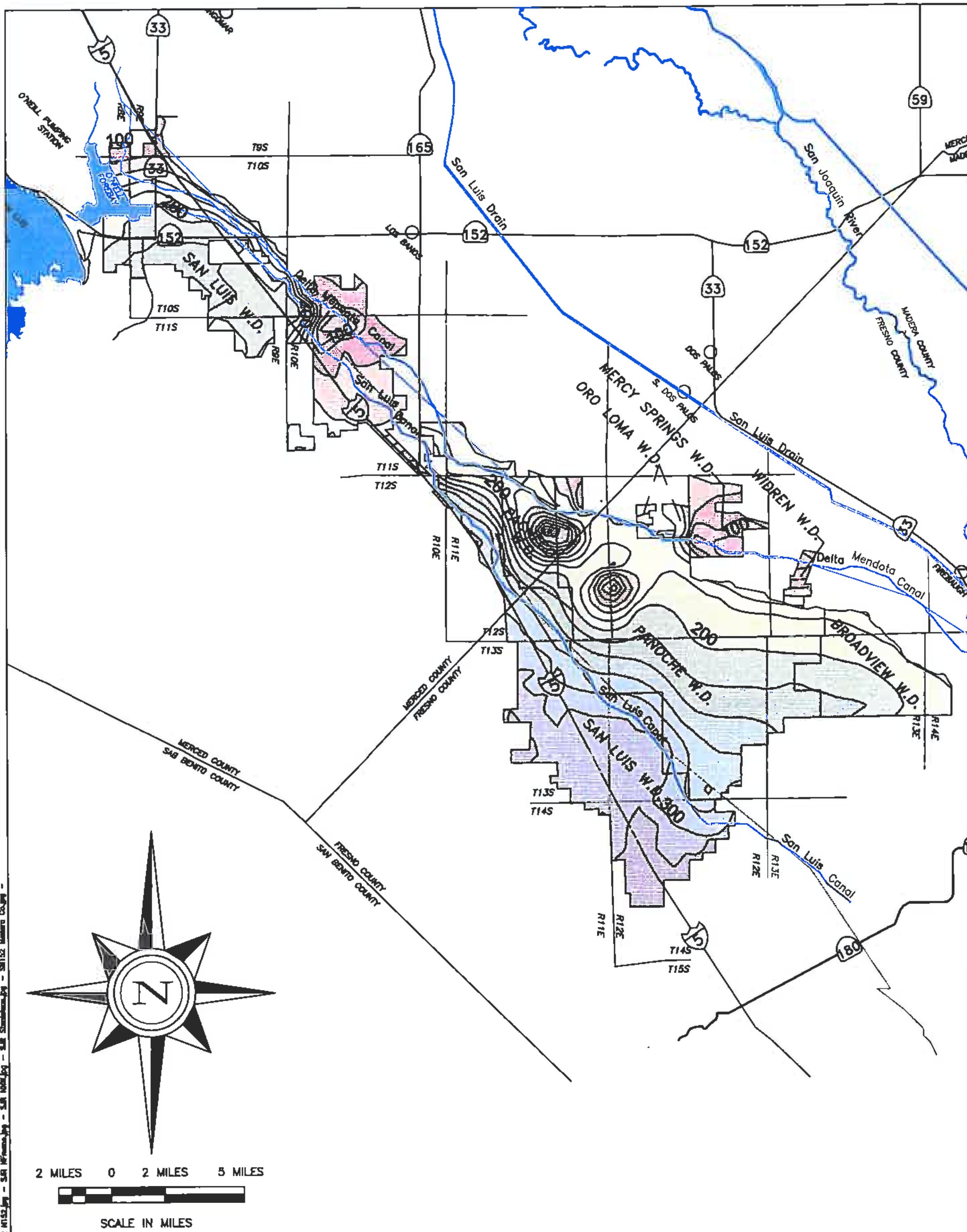
FIGURE
3



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WATER TABLE ELEVATION, SPRING 1996

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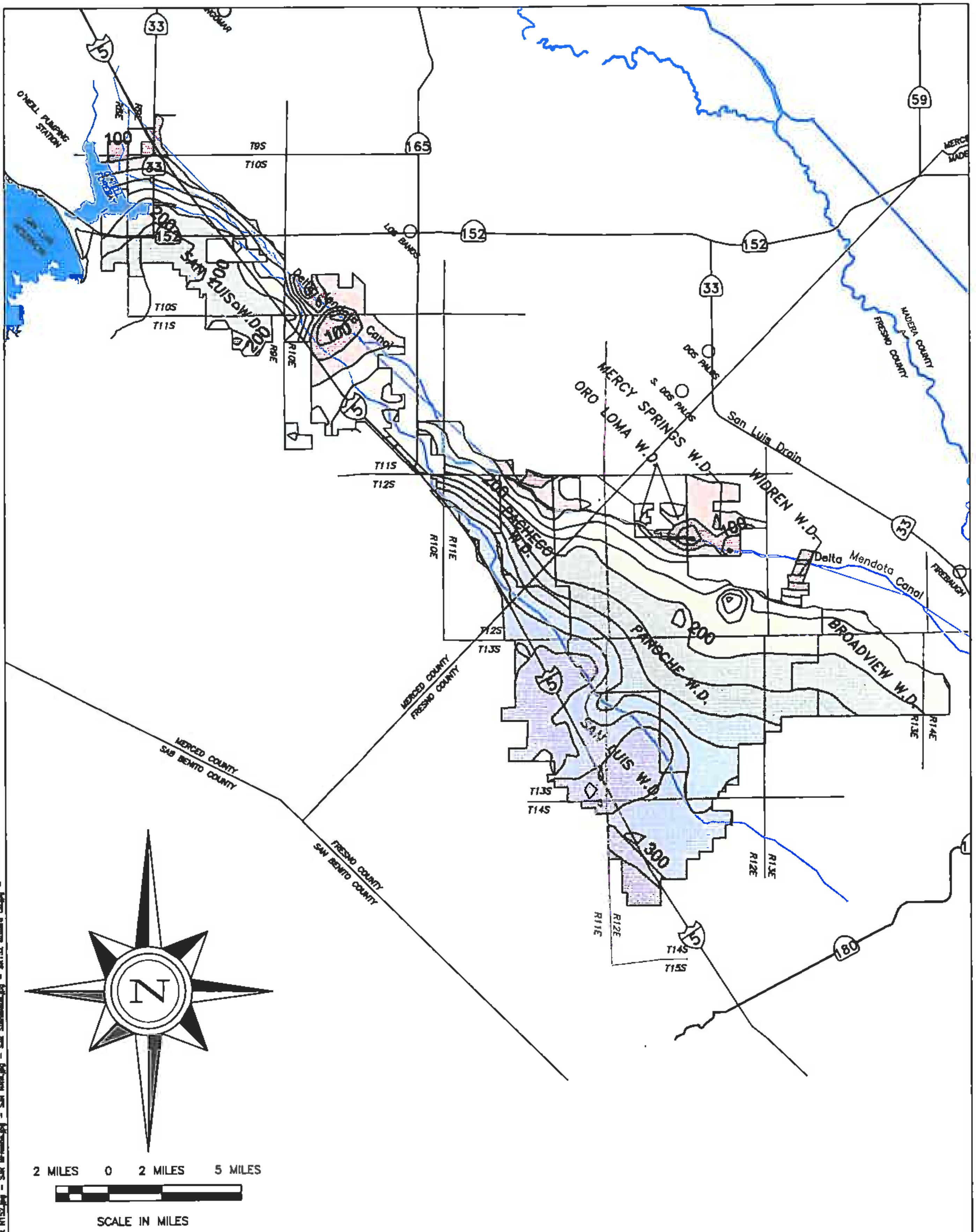
FIGURE 4



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WATER TABLE ELEVATION, SPRING 2000

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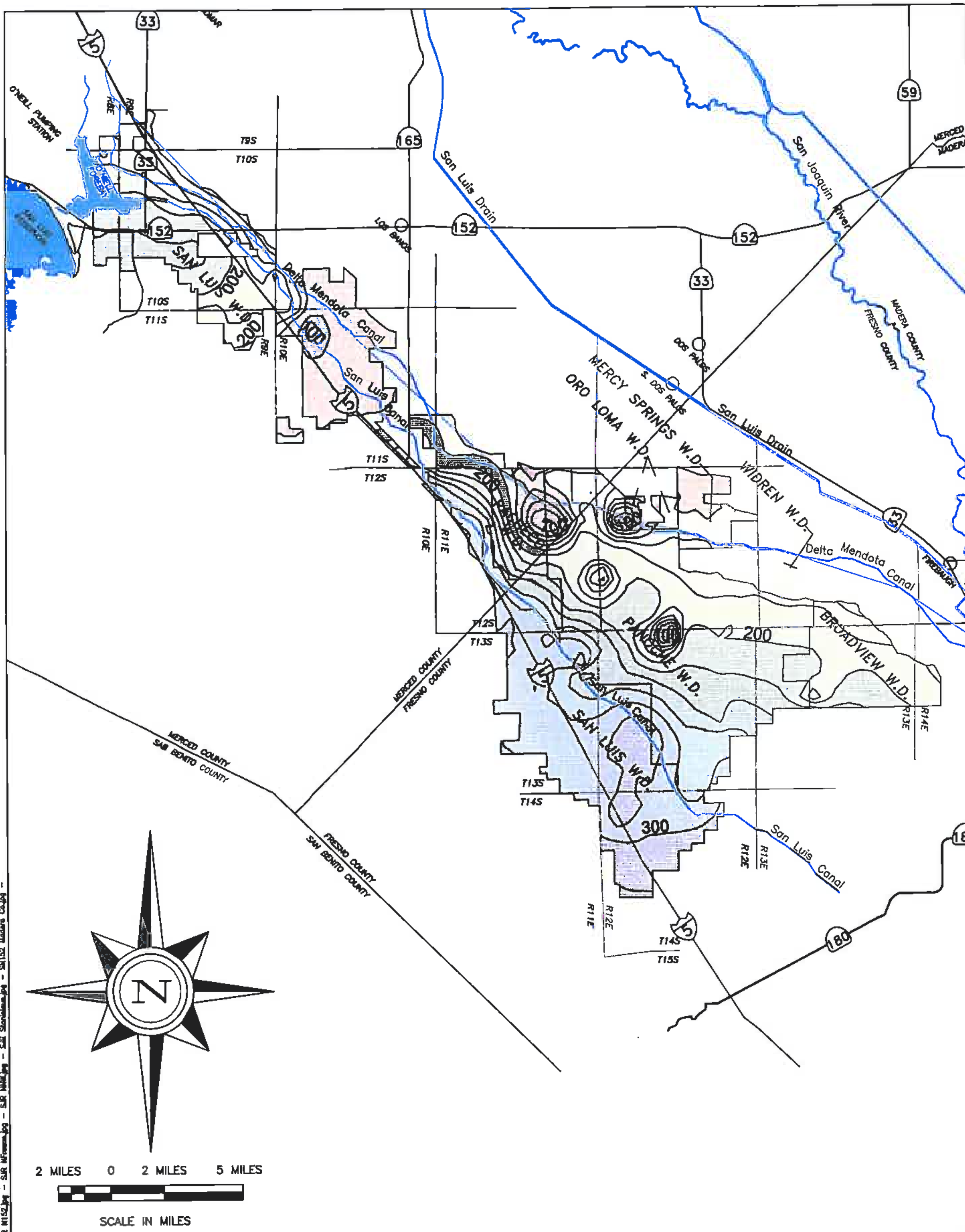
FIGURE 5



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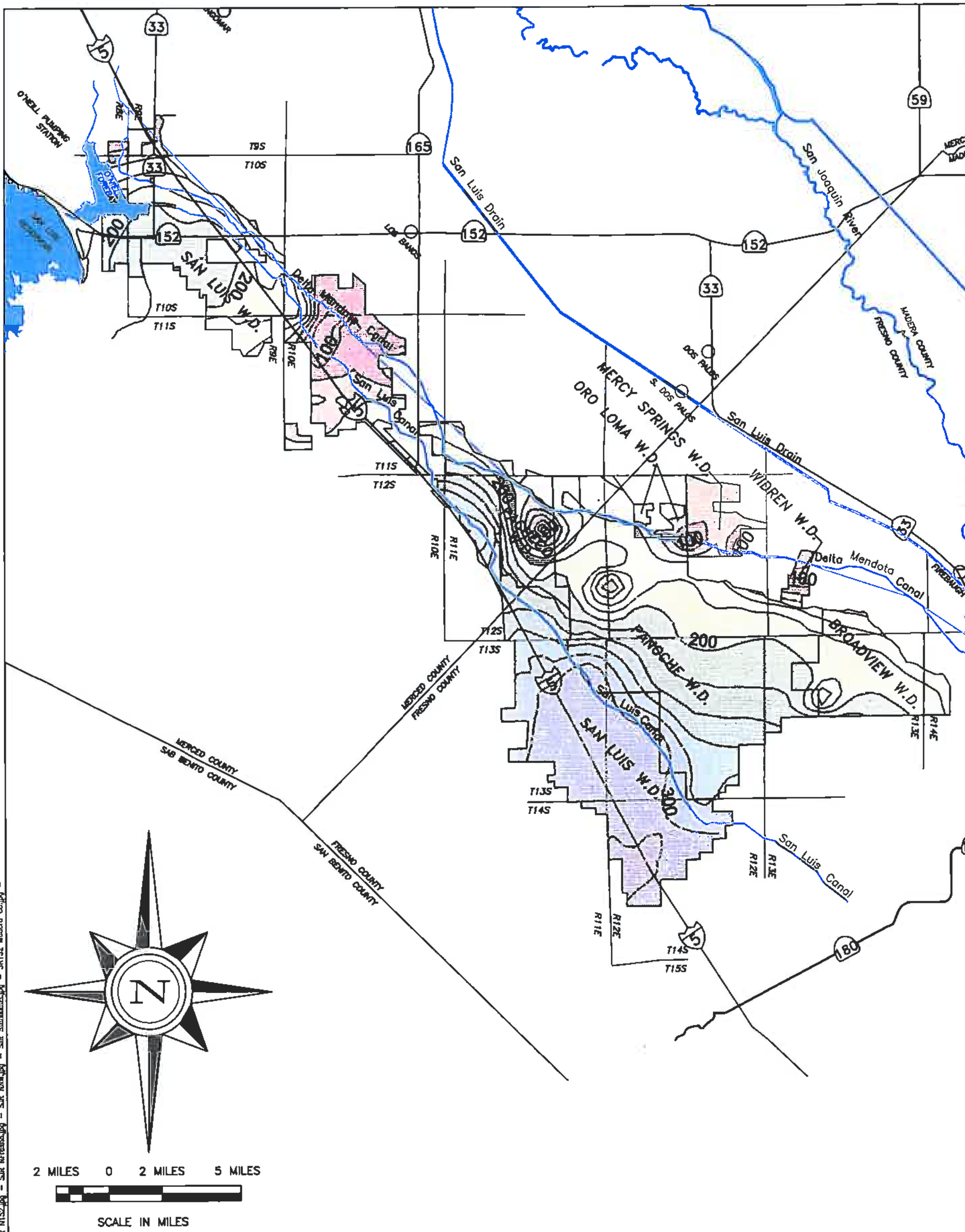
SAN LUIS DELTA MENDOTA WATER AUTHORITY	AECOM PROJECT NO.	FIGURE
WATER TABLE ELEVATION, SPRING 2004	60061544	6



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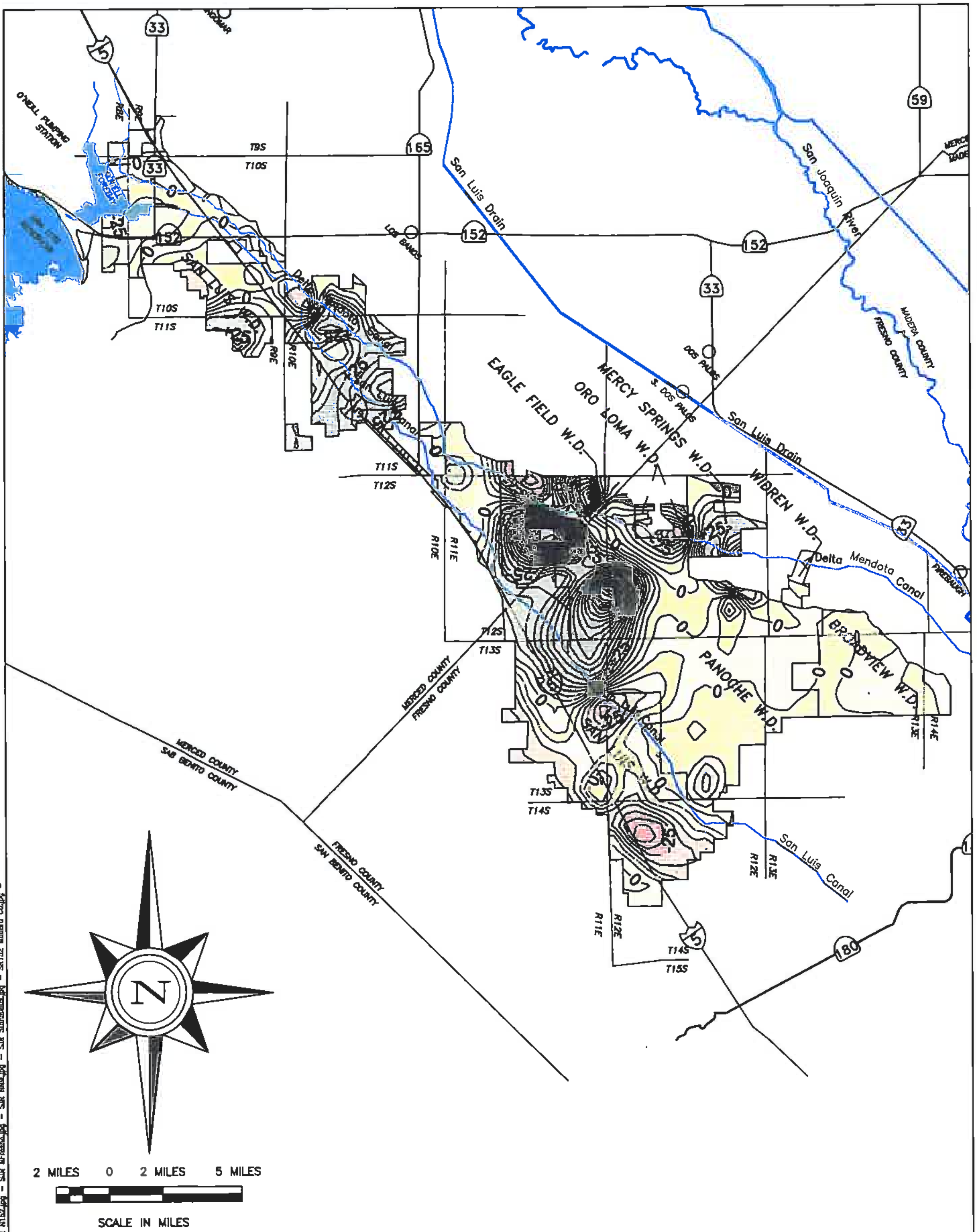
SAN LUIS DELTA MENDOTA WATER AUTHORITY	AECOM PROJECT NO.	FIGURE
WATER TABLE ELEVATION, SPRING 2008	60061544	7



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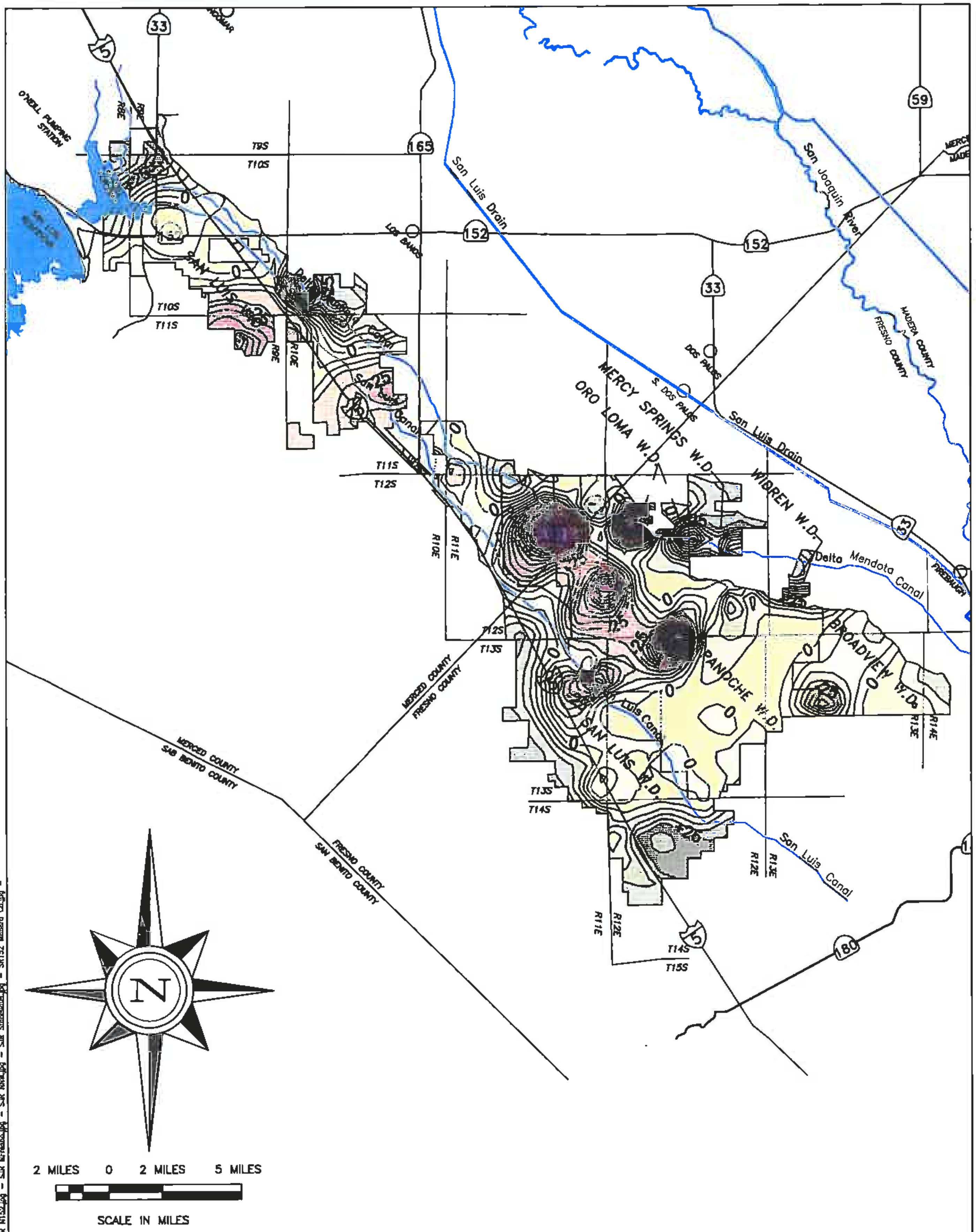
AECOM USA, Inc. 1120 W. I St. LOS BANOS, CA 93635, SUITE "C" T 209-826-5155 F 209-826-3307 www.aecom.com	CHANGE IN WATER TABLE ELEVATION SPRING 1996 TO SPRING 2000	60061544	8



AECOM Water / 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 CHANGE IN WATER TABLE ELEVATION SPRING 2000 TO SPRING 2004	AECOM PROJECT NO. 60061544	FIGURE 9