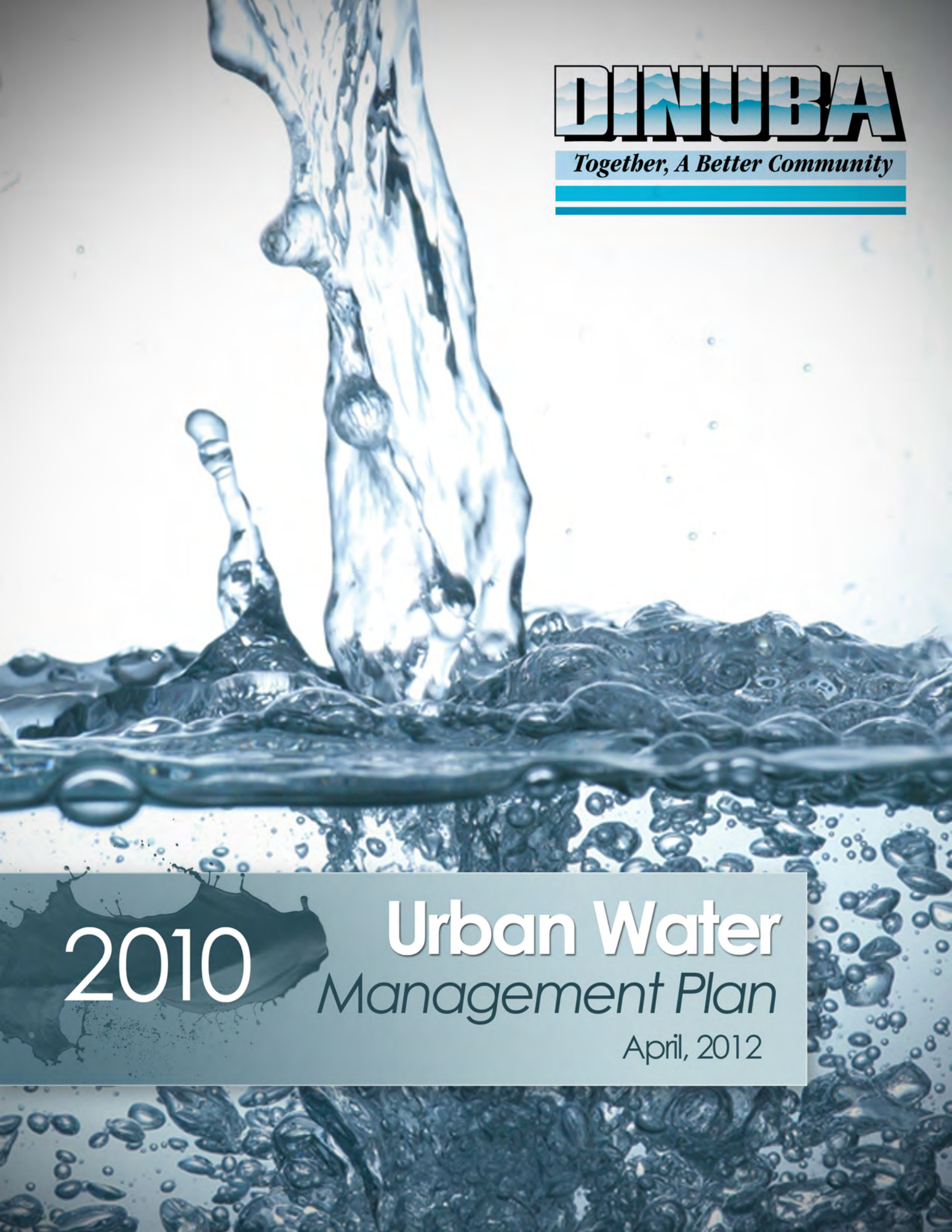

DINUBA

Together, A Better Community

2010 Urban Water Management Plan

April, 2012

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Section 1 – Plan Preparation

The City of Dinuba has prepared this updated version of its Urban Water Management Plan during 2012. The City of Dinuba's 2010 Urban Water Management Plan (UWMP) will be adopted by the City Council in June 2012 and will be submitted to the California Department of Water Resources within 30 days of its approval by the City Council. *See Appendix A for City Council resolution.*

1.1 Purpose

The California Water Code §10644(a) requires urban water suppliers to file with the Department of Water Resources (DWR), the California State Library, and any City or County within which the supplier provides water supplies, a copy of its Urban Water Management Plan. UWMP's are to be prepared every five years by urban water suppliers with 3,000 or more service connections or supplying 3,000 or more acre-feet of water per year.

The purpose of this UWMP is to be a baseline document and source of information for DWR and to serve as:

- A short and long range planning document for water supply;
- Data source for the development of a regional water supply plan,
- A source document for the City of Dinuba in preparing updated General Plans, and
- A key component of an Integrated Regional Water Management Plan.

1.2 Coordination

#4. Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable (10620(d)(2)).

The Table 1 displays each of the agencies that are involved in the coordination and preparation of the City of Dinuba's 2010 Urban Water Management Plan.

Table 1
Coordination with appropriate agencies

Coordinating Agencies	Participated in developing the plan	Commented on the draft	Attended public meetings	Was contacted for assistance	Was sent a copy of the draft plan	Was sent a notice of intention to adopt	Not involved / No information
City of Dinuba	X	X	X	X	X	X	
County of Tulare				X	X	X	
Alta Irrigation District				X	X	X	
Kings River Conservation District				X	X	X	
General Public			X	X			

#6. Every urban water supplier required to prepare a plan pursuant to this part shall, at least 60 days prior to the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision (10621(b)).

Notification letters regarding the review of the City of Dinuba's 2010 UWMP were mailed out approximately 60 days before the City Council's hearing on the plan. The agencies that were sent a 60 day notification letter are listed in Table 1. *See Appendix B for copies of 60-Day Notification Letters.*

#54. The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan (10635(b)).

A copy of the City of Dinuba's 2010 Urban Water Management Plan will be submitted to the County of Tulare and be filed with the City of Dinuba within 60 days of submission to the California Department of Water Resources.

#55. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan (10642).

The different organizations that were contacted for notification, input, and consideration regarding the creation of Dinuba's 2010 UWMP before and during the preparation process are listed in Table 1.

#56. Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area (10642).

Information regarding the time and location of the hearing on the City of Dinuba's 2010 Urban Water Management Plan has been made available to the public through newspaper publications (Dinuba Sentinel) per the requirements of Government Code 6066. The newspaper notifications stated that a copy was available on the front counter at City Hall for members of the public to review and comment on the plan. *See Appendix C for copies of the public notices.*

1.3 Plan Adoption

#7. The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640) (10621(c)).

If any changes to the City of Dinuba's 2010 Urban Water Management Plan are necessary after the plan has been adopted by the City Council, then additional public hearings will be performed prior to re-adoption by the City Council.

#57. After the hearing, the plan shall be adopted as prepared or as modified after the hearing (10642).

A copy of the City Council resolution has been included in this report. Any modifications or requests shall be included after the public hearing. *See Appendix A for City Council resolution.*

#58. An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan (10643).

The 2005 UWMP for the City of Dinuba was submitted to the Department of Water Resources but was not approved; however, the City of Dinuba has been implementing water conservation measures as discussed in its 2005 UWMP. The City has been a participant in the Alta Irrigation District Groundwater Management Plan and a board member of the Upper Kings Basin Integrated Regional Water Management Authority, actively assisting in meeting the goals and objectives of these local and regional project efforts.

The City of Dinuba plans on implementing the 2010 UWMP in order to achieve the goal of reducing water usage within the limits of its service area and continuing their involvement in the regional efforts, which target increased groundwater supply and groundwater quality. Copies of the current groundwater management and surface water plans that Dinuba has participated in. *See Appendix I for the Amended Groundwater Management Plan, Alta Irrigation District and Appendix J for the Kings Groundwater Basin Integrated Ground and Surface Water Model, Final Report.*

1.4 Submittal

#59. An urban water supplier shall submit to the department, the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be submitted to the department, the California State Library, and any city or county within which the supplier provides water supplies within 30 days after adoption (10644(a)).

A copy of the City of Dinuba's 2010 Urban Water Management Plan will be submitted to the California State Library, the City of Dinuba, and the County of Tulare within 30 days of submission to the California Department of Water Resources.

#60. Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours. (10645).

The 2010 Urban Water Management Plan for the City of Dinuba will be made available to the general public for review during normal business hours at the City of Dinuba City Hall.

1.5 Plan Organization

The 2010 UWMP is organized per the following table and outline. The report closely follows the Guidebook to Assist Urban Water Suppliers to Prepare a 2010 Urban Water Management Plan from the DWR.

1.6 Implementation

#58. An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan (10643).

4Creeks, Inc. and the City of Dinuba have partnered together to continue to meet the requirements of the 2010 UWMP Key Dates schedule in order to properly and efficiently implement the City of Dinuba's 2010 Urban Water Management Plan.

Section 2 – System Description

2.1 Service Area Physical Description

#8. Describe the service area of the supplier (10631(a)).

The City of Dinuba is located in the northwest corner of Tulare County, approximately 14 miles north of Visalia and 27 miles southeast of the Fresno/Clovis metropolitan area. The City of Dinuba also lies approximately 13 miles east of Highway 99 and 9 miles west of the foothills of the Sierra Nevada Mountain Range. The City of Dinuba is relatively flat with an elevation of approximately 330 feet above sea level. The City covers an approximate total area of 6.6 square miles of land. The area surrounding the City of Dinuba and outside its sphere of influence (SOI) consists mainly of land designated for urban reserve/agricultural use.

The main body of water within the vicinity of the City of Dinuba is the Kings River. The Kings River runs north and south in direction and lies approximately five miles to the west of Dinuba. Due to the large amount of agricultural land surrounding the City of Dinuba there have been many irrigation canals and waterways constructed to deliver water from the Kings River to the adjacent farmlands.

The main California Highways serving the area surrounding the City of Dinuba include State Route 198 (15 miles south), State Route 99 (13 miles west), State Route 63 (Rd 128 - 6 miles east), and State Route 201 (Ave. 400 - 1 mile south). The Tulare County Highways that also serve the Dinuba area include County Rd J40 (El Monte Way/Ave. 416) and County Hwy J19 (Alta Ave./Rd 80). The nearest passenger railways to Dinuba are Hanford Amtrak (21 miles southwest) and Fresno Amtrak (26 miles northwest). Additionally, the nearest major airports to the City of Dinuba are the Visalia Municipal Airport (15 miles south) and Fresno Yosemite International Airport (24 miles northwest). *See Appendix D for detailed system map.*

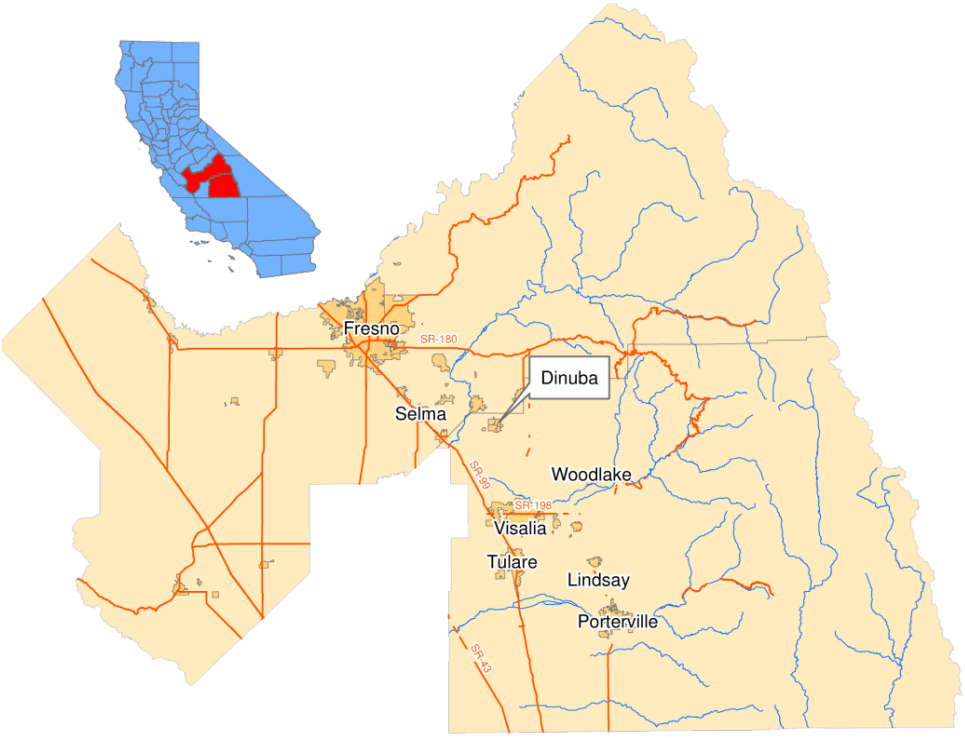


Figure 2.1-1, City of Dinuba Location Map

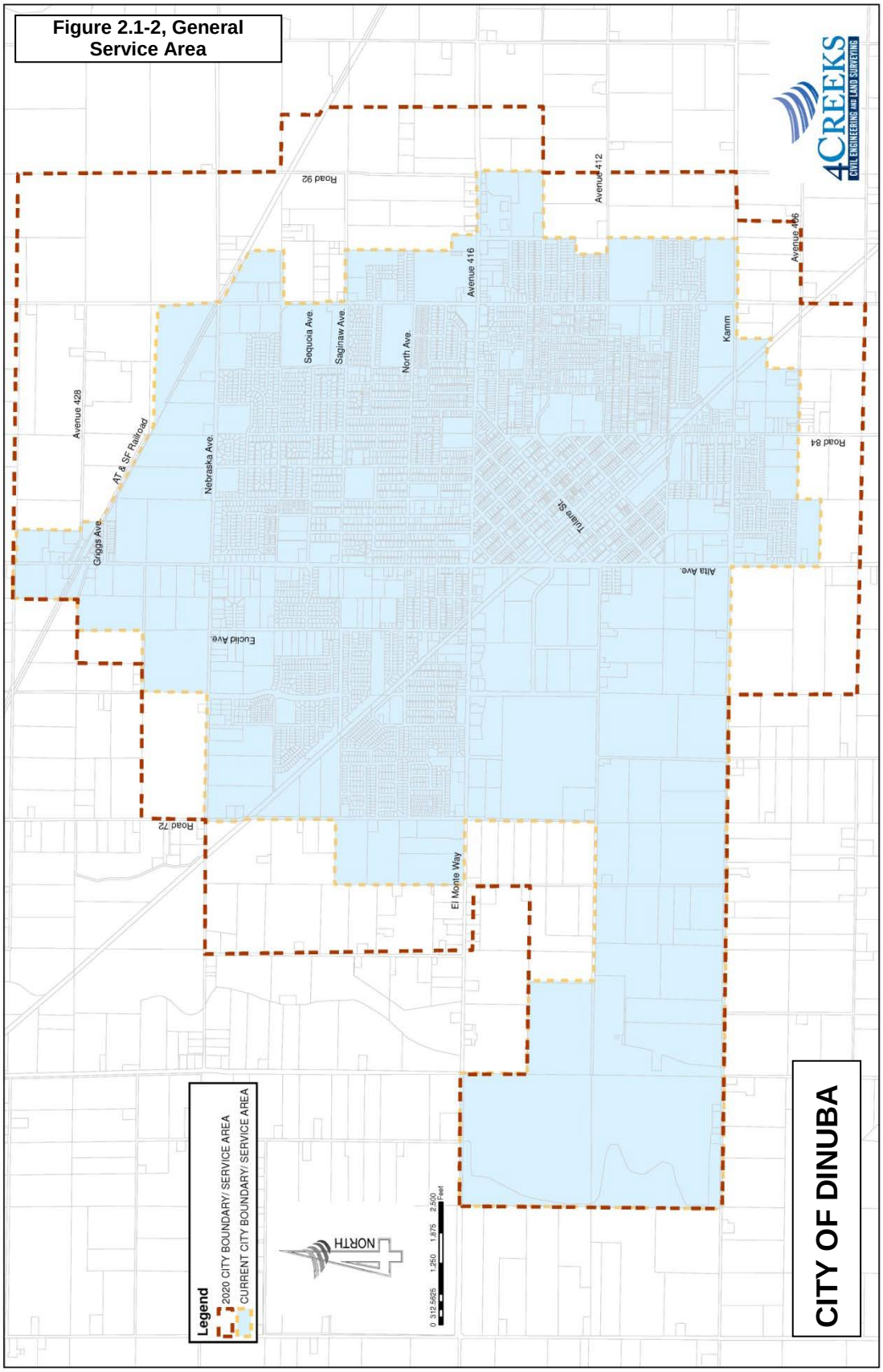
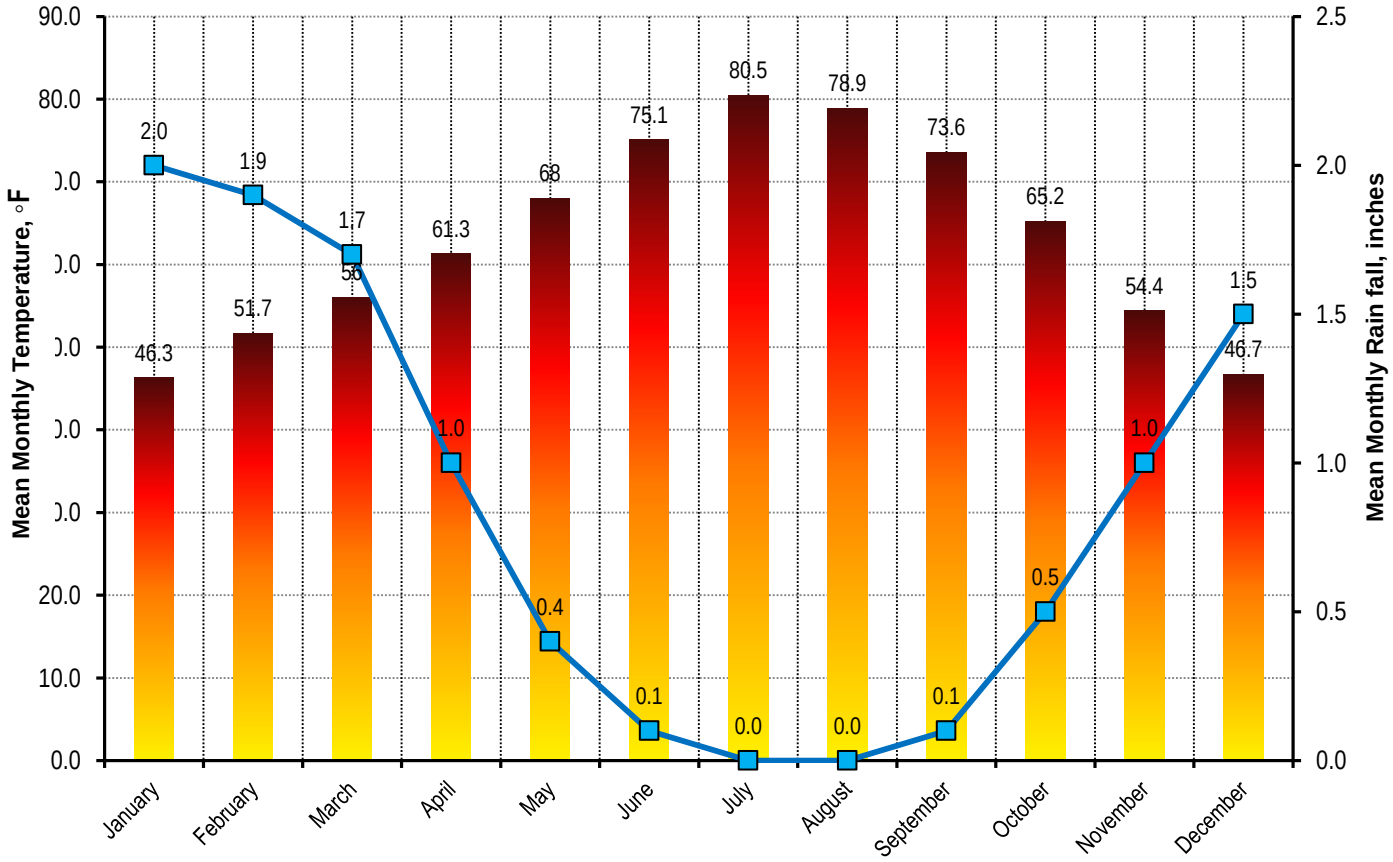


Figure 2.1-2, General Service Area

#9. (Describe the service area) climate (10631(a)).

The City of Dinuba is located within Tulare County, which experiences a semi-arid type of climate. The summers are typically very dry and hot, while the winters are cool with moderate moisture levels. The summer months experience an average temperature of 88.8 degrees and the winter months have an average temperature of 40.9 degrees. The average rainfall in the area surrounding the City of Dinuba is approximately 10.2 inches per year.

Figure 2.2, Average Monthly Temperature and Rainfall



Source: Western Regional Climate Center, Visalia Station: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9367

The amount of precipitation varies considerably from year to year, with precipitation largely confined to the late fall, winter, and early spring months. Water consumption during the summer months are typically much greater than the winter months due to high temperatures and low amounts of rainfall. The monthly average evapotranspiration values are listed for Dinuba. Evapotranspiration is the sum of water losses from a watershed because of the processes of evaporation from the earth's surface and transpiration from plant materials. The values are listed in Table 1.2 below.

Table 1.2, Average Annual Climate Data

Month	Average ETo Zone 12 (Inches)	Maximum Temperature (◦F)	Minimum Temperature (◦F)	Mean Temperature (◦F)	Precipitation (Inches)
January	1.24	56	37	46.3	2.0
February	1.96	63	40	51.7	1.9
March	3.41	68	43	56.0	1.7
April	5.10	76	56	61.3	1.0
May	6.82	85	52	68.0	0.4
June	7.80	93	58	75.1	0.1
July	8.06	99	62	80.5	0.0
August	7.13	98	61	78.9	0.0
September	5.40	92	57	73.6	0.1
October	3.72	82	49	65.2	0.5
November	1.80	66	41	54.4	1.0
December	0.93	56	36	46.7	1.5
Annual Totals	53.3	78	49	63.1	10.2

Climate Data:
Sources: CIMIS and DWR (Orange Cove Station), CIMIS Zone 12

2.2 Service Area Population

#10. (Describe the service area) current and projected population . . . The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier . . . (10631(a)).

The current and projected population estimates for the City of Dinuba are shown in Table 2 below, which encompasses the entire area served by the water distribution system. The projected population estimates are based off of data provided by the 2010 Census, conducted by the U.S. Census Bureau. Additionally, the population estimate for the area served by the distribution system was developed using the process described in Technical Methodology 2: Service Area Population (Part II, Section M).

#11. . . . (population projections) shall be in five-year increments to 20 years or as far as data is available (10631(a)).

See Table 2 below for the most recent population total as of 2010 and projected estimates (2% annual growth rate) for the next 25 years.

Table 2
Population — current and projected

	2010	2015	2020	2025	2030	2035 - optional	Data source
Service area population	21,453	23,686	26,151	28,873	31,878	35,196	U.S. Census Bureau

#12. Describe . . . other demographic factors affecting the supplier's water management planning (10631(a)).

Tulare County has one of the highest unemployment rates in the State, due in large part to the agricultural base and the prevalence of seasonal employment, and the national recession. According to data from the State of California Employment Development Department, May 2011, Dinuba's unemployment rate was 46% higher than Tulare County's, 94% higher than California's, and nearly three times higher than the national average. Dinuba's unemployment rate was 22.1% compared to Tulare County's rate of 15.1%. California's rate was 11.4% and the national rate was 8.7%.

Also, 26.5% of the total population remains below the poverty level. The food production and packing industry is the most dominant industry in Dinuba. Ruiz Foods stands alone as the largest single employer in the City of Dinuba with approximately 2,100 employees. Wal-Mart and the Best Buy distribution center are the next largest employers in Dinuba with about 425 employees each.

Water conservation and usage reduction measures, in communities with such high levels of unemployment and numbers of families under the poverty level prove to be difficult, since many households cannot afford to update older appliances or handle increased water rates.

Section 3 – System Demands

3.1 Baselines and Targets

#1. An urban retail water supplier shall include in its urban water management plan. . . due in 2010 the baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the basis for determining those estimates, including references to supporting data (10608.20(e)).

The base period ranges that have been used to determine the City of Dinuba's Base Daily Per Capita Water Use can be found in Table 13. Tables 14 and 15 display the Base Daily Per Capita Water Usages for the 10 year and 5 year ranges, respectively. The Base Daily Per Capita Water Use values were calculated per Sections 10608.20 and 10608.22 of the California Water Code.

The 2020 Urban Water Use Target and 2015 Interim Water Use Targets were calculated using the Base Daily Per Capita Water Use values of Tables 14 and 15 and the Tulare Lake Hydrologic Region water use estimates for the year 2020, Target Method 3. The 2020 Urban Water Use Target was calculated to be 179 GPCD. The 2015 Interim Water Use Target was calculated to be 198 GPCD. *See Appendix D for calculations and a map of California's Hydrologic Regions.*

Table 13
Base period ranges

Base	Parameter	Value	Units
10- to 15-year base period	2008 total water deliveries	1,682.36	*mgd*
	2008 total volume of delivered recycled water	0	*see below*
	2008 recycled water as a percent of total deliveries	0	percent
	Number of years in base period	10	years
	Year beginning base period range	2001	
	Year ending base period range	2010	
5-year base period	Number of years in base period	5	years
	Year beginning base period range	2006	
	Year ending base period range	2010	

The values were determined based upon data provided by the City of Dinuba, which included the monthly and yearly water well pumping amounts. Since, the entire distribution system is supplied by groundwater wells; this method is adequate to provide the amount of water used by the service area.

The baselines and targets are developed on an individual basis and apply only to the City of Dinuba's service area, which coincides with the current City Limits.

Table 14 Base daily per capita water use — 10- to 15-year range				
Base period year		Distribution System Population	Daily system gross water use (mgd)	Annual daily per capita water use (gpcd)
Sequence Year	Calendar Year			
Year 1	2001	18,072	3.84	213
Year 2	2002	18,383	4.10	223
Year 3	2003	18,633	4.17	224
Year 4	2004	19,138	4.12	215
Year 5	2005	19,351	3.97	205
Year 6	2006	19,491	4.05	208
Year 7	2007	20,118	4.53	225
Year 8	2008	20,489	4.61	225
Year 9	2009	20,792	4.58	220
Year 10	2010	21,453	4.31	201
Base Daily Per Capita Water Use				216

Table 15 Base daily per capita water use — 5-year range				
Base period year		Distribution System Population	Daily system gross water use (mgd)	Annual daily per capita water use (gpcd)
Sequence Year	Calendar Year			
Year 1	2006	19,491	4.05	208
Year 2	2007	20,118	4.53	225
Year 3	2008	20,489	4.61	225
Year 4	2009	20,792	4.58	220
Year 5	2010	21,453	4.31	201
Base Daily Per Capita Water Use				216

3.2 Water Demands

#25. Quantify, to the extent records are available, past and current water use, and projected water use (over the same five-year increments described in subdivision (a)), identifying the uses among water use sectors, including, but not necessarily limited to, all of the following uses: (A) Single-family residential; (B) Multifamily; (C) Commercial; (D) Industrial; (E) Institutional and governmental; (F) Landscape; (G) Sales to other agencies; (H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof; (I) Agricultural (10631(e)(1) and (2)).

The information for items (A) through (F) is displayed in the following tables (Tables 3 – 7). Tables 3 and 4 display the actual water deliveries for 2005 and 2010, based upon data provided by the City of Dinuba for the various land uses listed.

Table 3 Water deliveries — actual, 2005 (ac-ft/yr)					
	2005				
	Metered		Not metered		Total
Water use sectors	# of accounts	Volume	# of accounts	Volume	Volume
Single family	4,044	2,520	0	0	2,520
Multi-family	143	312	0	0	312
Commercial	322	530	0	0	530
Industrial	5	452	0	0	452
Institutional/governmental	83	266	0	0	266
Landscape	0	0	0	0	0
Agriculture	0	0	0	0	0
Other	0	0	0	0	0
Total	4,597	4,080	0	0	4,080

Table 4 Water deliveries — actual, 2010 (ac-ft/yr)					
	2010				
	Metered		Not metered		Total
Water use sectors	# of accounts	Volume	# of accounts	Volume	Volume
Single family	4,492	2,640	0	0	2,640
Multi-family	151	355	0	0	355
Commercial	375	602	0	0	602
Industrial	5	511	0	0	511
Institutional/governmental	110	401	0	0	401
Landscape	0	0	0	0	0
Agriculture	0	0	0	0	0
Other	0	0	0	0	0
Total	5,133	4,509	0	0	4,509

Tables 5-7 identify the projected number of additional accounts and subsequent volumes of water based on growth projections of 2.0% per year. The growth projection of services is based upon the average historical growth percentage from 2000 – 2006 of 2.0%.

Table 5 Water deliveries — projected, 2015 (ac-ft/yr)					
	2015				
	Metered		Not metered		Total
Water use sectors	# of accounts	Volume	# of accounts	Volume	Volume
Single family	4,960	2,915	0	0	2,915
Multi-family	167	392	0	0	392
Commercial	414	665	0	0	665
Industrial	6	564	0	0	564
Institutional/governmental	121	443	0	0	443
Landscape	0	0	0	0	0
Agriculture	0	0	0	0	0
Other	0	0	0	0	0
Total	5,667	4,979	0	0	4,979

Table 6 Water deliveries — projected, 2020 (ac-ft/yr)					
	2020				
	Metered		Not metered		Total
Water use sectors	# of accounts	Volume	# of accounts	Volume	Volume
Single family	5,476	2,870	0	0	2,870
Multi-family	184	375	0	0	375
Commercial	457	734	0	0	734
Industrial	6	623	0	0	623
Institutional/governmental	130	395	0	0	395
Landscape	4	0	0	0	0
Agriculture	0	0	0	0	0
Other	0	0	0	0	0
Total	6,257	4,997	0	0	4,997

Table 7 Water deliveries — projected 2025, 2030, and 2035 (ac-ft/yr)						
	2025		2030		2035 - optional	
	metered		metered		metered	
Water use sectors	# of accounts	Volume	# of accounts	Volume	# of accounts	Volume
Single family	6,046	3,209	6,675	3,546	7,370	3,950
Multi-family	203	435	224	480	248	540
Commercial	505	800	557	865	615	942
Industrial	7	650	7	735	8	815
Institutional/governmental	148	425	163	470	180	485
Landscape	8	0	12	0	16	0
Agriculture	0	0	0	0	0	0
Other	0	0	0	0	0	0
Total	6,916	5,519	7,639	6,096	8,437	6,732

Table 9 displays the actual and projected amounts of water sold to other agencies, which is not applicable due to the fact that the City of Dinuba does not sale/supply water to any other agencies.

Table 9 Sales to other water agencies (ac-ft/yr)							
Water distributed	2005	2010	2015	2020	2025	2030	2035 - opt
Other agencies	0	0	0	0	0	0	
Total	0	0	0	0	0	0	

The City of Dinuba's system is described further as follows, and in Table 10:

1. Recycled water
    a. The City of Dinuba is working on implementing a recycled water system from its Wastewater Reclamation Facility.
2. System losses
    a. The system losses were calculated as the difference between the well pumping data provided at the well sites and the final amount of water delivered to users in the system. The projected water system losses were projected using a 5% system loss factor.

Table 10 Additional water uses and losses (ac-ft/yr)							
Water use	2005	2010	2015	2020	2025	2030	2035 -opt
~~Saline barriers~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
~~Groundwater recharge~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
~~Conjunctive use~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
~~Raw water~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
Recycled water	0	0	0	0	0	0	0
System losses	371	321	273	246	270	296	325
Other (define)	0	0	0	0	0	0	0
Total	371	321	273	246	270	296	325

The data presented in the previously mentioned tables is summarized in Table 11. The projected volume amounts for 2015 and 2020 match the calculated reduction amounts based upon the populations and GPCD goals of 198 and 179, respectively. Based upon population projections for 2015 and 2020, the total amount of water volume used per year will be approximately 5,252 ac.ft./year and 5,243 ac.ft./year., respectively.

Table 11 Total water use (ac-ft/yr)							
Water Use	2005	2010	2015	2020	2025	2030	2035 - opt
Total water deliveries (from Tables 3 to 7)	4,080	4509	4,979	4,997	5,519	6,096	6,732
Sales to other water agencies (from Table 9)	0	0	0	0	0	0	0
Additional water uses and losses (from Table 10)	371	321	273	246	270	296	325
Total	4,451	4,830	5,252	5,243	5,789	6,392	7,057

The City of Dinuba has continued to decrease the amount of additional water uses and water loss from 2005-2010. In 2010, approximately 7% of the water supplied went unaccounted for. Capital projects that are slated to replace existing water pipelines, valves, and facilities will continue to reduce water losses. It is unrealistic to expect a complete elimination of water losses in the entire system; however, it would seem that continued efforts to reduce water losses, would significantly go to meeting targeted water usage amounts for 2015.

As can be seen, by 2020 major efforts to curtail residential water use and provide a recycled water system will have to be implemented to meet the targeted water use numbers. Considering the water use reductions and historical consumptions, Dinuba is already pro-actively conserving water. In comparison, the City of Visalia and California Water Service are proposing a 2020 goal of 194 GPCD; which is a neighbor City with much higher per capita income levels. Therefore, additional water conservation measures will be very costly and time consuming to implement for Dinuba. The City of Dinuba will continue to require new construction to have much more stringent water conservation measures installed, but retro-fitting existing neighborhoods will continue to prove difficult to obtain funding for.

#34. The water use projections required by Section 10631 shall include projected water use for single-family and multifamily residential housing needed for lower income households, as defined in Section 50079.5 of the Health and Safety Code, as identified in the housing element of any city, county, or city and county in the service area of the supplier (10631.1(a)).

The Housing Element of the City of Dinuba (2009-2014) lists 323 low and very low income housing units to meet the Tulare County Association of Governments Regional Housing Needs Assessment by 2014. The 2014 yearly numbers can be extrapolated out to 2015, resulting in a 2015 goal of 66 low and very low

income housing units. Additionally, we will match the population growth estimate of 2% per year to estimate the number of needed units for 2020 and beyond.

The estimated residential per unit water demand is 0.59 acre-feet/unit/year and, 38.65 acre-feet/year is needed to supply these projected lower income housing units by 2015. Water demands for these units are included in future water demand projections for single family and multi -family homes listed in Tables 5-7.

Table 8 summarizes the estimated low-income projected water demands for 2015 to 2030.

Table 8
Low-income projected water demands (ac-ft/yr)

Low Income Water Demands	2015	2020	2025	2030	2035 - opt
Single-family residential	25	25	26	27	27
Multi-family residential	15	15	16	17	17
Total	40	40	42	44	44

3.3 Water Demand Projections

#33. Urban water suppliers that rely upon a wholesale agency for a source of water shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c) (10631(k)).

The City of Dinuba acts as the City's only wholesale or retail water supplier. There is currently no other wholesale or retail water suppliers operating within the City limits. The City of Dinuba does not intend to sell or purchase any water from other agencies.

Table 12
Retail agency demand projections provided to wholesale suppliers (ac-ft/yr)

Wholesaler	Contracted Volume	2010	2015	2020	2025	2030	2035 -opt
None	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	

3.4 Water Use Reduction Plan

#2. Urban wholesale water suppliers shall include in the urban water management plans . . . an assessment of their present and proposed future measures, programs, and policies to help achieve the water use reductions required by this part (10608.36). Urban retail water suppliers are to prepare a plan for implementing the Water Conservation Bill of 2009 requirements and conduct a public meeting which includes consideration of economic impacts (CWC §10608.26).

The City of Dinuba adopted a Water Conservation Ordinance in 1989 and will plan on continuing to implement the adopted ordinance. Additionally, the City of Dinuba may have to modify the existing Water Conservation Ordinance in order to meet the required water use reductions by 2020. *See Appendix H for Water Conservation Ordinance.*

Since the ordinance contains various stages of water conservation, Stage 1 and/or Stage 2 requirements could be enacted. When these stages are implemented, it will provide additional water use reduction; but also result in much less revenue to run and operate the water system in a safe manner. The City would have to anticipate this revenue reduction by performing a water rate study and raising the water rates City-wide. Again, considering the low-income and minority demographics of Dinuba; a rate increase will have far reaching economic effects. Commercial and industrial users may not be required to adhere to the stricter guidelines, in order to facilitate job retention and growth opportunities; so that residents can keep working and pay the higher rates at their residences.

The potential requirements of implementing a Stage 1 or Stage 2 water conservation requirement will be discussed at the public hearing and presented with the potential economic impacts.

Additionally, the City has adopted the State Model Water Efficient Landscape Ordinance AB 1881 regarding any new irrigation and landscaping projects within the City limits. *See Appendix G for Model Water Efficient Landscape Ordinance.*

Section 4 – System Supplies

4.1 Water Sources

#13. Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a) (10631(b)).

The primary source of water for the City of Dinuba's distribution system is groundwater. The following is taken from the Alta Irrigation District's Amended Groundwater Management Plan, dated June 10, 2010, concerning the groundwater aquifer underlying its service boundary, which includes the City of Dinuba. "*The water supply aquifer is the Kings Sub-basin, which is not an adjudicated basin. The California Department of Water Resources has designated this basin to be a critically overdrafted groundwater basin. The District has been monitoring groundwater levels for at least the last seventy-five years. The results of this monitoring effort are consistent with the findings of the Department of Water Resources. The water level measurements taken within the District show a continued downward trend in the groundwater elevations within the District's boundaries. The average overdraft in the basin is approximately 22,000 acre feet per year…the estimated average irrigation crop demand within the District is 325,000 acre feet and the average surface water supply is 148,416 acre feet; therefore, there is a strong reliance on groundwater to supply the agricultural users.*"

The potential water supply sources for the City of Dinuba, listed in order of importance, are/could be:

1. Groundwater
2. Recycled water
3. Shallow aquifer groundwater (treated)
4. Surface water

Each of the existing water sources and potential water sources are discussed in further detail in the following sections.

The City of Dinuba does not intend to purchase water from a wholesale supplier.

Table 17
Wholesale supplies — existing and planned sources of water (ac-ft/yr)

Wholesale sources	Contracted Volume	2015	2020	2025	2030	2035 - opt
None	0	0	0	0	0	0

Table 16 Water supplies — current and projected (ac-ft/yr)							
Water Supply Sources		2010	2015	2020	2025	2030	2035 - opt
Water purchased from:	Wholesaler supplied volume (yes/no)						
Wholesaler 1	No	0	0	0	0	0	0
Supplier-produced groundwater		4,830	5,252	5,193	5,689	6,242	6,857
Supplier-produced surface water		0	0	0	0	0	0
Transfers in		0	0	0	0	0	0
Exchanges In		0	0	0	0	0	0
Recycled Water		0	0	50	100	150	200
Desalinated Water		0	0	0	0	0	0
Other		0	0	0	0	0	0
	Total	4,830	5,252	5,243	5,789	6,392	7,057

4.2 Groundwater

#14. (Is) groundwater . . . identified as an existing or planned source of water available to the supplier . . . (10631(b))?

Groundwater is currently the existing source of water available to the supplier (City of Dinuba) within the City limits. As the sole retail water supplier, the City of Dinuba utilizes the groundwater within its City limits as the primary source of its water supply. There are plans for additional projects to construct 3 new groundwater wells located inside the City limits within the next 10 years (see Table 26, Page 25). The City of Dinuba manages and operates all groundwater wells used for supplying water for the total population.

#15. (Provide a) copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management (10631(b)(1)).

A groundwater management plan for this portion of the basin was produced by Alta Irrigation District with input and coordination from the City of Dinuba. *See Appendix I for a copy of the Amended Groundwater Management Plan, Alta Irrigation District, June 10, 2010.*

#16. (Provide a) description of any groundwater basin or basins from which the urban water supplier pumps groundwater (10631(b)(2)).

The City of Dinuba is located within the Kings River Groundwater Subbasin. The Kings River Subbasin covers approximately 1,530 square miles (976,000 acres) of surface area and reaches across 3 counties (Fresno, Tulare, and Kings). The City of Dinuba draws its groundwater from the Kings River Subbasin. The City's groundwater wells are dispersed fairly evenly within Dinuba's City limits. Future groundwater wells are proposed to be evenly dispersed between urban and rural areas.

The Kings River Subbasin aquifer system is made up of permeable layered lenses of clay, silt, sand, course aggregate or gravel, cobbles and boulders. The groundwater levels in the basin have shown significant decreases in their elevation due to drought and pumping overdraft in the past years. Droughts in the years 1976-1977 and 1987-1992 caused the groundwater levels to decline 10 to 50 feet in most areas. The Kings River Subbasin has experienced an increase in groundwater levels over the past decade. The current ground surface-to-water surface distance in the Dinuba area is approximately 30 to 40 feet. *Appendix J for the Kings Groundwater Basin Integrated Ground and Surface Water Model, Final Report*

#17. For those basins for which a court or the board has adjudicated the rights to pump groundwater, (provide) a copy of the order or decree adopted by the court or the board (10631(b)(2)).

The Kings River Sub-basin is not an adjudicated basin.

#18. (Provide) a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree (10631(b)(2)).

The City of Dinuba is not restricted to a specific volume of groundwater pumped from the Kings River Sub-basin.

#19. For basins that have not been adjudicated, (provide) information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition (10631(b)(2)).

DWR Bulletin 118-80 identified the Kings Subbasin as being in a critical condition of overdraft. The overdraft status was not re-evaluated in DWR Bulletin 118-03, however the DWR Bulletin 118-03 recognizes water suppliers in the basin as conducting recharge efforts in order to maintain a viable water supply.

#20. (Provide a) detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records (10631(b)(3)).

The amount of groundwater pumped for the City of Dinuba over the past 5 years has been sufficient enough to meet the City's water demands. Table 18 (below) displays the total volume of groundwater that has been pumped within Dinuba's City limits over this time period.

Table 18
Groundwater — volume pumped (ac-ft/yr)

Basin name(s)	Metered or Unmetered	2006	2007	2008	2009	2010
Kings River Subbasin (5-22.08)	Metered	4,538	5,074	5,165	5,129	4,829
Total groundwater pumped		4,538	5,074	5,165	5,129	4,829
Groundwater as a percent of total water supply		**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.00%**

#21. (Provide a) detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records (10631(b)(4)).

The groundwater that is planned to be used to supply the water demands of the City of Dinuba shall be drawn from the Kings River Subbasin. The Kings River Subbasin will serve as the primary source for meeting the City of Dinuba's water needs. The projected volumes of groundwater to be pumped from the Kings River Subbasin are displayed in Table 19.

Table 19 Groundwater — volume projected to be pumped (ac-ft/yr)					
Basin name(s)	**2015**	**2020**	**2025**	**2030**	**2035 - opt**
Kings River Subbasin	5,252	5,243	5,789	6,392	7,057
Total groundwater pumped	5,252	5,243	5,789	6,392	7,057
Percent of total water supply	100.00%	100.00%	100.00%	100.00%	100.00%

4.3 Transfer Opportunities

#24. Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis (10631(d)).

Transfer opportunities of surface water currently exist with the Alta Irrigation District due to the fact that the City of Dinuba lies within the boundaries of the District. The drawback of utilizing surface water for domestic purposes is that it is not treated at a level appropriate for domestic consumption. A surface water treatment plant would be required to properly treat the water, which would unnecessarily increase capital and operating costs for the City. Another reason for not utilizing surface water is that it is only typically available in the Dinuba area for a 4 month period of time during the summer months each year.

Table 20 Transfer and exchange opportunities (ac-ft/yr)			
Transfer agency	**Transfer or exchange**	**Short term or long term**	**Proposed Volume**
Alta Irrigation District	Transfer	Short	Unknown
Total			

4.4 Desalinated Water Opportunities

#31. Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply (10631(i)).

There is a small amount of shallow brackish groundwater located along the western portion of the Kings River Subbasin. There are currently no signs of brackish water within the groundwater in the area surrounding the City of Dinuba.

4.5 Recycled Water Opportunities

#44. Provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area (10633).

The City has taken steps to be in a position to deliver recycled/reclaimed water to the planned residential development around the recently constructed Ridge Creek golf course and to the City's industrial park to irrigate landscaping areas or to use for non-contact cooling water. The City will consider the development of a master plan to use water from former municipal supply wells contaminated with DBCP, nitrates or other constituents for irrigating parks and landscape areas.

#45. (Describe) the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal (10633(a)).

The City operates a wastewater reclamation facility (WWRF) that receives and treats about 2.3 MGD to secondary treatment levels, which is then disposed of in percolation ponds on-site that in turn helps recharge the shallow aquifer. This ground water is currently reused for agricultural purposes (extracted groundwater) down gradient of the WWRF.

In 2006 and 2007 the City was engaged in a study to consider the use of groundwater extracted from beneath these disposal ponds for deliver back into the community for use in irrigating landscaping areas.

#46. (Describe) the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project (10633(b)).

Preliminary samples taken from test wells generally located at the WWRF indicated that groundwater extracted from 100 feet below the WWRF disposal ponds met Title 22 standards. However, regulatory agencies indicated to the City that this water would have to be filtered and disinfected before it could be reused. These requirements would make this process economically infeasible.

Table 21
Recycled water — wastewater collection and treatment (ac-ft/yr)

Type of Wastewater	2005	2010	2015	2020	2025	2030	2035 - opt
Wastewater collected & treated in service area	2,464	2,800	3,248	3,808	4,480		
Volume that meets recycled water standard	0	0	-	-	-		

Table 22
Recycled water — non-recycled wastewater disposal (ac-ft/yr)

Method of disposal	Treatment Level	2010	2015	2020	2025	2030	2035 - opt
		0	0	0	0	0	0
Total		0	0	0	0	0	0

#47. (Describe) the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use (10633(c)).

Recycled ground water is currently in use in several locations in the community as follows:

- Rose Ann Vulch Park (10 acres), which is irrigated from former City Well #2, which is contaminated with DBCP;
- Felix Delgado Park (8 acres) and Wilson Elementary School playground (8 acres), which are irrigated from former City Well #7, which is contaminated with DBCP.
- KC Vista Park (18.5 acres), which is irrigated from a modified on-site agricultural well that is contaminated with DBCP.
- Lincoln Elementary School playground (8 acres), which is irrigated from a modified on-site agricultural well that is contaminated with DBCP.
- Roosevelt Elementary School playground (10 acres), which is irrigated from a modified on-site agricultural well that is contaminated with DBCP.
- Jefferson Elementary School playground (8 acres), which is irrigated from a modified on-site agricultural well that is contaminated with DBCP.

- Washington Intermediate School athletic fields (15 acres), which is irrigated from a modified on-site agricultural well that is contaminated with DBCP.
- Dinuba High School athletic fields (20 acres), which is irrigated from a modified on-site agricultural well that is contaminated with DBCP.
- Ridge Creek Golf Course (240 acres), which is irrigated from a 12 acre lake fed by a former shallow agricultural well adjacent to the golf course and the WWRF.

Combined, these areas use about 4400 acre-feet of shallow aquifer ground water for irrigation annually. Additionally, the City in partnership with the Alta Irrigation District developed a 28 acre ground water recharge facility that seasonally collects urban drainage water from approximately 800 acres of the community and seasonally allows the District to store excess irrigation water available to the District. This water is then allowed to percolate into soil to recharge the shallow aquifer for agricultural uses.

Table 23
Recycled water — potential future use (ac-ft/yr)

User type	Description	Feasibility	2015	2020	2025	2030	2035 - opt
Agricultural irrigation			0	0	0	0	0
Landscape irrigation	Secondary Treatment Level	Feasible	1,176	1,736	1,848		0
Commercial irrigation			0	0	0	0	0
Golf course irrigation	Secondary Treatment Level	Feasible	1,120	1,120	1,120	1,120	1,120
Wildlife habitat			0	0	0	0	
Wetlands			0	0	0	0	
Industrial reuse			0	0	0	0	
Groundwater recharge			0	0	0	0	
Seawater barrier			0	0	0	0	
Getothermal/Energy			0	0	0	0	
Indirect potable reuse			0	0	0	0	
Other (user type)			0	0	0	0	
	Total	0	2,296	2,856	2,968	1,120	1,120

#48. (Describe and quantify) the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses (10633(d)).

In Dinuba, the likely uses of recycled water are: landscape irrigation, industrial use (non-contact cooling water) and ground water recharge.

The City has undertaken planning and limited infrastructure development to use groundwater extracted from the shallow aquifer near the WWRF for irrigating the Ridge Creek golf course, the landscaping areas adjacent to the golf course, the planned residential development around the golf course and potentially the industrial park just east of the WWRF. The 1.5 MGD primary well and the 800,000 GPM back-up well that produce this water keep a 12 MG reservoir filled. With the development of additional shallow aquifer wells in this area there would be an ability to supply enough water to irrigate up to an additional 500 acres or provide up to 3 MGD of non-potable water to the community for industrial purposes.

It should be noted that in Dinuba there are no points where storm water discharges into any waters of the US or natural drainage ways and, at present, there are only two sub-basins (one about 150 acres and the other about 10 acres) that directly discharge into an irrigation canal. All other basins discharge into city or privately owned and maintained detention or retention basins. Drainage water is typically pumped from these detention basins back to irrigation canals several days after a storm event to allow for maximum

recharge opportunities. In a typical winter there is a potential that between 1250 and 1500 acre-feet of drainage water could be recharged in this fashion.

#49. (Describe) the projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision (10633(e)).

In order for the City to take full advantage of recycled water, it would be necessary for the City to fully develop a recycled water distribution system. To date no comprehensive plan has been undertaken to do this. This plan would have to include comprehensive design of production and required treatment (if any) facilities, a delivery system, the development of standards for new development and a financial plan to fund the improvements. It is anticipated that within five years a master plan and development standards could be developed and implemented and a multi-year capital development plan could be developed. Within this period only the baseline use of recycled water would occur (the golf course, three city parks and six school playgrounds currently irrigated with shallow aquifer ground water, about 4400 acre-feet per year). During the next five year interval, new subdivision development landscaping, estimated at about 150 acres, could be irrigated with an additional 2000 acre-feet of shallow aquifer ground water. During the next two five year intervals growth in the use of shallow aquifer ground water would be new subdivision activity and limited development of shallow aquifer ground water distribution in the vicinity of existing supply sources (the three City parks and golf course currently irrigated with shallow aquifer ground water). Full scale community use of shallow aquifer ground water for irrigation is not likely to occur for 50 or so years.

Table 24
Recycled water — 2005 UWMP use projection compared to 2010 actual (ac-ft/yr)

Use type	2010 actual use	2005 Projection for 2010
Agricultural irrigation	0	0
Landscape irrigation	0	0
Commercial irrigation	0	0
Golf course irrigation	0	0
Wildlife habitat	0	0
Wetlands	0	0
Industrial reuse	0	0
Groundwater recharge	0	0
Seawater barrier	0	0
Getothermal/Energy	0	0
Indirect potable reuse	0	0
Other (user type)	**0**	0
Total	0	0

#50. (Describe the) actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year (10633(f)).

As stated previously, the City would have to develop a master plan and standards for community and new development's use of shallow aquifer ground water including a plan on how to fund the development of a supply, treatment (if required) and delivery system. Likely funding scenarios include establishing an impact fee structure to assist in the development of supply and treatment (if required) facilities, development requirements for constructing infrastructure in conjunction with all new development activity and a service charge for the operation and maintenance of a supply and delivery system. See #49 for estimates of the amount of shallow aquifer ground water used each year.

Table 25 Methods to encourage recycled water use (ac-ft/yr)						
Actions	Projected Results					
	2010	2015	2020	2025	2030	2035 - opt
Financial incentives	0	0	0	0	0	
Golf Course, Irrigating Parks, Landscape Areas	0	0	0	0	0	
Total	0	0	0	0	0	0

#51. (Provide a) plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use (10633(g)).

This has been previously described in some detail in sections #45, #46 and #48. The primary obstacle that needs to be overcome in order for the City to implement this plan is the regulatory agencies' unwillingness to allow the City to implement the plan without the imposition of onerous regulatory constraints.

4.6 Future Water Projects

#30. (Describe) all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single-dry, and multiple-dry water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program (10631(h)).

The City of Dinuba has planned future water supply projects that consist of constructing and implementing 3 new groundwater wells. Table 26 displays the timeline for project completion and the volume of groundwater that is to be supplied by each well per year (Units = Millions of Gallons).

TABLE 26 - Future water supply projects (mgd)								
Project name	Projected start date	Projected completion date	Potential project constraints	Normal-year supply	Single-dry year supply	Multiple-dry year first year supply	Multiple-dry year second year supply	Multiple-dry year third year supply
Well 21	2013	2013	0	1.10	1.05	0.99	0.94	0.88
Well 22	2016	2016	0	1.10	1.05	0.99	0.94	0.88
Well 23	2021	2021	0	1.10	1.05	0.99	0.94	0.88
		Total	0	3.30	3.15	2.97	2.82	2.64

Section 5 – Water Supply Reliability & Water Shortage Contingency Planning

5.1 Water Supply Reliability

#5. An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions (10620(f)).

The analysis for this is not applicable due to the fact that the City of Dinuba cannot import water from other regions at this point, nor is it possible in the foreseeable future. Additional discussion regarding water management tools and options are presented in the following paragraphs.

#23. For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable (10631(c)(2)).

At this time, the City has no entitlement to access to water from the Kings River or other surface water supplies. To acquire these rights the City would have to engage in arduous legal battles with area water purveyors.

If entitlements to surface water supplies are obtained, it would then be necessary for the City to construct a surface water treatment facility at significant cost to the rate payers.

The City's best supply choices are to continue to access shallow and deep groundwater aquifers within its jurisdiction and develop ways to reuse its wastewater and drainage run-off water for irrigation and non-contact industrial uses.

Table 29
Factors resulting in inconsistency of supply

Water supply sources	Specific source name, if any	Limitation quantification	Legal	Environmental	Water quality	Climatic	Additional information
City produced groundwater	Kings River Subbasin		X	X	X	X	
Recycled water				X	X	X	

5.2 Water Shortage Contingency Planning

#37. Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster (10632(c)).

In order to prevent any serious negative impacts on the City of Dinuba's water supply due to a catastrophic reduction in water that is available, a Water Shortage Contingency Plan will be implemented. The Water Shortage Contingency Plan consists of mandatory prohibitions, consumption reduction methods, and penalties/charges that will be placed upon the use of Dinuba's water supply in order to regulate water consumption. Tables 35 – 38 display the different stages of the Water Shortage Contingency Plan and at what stage each individual regulation will go into effect.

The City of Dinuba has implemented measures to allow for continued water deliveries in the event of a significant power outage. All wells developed since 1990 have standby power units installed to allow the well to be operated in the event of power interruptions. Additionally, a 2 MG tank put in service in 2009 has standby power. Together with the 1 MG elevated tank put in service in 1999 and the 250,000 gallon tank put in service in 1925, there is a one winter day supply of gravity-fed water without the use of standby power on the system's wells.

Table 35
Water shortage contingency — rationing stages to address water supply shortages

Stage No.	Water Supply Conditions	% Shortage
1	Reduction	15%
2	Reduction	20%
3	Reduction	30%

#38. Additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning (10632(d)).

These measures are described in the City's water conservation ordinance but to date have not been implemented.

Table 36
Water shortage contingency — mandatory prohibitions

Examples of Prohibitions	Stage When Prohibition is Voluntary	Stage When Prohibition is Mandatory
Water used for street washing	1	2
Irrigation hours	1	2
Automobile washing hours	1	2
Pool refilling hours	1	2
Sidewalk/Driveway washing	1	2
Fire hydrant use	1	3
Ornamental Fountains	1	3

#39. Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply (10632(e)).

The City of Dinuba enacted a water conservation ordinance in 1989. In 1991 the City put Stage 1 in force in response to drought conditions and the placement of restrictions on the operation of wells containing DBCP above allowable limits. The measures were so effective that usage was reduced by 30%. Unfortunately, revenues declined by 45%, which diminished the City's ability to operate the water system in a fiscally responsible manner. Given the economic conditions in the community it was not then and is not now possible to increase service charges sufficient to cover the operating shortfalls.

Table 37 Water shortage contingency — consumption reduction methods		
Consumption Reduction Methods	**Stage When Method Takes Effect**	**Projected Reduction (%)**
Voluntary rationing	1	15%
Mandatory rationing	2	20%
Restrict for priority use	3	30%
Implement prohibitions	2	20%
Reduce system pressure	3	20%
Public education	1	15%
Increase water pricing	3	30%

#40. Penalties or charges for excessive use, where applicable (10632(f)).

The City's use of meters and rate structure encourage customers to conserve water. Usage over the base amount (12 ccf per month) is accommodated in the base rate. Usage above this amount is charged a consumptive charge penalty.

Table 38 Water shortage contingency — penalties and charges	
Penalties or Charges	**Stage When Penalty Takes Effect**
Fines	3
Charge for excess use	Always
Service termination	Always

#41. An analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments (10632(g)).

a) Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions which are applicable to each stage.

a. The City cannot continue to operate the water system, if there was a 50% reduction in water supply. The revenues generated would not cover the overhead costs to run the system. The City has and will continue to run a reserve water fund and also as discussed consider a revised/new rate structure to compensate for this potential loss of revenue.

b) An estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.

a. The City has weathered temporary drought periods, but as noted water demand typically increases in short-term drought conditions. This creates additional revenue generated to operate the system.

c) Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.

a. The City has established a water conservation ordinance that details measures that are to be taken in the event of a water shortage/supply emergency.

d) Additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.

a. As previously indicated, Stage 1 of the water conservation ordinance (Voluntary Compliance) was instituted in 1991 with catastrophic results to water system operating revenues. Water usage declined 30% but water revenues for the year declined 45%, resulting in the inability of the City to operate its water system in a fiscally responsible manner. The reserves were depleted and the operating budget was reduced to the point where the City had insufficient revenue to operate the system effectively.

e) Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.

a. The City implemented these measures using a combination of funding from state-financed loans, City bond measures, lawsuit settlement proceeds, development impact fees and rate increases. This was done within the fiscal constraints of the community and at present the City has adequate reserves to effectively operate the system.
b. As previously indicated, Stage 1 of the water conservation ordinance (Voluntary Compliance) was instituted in 1991 with catastrophic results to water system operating revenues. Water usage declined 30% but water revenues for the year declined 45%, resulting in the inability of the City to operate its water system in a fiscally responsible manner. The reserves were depleted and the operating budget was reduced to the point where the City had insufficient revenue to operate the system effectively.

f) Penalties or charges for excessive use, where applicable.

a. The City has studied this in a recent water rate increase analysis. Pending approval of this plan, the City is considering moving the water rate increase forward; which would penalize and charge in a tiered structure the highest water users.

#42. A draft water shortage contingency resolution or ordinance (10632(h)).

The adopted water conservation ordinance is attached as Appendix H.

5.3 Water Quality

#52. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability (10634).

Water drawn from the deep aquifer is expected to meet State standards for the foreseeable future. Water drawn from the shallow aquifer typically does not meet water quality standards due to the presence of DBCP and cannot be used without adequate treatment. Additionally, water drawn from the shallow aquifer in the Downtown area may have MTBE present. Finally, water drawn from the shallow aquifer may have nitrates at levels close to the MCL.

Table 30 Water quality — current and projected water supply impacts							
Water source	**Description of condition**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035 - opt**
City produced groundwater	*Meets quality standards*	4,830.0	5,252.0	5,243.0	5,789.0	6,392	7,057
Recycled water	*Irrigation/agriculture only*	0.0	0.0	0.0	0.0	0	0

5.4 Drought Planning

#22. Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following: (A) an average water year, (B) a single dry water year, (C) multiple dry water years (10631(c)(1)).

During the drought conditions experienced over the last two decades the City has experienced substantial fluctuations in the shallow aquifer. During wet years ground water has typically been in the 40-45 foot range below the surface. During dry years ground water in the shallow aquifer had dropped to the 100 to 115 range and many shallow private domestic wells dried up, creating a need to drill the wells deeper or connect to the city's system. However, there was not a significant decline in the supply in the deep aquifer municipal wells during these drought conditions. Despite this situation, conservation measures were instituted in 1991 with catastrophic financial results.

For planning use, 2005 was chosen as a recent normal hydrologic year. Rainfall was within 1% of average. 2007 was chosen for the single-dry water year, since 2006 and 2010 were both wet years. 2007 had rainfall approximately 57% below average. The multiple-dry water year range used in the drought analysis was from 2007-2009.

The charts below show that during drought periods, demand actually increases; which is most likely due to increased landscape watering by residents of the City. With a decrease in precipitation, there is much more water required to keep trees, plants, and lawns alive during the long, hot Valley summers. Although, it is of note that following extended periods of drought, it seems that increased public awareness starts to reduce the amount of water demand.

Table 27 Basis of water year data	
Water Year Type	**Base Year(s)**
Average Water Year	**2005**
Single-Dry Water Year	**2007**
Multiple-Dry Water Years	**2007-2009**

Table 28 Supply reliability — historic conditions (gpcd)					
Average / Normal Water Year	**Single Dry**	**Multiple Dry Water Years**			
		Year 1	**Year 2**	**Year 3**	**Year 4**
201	225	225	225	220	201
Percent of Average/Normal Year:	111.9%	111.9%	111.9%	109.5%	100.0%

#35. Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions which are applicable to each stage (10632(a)).

See the Water Conservation Ordinance attached as Appendix H.

In addition to the Water Conservation Ordinance, the City of Dinuba is currently working on an updated Water Rate Study. The Water Rate Study will address the loss of revenue from a decrease in water supply and/or a decrease in consumption due to water use restrictions or conservation. The rate study is planned to be completed by the end of 2014 for implementation in 2015.

#36. An estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply (10632(b)).

There has never been a water shortage due to drought conditions in the deep groundwater aquifer; therefore there is no estimate of if the water supply will be adequate.

#43. A mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis 10632(i).

See the Water Conservation Ordinance attached as Appendix H.

#53. Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier (10635(a)).

The following Table will show a balance between supply and demand over planning period. There is expected to be an over-draft of groundwater; but enough available groundwater to meet the demand requirements. Additional reference is to be made to the City of Dinuba water system master plan prepared by Boyle Engineering in 2008; which in more detail projects the City's water system supply over the next few decades. The normal supply quantities are essentially just the projected target water demand numbers listed in Table 11.

Regarding long-term climate change and water supply, it should be noted that sustained increases in overall average temperatures and decreases in precipitation amounts would

Table 32
Supply and demand comparison — normal year (ac-ft/yr)

	2015	2020	2025	2030	2035 - opt
Supply totals (from Table 16)	5,252	5,243	5,789	6392	
Demand totals (From Table 11)	5,252	5,243	5,789	6392	
Difference	0	0	0	0	
Difference as % of Supply	0.0%	0.0%	0.0%	0.0%	
Difference as % of Demand	0.0%	0.0%	0.0%	0.0%	

Table 33 shows the projected supply and demand for the single dry year. As noted previously, historical data suggests that the water users use additional water during dry years due to increased stresses placed on landscaping and water offsets that precipitation would typically provide. To project the increased demand, a 12% increase has been included. Even with the additional water demand, there would be adequate water supply to meet the demand.

Table 33 Supply and demand comparison — single dry year (ac-ft/yr)					
	2015	2020	2025	2030	2035 - opt
Supply totals	5,882	5,872	6,484	7159	
Demand totals	5,882	5,872	6,484	7159	
Difference	0	0	0	0	
Difference as % of Supply	0.0%	0.0%	0.0%	0.0%	
Difference as % of Demand	0.0%	0.0%	0.0%	0.0%	

Again, Table 34 shows the projected supply and demand for the multiple dry year events. As noted previously, historical data suggests that the water users start to use less water as the drought persists due to increased public awareness and subsequent changes to habits and lifestyles. The data suggests that following two to three years, water usage returns to normal yearly levels. As discussed, there would be adequate water supply to meet the demand.

Table 34 Supply and demand comparison — multiple dry-year events (ac-ft/yr)						
		2015	2020	2025	2030	2035 - opt
Multiple-dry year first year supply	**Supply totals**	5,882	5,872	6,484	7,159	
	Demand totals	5,882	5,872	6,484	7,159	
	Difference	0	0	0	0	
	Difference as % of Supply	0.0%	0.0%	0.0%	0.0%	
	Difference as % of Demand	0.0%	0.0%	0.0%	0.0%	
Multiple-dry year second year supply	**Supply totals**	5,882	5,872	6,484	7,159	
	Demand totals	5,882	5,872	6,484	7,159	
	Difference	0	0	0	0	
	Difference as % of Supply	0.0%	0.0%	0.0%	0.0%	
	Difference as % of Demand	0.0%	0.0%	0.0%	0.0%	
Multiple-dry year third year supply	**Supply totals**	5,751	5,741	6,339	6,999	
	Demand totals	5,751	5,741	6,339	6,999	
	Difference	0	0	0	0	
	Difference as % of Supply	0.0%	0.0%	0.0%	0.0%	
	Difference as % of Demand	0.0%	0.0%	0.0%	0.0%	

Section 6 – Demand Management Measures

6.1 DMM's

#26. (Describe and provide a schedule of implementation for) each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following: (A) water survey programs for single-family residential and multifamily residential customers; (B) residential plumbing retrofit; (C) system water audits, leak detection, and repair; (D) metering with commodity rates for all new connections and retrofit of existing connections; (E) large landscape conservation programs and incentives; (F) high-efficiency washing machine rebate programs; (G) public information programs; (H) school education programs; (I) conservation programs for commercial, industrial, and institutional accounts; (J) wholesale agency programs; (K) conservation pricing;(L) water conservation coordinator; (M) water waste prohibition; (N) residential ultra-low flush toilet replacement programs (10631(f)(1) and (2).

The implementation of all DMM's are described in the following pages.

#27. A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan (10631(f)(3)).

Utility billing personnel monitor all accounts to detect excessive water usage utilizing an "exception report" feature in the billing software that "flags" any account where there is abnormal consumption. When so detected, the customer is notified to take steps to determine the cause and makes changes to reduce usage.

#28. An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand (10631(f)(4)).

No such estimate is available.

#29. An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following: (1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors; (2) Include a cost-benefit analysis, identifying total benefits and total costs; (3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost; (4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation (10631(g)).

A) The City has provided survey information, conservation "tips" and guidelines using a quarterly newsletter and its website and leak detection kits to customers and has found these to be effective ways to raise awareness of water conservation practices for residential users.

B) The City has provided guidelines to property owners on the proper ways to modify their plumbing to more efficiently conserve water, including the use of low-flow shower head flow restrictors, low-flow toilet fixture retrofits/change-outs and toilet tank volume restrictors.

C) The City is currently evaluating two options. The first is that the City has received a proposal from a leak detection company in order to perform a full system leak detection evaluation. The second option is that the

City has received a quote to purchase the leak detection equipment and have City forces trained to operate the equipment. Both options are still currently being evaluated. The current plan is to have this completed by December 2014. Based upon the reports or findings, the City would repair and fix the located leaks.

Considering that the entire City is metered, the City's leak detection program also includes notifying customers of unusually high meter readings. The system will "flag" atypical meter reads and a City staff member will notify the resident and request that it is fixed on their property or the meter will be red-tagged.

D) All service connections in the City of Dinuba have been metered since 1956. The City has found this to be an effective method of promoting water conservation.

E) The City does not have a formal large landscape conservation or incentive program in place. It has, however, since the early 1990s, made a concerted effort to separate irrigation water use from other uses for all large commercial, industrial and institutional uses. Also since the early 1990's, the City's Public Works Department has aggressively monitored wasteful irrigation practices and notified customers of a need to correct associated problems and, when it was necessary, corrected the problems using City forces.

At this time it is not considered cost effective to implement a landscape water survey program. If the City were to conduct a water survey on 90% of the existing Commercial, Institutional, and Industrial (CII) customers (399 surveys), it is estimated there would be 49 ac-ft/yr. of water savings (based on an assumed reduction of 20% per surveyed customer). The cost to implement a landscape audit program is estimated to be approximately $610,470 per year. The average cost for potable water in the City's system in 2010 was $570.55 per ac-ft (including commodity, capacity, and fire protection costs). By reducing use by 49 ac-ft/yr, the cost savings would only be about $27,957 per year, or $279,570 over 10 years. This information is summarized in the cost benefit table below. The cost to implement the landscape survey program far outweighs the benefit. Furthermore, given the current economic climate, the City does not have available funding to implement such a program. Therefore, the City has no plans to implement a landscape water survey program at this time.

Landscape Survey – Cost Benefit Analysis		
	Cost[3]	Basis
Landscape Survey Costs[1]		
Administrative	$51,870	798 hrs x $65/hr.
Field Labor	$239,400	12 hrs/survey x $50/hr x 399 surveys
Customer Participation	$319,200	$800/survey x 399 surveys
Total Cost	$610,470	
Ten Year Program Cost	$6,104,700	
Potential Savings[2]	49 ac-ft/yr	
Cost of Potable Water (over 10 years)	$279,570	$570.55/ac-ft x 49 ac-ft/yr x 10 years
Is a Landscape Survey Program Cost Effective?	No	1:22 Cost benefit ratio

1. The survey costs are based on surveying 90% of the City's existing potable water Commercial/Institutional/Industrial customers (399 surveys). The CUWCC BMP requires 90% of metered large landscape accounts to receive assistance over a 10-year period (or 9% of accounts per year).
2. Potential savings is based on a 20% reduction of 50% of the amount of water of the existing Commercial, Institutional, and Industrial (CII) customers' demands.
3. Costs do not include interest rate adjustments over the 10-year period and are comparative in 2014 dollars.

F) This DMM is implemented through the rebate program offered by P,G&E. (CWME, $75/unit for high efficiency clothes washers)

G) The City regularly uses the local newspaper, ConnectCTY (an automated telephone messaging service) and a quarterly newsletter to disseminate information on water conservation. Additionally, public service advertising by Fresno and Visalia on the local television stations has been effective in encouraging City customers to conserve.

H) The City will create an educational brochure to provide to the Dinuba Unified School District for their use in distributing to the school children in conjunction with an Earth Day program regarding water use and conservation. The City will prepare the educational brochure and provide to the City by April 1, 2015.

I) Utility billing personnel monitor all Commercial, Institutional, and Industrial accounts to detect excessive water usage utilizing an "exception report" feature in the billing software that "flags" any account where there is abnormal consumption. When so detected, the property owner is notified to take steps to determine the cause and makes changes to reduce usage. In addition, City staff will provide education on ways to reduce water usage or implement conservation programs.

J) This is not applicable.

K) The City is evaluating its water rate structure to consider measures to encourage water conservation and discourage excessive use of water. Regarding the latter, the City is considering the elimination of its tiered rate structure, which currently provides a reduced rate for water consumption over 8800 cubic feet per month; this measure will largely affect those customers that irrigate large areas of landscaping.

The City of Dinuba is currently working on an updated Water Rate Study. The Water Rate Study will address the loss of revenue from a decrease in water supply and/or a decrease in consumption due to water use restrictions or conservation. The rate study is planned to be completed by the end of 2014 for implementation in 2015.

L) Through the Water Conservation Ordinance, the City has implemented an administrative citation process that gives the following City personnel the authority to cite violations of the Water Conservation Ordinance. The Director of Public Works is designated as the Water Conservation Coordinator, overseeing all aspects of DMM implementation and administrative oversight of the Water Conservation Ordinance. The following staff have the authority to enforce restrictions:

- City Engineer
- Building Official
- Public Works Superintendent
- Building Inspectors
- Animal Control Officers

M) In Section 13.05.050 of the Water Conservation Ordinance the City specifically prohibits water waste.

N) The City has established a "Water Conservation Ultra-Low Flow Toilet Program," administered by the Public Works Director. The program has a yearly budget of $5,000 and offers $100/toilet rebates to upgrade to ultra low-flush toilets. The program is noticed through local newspaper.

Section 7 – Climate Change

Optional, not used.

Section 8 – Completed UWMP Checklist

The following UWMP Checklist has been provided for DWR staff use.

Table I-1 Urban Water Management Plan checklist, organized by legislation number

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
1	Provide baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.	10608.20(e)	System Demands		Page 11
2	*Wholesalers:* Include an assessment of present and proposed future measures, programs, and policies to help achieve the water use reductions. *Retailers:* Conduct at least one public hearing that includes general discussion of the urban retail water supplier's implementation plan for complying with the Water Conservation Bill of 2009.	10608.36 10608.26(a)	System Demands	Retailer and wholesalers have slightly different requirements	Page 16
3	Report progress in meeting urban water use targets using the standardized form.	10608.40	Not applicable	Standardized form not yet available	N/A
4	Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.	10620(d)(2)	Plan Preparation		Page 3
5	An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.	10620(f)	Water Supply Reliability . . .		Page 26
6	Every urban water supplier required to prepare a plan pursuant to this part shall, at least 60 days prior to the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.	10621(b)	Plan Preparation		Page 3
7	The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640).	10621(c)	Plan Preparation		Page 4
8	Describe the service area of the supplier	10631(a)	System Description		Page 6
9	(Describe the service area) climate	10631(a)	System Description		Page 8

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
10	(Describe the service area) current and projected population . . . The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier . . .	10631(a)	System Description	Provide the most recent population data possible. Use the method described in "Baseline Daily Per Capita Water Use." See Section M.	Page 9
11	. . . (population projections) shall be in five-year increments to 20 years or as far as data is available.	10631(a)	System Description	2035 and 2040 can also be provided to support consistency with Water Supply Assessments and Written Verification of Water Supply documents.	Page 9
12	Describe . . . other demographic factors affecting the supplier's water management planning	10631(a)	System Description		Page 10
13	Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a).	10631(b)	System Supplies	The 'existing' water sources should be for the same year as the "current population" in line 10. 2035 and 2040 can also be provided to support consistency with Water Supply Assessments and Written Verification of Water Supply documents.	Page 18

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
14	(Is) groundwater . . . identified as an existing or planned source of water available to the supplier . . .?	10631(b)	System Supplies	Source classifications are: surface water, groundwater, recycled water, storm water, desalinated sea water, desalinated brackish groundwater, and other.	Page 19
15	(Provide a) copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management. Indicate whether a groundwater management plan been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization.	10631(b)(1)	System Supplies		**Page 19**
16	(Provide a) description of any groundwater basin or basins from which the urban water supplier pumps groundwater.	10631(b)(2)	System Supplies		**Page 19**
17	For those basins for which a court or the board has adjudicated the rights to pump groundwater, (provide) a copy of the order or decree adopted by the court or the board	10631(b)(2)	System Supplies		**Page 20**
18	(Provide) a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree.	10631(b)(2)	System Supplies		**Page 20**
19	For basins that have not been adjudicated, (provide) information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.	10631(b)(2)	System Supplies		**Page 20**
20	(Provide a) detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.	10631(b)(3)	System Supplies		**Page 20**

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
21	(Provide a) detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.	10631(b)(4)	System Supplies	Provide projections for 2015, 2020, 2025, and 2030.	**Page 20**
22	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following: (A) An average water year, (B) A single dry \	10631(c)(1)	Water Supply Reliability . . .		**Page 30**
23	For any water source that may not be available at a consistent level of use - given specific legal, environmental, water quality, or climatic factors - describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.	10631(c)(2)	Water Supply Reliability . . .		**Page 26**
24	Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.	10631(d)	System Supplies		**Page 21**
25	Quantify, to the extent records are available, past and current water use, and projected water use (over the same five-year increments described in subdivision (a)), identifying the uses among water use sectors, including, but not necessarily limited to, all of the following uses: (A) Single-family residential; (B) Multifamily; (C) Commercial; (D) Industrial; (E) Institutional and governmental; (F) Landscape; (G) Sales to other agencies; (H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof;(I) Agricultural.	10631(e)(1)	System Demands	Consider “past” to be 2005, present to be 2010, and projected to be 2015, 2020, 2025, and 2030. Provide numbers for each category for each of these years.	**Page 12**

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
26	(Describe and provide a schedule of implementation for) each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following: (A) Water survey programs for single-family residential and multifamily residential customers; (B) Residential plumbing retrofit; (C) System water audits, leak detection, and repair; (D) Metering with commodity rates for all new connections and retrofit of existing connections; (E) Large landscape conservation programs and incentives; (F) High-efficiency washing machine rebate programs; (G) Public information programs; (H) School education programs; (I) Conservation programs for commercial, industrial, and institutional accounts; (J) Wholesale agency programs; (K) Conservation pricing; (L) Water conservation coordinator; (M) Water waste prohibition;(N) Residential ultra-low-flush toilet replacement programs.	10631(f)(1)	DMMs	Discuss each DMM, even if it is not currently or planned for implementation. Provide any appropriate schedules.	**Page 33**
27	A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.	10631(f)(3)	DMMs		**Page 33**
28	An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.	10631(f)(4)	DMMs		**Page 33**
29	An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following: (1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors; (2) Include a cost-benefit analysis, identifying total benefits and total costs; (3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost; (4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.	10631(g)	DMMs	See 10631(g) for additional wording.	**Page 33**

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
30	(Describe) all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single-dry, and multiple-dry water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.	10631(h)	System Supplies		**Page 25**
31	Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.	10631(i)	System Supplies		**Page 21**
32	Include the annual reports submitted to meet the Section 6.2 requirement (of the MOU), if a member of the CUWCC and signer of the December 10, 2008 MOU.	10631(j)	DMMs	Signers of the MOU that submit the annual reports are deemed compliant with Items 28 and 29.	**N/A**
33	Urban water suppliers that rely upon a wholesale agency for a source of water shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c).	10631(k)	System Demands	Average year, single dry year, multiple dry years for 2015, 2020, 2025, and 2030.	**Page 16**

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
34	The water use projections required by Section 10631 shall include projected water use for single-family and multifamily residential housing needed for lower income households, as defined in Section 50079.5 of the Health and Safety Code, as identified in the housing element of any city, county, or city and county in the service area of the supplier.	10631.1(a)	System Demands		**Page 15**
35	Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions which are applicable to each stage.	10632(a)	Water Supply Reliability . . .		**Page 30**
36	Provide an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.	10632(b)	Water Supply Reliability . . .		**Page 31**
37	(Identify) actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.	10632(c)	Water Supply Reliability . . .		**Page 26**
38	(Identify) additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.	10632(d)	Water Supply Reliability . . .		**Page 27**
39	(Specify) consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.	10632(e)	Water Supply Reliability . . .		**Page 27**
40	(Indicated) penalties or charges for excessive use, where applicable.	10632(f)	Water Supply Reliability . . .		**Page 27**
41	An analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.	10632(g)	Water Supply Reliability . . .		**Page 27**
42	(Provide) a draft water shortage contingency resolution or ordinance.	10632(h)	Water Supply Reliability . . .		**Page 27**

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
43	(Indicate) a mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.	10632(i)	Water Supply Reliability . . .		**Page 31**
44	Provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area	10633	System Supplies		**Page 21**
45	(Describe) the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.	10633(a)	System Supplies		**Page 22**
46	(Describe) the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.	10633(b)	System Supplies		**Page 22**
47	(Describe) the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.	10633(c)	System Supplies		**Page 22**
48	(Describe and quantify) the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.	10633(d)	System Supplies		**Page 23**
49	(Describe) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.	10633(e)	System Supplies		**Page 24**
50	(Describe the) actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.	10633(f)	System Supplies		**Page 24**
51	(Provide a) plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.	10633(g)	System Supplies		**Page 25**

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
52	The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability.	10634	Water Supply Reliability . . .	For years 2010, 2015, 2020, 2025, and 2030	**Page 29**
53	Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.	10635(a)	Water Supply Reliability . . .		**Page 31**
54	The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.	10635(b)	Plan Preparation		**Page 4**
55	Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan.	10642	Plan Preparation		**Page 4**
56	Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area.	10642	Plan Preparation		**Page 4**
57	After the hearing, the plan shall be adopted as prepared or as modified after the hearing.	10642	Plan Preparation		**Page 4**
58	An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.	10643	Plan Preparation		**Page 4**

No.	UWMP requirement [a]	Calif. Water Code reference	Subject [b]	Additional clarification	UWMP location
59	An urban water supplier shall submit to the department, the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be submitted to the department, the California State Library, and any city or county within which the supplier provides water supplies within 30 days after adoption.	10644(a)	Plan Preparation		**Page 5**
60	Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.	10645	Plan Preparation		**Page 5**

a The UWMP Requirement descriptions are general summaries of what is provided in the legislation. Urban water suppliers should review the exact legislative wording prior to submitting its UWMP.

b The Subject classification is provided for clarification only. It is aligned with the organization presented in Part I of this guidebook. A water supplier is free to address the UWMP Requirement anywhere with its UWMP, but is urged to provide clarification to DWR to facilitate review.

Appendix A – Resolution to Adopt UWMP

Final resolution to be inserted when adopted.

Declaration of Publication
State of California)
County of Tulare) ss.

Declarant says:
That at all times herein mention
Declarantis and was a resident of said County,
of **TULARE**, over the age of twenty-one years;
not a party to nor interested in the within matter;
that Declarant is now and was at all times herein
mentioned the **CHIEF CLERK TO THE PUBLISHER** of the Dinuba Sentinel, a weekly
newspaper, which said newspaper was reaffirmed
as a newspaper of general circulation on August
18, 1951 by Superior Court order No. 19523;
and that said newspaper is printed and published
every Thursday in the City of Dinuba,
in said County of Tulare; and that the

Public Notice:
Demand Management Measures

of which the copy annexed on the margin hereof
is a true and printed copy was published in said
newspaper in the issue of:

September 11, 2014

and that such publication was made in the regular
issue of said paper(and not in any supplemental edition
or extra thereof).

I declare under penalty of perjury that the foregoing
is true and correct.
Executed on September 11, 2014 at Dinuba,
California

Katherine J Saale
Declarant

City of Dinuba
PUBLIC NOTICE

To provide an opportunity for citizen participation, the City of Dinuba will hold a Public Hearing to discuss a proposed amendment to the 2010 Urban Water Management Plan to update Demand Management Measures to meet water conservation standards.

PUBLIC HEARING

DATE: September 23, 2014
TIME: 6:30 P.M.
PLACE: Council Chambers, City Hall
405 East El Monte Way, Dinuba, CA

The City is seeking public attendance and input regarding updates to the Demand Management Measures of the 2010 Urban Water Management Plan, a planning document for the City's water supply. If you plan to attend the public hearing and need a special accommodation because of a sensory or mobility impairment/disability, please contact the office of the City Clerk, Dinuba City Hall, 405 E. El Monte Way, Dinuba, CA 93618 or call (591) 591-5900 for those accommodations to be made.

If you are unable to attend the public hearing, you may direct written comments to the City of Dinuba at 405 E. El Monte Way, Dinuba, CA 93618, or you may telephone Blanca Beltran at (559) 591-5924. In addition, information is available for review prior to the public hearing by contacting the Dinuba Public Works Department between the hours of 8:00 a.m. and 5:00 p.m., Monday – Friday.

September 11, 2014

RESOLUTION NO. 2014-45

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF DINUBA
ACCEPTING THE 2010 DINUBA URBAN WATER
MANAGEMENT PLAN AMENDMENTS

WHEREAS, the California Legislature enacted Assembly Bill 797 (Water Code Section 10610 et seq., known as the Urban Water Management Planning Act) during the 1983-1984 Regular Session, and as amended subsequently, which mandates that every supplier providing water for municipal purposes to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually, prepare an Urban Water Management Plan, the primary objective of which is to plan for the conservation and efficient use of water; and

WHEREAS, the City of Dinuba is an urban water supplier providing water to 5,823 customers; and

WHEREAS, the City Council adopted Resolution 2012-34 adopting the 2010 Dinuba Urban Water Management Plan, after public review and hearing on June 12, 2012, and filed the plan with the California Department of Water Resources within thirty days of the adoption; and

WHEREAS, Section 6, Demand Management Measures, of the 2010 Dinuba Urban Water Management Plan is hereby further amended upon review by the California Department of Water Resources to meet updated conservation standard, as follows:

1. Measure C (Leak Detection) – The City shall undertake a City-wide program to detect and repair leaks in the water system;
2. Measure F (Rebate Program) – Promote rebate programs to encourage customers to purchase high-efficiency washing machines;
3. Measure H (Public Education) – Provide educational brochure to be used in schools to promote water conservation by April 15, 2015;
4. Measure I (Account monitoring) – Implement commercial, institutional, and industrial account monitoring to note unusual water usage, determine causes, and require action to correct issues;
5. Measure K (Water rate structure) – Revise water rates to promote water conservation;
6. Measure L (Enforcement of Water Conservation) – Specify the city staff empowered to enforce watering restrictions;
7. Measure M (Wasting water) – UWMP will specifically state that the water conservation ordinance prohibits water waste; and
8. Measure N (Low-Flow Toilet Rebate) – Enact and fund a city program to provide $100 rebates for replacement of old toilets with ultra-low flush toilets.

WHEREAS, the City Council considered amendments to the Plan at a duly noticed public hearing on September 23, 2014;

NOW, THEREFORE BE IT RESOLVED by the City Council of the City of Dinuba as follows:

1. The Dinuba Urban Water Management Plan 2010 is hereby amended and field with the City Clerk;
2. The City Manager is authorized and directed to file the amendments to the UWMP with the California Department of Water Resources;
3. The City Manager is hereby authorized and directed to implement the Water Conservations Programs as set forth in the amended Plan;
4. The City Manager is authorized to declare a Water Shortage Emergency according to the Plan, and implement necessary elements of the Plan;
5. The City Manager shall recommend to the City Council additional procedures, rules, and regulations to carryout effective and equitable allocations of water resources.

This resolution was adopted on September 23, 2014, by the City Council of the City of Dinuba by the following vote:

AYES: Smith, Hinesly, Gonzalez

NOES: None

ABSENT: Harness, Morales

ABSTAIN: None

Janet Hinesly, Mayor

ATTEST:

Linda Barkley, Deputy City Clerk

STATE OF CALIFORNIA)
COUNTY OF TULARE) ss.
CITY OF DINUBA)

CLERKS'S CERTIFICATE
OF AUTHENTICATION

I, Linda Barkley, Deputy City Clerk of the City of Dinuba, California, DO HEREBY CERTIFY that the above and foregoing is a full, true and correct copy of Resolution No. 2014-45, of the City Council of said City and that said Resolution was adopted at the time and by the vote stated on the above certificate, and has not been amended or repealed.

LINDA BARKLEY
Deputy City Clerk of the City of Dinuba, California

RESOLUTION NO. 2012-34

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF DINUBA
ADOPTING THE DINUBA 2010 URBAN WATER
MANAGEMENT PLAN

WHEREAS, the California Legislature enacted Assembly Bill 797 (California Water Code Section 10610 et seq., known as the Urban Water Management Planning Act) during the 1983-1984 Regular Session), which mandates that every supplier providing water for municipal purposes to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually, prepare and adopt an updated Urban Water Management Plan (UWMP) every five years, the primary objective of which is to plan for the conservation and efficient use of water; and

WHEREAS, the Water Conservation Act of 2009 (SBX7-7), extended the time by which urban retail water suppliers must adopt their 2010 UWMP's and, among other things, established requirements for urban retail water suppliers to prepare urban water use targets in accordance with the goals of SBX7-7 to reduce statewide daily per capita water use 15 percent by the year 2015 and 20 percent by the year 2020; and

WHEREAS, the City of Dinuba is an urban water supplier providing water to 5,133 customers and over 4,509 acre-feet of water annually; and

WHEREAS, in accordance with applicable law, including Water Code sections 10608.26 and 10642, and Government Code Section 6066, the City made its Draft 2010 UWMP available for public inspection, and caused to be published within the jurisdiction of the City at least two notices of the public hearing regarding the City's 2010 UWMP; and

WHEREAS, the plan must be adopted after public review and hearing, and filed with the California Department of Water Resources within thirty days of adoption; and

WHEREAS, the City Council considered the plan at a duly noticed public meeting on June 12, 2012, to among other things, provide members of the public and other interested entities with the opportunity to be heard in connection with the City's 2010 UWMP and the proposed adoption thereof; and

WHEREAS, the City of Dinuba did prepare said Plan entitled Dinuba 2010 Urban Water Management Plan with its own staff, with the assistance of consulting professionals, and in cooperation with other governmental agencies, and has utilized and relied upon industry standards and the expertise of industry professionals in preparing its 2010 UWMP, and has also utilized and relied in part upon the WR Guidebook to Assist Urban Water Suppliers to Prepare a 2010 Urban Water Management Plan, the DWR Methodologies for Calculating Baseline and Compliance Urban Per Capita Water Use, and coordination with DWR staff in preparing its 2010 UWMP; and

WHEREAS, pursuant to said public hearing on the 2010 UWMP, the City encouraged the active involvement of diverse social, cultural, and economic elements of the population within the City's service area with regard to the preparation of the 2010 UWMP, allowed input by members of the public and any other interested entities regarding all aspects of the 2010 UWMP, allowed community input regarding the City's implementation plan for complying with SBX7-7, and proposed the adoption of Target Method

3 under Water Code Section 10608.20(b) for determining the City's urban water use targets as set forth in the 2010 UWMP; and

WHEREAS, the City Council has reviewed and considered the purposes and requirements and of the Urban Water Management Planning Act and SBX7-7, the contents of the 2010 UWMP, the documentation contained in the administrative record in support of the 2010 UWMP, information provided by City staff, information provided by DWR staff, and all public and agency input received with regard to the 2010 UWMP, and has determined that the factual analysis and conclusions set forth in the 2010 UWMP are supported by substantial evidence.

NOW, THEREFORE BE IT RESOLVED by the City Council of the City of Dinuba as follows:

1. The Dinuba 2010 Urban Water Management Plan is hereby adopted and filed with the City Clerk;
2. The City Manager is authorized and directed to file the Dinuba 2010 Urban Water Management Plan with the California Department of Water Resources within thirty (30) days of this adoption date;
3. The City Manager is hereby authorized and directed, in accordance with the Water Code Section 10645, to make the 2010 Urban Water Management Plan available for public review during normal business hours not later than thirty (30) days after filing a copy thereof with the California Department of Water Resources;
4. The City Manager is hereby authorized and directed to implement the components of the 2010 Urban Water Management Plan in accordance with the Urban Water Management Planning Act and SBX7-7, including, but not limited to, the City's Demand Management Measures and its Water Shortage Contingency Plan;
5. The City Manager is hereby authorized to declare a Water Shortage Emergency according to the Plan, and implement necessary elements of the Plan;
6. The City Manager is hereby authorized and directed to recommend to the City Council additional procedures, rules, and regulations to effectively carry out the implementation of the 2010 Urban Water Management Plan, the Urban Water Management Planning Act and SBX7-7; with the goal of achieving the City of Dinuba's 2020 urban Water Use Target.

This resolution was adopted on June 12, 2012, by the City Council of the City of Dinuba by the following vote:

AYES: HARNESS, HINESLY, SMITH, MORALES, GONZALEZ

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

Mike Smith, Mayor

ATTEST:

Linda Barkley, Deputy City Clerk

STATE OF CALIFORNIA	)	CLERKS'S CERTIFICATE
COUNTY OF TULARE	) ss.	OF AUTHENTICATION
CITY OF DINUBA	)	

I, Linda Barkley, Deputy City Clerk of the City of Dinuba, California, DO HEREBY CERTIFY that the above and foregoing is a full, true and correct copy of Resolution No. 2012-34, of the City Council of said City and that said Resolution was adopted at the time and by the vote stated on the above certificate, and has not been amended or repealed.

AYES: Harness, Hinesly, Smith, Morales, Gonzalez

NOES: None

ABSENT: None

ABSTAIN: None

Linda Barkley

Deputy City Clerk of the City of Dinuba, California

Appendix B – 60-Day Notification Letters

4CREEKS

Alta Irrigation District
PO Box 715
Dinuba, CA 93618

April 6, 2012

RE: City of Dinuba 2010 UWMP, 60 Day Notice

Dear Mr. Kapheim,

The staff of 4Creeks, Inc. wishes to inform you that we are providing our services in the preparation of the 2010 Urban Water Management Plan for the City of Dinuba. We are informing you of this situation due to the fact that the City of Dinuba lies within the borders of your district's jurisdiction.

The 2010 Urban Water Management Plan Public Hearing and City Council adoption is planned to be June 12 at 6:30 in the City Council Chambers. Following adoption of the plan by the City of Dinuba, the Plan is to be submitted to the CA Department of Water Resources by July 1, 2012.

We would welcome your participation and input in regards to the preparation of the City of Dinuba's 2010 Urban Water Management Plan.

Please feel free to contact me if you would like to participate in the City of Dinuba's urban water management planning process or if there is another individual within your Agency that would be our main point of contact.

Sincerely,

Matt Ainley, President
4Creeks, Inc.
(559) 802-3052
matta@4-creeks.com
www.4-creeks.com

4CREEKS

Tulare County
2800 West Burrel Ave.
Visalia, CA 93291

April 6, 2012

RE: City of Dinuba 2010 UWMP, 60 Day Notice

Dear Mr. Rousseau,

The staff of 4Creeks, Inc. wishes to inform you that we are providing our services in the preparation of the 2010 Urban Water Management Plan for the City of Dinuba. We are informing you of this situation due to the fact that the City of Dinuba lies within the borders of your district's jurisdiction.

The 2010 Urban Water Management Plan Public Hearing and City Council adoption is planned to be June 12 at 6:30 in the City Council Chambers. Following adoption of the plan by the City of Dinuba, the Plan is to be submitted to the CA Department of Water Resources by July 1, 2012.

We would welcome your participation and input in regards to the preparation of the City of Dinuba's 2010 Urban Water Management Plan.

Please feel free to contact me if you would like to participate in the City of Dinuba's urban water management planning process or if there is another individual within your Agency that would be our main point of contact.

Sincerely,

Matt Ainley, President
4Creeks, Inc.
(559) 802-3052
matta@4-creeks.com
www.4-creeks.com

4CREEKS

Kings River Conservation District
4886 East Jensen Ave.
Fresno, CA 93725

April 6, 2012

RE: City of Dinuba 2010 UWMP, 60 Day Notice

Dear Mr. Hoelzel,

The staff of 4Creeks, Inc. wishes to inform you that we are providing our services in the preparation of the 2010 Urban Water Management Plan for the City of Dinuba. We are informing you of this situation due to the fact that the City of Dinuba lies within the borders of your district's jurisdiction.

The 2010 Urban Water Management Plan Public Hearing and City Council adoption is planned to be June 12 at 6:30 in the City Council Chambers. Following adoption of the plan by the City of Dinuba, the Plan is to be submitted to the CA Department of Water Resources by July 1, 2012.

We would welcome your participation and input in regards to the preparation of the City of Dinuba's 2010 Urban Water Management Plan.

Please feel free to contact me if you would like to participate in the City of Dinuba's urban water management planning process or if there is another individual within your Agency that would be our main point of contact.

Sincerely,

Matt Ainley, President
4Creeks, Inc.
(559) 802-3052
matta@4-creeks.com
www.4-creeks.com

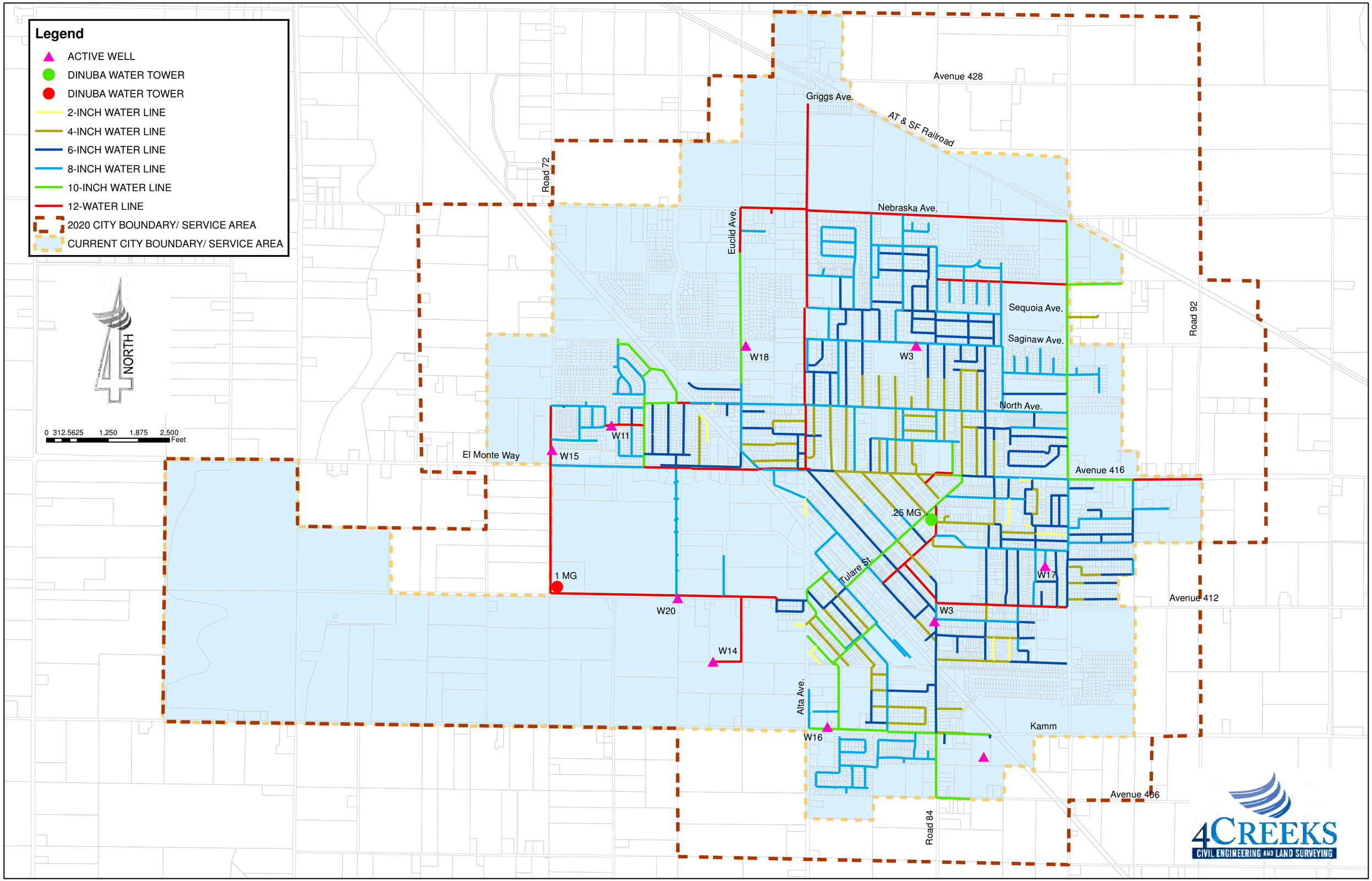
Appendix C – Public Meeting Notice

NOTICE OF PUBLIC HEARING

CITY COUNCIL

WHAT'S BEING PLANNED	The Dinuba City Council is scheduled to consider adoption of the 2010 Urban Water Management Plan.
WHEN	Tuesday, June 12, 2012 – 6:30 p.m. (or shortly thereafter) City Hall Council Chambers
APPLICANT	City of Dinuba
PURPOSE	To give the public an opportunity to provide input regarding the adoption of the 2010 Urban Water Management Plan as a planning document for the City's water supply.
CONTACT	If you desire more information or wish to review the report for this hearing, please contact City of Dinuba, Public Works Services Department, Deputy City Clerk, 405 E. El Monte Way, Dinuba or call (559) 591-5900.
PUBLISH	Dinuba Sentinel– April 12, 2012

Appendix D – Service Area Map


Legend
ACTIVE WELL
DINUBA WATER TOWER
DINUBA WATER TOWER
2-INCH WATER LINE
4-INCH WATER LINE
6-INCH WATER LINE
8-INCH WATER LINE
10-INCH WATER LINE
12-WATER LINE
2020 CITY BOUNDARY/ SERVICE AREA
CURRENT CITY BOUNDARY/ SERVICE AREA
NORTH
0 312.5625 1,250 1,875 2,500
Feet
Avenue 428
Griggs Ave.
AT & SF Railroad
Road 72
Euclid Ave.
Nebraska Ave.
Sequoia Ave.
Saginaw Ave.
Road 92
W18
W3
North Ave.
W11
El Monte Way
W15
Avenue 416
.25 MG
Tulare St.
W17
1 MG
W20
Avenue 412
W3
W14
Alta Ave.
Kamm
W16
Avenue 406
Road 84
4CREEKS
CIVIL ENGINEERING AND LAND SURVEYING

Appendix E – Correspondence

No correspondence received.

Appendix F – Urban Water Use Target Calculations

Target Method Analysis

URBAN WATER USE TARGET CALCULATIONS

Prepared for:

City of Dinuba

1088 East Kamm Avenue

Dinuba, CA 93618

Completed by:

4CREEKS

CIVIL ENGINEERING AND LAND SURVEYING

1150 N. CHINOWTH, SUITE B

VISALIA, CA 93291

(559) 802-3052

Matthew D. Ainley, RCE 66233

June 2011

Target Method 1

Calculated Base Daily Per Capita Water Use (5 year range) = 216 GPCD

2020 Urban Water Use Target = 0.80 x 216 GPCD = 173 GPCD

Target Method 2

N/A due to the use of the default *Indoor Residential Use* value of 15 GPCD (per SBX7-7 Provisional Method 4).

Target Method 3

Dinuba is located within the Tulare Lake Hydrologic Region.

2020 Hydrologic Region Target = 188 GPCD (See attached map)

2020 Urban Water Use Target = 0.95 x 188 GPCD = 179 GPCD

2015 Interim Water Use Target = (216 + 179 GPCD)/2 = 198 GPCD

Target Method 4

See attached Excel spreadsheets.

2020 Urban Water Use Target = 178 GPCD

The 2020 Urban Water Use Target and 2015 Interim Water Use Target are to be implemented in the City of Dinuba's 2010 Urban Water Management Plan.

Appendix G – Model Water Efficient Landscape Ordinance, September 10, 2009

CITY OF DINUBA
Together, A Better Community
CALIFORNIA • 1906

City Manager's Office 559/591-5904
City Attorney 559/437-1770
Administrative Services 559/591-5900
Development Services 559/591-5906
Public Works Services 559/591-5924
Engineering Services 559/591-5924
Parks & Community Services 559/591-5940
Fire/Ambulance Services 559/591-5931
Police Services 559/591-5914
Education, Resources & Housing Services 559/596-2170

ENGINEERING SERVICES

February 2, 2010

Mr. Simon Eching
California Department of Water Resources
Water Use and Efficiency Branch
1416 Ninth Street
P.O. Box 942836
Sacramento, CA 94236-0001

RE: AB 1881 Landscape Ordinance Notification

Dear Mr. Eching:

The City of Dinuba was unable to prepare its own Water Efficient Landscape Ordinance within the time provided by AB 1881 due to limited resources.

As provided for in the Water Conservation in Landscaping Act of 2006 (AB 1881), the City of Dinuba has elected to have the DWR's Model Water Efficient Landscape Ordinance (MWELO) be adopted by statute, effective January 1, 2010.

We would appreciate being placed on a distribution list for upcoming training sessions for MWELO defined "Landscape Designer" and "Irrigation Designer", as well as agency staff training for review of the required "Landscape Documentation Package".

Please contact our office if you require further notification.

Sincerely,

Dean K. Uota

Dean K. Uota, P.E.
Development & Engineering Services Director/City Engineer

405 E. El Monte Way, Dinuba, CA 93618
Fax 559/591-5923 E-Mail address: engineering@dinuba.ca.gov www.dinuba.ca.gov

Model Water Efficient Landscape Ordinance
September 10, 2009

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California Code of Regulations
Title 23. Waters
Division 2. Department of Water Resources
Chapter 2.7. Model Water Efficient Landscape Ordinance

§ 490. Purpose.
(a) The State Legislature has found:
(1) that the waters of the state are of limited supply and are subject to ever increasing demands;
(2) that the continuation of California's economic prosperity is dependent on the availability of adequate supplies of water for future uses;
(3) that it is the policy of the State to promote the conservation and efficient use of water and to prevent the waste of this valuable resource;
(4) that landscapes are essential to the quality of life in California by providing areas for active and passive recreation and as an enhancement to the environment by cleaning air and water, preventing erosion, offering fire protection, and replacing ecosystems lost to development; and
(5) that landscape design, installation, maintenance and management can and should be water efficient; and
(6) that Section 2 of Article X of the California Constitution specifies that the right to use water is limited to the amount reasonably required for the beneficial use to be served and the right does not and shall not extend to waste or unreasonable method of use.
(b) Consistent with these legislative findings, the purpose of this model ordinance is to:
(1) promote the values and benefits of landscapes while recognizing the need to invest water and other resources as efficiently as possible;
(2) establish a structure for planning, designing, installing, maintaining and managing water efficient landscapes in new construction and rehabilitated projects;
(3) establish provisions for water management practices and water waste prevention for existing landscapes;
(4) use water efficiently without waste by setting a Maximum Applied Water Allowance as an upper limit for water use and reduce water use to the lowest practical amount;
(5) promote the benefits of consistent landscape ordinances with neighboring local and regional agencies;
(6) encourage local agencies and water purveyors to use economic incentives that promote the efficient use of water, such as implementing a tiered-rate structure; and
(7) encourage local agencies to designate the necessary authority that implements and enforces the provisions of the Model Water Efficient Landscape Ordinance or its local landscape ordinance.

Note: Authority cited: Section 65593, Government Code. Reference: Sections 65591, 65593, 65596, Government Code.

§ 490.1 Applicability
(a) After January 1, 2010, this ordinance shall apply to all of the following landscape projects:
(1) new construction and rehabilitated landscapes for public agency projects and private development projects with a landscape area equal to or greater than 2,500 square feet requiring a building or landscape permit, plan check or design review;
(2) new construction and rehabilitated landscapes which are developer-installed in single-family and multi-family projects with a landscape area equal to or greater than 2,500 square feet requiring a building or landscape permit, plan check, or design review;

(3) new construction landscapes which are homeowner-provided and/or homeowner-hired in single-family and multi-family residential projects with a total project landscape area equal to or greater than 5,000 square feet requiring a building or landscape permit, plan check or design review;
(4) existing landscapes limited to Sections 493, 493.1 and 493.2; and
(5) cemeteries. Recognizing the special landscape management needs of cemeteries, new and rehabilitated cemeteries are limited to Sections 492.4, 492.11 and 492.12; and existing cemeteries are limited to Sections 493, 493.1 and 493.2.
(b) This ordinance does not apply to:
(1) registered local, state or federal historical sites;
(2) ecological restoration projects that do not require a permanent irrigation system;
(3) mined-land reclamation projects that do not require a permanent irrigation system; or
(4) plant collections, as part of botanical gardens and arboretums open to the public.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 491. Definitions.
The terms used in this ordinance have the meaning set forth below:
(a) “applied water” means the portion of water supplied by the irrigation system to the landscape.
(b) “automatic irrigation controller” means an automatic timing device used to remotely control valves that operate an irrigation system. Automatic irrigation controllers schedule irrigation events using either evapotranspiration (weather-based) or soil moisture data.
(c) “backflow prevention device” means a safety device used to prevent pollution or contamination of the water supply due to the reverse flow of water from the irrigation system.
(d) “Certificate of Completion” means the document required under Section 492.9.
(e) “certified irrigation designer” means a person certified to design irrigation systems by an accredited academic institution a professional trade organization or other program such as the US Environmental Protection Agency’s WaterSense irrigation designer certification program and Irrigation Association’s Certified Irrigation Designer program.
(f) “certified landscape irrigation auditor” means a person certified to perform landscape irrigation audits by an accredited academic institution, a professional trade organization or other program such as the US Environmental Protection Agency’s WaterSense irrigation auditor certification program and Irrigation Association’s Certified Landscape Irrigation Auditor program.
(g) “check valve” or “anti-drain valve” means a valve located under a sprinkler head, or other location in the irrigation system, to hold water in the system to prevent drainage from sprinkler heads when the sprinkler is off.
(h) “common interest developments” means community apartment projects, condominium projects, planned developments, and stock cooperatives per Civil Code Section 1351.
(i) “conversion factor (0.62)” means the number that converts acre-inches per acre per year to gallons per square foot per year
(j) “drip irrigation” means any non-spray low volume irrigation system utilizing emission devices with a flow rate measured in gallons per hour. Low volume irrigation systems are specifically designed to apply small volumes of water slowly at or near the root zone of plants.
(k) “ecological restoration project” means a project where the site is intentionally altered to establish a defined, indigenous, historic ecosystem.
(l)“effective precipitation” or “usable rainfall” (Eppt) means the portion of total precipitation which becomes available for plant growth.
(m) “emitter” means a drip irrigation emission device that delivers water slowly from the system to the soil.
(n) “established landscape” means the point at which plants in the landscape have developed significant root growth into the soil. Typically, most plants are established after one or two years of growth.

(o) “establishment period of the plants” means the first year after installing the plant in the landscape or the first two years if irrigation will be terminated after establishment. Typically, most plants are established after one or two years of growth.
(p) “Estimated Total Water Use” (ETWU) means the total water used for the landscape as described in Section 492.4.
(q) “ET adjustment factor” (ETAF) means a factor of 0.7, that, when applied to reference evapotranspiration, adjusts for plant factors and irrigation efficiency, two major influences upon the amount of water that needs to be applied to the landscape.
A combined plant mix with a site-wide average of 0.5 is the basis of the plant factor portion of this calculation. For purposes of the ETAF, the average irrigation efficiency is 0.71. Therefore, the ET Adjustment Factor is (0.7)=(0.5/0.71). ETAF for a Special Landscape Area shall not exceed 1.0. ETAF for existing non-rehabilitated landscapes is 0.8.
(r) “evapotranspiration rate” means the quantity of water evaporated from adjacent soil and other surfaces and transpired by plants during a specified time.
(s) “flow rate” means the rate at which water flows through pipes, valves and emission devices, measured in gallons per minute, gallons per hour, or cubic feet per second.
(t) “hardscapes” means any durable material (pervious and non-pervious).
(u) “homeowner-provided landscaping” means any landscaping either installed by a private individual for a single family residence or installed by a licensed contractor hired by a homeowner. A homeowner, for purposes of this ordinance, is a person who occupies the dwelling he or she owns. This excludes speculative homes, which are not owner-occupied dwellings.
(v) “hydrozone” means a portion of the landscaped area having plants with similar water needs. A hydrozone may be irrigated or non-irrigated.
(w) “infiltration rate” means the rate of water entry into the soil expressed as a depth of water per unit of time (e.g., inches per hour).
(x)“invasive plant species” means species of plants not historically found in California that spread outside cultivated areas and can damage environmental or economic resources. Invasive species may be regulated by county agricultural agencies as noxious species. “Noxious weeds” means any weed designated by the Weed Control Regulations in the Weed Control Act and identified on a Regional District noxious weed control list. Lists of invasive plants are maintained at the California Invasive Plant Inventory and USDA invasive and noxious weeds database.
(y) “irrigation audit” means an in-depth evaluation of the performance of an irrigation system conducted by a Certified Landscape Irrigation Auditor. An irrigation audit includes, but is not limited to: inspection, system tune-up, system test with distribution uniformity or emission uniformity, reporting overspray or runoff that causes overland flow, and preparation of an irrigation schedule.
(z) “irrigation efficiency” (IE) means the measurement of the amount of water beneficially used divided by the amount of water applied. Irrigation efficiency is derived from measurements and estimates of irrigation system characteristics and management practices. The minimum average irrigation efficiency for purposes of this ordinance is 0.71. Greater irrigation efficiency can be expected from well designed and maintained systems.
(aa) “irrigation survey” means an evaluation of an irrigation system that is less detailed than an irrigation audit. An irrigation survey includes, but is not limited to: inspection, system test, and written recommendations to improve performance of the irrigation system.
(bb) “irrigation water use analysis” means an analysis of water use data based on meter readings and billing data.
(cc) “landscape architect” means a person who holds a license to practice landscape architecture in the state of California Business and Professions Code, Section 5615.
(dd) “landscape area” means all the planting areas, turf areas, and water features in a landscape design plan subject to the Maximum Applied Water Allowance calculation. The landscape area does not include footprints of buildings or structures, sidewalks, driveways, parking lots, decks, patios, gravel or

stone walks, other pervious or non-pervious hardscapes, and other non-irrigated areas designated for non-development (e.g., open spaces and existing native vegetation).
(ee) “landscape contractor” means a person licensed by the state of California to construct, maintain, repair, install, or subcontract the development of landscape systems.
(ff) “Landscape Documentation Package” means the documents required under Section 492.3.
(gg) “landscape project” means total area of landscape in a project as defined in “landscape area” for the purposes of this ordinance, meeting requirements under Section 490.1.
(hh) “lateral line” means the water delivery pipeline that supplies water to the emitters or sprinklers from the valve.
(ii) “local agency” means a city or county, including a charter city or charter county, that is responsible for adopting and implementing the ordinance. The local agency is also responsible for the enforcement of this ordinance, including but not limited to, approval of a permit and plan check or design review of a project.
(jj) “local water purveyor” means any entity, including a public agency, city, county, or private water company that provides retail water service.
(kk) “low volume irrigation” means the application of irrigation water at low pressure through a system of tubing or lateral lines and low-volume emitters such as drip, drip lines, and bubblers. Low volume irrigation systems are specifically designed to apply small volumes of water slowly at or near the root zone of plants.
(ll) “main line” means the pressurized pipeline that delivers water from the water source to the valve or outlet.
(mm) “Maximum Applied Water Allowance” (MAWA) means the upper limit of annual applied water for the established landscaped area as specified in Section 492.4. It is based upon the area’s reference evapotranspiration, the ET Adjustment Factor, and the size of the landscape area. The Estimated Total Water Use shall not exceed the Maximum Applied Water Allowance. Special Landscape Areas, including recreation areas, areas permanently and solely dedicated to edible plants such as orchards and vegetable gardens, and areas irrigated with recycled water are subject to the MAWA with an ETAF not to exceed 1.0.
(nn) “microclimate” means the climate of a small, specific area that may contrast with the climate of the overall landscape area due to factors such as wind, sun exposure, plant density, or proximity to reflective surfaces.
(oo) “mined-land reclamation projects” means any surface mining operation with a reclamation plan approved in accordance with the Surface Mining and Reclamation Act of 1975.
(pp) “mulch” means any organic material such as leaves, bark, straw, compost, or inorganic mineral materials such as rocks, gravel, and decomposed granite left loose and applied to the soil surface for the beneficial purposes of reducing evaporation, suppressing weeds, moderating soil temperature, and preventing soil erosion.
(qq) “new construction” means, for the purposes of this ordinance, a new building with a landscape or other new landscape, such as a park, playground, or greenbelt without an associated building.
(rr) “operating pressure” means the pressure at which the parts of an irrigation system are designed by the manufacturer to operate.
(ss) “overhead sprinkler irrigation systems” means systems that deliver water through the air (e.g., spray heads and rotors).
(tt) “overspray” means the irrigation water which is delivered beyond the target area.
(uu) “permit” means an authorizing document issued by local agencies for new construction or rehabilitated landscapes.
(vv) “pervious” means any surface or material that allows the passage of water through the material and into the underlying soil.
(ww) “plant factor” or “plant water use factor” is a factor , when multiplied by ETo, estimates the amount of water needed by plants. For purposes of this ordinance, the plant factor range for low water

use plants is 0 to 0.3, the plant factor range for moderate water use plants is 0.4 to 0.6, and the plant factor range for high water use plants is 0.7 to 1.0. Plant factors cited in this ordinance are derived from the Department of Water Resources 2000 publication “Water Use Classification of Landscape Species”.
(xx) “precipitation rate” means the rate of application of water measured in inches per hour.
(yy) “project applicant” means the individual or entity submitting a Landscape Documentation Package required under Section 492.3, to request a permit, plan check, or design review from the local agency. A project applicant may be the property owner or his or her designee.
(zz) “rain sensor” or “rain sensing shutoff device” means a component which automatically suspends an irrigation event when it rains.
(aaa) “record drawing” or “as-builts” means a set of reproducible drawings which show significant changes in the work made during construction and which are usually based on drawings marked up in the field and other data furnished by the contractor.
(bbb) “recreational area” means areas dedicated to active play such as parks, sports fields, and golf courses where turf provides a playing surface.
(ccc) “recycled water”, “reclaimed water”, or “treated sewage effluent water” means treated or recycled waste water of a quality suitable for non-potable uses such as landscape irrigation and water features. This water is not intended for human consumption.
(ddd) “reference evapotranspiration” or “ETo” means a standard measurement of environmental parameters which affect the water use of plants. ETo is expressed in inches per day, month, or year as represented in Section 495.1, and is an estimate of the evapotranspiration of a large field of four- to seven-inch tall, cool-season grass that is well watered. Reference evapotranspiration is used as the basis of determining the Maximum Applied Water Allowance so that regional differences in climate can be accommodated.
(eee) “rehabilitated landscape” means any re-landscaping project that requires a permit , plan check, or design review, meets the requirements of Section 490.1, and the modified landscape area is equal to or greater than 2,500 square feet, is 50% of the total landscape area, and the modifications are completed within one year.
(fff) “runoff” means water which is not absorbed by the soil or landscape to which it is applied and flows from the landscape area. For example, runoff may result from water that is applied at too great a rate (application rate exceeds infiltration rate) or when there is a slope.
(ggg) “soil moisture sensing device” or “soil moisture sensor” means a device that measures the amount of water in the soil. The device may also suspend or initiate an irrigation event.
(hhh) “soil texture” means the classification of soil based on its percentage of sand, silt, and clay.
(iii)“Special Landscape Area” (SLA) means an area of the landscape dedicated solely to edible plants, areas irrigated with recycled water, water features using recycled water and areas dedicated to active play such as parks, sports fields, golf courses, and where turf provides a playing surface.
(jjj) “sprinkler head” means a device which delivers water through a nozzle.
(kkk) “static water pressure” means the pipeline or municipal water supply pressure when water is not flowing.
(lll) “station” means an area served by one valve or by a set of valves that operate simultaneously.
(mmm) “swing joint” means an irrigation component that provides a flexible, leak-free connection between the emission device and lateral pipeline to allow movement in any direction and to prevent equipment damage.
(nnn) “turf” means a ground cover surface of mowed grass. Annual bluegrass, Kentucky bluegrass, Perennial ryegrass, Red fescue, and Tall fescue are cool-season grasses. Bermudagrass, Kikuyugrass, Seashore Paspalum, St. Augustinegrass, Zoysiagrass, and Buffalo grass are warm-season grasses.
(ooo) “valve” means a device used to control the flow of water in the irrigation system.
(ppp) “water conserving plant species” means a plant species identified as having a low plant factor.
(qqq) “water feature” means a design element where open water performs an aesthetic or recreational function. Water features include ponds, lakes, waterfalls, fountains, artificial streams, spas, and

swimming pools (where water is artificially supplied). The surface area of water features is included in the high water use hydrozone of the landscape area. Constructed wetlands used for on-site wastewater treatment or stormwater best management practices that are not irrigated and used solely for water treatment or stormwater retention are not water features and, therefore, are not subject to the water budget calculation.
(rrr) "watering window" means the time of day irrigation is allowed.
(sss) "WUCOLS" means the Water Use Classification of Landscape Species published by the University of California Cooperative Extension, the Department of Water Resources and the Bureau of Reclamation, 2000.

Note: Authority Cited: Section 65595, Government Code. Reference: Sections 65592, 65596, Government Code.

§ 492. Provisions for New Construction or Rehabilitated Landscapes.
(a) A local agency may designate another agency, such as a water purveyor, to implement some or all of the requirements contained in this ordinance. Local agencies may collaborate with water purveyors to define each entity's specific responsibilities relating to this ordinance.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.1 Compliance with Landscape Documentation Package.
(a) Prior to construction, the local agency shall:
(1) provide the project applicant with the ordinance and procedures for permits, plan checks, or design reviews;
(2) review the Landscape Documentation Package submitted by the project applicant;
(3) approve or deny the Landscape Documentation Package;
(4) issue a permit or approve the plan check or design review for the project applicant; and
(5) upon approval of the Landscape Documentation Package, submit a copy of the Water Efficient Landscape Worksheet to the local water purveyor.
(b) Prior to construction, the project applicant shall:
(1) submit a Landscape Documentation Package to the local agency.
(c) Upon approval of the Landscape Documentation Package by the local agency, the project applicant shall:
(1) receive a permit or approval of the plan check or design review and record the date of the permit in the Certificate of Completion;
(2) submit a copy of the approved Landscape Documentation Package along with the record drawings, and any other information to the property owner or his/her designee; and
(3) submit a copy of the Water Efficient Landscape Worksheet to the local water purveyor.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.2 Penalties.
(a) A local agency may establish and administer penalties to the project applicant for non-compliance with the ordinance to the extent permitted by law.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.3 Elements of the Landscape Documentation Package.
(a) The Landscape Documentation Package shall include the following six (6) elements:
(1) project information;
(A) date
(B) project applicant
(C) project address (if available, parcel and/or lot number(s))
(D) total landscape area (square feet)
(E) project type (e.g., new, rehabilitated, public, private, cemetery, homeowner-installed)
(F) water supply type (e.g., potable, recycled, well) and identify the local retail water purveyor if the applicant is not served by a private well
(G) checklist of all documents in Landscape Documentation Package
(H) project contacts to include contact information for the project applicant and property owner
(I) applicant signature and date with statement, "I agree to comply with the requirements of the water efficient landscape ordinance and submit a complete Landscape Documentation Package".
(2) Water Efficient Landscape Worksheet;
(A) hydrozone information table
(B) water budget calculations
1. Maximum Applied Water Allowance (MAWA)
2. Estimated Total Water Use (ETWU)
(3) soil management report;
(4) landscape design plan;
(5) irrigation design plan; and
(6) grading design plan.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.4 Water Efficient Landscape Worksheet.
(a) A project applicant shall complete the Water Efficient Landscape Worksheet which contains two sections (see sample worksheet in Appendix B):
(1) a hydrozone information table (see Appendix B, Section A) for the landscape project; and
(2) a water budget calculation (see Appendix B, Section B) for the landscape project. For the calculation of the Maximum Applied Water Allowance and Estimated Total Water Use, a project applicant shall use the ETo values from the Reference Evapotranspiration Table in Appendix A. For geographic areas not covered in Appendix A, use data from other cities located nearby in the same reference evapotranspiration zone, as found in the CIMIS Reference Evapotranspiration Zones Map, Department of Water Resources, 1999.
(b) Water budget calculations shall adhere to the following requirements:
(1) The plant factor used shall be from WUCOLS. The plant factor ranges from 0 to 0.3 for low water use plants, from 0.4 to 0.6 for moderate water use plants, and from 0.7 to 1.0 for high water use plants.
(2) All water features shall be included in the high water use hydrozone and temporarily irrigated areas shall be included in the low water use hydrozone.
(3) All Special Landscape Areas shall be identified and their water use calculated as described below.
(4) ETAF for Special Landscape Areas shall not exceed 1.0.
(c) Maximum Applied Water Allowance
The Maximum Applied Water Allowance shall be calculated using the equation:

$$MAWA = (ETo)\ (0.62)\ [(0.7 \times LA) + (0.3 \times SLA)]$$

The example calculations below are hypothetical to demonstrate proper use of the equations and do not represent an existing and/or planned landscape project. The ETo values used in these calculations are from the Reference Evapotranspiration Table in Appendix A, for planning purposes only. For actual irrigation scheduling, automatic irrigation controllers are required and shall use current reference evapotranspiration data, such as from the California Irrigation Management Information System (CIMIS), other equivalent data, or soil moisture sensor data.

(1) Example MAWA calculation: a hypothetical landscape project in Fresno, CA with an irrigated landscape area of 50,000 square feet without any Special Landscape Area (SLA= 0, no edible plants, recreational areas, or use of recycled water). To calculate MAWA, the annual reference evapotranspiration value for Fresno is 51.1 inches as listed in the Reference Evapotranspiration Table in Appendix A.

MAWA = (ETo) (0.62) [(0.7 x LA) + (0.3 x SLA)]
MAWA = Maximum Applied Water Allowance (gallons per year)
ETo = Reference Evapotranspiration (inches per year)
0.62 = Conversion Factor (to gallons)
0.7 = ET Adjustment Factor (ETAF)
LA = Landscape Area including SLA (square feet)
0.3 = Additional Water Allowance for SLA
SLA = Special Landscape Area (square feet)
MAWA = (51.1 inches) (0.62) [(0.7 x 50,000 square feet) + (0.3 x 0)]
= 1,108,870 gallons per year
To convert from gallons per year to hundred-cubic-feet per year:
= 1,108,870/748 = 1,482 hundred-cubic-feet per year
(100 cubic feet = 748 gallons)

(2) In this next hypothetical example, the landscape project in Fresno, CA has the same ETo value of 51.1 inches and a total landscape area of 50,000 square feet. Within the 50,000 square foot project, there is now a 2,000 square foot area planted with edible plants. This 2,000 square foot area is considered to be a Special Landscape Area.

MAWA = (ETo) (0.62) [(0.7 x LA) + (0.3 x SLA)]
MAWA = (51.1 inches) (0.62) [(0.7 x 50,000 square feet) + (0.3 x 2,000 square feet)]
= 31.68 x [35,000 + 600] gallons per year
= 31.68 x 35,600 gallons per year
=1,127,808 gallons per year or 1,508 hundred-cubic-feet per year

(d) Estimated Total Water Use.

The Estimated Total Water Use shall be calculated using the equation below. The sum of the Estimated Total Water Use calculated for all hydrozones shall not exceed MAWA.

$$ETWU = (ETo)(0.62)\left(\frac{PF\ x\ HA}{IE} + SLA\right)$$

Where:

ETWU = Estimated Total Water Use per year (gallons)
ETo = Reference Evapotranspiration (inches)
PF = Plant Factor from WUCOLS (see Section 491)
HA = Hydrozone Area [high, medium, and low water use areas] (square feet)
SLA = Special Landscape Area (square feet)
0.62 = Conversion Factor
IE = Irrigation Efficiency (minimum 0.71)

(1) Example ETWU calculation: landscape area is 50,000 square feet; plant water use type, plant factor, and hydrozone area are shown in the table below. The ETo value is 51.1 inches per year. There are no Special Landscape Areas (recreational area, area permanently and solely dedicated to edible plants, and area irrigated with recycled water) in this example.

Hydrozone	Plant Water Use Type(s)	Plant Factor (PF)*	Hydrozone Area (HA) (square feet)	PF x HA (square feet)
1	High	0.8	7,000	5,600
2	High	0.7	10,000	7,000
3	Medium	0.5	16,000	8,000
4	Low	0.3	7,000	2,100
5	Low	0.2	10,000	2,000
			Sum	24,700

*Plant Factor from WUCOLS

$$ETWU = (51.1)(0.62)\left(\frac{24{,}700}{0.71} + 0\right)$$

= 1,102,116 gallons per year

Compare ETWU with MAWA: For this example MAWA = (51.1) (0.62) [(0.7 x 50,000) + (0.3 x 0)] = 1,108,870 gallons per year. The ETWU (1,102,116 gallons per year) is less than MAWA (1,108,870 gallons per year). In this example, the water budget complies with the MAWA.

(2) Example ETWU calculation: total landscape area is 50,000 square feet, 2,000 square feet of which is planted with edible plants. The edible plant area is considered a Special Landscape Area (SLA). The reference evapotranspiration value is 51.1 inches per year. The plant type, plant factor, and hydrozone area are shown in the table below.

Hydrozone	Plant Water Use Type(s)	Plant Factor (PF)*	Hydrozone Area (HA) (square feet)	PF x HA (square feet)
1	High	0.8	7,000	5,600
2	High	0.7	9,000	6,300
3	Medium	0.5	15,000	7,500
4	Low	0.3	7,000	2,100
5	Low	0.2	10,000	2,000
			Sum	23,500
6	SLA	1.0	2,000	2,000

*Plant Factor from WUCOLS

$$ETWU = (51.1)(0.62)\left(\frac{23{,}500}{0.71} + 2{,}000\right)$$

= (31.68) (33,099 + 2,000)

= 1,111,936 gallons per year

Compare ETWU with MAWA. For this example:
MAWA = (51.1) (0.62) [(0.7 x 50,000) + (0.3 x 2,000)]
= 31.68 x [35,000 + 600]
= 31.68 x 35,600
=1,127,808 gallons per year

The ETWU (1,111,936 gallons per year) is less than MAWA (1,127,808 gallons per year). For this example, the water budget complies with the MAWA.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.5 Soil Management Report.
(a) In order to reduce runoff and encourage healthy plant growth, a soil management report shall be completed by the project applicant, or his/her designee, as follows:
(1) Submit soil samples to a laboratory for analysis and recommendations.
(A) Soil sampling shall be conducted in accordance with laboratory protocol, including protocols regarding adequate sampling depth for the intended plants.
(B) The soil analysis may include:
1. soil texture;
2. infiltration rate determined by laboratory test or soil texture infiltration rate table;
3. pH;
4. total soluble salts;
5. sodium;
6. percent organic matter; and
7. recommendations.
(2) The project applicant, or his/her designee, shall comply with one of the following:
(A) If significant mass grading is not planned, the soil analysis report shall be submitted to the local agency as part of the Landscape Documentation Package; or
(B) If significant mass grading is planned, the soil analysis report shall be submitted to the local agency as part of the Certificate of Completion.
(3) The soil analysis report shall be made available, in a timely manner, to the professionals preparing the landscape design plans and irrigation design plans to make any necessary adjustments to the design plans.
(4) The project applicant, or his/her designee, shall submit documentation verifying implementation of soil analysis report recommendations to the local agency with Certificate of Completion.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.6 Landscape Design Plan.
(a) For the efficient use of water, a landscape shall be carefully designed and planned for the intended function of the project. A landscape design plan meeting the following design criteria shall be submitted as part of the Landscape Documentation Package.
(1) Plant Material
(A) Any plant may be selected for the landscape, providing the Estimated Total Water Use in the landscape area does not exceed the Maximum Applied Water Allowance. To encourage the efficient use of water, the following is highly recommended:
1. protection and preservation of native species and natural vegetation;
2. selection of water-conserving plant and turf species;

3. selection of plants based on disease and pest resistance;
4. selection of trees based on applicable local tree ordinances or tree shading guidelines; and
5. selection of plants from local and regional landscape program plant lists.
(B) Each hydrozone shall have plant materials with similar water use, with the exception of hydrozones with plants of mixed water use, as specified in Section 492.7(a)(2)(D).
(C) Plants shall be selected and planted appropriately based upon their adaptability to the climatic, geologic, and topographical conditions of the project site. To encourage the efficient use of water, the following is highly recommended:
1. use the Sunset Western Climate Zone System which takes into account temperature, humidity, elevation, terrain, latitude, and varying degrees of continental and marine influence on local climate;
2. recognize the horticultural attributes of plants (i.e., mature plant size, invasive surface roots) to minimize damage to property or infrastructure [e.g., buildings, sidewalks, power lines]; and
3. consider the solar orientation for plant placement to maximize summer shade and winter solar gain.
(D) Turf is not allowed on slopes greater than 25% where the toe of the slope is adjacent to an impermeable hardscape and where 25% means 1 foot of vertical elevation change for every 4 feet of horizontal length (rise divided by run x 100 = slope percent).
(E) A landscape design plan for projects in fire-prone areas shall address fire safety and prevention. A defensible space or zone around a building or structure is required per Public Resources Code Section 4291(a) and (b). Avoid fire-prone plant materials and highly flammable mulches.
(F) The use of invasive and/or noxious plant species is strongly discouraged.
(G) The architectural guidelines of a common interest development, which include community apartment projects, condominiums, planned developments, and stock cooperatives, shall not prohibit or include conditions that have the effect of prohibiting the use of low-water use plants as a group.
(2) Water Features
(A) Recirculating water systems shall be used for water features.
(B) Where available, recycled water shall be used as a source for decorative water features.
(C) Surface area of a water feature shall be included in the high water use hydrozone area of the water budget calculation.
(D) Pool and spa covers are highly recommended.
(3) Mulch and Amendments
(A) A minimum two inch (2″) layer of mulch shall be applied on all exposed soil surfaces of planting areas except in turf areas, creeping or rooting groundcovers, or direct seeding applications where mulch is contraindicated.
(B) Stabilizing mulching products shall be used on slopes.
(C) The mulching portion of the seed/mulch slurry in hydro-seeded applications shall meet the mulching requirement.
(D) Soil amendments shall be incorporated according to recommendations of the soil report and what is appropriate for the plants selected (see Section 492.5).
(b) The landscape design plan, at a minimum, shall:
(1) delineate and label each hydrozone by number, letter, or other method;
(2) identify each hydrozone as low, moderate, high water, or mixed water use. Temporarily irrigated areas of the landscape shall be included in the low water use hydrozone for the water budget calculation;
(3) identify recreational areas;
(4) identify areas permanently and solely dedicated to edible plants;
(5) identify areas irrigated with recycled water;
(6) identify type of mulch and application depth;
(7) identify soil amendments, type, and quantity;
(8) identify type and surface area of water features;
(9) identify hardscapes (pervious and non-pervious);

(10) identify location and installation details of any applicable stormwater best management practices that encourage on-site retention and infiltration of stormwater. Stormwater best management practices are encouraged in the landscape design plan and examples include, but are not limited to:
(A) infiltration beds, swales, and basins that allow water to collect and soak into the ground;
(B) constructed wetlands and retention ponds that retain water, handle excess flow, and filter pollutants; and
(C) pervious or porous surfaces (e.g., permeable pavers or blocks, pervious or porous concrete, etc.) that minimize runoff.
(11) identify any applicable rain harvesting or catchment technologies (e.g., rain gardens, cisterns, etc.);
(12) contain the following statement: "I have complied with the criteria of the ordinance and applied them for the efficient use of water in the landscape design plan"; and
(13) bear the signature of a licensed landscape architect, licensed landscape contractor, or any other person authorized to design a landscape. (See Sections 5500.1, 5615, 5641, 5641.1, 5641.2, 5641.3, 5641.4, 5641.5, 5641.6, 6701, 7027.5 of the Business and Professions Code, Section 832.27 of Title16 of the California Code of Regulations, and Section 6721 of the Food and Agriculture Code.)

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code and Section 1351, Civil Code.

§ 492.7 Irrigation Design Plan.
(a) For the efficient use of water, an irrigation system shall meet all the requirements listed in this section and the manufacturers' recommendations. The irrigation system and its related components shall be planned and designed to allow for proper installation, management, and maintenance. An irrigation design plan meeting the following design criteria shall be submitted as part of the Landscape Documentation Package.
(1) System
(A) Dedicated landscape water meters are highly recommended on landscape areas smaller than 5,000 square feet to facilitate water management.
(B) Automatic irrigation controllers utilizing either evapotranspiration or soil moisture sensor data shall be required for irrigation scheduling in all irrigation systems.
(C) The irrigation system shall be designed to ensure that the dynamic pressure at each emission device is within the manufacturer's recommended pressure range for optimal performance.
1. If the static pressure is above or below the required dynamic pressure of the irrigation system, pressure-regulating devices such as inline pressure regulators, booster pumps, or other devices shall be installed to meet the required dynamic pressure of the irrigation system.
2. Static water pressure, dynamic or operating pressure. and flow reading of the water supply shall be measured at the point of connection. These pressure and flow measurements shall be conducted at the design stage. If the measurements are not available at the design stage, the measurements shall be conducted at installation.
(D) Sensors (rain, freeze, wind, etc.), either integral or auxiliary, that suspend or alter irrigation operation during unfavorable weather conditions shall be required on all irrigation systems, as appropriate for local climatic conditions. Irrigation should be avoided during windy or freezing weather or during rain.
(E) Manual shut-off valves (such as a gate valve, ball valve, or butterfly valve) shall be required, as close as possible to the point of connection of the water supply, to minimize water loss in case of an emergency (such as a main line break) or routine repair.

(F) Backflow prevention devices shall be required to protect the water supply from contamination by the irrigation system. A project applicant shall refer to the applicable local agency code (i.e., public health) for additional backflow prevention requirements.
(G) High flow sensors that detect and report high flow conditions created by system damage or malfunction are recommended.
(H) The irrigation system shall be designed to prevent runoff, low head drainage, overspray, or other similar conditions where irrigation water flows onto non-targeted areas, such as adjacent property, non-irrigated areas, hardscapes, roadways, or structures.
(I) Relevant information from the soil management plan, such as soil type and infiltration rate, shall be utilized when designing irrigation systems.
(J) The design of the irrigation system shall conform to the hydrozones of the landscape design plan.
(K) The irrigation system must be designed and installed to meet, at a minimum, the irrigation efficiency criteria as described in Section 492.4 regarding the Maximum Applied Water Allowance.
(L) It is highly recommended that the project applicant or local agency inquire with the local water purveyor about peak water operating demands (on the water supply system) or water restrictions that may impact the effectiveness of the irrigation system.
(M) In mulched planting areas, the use of low volume irrigation is required to maximize water infiltration into the root zone.
(N) Sprinkler heads and other emission devices shall have matched precipitation rates, unless otherwise directed by the manufacturer's recommendations.
(O) Head to head coverage is recommended. However, sprinkler spacing shall be designed to achieve the highest possible distribution uniformity using the manufacturer's recommendations.
(P) Swing joints or other riser-protection components are required on all risers subject to damage that are adjacent to high traffic areas.
(Q) Check valves or anti-drain valves are required for all irrigation systems.
(R) Narrow or irregularly shaped areas, including turf, less than eight (8) feet in width in any direction shall be irrigated with subsurface irrigation or low volume irrigation system.
(S) Overhead irrigation shall not be permitted within 24 inches of any non-permeable surface. Allowable irrigation within the setback from non-permeable surfaces may include drip, drip line, or other low flow non-spray technology. The setback area may be planted or unplanted. The surfacing of the setback may be mulch, gravel, or other porous material. These restrictions may be modified if:
1. the landscape area is adjacent to permeable surfacing and no runoff occurs; or
2. the adjacent non-permeable surfaces are designed and constructed to drain entirely to landscaping; or
3. the irrigation designer specifies an alternative design or technology, as part of the Landscape Documentation Package and clearly demonstrates strict adherence to irrigation system design criteria in Section 492.7 (a)(1)(H). Prevention of overspray and runoff must be confirmed during the irrigation audit.
(T) Slopes greater than 25% shall not be irrigated with an irrigation system with a precipitation rate exceeding 0.75 inches per hour. This restriction may be modified if the landscape designer specifies an alternative design or technology, as part of the Landscape Documentation Package, and clearly demonstrates no runoff or erosion will occur. Prevention of runoff and erosion must be confirmed during the irrigation audit.
(2) Hydrozone
(A) Each valve shall irrigate a hydrozone with similar site, slope, sun exposure, soil conditions, and plant materials with similar water use.
(B) Sprinkler heads and other emission devices shall be selected based on what is appropriate for the plant type within that hydrozone.
(C) Where feasible, trees shall be placed on separate valves from shrubs, groundcovers, and turf.
(D) Individual hydrozones that mix plants of moderate and low water use, or moderate and high water use, may be allowed if:

1. plant factor calculation is based on the proportions of the respective plant water uses and their plant factor; or
2. the plant factor of the higher water using plant is used for calculations.
(E) Individual hydrozones that mix high and low water use plants shall not be permitted.
(F) On the landscape design plan and irrigation design plan, hydrozone areas shall be designated by number, letter, or other designation. On the irrigation design plan, designate the areas irrigated by each valve, and assign a number to each valve. Use this valve number in the Hydrozone Information Table (see Appendix B Section A). This table can also assist with the irrigation audit and programming the controller.
(b) The irrigation design plan, at a minimum, shall contain:
(1) location and size of separate water meters for landscape;
(2) location, type and size of all components of the irrigation system, including controllers, main and lateral lines, valves, sprinkler heads, moisture sensing devices, rain switches, quick couplers, pressure regulators, and backflow prevention devices;
(3) static water pressure at the point of connection to the public water supply;
(4) flow rate (gallons per minute), application rate (inches per hour), and design operating pressure (pressure per square inch) for each station;
(5) recycled water irrigation systems as specified in Section 492.14;
(6) the following statement: "I have complied with the criteria of the ordinance and applied them accordingly for the efficient use of water in the irrigation design plan"; and
(7) the signature of a licensed landscape architect, certified irrigation designer, licensed landscape contractor, or any other person authorized to design an irrigation system. (See Sections 5500.1, 5615, 5641, 5641.1, 5641.2, 5641.3, 5641.4, 5641.5, 5641.6, 6701, 7027.5 of the Business and Professions Code, Section 832.27 of Title 16 of the California Code of Regulations, and Section 6721 of the Food and Agricultural Code.)

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.8 Grading Design Plan.
(a) For the efficient use of water, grading of a project site shall be designed to minimize soil erosion, runoff, and water waste. A grading plan shall be submitted as part of the Landscape Documentation Package. A comprehensive grading plan prepared by a civil engineer for other local agency permits satisfies this requirement.
(1) The project applicant shall submit a landscape grading plan that indicates finished configurations and elevations of the landscape area including:
(A) height of graded slopes;
(B) drainage patterns;
(C) pad elevations;
(D) finish grade; and
(E) stormwater retention improvements, if applicable.
(2) To prevent excessive erosion and runoff, it is highly recommended that project applicants:
(A) grade so that all irrigation and normal rainfall remains within property lines and does not drain on to non-permeable hardscapes;
(B) avoid disruption of natural drainage patterns and undisturbed soil; and
(C) avoid soil compaction in landscape areas.
(3) The grading design plan shall contain the following statement: "I have complied with the criteria of the ordinance and applied them accordingly for the efficient use of water in the grading design plan" and shall bear the signature of a licensed professional as authorized by law.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.9 Certificate of Completion.
(a) The Certificate of Completion (see Appendix C for a sample certificate) shall include the following six (6) elements:
(1) project information sheet that contains:
(A) date;
(B) project name;
(C) project applicant name, telephone, and mailing address;
(D) project address and location; and
(E) property owner name, telephone, and mailing address;
(2) certification by either the signer of the landscape design plan, the signer of the irrigation design plan, or the licensed landscape contractor that the landscape project has been installed per the approved Landscape Documentation Package;
(A) where there have been significant changes made in the field during construction, these "as-built" or record drawings shall be included with the certification;
(3) irrigation scheduling parameters used to set the controller (see Section 492.10);
(4) landscape and irrigation maintenance schedule (see Section 492.11);
(5) irrigation audit report (see Section 492.12); and
(6) soil analysis report, if not submitted with Landscape Documentation Package, and documentation verifying implementation of soil report recommendations (see Section 492.5).
(b) The project applicant shall:
(1) submit the signed Certificate of Completion to the local agency for review;
(2) ensure that copies of the approved Certificate of Completion are submitted to the local water purveyor and property owner or his or her designee.
(c) The local agency shall:
(1) receive the signed Certificate of Completion from the project applicant;
(2) approve or deny the Certificate of Completion. If the Certificate of Completion is denied, the local agency shall provide information to the project applicant regarding reapplication, appeal, or other assistance.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.10 Irrigation Scheduling.
(a) For the efficient use of water, all irrigation schedules shall be developed, managed, and evaluated to utilize the minimum amount of water required to maintain plant health. Irrigation schedules shall meet the following criteria:
(1) Irrigation scheduling shall be regulated by automatic irrigation controllers.
(2) Overhead irrigation shall be scheduled between 8:00 p.m. and 10:00 a.m. unless weather conditions prevent it. If allowable hours of irrigation differ from the local water purveyor, the stricter of the two shall apply. Operation of the irrigation system outside the normal watering window is allowed for auditing and system maintenance.
(3) For implementation of the irrigation schedule, particular attention must be paid to irrigation run times, emission device, flow rate, and current reference evapotranspiration, so that applied water meets the Estimated Total Water Use. Total annual applied water shall be less than or equal to Maximum Applied Water Allowance (MAWA). Actual irrigation schedules shall be regulated by automatic irrigation controllers using current reference evapotranspiration data (e.g., CIMIS) or soil moisture sensor data.
(4) Parameters used to set the automatic controller shall be developed and submitted for each of the following:
(A) the plant establishment period;

(B) the established landscape; and
(C) temporarily irrigated areas.
(5) Each irrigation schedule shall consider for each station all of the following that apply:
(A) irrigation interval (days between irrigation);
(B) irrigation run times (hours or minutes per irrigation event to avoid runoff);
(C) number of cycle starts required for each irrigation event to avoid runoff;
(D) amount of applied water scheduled to be applied on a monthly basis;
(E) application rate setting;
(F) root depth setting;
(G) plant type setting;
(H) soil type;
(I) slope factor setting;
(J) shade factor setting; and
(K) irrigation uniformity or efficiency setting.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.11 Landscape and Irrigation Maintenance Schedule.
(a) Landscapes shall be maintained to ensure water use efficiency. A regular maintenance schedule shall be submitted with the Certificate of Completion.
(b) A regular maintenance schedule shall include, but not be limited to, routine inspection; adjustment and repair of the irrigation system and its components; aerating and dethatching turf areas; replenishing mulch; fertilizing; pruning; weeding in all landscape areas, and removing and obstruction to emission devices. Operation of the irrigation system outside the normal watering window is allowed for auditing and system maintenance.
(c) Repair of all irrigation equipment shall be done with the originally installed components or their equivalents.
(d) A project applicant is encouraged to implement sustainable or environmentally-friendly practices for overall landscape maintenance.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.12 Irrigation Audit, Irrigation Survey, and Irrigation Water Use Analysis.
(a) All landscape irrigation audits shall be conducted by a certified landscape irrigation auditor.
(b) For new construction and rehabilitated landscape projects installed after January 1, 2010, as described in Section 490.1:
(1) the project applicant shall submit an irrigation audit report with the Certificate of Completion to the local agency that may include, but is not limited to: inspection, system tune-up, system test with distribution uniformity, reporting overspray or run off that causes overland flow, and preparation of an irrigation schedule;
(2) the local agency shall administer programs that may include, but not be limited to, irrigation water use analysis, irrigation audits, and irrigation surveys for compliance with the Maximum Applied Water Allowance.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.13 Irrigation Efficiency.
(a) For the purpose of determining Maximum Applied Water Allowance, average irrigation efficiency is assumed to be 0.71. Irrigation systems shall be designed, maintained, and managed to meet or exceed an average landscape irrigation efficiency of 0.71.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.14 Recycled Water.
(a) The installation of recycled water irrigation systems shall allow for the current and future use of recycled water, unless a written exemption has been granted as described in Section 492.14(b).
(b) Irrigation systems and decorative water features shall use recycled water unless a written exemption has been granted by the local water purveyor stating that recycled water meeting all public health codes and standards is not available and will not be available for the foreseeable future.
(c) All recycled water irrigation systems shall be designed and operated in accordance with all applicable local and State laws.
(d) Landscapes using recycled water are considered Special Landscape Areas. The ET Adjustment Factor for Special Landscape Areas shall not exceed 1.0.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.15 Stormwater Management.
(a) Stormwater management practices minimize runoff and increase infiltration which recharges groundwater and improves water quality. Implementing stormwater best management practices into the landscape and grading design plans to minimize runoff and to increase on-site retention and infiltration are encouraged.
(b) Project applicants shall refer to the local agency or Regional Water Quality Control Board for information on any applicable stormwater ordinances and stormwater management plans.
(c) Rain gardens, cisterns, and other landscapes features and practices that increase rainwater capture and create opportunities for infiltration and/or onsite storage are recommended.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.16 Public Education.
(a) Publications. Education is a critical component to promote the efficient use of water in landscapes. The use of appropriate principles of design, installation, management and maintenance that save water is encouraged in the community.
(1) A local agency shall provide information to owners of new, single-family residential homes regarding the design, installation, management, and maintenance of water efficient landscapes.
(b) Model Homes. All model homes that are landscaped shall use signs and written information to demonstrate the principles of water efficient landscapes described in this ordinance.
(1) Signs shall be used to identify the model as an example of a water efficient landscape featuring elements such as hydrozones, irrigation equipment, and others that contribute to the overall water efficient theme.
(2) Information shall be provided about designing, installing, managing, and maintaining water efficient landscapes.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 492.17 Environmental Review.
(a) The local agency must comply with the California Environmental Quality Act (CEQA), as appropriate.

Note: Authority cited: Section 21082, Public Resources Code. Reference: Sections 21080, 21082, Public Resources Code.

§ 493. Provisions for Existing Landscapes.
(a) A local agency may designate another agency, such as a water purveyor, to implement some or all of the requirements contained in this ordinance. Local agencies may collaborate with water purveyors to define each entity's specific responsibilities relating to this ordinance.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 493.1 Irrigation Audit, Irrigation Survey, and Irrigation Water Use Analysis.
(a) This section, 493.1, shall apply to all existing landscapes that were installed before January 1, 2010 and are over one acre in size.
(1) For all landscapes in 493.1(a) that have a water meter, the local agency shall administer programs that may include, but not be limited to, irrigation water use analyses, irrigation surveys, and irrigation audits to evaluate water use and provide recommendations as necessary to reduce landscape water use to a level that does not exceed the Maximum Applied Water Allowance for existing landscapes. The Maximum Applied Water Allowance for existing landscapes shall be calculated as: MAWA = (0.8)(ETo)(LA)(0.62).
(2) For all landscapes in 493.1(a), that do not have a meter, the local agency shall administer programs that may include, but not be limited to, irrigation surveys and irrigation audits to evaluate water use and provide recommendations as necessary in order to prevent water waste.
(b) All landscape irrigation audits shall be conducted by a certified landscape irrigation auditor.

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

§ 493.2 Water Waste Prevention.
(a) Local agencies shall prevent water waste resulting from inefficient landscape irrigation by prohibiting runoff from leaving the target landscape due to low head drainage, overspray, or other similar conditions where water flows onto adjacent property, non-irrigated areas, walks, roadways, parking lots, or structures. Penalties for violation of these prohibitions shall be established locally.
(b) Restrictions regarding overspray and runoff may be modified if:
(1) the landscape area is adjacent to permeable surfacing and no runoff occurs; or
(2) the adjacent non-permeable surfaces are designed and constructed to drain entirely to landscaping.

Note: Authority cited: Section 65594, Government Code. Reference: Section 65596, Government Code.

§ 494. Effective Precipitation.
(a) A local agency may consider Effective Precipitation (25% of annual precipitation) in tracking water use and may use the following equation to calculate Maximum Applied Water Allowance:
MAWA= (ETo - Eppt) (0.62) [(0.7 x LA) + (0.3 x SLA)].

Note: Authority Cited: Section 65595, Government Code. Reference: Section 65596, Government Code.

Appendices.

Appendix A. Reference Evapotranspiration (ETo) Table.

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
ALAMEDA													
Fremont	1.5	1.9	3.4	4.7	5.4	6.3	6.7	6.0	4.5	3.4	1.8	1.5	47.0
Livermore	1.2	1.5	2.9	4.4	5.9	6.6	7.4	6.4	5.3	3.2	1.5	0.9	47.2
Oakland	1.5	1.5	2.8	3.9	5.1	5.3	6.0	5.5	4.8	3.1	1.4	0.9	41.8
Oakland Foothills	1.1	1.4	2.7	3.7	5.1	6.4	5.8	4.9	3.6	2.6	1.4	1.0	39.6
Pleasanton	0.8	1.5	2.9	4.4	5.6	6.7	7.4	6.4	4.7	3.3	1.5	1.0	46.2
Union City	1.4	1.8	3.1	4.2	5.4	5.9	6.4	5.7	4.4	3.1	1.5	1.2	44.2
ALPINE													
Markleeville	0.7	0.9	2.0	3.5	5.0	6.1	7.3	6.4	4.4	2.6	1.2	0.5	40.6
AMADOR													
Jackson	1.2	1.5	2.8	4.4	6.0	7.2	7.9	7.2	5.3	3.2	1.4	0.9	48.9
Shanandoah Valley	1.0	1.7	2.9	4.4	5.6	6.8	7.9	7.1	5.2	3.6	1.7	1.0	48.8
BUTTE													
Chico	1.2	1.8	2.9	4.7	6.1	7.4	8.5	7.3	5.4	3.7	1.7	1.0	51.7
Durham	1.1	1.8	3.2	5.0	6.5	7.4	7.8	6.9	5.3	3.6	1.7	1.0	51.1
Gridley	1.2	1.8	3.0	4.7	6.1	7.7	8.5	7.1	5.4	3.7	1.7	1.0	51.9
Oroville	1.2	1.7	2.8	4.7	6.1	7.6	8.5	7.3	5.3	3.7	1.7	1.0	51.5
CALAVERAS													
San Andreas	1.2	1.5	2.8	4.4	6.0	7.3	7.9	7.0	5.3	3.2	1.4	0.7	48.8
COLUSA													
Colusa	1.0	1.7	3.4	5.0	6.4	7.6	8.3	7.2	5.4	3.8	1.8	1.1	52.8
Williams	1.2	1.7	2.9	4.5	6.1	7.2	8.5	7.3	5.3	3.4	1.6	1.0	50.8
CONTRA COSTA													
Benicia	1.3	1.4	2.7	3.8	4.9	5.0	6.4	5.5	4.4	2.9	1.2	0.7	40.3
Brentwood	1.0	1.5	2.9	4.5	6.1	7.1	7.9	6.7	5.2	3.2	1.4	0.7	48.3
Concord	1.1	1.4	2.4	4.0	5.5	5.9	7.0	6.0	4.8	3.2	1.3	0.7	43.4
Courtland	0.9	1.5	2.9	4.4	6.1	6.9	7.9	6.7	5.3	3.2	1.4	0.7	48.0
Martinez	1.2	1.4	2.4	3.9	5.3	5.6	6.7	5.6	4.7	3.1	1.2	0.7	41.8
Moraga	1.2	1.5	3.4	4.2	5.5	6.1	6.7	5.9	4.6	3.2	1.6	1.0	44.9
Pittsburg	1.0	1.5	2.8	4.1	5.6	6.4	7.4	6.4	5.0	3.2	1.3	0.7	45.4
Walnut Creek	0.8	1.5	2.9	4.4	5.6	6.7	7.4	6.4	4.7	3.3	1.5	1.0	46.2
DEL NORTE													
Crescent City	0.5	0.9	2.0	3.0	3.7	3.5	4.3	3.7	3.0	2.0	0.9	0.5	27.7
EL DORADO													
Camino	0.9	1.7	2.5	3.9	5.9	7.2	7.8	6.8	5.1	3.1	1.5	0.9	47.3
FRESNO													
Clovis	1.0	1.5	3.2	4.8	6.4	7.7	8.5	7.3	5.3	3.4	1.4	0.7	51.4
Coalinga	1.2	1.7	3.1	4.6	6.2	7.2	8.5	7.3	5.3	3.4	1.6	0.7	50.9
Firebaugh	1.0	1.8	3.7	5.7	7.3	8.1	8.2	7.2	5.5	3.9	2.0	1.1	55.4
FivePoints	1.3	2.0	4.0	6.1	7.7	8.5	8.7	8.0	6.2	4.5	2.4	1.2	60.4
Fresno	0.9	1.7	3.3	4.8	6.7	7.8	8.4	7.1	5.2	3.2	1.4	0.6	51.1
Fresno State	0.9	1.6	3.2	5.2	7.0	8.0	8.7	7.6	5.4	3.6	1.7	0.9	53.7
Friant	1.2	1.5	3.1	4.7	6.4	7.7	8.5	7.3	5.3	3.4	1.4	0.7	51.3
Kerman	0.9	1.5	3.2	4.8	6.6	7.7	8.4	7.2	5.3	3.4	1.4	0.7	51.2
Kingsburg	1.0	1.5	3.4	4.8	6.6	7.7	8.4	7.2	5.3	3.4	1.4	0.7	51.6
Mendota	1.5	2.5	4.6	6.2	7.9	8.6	8.8	7.5	5.9	4.5	2.4	1.5	61.7
Orange Cove	1.2	1.9	3.5	4.7	7.4	8.5	8.9	7.9	5.9	3.7	1.8	1.2	56.7
Panoche	1.1	2.0	4.0	5.6	7.8	8.5	8.3	7.3	5.6	3.9	1.8	1.2	57.2
Parlier	1.0	1.9	3.6	5.2	6.8	7.6	8.1	7.0	5.1	3.4	1.7	0.9	52.0
Reedley	1.1	1.5	3.2	4.7	6.4	7.7	8.5	7.3	5.3	3.4	1.4	0.7	51.3
Westlands	0.9	1.7	3.8	6.3	8.0	8.6	8.6	7.8	5.9	4.3	2.1	1.1	58.8

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
GLENN													
Orland	1.1	1.8	3.4	5.0	6.4	7.5	7.9	6.7	5.3	3.9	1.8	1.4	52.1
Willows	1.2	1.7	2.9	4.7	6.1	7.2	8.5	7.3	5.3	3.6	1.7	1.0	51.3
HUMBOLDT													
Eureka	0.5	1.1	2.0	3.0	3.7	3.7	3.7	3.7	3.0	2.0	0.9	0.5	27.5
Ferndale	0.5	1.1	2.0	3.0	3.7	3.7	3.7	3.7	3.0	2.0	0.9	0.5	27.5
Garberville	0.6	1.2	2.2	3.1	4.5	5.0	5.5	4.9	3.8	2.4	1.0	0.7	34.9
Hoopa	0.5	1.1	2.1	3.0	4.4	5.4	6.1	5.1	3.8	2.4	0.9	0.7	35.6
IMPERIAL													
Brawley	2.8	3.8	5.9	8.0	10.4	11.5	11.7	10.0	8.4	6.2	3.5	2.1	84.2
Calipatria/Mulberry	2.4	3.2	5.1	6.8	8.6	9.2	9.2	8.6	7.0	5.2	3.1	2.3	70.7
El Centro	2.7	3.5	5.6	7.9	10.1	11.1	11.6	9.5	8.3	6.1	3.3	2.0	81.7
Holtville	2.8	3.8	5.9	7.9	10.4	11.6	12.0	10.0	8.6	6.2	3.5	2.1	84.7
Meloland	2.5	3.2	5.5	7.5	8.9	9.2	9.0	8.5	6.8	5.3	3.1	2.2	71.6
Palo Verde II	2.5	3.3	5.7	6.9	8.5	8.9	8.6	7.9	6.2	4.5	2.9	2.3	68.2
Seeley	2.7	3.5	5.9	7.7	9.7	10.1	9.3	8.3	6.9	5.5	3.4	2.2	75.4
Westmoreland	2.4	3.3	5.3	6.9	8.7	9.6	9.6	8.7	6.9	5.0	3.0	2.2	71.4
Yuma	2.5	3.4	5.3	6.9	8.7	9.6	9.6	8.7	6.9	5.0	3.0	2.2	71.6
INYO													
Bishop	1.7	2.7	4.8	6.7	8.2	10.9	7.4	9.6	7.4	4.8	2.5	1.6	68.3
Death Valley Jct	2.2	3.3	5.4	7.7	9.8	11.1	11.4	10.1	8.3	5.4	2.9	1.7	79.1
Independence	1.7	2.7	3.4	6.6	8.5	9.5	9.8	8.5	7.1	3.9	2.0	1.5	65.2
Lower Haiwee Res.	1.8	2.7	4.4	7.1	8.5	9.5	9.8	8.5	7.1	4.2	2.6	1.5	67.6
Oasis	2.7	2.8	5.9	8.0	10.4	11.7	11.6	10.0	8.4	6.2	3.4	2.1	83.1
KERN													
Arvin	1.2	1.8	3.5	4.7	6.6	7.4	8.1	7.3	5.3	3.4	1.7	1.0	51.9
Bakersfield	1.0	1.8	3.5	4.7	6.6	7.7	8.5	7.3	5.3	3.5	1.6	0.9	52.4
Bakersfield/Bonanza	1.2	2.2	3.7	5.7	7.4	8.2	8.7	7.8	5.7	4.0	2.1	1.2	57.9
Bakersfield/Greenlee	1.2	2.2	3.7	5.7	7.4	8.2	8.7	7.8	5.7	4.0	2.1	1.2	57.9
Belridge	1.4	2.2	4.1	5.5	7.7	8.5	8.6	7.8	6.0	3.8	2.0	1.5	59.2
Blackwells Corner	1.4	2.1	3.8	5.4	7.0	7.8	8.5	7.7	5.8	3.9	1.9	1.2	56.6
Buttonwillow	1.0	1.8	3.2	4.7	6.6	7.7	8.5	7.3	5.4	3.4	1.5	0.9	52.0
China Lake	2.1	3.2	5.3	7.7	9.2	10.0	11.0	9.8	7.3	4.9	2.7	1.7	74.8
Delano	0.9	1.8	3.4	4.7	6.6	7.7	8.5	7.3	5.4	3.4	1.4	0.7	52.0
Famoso	1.3	1.9	3.5	4.8	6.7	7.6	8.0	7.3	5.5	3.5	1.7	1.3	53.1
Grapevine	1.3	1.8	3.1	4.4	5.6	6.8	7.6	6.8	5.9	3.4	1.9	1.0	49.5
Inyokern	2.0	3.1	4.9	7.3	8.5	9.7	11.0	9.4	7.1	5.1	2.6	1.7	72.4
Isabella Dam	1.2	1.4	2.8	4.4	5.8	7.3	7.9	7.0	5.0	3.2	1.7	0.9	48.4
Lamont	1.3	2.4	4.4	4.6	6.5	7.0	8.8	7.6	5.7	3.7	1.6	0.8	54.4
Lost Hills	1.6	2.2	3.7	5.1	6.8	7.8	8.7	7.8	5.7	4.0	2.1	1.6	57.1
McFarland/Kern	1.2	2.1	3.7	5.6	7.3	8.0	8.3	7.4	5.6	4.1	2.0	1.2	56.5
Shafter	1.0	1.7	3.4	5.0	6.6	7.7	8.3	7.3	5.4	3.4	1.5	0.9	52.1
Taft	1.3	1.8	3.1	4.3	6.2	7.3	8.5	7.3	5.4	3.4	1.7	1.0	51.2
Tehachapi	1.4	1.8	3.2	5.0	6.1	7.7	7.9	7.3	5.9	3.4	2.1	1.2	52.9
KINGS													
Caruthers	1.6	2.5	4.0	5.7	7.8	8.7	9.3	8.4	6.3	4.4	2.4	1.6	62.7
Corcoran	1.6	2.2	3.7	5.1	6.8	7.8	8.7	7.8	5.7	4.0	2.1	1.6	57.1
Hanford	0.9	1.5	3.4	5.0	6.6	7.7	8.3	7.2	5.4	3.4	1.4	0.7	51.5
Kettleman	1.1	2.0	4.0	6.0	7.5	8.5	9.1	8.2	6.1	4.5	2.2	1.1	60.2
Lemoore	0.9	1.5	3.4	5.0	6.6	7.7	8.3	7.3	5.4	3.4	1.4	0.7	51.7
Stratford	0.9	1.9	3.9	6.1	7.8	8.6	8.8	7.7	5.9	4.1	2.1	1.0	58.7

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
LAKE													
Lakeport	1.1	1.3	2.6	3.5	5.1	6.0	7.3	6.1	4.7	2.9	1.2	0.9	42.8
Lower Lake	1.2	1.4	2.7	4.5	5.3	6.3	7.4	6.4	5.0	3.1	1.3	0.9	45.4
LASSEN													
Buntingville	1.0	1.7	3.5	4.9	6.2	7.3	8.4	7.5	5.4	3.4	1.5	0.9	51.8
Ravendale	0.6	1.1	2.3	4.1	5.6	6.7	7.9	7.3	4.7	2.8	1.2	0.5	44.9
Susanville	0.7	1.0	2.2	4.1	5.6	6.5	7.8	7.0	4.6	2.8	1.2	0.5	44.0
LOS ANGELES													
Burbank	2.1	2.8	3.7	4.7	5.1	6.0	6.6	6.7	5.4	4.0	2.6	2.0	51.7
Claremont	2.0	2.3	3.4	4.6	5.0	6.0	7.0	7.0	5.3	4.0	2.7	2.1	51.3
El Dorado	1.7	2.2	3.6	4.8	5.1	5.7	5.9	5.9	4.4	3.2	2.2	1.7	46.3
Glendale	2.0	2.2	3.3	3.8	4.7	4.8	5.7	5.6	4.3	3.3	2.2	1.8	43.7
Glendora	2.0	2.5	3.6	4.9	5.4	6.1	7.3	6.8	5.7	4.2	2.6	2.0	53.1
Gorman	1.6	2.2	3.4	4.6	5.5	7.4	7.7	7.1	5.9	3.6	2.4	1.1	52.4
Hollywood Hills	2.1	2.2	3.8	5.4	6.0	6.5	6.7	6.4	5.2	3.7	2.8	2.1	52.8
Lancaster	2.1	3.0	4.6	5.9	8.5	9.7	11.0	9.8	7.3	4.6	2.8	1.7	71.1
Long Beach	1.8	2.1	3.3	3.9	4.5	4.3	5.3	4.7	3.7	2.8	1.8	1.5	39.7
Los Angeles	2.2	2.7	3.7	4.7	5.5	5.8	6.2	5.9	5.0	3.9	2.6	1.9	50.1
Monrovia	2.2	2.3	3.8	4.3	5.5	5.9	6.9	6.4	5.1	3.2	2.5	2.0	50.2
Palmdale	2.0	2.6	4.6	6.2	7.3	8.9	9.8	9.0	6.5	4.7	2.7	2.1	66.2
Pasadena	2.1	2.7	3.7	4.7	5.1	6.0	7.1	6.7	5.6	4.2	2.6	2.0	52.3
Pearblossom	1.7	2.4	3.7	4.7	7.3	7.7	9.9	7.9	6.4	4.0	2.6	1.6	59.9
Pomona	1.7	2.0	3.4	4.5	5.0	5.8	6.5	6.4	4.7	3.5	2.3	1.7	47.5
Redondo Beach	2.2	2.4	3.3	3.8	4.5	4.7	5.4	4.8	4.4	2.8	2.4	2.0	42.6
San Fernando	2.0	2.7	3.5	4.6	5.5	5.9	7.3	6.7	5.3	3.9	2.6	2.0	52.0
Santa Clarita	2.8	2.8	4.1	5.6	6.0	6.8	7.6	7.8	5.8	5.2	3.7	3.2	61.5
Santa Monica	1.8	2.1	3.3	4.5	4.7	5.0	5.4	5.4	3.9	3.4	2.4	2.2	44.2
MADERA													
Chowchilla	1.0	1.4	3.2	4.7	6.6	7.8	8.5	7.3	5.3	3.4	1.4	0.7	51.4
Madera	0.9	1.4	3.2	4.8	6.6	7.8	8.5	7.3	5.3	3.4	1.4	0.7	51.5
Raymond	1.2	1.5	3.0	4.6	6.1	7.6	8.4	7.3	5.2	3.4	1.4	0.7	50.5
MARIN													
Black Point	1.1	1.7	3.0	4.2	5.2	6.2	6.6	5.8	4.3	2.8	1.3	0.9	43.0
Novato	1.3	1.5	2.4	3.5	4.4	6.0	5.9	5.4	4.4	2.8	1.4	0.7	39.8
Point San Pedro	1.1	1.7	3.0	4.2	5.2	6.2	6.6	5.8	4.3	2.8	1.3	0.9	43.0
San Rafael	1.2	1.3	2.4	3.3	4.0	4.8	4.8	4.9	4.3	2.7	1.3	0.7	35.8
MARIPOSA													
Coulterville	1.1	1.5	2.8	4.4	5.9	7.3	8.1	7.0	5.3	3.4	1.4	0.7	48.8
Mariposa	1.1	1.5	2.8	4.4	5.9	7.4	8.2	7.1	5.0	3.4	1.4	0.7	49.0
Yosemite Village	0.7	1.0	2.3	3.7	5.1	6.5	7.1	6.1	4.4	2.9	1.1	0.6	41.4
MENDOCINO													
Fort Bragg	0.9	1.3	2.2	3.0	3.7	3.5	3.7	3.7	3.0	2.3	1.2	0.7	29.0
Hopland	1.1	1.3	2.6	3.4	5.0	5.9	6.5	5.7	4.5	2.8	1.3	0.7	40.9
Point Arena	1.0	1.3	2.3	3.0	3.7	3.9	3.7	3.7	3.0	2.3	1.2	0.7	29.6
Sanel Valley	1.0	1.6	3.0	4.6	6.0	7.0	8.0	7.0	5.2	3.4	1.4	0.9	49.1
Ukiah	1.0	1.3	2.6	3.3	5.0	5.8	6.7	5.9	4.5	2.8	1.3	0.7	40.9
MERCED													
Kesterson	0.9	1.7	3.4	5.5	7.3	8.2	8.6	7.4	5.5	3.8	1.8	0.9	55.1
Los Banos	1.0	1.5	3.2	4.7	6.1	7.4	8.2	7.0	5.3	3.4	1.4	0.7	50.0
Merced	1.0	1.5	3.2	4.7	6.6	7.9	8.5	7.2	5.3	3.4	1.4	0.7	51.5

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
MODOC													
Modoc/Alturas	0.9	1.4	2.8	3.7	5.1	6.2	7.5	6.6	4.6	2.8	1.2	0.7	43.2
MONO													
Bridgeport	0.7	0.9	2.2	3.8	5.5	6.6	7.4	6.7	4.7	2.7	1.2	0.5	43.0
MONTEREY													
Arroyo Seco	1.5	2.0	3.7	5.4	6.3	7.3	7.2	6.7	5.0	3.9	2.0	1.6	52.6
Castroville	1.4	1.7	3.0	4.2	4.6	4.8	4.0	3.8	3.0	2.6	1.6	1.4	36.2
Gonzales	1.3	1.7	3.4	4.7	5.4	6.3	6.3	5.9	4.4	3.4	1.9	1.3	45.7
Greenfield	1.8	2.2	3.4	4.8	5.6	6.3	6.5	6.2	4.8	3.7	2.4	1.8	49.5
King City	1.7	2.0	3.4	4.4	4.4	5.6	6.1	6.7	6.5	5.2	2.2	1.3	49.6
King City-Oasis Rd.	1.4	1.9	3.6	5.3	6.5	7.3	7.4	6.8	5.1	4.0	2.0	1.5	52.7
Long Valley	1.5	1.9	3.2	4.1	5.8	6.5	7.3	6.7	5.3	3.6	2.0	1.2	49.1
Monterey	1.7	1.8	2.7	3.5	4.0	4.1	4.3	4.2	3.5	2.8	1.9	1.5	36.0
Pajaro	1.8	2.2	3.7	4.8	5.3	5.7	5.6	5.3	4.3	3.4	2.4	1.8	46.1
Salinas	1.6	1.9	2.7	3.8	4.8	4.7	5.0	4.5	4.0	2.9	1.9	1.3	39.1
Salinas North	1.2	1.5	2.9	4.1	4.6	5.2	4.5	4.3	3.2	2.8	1.5	1.2	36.9
San Ardo	1.0	1.7	3.1	4.5	5.9	7.2	8.1	7.1	5.1	3.1	1.5	1.0	49.0
San Juan	1.8	2.1	3.4	4.6	5.3	5.7	5.5	4.9	3.8	3.2	2.2	1.9	44.2
Soledad	1.7	2.0	3.4	4.4	5.5	5.4	6.5	6.2	5.2	3.7	2.2	1.5	47.7
NAPA													
Angwin	1.8	1.9	3.2	4.7	5.8	7.3	8.1	7.1	5.5	4.5	2.9	2.1	54.9
Carneros	0.8	1.5	3.1	4.6	5.5	6.6	6.9	6.2	4.7	3.5	1.4	1.0	45.8
Oakville	1.0	1.5	2.9	4.7	5.8	6.9	7.2	6.4	4.9	3.5	1.6	1.2	47.7
St Helena	1.2	1.5	2.8	3.9	5.1	6.1	7.0	6.2	4.8	3.1	1.4	0.9	44.1
Yountville	1.3	1.7	2.8	3.9	5.1	6.0	7.1	6.1	4.8	3.1	1.5	0.9	44.3
NEVADA													
Grass Valley	1.1	1.5	2.6	4.0	5.7	7.1	7.9	7.1	5.3	3.2	1.5	0.9	48.0
Nevada City	1.1	1.5	2.6	3.9	5.8	6.9	7.9	7.0	5.3	3.2	1.4	0.9	47.4
ORANGE													
Irvine	2.2	2.5	3.7	4.7	5.2	5.9	6.3	6.2	4.6	3.7	2.6	2.3	49.6
Laguna Beach	2.2	2.7	3.4	3.8	4.6	4.6	4.9	4.9	4.4	3.4	2.4	2.0	43.2
Santa Ana	2.2	2.7	3.7	4.5	4.6	5.4	6.2	6.1	4.7	3.7	2.5	2.0	48.2
PLACER													
Auburn	1.2	1.7	2.8	4.4	6.1	7.4	8.3	7.3	5.4	3.4	1.6	1.0	50.6
Blue Canyon	0.7	1.1	2.1	3.4	4.8	6.0	7.2	6.1	4.6	2.9	0.9	0.6	40.5
Colfax	1.1	1.5	2.6	4.0	5.8	7.1	7.9	7.0	5.3	3.2	1.4	0.9	47.9
Roseville	1.1	1.7	3.1	4.7	6.2	7.7	8.5	7.3	5.6	3.7	1.7	1.0	52.2
Soda Springs	0.7	0.7	1.8	3.0	4.3	5.3	6.2	5.5	4.1	2.5	0.7	0.7	35.4
Tahoe City	0.7	0.7	1.7	3.0	4.3	5.4	6.1	5.6	4.1	2.4	0.8	0.6	35.5
Truckee	0.7	0.7	1.7	3.2	4.4	5.4	6.4	5.7	4.1	2.4	0.8	0.6	36.2
PLUMAS													
Portola	0.7	0.9	1.9	3.5	4.9	5.9	7.3	5.9	4.3	2.7	0.9	0.5	39.4
Quincy	0.7	0.9	2.2	3.5	4.9	5.9	7.3	5.9	4.4	2.8	1.2	0.5	40.2
RIVERSIDE													
Beaumont	2.0	2.3	3.4	4.4	6.1	7.1	7.6	7.9	6.0	3.9	2.6	1.7	55.0
Blythe	2.4	3.3	5.3	6.9	8.7	9.6	9.6	8.7	6.9	5.0	3.0	2.2	71.4
Cathedral City	1.6	2.2	3.7	5.1	6.8	7.8	8.7	7.8	5.7	4.0	2.1	1.6	57.1
Coachella	2.9	4.4	6.2	8.4	10.5	11.9	12.3	10.1	8.9	6.2	3.8	2.4	88.1
Desert Center	2.9	4.1	6.4	8.5	11.0	12.1	12.2	11.1	9.0	6.4	3.9	2.6	90.0
Elsinore	2.1	2.8	3.9	4.4	5.9	7.1	7.6	7.0	5.8	3.9	2.6	1.9	55.0
Indio	**3.1**	3.6	6.5	8.3	10.5	11.0	10.8	9.7	8.3	5.9	3.7	2.7	83.9

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
RIVERSIDE													
La Quinta	2.4	2.8	5.2	6.5	8.3	8.7	8.5	7.9	6.5	4.5	2.7	2.2	66.2
Mecca	2.6	3.3	5.7	7.2	8.6	9.0	8.8	8.2	6.8	5.0	3.2	2.4	70.8
Oasis	2.9	3.3	5.3	6.1	8.5	8.9	8.7	7.9	6.9	4.8	2.9	2.3	68.4
Palm Deser	2.5	3.4	5.3	6.9	8.7	9.6	9.6	8.7	6.9	5.0	3.0	2.2	71.6
Palm Springs	2.0	2.9	4.9	7.2	8.3	8.5	11.6	8.3	7.2	5.9	2.7	1.7	71.1
Rancho California	1.8	2.2	3.4	4.8	5.6	6.3	6.5	6.2	4.8	3.7	2.4	1.8	49.5
Rancho Mirage	2.4	3.3	5.3	6.9	8.7	9.6	9.6	8.7	6.9	5.0	3.0	2.2	71.4
Ripley	2.7	3.3	5.6	7.2	8.7	8.7	8.4	7.6	6.2	4.6	2.8	2.2	67.8
Salton Sea North	2.5	3.3	5.5	7.2	8.8	9.3	9.2	8.5	6.8	5.2	3.1	2.3	71.7
Temecula East II	2.3	2.4	4.1	4.9	6.4	7.0	7.8	7.4	5.7	4.1	2.6	2.2	56.7
Thermal	2.4	3.3	5.5	7.6	9.1	9.6	9.3	8.6	7.1	5.2	3.1	2.1	72.8
Riverside UC	2.5	2.9	4.2	5.3	5.9	6.6	7.2	6.9	5.4	4.1	2.9	2.6	56.4
Winchester	2.3	2.4	4.1	4.9	6.4	6.9	7.7	7.5	6.0	3.9	2.6	2.1	56.8
SACRAMENTO													
Fair Oaks	1.0	1.6	3.4	4.1	6.5	7.5	8.1	7.1	5.2	3.4	1.5	1.0	50.5
Sacramento	1.0	1.8	3.2	4.7	6.4	7.7	8.4	7.2	5.4	3.7	1.7	0.9	51.9
Twitchell Island	1.2	1.8	3.9	5.3	7.4	8.8	9.1	7.8	5.9	3.8	1.7	1.2	57.9
SAN BENITO													
Hollister	1.5	1.8	3.1	4.3	5.5	5.7	6.4	5.9	5.0	3.5	1.7	1.1	45.1
San Benito	1.2	1.6	3.1	4.6	5.6	6.4	6.9	6.5	4.8	3.7	1.7	1.2	47.2
San Juan Valley	1.4	1.8	3.4	4.5	6.0	6.7	7.1	6.4	5.0	3.5	1.8	1.4	49.1
SAN BERNARDINO													
Baker	2.7	3.9	6.1	8.3	10.4	11.8	12.2	11.0	8.9	6.1	3.3	2.1	86.6
Barstow NE	2.2	2.9	5.3	6.9	9.0	10.1	9.9	8.9	6.8	4.8	2.7	2.1	71.7
Big Bear Lake	1.8	2.6	4.6	6.0	7.0	7.6	8.1	7.4	5.4	4.1	2.4	1.8	58.6
Chino	2.1	2.9	3.9	4.5	5.7	6.5	7.3	7.1	5.9	4.2	2.6	2.0	54.6
Crestline	1.5	1.9	3.3	4.4	5.5	6.6	7.8	7.1	5.4	3.5	2.2	1.6	50.8
Lake Arrowhead	1.8	2.6	4.6	6.0	7.0	7.6	8.1	7.4	5.4	4.1	2.4	1.8	58.6
Lucerne Valley	2.2	2.9	5.1	6.5	9.1	11.0	11.4	9.9	7.4	5.0	3.0	1.8	75.3
Needles	3.2	4.2	6.6	8.9	11.0	12.4	12.8	11.0	8.9	6.6	4.0	2.7	92.1
Newberry Springs	2.1	2.9	5.3	8.4	9.8	10.9	11.1	9.9	7.6	5.2	3.1	2.0	78.2
San Bernardino	2.0	2.7	3.8	4.6	5.7	6.9	7.9	7.4	5.9	4.2	2.6	2.0	55.6
Twentynine Palms	2.6	3.6	5.9	7.9	10.1	11.2	11.2	10.3	8.6	5.9	3.4	2.2	82.9
Victorville	2.0	2.6	4.6	6.2	7.3	8.9	9.8	9.0	6.5	4.7	2.7	2.1	66.2
SAN DIEGO													
Chula Vista	2.2	2.7	3.4	3.8	4.9	4.7	5.5	4.9	4.5	3.4	2.4	2.0	44.2
Escondido SPV	2.4	2.6	3.9	4.7	5.9	6.5	7.1	6.7	5.3	3.9	2.8	2.3	54.2
Miramar	2.3	2.5	3.7	4.1	5.1	5.4	6.1	5.8	4.5	3.3	2.4	2.1	47.1
Oceanside	2.2	2.7	3.4	3.7	4.9	4.6	4.6	5.1	4.1	3.3	2.4	2.0	42.9
Otay Lake	2.3	2.7	3.9	4.6	5.6	5.9	6.2	6.1	4.8	3.7	2.6	2.2	50.4
Pine Valley	1.5	2.4	3.8	5.1	6.0	7.0	7.8	7.3	6.0	4.0	2.2	1.7	54.8
Ramona	2.1	2.1	3.4	4.6	5.2	6.3	6.7	6.8	5.3	4.1	2.8	2.1	51.6
San Diego	2.1	2.4	3.4	4.6	5.1	5.3	5.7	5.6	4.3	3.6	2.4	2.0	46.5
Santee	2.1	2.7	3.7	4.5	5.5	6.1	6.6	6.2	5.4	3.8	2.6	2.0	51.1
Torrey Pines	2.2	2.3	3.4	3.9	4.0	4.1	4.6	4.7	3.8	2.8	2.0	2.0	39.8
Warner Springs	1.6	2.7	3.7	4.7	5.7	7.6	8.3	7.7	6.3	4.0	2.5	1.3	56.0
SAN FRANCISCO													
San Francisco	1.5	1.3	2.4	3.0	3.7	4.6	4.9	4.8	4.1	2.8	1.3	0.7	35.1
SAN JOAQUIN													
Farmington	1.5	1.5	2.9	4.7	6.2	7.6	8.1	6.8	5.3	3.3	1.4	0.7	50.0

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
SAN JOAQUIN													
Lodi West	1.0	1.6	3.3	4.3	6.3	6.9	7.3	6.4	4.5	3.0	1.4	0.8	46.7
Manteca	0.9	1.7	3.4	5.0	6.5	7.5	8.0	7.1	5.2	3.3	1.6	0.9	51.2
Stockton	0.8	1.5	2.9	4.7	6.2	7.4	8.1	6.8	5.3	3.2	1.4	0.6	49.1
Tracy	1.0	1.5	2.9	4.5	6.1	7.3	7.9	6.7	5.3	3.2	1.3	0.7	48.5
SAN LUIS OBISPO													
Arroyo Grande	2.0	2.2	3.2	3.8	4.3	4.7	4.3	4.6	3.8	3.2	2.4	1.7	40.0
Atascadero	1.2	1.5	2.8	3.9	4.5	6.0	6.7	6.2	5.0	3.2	1.7	1.0	43.7
Morro Bay	2.0	2.2	3.1	3.5	4.3	4.5	4.6	4.6	3.8	3.5	2.1	1.7	39.9
Nipomo	2.2	2.5	3.8	5.1	5.7	6.2	6.4	6.1	4.9	4.1	2.9	2.3	52.1
Paso Robles	1.6	2.0	3.2	4.3	5.5	6.3	7.3	6.7	5.1	3.7	2.1	1.4	49.0
San Luis Obispo	2.0	2.2	3.2	4.1	4.9	5.3	4.6	5.5	4.4	3.5	2.4	1.7	43.8
San Miguel	1.6	2.0	3.2	4.3	5.0	6.4	7.4	6.8	5.1	3.7	2.1	1.4	49.0
San Simeon	2.0	2.0	2.9	3.5	4.2	4.4	4.6	4.3	3.5	3.1	2.0	1.7	38.1
SAN MATEO													
Hal Moon Bay	1.5	1.7	2.4	3.0	3.9	4.3	4.3	4.2	3.5	2.8	1.3	1.0	33.7
Redwood City	1.5	1.8	2.9	3.8	5.2	5.3	6.2	5.6	4.8	3.1	1.7	1.0	42.8
Woodside	1.8	2.2	3.4	4.8	5.6	6.3	6.5	6.2	4.8	3.7	2.4	1.8	49.5
SANTA BARBARA													
Betteravia	2.1	2.6	4.0	5.2	6.0	5.9	5.8	5.4	4.1	3.3	2.7	2.1	49.1
Carpenteria	2.0	2.4	3.2	3.9	4.8	5.2	5.5	5.7	4.5	3.4	2.4	2.0	44.9
Cuyama	2.1	2.4	3.8	5.4	6.9	7.9	8.5	7.7	5.9	4.5	2.6	2.0	59.7
Goleta	2.1	2.5	3.9	5.1	5.7	5.7	5.4	5.4	4.2	3.2	2.8	2.2	48.1
Goleta Foothills	2.3	2.6	3.7	5.4	5.3	5.6	5.5	5.7	4.5	3.9	2.8	2.3	49.6
Guadalupe	2.0	2.2	3.2	3.7	4.9	4.6	4.5	4.6	4.1	3.3	2.4	1.7	41.1
Lompoc	2.0	2.2	3.2	3.7	4.8	4.6	4.9	4.8	3.9	3.2	2.4	1.7	41.1
Los Alamos	1.8	2.0	3.2	4.1	4.9	5.3	5.7	5.5	4.4	3.7	2.4	1.6	44.6
Santa Barbara	2.0	2.5	3.2	3.8	4.6	5.1	5.5	4.5	3.4	2.4	1.8	1.8	40.6
Santa Maria	1.8	2.3	3.7	5.1	5.7	5.8	5.6	5.3	4.2	3.5	2.4	1.9	47.4
Santa Ynez	1.7	2.2	3.5	5.0	5.8	6.2	6.4	6.0	4.5	3.6	2.2	1.7	48.7
Sisquoc	2.1	2.5	3.8	4.1	6.1	6.3	6.4	5.8	4.7	3.4	2.3	1.8	49.2
Solvang	2.0	2.0	3.3	4.3	5.0	5.6	6.1	5.6	4.4	3.7	2.2	1.6	45.6
SANTA CLARA													
Gilroy	1.3	1.8	3.1	4.1	5.3	5.6	6.1	5.5	4.7	3.4	1.7	1.1	43.6
Los Gatos	1.5	1.8	2.8	3.9	5.0	5.6	6.2	5.5	4.7	3.2	1.7	1.1	42.9
Morgan Hill	1.5	1.8	3.4	4.2	6.3	7.0	7.1	6.0	5.1	3.7	1.9	1.4	49.5
Palo Alto	1.5	1.8	2.8	3.8	5.2	5.3	6.2	5.6	5.0	3.2	1.7	1.0	43.0
San Jose	1.5	1.8	3.1	4.1	5.5	5.8	6.5	5.9	5.2	3.3	1.8	1.0	45.3
SANTA CRUZ													
De Laveaga	1.4	1.9	3.3	4.7	4.9	5.3	5.0	4.8	3.6	3.0	1.6	1.3	40.8
Green Valley Rd	1.2	1.8	3.2	4.5	4.6	5.4	5.2	5.0	3.7	3.1	1.6	1.3	40.6
Santa Cruz	1.5	1.8	2.6	3.5	4.3	4.4	4.8	4.4	3.8	2.8	1.7	1.2	36.6
Watsonville	1.5	1.8	2.7	3.7	4.6	4.5	4.9	4.2	4.0	2.9	1.8	1.2	37.7
Webb	1.8	2.2	3.7	4.8	5.3	5.7	5.6	5.3	4.3	3.4	2.4	1.8	46.2
SHASTA													
Burney	0.7	1.0	2.1	3.5	4.9	5.9	7.4	6.4	4.4	2.9	0.9	0.6	40.9
Fall River Mills	0.6	1.0	2.1	3.7	5.0	6.1	7.8	6.7	4.6	2.8	0.9	0.5	41.8
Glenburn	0.6	1.0	2.1	3.7	5.0	6.3	7.8	6.7	4.7	2.8	0.9	0.6	42.1
McArthur	0.7	1.4	2.9	4.2	5.6	6.9	8.2	7.2	5.0	3.0	1.1	0.6	46.8
Redding	1.2	1.4	2.6	4.1	5.6	7.1	8.5	7.3	5.3	3.2	1.4	0.9	48.8

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
SIERRA													
Downieville	0.7	1.0	2.3	3.5	5.0	6.0	7.4	6.2	4.7	2.8	0.9	0.6	41.3
Sierraville	0.7	1.1	2.2	3.2	4.5	5.9	7.3	6.4	4.3	2.6	0.9	0.5	39.6
SISKIYOU													
Happy Camp	0.5	0.9	2.0	3.0	4.3	5.2	6.1	5.3	4.1	2.4	0.9	0.5	35.1
MacDoel	1.0	1.7	3.1	4.5	5.9	7.2	8.1	7.1	5.1	3.1	1.5	1.0	49.0
Mt Shasta	0.5	0.9	2.0	3.0	4.5	5.3	6.7	5.7	4.0	2.2	0.7	0.5	36.0
Tule lake FS	0.7	1.3	2.7	4.0	5.4	6.3	7.1	6.4	4.7	2.8	1.0	0.6	42.9
Weed	0.5	0.9	2.0	2.5	4.5	5.3	6.7	5.5	3.7	2.0	0.9	0.5	34.9
Yreka	0.6	0.9	2.1	3.0	4.9	5.8	7.3	6.5	4.3	2.5	0.9	0.5	39.2
SOLANO													
Dixon	0.7	1.4	3.2	5.2	6.3	7.6	8.2	7.2	5.5	4.3	1.6	1.1	52.1
Fairfield	1.1	1.7	2.8	4.0	5.5	6.1	7.8	6.0	4.8	3.1	1.4	0.9	45.2
Hastings Tract	1.6	2.2	3.7	5.1	6.8	7.8	8.7	7.8	5.7	4.0	2.1	1.6	57.1
Putah Creek	1.0	1.6	3.2	4.9	6.1	7.3	7.9	7.0	5.3	3.8	1.8	1.2	51.0
Rio Vista	0.9	1.7	2.8	4.4	5.9	6.7	7.9	6.5	5.1	3.2	1.3	0.7	47.0
Suisun Valley	0.6	1.3	3.0	4.7	5.8	7.0	7.7	6.8	5.3	3.8	1.4	0.9	48.3
Winters	0.9	1.7	3.3	5.0	6.4	7.5	7.9	7.0	5.2	3.5	1.6	1.0	51.0
SONOMA													
Bennett Valley	1.1	1.7	3.2	4.1	5.5	6.5	6.6	5.7	4.5	3.1	1.5	0.9	44.4
Cloverdale	1.1	1.4	2.6	3.4	5.0	5.9	6.2	5.6	4.5	2.8	1.4	0.7	40.7
Fort Ross	1.2	1.4	2.2	3.0	3.7	4.5	4.2	4.3	3.4	2.4	1.2	0.5	31.9
Healdsburg	1.2	1.5	2.4	3.5	5.0	5.9	6.1	5.6	4.5	2.8	1.4	0.7	40.8
Lincoln	1.2	1.7	2.8	4.7	6.1	7.4	8.4	7.3	5.4	3.7	1.9	1.2	51.9
Petaluma	1.2	1.5	2.8	3.7	4.6	5.6	4.6	5.7	4.5	2.9	1.4	0.9	39.6
Santa Rosa	1.2	1.7	2.8	3.7	5.0	6.0	6.1	5.9	4.5	2.9	1.5	0.7	42.0
Valley of the Moon	1.0	1.6	3.0	4.5	5.6	6.6	7.1	6.3	4.7	3.3	1.5	1.0	46.1
Windsor	0.9	1.6	3.0	4.5	5.5	6.5	6.5	5.9	4.4	3.2	1.4	1.0	44.2
STANISLAUS													
Denair	1.0	1.9	3.6	4.7	7.0	7.9	8.0	6.1	5.3	3.4	1.5	1.0	51.4
La Grange	1.2	1.5	3.1	4.7	6.2	7.7	8.5	7.3	5.3	3.4	1.4	0.7	51.2
Modesto	0.9	1.4	3.2	4.7	6.4	7.7	8.1	6.8	5.0	3.4	1.4	0.7	49.7
Newman	1.0	1.5	3.2	4.6	6.2	7.4	8.1	6.7	5.0	3.4	1.4	0.7	49.3
Oakdale	1.2	1.5	3.2	4.7	6.2	7.7	8.1	7.1	5.1	3.4	1.4	0.7	50.3
Patterson	1.3	2.1	4.2	5.4	7.9	8.6	8.2	6.6	5.8	4.0	1.9	1.3	57.3
Turlock	0.9	1.5	3.2	4.7	6.5	7.7	8.2	7.0	5.1	3.4	1.4	0.7	50.2
SUTTER													
Nicolaus	0.9	1.6	3.2	4.9	6.3	7.5	8.0	6.9	5.2	3.4	1.5	0.9	50.2
Yuba City	1.3	2.1	2.8	4.4	5.7	7.2	7.1	6.1	4.7	3.2	1.2	0.9	46.7
TEHAMA													
Corning	1.2	1.8	2.9	4.5	6.1	7.3	8.1	7.2	5.3	3.7	1.7	1.1	50.7
Gerber	1.0	1.8	3.5	5.0	6.6	7.9	8.7	7.4	5.8	4.1	1.8	1.1	54.7
Gerber Dryland	0.9	1.6	3.2	4.7	6.7	8.4	9.0	7.9	6.0	4.2	2.0	1.0	55.5
Red Bluff	1.2	1.8	2.9	4.4	5.9	7.4	8.5	7.3	5.4	3.5	1.7	1.0	51.1
TRINITY													
Hay Fork	0.5	1.1	2.3	3.5	4.9	5.9	7.0	6.0	4.5	2.8	0.9	0.7	40.1
Weaverville	0.6	1.1	2.2	3.3	4.9	5.9	7.3	6.0	4.4	2.7	0.9	0.7	40.0
TULARE													
Alpaugh	0.9	1.7	3.4	4.8	6.6	7.7	8.2	7.3	5.4	3.4	1.4	0.7	51.6
Badger	1.0	1.3	2.7	4.1	6.0	7.3	7.7	7.0	4.8	3.3	1.4	0.7	47.3
Delano	1.1	1.9	4.0	4.9	7.2	7.9	8.1	7.3	5.4	3.2	1.5	1.2	53.6

Appendix A - Reference Evapotranspiration (ETo) Table*

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual ETo
TULARE													
Dinuba	1.1	1.5	3.2	4.7	6.2	7.7	8.5	7.3	5.3	3.4	1.4	0.7	51.2
Lindcove	0.9	1.6	3.0	4.8	6.5	7.6	8.1	7.2	5.2	3.4	1.6	0.9	50.6
Porterville	1.2	1.8	3.4	4.7	6.6	7.7	8.5	7.3	5.3	3.4	1.4	0.7	52.1
Visalia	0.9	1.7	3.3	5.1	6.8	7.7	7.9	6.9	4.9	3.2	1.5	0.8	50.7
TUOLUMNE													
Groveland	1.1	1.5	2.8	4.1	5.7	7.2	7.9	6.6	5.1	3.3	1.4	0.7	47.5
Sonora	1.1	1.5	2.8	4.1	5.8	7.2	7.9	6.7	5.1	3.2	1.4	0.7	47.6
VENTURA													
Camarillo	2.2	2.5	3.7	4.3	5.0	5.2	5.9	5.4	4.2	3.0	2.5	2.1	46.1
Oxnard	2.2	2.5	3.2	3.7	4.4	4.6	5.4	4.8	4.0	3.3	2.4	2.0	42.3
Piru	2.8	2.8	4.1	5.6	6.0	6.8	7.6	7.8	5.8	5.2	3.7	3.2	61.5
Port Hueneme	2.0	2.3	3.3	4.6	4.9	4.9	4.9	5.0	3.7	3.2	2.5	2.2	43.5
Thousand Oaks	2.2	2.6	3.4	4.5	5.4	5.9	6.7	6.4	5.4	3.9	2.6	2.0	51.0
Ventura	2.2	2.6	3.2	3.8	4.6	4.7	5.5	4.9	4.1	3.4	2.5	2.0	43.5
YOLO													
Bryte	0.9	1.7	3.3	5.0	6.4	7.5	7.9	7.0	5.2	3.5	1.6	1.0	51.0
Davis	1.0	1.9	3.3	5.0	6.4	7.6	8.2	7.1	5.4	4.0	1.8	1.0	52.5
Esparto	1.0	1.7	3.4	5.5	6.9	8.1	8.5	7.5	5.8	4.2	2.0	1.2	55.8
Winters	1.7	1.7	2.9	4.4	5.8	7.1	7.9	6.7	5.3	3.3	1.6	1.0	49.4
Woodland	1.0	1.8	3.2	4.7	6.1	7.7	8.2	7.2	5.4	3.7	1.7	1.0	51.6
Zamora	1.1	1.9	3.5	5.2	6.4	7.4	7.8	7.0	5.5	4.0	1.9	1.2	52.8
YUBA													
Browns Valley	1.0	1.7	3.1	4.7	6.1	7.5	8.5	7.6	5.7	4.1	2.0	1.1	52.9
Brownsville	1.1	1.4	2.6	4.0	5.7	6.8	7.9	6.8	5.3	3.4	1.5	0.9	47.4

* The values in this table were derived from:
1) California Irrigation Management Information System (CIMIS);
2) Reference EvapoTranspiration Zones Map, UC Dept. of Land, Air & Water Resources and California Dept of Water Resources 1999; and
3) Reference Evapotranspiration for California, University of California, Department of Agriculture and Natural Resources
(1987) Bulletin 1922, 4) Determining Daily Reference Evapotranspiration, Cooperative Extension UC Division of Agriculture and Natural Resources (1987), Publication Leaflet 21426

Appendix B – Sample Water Efficient Landscape Worksheet.

WATER EFFICIENT LANDSCAPE WORKSHEET

This worksheet is filled out by the project applicant and it is a required element of the Landscape Documentation Package.
Please complete all sections (A and B) of the worksheet.

SECTION A. HYDROZONE INFORMATION TABLE

Please complete the hydrozone table(s) for each hydrozone. Use as many tables as necessary to provide the square footage of landscape area per hydrozone.

Hydrozone*	Zone or Valve	Irrigation Method**	Area (Sq. Ft.)	% of Landscape Area
	Total			**100%**

**** Hydrozone***
HW = High Water Use Plants
MW = Moderate Water Use Plants
LW = Low Water Use Plants

*****Irrigation Method***
MS = Micro-spray
S = Spray
R = Rotor
B= Bubbler
D= Drip
O = Other

SECTION B. WATER BUDGET CALCULATIONS

Section B1. Maximum Applied Water Allowance (MAWA)

The project's Maximum Applied Water Allowance shall be calculated using this equation:

MAWA = (ETo) (0.62) [(0.7 x LA) + (0.3 x SLA)]

where:

MAWA = Maximum Applied Water Allowance (gallons per year)
ETo = Reference Evapotranspiration from Appendix A (inches per year)
0.7 = ET Adjustment Factor (ETAF)
LA = Landscaped Area includes Special Landscape Area (square feet)
0.62 = Conversion factor (to gallons per square foot)
SLA = Portion of the landscape area identified as Special Landscape Area (square feet)
0.3 = the additional ET Adjustment Factor for Special Landscape Area (1.0 - 0.7 = 0.3)

Maximum Applied Water Allowance = _____**gallons per year**

Show calculations.

Effective Precipitation (Eppt)

If considering Effective Precipitation, use 25% of annual precipitation. Use the following equation to calculate Maximum Applied Water Allowance:

MAWA= (ETo – Eppt) (0.62) [(0.7 x LA) + (0.3 x SLA)]

Maximum Applied Water Allowance = _____**gallons per year**

Show calculations.

Section B2. Estimated Total Water Use (ETWU)

The project's Estimated Total Water Use is calculated using the following formula:

$$ETWU = (ETo)(0.62)\left(\frac{PF\,x\,HA}{IE} + SLA\right)$$

where:

ETWU = Estimated total water use per year (gallons per year)
ETo = Reference Evapotranspiration (inches per year)
PF = Plant Factor from WUCOLS (see Definitions)
HA = Hydrozone Area [high, medium, and low water use areas] (square feet)
SLA = Special Landscape Area (square feet)
0.62 = Conversion Factor (to gallons per square foot)
IE = Irrigation Efficiency (minimum 0.71)

Hydrozone Table for Calculating ETWU

Please complete the hydrozone table(s). Use as many tables as necessary.

Hydrozone	Plant Water Use Type(s)	Plant Factor (PF)	Area (HA) (square feet)	PF x HA (square feet)
			Sum	
	SLA			

Estimated Total Water Use = **_____gallons**

Show calculations.

Appendix C – Sample Certificate of Completion.

CERTIFICATE OF COMPLETION

This certificate is filled out by the project applicant upon completion of the landscape project.

PART 1. PROJECT INFORMATION SHEET

Date		
Project Name		
Name of Project Applicant	Telephone No.	
	Fax No.	
Title	Email Address	
Company	Street Address	
City	State	Zip Code

Project Address and Location:

Street Address		Parcel, tract or lot number, if available.
City		Latitude/Longitude (optional)
State	Zip Code	

Property Owner or his/her designee:

Name	Telephone No.	
	Fax No.	
Title	Email Address	
Company	Street Address	
City	State	Zip Code

Property Owner

"I/we certify that I/we have received copies of all the documents within the Landscape Documentation Package and the Certificate of Completion and that it is our responsibility to see that the project is maintained in accordance with the Landscape and Irrigation Maintenance Schedule."

_____

Property Owner Signature Date

Please answer the questions below:

1. Date the Landscape Documentation Package was submitted to the local agency_____
2. Date the Landscape Documentation Package was approved by the local agency_____
3. Date that a copy of the Water Efficient Landscape Worksheet (including the Water Budget Calculation) was submitted to the local water purveyor_____

PART 2. CERTIFICATION OF INSTALLATION ACCORDING TO THE LANDSCAPE DOCUMENTATION PACKAGE

"I/we certify that based upon periodic site observations, the work has been substantially completed in accordance with the ordinance and that the landscape planting and irrigation installation conform with the criteria and specifications of the approved Landscape Documentation Package."

Signature*	Date	
Name (print)	Telephone No.	
	Fax No.	
Title	Email Address	
License No. or Certification No.		
Company	Street Address	
City	State	Zip Code

*Signer of the landscape design plan, signer of the irrigation plan, or a licensed landscape contractor.

PART 3. IRRIGATION SCHEDULING

Attach parameters for setting the irrigation schedule on controller per ordinance Section 492.10.

PART 4. SCHEDULE OF LANDSCAPE AND IRRIGATION MAINTENANCE

Attach schedule of Landscape and Irrigation Maintenance per ordinance Section 492.11.

PART 5. LANDSCAPE IRRIGATION AUDIT REPORT

Attach Landscape Irrigation Audit Report per ordinance Section 492.12.

PART 6. SOIL MANAGEMENT REPORT

Attach soil analysis report, if not previously submitted with the Landscape Documentation Package per ordinance Section 492.5.

Attach documentation verifying implementation of recommendations from soil analysis report per ordinance Section 492.5.

Assembly Bill No. 1881

CHAPTER 559

An act to add Section 1353.8 to the Civil Code, to repeal and add Article 10.8 (commencing with Section 65591) of Chapter 3 of Division 1 of Title 7 of the Government Code, to add Section 25401.9 to the Public Resources Code, and to add Article 4.5 (commencing with Section 535) to Chapter 8 of Division 1 of the Water Code, relating to water conservation.

[Approved by Governor September 28, 2006. Filed with Secretary of State September 28, 2006.]

LEGISLATIVE COUNSEL'S DIGEST

AB 1881, Laird. Water conservation.

(1) Existing law, the Davis-Sterling Common Interest Development Act, defines and regulates common interest developments, which include community apartment projects, condominium projects, planned developments, and stock cooperatives.

This bill would provide that the architectural guidelines of a common interest development shall not prohibit or include conditions that have the effect of prohibiting the use of low water-using plants as a group.

(2) The Water Conservation in Landscaping Act requires the Department of Water Resources to appoint an advisory task force to work with the department to draft a model local water efficient landscape ordinance that local agencies may adopt, requires the task force to submit the ordinance to the department on or before May 1, 1991, and requires the task force to cease to exist on the date the department adopts the model ordinance or January 1, 1992, whichever occurs first. The act requires the department, not later than January 1, 1992, to adopt a model local water efficient landscape ordinance which each local agency may adopt. The act makes the model local water efficient landscape ordinance adopted by the department applicable within the jurisdiction of a local agency if that local agency, by January 1, 1993, has not adopted a water efficient landscape ordinance or has not adopted certain findings that the adoption of the ordinance is unnecessary.

This bill would specify that the provision making the model ordinance applicable to a local agency on and after January 1, 1993, does not apply to chartered cities. The bill would require the department, to the extent funds are appropriated, not later than January 1, 2009, by regulation, to update the model ordinance in accordance with specified requirements. The bill would require the department to prepare and submit to the Legislature a prescribed report before the adoption of the updated model ordinance. The bill would require a local agency, not later than January 1, 2010, to adopt the updated model ordinance or other water efficient

landscape ordinance that is at least as effective in conserving water as the updated model ordinance. The bill would make the updated model ordinance applicable within the jurisdiction of a local agency, including a chartered city, if, by January 1, 2010, the local agency has not adopted its own water efficient landscape ordinance or the updated model ordinance. The bill would require each local agency, not later than January 31, 2010, to notify the department as to whether the local agency is subject to the department's updated model ordinance and, if not, to submit to the department a copy of the water efficient landscape ordinance adopted by the local agency, among other documents. The bill would require the department, to the extent funds are appropriated, not later than January 31, 2011, to prepare and submit a report to the Legislature relating to the status of water efficient landscape ordinances adopted by local agencies.

By imposing requirements on local agencies in connection with the adoption of water efficient landscape ordinances, the bill would impose a state-mandated local program.

(3) Existing law requires the State Energy Resources Conservation and Development Commission (Energy Commission), after one or more public hearings, to take specified action to reduce the wasteful, uneconomic, inefficient, or unnecessary consumption of energy. Existing law requires the Energy Commission, by January 1, 2004, to amend specified regulations to require that residential clothes washers manufactured on or after January 1, 2007, be at least as water efficient as commercial clothes washers, and to take certain other related action.

This bill would require the Energy Commission, in consultation with the department, to adopt, to the extent funds are available, by regulation performance standards and labeling requirements for landscape irrigation equipment, including irrigation controllers, moisture sensors, emission devices, and valves to reduce the wasteful, uneconomic, inefficient, or unnecessary consumption of energy or water. The bill would require the Energy Commission to adopt those requirements for landscape irrigation controllers and moisture sensors by January 1, 2010, and, on and after January 1, 2012, would prohibit the sale or installation of an irrigation controller or moisture sensor for landscape use unless the controller or sensor meets those adopted requirements. The bill would require the Energy Commission, on or before January 1, 2010, to prepare and submit to the Legislature a report that sets forth a proposed schedule for adopting performance standards and labeling requirements for emission devices and valves.

(4) Existing law generally requires an urban water supplier to install water meters on all municipal and industrial service connections located within its service area on or before January 1, 2025.

This bill would require a water purveyor as defined, to require as a condition of new retail water service on and after January 1, 2008, the installation of separate water meters to measure the volume of water used exclusively for landscape purposes. The bill would make this requirement applicable to specified service connections.

(5) The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement.

This bill would provide that, if the Commission on State Mandates determines that the bill contains costs mandated by the state, reimbursement for those costs shall be made pursuant to these statutory provisions.

The people of the State of California do enact as follows:

SECTION 1. Section 1353.8 is added to the Civil Code, to read:

1353.8. The architectural guidelines of a common interest development shall not prohibit or include conditions that have the effect of prohibiting the use of low water-using plants as a group.

SEC. 2. Article 10.8 (commencing with Section 65591) of Chapter 3 of Division 1 of Title 7 of the Government Code is repealed.

SEC. 3. Article 10.8 (commencing with Section 65591) is added to Chapter 3 of Division 1 of Title 7 of the Government Code, to read:

Article 10.8. Water Conservation in Landscaping

65591. This article shall be known and may be cited as the Water Conservation in Landscaping Act.

65592. Unless the context requires otherwise, the following definitions govern the construction of this article:

(a) "Department" means the Department of Water Resources.

(b) "Local agency" means any city, county, or city and county, including a charter city or charter county.

(c) "Water efficient landscape ordinance" means an ordinance or resolution adopted by a local agency, or prepared by the department, to address the efficient use of water in landscaping.

65593. The Legislature finds and declares all of the following:

(a) The waters of the state are of limited supply and are subject to ever increasing demands.

(b) The continuation of California's economic prosperity is dependent on adequate supplies of water being available for future uses.

(c) It is the policy of the state to promote the conservation and efficient use of water and to prevent the waste of this valuable resource.

(d) Landscapes are essential to the quality of life in California by providing areas for active and passive recreation and as an enhancement to the environment by cleaning air and water, preventing erosion, offering fire protection, and replacing ecosystems lost to development.

(e) Landscape design, installation, maintenance, and management can and should be water efficient.

(f) Section 2 of Article X of the California Constitution specifies that the right to use water is limited to the amount reasonably required for the

beneficial use to be served and the right does not and shall not extend to waste or unreasonable use or unreasonable method of use.

(g) (1) The Legislature, pursuant to Chapter 682 of the Statutes of 2004, requested the California Urban Water Conservation Council to convene a stakeholders work group to develop recommendations for improving the efficiency of water use in urban irrigated landscapes.

(2) The work group report includes a recommendation to update the model water efficient landscape ordinance adopted by the department pursuant to Chapter 1145 of the Statutes of 1990.

(3) It is the intent of the Legislature that the department promote the use of this updated model ordinance.

(h) Notwithstanding Article 13 (commencing with Section 65700), this article addresses a matter that is of statewide concern and is not a municipal affair as that term is used in Section 5 of Article XI of the California Constitution. Accordingly, it is the intent of the Legislature that this article, except as provided in Section 65594, apply to all cities and counties, including charter cities and charter counties.

65594. (a) Except as provided in Section 65595, if by January 1, 1993, a local agency did not adopt a water efficient landscape ordinance and did not adopt findings based on climatic, geological, or topographical conditions, or water availability that state that a water efficient landscape ordinance is unnecessary, the model water efficient landscape ordinance adopted by the department pursuant to Chapter 1145 of the Statutes of 1990 shall apply within the jurisdiction of the local agency as of that date, shall be enforced by the local agency, and shall have the same force and effect as if adopted by the local agency.

(b) Notwithstanding subdivision (b) of Section 65592, subdivision (a) does not apply to chartered cities.

(c) This section shall apply only until the department updates the model ordinance.

65595. (a) (1) To the extent funds are appropriated, not later than January 1, 2009, by regulation, the department shall update the model water efficient landscape ordinance adopted pursuant to Chapter 1145 of the Statutes of 1990, after holding one or more public hearings. The updated model ordinance shall be based on the recommendations set forth in the report prepared pursuant to Chapter 682 of the Statutes of 2004 and shall meet the requirements of Section 65596.

(2) Before the adoption of the updated model ordinance pursuant to paragraph (1), the department shall prepare and submit to the Legislature a report relating to both of the following:

(A) The extent to which local agencies have complied with the model water efficient landscape ordinance adopted pursuant to Chapter 1145 of the Statutes of 1990.

(B) The department's recommendations regarding the landscape water budget component of the updated model ordinance described in subdivision (b) of Section 65596.

(b) Not later than January 31, 2009, the department shall distribute the updated model ordinance adopted pursuant to subdivision (a) to all local agencies and other interested parties.

(c) On or before January 1, 2010, a local agency shall adopt one of the following:

(1) A water efficient landscape ordinance that is, based on evidence in the record, at least as effective in conserving water as the updated model ordinance adopted by the department pursuant to subdivision (a).

(2) The updated model ordinance described in paragraph (1).

(d) If the local agency has not adopted, on or before January 1, 2010, a water efficient landscape ordinance pursuant to subdivision (c), the updated model ordinance adopted by the department pursuant to subdivision (a) shall apply within the jurisdiction of the local agency as of that date, shall be enforced by the local agency, and shall have the same force and effect as if adopted by the local agency.

(e) Nothing in this article shall be construed to require the local agency's water efficient landscape ordinance to duplicate, or to conflict with, a water efficiency program or measure implemented by a public water system, as defined in Section 116275 of the Health and Safety Code, within the jurisdictional boundaries of the local agency.

65596. The updated model ordinance adopted pursuant to Section 65595 shall do all the following in order to reduce water use:

(a) Include provisions for water conservation and the appropriate use and groupings of plants that are well-adapted to particular sites and to particular climatic, soil, or topographic conditions. The model ordinance shall not prohibit or require specific plant species, but it may include conditions for the use of plant species or encourage water conserving plants. However, the model ordinance shall not include conditions that have the effect of prohibiting or requiring specific plant species.

(b) Include a landscape water budget component that establishes the maximum amount of water to be applied through the irrigation system, based on climate, landscape size, irrigation efficiency, and plant needs.

(c) Promote the benefits of consistent local ordinances in neighboring areas.

(d) Encourage the capture and retention of stormwater onsite to improve water use efficiency or water quality.

(e) Include provisions for the use of automatic irrigation systems and irrigation schedules based on climatic conditions, specific terrains and soil types, and other environmental conditions. The model ordinance shall include references to local, state, and federal laws and regulations regarding standards for water-conserving irrigation equipment. The model ordinance may include climate information for irrigation scheduling based on the California Irrigation Management Information System.

(f) Include provisions for onsite soil assessment and soil management plans that include grading and drainage to promote healthy plant growth and to prevent excessive erosion and runoff, and the use of mulches in shrub areas, garden beds, and landscaped areas where appropriate.

(g) Promote the use of recycled water consistent with Article 4 (commencing with Section 13520) of Chapter 7 of Division 7 of the Water Code.

(h) Seek to educate water users on the efficient use of water and the benefits of doing so.

(i) Address regional differences, including fire prevention needs.

(j) Exempt landscaping that is part of a registered historical site.

(k) Encourage the use of economic incentives to promote the efficient use of water.

(*l*) Include provisions for landscape maintenance practices that foster long-term landscape water conservation. Landscape maintenance practices may include, but are not limited to, performing routine irrigation system repair and adjustments, conducting water audits, and prescribing the amount of water applied per landscaped acre.

(m) Include provisions to minimize landscape irrigation overspray and runoff.

65597. Not later than January 31, 2010, each local agency shall notify the department as to whether the local agency is subject to the department's updated model ordinance adopted pursuant to Section 65595, and if not, shall submit to the department a copy of the water efficient landscape ordinance adopted by the local agency, and a copy of the local agency's findings and evidence in the record that its water efficient landscape ordinance is at least as effective in conserving water as the department's updated model ordinance. Not later than January 31, 2011, the department shall, to the extent funds are appropriated, prepare and submit a report to the Legislature summarizing the status of water efficient landscape ordinances adopted by local agencies.

65598. Any model ordinance adopted pursuant to this article shall exempt cemeteries from all provisions of the ordinance except those set forth in subdivisions (h), (k), and (*l*) of Section 65596. In adopting language specific to cemeteries, the department shall recognize the special landscape management needs of cemeteries.

65599. Any actions or proceedings to attach, review, set aside, void, or annul the act, decision, or findings of a local agency on the ground of noncompliance with this article shall be brought pursuant to Section 1085 of the Code of Civil Procedure.

SEC. 4. Section 25401.9 is added to the Public Resources Code, to read:

25401.9. (a) To the extent that funds are available, the commission, in consultation with the Department of Water Resources, shall adopt by regulation, after holding one or more public hearings, performance standards and labeling requirements for landscape irrigation equipment, including, but not limited to, irrigation controllers, moisture sensors, emission devices, and valves, for the purpose of reducing the wasteful, uneconomic, inefficient, or unnecessary consumption of energy or water.

(b) For the purposes of complying with subdivision (a), the commission shall do all of the following:

(1) Adopt performance standards and labeling requirements for landscape irrigation controllers and moisture sensors on or before January 1, 2010.

(2) Consider the Irrigation Association's Smart Water Application Technology Program testing protocols when adopting performance standards for landscape irrigation equipment, including, but not limited to, irrigation controllers, moisture sensors, emission devices, and valves.

(3) Prepare and submit a report to the Legislature, on or before January 1, 2010, that sets forth on a proposed schedule for adopting performance standards and labeling requirements for emission devices and valves.

(c) On and after January 1, 2012, an irrigation controller or moisture sensor for landscape irrigation uses may not be sold or installed in the state unless the controller or sensor meets the performance standards and labeling requirements established pursuant to this section.

SEC. 5. Article 4.5 (commencing with Section 535) is added to Chapter 8 of Division 1 of the Water Code, to read:

Article 4.5. Irrigated Landscape

535. (a) A water purveyor shall require as a condition of new retail water service on and after January 1, 2008, the installation of separate water meters to measure the volume of water used exclusively for landscape purposes.

(b) Subdivision (a) does not apply to either of the following:

(1) Single-family residential connections.

(2) Connections used to supply water for the commercial production of agricultural crops or livestock.

(c) Subdivision (a) applies only to a service connection for which both of the following apply:

(1) The connection serves property with more than 5,000 square feet of irrigated landscape.

(2) The connection is supplied by a water purveyor that serves 15 or more service connections.

(d) For the purposes of this section, "new retail water service" means the installation of a new water meter where water service has not been previously provided, and does not include applications for new water service submitted before January 1, 2007.

SEC. 6. If the Commission on State Mandates determines that this act contains costs mandated by the state, reimbursement to local agencies and school districts for those costs shall be made pursuant to Part 7 (commencing with Section 17500) of Division 4 of Title 2 of the Government Code.

O

Appendix H – City of Dinuba Water Conservation Ordinance

Chapter 13.05
WATER CONSERVATION

Sections:

13.05.010 Purpose.
13.05.020 Short title.
13.05.030 Authorization.
13.05.040 Application.
13.05.050 Prohibition on water waste.
13.05.060 Outdoor water use—Water conservation stages.
13.05.070 Mandatory conservation phase implementation.
13.05.080 Enforcement.
13.05.090 Public nuisance—Definitions.
13.05.100 Enforcement officers.
13.05.110 Exceptions.

13.05.010 Purpose.
It is the purpose and intent of this chapter to minimize outdoor water use and to control unnecessary consumption of the available potable water supplies in the city from city and private wells. (Ord. 723 § 1 (part), 1989)

13.05.020 Short title.
This chapter shall be known as the “Water Conservation Ordinance of the City of Dinuba.” (Ord. 723 § 1 (part), 1989)

13.05.030 Authorization.
The city manager, or his designee, is authorized and directed to implement the applicable provisions of this chapter upon their determination that such implementation is necessary to protect the public welfare and safety. (Ord. 723 § 1 (part), 1989)

13.05.040 Application.
The provisions of this chapter shall apply to all persons, customers and property whether receiving water from the city or other source, such as private wells, within the limits of the city. (Ord. 723 § 1 (part), 1989)

13.05.050 Prohibition on water waste.
The following uses of water are defined as a “waste of water” and are prohibited except as otherwise authorized:

A. The use of water which allows substantial amounts of water to run off to a gutter, ditch or drain. Every water user is deemed to have their water distribution lines and facilities under their control at all times and to know the manner and extent of their water use and excess runoff;

B. The excessive use, loss or escape of water through breaks, leaks or malfunctions in the water user’s plumbing or distribution facilities for any period of time after such escape of water should reasonably have been discovered and corrected. It shall be presumed that a period of forty-eight hours after discovery is a reasonable time within which to correct such

leak or break;

C. The washing of vehicles, building exteriors, sidewalks, driveways, parking areas, tennis courts, patios or other paved areas without the use of a positive shutoff nozzle on the hose, which results in excessive runoff, except where necessary to dispose of liquids or substances that would endanger the public's health and safety after obtaining authorization from city officials;

D. The watering of lawns, groundcover and shrubbery between the hours of eleven a.m. and six p.m. from May 1st to September 30th.

Exception: Commercial nurseries, commercial sod farmers, golf courses and similar establishments are exempt from the restrictions in subsection (D) of this section, but will be requested to minimize water waste at all times. (Ord. 723 § 1 (part), 1989)

13.05.060 Outdoor water use—Water conservation stages.
No one within the city shall knowingly make, cause, use or permit the use of water for residential, commercial, industrial, agricultural, governmental or any other purpose in a manner contrary to any provision of this chapter, or in an amount in excess of that use permitted by the conservation stage in effect pursuant to action taken by the city manager, or his designee, in accordance with the provisions of this chapter. Authorized personnel shall promulgate guidelines which shall set forth the criteria for determining when a particular conservation stage is to be implemented and terminated. Such guidelines shall be updated when, in the opinion of the city manager, the conditions of the utility system have changed so as to necessitate such update. The city manager shall include in such guidelines a scheduling system designating allowed days for irrigation by customers. Said guidelines shall be available for inspection at the city offices, and the public works administrative office, Alta Irrigation District, and the library during normal business hours.

A. Stage 1. Voluntary Conservation. Water users in the city are requested to voluntarily limit the amount of water used at all times to that amount absolutely necessary for health, business and irrigation.

B. Stage 2. Mandatory Compliance-Water Alert. Upon implementation by the city manager, and publication of notice, the following restrictions shall apply to all persons. All elements of Stage 1 shall remain in effect in Stage 2 except that:

1. Irrigation utilizing individual sprinklers or sprinkler systems of lawns, gardens, landscaped areas, trees, shrubs or other plants is permitted only on designated days between the hours of seven p.m. and ten a.m. Irrigation of lawns, gardens, landscaped areas, trees, shrubs or other plants is permitted at any time if:

    a. A handheld hose with a positive shut off nozzle is used or,

    b. A handheld bucket is used or,

    c. A drip irrigation system is used.

Exception: Commercial nurseries, commercial sod farmers, and similar establishments are exempt from Stage 2 irrigation restrictions, but will be requested to curtail all nonessential water use.

2. The washing of automobiles, trucks, trailers, boats, airplanes and other types of mobile equipment is permitted only between the hours of seven p.m. and ten a.m. Such washing, when allowed, shall be done with a handheld bucket, or a handheld hose equipped with a positive shutoff nozzle for quick rinses.

Exception: Washing may be done at any time on the immediate premises of a commercial carwash or commercial service station. Further, such washing may be exempted from these regulations if the health, safety and welfare of the public is contingent upon frequent vehicle cleanings, such as emergency vehicles, garbage trucks and vehicles to transport food and perishables.

3. The refilling or adding of water to swimming pools, wading pools and/or spas is permitted only between the hours of seven p.m. and ten a.m.

4. The operation of any ornamental fountain or other structure making similar use of water is prohibited unless the fountain uses a recycling system, such as an electric pump.

5. The washing of sidewalks, driveways, parking areas, courts, patios or other paved areas is absolutely prohibited.

6. All restaurants are requested to serve water to customers only when specifically requested by the customers.

C. Stage 3. Mandatory Compliance-Water Emergency. Upon implementation by the city manager and publication of notice, the following restrictions shall apply to all persons. All elements of Stage 2 shall remain in effect in Stage 3 except that:

1. All outdoor irrigation of vegetation shall be permitted only between the hours of eight p.m. and twelve midnight on designated days.

2. The washing of automobiles, trucks, trailers, boats, airplanes and other types of mobile equipment not occurring upon the immediate premises of commercial carwashes and commercial service stations and not in the immediate interest of the public health, safety and welfare shall be prohibited.

3. Use of water from fire hydrants shall be limited to firefighting and/or other activities immediately necessary to maintaining the health, safety and welfare of the citizens of Dinuba.

4. Commercial nurseries, commercial sod farmers, and similar establishments shall water only on designated days between the hours of ten a.m. and six p.m. and shall use only handheld hoses, drip irrigation systems, or handheld buckets.

5. The filling, refilling, water to swimming pools, wading pools and/or spas is prohibited.

6. The operation of any ornamental fountain or similar structure is prohibited. (Ord. 723 § 1 (part), 1989)

13.05.070 Mandatory conservation phase implementation.
The public works department along with Alta Irrigation District shall monitor the projected

supply and demand for water within the city shall recommend to the city manager the extent of the conservation required through the implementation and/or termination of particular conservation stages in order to assure the water supply of the city. Thereafter, the city manager, as directed by administrative policies, shall order that the appropriate phase of water conservation be implemented or terminated in accordance with the applicable provisions of this chapter. Said order shall be made by public announcement and shall be published a minimum of one time in a daily newspaper of general circulation and shall continue to be published on a weekly basis until such time as all restrictions are removed and shall become effective immediately upon such publication. (Ord. 723 § 1 (part), 1989)

13.05.080 Enforcement.
It is one of the objectives of the city council that the residents of Dinuba be encouraged to voluntarily comply with the provisions of this chapter, therefore, in furtherance of said objective, the enforcement of this chapter will permit the issuance of up to three warnings of violations of Sections 13.04.090 and/or 13.04.100, by way of written notices of violation to the violating water use, before the issuance of a citation for said violations.

Notwithstanding the foregoing, any person, firm or corporation violating any provisions of Sections 13.04.090 and/or 13.04.100, of this chapter, including any or all other amendments, revisions or supplements, is guilty of an infraction and, upon conviction, shall be punished accordingly, as set forth in Section 1.16.010 of this code. If any violation is continued, each day's violation is deemed a separate infraction. (Ord. 96-2 § 10, 1996: Ord. 723 § I (part), 1989)

13.05.090 Public nuisance—Definitions.
In addition to any other remedies which may otherwise be available to the city, the city council makes the following findings and declarations:

The waste of water, as that term is defined herein, on public or private property within the city, is hereby found to contribute to and compound drought conditions which may, from time to time, exist in the city, to the detriment of one of our most precious and finite resources, water. Such conditions cause injury to the health, safety and general welfare of the citizens of Dinuba. Therefore, the waste of water within the city on private or public property, except as expressly permitted in this chapter is declared to constitute a public nuisance which may be abated in an action brought on behalf of the people of the state, by the city attorney, in any court of competent jurisdiction. (Ord. 723 § I (part), 1989)

13.05.100 Enforcement officers.
All peace officers and persons authorized by law to issue citations within the city shall, in conjunction with duties imposed by the law, diligently enforce the provisions of this chapter.

Pursuant to the provisions of Section 836.5 of the Penal Code, the following officers and employees of the city are designated as enforcement officers and authorized to issue citations for enforcement of this chapter:

Director of public works Animal control officer City engineer

Building official

Public works superintendent Building inspector

Employees of the city are authorized by this chapter to issue written notices of violations of Sections 13.04.090 and 13.04.100 but are not authorized by law to issue citations for said violations. (Ord. 723 § I (part), 1989)

13.05.110 Exceptions.
Consideration of written applications for exceptions regarding regulations and restrictions on water use not otherwise set forth in previous sections of this chapter shall be as follows:

1. Written application for exception may be granted by the director of the public works department.

2. Exceptions may be granted if.

   a. Compliance with this chapter would cause an unnecessary and undue hardship to the applicant, including, but not limited to, adverse economic impacts, such as loss of production or jobs; or

   b. Compliance with this chapter would cause a condition affecting the health, sanitation, fire protection or safety of the applicant or the public. (Ord. 723 § 1 (part), 1989)

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Appendix I – Amended Groundwater Management Plan, Alta Irrigation District

AMENDED
GROUNDWATER MANAGEMENT PLAN

ADOPTED JUNE 10, 2010

ALTA IRRIGATION DISTRICT

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GROUNDWATER MANAGEMENT PLAN

I. INTRODUCTION

A. General

The Kings River ("River"), which provides the surface water supply for the Alta Irrigation District, a California Irrigation District ("District"), is one of the largest streams entering the San Joaquin Valley. The River's watershed covers 1,742 square miles, ranging in elevation from 500 to 14,000 feet above sea level. The majority of the watershed area is located in the high Sierra Mountains and receives heavy snowfall in the winter months. Usually, this snow melts slowly. Thus in average years, the River does not reach its highest stage until the middle of May or early June. The current yearly average runoff for the Kings River is 1,689,700 acre-feet. However, the average runoff does not guarantee this volume will be developed in any given year. The variation with the amount of runoff is great, not only from year to year, but also from month to month. As a result of this great variation, there were alternating periods of flood and drought in the drainage area of the River until Pine Flat Dam was completed in 1954.

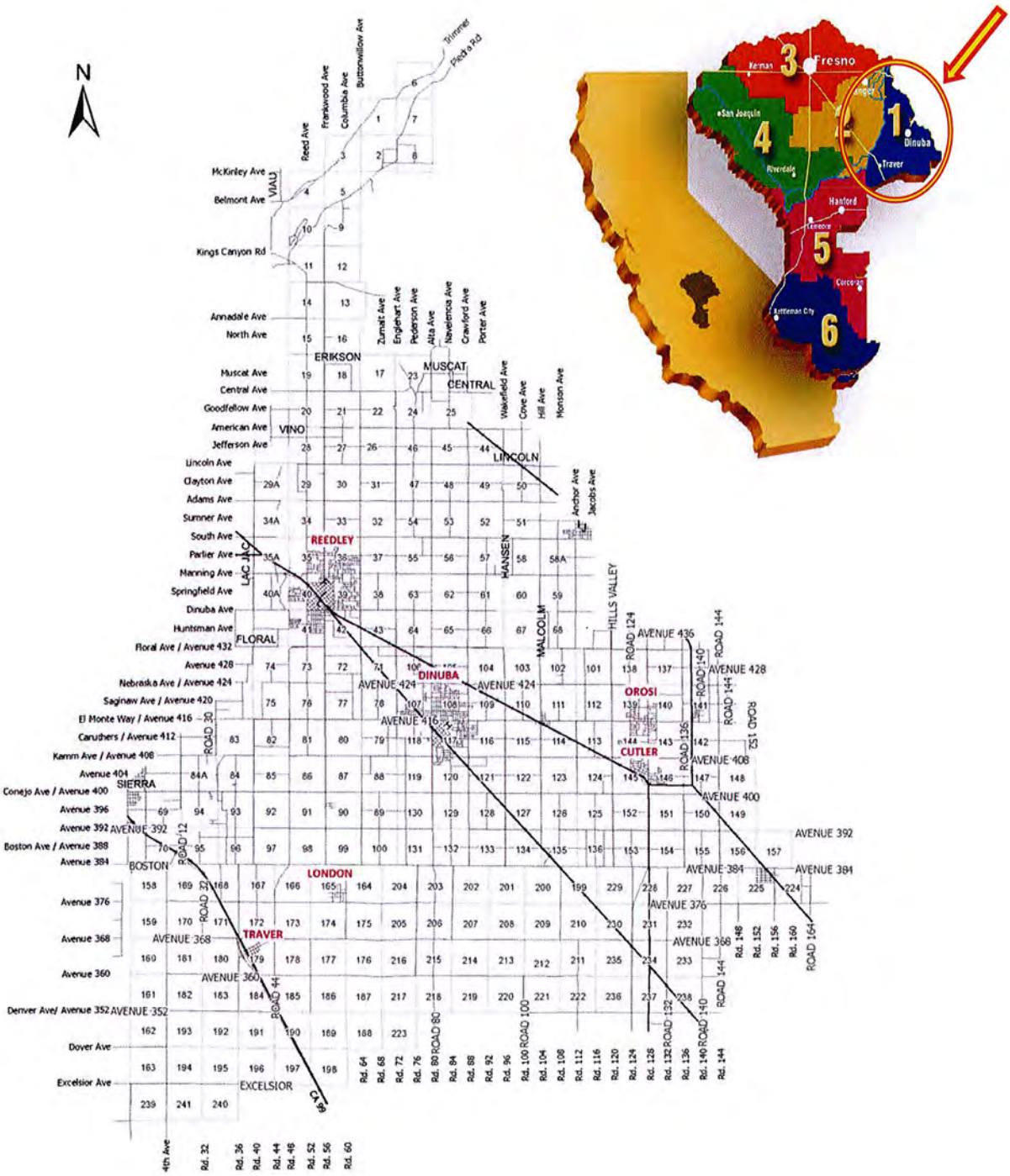
Rainfall occurs primarily in the winter months with virtually no rainfall in the summer months. The average annual rainfall within the District for the fifty-year period preceding 1956 was 11.39 inches with the annual crop use per acre ranging from 24 to 36 inches. As a result, the agricultural crops within the District cannot and do not depend upon rainfall for all their irrigation needs; instead, they depend upon surface water deliveries and deep well pumps.

Historical water deliveries to the service area of the District were initiated in 1882 by a private water company called the "76" Land and Water Company. In 1887, the California legislature passed the Wright Act, which conferred on farming communities the powers of municipalities to purchase, construct and operate irrigation works. On July 7, 1888, sixty-six landowners interested in developing a new public irrigation district filed petitions with the Tulare County Clerk. The District would now comprise 130,000 acres in Tulare, Fresno and Kings Counties and would become the Alta Irrigation District. The present communities of Dinuba, Reedley, Traver, Cutler, and Orosi lie within these boundaries.

Historically, the District enjoyed a shallow water table. In the early 1900's the distance from the ground surface to the groundwater table averaged less than ten feet. However, each successive drought period during the last fifty years has caused an increase in the agricultural groundwater pumping. Consequently the water table has

dropped significantly. As agricultural land is paved over for urbanization, the competition for control of water resources among agricultural, urban and environmental interests will significantly increase.

B. Map of District



C. Purpose and Goals

The Alta Irrigation District has long recognized the importance of groundwater to its service area. On August 14, 1994 its Board of Directors initially adopted a Groundwater Management Plan (***see APPENDIX, AB 3030 Groundwater Management Plan, Attachment A***). Later they amended that Plan in order to be in compliance with SB 1938 (***see APPENDIX, Notice of Intent, Attachment B***). The District intends to continue using the existing AB 3030 Groundwater Management Plan and to include in it the information required by SB 1938 under WC 10753.7 as allowed for in Section 10750.9(b), (hereinafter referred to as the "Plan").

The Plan being adopted under SB 1938 incorporates and advocates a regional perspective on groundwater management planning by establishing basin-wide management objectives for the Plan to achieve. In addition, the proposed Plan would require additional monitoring of groundwater levels, subsidence and water quality to evaluate and determine proposed management actions.

The principal action item in the Plan will be gathering and evaluating additional data concerning quantity and quality of groundwater so the District can develop and implement management actions and best management practices on a local and regional basis. Those actions will enhance the valuable groundwater resource by at least reducing the long-term groundwater level decline in the area and by addressing groundwater quality issues that impact potable water supplies. The District is now pursuing many of the action items already identified in the plan and will, when the Plan is adopted, begin pursuing additional actions. Other action items will require further study prior to implementation.

Water users in the District use conjunctively both surface water and groundwater so the District well understands that both surface water and groundwater are necessary to meet the water demands of the area and are critical to achieving a successful water management program. The goals developed and implemented through the Plan will be designed to achieve and maintain this primary single purpose in all groundwater and surface water management actions. Activities to accomplish this goal may range from addressing water quality issues to importing additional water supplies. Specific actions recommended for implementation are discussed in Section VI.

The proposed Plan will reduce duplication of activities by local agencies, which will utilize it in their long-term planning activities within the District. The Plan will be flexible by allowing updates to be made as needed, based on the additional information that is gathered through the monitoring programs.

The District is funding preparation of the Plan. Future activities required to fully implement the Plan may require additional funding sources. SB 1938 allows for the levying of groundwater assessments or fees under certain circumstances and according to specific procedures. Prior to instituting a fee structure, the District must hold an election on whether or not to impose these levies. A majority of the votes cast at the election will be required to implement any levy to provide additional funding.

D. Reasons for Updating Plan

Historically, the use of groundwater within the State of California has not been regulated except in basins where the groundwater extraction rights have been adjudicated by the courts or special management districts have been authorized by the state legislature. Groundwater accounts for approximately one-third of the water used within the state and will become even more important in the future with the growth of competing demands on groundwater resources. The District's primary role as a regional water resource agency is to sustain and improve its conjunctive use programs to enhance surface and groundwater supply and quality. The principal reason for updating the Plan will be to institute regionally-based management actions that will address the issues of long-term water supply and water quality using, for example, groundwater banking. This approach will require more intensive monitoring efforts along with implementation of action items as part of a regional management plan. This Plan will enable the District to make a comprehensive effort either through participating in the Upper Kings Basin Integrated Regional Water Management Plan Joint Powers Authority ("JPA") or adopting principles linking the various SB 1938 plans in the Kings Sub-basin. The JPA is more fully discussed in Section V of this Plan. The Kings Sub-basin is defined under Bulletin 118 ***(see APPENDIX, Kings Sub-basin, Bulletin 118, Attachment C)***. The JPA's primary focus will be to monitor water quality, depth to groundwater and subsidence on a regional basis. Localized trends will be addressed through the SB 1938 Plans of various agencies.

E. Advisory Committee

To initiate the groundwater management plan, the District formed a regionally diverse advisory committee comprised of representatives of the following agencies: City of Dinuba, City of Reedley, County of Tulare, Alta Irrigation District, Kings River Conservation District, Cutler Public Utility District, Orosi Public Utility District and Community Water Center. Upon adoption of the Plan by the Alta Irrigation District Board of Directors, the SB 1938 Advisory Committee will be terminated. The purpose of the SB 1938 Advisory Committee is to incorporate localized community interest and input from public agencies that overlie Alta Irrigation District's sphere of interest.

F. Public Participation

All meetings of the SB 1938 Advisory Committee would be noticed on the District's website and any member of the public can attend the meeting or email comments on the website pertinent to the Plan (***see APPENDIX, Attached Meeting Notices and Minutes, Attachment D***). In addition, all information received from the public will be noted and reviewed at those public meetings and in the minutes of such meetings.

II. EXISTING CONDITIONS

A. Groundwater Basin

The Alta Irrigation District overlies a portion of a groundwater sub-basin designated as the Kings Sub-basin. The California Department of Water Resources has designated this basin to be a critically overdrafted groundwater basin. The District has been monitoring groundwater levels for at least the last seventy-five years. The results of this monitoring effort are consistent with the findings of the Department of Water Resources. The water level measurements taken within the District show a continued downward trend in the groundwater elevations within the District's boundaries. This average overdraft is approximately 22,000 acre feet per year.

The total water supply available to the District is extremely variable and dependent on the snowpack that occurs in the Sierra Nevada Mountain Range to the east. The pumping within the groundwater basin is inversely proportional to the surface water supply made available from runoff within the Kings River Watershed.

The boundaries of the District include land within three counties, two incorporated cities and numerous unincorporated urban water districts. All of the urban communities, along with many individual residences scattered throughout the District, are dependent on the groundwater supply to meet their domestic demands. Surface water is currently not available to meet those needs. The conjunctive use of both the groundwater and surface supplies is necessary to meet the irrigation requirements within the District. This irrigation demand represents by far the largest water use within the basin.

The District recognizes that the continuation of the agricultural, municipal and industrial developments within the basin is dependent on maintaining an adequate water supply. With the conjunctive use that already occurs within the District, adequate surface water supplies are necessary to achieve a water balance. However,

additional facilities to develop new water supplies can be constructed to increase water resources within the District.

B. Geology

The District is located in the eastern portion of the San Joaquin Valley and southern half of the Great Valley geomorphic province of California. The District is part of the valley, which is a nearly flat northwest to southeast trending alluvial plain. Alluvial sediments are found within the District and are bounded on the east by granitic rocks of the Sierra Nevada. The alluvium within the District is a heterogeneous mix of clay, silt, sand and gravel (USGS, 1968). The soils within the District are complex with the unconsolidated alluvial fans being made up of varied textured material. The upper soils vary from very heavy clays near the base of the Sierra Nevada (on the east side of the District) to relatively coarse sand near the western boundary along the Kings River. Much of the area is underlain by hardpan that restricts the vertical percolation of the water. These areas are typically ripped and/or soil amendments are applied to improve the vertical percolation. Throughout the District there are isolated locations of coarse grained material with high percolation rates. These are typically found at locations where old streambeds historically meandered throughout the District.

Along the east side of the District, the basement complex is shallow and the aquifer depth is very limited. The granite bedrock slopes quickly westward within the District resulting in a deeper aquifer along the western boundary of the District. The bedrock depth is approximately 500 feet below the ground surface along the eastern perimeter of the District and increases to 5,500 feet near its southwest limits. The coarse, sandy materials that are found along the west side of the District are reflected in the higher specific yields for those soils, which are typically 50 percent to 100 percent greater than for the finer textured clay materials found on the east side of the District. This same correlation is also found in the deeper soils, which are much less permeable and have significantly lower specific yields than the upper soils. Therefore, the specific yields from wells drilled into the deeper portions of the aquifer are considerably less than the yields from shallower wells.

C. Hydrology

The hydrology of this area is principally impacted by the snowpack that occurs within the Kings River Watershed and to a limited extent by both the local runoff from the foothills lying just easterly of the District and the precipitation that occurs within the District. The water table within the District is unconfined and typically flows in a southwesterly direction. Groundwater extractions are made for agricultural,

municipal and industrial purposes. These extractions are very significant during periods when there is little surface water available to augment the water needs within the District. The groundwater levels, during those periods, experience a significant decline. Surface water made available to the irrigation canals and pipelines through diversion from the Kings River provides a stabilizing factor on the groundwater levels. This surface water supply reduces the amount of pumping, provides recharge and is the principal contributing factor that influences the groundwater conditions. This effect is evident in years of below normal runoff when a rapid decline in the groundwater level is experienced. Based on the District's fall 2009 groundwater measurements, the average depth to groundwater level was 53.16 feet.

D. Climate

The area is semi-arid with mild winters and hot, dry summers. The average rainfall, based on District records, is approximately 11 inches per year. The majority of this rainfall occurs from November through April. With the long, hot summers that normally occur in the valley, there is about 6 feet of evaporation per year with the majority of that evaporation occurring during the period May through October. The winds in the area are principally from the northwest with a southeast wind usually indicating that a rainstorm is imminent.

E. Surface Water Supplies

The District is located east of the Kings River in the Central San Joaquin Valley. To the east of the District are the Sierra Nevada Foothills. The District is composed primarily of alluvial fans sloping to the southwest with elevations ranging from about 425 feet at the northern point to 270 feet in the southwest corner. The incorporated communities within the district are Reedley (population 23,000) and Dinuba (population 21,700). There are also several unincorporated communities, housing clusters and individual rural residences.

The primary economy within the District is agriculture or businesses related to agriculture. The primary crops grown within the region are grapes, nectarines, plums, peaches and citrus. Due to the relatively high land prices and high production costs in for hand labor, spraying and fertilizer, the average parcel size is approximately 36 acres. There are approximately 4,000 agricultural parcels within the district.

Initially, agricultural production in the region was primarily dry land farming; but with the development of a dependable surface water supply and groundwater wells and a willingness of farmers to take the risk of raising high value crops, the cropping

pattern changed to perennial crops and the need for a stable water supply became paramount.

The estimated average irrigation crop demand within the District is 325,000 acre feet and the average surface water supply is 148,416 acre feet; therefore, there is a strong reliance on an alternate water supply: groundwater.

The District diverts water from the Kings River at the "Cobbles Weir" and measures water into the District at a computer-controlled headgate ("Headgate") located near the community of Piedra. Downstream of the Headgate are 78 ditch laterals serving approximately 4,000 agricultural parcels. The total length of canals and pipelines is between 350 and 400 miles. The canal widths vary from 4 to 100 feet; lengths range from 3,000 feet to nearly 18 miles ***(see APPENDIX, KRCD Surface Water Study Table 111-1, Attachment E)***.

The range of annual diversions from the Headgate during a recent twenty-year period were as follows: 248,042 acre feet in 1993 (highest annual diversion); 58,284 acre feet in 1990 (lowest annual diversion) and 150,261 acre feet was the average annual diversion. The average time period for each water run within said twenty-year period is 115 days; the shortest water run being 48 days; and the longest water run being 183 days ***(see AID Twenty-Year Diversion Table as Table 1)***. The District's diversion and storage rights are based upon riparian and appropriative claims as well as contractual agreements and licenses granted by the State Water Resources Control Board. Such agreements control the use of District's rights in conjunction with the rights of the other twenty-seven (27) entities storing and diverting water from the Kings River. All the twenty-eight (28) entities comprise the Kings River Water Association. It is typical for weather patterns and the resulting volume of water in storage to vary significantly from year to year, thus illustrating the necessity of water storage in the production of perennial crops.

Table 1: AID Twenty –Year Diversion Table

Year	HG Diversion	Days Ran
2009	150,834	107
2008	131,685	89
2007	76,225	54
2006	211,646	161
2005	212,052	165
2004	128,426	91
2003	137,603	100
2002	133,219	99
2001	124,465	92
2000	166,411	139
1999	147,120	117
1998	172,176	182
1997	214,341	156
1996	221,084	152
1995	235,729	178
1994	122,697	92
1993	248,042	183
1992	66,624	58
1991	107,017	81
1990	58,284	48
1989	89,807	69

F. Water Management Strategies

Alta Irrigation District operates an "arranged delivery system" allowing farmers to order water on or off within the system with at least 24 hour's notice. Primarily, water orders are called in between 7:00 a.m. and 3:00 p.m. each day; with a subsequent coordinating meeting each morning and afternoon to determine changes within the system. All water use is measured on a daily basis. The District uses a calibrated submerged orifice to determine the instantaneous flow rate. The District is in the process of updating its distribution system by requiring cumulative flow meters on all turnouts when open canals are replaced by pipelines.

Daily water measurements are the basis of the District's levying a volumetric surcharge, which pays for all water-run related costs (***see APPENDIX, Table 9 FUTURE DISTRICT OPERATIONAL BUDGET, Engineer's Report Proposition***

218 Procedures, December 2005, Attachment F). The conjunctive use pattern of utilizing surface water in wet years and relying more on groundwater in dry years helps to maintain sufficient water supplies to irrigate the predominantly permanent crops. The most beneficial use of surface water is to motivate farmers to avoid using their groundwater pumps, thus leaving in place and conserving the groundwater to be utilized only when needed.

In 1990, Alta Irrigation District commissioned the Kings River Conservation District to complete a "Surface Water Study" to study and review the District's surface water delivery system. A system water balance was evaluated in wet and dry years to determine seepage evaporation, evapotranspiration (ET) of bank vegetation, and operational spillage. The study showed that seepage (estimated to be approximately 23 percent of the District's total diversion) was the most significant loss in the system.

The water flow in the District's canals and pipelines is measured by means of overflow weirs, undershot gates, parshall flumes or a current meter. The District has developed rating tables that are used to set the proper flow rate in each of the canals and pipelines. However, the District may reallocate water from the different laterals if the demand warrants such reallocation.

The District has instituted a water allocation formula to equitably distribute water to farmers based on the estimated snowpack runoff. The formula is based on four days per twenty acres utilizing one cubic foot per second per entitlement percentage. Approximately eighty percent of the District's irrigable acres receive one hundred percent entitlement; the remaining acreage is entitled to receive seventy-five percent, fifty percent, twenty-five percent, or no surface water entitlement. Historically, the lower water entitlement areas either were not farmed or were being farmed to low value crops. The allocation formula is set by the Board of Directors and can be adjusted by lengthening or shortening the number of irrigation days per twenty acres. Typically, in less than average water years, water is held in storage until peak demand occurs in May, June and July.

Water regulating reservoirs used by the District have been designed to better maintain constant flows in the lower areas of the district. In 1991, the district developed the fifty-seven acre Button Ponding Basin, which is fed by five tributary canals. The flow rates of those canals have been prone to fluctuate between midweek and weekend days. All the inflow entering the regulating basin is now being stored for downstream agricultural deliveries when needed. Additional regulating reservoirs are being evaluated for future construction.

In any conjunctive use area, groundwater recharge is a critical part of the overall Plan. For many years, the District has maintained recharge basins along the southwesterly perimeter of its boundaries. They are located in areas of highly permeable soils. In addition, some effective recharge results simply from conveying water through the District's canals, even though the majority of the soil types are such that the recharge capability of the soil is very limited.

The District has been conducting extensive research to locate additional recharge sites in the eastern portion of the District, since that area is severely impacted in dry years due to the low specific yields and the limited water storage depth of the aquifers. In 1987, the District was selected for funding through the Proposition 44 program to develop a groundwater recharge basin in an area that had limited groundwater resources. The site appeared to have soil types that would be conducive to recharge efforts. An in-depth geological study was undertaken and it was determined that the site would not be effective for groundwater recharge. The District has continued its efforts to locate sites for developing percolation basins in the eastern part of the District, but it is not likely that a suitable location will be found.

To proceed with a groundwater recharge program, additional surface water supplies are necessary to fully implement the Plan. The District's average annual water supply is already committed. The surface water necessary to conduct an extensive program is available only in wet years when additional water supplies or floodwaters are available on the Kings River. The District's goal has been and will be to make beneficial use of those waters by recharging the underground. For the most part, District conveyance facilities are currently available to transport these waters to the basin locations. Unfortunately, the prospects for locating effective recharge basin sites within the areas of greatest need are not promising.

The District will also be negotiating with cities interested in jointly funding new recharge sites. If suitable sites are located within or adjacent to the boundaries of a municipal jurisdiction, the possibility of a joint use facility would be evaluated. The potential exists for water to be delivered to all or part of the site for recharge purposes during a portion of the year, with consideration given to other uses during the remainder of the year.

As a complement to the District's local recharge program, one of the action items is to evaluate "groundwater banking". This could be accomplished by assisting the recharge efforts of other districts that have access to better groundwater recharge sites. Floodwaters would be recharged (banked) in a district thereby improving groundwater levels in its service area. The amount of water banked would be quantified on an annual basis and an agreement developed so that the District would

have rights to extract or receive a stipulated portion of the water banked through the joint agreement. In both the short and long terms, this approach appears to be the most effective way for the District to benefit the Basin Plan Area. In addition, investigations will continue on potential local recharge sites.

In 2009, the District did aggressively implement groundwater management projects to address issues of localized overdraft. The District and the City of Dinuba developed a recharge project to collect storm water and other surplus water supplies in a series of basins comprising 28 acres. The project will be effective in utilizing local supplies to mitigate groundwater pumping within the City of Dinuba. The District implemented the Harder Pond Banking Project to recharge stormwater and other surplus water supplies in the westerly portion of the District. The project will enable the District to direct water supplies to designed recharge areas and by means of extraction wells, to make more efficient downstream agricultural deliveries. The District is also moving forward with the Traver Pond Banking Project, which will also allow water to be recharged and extracted for downstream agricultural deliveries. The Harder and Traver Banking Projects are designed to conserve and thus generate the two million gallons per day of potable surface water for the proposed surface water treatment plant to serve Cutler and Orosi (***see APPENDIX, Water Banking Annual Report, Attachment G***).

Water banking is an important tool available to the District enabling it to better utilize available water supplies. The water banked will always exceed the extraction amount. The water remaining in the ground will bolster the groundwater in the immediate area of the banking project. The water extracted will be utilized to supplement the surface water deliveries, thereby reducing downstream groundwater extractions.

Additional locations for future banking projects will continue to be evaluated by the District. Where suitable locations are found and it is determined additional water is available to effectively utilize the site, the District will seek additional funding. Expansion of the Harder and Traver Pond sites will also be considered.

III. WATER QUALITY

A. Surface Water Quality

The surface water supply for the District consists principally of diversions from the Kings River. The snowpack and rainfall within the Kings River watershed produce extremely high quality water with very low amounts of dissolved salts. This has allowed consistently high agricultural yields to occur on the heavier soils, which

are not freely drained, without causing a serious drainage problem. The surface water also provides an excellent source of water for recharging the District's groundwater supply. It is important that the District maintain the high quality of this water. To this end, the District has been active in identifying any surface water discharges within the Basin that may negatively impact water quality. These will be continually monitored and may require a discharger to obtain a permit through the NPDES process. Anyone causing overland surface flows that are found to be detrimental to the District's water supply, groundwater or surface water, will be put on notice that they must either eliminate the discharge or clean those flows to avoid compromising the quality of the District's water supply.

The District regulates municipal storm water discharges into District facilities by enforcing the terms of permits granted by the District to those dischargers. The permits specify the exact area being drained and/or flow allowed to be discharged. Permit conditions require that the quality of this discharged water meet the existing and future standards set by the Regional Water Quality Control Board. The right to discharge can be terminated at any time the conditions of the permit are not met by the discharger.

B. Groundwater Quality/Source Water Quality Protection

Except for dibromochloropropane (DBCP) and nitrates, the quality of groundwater in the District is high because its source is excellent Kings River surface water flowing from the western slope of the Sierras. This results in having excellent quality water for recharge within the Kings River Watershed. When the groundwater is used for domestic purposes, construction of ground level treatment facilities to remove specific contaminants or the drilling of deeper uncontaminated wells have been required. The nitrate contamination is usually the result of agricultural fertilizer, domestic sewage, livestock wastes, or from natural sources. In some isolated locations, nitrate levels in groundwater have also caused problems for the agricultural pumpers. Since DBCP is no longer used for nematode control, concentration levels are expected to drop over time. In addition, some wells require chlorination because of bacteriological concerns. The groundwater management plan will include locally cost effective recommended procedures to maintain the existing excellent water quality (***see Best Management Practices, Section VI.B.15, page 23***). In the Kings Sub-basin, typical contaminates of concern in the water used for domestic purposes are DBCP and nitrates.

Groundwater wells are prevalent throughout the District. The wells are used by cities, agricultural producers, industrial developments and individual homeowners. With the many water production wells, there is a risk that cross-aquifer contamination

can occur. The greatest potential for groundwater contamination within the basin is cross-aquifer flow through improperly abandoned wells and the improper sealing of new wells. Therefore, it is necessary that proper sealing of new wells and abandonment of old wells always be accomplished. At a minimum, the water well standards of Tulare, Kings & Fresno Counties along with Bulletin 74 requirements must be met. In addition, it may be advantageous to require construction standards that exceed those presently mandated by either the county or state. With the continual raising of standards for drinking water, maintaining the quality of the groundwater becomes ever more important.

Water quality is an important aspect of groundwater management. Contamination of the groundwater, resulting in a limitation on its use, is equivalent to a reduction in total water supply with a negative impact on the water balance for the Kings Sub-basin. This loss of supply will require obtaining additional supplies or incurring additional costs for treatment of the contamination.

C. Well Abandonment

An objective of the Plan is to maintain superior water quality within the District. This is of extreme importance because the municipal, industrial and agricultural users need a dependable high quality water supply. A reduction in the quality of the groundwater is tantamount to a loss of water supply, since the quality problem will require additional funding for the construction of treatment facilities. This cleanup will be necessary to allow the water to be integrated into the system.

One of the action items listed in the Plan recommends increased monitoring of groundwater quality in selected areas. This monitoring information will be collected and utilized to evaluate the best management practices available to reduce and/or eliminate the contamination. In addition, the action items recommend working with the Department of Water Resources and the counties of jurisdiction in upgrading water well standards. Since the natural minerals occur in low concentrations, the major thrust of the water quality monitoring and recommended practices will be to prevent chemical contamination.

The quality of both surface and groundwater within the District must be maintained. The Plan provides a mechanism that will help achieve those long-term goals. The initial action of increasing the amount of monitoring will provide the additional data needed to proceed with future programs to maintain water quality.

D. Water Quality Monitoring and Protocols

The District performed general groundwater quality testing for nitrates and DBCP for a three-year period: 1997, 1998 and 1999. The reason for performing the general water quality sampling was to determine and prioritize areas of interest. In the future, the District will need to study how and why nitrate and DBCP levels are exceeding relevant water quality standards (***see Section VI. PLANNED ACTIONS AND REPORTS, B. Management Actions, 14. Regional Monitoring***).

E. Goals, Objectives and Strategies

There is little potential for increasing the water supply through wastewater reclamation in this basin. The majority of the wastewater is currently being utilized for the irrigation of agricultural crops or groundwater recharge with only a minor portion being consumed through evaporation basins. The District will continue to work with the wastewater treatment agencies, where practical, to reduce the amount of effluent disposed of through evaporation. In addition, the District will continue to promote the past practices of reusing all wastewater effluent within the local basin, in order to maintain the total water balance within the area. In a water deficient region such as the District, the reuse of the wastewater effluent is a key element of establishing and maintaining a water balance.

IV. WATER MAPPING

A. Depth to Groundwater / Water Quality Mapping

The District has been monitoring groundwater levels for the last seventy-five (75) years. This is accomplished through water level measurements taken in the late fall and early spring. A map of the District showing the well locations has been attached (***see APPENDIX, Map of Well Locations, Attachment H***). As wells are lost, new wells are substituted to maintain the continuity of the grid pattern. From these readings, groundwater contour maps have been made depicting both the water elevation and changes in groundwater levels. Groundwater level readings are obtained utilizing an electric well sounder.

Based on the water level readings, the overall trend has shown a declining groundwater level within the District. This decline has been periodically interrupted by a short-term groundwater recovery during wet years when surface water supplies are abundant and groundwater pumping is reduced. Based on this long-term data, it has been determined that it would take approximately 22,000 acre-feet per year of additional surface water to correct the overdraft situation that presently exists. Based

on average porosity and specific yield considerations, this amount of overdraft results in a decline in the groundwater storage of one foot for every 7,000 acre-feet of overdraft. This storage can be regained if sufficient surface water supplies are made available to reduce the amount of groundwater pumping that is necessary to meet the water demands. In addition, the overdraft results in additional pumping costs to overcome the increased lift. As the water table continues to drop, the pumping occurs from lower portions of the aquifer, which have lower porosity and specific yield factors than those found in the upper portions of the unconfined aquifer. The long-term impact is a greater incremental reduction in the available groundwater storage capacity per acre-foot of overdraft. Using the historical data collected and the transmissivity of the aquifer, a determination can be made of the estimated quantity of inflow and/or outflow of groundwater within the limits of the District. This data also will allow the District to evaluate areas that are more severely impacted during periods of sustained drought due to the low yield of the wells and the limited depth of the aquifer. This is an important water management tool that is useful to the District in developing long-term planning decisions.

The collection of this data will be continued with the Plan. The information that has been prepared from this data in the past includes the following:

1. Maps of spring and fall water elevations.
2. Maps of spring and fall depth to groundwater.
3. Maps showing the changes in groundwater levels over time.

In addition, the groundwater reports can include estimates of changes in groundwater storage, water delivered, water use, and overdraft. This information will allow the District to better evaluate the effectiveness of various management actions as stated in Section VI.

The District will use the results of water quality monitoring that is being proposed as one of the action items to augment the information obtained through the historical water level readings. The District will take water quality samples in critical areas adjacent to urban centers and known locations of contamination. By correlating the water quality tests and the groundwater level measurements, the District will improve its ability to effectively manage the groundwater by utilizing monitoring data and applying it to a management action. For example, this information can provide the additional data needed to establish programs to reduce the movement of any contaminants. Typically, the urban centers have a higher concentration of wells resulting in a cone of depression within and surrounding the community. This can accelerate the movement of contaminants towards the urban well fields. Using the information gathered through the Plan, the District could pursue an additional future

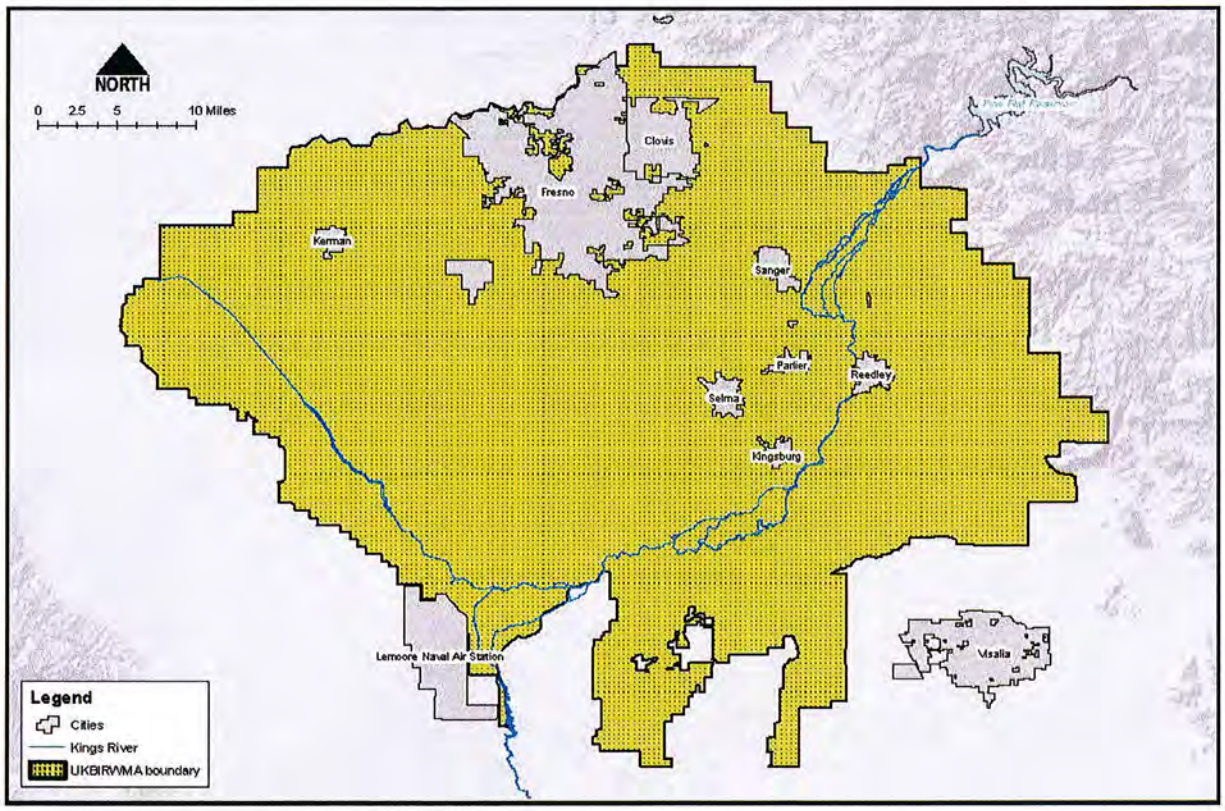
action item; namely, the analysis of the potential benefits of creating a hydraulic barrier or modification of the local pumping regime to reduce or impede the migration of any contamination.

V. BASIN MANAGEMENT OBJECTIVES

A. Upper Kings IRWMP

The Upper Kings Water Forum in 2003 and 2004 reviewed criteria to determine and identify concerns, issues and purposes for an integrated planning process to be undertaken by the Upper Kings Integrated Regional Water Management Plan ("IRWMP"). The intent was to develop a framework enabling urban, agricultural and environmental interests to formulate a consensus on regional problems, issues and conflicts. The IRWMP was established on July 27, 2007.

B. Map of JPA Service Area



C. Goals and Management Objectives

As identified in the IRWMP, the constituents established goals to address the primary problems and issues in the region, which are:

1. Halt, and ultimately reverse, the current overdraft and provide for sustainable management of surface and groundwater;
2. Increase the water supply reliability , enhance operational flexibility, and reduce system constraints;
3. Improve and protect water quality;
4. Provide additional flood protection; and
5. Protect and enhance aquatic ecosystems and wildlife habitat.

Additionally, the Upper Kings Basin IRWMP established water management objectives, which are to:

1. Define local and regional opportunities for groundwater recharge, water reuse/reclamation, and drinking water treatment;
2. Develop large scale regional conjunctive use projects and artificial recharge facilities to:
    a. Enhance operational flexibility of existing water facilities, consistent with existing agreements, entitlements, and water rights;
    b. Improve the ability to store available sources of surface water in the groundwater basin;
    c. Capture storm water and flood water currently lost in the region;
    d. Provide multipurpose groundwater recharge facilities that provide flood control, recreation and ecosystem benefits; and
    e. Integrate the fishery management plan;
3. Promote 'in-lieu' groundwater recharge to reduce reliance on groundwater through reclamation and reuse of treated wastewater, surface water treatment and delivery for municipal drinking water, and delivery of untreated water for agricultural use;
4. Negotiate and develop institutional arrangements and cost sharing for water banking, water exchange, water reclamation, and water treatment;
5. Design programs to improve water conservation and water use efficiency by all water users;
6. Identify interconnections or improvement of conveyance systems to provide multiple benefits; and
7. Enhance wildlife habitat through surface water reclamation, recharge, and treatment facilities.

D. Local Agency Coordination

To plan and implement regional goals and management objectives, the IRWMP has adopted regional planning objectives (***see APPENDIX, IRWMP Chapter 5 Goals and Objectives, Attachment I***) and has provided a framework and forum to mediate conflicts among urban, agricultural and environmental interests in the region.

Currently, the Upper Kings Basin Water Forum has established an Upper Kings Basin Water Forum Joint Powers Authority ("JPA") to provide for more structure and governance in the administration and implementation of the IRWMP on September 10, 2009. The current JPA member agencies are attached (***see APPENDIX, JPA Member Agencies, Attachment J***).

VI. PLANNED ACTIONS & REPORTS

A. Historical Trends

District will prepare bi-annual reports compiling, recording and reviewing:

1. Annual monitoring data, which will include as a minimum, water quality, depth to groundwater, trends, findings and changes
2. Attainment/nonattainment of goals
3. Actions, coordination, activities and disputes with other agencies
4. Recommendations

B. Management Actions

The District will continue to pursue the thirteen (13) action items identified in the AB 3030 Plan, which will be implemented according to the Rules and Regulations (***see APPENDIX, AB 3030 Groundwater Management Plan, Attachment A***), as amended from time to time. However, this Plan will provide the additional elements required to satisfy the requirements of an SB 1938 Plan. To have a successful Plan, it is not necessary to implement all of the action items identified. The last three items would be implemented only as a last resort due to the occurrence of emergency conditions within the Basin Plan Area. It is important that all the potential action items be identified and contingency plans developed in case any one of them becomes necessary. It is recommended that the District implement items one (1) through six (6) immediately and/or as it is now continuing to pursue them. Upon approval of the Plan, the District should begin investigations into items seven (7), eight (8) and fifteen (15), and submit a staff report regarding their status within one year. Action items nine (9) thru fourteen (14) will require additional staff study, board approval, public hearing and a possibly, a funding source. If funding is necessary to implement a portion of the Plan, then an election will be required prior to instituting an assessment or other levy. The District believes that through the management activities listed in the Plan, the District can preserve the groundwater resource and avoid the drastic steps identified in the last three action items.

1. Water Monitoring: The District shall continue to monitor water levels every six months. In addition, it will also assist in water quality sampling. Further, the District will prepare maps depicting the information gathered during the monitoring phase, as well as reports quantifying the water demands, surface water and groundwater supplies. This monitoring and reporting will assist the District in evaluating the effectiveness of the various elements of the program. The monitoring process will soon detect any migration of contaminated plumes thereby allowing ample additional time for plans to be developed and implemented before presently unaffected portions of the basin are impacted. The District will coordinate and assist in implementing a management program to address groundwater quality issues, especially in the east side of the District.

2. Direct Recharge: The District will continue to use surface waters when available to recharge the underground by sinking those waters in its basins. Basin sites will be located in the areas of greatest need. The District will actively seek the cooperation of other government entities in construction of such sites.

3. Indirect/In-lieu Recharge: The District has approximately 250 miles of unlined canals. The indirect recharge is accomplished through the seepage that occurs in some reaches of the canals. In addition, during winter months many of the natural channels carry surface runoff that recharges the groundwater. These old channels are typically located in the more permeable soils. The effective amount of this recharge varies from year to year and is dependent upon the amount of runoff that occurs. Additional water supplies will be pursued for groundwater recharge in natural channels and during non-irrigation seasons in the District's canals. By providing surface water to the area, the District has reduced the amount of groundwater pumping that would have otherwise occurred, resulting in an effective in-lieu recharge program. The District will continue efforts to maximize the amount of surface water available to users within its boundaries.

4. Water Conservation - Water Regulation: The District has a long-standing practice of conjunctive water use. Conjunctive use is the integration of surface and groundwater supplies to meet the total water demand. In the past, a cooperative program termed the "mobile lab" has been operated by the Kings River Conservation District in cooperation with local irrigation districts to measure applied water efficiencies. The purpose of this program has been to promote on-farm water conservation. The District has strongly supported programs that conserve water along with enhancing crop production.

Through the construction of water regulating basins, the District has been able to conserve and more efficiently utilize water within its system. The most recent

regulating basin was constructed on a 50-acre site in the southeast portion of the District.

The Alta Irrigation District, the cities and the unincorporated water purveyors, all have water conservation plans. The Plan will encourage agricultural, industrial and residential users to implement water conservation measures throughout the basin. Existing and new irrigation methods, reuse of industrial water and domestic water saving devices will all be encouraged. The water use requirements of new developments will also be evaluated to insure compatibility with this water deficient basin.

5. No Net Exportation of Groundwater: Since the District is located within an over-drafted basin, it is prudent to utilize groundwater resources within the District's boundaries. Effluent discharged by the City of Reedley ("Agency") from its sewer treatment plant into the Kings River should not be considered to be prohibited exportation of groundwater if such effluent recharges or benefits underground supplies available to landowners in the District.

6. Intra-district Water Transfer: Water transfers within the District have taken place on a routine basis. Each year the District evaluates the water transfer policy and specifies the circumstances warranting internal water transfers. Approximately 60 transfers are approved each year within the District.

7. Well Drilling and Abandonment: Portions of the groundwater have been contaminated, principally by volatile organic chemicals or nitrates. This contamination is most prevalent in the upper aquifers. Interaquifer mixing can occur through inadequate seals or improperly abandoned wells. Working through the Department of Water Resources and the county of jurisdiction, the District will seek to upgrade standards for construction and abandonment of water wells to reduce the potential for aquifer contamination.

8. Groundwater Banking: Given the scarcity of suitable recharge sites within the District, the District will cooperate with other agencies that have soil types more suitable for recharge basins. The District could then recharge (bank) surface water within their boundaries for withdrawal at a later time. This arrangement can provide benefit to the groundwater basins for both the District and the cooperating agency. The District benefits because it has few areas suitable for recharge. The participating agency receives the benefit of reduced pumping lifts during the time the water is banked and retains a percentage of the banked water that is not extracted by the District. In spite of having only limited recharge areas, the District does have two banking projects within its own boundaries and under its own management: the

Harder Pond and Traver Pond projects. In the future, the District will continue to expand its own water banking potential to address water resource issues. The intent of both banking projects is to address groundwater quality issues in the easterly areas of the District by using surface water to mitigate groundwater pumping for drinking water purposes.

9. Inter-district Water Transfer: Water transfers between different water districts are currently taking place. In the past, the District has completed such transfers on a limited basis. This mechanism would be used to increase the total water supply within the District or to augment the water supply in specific areas of the basin during critically dry years.

10. Reduction in Groundwater outflow: The direction and quantity of groundwater flow is susceptible to changes that occur to the hydraulic gradient. The groundwater level measurements taken twice a year within the District will identify the direction of groundwater flow. Typically, this outflow has been to the west and southwest creating hydraulic barriers by mounding of the groundwater can lead to a reduction in the amount of water that leaves the District. This can be an especially effective procedure along the perimeter of the District. Likewise, increased pumping by landowners along the perimeter of the basin can increase the groundwater outflow. The District will continue its efforts to assure that all necessary steps are taken to reduce the amount of such groundwater outflow.

11. Pumping Restrictions: Pumping restrictions would definitely reduce the amount of groundwater use. This is a controversial item so pumping restrictions would be the last item the District would consider. This step could have severe economic implications since the local economy that has been developed with a reliance on groundwater would be detrimentally impacted. Initially, any program requiring pumping restrictions would be voluntary rather than mandatory. From a practical standpoint, only if the urban water supplies are being severely restricted, will mandatory agricultural pumping restrictions be implemented.

12. Additional Water Supply and Storage: The generation of additional water supplies would enhance the local groundwater levels. Present political realities prevent developing additional water by building dams and surface water storage projects. As a result, additional water supplies will most likely come through water conservation efforts, recycling and storm water supplies. The limiting factor to securing additional water supplies is addressing actual or perceived environmental considerations.

13. Redistribution of Surface Water: There is a tremendous difference in the aquifer characteristics within the District. These affect both storage capability and yield. The impacts of recent droughts are evidenced by the continued lowering in groundwater levels for those areas with limited aquifer depth versus portions of the basin that are located over a deeper and higher yielding aquifer. During critically dry years, all or a disproportionately high percentage of the available surface water may need to be directed to the severely impacted areas. Increased pumping could then occur in those areas having better groundwater conditions to offset the redistribution of the available surface water supply.

14. Regional Monitoring: The District will help urban, agricultural and environmental interests to better monitor and implement management strategies affecting the region and basin. Currently, Alta Irrigation District is a founding member of the Upper Kings Basin Integrated Regional Water Management Authority ("JPA") representing portions of Fresno, Kings and Tulare Counties. The JPA would be the means to address the monitoring of groundwater levels, water quality, subsidence, impacts of changes in surface water quality or groundwater pumping that may impact groundwater quality and address regional trends on a basin or sub-basin basis.

15. Implement Locally Cost Effective Best Management Practices:

District will:

A. Lead a coordinated effort to increase groundwater pumping for irrigation purposes in the impacted area. This could result in a reduction in surface water deliveries to lands lying easterly of the communities. Increased pumping would extract the contaminated water for surface irrigation of crops and create a cone of depression to pull any contaminants away from domestic wells;
B. Hold workshops with the farm advisor to encourage more effective utilization of fertilizers;
C. Actively encourage implementation of Fresno and Tulare County's program for locating and properly abandoning of groundwater wells;
D. Work and coordinate efforts with interested parties, i.e., extension service, academic experts, etc., to identify potential sources of contamination;
E. Develop a program with the farm operators and testing laboratories to evaluate nitrate applications on individual parcels;

F. Use various media sources to disseminate information on fertilizer application, problems and availability of programs to assist farm operators;
G. Search out funding sources to help develop programs for farm operators; and
H. Lead a coordinated effort to alter surface water supplies/groundwater pumping available to the lands near those communities to more effectively manage groundwater movement to minimize the degradation of water quality.

C. Current and Future Monitoring Results

The District intends to compile, review and analyze monitoring data on an annual basis and to develop a bi-annual report to synthesize the data and trends. Incidental information that may be of landowner interest will be posted on the District's website.

D. Summary of Coordinated Actions with Water Management & Land Use Agencies

District shall endeavor to enter into a Memorandum of Understanding with Water Management and Land Use Agencies within the District (***see APPENDIX, MOU, Attachment K***).

E. Implementation Schedule

1. Management Action Item Number 1, (Monitoring Groundwater Levels) will continue. The District will actively pursue the implementation of programs to address groundwater quality issues.

2. Management Action Item Number 2, (Direct Recharge) will continue to be implemented.

3. Management Action Item Number 3, (Indirect/In Lieu Recharge) will continue as a basic District operation.

4. Management Action Item Number 4, (Water Conservation – Water Regulation) District will continue to promote water conservation activities and water ruse programs.

5. Management Action Item Number 5, (No Net Exportation of Groundwater) is a basic philosophy of the District that will continue.

6. Management Action Item Number 6, (Intra-District Water Transfer) is a basic philosophy of the District that will continue.

7. Management Action Item Number 7, (Well Drilling and Abandonment) is critical to maintaining groundwater quality. The District will work with agencies of jurisdiction to upgrade the standard.

8. Management Action Item Number 8, (Groundwater Banking) is a basic philosophy of the District that will continue. Currently the District is working on the Traver Pond Banking Project which is to be completed and operational on or before December 31, 2011. Currently the land has been purchased and the environmental documents are being prepared for review and comment. The District will be actively pursuing additional areas for groundwater banking in cooperation with other entities.

   Management Action Item Number 8 (Groundwater Banking) and the groundwater quality issues identified in Management Action Item Number 1 (Water Monitoring), will be addressed in a planning grant for the Orosi Water Supply Study. That grant is expected to be authorized by December 31, 2010. The estimated time to complete the planning grant is eighteen months. Listed below are the identified items to be addressed in the planning grant:

   a. Identify location for surface water treatment plant
   b. Identify Pipeline alignments and right-of-way requirements
   c. Environmental documentation
   d. 30% design level plans for project
   e. Develop organizational structure and service area
   f. Finalize Orosi and Cutler treatment plant capacity requirements
   g. Meet with adjacent communities regarding potential water needs and treatment plant capacity
   h. Identify water supply, transfer requirements and conveyance facility agreements
   i. File application for regional water supply permit
   j. Adoption of funding

Within the next five years, the Plan proposes to commence construction of a regional surface water treatment plant to serve the northeast portion of the District.

9. Management Action Item Number 9, (Inter-District Water Transfer) the District will pursue these opportunities as they develop and are beneficial to the Districts water management plan.

10. Management Action Item Number 10, (Reduction in Groundwater Outflow) this activity will continue to be studied and evaluated by the District for possible future implementation.

11. Management Action Item Number 11, (Pumping Restrictions) this activity will continue to be studied and evaluated by the District for possible future implementation.

12. Management Action Item Number 12, (Additional Water Supply and Storage) this activity will continue to be studied and evaluated by the District for possible future implementation.

13. Management Action Item Number 13, (Redistribution of Surface Water) this activity will continue to be studied and evaluated by the District for possible future implementation.

14. Management Action Item Number 14, (Regional Monitoring) is a basic philosophy of the District that will continue. Additionally the District will be implementing a subsidence network along with monitoring of groundwater and groundwater depths through the JPA on or before December 31, 2010.

15. Management Action Item Number 15, (Implement Locally Cost Effective Best Management Practices) is a basic philosophy of the District that will continue. Ongoing efforts in this regard will continue. Additional Best Management Practices will be implemented as they are deemed prudent and economically feasible.

F. Dispute Resolution

Under current law, a district with an adopted groundwater management plan, i.e., AB 3030, SB 1938, or an amended AB 3030 plan, is the groundwater authority for the lands within such defined boundaries. Alta Irrigation District has an existing

obligation to manage groundwater, as defined under AB 3030, which under this Plan would also comply with the provisions of SB 1938 and the resulting obligations for implementation thereof. The Plan provides that disputes would be addressed by the Board of Directors of Alta Irrigation District.

VII. RE-EVALUATION OF PLAN

A. Amendment of Plan

Prior to amending the Plan, the District shall hold a hearing, after publication of notice pursuant to Section 6066 of the Government Code, on whether or not to adopt a resolution of intention to draft an amendment to the Plan. After the conclusion of the hearing, and if the District adopts a resolution of intention to amend the Plan, the District shall publish the resolution of intention in the same manner that notice for the hearing was published.

B. Schedule to Update the Plan

The District will review, and if necessary, update the Plan every five years on years ending in zero and five. Prior to adopting a resolution of intention to update the Plan, the District administering the Plan shall hold a hearing, after publication of notice pursuant to Section 6066 of the Government Code, on whether or not to adopt a resolution of intention to draft a resolution of intention to adopt an update to the Plan. After the conclusion of the hearing, and if the District adopts a resolution of intention to update the Plan, the District shall publish the resolution of intention in the same manner that notice for the hearing was published.

APPENDIX
SCHEDULE OF ATTACHMENTS

Attachment A	**AB 3030 Groundwater Management Plan (1994)**
Attachment B	**Notice of Intent to Adopt a SB 1938 Groundwater Management Plan (July 10, 2008)**
Attachment C	**Bulletin 118, Department of Water Resources**
Attachment D	**SB 1938 Advisory Meeting Notice and Minutes**
Attachment E	**Table 111-1, KRCD Surface Water Study (1991)**
Attachment F	**Table 9, Future District Operating Budget - Engineer's Report Proposition 218 Procedures (2005)**
Attachment G	**Water Banking Annual Report (2009)**
Attachment H	**Map of Monitoring Well Locations**
Attachment I	**Section 5 Goals and Objectives, Upper Kings Basin IRWMP**
Attachment J	**Member Agencies Upper Kings Basin IRWMP Authority**
Attachment K	**Memorandum of Understanding with Overlapping Local Agencies**

ATTACHMENT A

AB 3030 Groundwater Management Plan (1994)

Groundwater Management Plan

Adopted August 14, 1994

By

ALTA IRRIGATION DISTRICT

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GROUNDWATER MANAGEMENT PLAN

I. INTRODUCTION

A. General

The Kings River ("River"), which provides the surface water for the Alta Irrigation District, a California Irrigation District ("District"), is one of the largest streams entering the San Joaquin Valley. The River's watershed covers 1,742 square miles, ranging in elevation from 500 to 14,000 feet above sea level. The majority of the watershed area is in the high Sierra Mountains and receives heavy snowfall in the winter months. This snow melts slowly. Thus in average years, the River does not reach its highest stage until the middle of May or early June. The current yearly average runoff for the Kings River is 1,689,700 acre feet. However, the average runoff does not guarantee this quantity in any given year. Variation is great, not only from year to year, but also from month to month. As a result of this great variation, there were alternating periods of flood and drought in the drainage area of the River until Pine Flat Dam was completed in 1954.

Rainfall occurs primarily in the winter months with virtually no rainfall in the summer months. The average annual rainfall for the fifty-year period preceding 1956 was 11.39 inches with the annual crop use per acre ranging from 24 to 36 inches. As a result, the agricultural crops within the District do not depend upon rainfall for their irrigation needs; but instead depend upon surface water deliveries and deep well pumps.

Historical water deliveries were initiated in 1882 by a private water company called the "76" Land and Water Company. In 1887, the California legislature passed the Wright Act, which conferred on farming communities the powers of municipalities to purchase, construct and operate irrigation works. On July 7, 1888, sixty-six landowners interested in developing a new public irrigation district filed petitions with the Tulare County Clerk. The District would now comprise 130,000 acres in Tulare, Fresno and Kings Counties and would become the Alta Irrigation District. The present communities of Dinuba, Reedley, Traver, Cutler, and Orosi lie within these boundaries.

Historically, the district had a shallow water table; in the early 1900's the distance from the ground surface to the groundwater table averaged less than ten feet with each successive drought period resulting in an increase in the agricultural groundwater pumping, the water table has dropped significantly over the last fifty years. As agricultural land is paved over for urbanization, the competition for control

of water resources among agricultural, urban and environmental interests will be significantly increased.

B. Purpose and Goals

The Alta Irrigation District has long recognized the importance of groundwater to the area. With the new state Legislation, AB 3030 (Section 10750, et. seq. California Water Code), an opportunity is available to the District to prepare and implement a Groundwater Management Plan ("Plan") on a local basis in-lieu of a mandated plan administered by the State of California Department of Water Resources. While this legislation allows for separate plans to be developed by each water purveyor, such as cities and special districts, within the irrigation district, a well conceived Plan covering the entire District will be more manageable and will have the potential to provide greater benefit. Separate plans prepared by the individual communities will not be effective, since groundwater does not recognize political boundaries. In addition, the availability of groundwater pumped to serve a community can be impacted by activities that take place a considerable distance beyond local boundaries. There is common use of the groundwater resource and it is hoped that this coordinated Plan will be of benefit to competing interests using the groundwater resource. The coordination will be accomplished through the establishment of Memorandums of Understanding between the District and the local agencies.

The proposed Plan recognizes that the conjunctive use of the water supplies within the District must be continued. To achieve this delicate hydrologic equilibrium requires the management of both surface and groundwater supplies. The long-term continuation of this balance will be the principal benefit to be derived from the Plan. Retaining all existing surface and groundwater supplies within the District is critical to maintaining this delicate balance.

The principal action item in the Plan will be gathering and evaluating additional data concerning the quantity and quality of groundwater. Action items will be developed to enhance the valuable groundwater resource by promoting those actions necessary to reduce the long-term groundwater level decline in the area. Many of the action items identified are currently being conducted or will begin with adoption of the Plan. Other action items will require further study prior to implementation.

Through the proposed Plan, duplication of activities by local jurisdictions will be reduced and the adopted Plan can be utilized in the long-term planning activities of all the agencies within the District. The Plan will be flexible allowing updates to be

made as needed, based on the additional information that is gathered through the monitoring programs.

The Plan preparation is being funded by the Alta Irrigation District. The water quality sampling and testing costs will be shared among the City of Reedley, City of Dinuba, Alta Irrigation District and other local agencies. Future activities required to fully implement the Plan may require funding sources in addition to those outlined. AB 3030 allows for the levying of groundwater assessments or fees under certain circumstances and according to specific procedures. Prior to instituting a fee structure, the District must hold an election on whether or not to proceed with the enactment of the assessments. A majority of the votes cast at the election will be required to implement an additional funding assessment.

C. Institutional Requirements

Historically, the use of groundwater within the state of California has not been regulated except in a few basins where the rights have been adjudicated by the courts or special management districts have been authorized by the state legislature. Groundwater accounts for approximately one-third of the water used within the state. With the continued increasing demand being placed on the limited water supplies of the state, groundwater usage is being scrutinized to a much greater extent.

II. EXISTING CONDITIONS

A. Groundwater Basin

The Alta Irrigation District overlies a portion of a larger groundwater basin designated as the Kings River Basin. The California Department of Water Resources has designated this basin to be a critically over drafted groundwater basin. The District has been monitoring groundwater levels for at least the last seventy-five years. The results of this monitoring effort are consistent with the findings of the Department of Water Resources. The water level measurements taken within the District show a continued downward trend in the groundwater elevations within the District's boundaries. This average overdraft is approximately 22,000 acre feet per year.

The total water supply available to the District is extremely variable and dependent on the snowpack that occurs in the Sierra Nevada mountain range to the east. The pumping within the groundwater basin is inversely proportional to the surface water supply made available by runoff within the Kings River watershed.

The boundaries of the District include land within three counties, two incorporated cities and numerous unincorporated urban water districts. All of the urban communities, along with many individual residences scattered throughout the District, are dependent on the groundwater supply to meet their domestic demands. Surface water is currently not available to meet those needs. The conjunctive use of both the groundwater and surface supplies is necessary to meet the irrigation requirements within the District. This irrigation demand represents by far the largest water use within the basin.

The District recognizes that the continuation of the agricultural, municipal and industrial developments within the basin is dependent on maintaining an adequate water supply. With the conjunctive use that already occurs within the District, adequate surface water supplies are necessary to achieve a water balance. Both the groundwater and surface supplies are already fully developed and cannot be augmented by increased groundwater production.

B. Geology

The District is located in the eastern portion of the San Joaquin Valley and southern half of the Great Valley geomorphic province of California. The District is part of the valley which is a nearly flat northwest to southeast trending alluvial plain. Alluvial sediments are found within the District and are bounded on the east by granitic rocks of the Sierra Nevada. The alluvium within the District is a heterogeneous mix of clay, silt, sand and gravel (USGS, 1968). The soils within the District are complex with the unconsolidated alluvial fans being made up of varied textured material. The upper soils vary from very heavy clays near the base of the Sierra Nevada (on the east side of the District) to relatively coarse sand near the western boundary along the Kings River. Much of the area is underlain by hardpan that restricts the vertical percolation of the water. These areas are typically ripped and/or soil amendments are applied to improve the vertical percolation. Throughout the District there are isolated locations of coarse grained material with high percolation rates. These are typically found at locations where old stream beds historically meandered throughout the District.

Along the east side of the District, the basement complex is shallow and the aquifer depth is very limited. The granite bedrock slopes quickly westward within the District resulting in a deeper aquifer along the western boundary of the District. The bedrock depth is approximately 500 feet below the ground surface along the eastern perimeter of the District and increases to 5,500 feet near its southwest limits. The coarse, sandy materials that are found along the west side of the District are reflected in the higher specific yields for those soils which are typically 50 percent to100

percent greater than for the finer textured clay materials found on the east side of the District. This same correlation is also found in the deeper soils which are much less permeable and have significantly lower specific yields than the upper soils. Therefore, the specific yields from wells drilled into the deeper portions of the aquifer are considerably less than the yields from shallower wells.

C. Hydrology

The hydrology of this area is principally impacted by the snowpack that occurs within the Kings River watershed and to a limited extent by both the local runoff from the foothills lying just easterly of the District and the precipitation that occurs within the District. The water table within the District is unconfined and typically flows in a southwesterly direction. Groundwater extractions are made for agricultural, municipal and industrial purposes. These extractions are very significant during periods when there is little surface water available to augment the water needs within the District. The groundwater levels, during those periods, experience a significant decline. Surface water made available to the irrigation canals and pipelines through diversion from the Kings River provides a stabilizing factor on the groundwater levels. This surface water supply reduces the amount of pumping, provides recharge and is the principal contributing factor that influences the groundwater conditions. This effect is evident in years of below normal runoff when a rapid decline in the groundwater level is experienced. Based on the District's fall 1993 groundwater measurements, the average groundwater level was 53.16 feet below ground.

D. Climate

The area is semi-arid with mild winters and hot, dry summers. The average rainfall, based on District records, is approximately 11 inches per year. The majority of this rainfall occurs from November through April. With the long, hot summers that normally occur in the valley, there is about 6 feet of evaporation per year with the majority of that evaporation occurring during the period May through October. The winds in the area are principally from the northwest with a southeast wind usually indicating that a rain storm is imminent.

E. Surface Water Management

Alta Irrigation District operates a "demand" system allowing farmers to order water on or off within the system. Primarily, water orders are called in between 7:00 a.m. and 8:00 a.m. each morning; with a subsequent coordinating meeting each morning to determine changes within the system. The conjunctive use pattern of utilizing surface water in wet years and relying more on ground water in dry years

helps to maintain sufficient water supplies to the District's significant acreage of permanent crops. The most beneficial use of surface water is to turn off the farmer's groundwater pump, thus conserving the groundwater to be utilized when needed.

All primary canal and pipeline measuring locations are measured daily prior to 7:00 a.m. Each farmer's delivery is measured at least once a day. The District uses a calibrated submerged orifice to determine the instantaneous flow rate. The District is in the process of updating its distribution system by requiring cumulative flow meters on all turnouts when open canals are replaced by pipelines.

In 1990, Alta Irrigation District commissioned the Kings River Conservation District to complete a "Surface Water Study" to study and review the District's surface water delivery system. A system water balance was evaluated in wet and dry years to determine seepage evaporation, evapotranspiration (ET) of bank vegetation, and operational spillage. The study showed that seepage (estimated to be approximately 23 percent of the District's total diversion) was the most significant loss in the system (see Exhibit "A").

The water flow in the District's canals and pipelines is measured by means of overflow weirs, undershot gates, parshall flumes and a current meter. The District has developed rating tables to set the proper flow rate in each of the canals and pipelines. However, the District may reallocate water from the different laterals if the demand warrants such reallocation.

The District has instituted a water allocation formula to equitably distribute water to farmers. The formula is based on four days per twenty acres utilizing one cubic foot per second per entitlement percentage. Approximately eighty percent of the District's irrigable acres receive one-hundred percent entitlement; the remaining acreage is entitled to receive seventy-five percent, fifty percent, twenty-five percent, or no surface water entitlement. Historically, the lower water entitlement areas either were not farmed or were being farmed to low value crops. The allocation formula is set by the Board of Directors and can be adjusted by lengthening or shortening the number of irrigation days per twenty acres. Typically, in less than average water years, water is held in storage until peak demand occurs in May, June and July.

Water regulating reservoirs have been designed to better maintain constant flows in the lower areas of the district. In 1991 the district developed the fifty-seven acre Button Ponding Basin which is fed by five tributary canals. The flow rates within the canals served by the pond, have been prone to large fluctuation between mid-week and weekend days. All the inflow is now funneled into the ponding basin with a single discharge point: the result being that on weekend's additional water *is*

stored in the basin; and on weekdays, when there is normally higher demand, additional water is used from the storage basin. Additional regulating reservoirs are being evaluated for future construction.

F. Surface Water supply

The District *is* located east of the Kings River in the Central San Joaquin Valley (see Exhibit "B"). To the east of the District are the Sierra Nevada Foothills. The District is composed primarily of alluvial fans sloping to the southwest with elevations ranging from about 425 feet at the northern point to 270 feet in the southwest corner. The incorporated communities within the district are Reedley (population 18,000) and Dinuba (population 13,700). There are also several unincorporated communities, housing clusters and individual rural residences.

The primary economy within the District is agriculture or agriculturally related business. The primary crops grown within the region are grapes (22,056 acres), nectarines (14,394 acres), plums (12,285 acres), and peaches (10,080 acres). Due to the relatively high land prices and high production costs in terms of hand labor, spraying and fertilizer costs, the average parcel size is approximately 36 acres. There are approximately 4,000 farm parcels within the district.

Initially, agricultural production in the region was primarily dry land farming; but with the development of a dependable surface water supply and a willingness of farmers to risk high value crops, the cropping pattern changed to perennial crops and need for a stable water supply became apparent.

The estimated crop demand within the District is 325,000 acre feet and the average surface water supply is 148,416 acre feet; therefore, there is a strong reliance on an alternate water supply; i.e., groundwater.

The District diverts water from the Kings River at the "Cobbles Weir" and measures water into the District at a computerized headgate ("Headgate") located near the community of Piedra. Downstream of the Headgate are 78 ditch laterals serving approximately 4,000 farm parcels. The total length of canals and pipelines is between 350 and 400 miles. The canal widths vary from 4 to 70 feet; lengths range from 3,000 feet to nearly 18 miles (see Exhibit "D")

The annual diversions from the Headgate during a recent twenty-year period were as follows: 253,269 acre feet in 1980 (highest annual diversion); 38,721 acre feet in 1977 (lowest annual diversion) and 148,446 acre was the average annual diversion.

The average time period for each water run within such twenty-year period is 112 days; the shortest water run being 28 days; and the longest water run being 195 days (see Exhibit "C"). The District's diversion and storage rights are based upon riparian and appropriative claims as well as contractual agreements and licenses granted by the state Water Resources Control Board. Such agreements stipulate the use of District's rights in conjunction with the rights of the other twenty-seven (27) entities storing and diverting water from the Kings River: the twenty-eight (28) entities comprise the Kings River Water Association. It is typical for weather patterns and the resulting water storage to vary significantly from year to year, thus illustrating the value of water storage in the production of perennial crops.

III. WATER QUALITY

A. Groundwater Quality

Overall, the quality of the groundwater within the basin is very good. This is the result of the excellent quality of the basin recharge waters originating in the Kings River watershed. The most prevalent water quality problems occurring within this basin are caused by synthetic chemicals. The predominant chemical contamination is DBCP. When the groundwater is used for domestic purposes, construction of ground level treatment facilities to remove the contaminants or the drilling of deeper uncontaminated wells has been required. The contamination has not resulted in any problems when the well water is used for irrigation purposes. Additional contaminates of the water used for domestic purposes include nitrate and bacteriological. The nitrate contamination is usually the result of agricultural fertilizer, domestic sewage, or livestock wastes. In some isolated locations, nitrate levels in groundwater have also caused problems for the agricultural pumpers. The groundwater management plan will include recommended procedures to maintain the existing excellent water quality. Initially, this will include additional water quality monitoring.

Groundwater wells are prevalent throughout the District. The wells are used by cities, agricultural producers, industrial developments and individual homeowners. With the many water production wells, there is a risk that cross aquifer contamination can occur. The greatest potential for groundwater contamination within the basin is cross aquifer contamination through abandoned wells and the improper sealing of new wells. Therefore, it is necessary that proper sealing of new wells and abandonment of old wells is always accomplished. At a minimum, the water well standards of Tulare, Kings & Fresno Counties along with Bulletin 74 requirements must be met. In addition, it may be advantageous to require construction standards that exceed those presently mandated by either the county or state. With the continual raising of

standards for drinking water, maintaining the quality of the groundwater becomes ever more important.

B. Surface Water Quality

The surface supply for the District consists principally of diversions from the Kings River. The snowpack and rainfall within the Kings River watershed produce extremely high quality water with very low amounts of dissolved salts. This has allowed consistently high yields to occur on the heavier soils that are not freely drained without the development of a serious drainage problem. The surface water also provides an excellent source of water for recharging the District's groundwater supply. It is important that the quality of this water be maintained. To this end, the District has been active in identifying surface water discharges within the Basin that may impact water quality. These will be continually monitored and may require the issuance of permits through the NPDES process. Anyone causing overland surface flows that are found to be detrimental to the District's water supply will be put on notice that they must either eliminate or clean those flows to avoid impacting the quality of the District's water supply.

Municipal storm water discharges into District facilities are regulated by permits between the discharger and the District. The permits are specific as to area being drained and/or flow allowed to be discharged. Permit conditions require that the quality of this water meet the existing and future standards set by the Regional Water Quality Control Board. The right to discharge can be terminated at any time the conditions of the permit are not met by the discharger.

C. Water Quality Requirements/Objectives

A primary objective of the Plan is to maintain the water quality within the District. This is of extreme importance because the municipal, industrial and agricultural users need a dependable high quality water supply. A reduction in the quality of the groundwater is tantamount to a loss of water supply, since the quality problem will require additional costs for the construction of treatment facilities. This cleanup will be necessary to allow the water to be integrated into the system.

One of the action items listed in the Plan recommends increased monitoring of groundwater quality in selected areas. This monitoring information will be collected and utilized to evaluate the best management practices to reduce and/or eliminate the contamination. In addition, the action items recommend working with the Department of Water Resources and the counties of jurisdiction in upgrading certain provisions of the water well standards. Since the natural minerals occur in low

concentrations, the major thrust of the water quality monitoring and recommended practices will be to prevent chemical contamination.

The quality of both surface and groundwater within the District must be maintained. The Plan provides a mechanism that will help achieve those long-term goals. The initial action of increasing the amount of monitoring will provide the additional data needed to proceed with future programs to maintain water quality.

D. Wastewater Reclamation

There is little potential for increasing the water supply through wastewater reclamation in this basin. The majority of the wastewater is currently being utilized for the irrigation of agricultural crops or groundwater recharge with only a minor portion being consumed through evaporation basins. The District will continue to work with the wastewater agencies, where practical, to reduce the amount of effluent disposed of through evaporation. In addition, the District will continue to promote the past practices of reusing all wastewater effluent within the local basin, in order to maintain the total water balance within the area. In a water deficient region such as the Alta Irrigation District, the reuse of the wastewater effluent is a key element of establishing a water balance.

IV. GROUNDWATBR CONDITIONS

A. Groundwater Mapping

The District has been monitoring- the groundwater level for the last seventy-five (75) years. This is accomplished through water level measurements taken in the late fall and early spring. A map of the District showing the well locations has been attached (see Exhibit "E"). As wells are lost, new wells are substituted to maintain the continuity of the grid pattern. From these readings, groundwater contour maps have been made depicting both the water elevation and changes in groundwater levels. This mapping has shown drastic differences between various regions of the District during the last drought period.

Based on the water level readings, the overall trend has shown a declining groundwater level within the District. This decline has been periodically interrupted by a short-term groundwater recovery. Based on this long-term data, it has been determined that it would take approximately 22,000 acre-feet per year of additional surface water to correct the overdraft situation that presently exists. Based on average porosity and specific yield considerations, this results in a decline in the groundwater storage of one foot for every 7,000 acre-feet of overdraft. This storage can be

regained if sufficient surface water supplies are made available to reduce the amount of groundwater pumping that is necessary to meet the water demands. In addition, the overdraft results in additional pumping costs to overcome the increased lift. As the water table continues to drop, the pumping occurs from lower portions of the aquifer which have lower porosity and specific yield factors than those found in the upper portions of the unconfined aquifer. The long-term impact is a greater incremental reduction in the available groundwater storage per acre foot of overdraft. Using the historical data collected and the transmissivity of the aquifer, a determination can be made of the estimated quantity of inflow and/or outflow of groundwater within the limits of the District. This data also will allow the District to evaluate areas that are more severely impacted during periods of sustained drought due to the low yield of the wells and the limited depth of the aquifer. This is an important water management tool that is useful to the District in developing long term planning decisions.

The collection of this data will be continued with the Plan. The information that has been prepared from this data in the past includes the following:

1. Maps of spring and fall water elevations.
2. Maps of spring and fall depths to groundwater.
3. Maps showing the changes in groundwater levels over time.

In addition, the groundwater reports can include estimates of changes in groundwater storage, water delivered, water use, and overdraft. This will allow an evaluation of the management activities to be made.

The water quality monitoring that is being proposed as one of the action items will be used to augment the information obtained through the historical water level readings. The water quality samples will be taken *in* critical areas adjacent to urban centers and known locations of contamination. With the compilation of the quality tests and the groundwater level measurement, the District will improve its ability to effectively manage the groundwater.

This information can provide the additional data needed to establish programs to reduce the movement of the contaminates. Typically, the urban centers have a higher concentration of wells resulting in a cone of depression within and surrounding the community. This can accelerate the movement of contaminates towards the urban well fields with the information gathered through the Plan, an additional future action item could include the analysis of the potential benefits of creating a hydraulic barrier or modification of the local pumping regime to reduce or impede the migration of the contamination.

B. Groundwater Recharge

In any conjunctive use area, groundwater recharge is a critical part of the overall Plan. For many years, the District has maintained recharge basins along the southwesterly perimeter of its boundaries. They are located in areas of highly permeable soils. In addition, some amount of affective recharge is also obtained through the District's 700 miles of canals, even though the majority of the soil types are such that the recharge capability of the soil is very limited.

The District has been conducting extensive research to locate additional recharge sites in the eastern portion of the District, since that area is severely impacted in dry years due to the low specific yields and the limited depth of the aquifers. In 1987, the District was selected for funding through the Proposition 44 program to develop a groundwater recharge basin in an area that had limited groundwater resources. The site appeared to have soil types that would be conducive to recharge efforts. An in-depth geological study was undertaken and it was determined that the site would not be effective for groundwater recharge. The District has continued in their efforts to locate additional sites, but so far a suitable location has not been found.

To proceed with a groundwater recharge program, additional surface water supplies are necessary to fully implement the Plan. The District's average annual water supply is already committed. The surface water necessary to conduct an extensive program is available only in wet years when additional water supplies or flood waters are available on the Kings River. The District's goal has been and will continue in the future to make beneficial use of those waters by recharging the underground. For the most part, District conveyance facilities are currently available to transport these waters to the basin locations. Unfortunately, the prospects for locating effective recharge basin sites within the areas of greatest need are not promising.

The District will also be looking at joint recharge sites with the cities. If suitable sites are located within the boundaries of a municipal jurisdiction, the possibility of a joint use facility would be evaluated. The potential exists for water to be delivered to all or part of the site for recharge purposes during a portion of the year, with consideration given to other uses during the remainder of the year.

As a complement to the District's local recharge program, one of the action items is to evaluate "groundwater banking". This could be accomplished by assisting the recharge efforts of other districts that have access to better groundwater recharge sites. Flood waters would be recharged (banked) in a particular district thereby improving their groundwater levels. The amount of water banked would be quantified

on an annual basis and an agreement developed so that the District would have .rights to a stipulated portion of the water banked through the joint agreement. In both the short and long terms, this approach appears to be the most effective way for the Basin Plan Area to proceed. In addition, investigations will continue on potential local recharge sites.

V. ACTION ITEMS

A. Groundwater Management Program

There have been thirteen (13) action items identified for the Plan and those items will be implemented according to the Rules and Regulations (see Exhibit "Fit), as amended from time to time. To have a successful Plan, it is not necessary to implement all of the action items identified. The last three items would be required only as a last resort due to the occurrence of emergency conditions within the Basin Plan Area. It is important that all the potential action items be identified and contingency plans developed in case anyone of them becomes necessary. It is recommended that items one (1) through six (6) be implemented immediately. Investigations into items seven (7) and eight (8) should begin upon approval of the Plan with a staff report regarding their status provided within one year. Action items nine (9) through thirteen (13) will require additional staff study, board approval and public hearings. If funding is necessary to implement a portion of the Plan, then an election will be required prior to instituting an assessment. It is felt that through the management activities listed in the Plan, the District can preserve the groundwater resource and avoid the drastic steps identified in the last three action items.

1. Water Monitoring: The District shall continue to monitor water levels every six months In addition, it will also assist in sampling for water quality testing. Further, the District will prepare maps depicting the information gathered through the monitoring phase, as well as reports quantifying the water demands, surface water and groundwater supplies. These summaries will assist the District in evaluating the effectiveness of the various elements of the program. The migration of contaminated plumes can be detected earlier though the monitoring process allowing additional time for plans to be developed and implemented before additional portions of the basin are impacted.

2. Direct Recharge: The District will continue to use surface waters when available to recharge the underground by sinking those waters in its basins. Basin sites will be located in the areas of greatest need. The District will actively seek the cooperation of other government entities in construction of such sites.

3. Indirect/In-lieu Recharge: The District has approximately 250 miles of unlined canals. The indirect recharge *is* accomplished through the seepage that occurs in some reaches of the canals. In addition, during winter months many of the natural channels carry surface runoff that recharges the groundwater. These old channels are typically located in the more permeable soils. The effective amount of this recharge varies from year to year and is dependent upon the amount of rainfall that occurs. Additional water supplies will be pursued for groundwater recharge in natural channels and during non-irrigation seasons in the District's canals. By providing surface water to the area, the District has reduced the amount of groundwater pumping, resulting in an effective in-lieu recharge program. The District will continue efforts to maximize the amount of surface water available to users within its boundaries.

4. Water Conservation - Water Regulation: The District has a long standing practice of conjunctive water use. Conjunctive use is the integration of surface and groundwater supplies to meet the total water demand. Recently, a cooperative program called the "mobile lab," has been operated by the Kings River Conservation District with support from the local irrigation districts. The purpose of this program has been to promote on-farm water conservation. The District has strongly supported programs that conserve water along with enhancing crop production. Through the construction of water regulating basins, the District has been able to conserve and more efficiently utilize water within its system. The most recent regulating basin was constructed on a 50-acre site in the southeast portion of the District. The Alta Irrigation District, the cities and the unincorporated water purveyors, all have water conservation plans. Water conservation efforts will be encouraged throughout the basin for agricultural, industrial and residential users. Existing and new irrigation methods, reuse of industrial water and domestic water saving devices will all be encouraged. The water use requirements of new developments will also be evaluated to insure compatibility with this water deficient basin.

5. No Exportation of Groundwater: Since the District is located within an overdrafted basin, it is prudent to utilize groundwater resources within the District's boundaries. Effluent discharged by the City of Reedley ("Agency") from its sewer treatment plant into the Kings River should not be considered to be prohibited exportation of groundwater if such effluent recharges or benefits underground supplies available to landowners in the District.

6. Intra-district Water Transfer: Water transfers within the District have taken place on a routine basis. Each year the District evaluates the water transfer policy and specifies the circumstances warranting internal water transfers. Approximately 60 transfers are approved each year within the District.

7. Well Drilling and Abandonment: Portions of the groundwater have been contaminated principally by volatile organic chemicals or nitrates. This contamination is most prevalent in the upper aquifers. Interaquifer mixing can occur through inadequate seals or improperly abandoned wells. Working through the Department of Water Resources and the county of jurisdiction, the District will seek to upgrade standards for construction and abandonment of water wells to reduce the potential for aquifer contamination.

8. Groundwater Banking: With the scarcity of suitable recharge sites within the District, the Alta Irrigation District will look to other agencies that have soil types more suitable for recharge basins. The District could then recharge (bank) surface water within the boundaries of the Agency for withdrawal at a later time. This arrangement can provide benefit to the groundwater basins for both the and the cooperating Agency. The District benefits since otherwise it has few areas suitable for recharge and the participating Agency receives the benefit of reduced pumping lifts during the time the water is banked.

9. Inter-district Water Transfer: Water transfers between different water districts are currently taking place. New legislation is being proposed that will enhance the water transfer process. In the past, the District has completed such transfers on a limited basis. This mechanism would be used to increase the total water supply within the District or to augment the water supply in specific areas of the basin during critically dry years.

10. Reduction in Groundwater outflow: The direction and quantity of groundwater flow is susceptible to changes that occur to the hydraulic gradient. The groundwater level measurements taken twice a year within the District will identify the direction of groundwater flow. Typically, this outflow has been to the west and southwest creating hydraulic barriers by mounding of the groundwater can lead to a reduction in the amount of water that leaves the District. This can be an especially effective procedure along the perimeter of the District. Likewise, increased pumping by landowners along the perimeter of the basin can increase the groundwater outflow. The District will continue its efforts to assure that all necessary steps are taken to reduce the amount of such groundwater outflow.

11. Pumping Restrictions: Pumping restrictions would definitely reduce the amount of groundwater use. This is a controversial item and pumping restrictions would be the last item to be considered. This step could have severe economic implications since the local economy that has been developed with a reliance on groundwater would be detrimentally impacted. Initially, any program requiring pumping restrictions would be voluntary rather than mandatory. From a practical

standpoint, only if the urban water supplies are being severely restricted, will mandatory agricultural pumping restrictions be implemented.

12. Additional Water supply and Storage: The generation of additional water supplies would enhance the local groundwater. Present political realities prevent developing additional water by building dams and water storage projects. As a result, additional water supplies will most likely come through water conservation efforts, recycling and storm water supplies. The limiting factor to securing additional water supplies is addressing actual or perceived environmental considerations.

13. Redistribution of Surface Water: There is a tremendous difference in the aquifer characteristics within the District. This is evident in both storage capability and yield. The impact of the recent and apparently ongoing drought is evidenced by the larger drop in water level for those areas with limited aquifer depth versus portions of the basin that are located over a deeper and higher yielding aquifer. During critically dry years, all or a disportionately high percentage of the available surface water may need to be directed to the severely impacted areas. Increased pumping could then occur in those areas having better groundwater conditions to offset the redistribution of the available surface water supply.

B. Memorandum of understanding

The District shall endeavor to enter into a Memorandum of Understanding with public or private entities providing water service in accordance with Water Code section 10755.2. It is hoped that such local agencies will adopt and implement this Plan within their boundaries to provide a coordinated groundwater management program in accordance with that section.

IN WITNESS WHEREOF, the Alta Irrigation District has executed this Groundwater Management Plan as of **October 14, 1994.**

"DISTRICT"

ALTA IRRIGATION DISTRICT, a
California Irrigation District

BY Norman Waldner
Norman Waldner, President

BY Janelle M. Cochran
Janelle M. Cochran, Secretary

MEMORANDUM OF UNDERSTANDING
BETWEEN
ALTA IRRIGATION DISTRICT
AND
LOCAL AGENCY

ARTICLE I – AGREEMENT

The articles and provisions contained herein constitute a bilateral and binding agreement by and between ALTA IRRIGATION DISTRICT, a California Irrigation District ("District") and LOCAL AGBNCY, A Public Agency ("Agency").

ARTICLE II – RECOGNTION

The District has developed a Groundwater Management Plan ("Plan") with input from several local agencies which are water purveyors with overlapping spheres of influence within the District. It is the intent of District to allow and encourage such agencies to coordinate efforts and be a part of the District's Plan by means of a separate Memorandum of Understanding ("MOU") between each agency and District.

ARTICLE III - PURPOSE

It is the purpose of this MOU, entered willingly, between District and Agency, to document the interests and responsibilities of both parties in the adoption and implementation of a coordinated Plan. It is also hoped that such MOU will promote and provide a means to establish an orderly process to share information, develop a course of action and resolve any misunderstandings or differences that may arise.

ARTICLE IV - COORDINATION

There shall be an annual coordinating meeting ("Meeting") between the District and the Agency. District shall give notice to the Agency thirty (30) days prior to date of the Meeting. If there are concerns or questions regarding the Plan, Agency shall transmit its concerns in writing to District seven (7) days prior to the Meeting.

ARTICLE IV - OBLIGATIONS

The Plan shall be binding on the parties hereto unless superseded by the MOU or amendment thereto. It is agreed between both parties that District shall pay one-third of the cost and expense of water quality testing I sampling and monitoring and Agency shall pay prorated portion of two-thirds of such cost provided that the total annual cost payable by each party shall not exceed six thousand eight hundred dollars ($6,800). Within one year from the date hereof, the parties shall establish procedures and arrangements to carry out such sampling, testing and monitoring.

ARTICLE VI – AREA OF PLAN

The plan shall be effective in all areas within the Agency boundaries. The Plan shall also be effective in any area annexed to the Agency Subsequent to the adoption of the Plan.

ARTICLE VII – TERM

The initial term of the MOU shall commence on the date hereof and continue for five (5) years, and shall continue year to year thereafter, unless terminated by written notice given at least one (1) year prior to such termination.

"DISTRICT"

ALTA IRRIGATION DISTRICT, a California Irrigation District

By_____
Norman Waldner, President

By_____
Janelle M. Cochran, Secretary

"AGENCY"

LOCAL AGENCY, a Public Agency

By_____

By_____

Table III-1
Alta I.D. Canal Seepage for Wet (1984) and Dry (1990) Years

Canal Name	Length (mi)	Seepage (cfs)	1984 Seepage (AF)	1984 Seepage % of Diversion	1990 Seepage (AF)	1990 Seepage % of Diversion
Alta Main	8.9	11.2	3,592	1.7%	1,071	1.8%
A.B. Clark	4.4	2.5	810	0.4%	242	0.4%
A.N. Smith	1.8	0.2	62	0.0% *	18	0.0% *
A.W. Clark	2.9	0.6	186	0.1%	56	0.1%
Andrews	2.5	0.4	130	0.1%	39	0.1%
Ballard	2.8	0.2	79	0.0% *	23	0.0% *
Banks	17.7	4.4	1,409	0.7%	151	0.3%
Bowhay	3.1	1.1	336	0.2%	100	0.2%
Bump & Edmison	1.8	0.2	64	0.0% *	19	0.0%
Button	15.0	4.2	1,345	0.6%	281	0.5%
Buttonwillow	11.0	8.9	2,830	1.3%	844	1.4%
Caesar	5.3	4.4	1,397	0.7%	417	0.7%
California Vineyard	6.9	6.1	1,938	0.9%	578	1.0%
Carey-Hunter	7.7	2.8	885	0.4%	263	0.5%
Carpenter	1.2	0.0	10	0.0% *	3	0.0% *
Clapp	1.5	0.0	5	0.0% *	2	0.0% *
Clements	4.0	2.1	667	0.3%	199	0.3%
Clough	3.9	1.6	502	0.2%	15	0.0% *
Cross Creek W.W.	1.9	0.4	129	0.1%	4	0.0% *
Curtis Cutoff	1.5	0.5	155	0.1%	46	0.1%
Lower Curtis Cutoff	0.9	0.2	73	0.0% *	22	0.0% *
Upper Curtis Cutoff	1.0	0.1	19	0.0% *	6	0.0% *
Dinuba Town	8.8	4.7	1,507	0.7%	449	0.8%
East Branch	15.5	18.0	5,753	2.7%	1,715	2.9%
East Gould	1.5	0.1	31	0.0% *	9	0.0% *
East Reedley	5.5	1.8	563	0.3%	168	0.3%
East Section 20	1.2	0.1	20	0.0% *	6	0.0% *
Elter	2.5	0.1	38	0.0% *	11	0.0% *
Floyd	1.5	0.1	42	0.0% *	13	0.0% *
Frane	1.4	0.0	3	0.0% *	1	0.0% *
Gordon	1.0	0.1	41	0.0% *	12	0.0% *
Grove	1.7	0.0	16	0.0% *	5	0.0% *
Haden & Boone	2.7	0.4	141	0.1%	42	0.1%
Hogan	2.1	0.1	37	0.0% *	11	0.0% *
Horsman	5.0	1.7	550	0.3%	164	0.3%
J.T. Williams	2.4	0.0	9	0.0% *	3	0.0% *
Jack	1.2	0.3	103	0.0% *	31	0.1%
Kennedy School House	5.0	0.3	82	0.0% *	24	0.0% *
Kennedy Waste Way	7.3	3.7	1,168	0.5%	347	0.6%
King	4.4	3.1	979	0.5%	206	0.4%
Kirk	1.7	0.3	84	0.0% *	25	0.0% *
Knestric	5.6	0.8	254	0.1%	76	0.1%
Loper	3.2	0.5	162	0.1%	48	0.1%
Lovell	2.0	0.4	136	0.1%	41	0.1%
McBriar	2.0	0.0	8	0.0% *	2	0.0% *
McClanahan	5.9	4.8	1,527	0.7%	446	0.8%
Mc Gee	1.9	0.2	54	0.0% *	16	0.0% *
Monson	7.0	3.5	1,128	0.5%	336	0.6%
Montague	1.3	0.2	52	0.0% *	16	0.0% *
Mt. Campbell	3.7	1.5	466	0.2%	139	0.2%
Nichols-Cann	1.9	0.0	6	0.0% *	2	0.0% *
Nuss	1.2	0.0	2	0.0% *	1	0.0% *
Orosi School House	3.2	0.9	279	0.1%	83	0.1%
Parenti	1.3	0.0	4	0.0% *	1	0.0% *
Parks	1.5	0.2	78	0.0% *	23	0.0% *
Peck	0.6	0.0	2	0.0% *	0	0.0% *
Red Williams	1.5	0.2	67	0.0% *	10	0.0% *
Reedley Main	3.0	2.9	917	0.4%	273	0.5%
Reo	1.5	0.2	63	0.0% *	19	0.0%
Rice-Brubaker	2.2	0.3	99	0.0% *	30	0.1%
Sandridge	2.9	0.4	140	0.1%	42	0.1%
Segrue	0.3	0.0	1	0.0% *	0	0.0% *
Smith Mountain	9.3	3.1	977	0.5%	291	0.5%
Sontag	6.7	0.2	59	0.0% *	14	0.0% *
Tout	6.0	1.4	439	0.2%	131	0.2%
Traver Creek	10.1	12.1	3,878	1.8%	1,156	2.0%
Traver Canal	12.3	21.6	6,910	3.2%	1,788	3.1%
Uphill	0.6	0.0	2	0.0% *	0	0.0% *
Van Noy	2.2	0.3	96	0.0% *	18	0.0% *
Wahtoke	5.1	0.7	224	0.1%	67	0.1%
Weise	1.0	0.3	80	0.0% *	2	0.0% *
West Gould	4.9	0.9	281	0.1%	84	0.1%
West Reedley	5.6	1.4	442	0.2%	132	0.2%
West Section 20	1.8	0.1	26	0.0% *	8	0.0% *
Wilson	10.7	7.0	2,220	1.0%	662	1.1%
Wilson Hunter	1.5	0.5	151	0.1%	45	0.1%
Wilson School House	3.4	0.9	287	0.1%	85	0.1%
Windsor	1.3	0.0	3	0.0%	1	0.0%
TOTAL	316.7	154	49,306	23.1%	13,727	23.6%

Note: * Indicates that canal seepage is less than 0.05% of Alta's total district diversion.

SCHEDULE OF DIVERSIONS & WATER RUN, 1973 - 1992

DIVERSIONS FROM HEADGATE		WATER RUN	
1973	86,773 Acre Feet	04/16-08/31	138 Days
1974	220,041 Acre Feet	05/15-08/31	139 Days
1975	184,034 Acre Feet	04/21-08/22	124 Days
1976	43,381 Acre Feet	06/14-07/17	34 Days
1977	38,721 Acre Feet	07/01-07/28	28 Days
1978	246,204 Acre Feet	05/11-10/31 & 5 days in Sept.	169 Days
1979	181,999 Acre Feet	05/01-08/31	123 Days
1980	253,269 Acre Feet	04/01-09/13	166 Days
1981	145,581 Acre Feet	05/04-08/14	103 Days
1982	247,599 Acre Feet	04/20-10/31	195 Days
1983	205,445 Acre Feet	04/28-09/29 & 10/02-10/14	167 Days
1984	214,165 Acre Feet	03/31-09/07	161 Days
1985	170,826 Acre Feet	04/28-08/26	121 Days
1986	227,709 Acre Feet	04/07-09/30	177 Days
1987	121,270 Acre Feet	05/04-08/04	93 Days
1988	59,118 Acre Feet	06/13-08/01	50 Days
1989	89,983 Acre Feet	05/28-08/04	69 Days
1990	58,468 Acre Feet	06/21-08/07	48 Days
1991	107,706 Acre Feet	05/21-08/10	82 Days
1992	66,623 Acre Feet	05/28-07/26	59 Days
AVERAGE	**148,446 Acre Feet**	**AVERAGE**	**112 Days**
MOST	**253,269 Acre Feet**	**LONGEST**	**195 Days**
LEAST	**38,721 Acre Feet**	**SHORTEST**	**28 Days**

Reference: Alta Irrigation District
1992 Annual Report

Figure I - 1
Location of Alta
Irrigation District

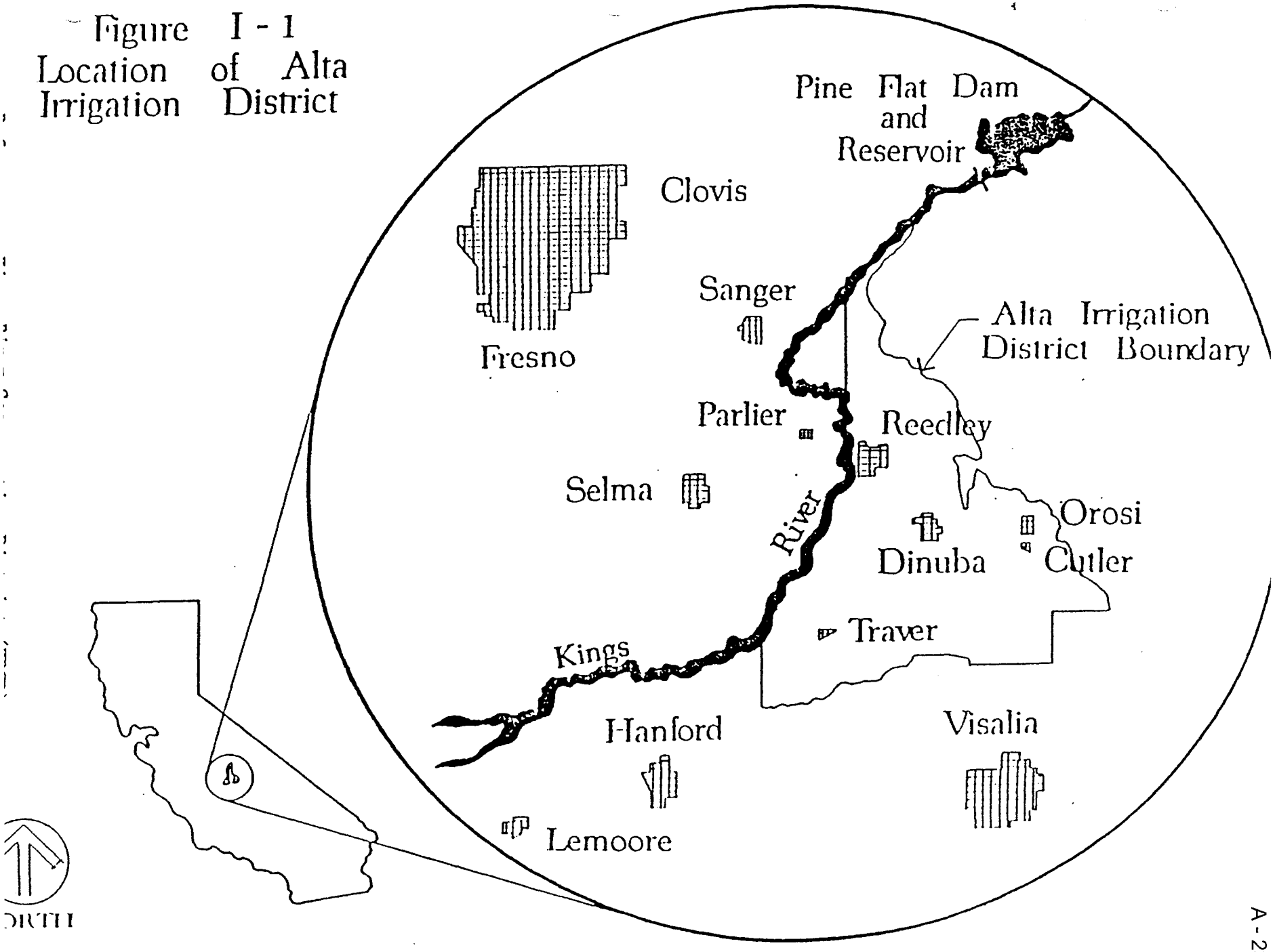

Table I-1
Alta I.D. Canal Specifications

Canal Name	Length (mi)	Average Top Width (ft)	Average Cross Sectional Area (sq ft)	Canal Volume (AF)
Alta Main	8.9	72.4	245	265.3
A.B. Clark	4.4	12.4	19	8.8
A.N. Smith	1.8	5.7	5	0.7
A.W. Clark	2.9	8.3	9	2.6
Andrews	2.5	4.0	3	1.0
Ballard	2.8	9.3	11	1.5
Banks	17.7	13.2	21	44.8
Bowhay	3.1	12.6	20	7.5
Bump & Edmison	1.8	7.3	7	0.6
Button	15.0	17.7	28	50.9
Buttonwillow	11.0	19.9	48	60.4
Caesar	5.3	15.7	27	17.1
California Vineyard	6.9	19.2	46	37.6
Carey-Hunter	7.7	12.9	19	16.0
Carpenter	1.2	10.9	15	1.0
Clapp	1.5	6.1	6	0.3
Clements	4.0	13.5	20	9.7
Clough	3.9	10.7	14	6.8
Cross Creek W.W.	1.9	11.6	17	3.9
Curtis Cutoff	1.5	15.0	24	2.3
Lower Curtis Cutoff	0.9	10.2	13	1.0
Upper Curtis Cutoff	1.0	11.0	14	0.5
Dinuba Town	8.8	13.9	24	24.5
East Branch	15.5	42.8	123	231.5
East Gould	1.5	4.5	2	0.2
East Reedley	5.5	17.5	46	18.1
East Section 20	1.2	8.3	10	1.4
Elter	2.5	6.5	5	1.5
Floyd	1.5	4.8	4	0.6
Frane	1.4	N/A	N/A	0.1
Gordon	1.0	5.7	6	0.5
Grove	1.7	7.5	10	1.2
Haden & Boone	2.7	6.0	6	1.3
Hogan	2.1	5.4	5	0.4
Horsman	5.0	9.2	9	5.7
J.T. Williams	2.4	N/A	N/A	0.8
Jack	1.2	8.0	10	1.4
Kennedy School House	5.0	13.4	23	2.9
Kennedy Waste Way	7.3	13.4	22	15.2
King	4.4	13.8	19	10.1
Kirk	1.7	4.6	4	0.7
Knestric	5.6	6.2	4	2.6
Loper	3.2	6.3	4	1.7
Lovell	2.0	5.7	5	1.1
McBriar	2.0	N/A	N/A	0.8
McClanahan	5.9	15.1	27	18.3
Mc Gee	1.9	4.6	4	1.3
Monson	7.0	13.9	27	23.0
Montague	1.3	4.4	4	0.5
Mt. Campbell	3.7	12.8	20	6.4
Nichols-Cann	1.9	N/A	N/A	0.5
Nuss	1.2	N/A	N/A	0.1
Orosi School House	3.2	7.5	7	2.8
Parenti	1.3	N/A	N/A	0.3
Parks	1.5	7.7	9	0.9
Peck	0.6	N/A	N/A	0.1
Red Williams	1.5	16.1	18	3.3
Reedley Main	3.0	21.5	45	16.7
Reo	1.5	4.5	2	0.4
Rice-Brubaker	2.2	5.4	5	0.8
Sandridge	2.9	15.4	30	5.8
Segrue	0.3	N/A	N/A	0.1
Smith Mountain	9.3	12.8	17	17.9
Sontag	6.7	9.5	12	9.3
Tout	6.0	10.2	13	8.2
Traver Creek	10.1	28.0	78	95.6
Traver Canal	12.3	39.4	58	86.6
Uphill	0.6	N/A	N/A	0.1
Van Noy	2.2	8.9	12	3.3
Wahtoke	5.1	12.8	15	7.1
Weise	1.0	9.1	11	1.3
West Gould	4.9	7.6	10	4.8
West Reedley	5.6	10.6	13	7.6
West Section 20	1.8	7.5	7	1.5
Wilson	10.7	16.4	31	40.1
Wilson Hunter	1.5	10.4	18	3.3
Wilson School House	3.4	11.1	16	6.2
Windsor	1.3	N/A	N/A	0.2
TOTAL	316.7			1,239.1

Notes: Width and area values as N/A denote canals that are completely piped.
Width and area values are for open channel segments only.

WELL LOCATIONS
ALTA IRRIGATION DISTRICT

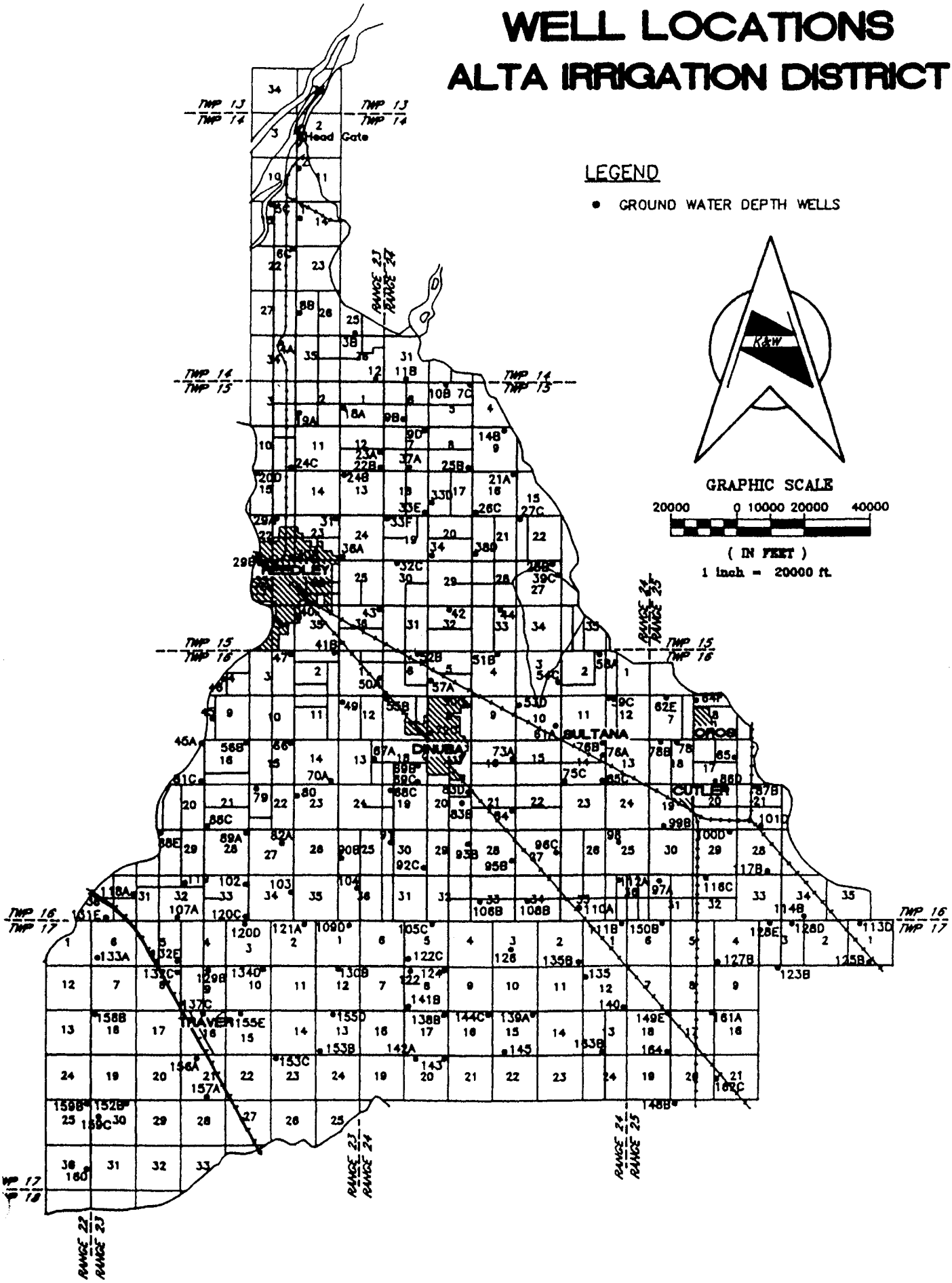

EXHIBIT "F"
GROUNDWATER MANAGEMENT PLAN
RULES AND REGULATIONS
TO IMPLEMENT THE
GROUNDWATER MANAGEMENT PLAN
OF
ALTA IRRIGATION DISTRICT

1. Rules and Regulations Governing Distribution of Water and Maintenance of Distribution System to Alta Irrigation District: The Rules and Regulation adopted by the District on March 9, 1990 and attached hereto as Exhibit "G" are hereby incorporated in these Rules and Regulations.

2. Water Monitoring:

(a) Semi-annual Groundwater Level Measurement: At least twice per year, District shall provide staff at its expense to monitor and measure the depth to standing groundwater at well sites within District. In its sole discretion, District shall select the number and location of well sites. District shall prepare maps as required by the Plan.

(b) Water Quality sampling and testing: District along with other local agencies as defined in water Code Section 10752g, ("Local Agencies") shall implement a water sampling and monitoring program for water quality purposes in accordance with a Memorandum of Understanding entered into by District and those Local Agencies.

3. Direct Recharge: When feasible, District will consider delivery of water to recharge basins owned and maintained by Local Exhibit "F" Agencies within the District. All such deliveries of recharge water shall be at the discretion of District Board of Directors. ("Board of Directors"). The Local Agency owning the recharge basin shall be liable for any damages connected with or arising out of transportation use, storage or recharge of such water. District shall be responsible for any damage to Agency resulting from the intentional or negligent acts of District or its employees or agents.

4. Indirect Recharge:

(a) Canal Recharge: District shall endeavor to monitor and evaluate recharge from canals when appropriate, as determined by District. Canals with good

recharge capabilities will be evaluated for potential use as groundwater recharge facilities to receive recharge water during the off-irrigation season.

(b) Surface Water/Groundwater Pumping: The District shall continue to divert and deliver surface water supplies of the District to reduce groundwater pumping.

5. Water Conservation - Water Regulation: District's policies and procedures promote the beneficial use of water. Specific examples include instantaneous (orifice type of metering) flow measurements at all turnouts; with propeller meters at all turnouts associated with current or future pipeline projects. The District shall continue to promote policies that enhance water conservation policies (see enclosed Alta Irrigation District Rules and Regulations, adopted March 9, 1990). The District Board of Directors has the authority to adopt water conservation and water regulation policies for the District. If Agency adopts and enforces a water conservation plan within its boundaries, such Plan shall be effective to the extent it is not inconsistent with the District's Plan.

6. No Exportation of Groundwater: After the adoption hereof, there shall be no exportation of groundwater that results in any additional net loss to District's total available water supplies. Minor amounts of urban drainage shall not be considered groundwater exportation subject to this paragraph. The District Board of Directors has the authority to renew any mitigating measures proposed to prevent such net loss.

7. Well Drilling and Abandonment: District will work with the agencies of jurisdiction in amending the water well ordinance applicable within the District to require a minimum of fifty (50) foot annular seal on all gravel packed wells.

8. Groundwater Banking: District shall endeavor to promote advantageous groundwater banking projects. The Board of Directors has the authority to control the destination of the District's Kings River water under appropriate licenses.

9. Intra-district water Transfer: District annually adopts a specific policy to address the issue of internal water transfers within the District. The District desires to reduce pumping from the groundwater by better utilization of surface water supplies. The Board of Directors has the authority to control the destination of the District's Kings River water under appropriate licenses.

10. Inter-district water Transfer: District shall endeavor to promote advantageous water transfers (water transfers that increase the water supply available

within the District) between the District and other entities. The Board of Directors has the authority to initiate such transfers.

11. Reduction in Groundwater outflow: The District's current water entitlement allocations result in additional pumping in the south and southwesterly areas of the District which may reduce groundwater outflow under certain circumstances. The groundwater outflow from the District is principally to the south and west. Existing surface water along with supplemental water,' when available, will be used to improve the groundwater barrier along the perimeter of the District to reduce the amount of outflow. The Board of Directors has the authority to adjust water entitlement allocations.

12. Pumping Restrictions: Only under special circumstances would pumping restrictions be imposed. The Board of Directors shall not impose such restrictions until after consulting with Local Agencies and holding a mandatory public hearing at least sixty (60) days prior to the effective date of such restrictions.

13. Additional Water Supply and storage: The Board of Directors could impose such action only by Resolution.

14. Redistribution of Surface Water: The Board of Directors could impose such action by Resolution adopted after a mandatory public hearing held at least sixty (60) days prior to imposing such action.

ATTACHMENT B

Notice of Intent to Adopt a SB 1938 Groundwater Management Plan (July 10, 2008)

RESOLUTION OF INTENT

A RESOLUTION FOR THE ALTA IRRIGATION DISTRICT TO APPROVE AND AUTHORIZE THE NOTICE OF AN INTENT TO UPDATE ALTA IRRIGATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN UNDER Section 10750 et seq. TO BE IN COMPLIANCE WITH SB 1938(Stats 2002, Ch 603)

WHEREAS, ALTA IRRIGATION DISTRICT, a public agency duly organized and existing under and by virtue of the laws of the State of California (the "Entity"), has determined that it is in the best interest and to the advantage of the Entity to update its current groundwater management plan. The current groundwater management plan is a AB 3030 type of plan and it is intent of Entity to update its current plan to meet the requirements of a SB 1938 type of plan; and

WHEREAS, the Entity is located in Fresno, Tulare and Kings Counties; and

WHEREAS, participation will include local agencies and interested parties located within the Entity; and

WHEREAS, The Entity will act as the lead agency in the governance of the groundwater management plan, as updated.

NOW, THEREFORE, BE IT RESOLVED BY THE GOVERNING BODY OF THE ENTITY AS FOLLOWS:

Section 1. Findings. The Entity's Governing Body hereby specifically finds and determines that the actions authorized hereby relate to the public affairs of the Entity and the inter-relationship with other water interests within the Upper Kings Sub Basin.

Section 2. Memorandum of Understandings. Existing Memorandum of Understandings, to be updated and entered into by and between the Entity and the local agencies with overlapping spheres of interest within the Entity.

Section 3. Effective Date. This Resolution of Intent shall be advertised under the prescribed guidelines of Government Code 6066 prior to action being considered.

PASSED AND ADOPTED this 10th day of July, 2008 by the following vote:

AYES: Waldner, Marshall, Astiasuain and Halford

NOES: None

ABSENT: Belknap, Krahn and Warkentin

Attested by: Chris M. Kapheim

Chris M. Kapheim, General Manager/Secretary

ATTACHMENT C

Bulletin 118, Department of Water Resources

Tulare Lake Hydrologic Region

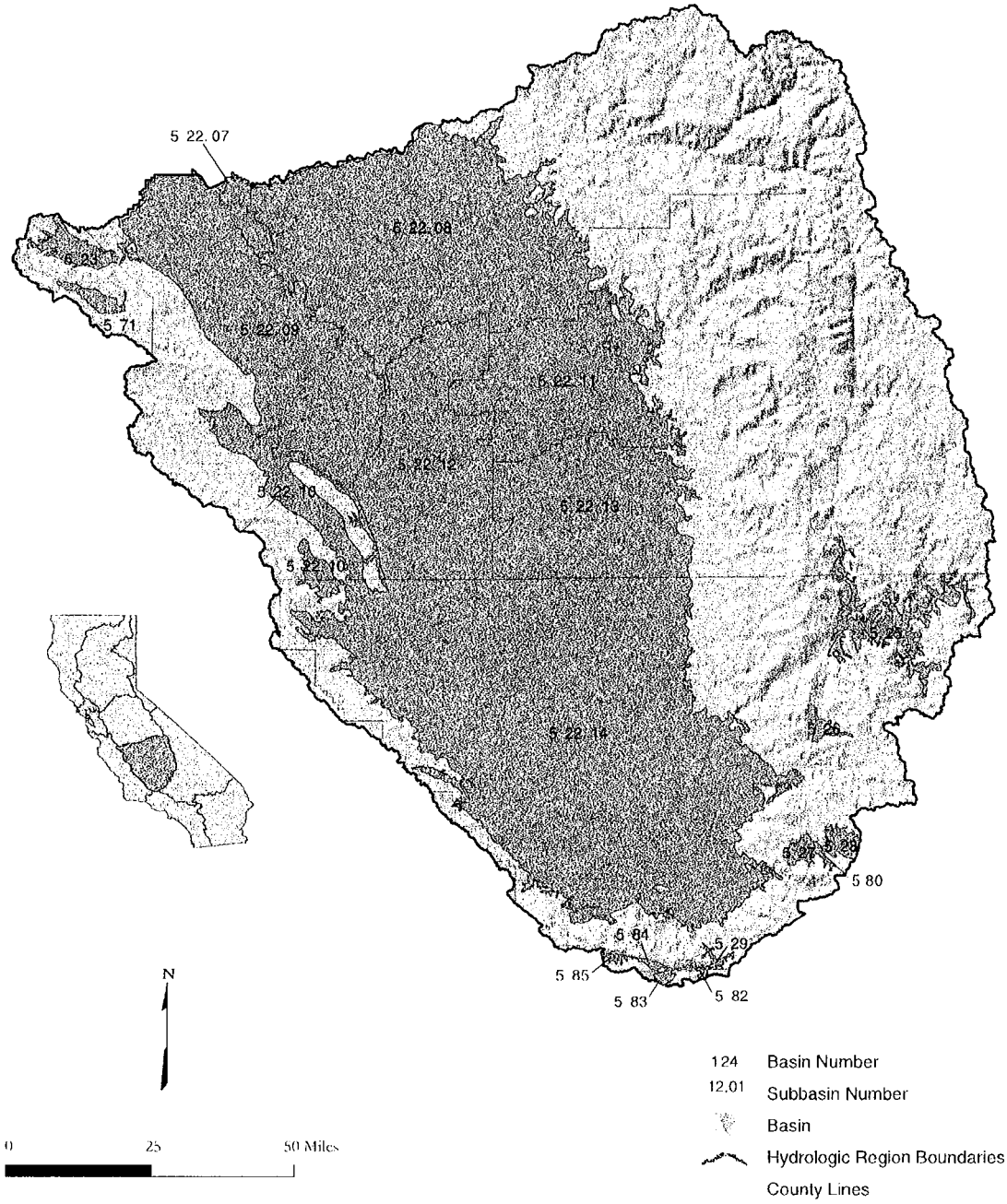

Figure 37 Tulare Lake Hydrologic Region

Basins and Subbasins of Tulare Lake Hydrologic Region

Basin/subbasin	Basin name
5-22	San Joaquin Valley
5-22.08	Kings
5-22.09	Westside
5-22.10	Pleasant Valley
5-22.11	Kaweah
5-22.12	Tulare Lake
5-22.13	Tule
5-22.14	Kern County
5-23	Panoche Valley
5-25	Kern River Valley
5-26	Walker Basin Creek Valley
5-27	Cummings Valley
5-28	Tehachapi Valley West
5-29	Castaic Lake Valley
5-71	Vallecitos Creek Valley
5-80	Brite Valley
5-82	Cuddy Canyon Valley
5-83	Cuddy Ranch Area
5-84	Cuddy Valley
5-85	Mil Potrero Area

Description of the Region

The Tulare Lake HR covers approximately 10.9 million acres (17,000 square miles) and includes all of Kings and Tulare counties and most of Fresno and Kern counties (Figure 37). The region corresponds to approximately the southern one-third of RWQCB 5. Significant geographic features include the southern half of the San Joaquin Valley, the Temblor Range to the west, the Tehachapi Mountains to the south, and the southern Sierra Nevada to the east. The region is home to more than 1.7 million people as of 1995 (DWR, 1998). Major population centers include Fresno, Bakersfield, and Visalia. The cities of Fresno and Visalia are entirely dependent on groundwater for their supply, with Fresno being the second largest city in the United States reliant solely on groundwater.

Groundwater Development

The region has 12 distinct groundwater basins and 7 subbasins of the San Joaquin Valley Groundwater Basin, which crosses north into the San Joaquin River HR. These basins underlie approximately 5.33 million acres (8,330 square miles) or 49 percent of the entire HR area.

Groundwater has historically been important to both urban and agricultural uses, accounting for 41 percent of the region's total annual supply and 35 percent of all groundwater use in the State. Groundwater use in the region represents about 10 percent of the State's overall supply for agricultural and urban uses (DWR 1998).

The aquifers are generally quite thick in the San Joaquin Valley subbasins with groundwater wells commonly exceeding 1,000 feet in depth. The maximum thickness of freshwater-bearing deposits (4,400 feet) occurs at the southern end of the San Joaquin Valley. Typical well yields in the San Joaquin Valley range from 300 gpm to 2,000 gpm with yields of 4,000 gpm possible. The smaller basins in the mountains surrounding the San Joaquin Valley have thinner aquifers and generally lower well yields averaging less than 500 gpm.

The cities of Fresno, Bakersfield, and Visalia have groundwater recharge programs to ensure that groundwater will continue to be a viable water supply in the future. Extensive groundwater recharge programs are also in place in the south valley where water districts have recharged several million acre-feet for future use and transfer through water banking programs.

The extensive use of groundwater in the San Joaquin Valley has historically caused subsidence of the land surface primarily along the west side and south end of the valley.

Groundwater Quality

In general, groundwater quality throughout the region is suitable for most urban and agricultural uses with only local impairments. The primary constituents of concern are high TDS, nitrate, arsenic, and organic compounds.

The areas of high TDS content are primarily along the west side of the San Joaquin Valley and in the trough of the valley. High TDS content of west-side water is due to recharge of stream flow originating from marine sediments in the Coast Range. High TDS content in the trough of the valley is the result of concentration of salts because of evaporation and poor drainage. In the central and west-side portions of the valley, where the Corcoran Clay confining layer exists, water quality is generally better beneath the clay than above it. Nitrates may occur naturally or as a result of disposal of human and animal waste products and fertilizer. Areas of high nitrate concentrations are known to exist near the town of Shafter and other isolated areas in the San Joaquin Valley. High levels of arsenic occur locally and appear to be associated with lakebed areas. Elevated arsenic levels have been reported in the Tulare Lake, Kern Lake and Buena Vista Lake bed areas. Organic contaminants can be broken into two categories, agricultural and industrial. Agricultural pesticides and herbicides have been detected throughout the valley, but primarily along the east side where soil permeability is higher and depth to groundwater is shallower. The most notable agricultural contaminant is DBCP, a now-banned soil fumigant and known carcinogen once used extensively on grapes. Industrial organic contaminants include TCE, DCE, and other solvents. They are found in groundwater near airports, industrial areas, and landfills.

Water Quality in Public Supply Wells

From 1994 through 2000, 1,476 public supply water wells were sampled in 14 of the 19 groundwater basins and subbasins in the Tulare Lake HR. Evaluation of analyzed samples shows that 1,049 of the wells, or 71 percent, met the state primary MCLs for drinking water. Four-hundred-twenty-seven wells, or 29 percent, exceeded one or more MCL. Figure 38 shows the percentages of each contaminant group that exceeded MCLs in the 427 wells.

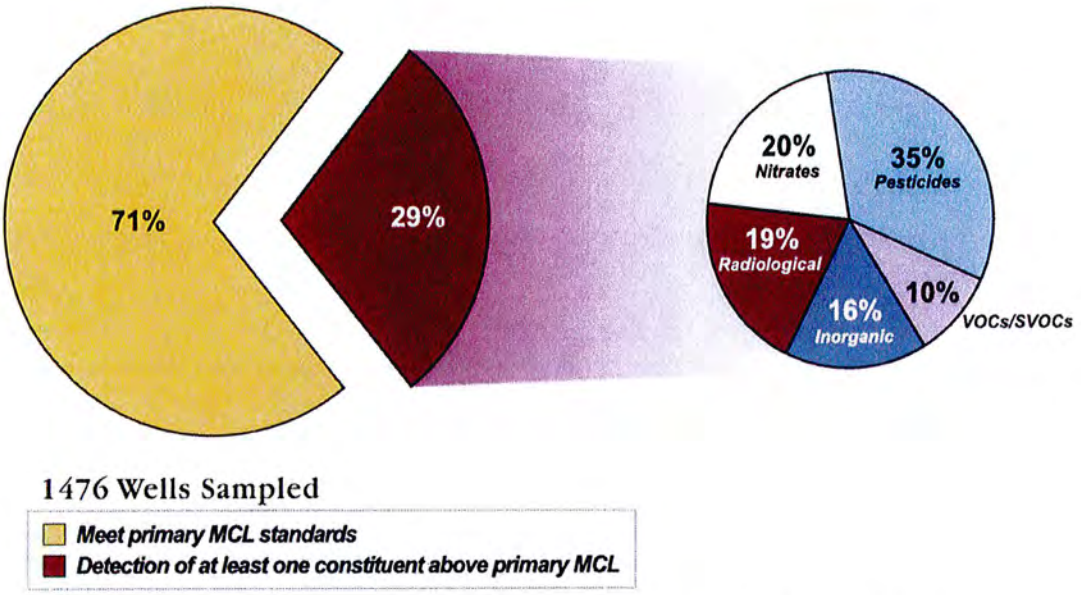

Figure 38 MCL exceedances by contaminant group in public supply wells in the Tulare Lake Hydrologic Region

Table 31 lists the three most frequently occurring contaminants in each of the six contaminant groups and shows the number of wells in the HR that exceeded the MCL for those contaminants.

Table 31 Most frequently occurring contaminants by contaminant group in the Tulare Lake Hydrologic Region

Contaminant group	Contaminant - # of wells	Contaminant - # of wells	Contaminant - # of wells
Inorganics - Primary	Fluoride – 32	Arsenic – 16	Aluminum – 13
Inorganics - Secondary	Iron – 155	Manganese – 82	TDS – 9
Radiological	Gross Alpha – 74	Uranium – 24	Radium 228 – 8
Nitrates	Nitrate(as NO_3) – 83	Nitrate + Nitrite – 14	Nitrite(as N) – 3
Pesticides	DBCP – 130	EDB – 24	Di(2-Ethylhexyl)phthalate – 7
VOCs/SVOCs	TCE – 17	PCE – 16	Benzene – 6 MTBE – 6

DBCP = Dibromochloropropane
EDB = Ethylenedibromide
TCE = Trichloroethylene
PCE = Tetrachlorochylene
VOC = Volatile organic compound
SVOC = Semivolatile organic compound

Changes from Bulletin 118-80

There are no newly defined basins since Bulletin 118-80. However, the subbasins of the San Joaquin Valley, which were delineated as part of the 118-80 update, are given their first numeric designation in this report (Table 32).

Table 32 Modifications since Bulletin 118-80 of groundwater basins and subbasins in Tulare Lake Hydrologic Region

Subbasin name	New number	Old number
Kings	5-22.08	5-22
Westside	5-22.09	5-22
Pleasant Valley	5-22.10	5-22
Kaweah	5-22.11	5-22
Tulare Lake	5-22.12	5-22
Tule	5-22.13	5-22
Kern County	5-22.14	5-22
Squaw Valley	deleted	5-24
Cedar Grove Area	deleted	5-72
Three Rivers Area	deleted	5-73
Springville Area	deleted	5-74
Templeton Mountain Area	deleted	5-75
Manache Meadow Area	deleted	5-76
Sacator Canyon Valley	deleted	5-77
Rockhouse Meadows Valley	deleted	5-78
Inns Valley	deleted	5-79
Bear Valley	deleted	5-81

Several basins have been deleted from the Bulletin 118-80 report. In Squaw Valley (5-24) all 118 wells are completed in hard rock. Cedar Grove Area (5-72) is a narrow river valley in Kings Canyon National Park with no wells. Three Rivers Area (5-73) has a thin alluvial terrace deposit but 128 of 130 wells are completed in hard rock. Springville Area (5-74) is this strip of alluvium adjacent to Tule River and all wells are completed in hard rock. Templeton Mountain Area (5-75), Manache Meadow Area (5-76), and Sacator Canyon Valley (5-77) are all at the crest of mountains with no wells. Rockhouse Meadows Valley (5-78) is in wilderness with no wells. Inns Valley (5-79) and Bear Valley (5-81) both have all wells completed in hard rock.

Table 33 Tulare Lake Hydrologic Region groundwater data

Basin/Subbasin	Basin Name	Area (acres)	Groundwater Budget Type	Well Yields (gpm)		Types of Monitoring			TDS (mg/L)	
				Maximum	Average	Levels	Quality	Title 22	Average	Range
5-22	SAN JOAQUIN VALLEY									
5-22.08	KINGS	976,000	C	3,000	500-1,500	909	-	722	200-700	40-2000
5-22.09	WESTSIDE	640,000	C	2,000	1,100	960	-	50	520	220-35,000
5-22.10	PLEASANT VALLEY	146,000	B	3,300	-	151	-	2	1,500	1000-3000
5-22.11	KAWEAH	446,000	B	2,500	1,000-2,000	568	-	270	189	35-580
5-22.12	TULARE LAKE	524,000	B	3,000	300-1,000	241	-	86	200-600	200-40,000
5-22.13	TULE	467,000	B	3,000	-	459	-	150	256	200-30,000
5-22.14	KERN COUNTY	1,950,000	A	4,000	1,200-1,500	2,258	249	476	400-450	150-5000
5-23	PANOCHE VALLEY	33,100	C	-	-	48	-	-	1,300	394-3530
5-25	KERN RIVER VALLEY	74,000	C	3,650	350	-	-	92	378	253-480
5-26	WALKER BASIN CREEK VALLEY	7,670	C	650	-	-	-	1	-	-
5-27	CUMMINGS VALLEY	10,000	A	150	56	51	-	15	344	-
5-28	TEHACHAPI VALLEY WEST	14,800	A	1,500	454	64	-	19	315	280-365
5-29	CASTAC LAKE VALLEY	3,600	C	400	375	-	-	3	583	570-605
5-71	VALLECITOS CREEK VALLEY	15,100	C	-	-	-	-	0	-	-
5-80	BRITE VALLEY	3,170	A	500	50	-	-	-	-	-
5-82	CUDDY CANYON VALLEY	3,300	C	500	400	-	-	3	693	695
5-83	CUDDY RANCH AREA	4,200	C	300	180	-	-	4	550	480-645
5-84	CUDDY VALLEY	3,500	A	160	135	3	-	3	407	325-645
5-85	MIL POTRERO AREA	2,300	C	3,200	240	7	-	7	460	372-657

gpm - gallons per minute
mg/L - milligram per liter
TDS -total dissolved solids

ATTACHMENT D

SB 1938 Advisory Meeting Notice and Minutes

SB 1938 Advisory Meeting
Alta ID Board Room
Thursday, April 9, 2009, 8:00 a.m.

AGENDA

1. Introductions
2. Review of Handouts
    a. Tulare Lake Hydrologic Region
    b. Requirements of 1938 Plan
    c. Alta's AB 3030 Plan
    d. Specific Goals and Objectives
3. Other Items for Discussion

SB 1938 AVDISORY MEETING
ALTA IRRIGATION DISTRICT BOARD ROOM
Thursday, April 9, 2009, 8:00 a.m.

CALL TO ORDER: The first advisory meeting for the SB 1938 groundwater plan was called to order at 8:00am by Chris Kapheim w/AID. Members present were David Cone w/KRCD, Laurel Firestone w/Community Water Center, Jerry Halford w/AID, David Orth w/KRCD, Russ Robertson w/City of Reedley, Dean Uota w/City of Dinuba, Norman Waldner w/AID, Jim Wegley w/Keller Wegley Engineering, Steve Worthley w/Tulare County and Mike Ayala w/AID.

INTRODUCTIONS: The advisory committee members all did a short self-introduction stating their organization and position.

REVIEW OF HANDOUTS:

Tulare Lake Hydrologic Region: Reviewed existing bulletin

Requirements of 1938 Plan: Committee discussed water quality & groundwater level information, monitoring and reporting plan. The committee discussed integrating regional goals and objectives from the Upper Kings IRWMP to correspond with the District's SB 1398 plan. Furthermore, it was discussed that it would be beneficial to also review data from surrounding areas outside of the Kings sub basin.

Additionally, abandoned wells was discussed as a concern that needs to be addressed county wide. Discussion focused on finding cost efficient means to initiate an incentive based program with landowners to give a reasonable time frame to abandon wells; funding and coordination of such efforts will require further input.

Water Quality Testing was reviewed, with nitrates being a principal concern. KRCD will evaluate current irrigation efficiency analysis to include nitrate testing of pumps.

The Committee reviewed Alta's water quality monitoring efforts for nitrates and DBCP and discussed the County's efforts in nitrate monitoring.

Alta's AB 3030 Plan: Alta's current groundwater plan was reviewed

Specific Goals and Objectives: Reviewed potential goals and objectives:

1. Evaluate a coordinated effort to increase groundwater pumping for irrigation purposes in the impacted area. This could result in a reduction in surface water to lands overlying the lands lying easterly of the communities. Excess pumping would remove the contaminated water for surface irrigation of crops and create a cone of depression away from the domestic wells;

2. Hold workshops with the farm advisor to encourage more effective utilization of fertilizers;

3. Actively encourage implementation of Tulare County's program for locating and properly abandoning of groundwater wells;
4. Work and coordinate efforts with interested parties, i.e., extension service, academic experts, etc., to identify potential sources of contamination;

5. Develop a program with the farm operators and testing laboratories to evaluate nitrate applications on individual parcels;

6. Use various media sources to disseminate information on fertilizer application, problems and availability of programs to assist farm operators;

7. Search out funding sources to work with and develop programs for farm operators; and

8. Evaluate a coordinated effort to alter surface water supplies/groundwater pumping available to the lands to more effectively manage groundwater movement to minimize the degradation to water quality.

ADDITIONAL ITEMS FOR DISCCUSSION: Information will be forwarded to the committee to be reviewed prior to further discussion.

ADJOURNMENT: There being no further items to discuss the meeting was adjourned until the next Advisory Meeting.

Sincerely,

Chris M. Kapheim
SB 1938 Advisory Committee

CMK: ma

ATTACHMENT E

Table 111-1, KRCD Surface Water Study (1991)

Table III-1
Alta I.D. Canal Seepage for Wet (1984) and Dry (1990) Years

Canal Name	Length (mi)	Seepage (cfs)	1984 Seepage (AF)	1984 Seepage % of Diversion	1990 Seepage (AF)	1990 Seepage % of Diversion
Alta Main	8.9	11.2	3,592	1.7%	1,071	1.8%
A.B. Clark	4.4	2.5	810	0.4%	242	0.4%
A.N. Smith	1.8	0.2	62	0.0% *	18	0.0% *
A.W. Clark	2.9	0.6	186	0.1%	56	0.1%
Andrews	2.5	0.4	130	0.1%	39	0.1%
Ballard	2.8	0.2	79	0.0% *	23	0.0% *
Banks	17.7	4.4	1,409	0.7%	151	0.3%
Bowhay	3.1	1.1	336	0.2%	100	0.2%
Bump & Edmiston	1.8	0.2	64	0.0% *	19	0.0% *
Button	15.0	4.2	1,345	0.6%	281	0.5%
Buttonwillow	11.0	8.9	2,830	1.3%	844	1.4%
Caesar	5.3	4.4	1,397	0.7%	417	0.7%
California Vineyard	6.9	6.1	1,938	0.9%	578	1.0%
Cary-Hunter	7.7	2.8	885	0.4%	263	0.5%
Carpenter	1.2	0.0	10	0.0% *	3	0.0% *
Clapp	1.5	0.0	5	0.0% *	2	0.0% *
Clements	4.0	2.1	667	0.3%	199	0.3%
Clough	3.9	1.6	502	0.2%	15	0.0% *
Cross Creek W.W.	1.9	0.4	129	0.1%	4	0.0% *
Curtis Cutoff	1.5	0.5	155	0.1%	46	0.1%
Lower Curtis Cutoff	0.9	0.2	73	0.0% *	22	0.0% *
Upper Curtis Cutoff	1.0	0.1	19	0.0% *	6	0.0% *
Dinuba Town	8.8	4.7	1,507	0.7%	449	0.8%
East Branch	15.5	18.0	5,753	2.7%	1,715	2.9%
East Gould	1.5	0.1	31	0.0% *	9	0.0% *
East Reedley	5.5	1.8	563	0.3%	168	0.3%
East Section 20	1.2	0.1	20	0.0% *	6	0.0% *
Elter	2.5	0.1	38	0.0% *	11	0.0% *
Floyd	1.5	0.1	42	0.0% *	13	0.0% *
Frane	1.4	0.0	3	0.0% *	1	0.0% *
Gordon	1.0	0.1	41	0.0% *	12	0.0% *
Grove	1.7	0.0	16	0.0% *	5	0.0% *
Haden & Boone	2.7	0.4	141	0.1%	42	0.1%
Hogan	2.1	0.1	37	0.0% *	11	0.0% *
Horseman	5.0	1.7	550	0.3%	164	0.3%
J.T. Williams	2.4	0.0	9	0.0% *	3	0.0% *
Jack	1.2	0.3	103	0.0% *	31	0.1%
Kennedy School Hous	5.0	0.3	82	0.0% *	24	0.0% *
Kennedy Waste Way	7.3	3.7	1,166	0.5%	347	0.6%
King	4.4	3.1	979	0.5%	206	0.4%
Kirk	1.7	0.3	84	0.0% *	25	0.0% *
Knestric	5.6	0.8	254	0.1%	76	0.1%
Loper	3.2	0.5	162	0.1%	48	0.1%
Lovell	2.0	0.4	136	0.1%	41	0.1%
McBriar	2.0	0.0	8	0.0% *	2	0.0% *
McClanahan	5.9	4.8	1,527	0.7%	446	0.8%
Mc Gee	1.9	0.2	54	0.0% *	16	0.0% *
Monson	7.0	3.5	1,128	0.5%	336	0.6%
Montague	1.3	0.2	52	0.0% *	16	0.0% *
Mt. Campbell	3.7	1.5	466	0.2%	139	0.2%
Nichols-Cann	1.9	0.0	6	0.0% *	2	0.0% *
Nuss	1.2	0.0	2	0.0% *	1	0.0% *
Orosi School House	3.2	0.9	279	0.1%	83	0.1%
Parenti	1.3	0.0	4	0.0% *	1	0.0% *
Parks	1.5	0.2	78	0.0% *	23	0.0% *
Peck	0.6	0.0	2	0.0% *	0	0.0% *
Red Williams	1.5	0.2	67	0.0% *	10	0.0% *
Reedley Main	3.0	2.9	917	0.4%	273	0.5%
Reo	1.5	0.2	63	0.0% *	19	0.0% *
Rice-Brubaker	2.2	0.3	99	0.0% *	30	0.1%
Sandridge	2.9	0.4	140	0.1%	42	0.1%
Segrue	0.3	0.0	1	0.0% *	0	0.0% *
Smith Mountain	9.3	3.1	977	0.5%	291	0.5%
Sontag	6.7	0.2	59	0.0% *	14	0.0% *
Tout	6.0	1.4	439	0.2%	131	0.2%
Traver Creek	10.1	12.1	3,878	1.8%	1,156	2.0%
Traver Canal	12.3	21.6	6,910	3.2%	1,788	3.1%
Uphill	0.6	0.0	2	0.0% *	0	0.0% *
Van Noy	2.2	0.3	96	0.0% *	18	0.0% *
Wahtoke	5.1	0.7	224	0.1%	67	0.1%
Weisse	1.0	0.3	80	0.0% *	2	0.0% *
West Gould	4.9	0.9	281	0.1%	84	0.1%
West Reedley	5.6	1.4	442	0.2%	132	0.2%
West Section 20	1.8	0.1	26	0.0% *	8	0.0% *
Wilson	10.7	7.0	2,220	1.0%	662	1.1%
Wilson Hunter	1.5	0.5	151	0.1%	45	0.1%
Wilson School House	3.4	0.9	287	0.1%	85	0.1%
Windsor	1.3	0.0	3	0.0%	1	0.0%
Total	316.7	154	49,306	23.1%	13,727	23.6%

Note: * indicates that canal seepage is less than 0.05% of Alta's total district diversion.

ATTACHMENT F

Table 9, Future District Operating Budget –

Engineers Report Proposition 218 Procedures (2005)

TABLE 9
FUTURE DISTRICT OPERATIONAL BUDGETS

Volumetric Water Surcharge	**$3.65**	**$3.76**	**$3.90**	**$4.10**
Fiscal Year	**06/07**	**07/08**	**08/09**	**09/10**
Water Run Revenues				
Water Surcharge	$ 365,000	$ 376,000	$ 390,000	$ 410,000
Water Surcharge Penalty	500	500	500	500
Pine Flat Power Income 50%	84,476	84,476	84,476	84,476
Total Water Run Revenues	$ 449,976	$ 460,976	$ 474,976	$ 494,976
Water Run Costs				
Maintenance Ditchtender Trucks	$ 8,000	$ 8,400	$ 8,800	$ 9,200
Fuel - Ditchtender trucks	30,000	33,000	36,000	39,000
Cell Phone - Ditchtenders	6,000	6,000	6,000	6,000
Answering Service	400	400	400	400
Algicide	24,000	24,000	24,000	24,000
Operational Payroll	263,423	270,535	277,840	285,342
Payroll Tax/Benefits	84,885	87,177	89,531	91,948
Drop Boards	6,100	6,400	6,800	7,200
Total Water Run Costs	$ 422,808	$ 435,913	$ 449,371	$ 463,090
Add reserves for maintenance of pipelines	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Net Operational Cash Flow	$ 2,168	$ 63	$ 605	$ 6,886

ATTACHMENT G

Water Banking Annual Report (2009)

ALTA IRRIGATION DISTRICT

WATER BANKING

2009 ANNUAL REPORT

Adopted 03/11/2010

TABLE OF CONTENTS

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Glossary of Terms _____ *11*

Water Banking Implementation Strategy

Project Yield: Project Yield is determined by measuring the water efficiency benefits of the project which result in a measured volume of conserved water. The basic premise of the program is that it is efficient from a water management perspective to make water deliveries at the lower end of the system from a localized source in the vicinity of the targeted water deliveries rather than delivering water more than 38 miles from the Kings River from AID's storage account in Pine Flat Reservoir. System readjustments and changing variables of demand diminish the efficiency of system deliveries from the Kings River by a factor of two (2).

It would take at least twice the volume of releases from the Kings River to meet surface water demands down steam from localized project sources in the lower reaches of the District. Localized projects can more efficiently meet surface water demands by pumping groundwater that was previously recharged. As a result, the water management efficiency for that delivery has been shown to require a 50% of the water release required to meet localized surface water demands. Making water deliveries from a localized source allows for greater system flexibility and water use efficiency with an end result of more reliable deliveries.

Water Resource Benefits: The Project Yield for Harder and Traver Banking Projects is to be used to address long-term water resource issues within the District. Long-term, where the planning horizon is more than five years, water will be developed for water transfers to meet Cutler-Orosi surface water demands. Short-term, where the planning horizon is less than five years, water will be developed for water transfers to address and improve water use efficiency issues for groundwater or surface water, i.e., Wahtoke Lake Pumping Project.

Available Recharge: Water available for recharge is the total water recharged in the project basins minus fifteen percent minus the extracted water. It is the intent to coordinate pumping during the mid-week periods of Tuesday through Friday to compliment enhanced irrigation demand during the mid-week period. During the non-operational irrigation period, water will be transferred from the East Branch to the Traver Canal via the Willow Creek Project to supply flows to Harder and Traver Banking Projects. The origin of Willow Creek flows is eastside watershed and the measured volume of water utilized shall be accounted for accordingly. In addition, there will also be inflow from the Kings River Watershed that will be accounted for in the water banking program.

Banking Advisory Committee

ATTENDANCE :

Chris Kapheim, Alta ID (GM)
Tom Marshall, Alta ID (Board Member)
Jim Wegley, Alta ID (Consulting Engineer)
Mike Swanson, landowner
Robert Jackson, landowner
Brad Jones, landowner
Jason George, landowner

DISCUSSION:

Chris Kapheim gave a general overview of the Harder Pond and proposed Traver Banking projects and their relative importance to the region. It was emphasized that monitoring data would be shared with Advisory Committee members to encourage information sharing and questions on the banking process. It is anticipated that there will be at least one annual meeting to review the performance of banking projects. Projects will allow water to be recharged in designed projects that will enable the District to address (i) uncontrolled flood flows, (ii) enhance groundwater recharge, (iii) improve water deliveries to downstream landowners from a groundwater source, and (iv) improve the District's water balance (new water) by being able to capture previously uncontrolled sources of water with application to a beneficial use. Furthermore, it was stated that of recharged water, at least 15% would be designated for recharge. Of the water to be extracted for landowner deliveries, such extracted water would be used incrementally to provide better service to landowner demands where it can be shown that there would be no negative influence on neighboring wells. Monitoring would be designed to show operational use of the banking process and resulting groundwater impacts, i.e., landowner groundwater and banking groundwater.

Discussion focused on the need for groundwater extraction. It was mentioned that there will be two wells located at each of the project sites. Water will not be extracted until sufficient groundwater recharge has taken place. It was further explained, that at some District projects (London Pond, Avenue 384) diversion pumps deliver stored water from basins to meet demand from downstream landowners. The London Pond site, based on its soil characteristics, recharges very slowly thus enabling the District to use the stored water for reregulation purposes. Both the Harder Pond and Traver pond have greater recharge potential thus storing the water in the soil aquifer and pumping on demand when necessary has been incorporated into their design features. It was also emphasized that efforts would be implemented to enhance sources of water to banking locations. On wet water years summer flows and winter flows would be utilized.

Banking Advisory Committee

ATTENDANCE:

Chris Kapheim, Alta ID (GM)
Tom Marshall, Alta ID (Board Member)
Jim Wegley, Alta ID (Consulting Engineer)
Dean Thonesen, landowner
Brad Jones, landowner
Mike Swanson, landowner

NOT IN ATTENDANCE:

Brent Smittcamp, landowner

DISCUSSION:

1. Review of the AID Banking Program.

The banking program consists of developing recharge and extraction sites that provide the following benefits: groundwater recharge, flood control, enhanced surface water efficiency and address water quality issues. Water delivered from the Kings River to the lower reaches of the AID has limitations in terms of timing with ordered demands, changes in environmental conditions (weather) and distance from inception to destination (approximately 38 miles). As a result, it has been determined that it is more efficient to store surplus waters in engineered basins and extract necessary volumes to meet demand as opposed to delivering water over extended distances that in some cases take two to three days from the Kings River to landowner delivery. As a result, extracted water from the banking project (Pumping) has a conserved value or Project Yield of twice the amount pumped. The Project Yield is the water available to address groundwater water quality issues in the easterly portion of AID, i.e., Cutler-Orosi areas. Furthermore, the program will take advantage of wintertime storm water flows. Such storm water flows will be recharged into Harder, Dinuba & Traver Pond recharge basins.

2. Review of the Harder Pond Banking Annual Report

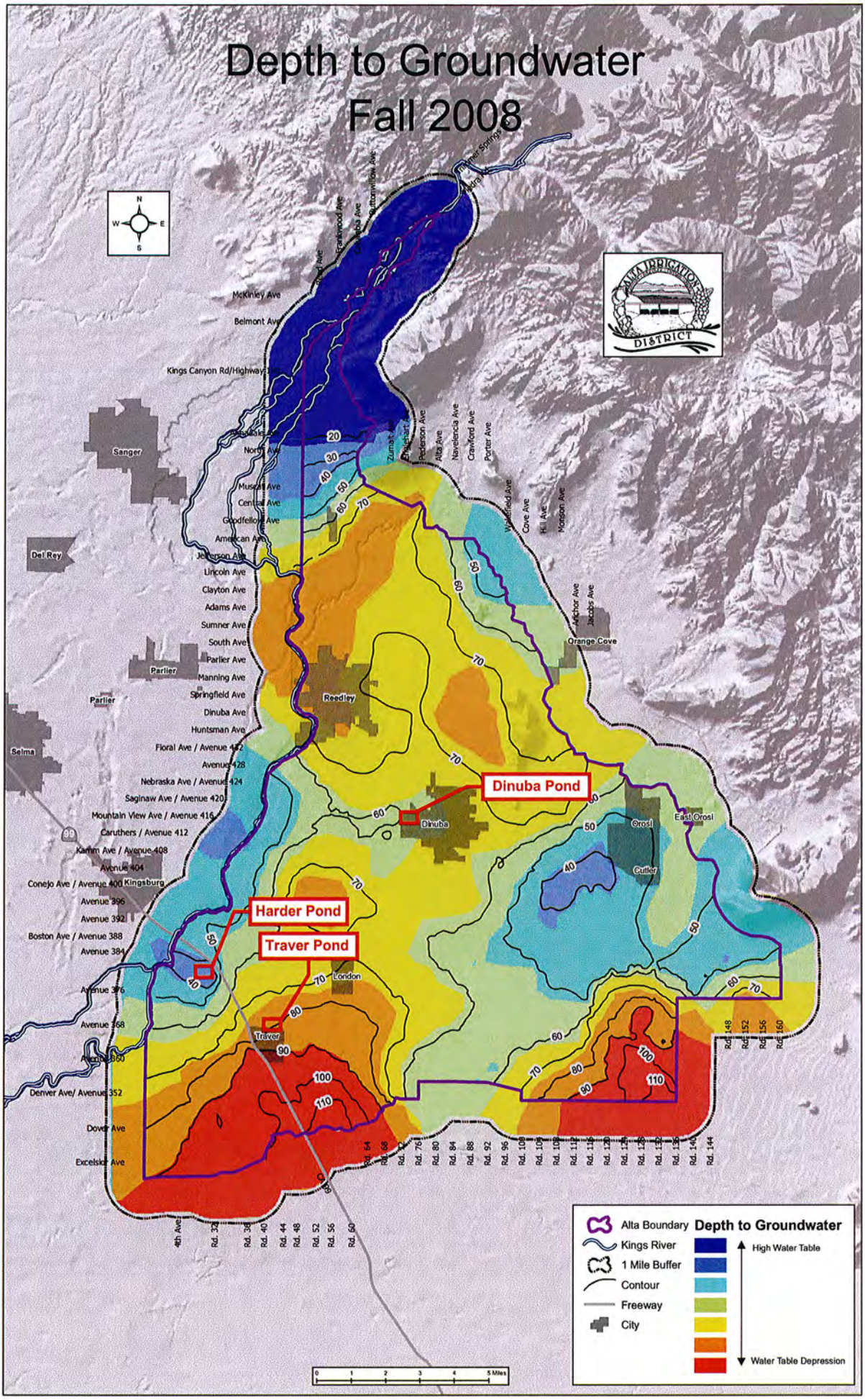
Discussion was held on the review of past practices and results for years 2008 and 2009 for AID's water banking program. AID showed data that illustrated the amount of water recharged in 2008, 563 acre-feet, and an additional 399 acre-feet in 2009. In 2009 188 acre-feet was extracted from the Harder Pond Banking Project. The result for 2009 was that forty-seven percent (47%) of the water recharged in the basins was extracted leaving a remainder of fifty-three percent (53%) for recharge. It was further discussed that in the future AID would extract up to eighty-five (85%) of the recharged water in the basins.

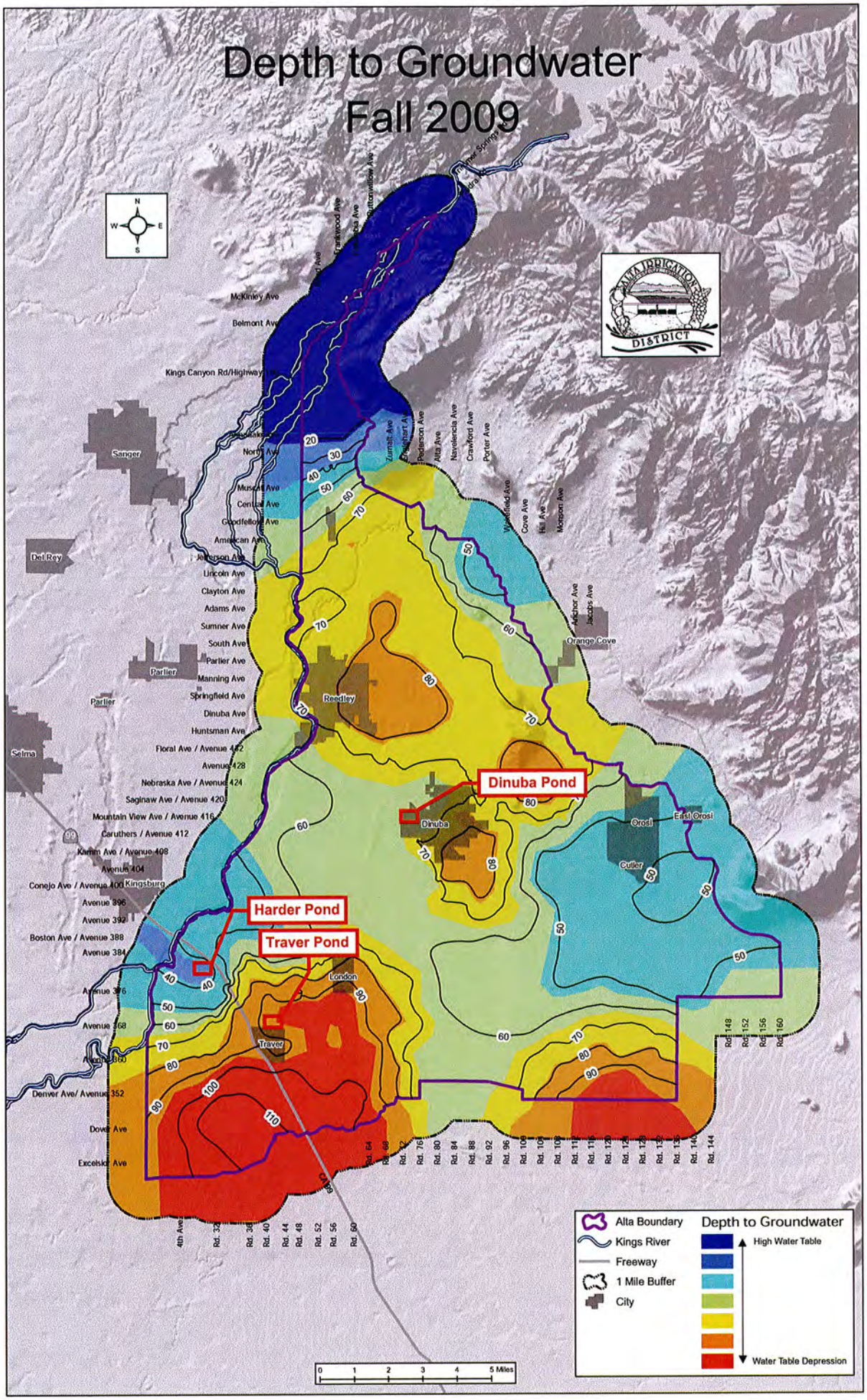
AID did review the monitoring of project wells and adjacent landowners wells. The results thus far illustrate no negative impacts of water extractions from the project site.

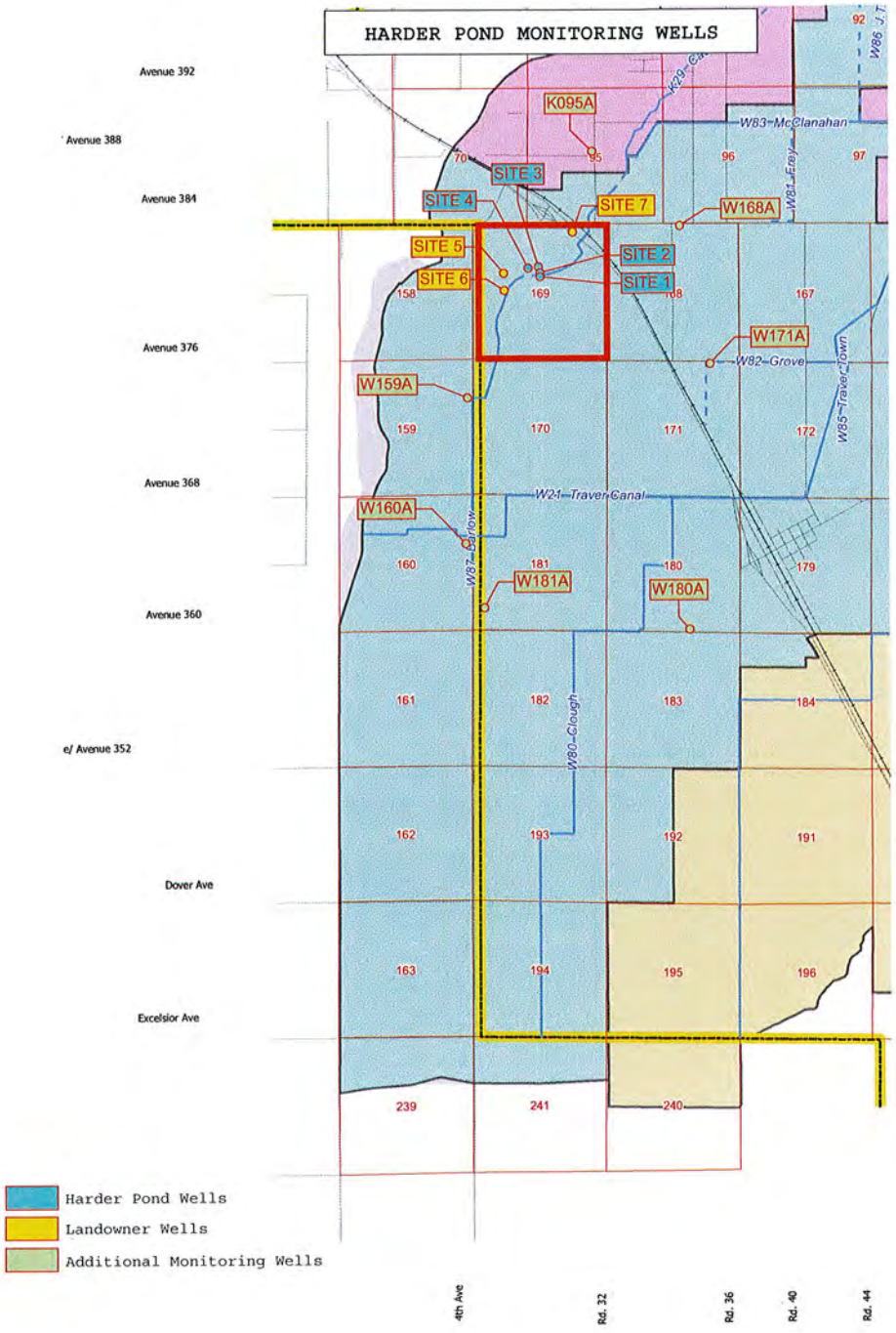
A review of regional benefits was discussed in terms of utilization of conserved water from the project and use on an interim basis. In 2009, 113.30 acre-feet was sold to a landowner that was experiencing groundwater limitations.

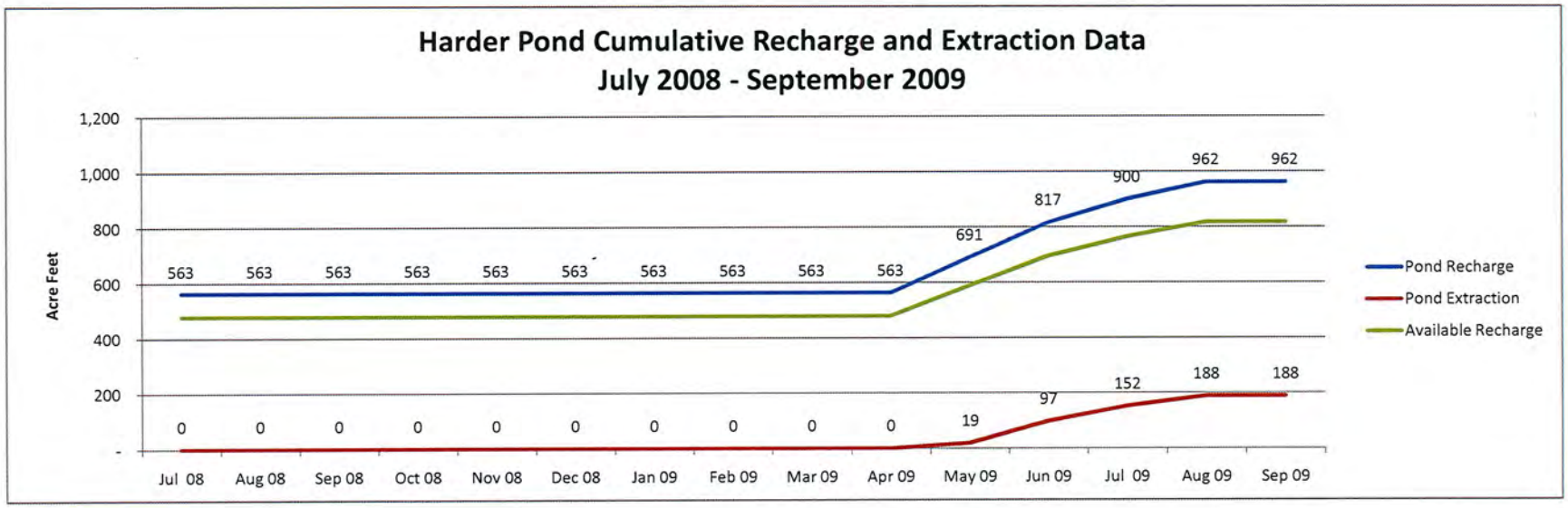
3. Review of the Traver Banking Project:

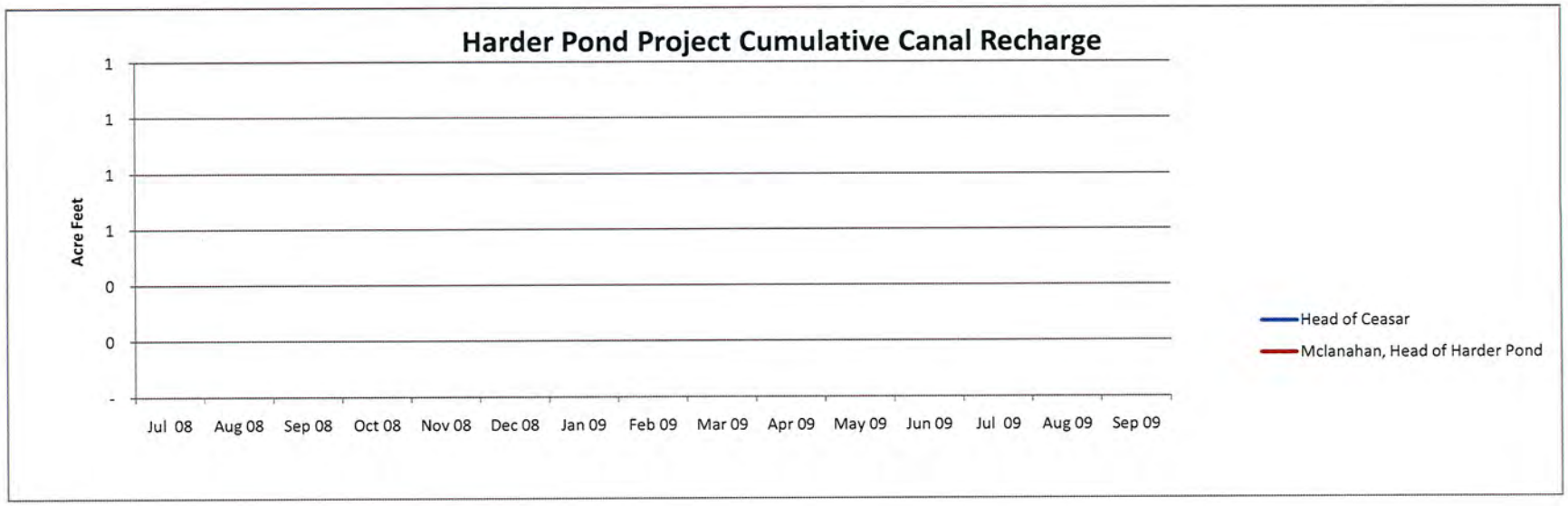
AID will be closing escrow in February of 2010 on the Anderson Property (28 acres) in the vicinity of Road 44 and 376. Discussion of how the project will operate and improve water resource flexibility.

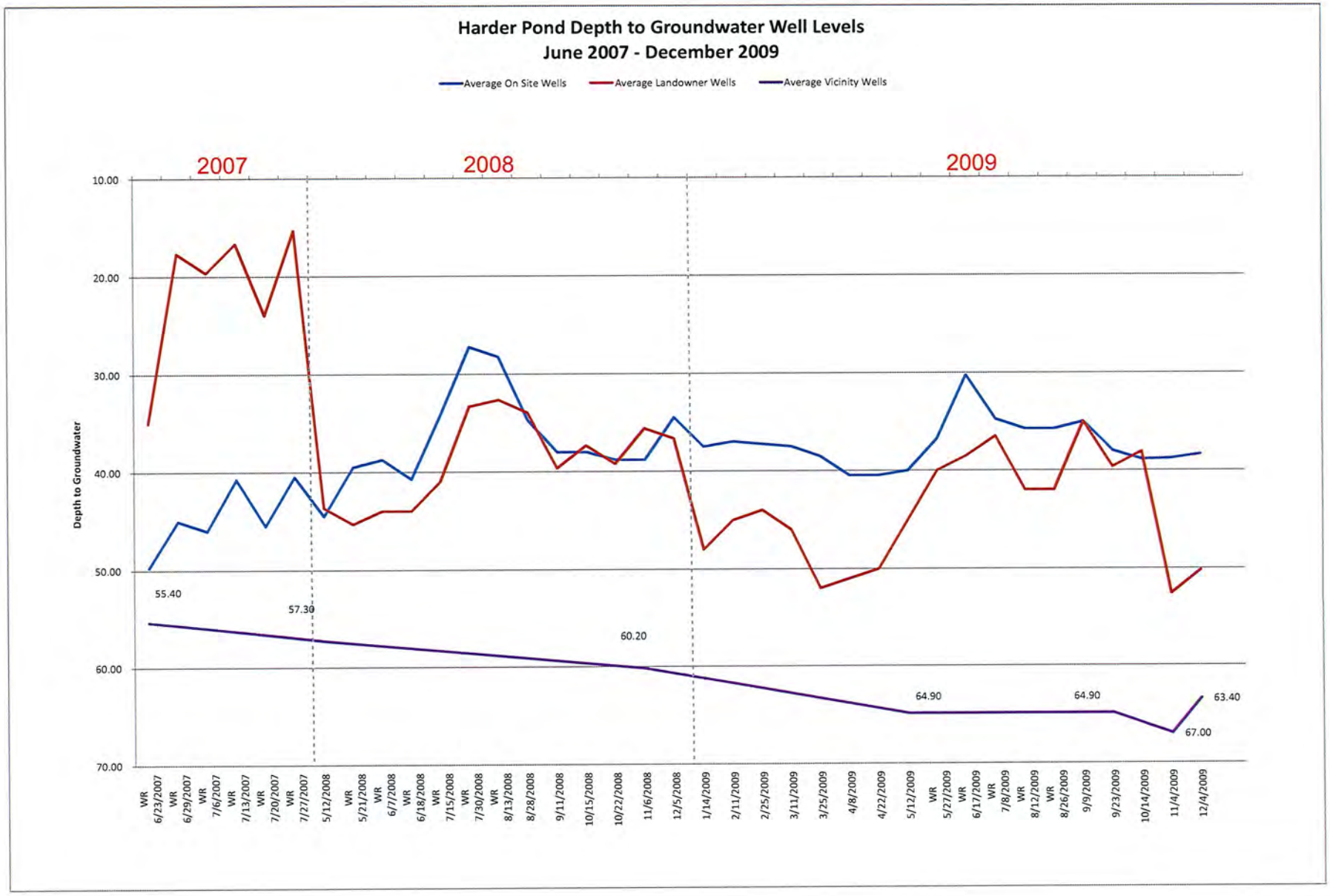

Depth to Groundwater
Fall 2008
ALTA IRRIGATION DISTRICT
Dinuba Pond
Harder Pond
Traver Pond
Sanger
Del Rey
Parlier
Selma
Reedley
Dinuba
Orosi
East Orosi
Cutler
London
Traver
Orange Cove
Kingsburg
McKinley Ave
Belmont Ave
Kings Canyon Rd/Highway 180
Mountain View Ave / Avenue 416
Caruthers / Avenue 412
Boston Ave / Avenue 388
Denver Ave/ Avenue 352
Dover Ave
Excelsior Ave
Alta Boundary
Kings River
1 Mile Buffer
Contour
Freeway
City
Depth to Groundwater
High Water Table
Water Table Depression
0 1 2 3 4 5 Miles


Depth to Groundwater
Fall 2009
Dinuba Pond
Harder Pond
Traver Pond
Sanger
Del Rey
Parlier
Selma
Kingsburg
Reedley
Dinuba
Orosi
East Orosi
Cutler
London
Traver
Orange Cove
McKinley Ave
Belmont Ave
Kings Canyon Rd/Highway 180
Mountain View Ave / Avenue 416
Caruthers / Avenue 412
Boston Ave / Avenue 388
Denver Ave/ Avenue 352
Dover Ave
Excelsior Ave
Alta Boundary
Kings River
Freeway
1 Mile Buffer
City
Depth to Groundwater
High Water Table
Water Table Depression
0 1 2 3 4 5 Miles


HARDER POND MONITORING WELLS
Avenue 392
Avenue 388
Avenue 384
Avenue 376
Avenue 368
Avenue 360
e/ Avenue 352
Dover Ave
Excelsior Ave
K095A
SITE 3
SITE 4
SITE 7
W168A
SITE 5
SITE 2
SITE 6
SITE 1
W171A
W159A
W160A
W181A
W180A
W83-McClanahan
W81-Fray
W82-Grove
W85-Traver-Town
W21-Traver Canal
W87-Barlow
W80-Clough
4th Ave
Rd. 32
Rd. 36
Rd. 40
Rd. 44
Harder Pond Wells
Landowner Wells
Additional Monitoring Wells


Harder Pond Cumulative Recharge and Extraction Data
July 2008 - September 2009
Acre Feet
1,200
1,000
800
600
400
200
-
563 563 563 563 563 563 563 563 563 563 691 817 900 962 962
0 0 0 0 0 0 0 0 0 0 19 97 152 188 188
Jul 08 Aug 08 Sep 08 Oct 08 Nov 08 Dec 08 Jan 09 Feb 09 Mar 09 Apr 09 May 09 Jun 09 Jul 09 Aug 09 Sep 09
Pond Recharge
Pond Extraction
Available Recharge


Harder Pond Project Cumulative Canal Recharge
Acre Feet
1
1
1
1
0
0
-
Jul 08 Aug 08 Sep 08 Oct 08 Nov 08 Dec 08 Jan 09 Feb 09 Mar 09 Apr 09 May 09 Jun 09 Jul 09 Aug 09 Sep 09
Head of Ceasar
Mclanahan, Head of Harder Pond


Harder Pond Depth to Groundwater Well Levels
June 2007 - December 2009
Average On Site Wells
Average Landowner Wells
Average Vicinity Wells
2007
2008
2009
Depth to Groundwater
10.00
20.00
30.00
40.00
50.00
60.00
70.00
55.40
57.30
60.20
64.90
64.90
63.40
67.00
WR 6/23/2007
WR 6/29/2007
WR 7/6/2007
WR 7/13/2007
WR 7/20/2007
WR 7/27/2007
5/12/2008
WR 5/21/2008
WR 6/7/2008
WR 6/18/2008
WR 7/15/2008
WR 7/30/2008
WR 8/13/2008
8/28/2008
9/11/2008
10/15/2008
10/22/2008
11/6/2008
12/5/2008
1/14/2009
2/11/2009
2/25/2009
3/11/2009
3/25/2009
4/8/2009
4/22/2009
5/12/2009
WR 5/27/2009
WR 6/17/2009
WR 7/8/2009
WR 8/12/2009
WR 8/26/2009
9/9/2009
9/23/2009
10/14/2009
11/4/2009
12/4/2009

Harder Pond Summary and Conclusion

In May of 2008, during the 2009 operational season (water run) water recharge was initiated at the Harder Pond Project ("Project"). Measured flows at the Harder Pond were used to meet downstream agricultural demand with excess flows being recharged in on-site basins. From May through August of 2008 water was recharged with no extraction of recharged water resulting in 562.9 acre-feet of recharged water credited to the Project. The following winter months resulted in less than average rainfall and snowpack thus precluding the recharge of storm water in the Project.

2009 Water run deliveries were initiated on May 14, 2009 and continued until August 28, 2009. Measured recharged water for the period was 399.3 acre-feet. During the same period 188.31 acre-feet of water was extracted from the Project. For the 2009 water run, the ratio of recharged water to extracted water is forty-seven percent. The pre-determined cumulative maximum recharge to extraction ration for the project is eighty-five percent. As a result, the Project recharge to extraction ratio was well under the allowable maximum.

In review of the Harder Pond Depth to Groundwater Levels (June 2007 – December 2009), adjacent area groundwater levels have dropped from 20 feet in June 2007 to 50 feet in November of 2009. The drop in depicted surrounding groundwater levels is primarily due to less than average water years resulting in lower precipitation and snowpack levels thus reducing surface water deliveries and increasing agricultural groundwater pumping. There was no correlation of groundwater pumping from the Project enhancing the decline of adjacent area groundwater levels. Harder Pond depth to groundwater levels for 2008 and 2009 ranged in the 30 to 40 feet range which is higher than surrounding groundwater levels (see attached Harder Pond Depth to Groundwater Levels on page 6).

Harder Pond Regional Benefits

The Available Recharge water from the Hard Pond Project ("Project") will have short-term and long-term regional benefits. Ultimately, the Available Recharge from the Project will be used to address water quality and supply issues in the easterly portion of the District, i.e., Cutler and Orosi areas. On a short-term basis the Available Recharge can be used to address other local water resource issues.

In 2009, local groundwater resources in the vicinity of Smith Mountain, within the District, experienced significant groundwater limitations. A landowner desired to acquire additional surface water supplies to mitigate groundwater pumping near Smith Mountain. As a result, 500 acre-feet of water was sold from the Project to mitigate the Smith Mountain groundwater impacts. In 2009 operational season, 113.30 acre feet were delivered to landowners with the balance available the following year's operational season.

Financial Data on Harder Pond
For Year Ending 09/30/09

PGE pump costs (2 meters)

10/2008	$	-
11/2008	$	-
12/2008	$	-
1/2009	$	-
2/2009	$	322.14
3/2009	$	115.87
4/2009	$	651.85
5/2009	$	110.43
6/2009		
7/2009	$	1,413.05
8/2009	$	1,195.97
9/2009	$	1,010.47
	$	4,819.78

PGE Power	$	4,819.78
Engineering	$	317.09
Well Monitoring	$	4,069.00
Cash Expenses	$	9,205.87
Depreciation	$	41,263
Total Expenses	$	50,468.54

Engineering (Management)

9/2009	$	317.09
	$	317.09

Well Monitoring

	Quantity	Miles (RT)	Hours		Rate		Total
Vehicle	26	30	0	$	0.55	$	429.00
Employee	26		4	$	35.00	$	3,640.00
						$	4,069.00

based on bi-weekly well monitoring, supervisor rates

5 years on SCADA
15 years on pumps
40 years for everything else

Depreciation

		5 Year	15 Year	40 Year	Not Depreciable
Land	$ 134,817.81				$ 134,817.81
Extraction Wells and Pumps	$ 189,229.08		$ 100,000.00	$ 89,229.08	
Flow Measurement and SCADA	$ 73,250.80	$ 73,250.80			
Monitoring Wells	$ 33,699.03			$ 33,699.03	
IRTC Flap Gates	$ 16,397.00			$ 16,397.00	
Other	$ 658,508.79			$ 658,508.79	
	$ 1,105,902.51	$ 73,250.80	$ 100,000.00	$ 797,833.90	$ 134,817.81

Annual Depreciation

1-5 years	$	41,262.67
6-15 years	$	26,612.51
16-40 years	$	19,945.85

GLOSSARY OF TERMS

A. Project Yield (PY)

= Conserved Water = Water Available for Transfers
= 2x Pumped Water (PW)
PY=2xPW
50% efficiency from Non Project source, i.e. Kings River

B. Available Water Resource Benefits (AWRB) Long/Short Term

Long Term > 5 years - Water Transfers available for Cutler/Orosi
Short Term > 5 years - Water Transfers available to address/improving water use efficiency
WRB = Project Yield less Water Transferred Delivered
WRB = 2x Pumped Water less Water Transferred Delivered
WRB = 2xPW – WTD

C. Water Transferred (WT)

Total amount of water transferred

D. Water Transferred Delivered (WTD)

Total amount of water transferred measured to date

E. Water Transferred Outstanding Balance (WTOB)

= WT – WTD

F. Available Recharge (AR)

Tracked by water shed = Water Availability
= Meter Readings into the pond, less 15% protected recharge, less pumped water
AR = MR-(.15xMR) – PW
AR = .85MR – PW

G. Project Recharge to Extraction Ratio must be less than 85%

H. Canal Recharge (CR)

Accrued during non operational season
CR = Meter reading at the Head of the Caesar – Meter Reading into the Pond

I. Kings River Water Shed – All water attributed to the Kings River Water Shed

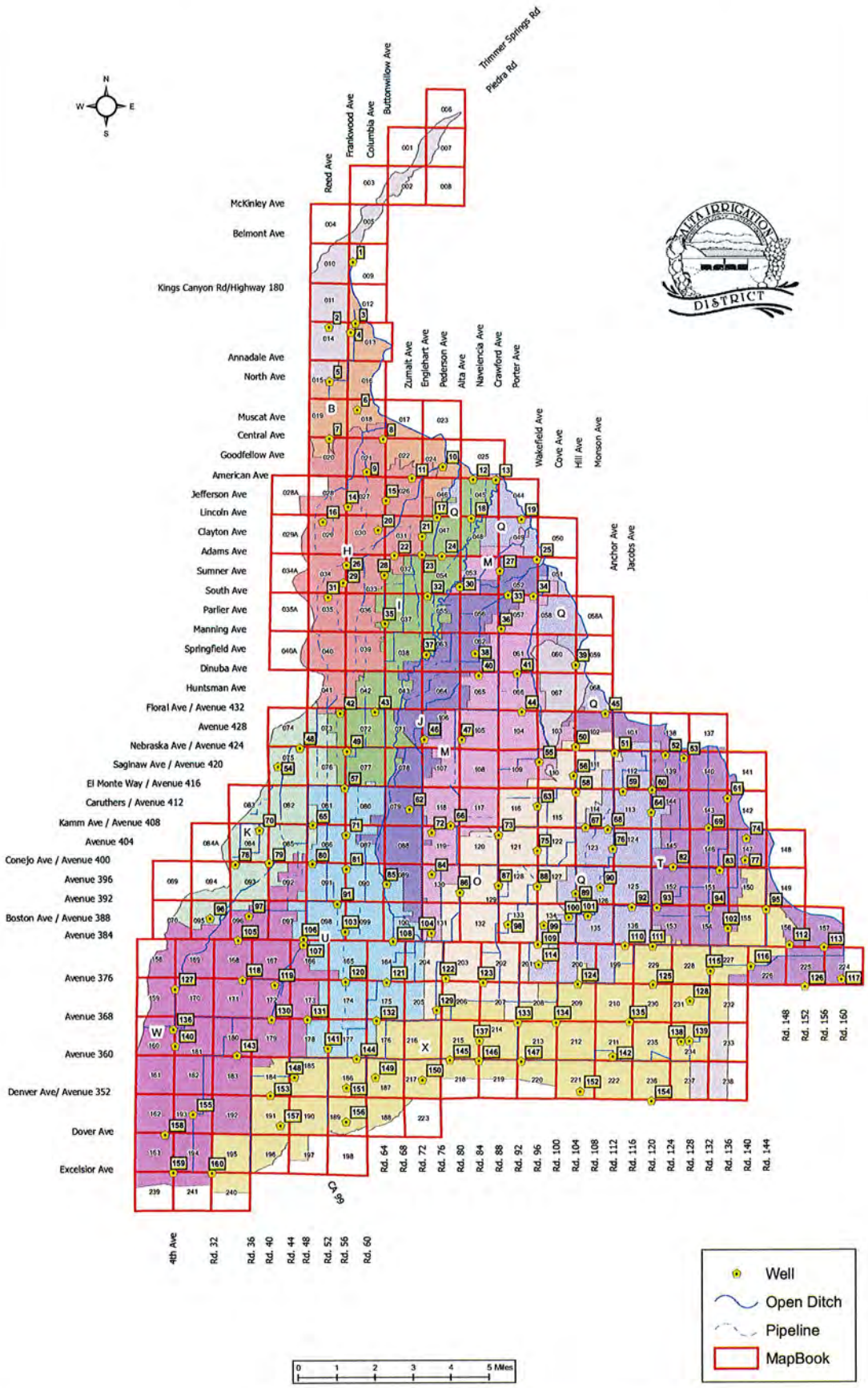
J. Non-Kings River Watershed

Wet Year, watershed attributed to Willow Creek flows

ATTACHMENT H

Map of Monitoring Well Locations

Depth to Groundwater Monitoring Wells



ATTACHMENT I

Section 5 Goals and Objectives, Upper Kings Basin IRWMP

CHAPTER 5 GOALS AND OBJECTIVES

An explanation of the regional planning process and overall integration strategy used to develop the Upper Kings Basin IRWMP is provided in this section along with the description of the goals and objectives. This IRWMP provides a planning framework and management structure from which local water management policies, projects, and programs can be formulated, evaluated, integrated, and implemented. The Water Forum first worked to develop a consensus on the regional problems, issues, and potential conflicts. Goals and objectives were then established to address these issues and to set the stage for the development of the projects, programs, and actions. A planning framework and integration strategy was defined to help the Water Forum work with stakeholders to prioritize projects and alternatives to be included in the IRWMP.

5.1 PROCESS OF DETERMINATION OF REGIONAL PLANNING ISSUES, GOALS, AND OBJECTIVES

The Water Forum worked through the fall of 2003 and winter of 2004 to identify priority problems and issues, and generate a consensus on the purpose and need for the IRWMP. A number of existing information sources, as listed below, were reviewed during this process:

- The original MOU adopted in May 2001 by the DWR, KRCD, AID, CID, and FID;
- The Water Forum Concept Paper (2004);
- Basin Assessment Report (WRIME, 2003b); and
- IRWMP Guidelines (DWR, 2004).

On the basis of the above review, the Water Forum members developed the IRWMP goals, regional planning objectives, and specific water management objectives for the region. These goals and objectives were adopted at the February 2004 Water Forum meeting. These were forwarded to each of the stakeholder groups for consideration before adopting the Resolution of Support for the IRWMP.

5.2 REGIONAL PROBLEMS, ISSUES, AND CONFLICTS

Water Forum participants have identified and developed consensus on priority problems, issues, and sources of potential conflicts in the Kings Basin.

5.2.1 GROUNDWATER OVERDRAFT

Overdraft of the groundwater resource is the primary problem to be addressed in the Upper Kings Basin IRWMP. Overdraft provides a unifying theme for the IRWMP and is the major "driver" for the planning process. The Basin Advisory Panel (BAP) composed of original MOU partners documented that the Kings groundwater basin was in overdraft condition (WRIME, 2003) and recommended that the Water Forum support development of the Kings IGSM to provide a tool to analyze the regional water budget and quantify the nature and extent of overdraft. The Kings IGSM was developed and applied under direction of the Water Forum's Technical Analysis and Data Work Group. The Kings IGSM provides the scientific and technical basis for quantifying the current and potential future overdraft (WRIME 2007b). The area water budget and model results are further explained in Chapter 4 and in Appendix B.

The model and related technical work helped the Water Forum by providing data and analysis results to conclude that the primary water management goal should be to "halt and ultimately reverse the current overdraft of the groundwater aquifer". It is expected that attainment of this goal would "lead to overall maintenance or improvement in the quantity, quality and cost of development of groundwater resources in the region." The continued overdraft over a long period has resulted in the loss of groundwater supply in some areas in the eastern part of the Kings Basin and is not sustainable.

Overdraft increases the competition for the available supply and creates conflicts between agricultural, environmental, and urban water users, and between geographic areas within the region. Declining groundwater levels and groundwater migration across jurisdictional boundaries are also a potential source of increased conflict. In addition, site-specific issues associated with groundwater quality, groundwater recharge, and the need for water and wastewater management facilities to address overdraft have been identified as high priority issues.

5.2.2 WATER SUPPLY RELIABILITY

Water demand has exceeded the available surface and groundwater supplies as they are currently developed and managed with the existing capital facilities and institutional arrangements. A reliable surface water supply is not assured in normal and dry years. Groundwater makes up the balance of urban and agricultural water demands when surface water is not available. In addition, some areas in the basin are entirely reliant on groundwater. Therefore, the long-term sustainability and reliability of the surface and groundwater supply must be addressed in the IRWMP.

An improvement in the capture and storage of storm water and flood water both annually (winter storage for summer use) and during multi-year climatic variations (wet year storage to meet dry year demands) will increase the water supply reliability in the region. The ability to utilize the available groundwater storage is contingent upon construction of capital facilities and on agreements for how to operate and manage the available groundwater storage space. The community, through the Water Forum and IRWMP process, seeks to avoid litigation over water resources and to develop a consensus solution for creating sustainable water supplies with minimum environmental impact.

5.2.3 Degradation of Water Quality

Degradation of water quality in parts of the IRWMP Region has the potential to reduce the available supply or increase treatment costs. Also, the migration of poor quality water is a factor in the operation of the groundwater basin. Therefore, existing water quality needs to be maintained or improved to ensure that there is water of acceptable quality to meet current and future agricultural, urban, and environmental requirements. A wide range of local, state, and federal programs, both regulatory and voluntary, need to be better coordinated to avoid additional burdensome regulations and to provide benefits to the region.

5.2.4 Urban Development

Significant urban development is occurring throughout the planning area, placing increased demands on already stressed resources and increasing the potential for conflicts between existing and new water users. Recent legislation requires urban areas to document and prove that long-term water supplies are available. Potential conflicts exist due to inconsistent planning horizons, lack of compatibility between land use and water supply plans, decreased water quality, and increased treatment costs and requirements for both drinking water and wastewater treatment. Urban areas reduce the amount of applied irrigation water and have a potential effect on the amount of groundwater recharge. Urban water use serves to "harden" the water demand and require a reliable supply of high quality water as compared to agricultural uses. Current urban use is not measured in some areas.

5.2.5 Protection of Water Rights

A complex system of water rights exists and is managed by the KRWA on behalf of its 28 members. This water rights system and the associated agreements were put in place to resolve long standing historical conflicts. These agreements demonstrate that local interests can solve and manage conflicts at a local level. The existing agreements, rights, and entitlements

will provide the basis for further basin planning and management because the protection of existing rights is a premise for the IRWMP planning effort and is required to avoid conflicts.

Overlying groundwater rights must also be protected to avoid conflicts. Agreements, similar to those that are used in surface water management, need to be developed for the operation of the groundwater basin and any potential groundwater management facilities for recharge and storage.

5.2.6 Sustaining the Agricultural Economy

The Kings Basin is a rich agricultural region, and agriculture is a pillar of the local economic and cultural landscape. Agricultural interests developed and paid for many of the local water supply facilities and hold some of the most senior water rights in the Kings Basin. Agricultural and urban users have differences in the ability to pay for new water supplies. Existing agricultural land uses need to be protected to avoid conflicts associated with water and land use conversions.

5.2.7 Protection of Life and Property from Flooding

Major storm events have the potential for impacts to existing land use. Regional and local flood control facilities may need improvement to better manage flood runoff and protect existing or proposed land uses. Urbanization increases impervious areas and therefore, will increase runoff, which will have impacts on existing drainage, water delivery infrastructure, and downstream agricultural land uses. Cities and water districts need to work together to avoid these impacts and plan for long-term regional flood control solutions.

5.2.8 Protection of the Environment

Community and social programs designed to protect or enhance environmental conditions must be identified and factored into project designs. Environmental protection goals and objectives may be in conflict with other economic development goals and objectives. Integrated solutions to land use and water supply issues also need to factor in potential ecosystem management benefits and costs. Ignoring ecosystem needs could result in projects that do not meet regulatory requirements, are subject to legal challenge, and therefore are subject to schedule delays, cost overruns, or abandonment.

5.2.9 ENVIRONMENTAL JUSTICE

Environmental justice issues can be a source of conflict for IRWMP projects. Therefore, a scientific and open approach needs to be followed in selecting potential project sites. The project sites will be selected based upon soil conditions, water availability, water delivery facilities, agency coordination, and landowner cooperation. Potential projects in areas, towns, or cities will not be rated and prioritized based upon characters of size, ethnicity, economics, or religious beliefs.

5.3 REGIONAL GOALS AND PLANNING OBJECTIVES

The regional goals and planning objectives were established to guide the development of the IRWMP and the planning process. These objectives also defined how the Kings Basin stakeholders integrated other community values into the process to define water management strategies.

5.3.1 REGIONAL GOALS

The regional goals are the broadest statement of intent or purpose for the IRWMP and are intended to address the primary problems and resource conflicts in the region. The Water Forum consulted and elaborated on the original goals and objectives developed by the Basin Advisory Panel (WRIME, 2003b). The goals of the IRWMP are:

- Halt, and ultimately reverse, the current overdraft and provide for sustainable management of surface and groundwater;
- Increase the water supply reliability, enhance operational flexibility, and reduce system constraints;
- Improve and protect water quality;
- Provide additional flood protection; and
- Protect and enhance aquatic ecosystems and wildlife habitat.

5.3.2 REGIONAL WATER RESOURCES OBJECTIVES

Regional water resources objectives were adopted by the Water Forum to address specifically the water resources issues. They are designed to address the priority water supply problems by integrating land, water, and environmental management strategies that will provide multiple benefits and the greatest return on investment. It should be noted that resolution of the groundwater overdraft is still a primary purpose and unifying theme for the IRWMP. The IRWMP water management objectives are:

- Define local and regional opportunities for groundwater recharge, water reuse/reclamation, and drinking water treatment;
- Develop large scale regional conjunctive use projects and artificial recharge facilities to:
  - Enhance operational flexibility of existing water facilities, consistent with existing agreements, entitlements, and water rights;
  - Improve the ability to store available sources of surface water in the groundwater basin;
  - Capture storm water and flood water currently lost in the region;
  - Provide multipurpose groundwater recharge facilities that provide flood control, recreation, and ecosystem benefits; and
  - Integrate the fishery management plan;
- Promote 'in-lieu' groundwater recharge to reduce reliance on groundwater through reclamation and reuse of treated wastewater, surface water treatment and delivery for municipal drinking water, and delivery of untreated water for agricultural use;
- Negotiate and develop institutional arrangements and cost sharing for water banking, water exchange, water reclamation, and water treatment;
- Design programs to improve water conservation and water use efficiency by all water users;
- Identify interconnections or improvement of conveyance systems to provide multiple benefits; and
- Enhance wildlife habitat through surface water reclamation, recharge, and treatment facilities.

5.3.3 Regional Planning Objectives for the Upper Kings Basin IRWMP and Planning Process

The regional planning objectives were adopted by the Water Forum to guide the Upper Kings Basin IRWMP development process. The regional planning objectives reflect community values and acknowledge a range of stakeholder perspectives towards land use, water supply, and environmental resources. Proposed regional planning objectives included:

- Use the Water Forum to help:
  - Create a framework for ongoing regional collaboration and conflict resolution;
  - Coordinate the regional planning process to produce an IRWMP;
  - Define local and regional water management strategies;
  - Evaluate and compare alternatives;

  - Prioritize cost effective local and regional solutions; and
  - Increase public understanding of water management issues.
- Collect and compile water quality baseline data for the region and define opportunities to integrate existing local, state, and federal programs.
- Investigate and resolve legal and institutional issues that may affect project development.
- Identify and pursue sources of funding needed to support project development.
- Compile an inventory of existing water resources plans and policies for the region (including state agencies); include an inventory of local government and water district strategies and initiatives for dealing with water resources problems.
- Develop an integrated hydrologic model to determine regional water budgets, understand how the groundwater basin operates, evaluate and compare alternatives, and support decision making.
- Involve local water districts and land use agencies in generating and confirming the current and future water needs.
- Seek to ensure compatibility and consistency with land use and water supply plans.
- Create and define opportunities to share data and information.
- Develop and implement a community affairs strategy to provide outreach and educate the public and decision makers on water management problems and solutions.
- Evaluate local and regional economic impacts and benefits of proposed projects.
- Identify potential environmental and ecosystem benefits associated with developing the IRWMP.
- Avoid environmental impacts during planning and project design where possible.
- Coordinate needed environmental review of the final alternative projects and programs.

During development of the IRWMP, the Water Forum has realized many of the preliminary planning objectives that were initially established in 2005. The implementation plan contained herein updates the approach to oversight and coordination and establishes long-term strategies for ongoing Water Forum operations. The Water Forum will continue to coordinate stakeholder involvement during implementation of the Upper Kings Basin IRWMP and will use adaptive management to continuously respond to changing circumstances.

ATTACHMENT J

Member Agencies Upper Kings Basin IRWMP Authority

Directors

The Upper Kings Basin Integrated Regional Water Management Authority is governed by a board of directors, which is composed of one representative from each of the 15 member agencies. The directors and alternates are appointed by each member's governing board.

Member Agency	Director
Alta Irrigation District	Norman Waldner, Director Alternate: Chris Kapheim, General Manager
City of Clovis	Harry Armstrong, Mayor Alternate: Mike Leonardo, Public Utilities Director Alternate: Lisa Koehn, Assistant Public Utilities Director
City of Dinuba	Mark Wallace, Mayor Alternate: Dan Meinert, Deputy City Manager Alternate: Dean K. Uota, City Engineer
City of Fresno	Andreas Borgeas, Council Member Alternate: Rene Ramirez, Department of Public Utilities Director
City of Kerman	Trinidad M. Rodriquez, Mayor Alternate: Ken Moore, Public Works Director
City of Kingsburg	Bruce Blayney, Mayor Alternate: David Karstetter, Mayor Pro Tem
City of Parlier	Armando Lopez, Mayor Alternate: Lou Martinez, City Manager
City of Reedley	Steven Rapada, Council Member Alternate: Anita Betancourt, Council Member
City of Sanger	José R. Villarreal, Mayor Alternate: John White, Interim City Manager
City of Selma	Dennis Lujan, Mayor Alternate: D-B Heusser, City Manager Alternate: Roseann Galvan, Administrative Analyst
Consolidated Irrigation District	Robert Nielsen, Jr., Board President Alternate: Phillip Desatoff, General Manager
Fresno Irrigation District	Jeffrey Boswell, Board President Alternate: Gary Serrato, General Manager
Kings County Water District	Barry McCutcheon, President Alternate: Donald Mills, General Manager
Kings River Conservation District	Mark McKean, Board President Alternate: David Orth, General Manager
Raisin City Water District	Jerry K. Boren, President

Alternate:

Board Officers

Chair
Harry Armstrong, Mayor
City of Clovis

Vice Chair
Gary Serrato, General Manager
Fresno Irrigation District

Secretary/Treasurer
David Orth, General Manager
Kings River Conservation District

Last updated 02-26-10

4886 East Jensen Avenue
Fresno, CA 93725

Tel: 559-237-5567
Fax: 559-237-5560

ATTACHMENT K

Memorandum of Understanding with Overlapping Local Agencies

MEMORANDUM OF UNDERSTANDING
BETWEEN
ALTA IRRIGATION DISTRICT
AND
LOCAL AGENCY

ARTICLE I - AGREEMENT

The articles and provisions contained herein constitute a bilateral and binding agreement by and between ALTA IRRIGATION DISTRICT, a California Irrigation District ("District") and LOCAL AGENCY, A Public Agency ("Agency").

ARTICLE II - RECOGNTION

The District has developed an amended Groundwater Management Plan ("Plan") with input from several local agencies which are water purveyors with overlapping spheres of influence within the District. It is the intent of the District to implement the plan with the support and coordination of such local agencies by means of a separate Memorandum of Understanding ("MOU") between each agency and the District.

ARTICLE III - PURPOSE

It is the purpose of this MOU, entered willingly, between District and Agency, to document the interests and responsibilities of both parties in the adoption and implementation of a coordinated Plan. It is also hoped that such MOU will promote and provide a means to establish an orderly process to share information, develop a course of action and resolve any misunderstandings or differences that may arise.

ARTICLE IV - COORDINATION

There shall be bi-annual coordinating meeting ("Meeting") between the District and the Agency. District shall give notice to the Agency thirty (30) days prior to date of the Meeting. If there are concerns or questions regarding the Plan, Agency shall transmit its concerns in writing to District seven (7) days prior to the Meeting.

ARTICLE V - OBLIGATIONS

The Plan shall be binding on the parties hereto unless superseded by the MOU or amendment thereto. It is agreed between both parties that information pertaining to depth to groundwater and groundwater quality shall be shared and coordinated between the parties.

ARTICLE VI - AREA OF PLAN

The plan shall be effective in all areas within the Agency boundaries. The Plan shall also be effective in any area annexed to the Agency Subsequent to the adoption of the Plan.

ARTICLE VII - TERM

The initial term of the MOD shall commence on the date hereof and continue for five (5) years, and shall continue year to year thereafter, unless terminated by written notice given at least one (l) year prior to such termination.

ALTA IRRIGATION DISTRICT

_____

Norman Waldner, President

_____ _____

Chris Kapheim, Secretary Date

LOCAL AGENCY

_____

Members Name, President

_____ _____

Members Name, Secretary Date

Appendix J – Kings Basin Integrated Groundwater and Surface Water Model

Kings Basin
Integrated Groundwater and Surface water Model
(Kings IGSM)

Model Development and Calibration

Prepared for:

Upper Kings Basin Water Forum
Kings River Conservation District
City of Fresno

In Coordination with:

California Department of Water Resources

WRIME

November 2007

WRIME Water Resources & Information Management Engineering, Inc.

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November 14, 2007

Mr. Lyn Garver
Kings River Conservation District
4886 East Jensen Avenue
Fresno, CA 93725

Subject: Kings Groundwater Basin Integrated Ground and Surface water Model (KingsIGSM), Final Report

Dear Mr. Garver:

I am pleased to provide you with the final report on the "Kings Groundwater Basin Integrated Ground and Surface water Model (KingsIGSM)". This project was initiated to develop a comprehensive, defensible and robust analytical tool for (i) better representation of the physical conditions in the Kings groundwater basin, (ii) analysis of regional effects of various water management strategies and conjunctive use programs and projects on the surface and groundwater resources and environment in the basin.

The final report for the subject project documents the work performed to collect and analyze data, develop conceptual and numerical integrated hydrologic model, calibrate the model, and perform sensitivity analysis. Significant additional work were conducted prior to this document, including development of hydrogeologic characterization of the basin, development and analysis of water demand and water supply information, as well as water quality conditions in the basin. In addition, the model benefited from significant data and information available from various sources, including KRCD, the Kings River Water Agency (KRWA), the irrigation districts, the cities of Fresno and Clovis, and federal and state agencies, such as USGS and DWR. The model features specific details in the City of Fresno Sphere of Influence to provide the city with appropriate level of detail to support the planning and design goals of the Fresno Metroplan.

One of the important outcomes of the model development exercise, in my opinion, is the compilation and analysis of significant amount of data for the water years 1964-04, all in one location, including rainfall, streamflow, canal flows, surface water diversions, land use conditions and cropping patters, municipal and agricultural groundwater pumping, municipal water use, agricultural water use estimates, stream accretions and depletions, artificial recharge, recycled water use, groundwater levels, lithologic logs, water quality data, and many other data. This data has been controlled and analyzed for quality, reviewed by experts in the area, including scientists, consultants, and stakeholders, and will be the basis for development of the Database Management System (DMS) that KRCD has initiated.

The model development process was conducted in close coordination with the Technical Analysis and Data (TAD) Workgroup of the Kings Basin Water Forum. The data, information,

and analysis were presented in numerous meeting with TAD, and the draft model document was reviewed by the TAD as well as other Water Forum stakeholders. The comments were addressed and incorporated as appropriate to produce the final document.

Enclosed please find ten (10) copies of the final report, along with ten (10) copies of a CD containing a PDF version of the final report.

It was a great pleasure for the WRIME team to have worked with you and other KRCD staff, and stakeholders in the Kings Basin Water Forum on this project, and we look forward to providing consulting services to KRCD and the Water Forum stakeholders in the future. If you have any questions or need further information please do not hesitate to contact me.

Sincerely,

Water Resources &
Information Management Engineering, Inc.

Ali Taghavi, Ph.D., P.E.
Vice President

AT:paa
Enclosures (20)

cc (w/o encl.): Gary Serrato, FID
Brock Buche, City of Fresno
David Cehrs, Private Citizen
Steve Haugen, KRWA
Ken Schmidt, KSA
Rick Thaxton, Fresno County
Tom Lutterman, DWR

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SECTION 1 INTRODUCTION

1.1 PURPOSE

This purpose of this report is to presents the development and calibration of the Kings Integrated Groundwater and Surface water Model (Kings IGSM). The Kings IGSM model is developed to support the planning analysis required for the Upper Kings Basin Integrated Regional Water Management Plan (IRWMP) project.

As part of the cooperative efforts of local stakeholders, the Water Forum has evaluated structural and non- structural water management strategies that would help the Kings Region meet the IRWMP goals and objectives. The Water Forum recognized the need for a tool to quantitatively evaluate the nature and extent of the water resources problems and to compare potential future conditions and project effects.

The purpose, goals, and objectives for the Kings IGSM were defined by the Water Forum and documented in the (WRIME, 2006a). The purpose of the Kings IGSM are:

1. to provide an analytical tool for the Kings Basin area that can represent the groundwater and surface water flow systems and their interactions; and
2. to provide a regional planning level analytical tool that can provide quantitative information on a comparative basis to help answer different questions on the groundwater and surface water system characteristics and to evaluate alternative conjunctive water management strategies.

The Kings IGSM is a regional model that covers the entire Kings Basin and simulates the surface water and groundwater systems of Kings Basin, and is the first comprehensive model of the Kings Basin that incorporates the past four decades of detailed historic information of the Kings Basin. Hydrogeologic conditions, land use, crop pattern, major diversions of King River and major canals in the Kings Region are included in Kings IGSM. The Kings IGSM was calibrated using a representative 41-year period from 1964 to 2004. This period was selected because it contains an array of representative wet and dry periods and includes the operations of Pine Flat Reservoir under the final agreements as coordinated by the KRWA acting as the water master for allocating and managing Kings River surface water rights. It also follows importation of Friant-Kern water to Kings Basin.

The development of the Kings IGSM was coordinated by the TAD Work Group of the Water Forum. The Kings IGSM development process included a series of steps each of which was conducted and completed in cooperation with the TAD Work Group which provided technical review, guidance, and coordination to the Kings IGSM modeling team. TAD Work Group has

met ten times and participated in discussion, review, and decision-making regarding the technical assumptions and analysis, and data used in the Kings IGSM development. The specific meetings of TAD and Water Forum and Kings IGSM deliverables are shown in Figure 1-1.

The development of the model was supported by a series of technical studies that were reviewed by the TAD Work Group and included:

1. Modeling Objectives and Strategy (WRIME, 2006a);
2. Hydrogeologic Investigation (Brown and Caldwell, 2006);
3. Analysis of Water Demand Conditions (WRIME, 2006b);
4. Analysis of Water Supplies (WRIME, 2006c); and
5. State of Groundwater Quality in the Basin (WRIME, 2007a).

These technical studies were conducted to provide sufficient detail on the respective data to be used in the model. The following tasks were part of the Kings IGSM development:

1. Conceptual Model Formulation;
2. Model Development;
3. Model Calibration; and
4. Sensitivity Analysis.

1.2 PROJECT BACKGROUND

1.2.1 KINGS BASIN

Historically, the Kings Basin was primarily an agricultural area which relied on both surface water and groundwater for irrigation purposes, and groundwater for municipal water supply. The Kings River is the major source of surface water in Kings Basin. Pine Flat Reservoir regulates the flow of the Kings River and provides storage, flood control, and recreational benefits. The San Joaquin River defines the northern boundary of the Kings Basin and is a source of surface water supply and groundwater recharge in the Kings Basin. An extensive network of canals is used to deliver water to agricultural lands and to existing groundwater recharge facilities. Over the past twenty years there have been increases in population and municipal development; and in the use of treated surface water in lieu of groundwater by the cities of Fresno and Clovis.

Water use in Kings Basin exceeds the natural supply and the Basin is operated under overdraft conditions. Overdraft conditions have resulted in development of two groundwater depressions; one beneath the Fresno/Clovis metropolitan area, and the second larger and deeper depression in Lower Kings Basin in the area of the Raisin City Water District (RCWD). Over the past 40 years, water levels in Fresno area have dropped by an average of 40 feet. Some

of the wells in the Fresno area have been deepened and tap strata with lower hydraulic heads. Water levels drop in RCWD area has been more drastic and exceeds 150 feet.

The general movement of groundwater in the Kings Basin is from the northeast to the southwest direction. The primary drivers contributing to the changes in groundwater levels and overdraft are:

- groundwater pumping to meet agricultural water demand when surface water diversions are inadequate to fully meet the crop water requirements;
- development of new irrigated land;
- rural residential development relying solely on groundwater;
- high reliance on groundwater for all demands in much of the western parts of Kings Basin; and
- urban development and reliance on groundwater once lands are converted to urban use from agricultural uses, except recently in Fresno and Clovis.

Historical conditions in the Kings Basin and the expected future growth and changes in land use indicate that without corrective measures water levels will continue to drop, the existing depression areas will expand, and new depression areas will develop.

1.2.2 Regional Cooperation for Water Resources Management

The continued groundwater overdraft, competition for the available supplies, and the potential for conflicts in the region call for improved water resources management in the Kings Basin. As a result, the local agencies have initiated a process of regional cooperation in 2001 to address the overdraft problem and develop practical solutions. Kings River Conservation District (KRCD), Alta Irrigation District (AID), Consolidated Irrigation District (CID), and Fresno Irrigation District (FID) formed a Basin Advisory Panel (BAP); sought technical, facilitation, and financial support from the California Department of Water Resources (DWR); and signed a Memorandum of Understanding (MOU) that defined how they would work together to manage existing supplies and develop new supplies for the Kings Region. This water management group is formed pursuant to the IRWMP standards and guidelines (DWR, 2004).

The BAP members solicited wider stakeholder participation and the Water Forum was formed in 2004 to coordinate water resources planning in the Upper Kings Basin Region (Kings Region). The Water Forum embarked on developing an IRWMP for the Kings Region to improve water management, reduce conflicts, protect water quality, and ensure sustainable resources management through regional cooperation. The objective of the IRWMP is to identify and define different water management scenarios for the Kings Basin and evaluate alternatives to determine the most economical and best use of the water resources of the region as a whole.

The Upper Kings Basin IRWMP is the outcome of a two-year collaborative planning and facilitated process that included completion of a wide range of technical studies, preparation of briefings and technical memorandums, development of the Kings IGSM, extensive stakeholder involvement and community affairs process, and numerous meetings among various work groups and Water Forum participants. The IRWMP planning horizon extends 25 years into the future, until 2030.

1.2.3 ANTICIPATED USES AND APPLICATION OF THE KINGS IGSM

The Kings IGSM is expected to be used extensively for water resources planning and management in the Kings Basin. KRCD will continue to coordinate the use and application of the model and the TAD Work Group.

During the development of the Kings IRWMP, the model was used to conduct a Baseline Analysis. The Baseline Analysis evaluated the future without project conditions and is documented in the Upper Kings Basin IRWMP final report (WRIME, 2007b). A 2005 Existing Conditions scenario was performed to quantify the overdraft conditions assuming there are no changes to land use or no new water supply facilities constructed. The 2030 Baseline Conditions scenario was performed to evaluate the effects of land use at build out in the spheres of influence of the cities in the Kings Region. Both provide a basis for comparison of the benefits and impacts of any proposed water supply projects or other management actions. The Baseline analysis shows the cumulative effects of all of the land use changes that may occur or are currently planned within the spheres of influence of the cities. These analysis results can be incorporated by reference or used to meet any required California Environmental Quality Act (CEQA) or National Environmental Policy Act (NEPA) evaluations of cumulative impacts of proposed projects.

It is anticipated that the Kings IGSM will be used to further support the Water Forum in sizing capital projects and evaluating the IRWMP alternatives once these are firmly defined. The analysis of project alternatives will support any program or project level environmental evaluations that are needed to comply with the CEQA or NEPA should there be any federal involvement in proposed projects (funding, permitting, federal lands).

Stakeholders in the Kings Basin may also benefit by model analysis conducted as part of the IRWMP development or by using the Kings IGSM when it is necessary to quantify benefits or impacts of proposed actions. Contemporary examples of the model application within the Kings Basin include:

- The City of Fresno use of the model to support the development of the Metro Plan, a capital facilities plan for the city. The Kings IGSM will be used to size

projects, compare alternatives benefits and impacts, and support the preparation of any required program or project level environmental documents.

- Analysis of the groundwater impacts of the power plant being proposed by KRCD to support the permit application to the California Energy Commission.

The Kings IGSM may also be applied to circumstances which require quantification of project or program benefit and effects and comparison of alternatives. This could include:

- Preparing required engineering analysis for purposes of conducting a Proposition 218 electoral initiative;
- Integrating the model results with econometric models to evaluate and distribute project costs;
- Document project impacts and evaluating the nexus between a proposed project, mitigation costs, and impact fees and assessments;
- City or County General Plan updates and alternatives evaluation;
- City or special district capital facilities plans;
- Conjunctive use assessment;
- Historical benefits analysis;
- Project definition and design;
- EIR/EIS Support; and
- Water Quality Assessment.

The Kings IGSM does not currently include water quality modeling capabilities or operational modeling of the Pine Flat Reservoir or major CID, or AID distribution systems. The model, however, provides the fundamental data and information framework, as well appropriate level of spatial and temporal details for future development of additional features, such as the water quality simulation and river/reservoir operations. The development of these additional capabilities may be a potential future improvement to the Kings IGSM.

1.2.4 MODEL REFINEMENT FOR CITY OF FRESNO

The City is updating its Metro Plan to guide the development and management of the available water supply for current demands and future growth through 2060. The City was interested in developing an analytical tool to assist in:

- Better understanding the hydrologic and hydrogeologic conditions in Fresno area,
- Evaluation of no-project conditions as defined by the Metro Plan,
- Evaluation of Metro Plan project conditions, and
- Evaluation of local and regional effects of the projects.

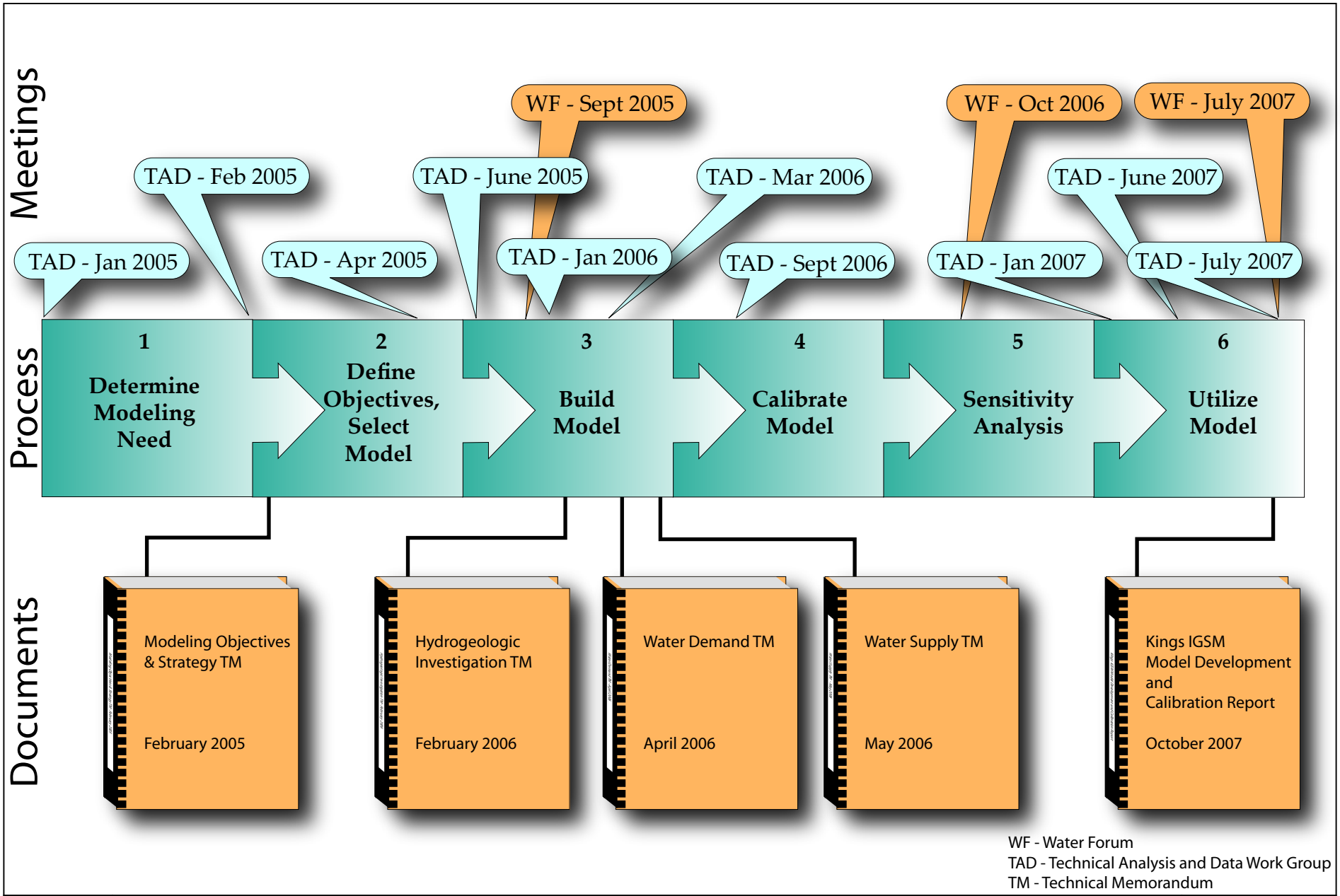
The City decided to use the Kings IGSM as an analytical tool for development of the Metro Plan and supported the enhancement of the model in Fresno area and incorporation of detailed data. Enhancement of the model in Fresno area supports the evaluation of proposed Metro Plan

facilities and alternatives at an appropriate level of resolution and detail required by the Metro Plan. Detailed model input data and analysis of model results for Fresno area are presented in this report.

1.3 ORGANIZATION OF THE REPORT

This report is organized as follows:

- **Section 1 - Introduction**: This section;
- **Section 2 - Model Area**: describes the area that is being modeled;
- **Section 3 - Model Data Requirements**: presents the model data requirements, key data sources and the simulation time period;
- **Section 4 - Model Characterization**: presents the model subregions, model grid and surface water configuration;
- **Section 5 - Model Input Data**: presents the data used in the input files of the model;
- **Section 6 - Model Calibration**: presents the calibration procedure and calibration results of Kings IGSM;
- **Section 7 - Sensitivity Analysis**: presents the results of the sensitivity analysis of the model parameters of the Kings IGSM;
- **Section 8 – Summary and Recommendations**: presents the summary of the report and provides recommendations for future course of action;
- **Section 9 - References:** lists the documents cited in the Kings IGSM Development and Calibration Report;
- **Appendix A – Characteristics of Municipal Wells in Fresno and Clovis:** presents location, capacity, screen interval, well depth, and assigned model layers for Fresno and Clovis Municipal Wells;
- **Appendix B – Calibration Well Hydrographs:** presents groundwater hydrographs for 1964 to 2004 at 240 calibration wells; and
- **Appendix C – Kings IGSM Sensitivity Analysis Results:** presents the results of Kings IGSM sensitivity analysis at selected impact areas.



WRIME

Model Development Process, Meetings, and Documents

Kings IGSM Model Development and Calibration

July 2007

FIGURE 1-1

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SECTION 2 MODEL AREA

The model area for the Kings IGSM is defined by the political, hydrologic and hydrogeologic settings of the study area and with due considerations for future applications of the Kings IGSM in the IRWMP area.

2.1 KINGS BASIN

The boundaries of the Kings IGSM are primarily based on the Kings groundwater basin, as defined by the DWR Bulletin 118. The Kings groundwater basin is located in the southern part of the San Joaquin Valley groundwater basin in the Central Valley of California (Figure 2-1).

The Kings Basin is bounded on the north by the San Joaquin River. The west boundary of Kings Basin is the eastern boundaries of the Westside and Delta-Mendota Basins. The southern boundary is the southern fork of the Kings River and the southern boundaries of Laguna Irrigation District, CID, and AID. The eastern boundary of the subbasin is the alluvium-granitic rock interface of the Sierra Nevada foothills.

The aquifer system consists of unconsolidated continental deposits of Tertiary and Quaternary age overlain by a younger series of deposits of Quaternary age. The Quaternary age deposits are divided into older alluvium, lacustrine and marsh deposits, younger alluvium, and flood-basin deposits. The older alluvium consisting of sand, gravel, cobbles, boulders, clay, silt, silty and sandy clay, and clayey and silty sand is an important aquifer in the Basin. The younger alluvium overlies the older alluvium and is interbedded with the flood-basin deposits. The younger alluvium is highly permeable beneath river channels.

Kings Basin is primarily an agricultural area, which has historically used both surface water and groundwater for irrigation purposes and primarily groundwater for municipal water supplies. Water use in Kings Basin exceeds the natural supply and the Basin has been operating under overdraft conditions for many years. The continued groundwater overdraft and the urban growth pressure in the region call for improved water resources management in the Kings Basin.

Historically, irrigation water supply in the basin has been provided by the surface water from the Kings River, supplemented by Friant-Kern water and Delta-Mendota Canal (DMC) water. Over the years, to further improve the agricultural productivity of the basin, the natural system has been modified by construction of canals, dams and reservoirs, and groundwater recharge ponds. To meet the water demands in the basin, the surface water supplies are supplemented

in dry years by groundwater pumping. In wet years, water may be intentionally applied in excess of the immediate irrigation demand to recharge groundwater.

Pine Flat Dam and Reservoir was constructed and began full operations in the early 1960s. The dam was constructed for both flood control and water conservation. The dam is operated by the US Army Corps of Engineers, however, the conservation pool is managed by the Kings River Watermaster, for the KRWA. The Watermaster is responsible for accounting and managing of the water released and delivered to the 28 member KRWA for irrigation and other beneficial uses. Pine Flat Dam has 1 million acre feet of storage and captures water in the winter for release in the summer irrigation season, and in wet years for release in dry years, when carry-over storage space is available. To alleviate depletion in the groundwater basin, recharge ponds have been built to store water in the groundwater basin, when surface water is available. Despite this and the other conjunctive use measures, groundwater overdraft continues.

2.1.1 SURFACE WATER SYSTEM

The primary source of surface water in the Kings Basin is the Kings River, including Pine Flat Reservoir releases, and stream inflows from Mills and Hughes Creeks, supplemented by imports from Friant Kern Canal of the Federal Central Valley Project (CVP) and Delta-Mendota Canal. The KRWA is the water master for the Kings River and includes 28 members that divert water and have rights to the Kings River. Based on streamflow data for water years from 1964 to 2004, the average annual total surface water inflow to the basin is about 1.85 million acre-feet (MAF). Of the total inflow, the Kings River on the average contributes 1.78 MAF, with a low of 500 thousand acre-feet (TAF) in dry years, and a high of 4.25 MAF in wet years. Much like the rest of California, the Kings Region observes the "average conditions" on a relatively infrequent basis, and water management activities must respond to wet or dry conditions. In addition, wet and dry periods can be prolonged and occur over multiple years.

2.1.2 LAND AND WATER USE SYSTEM

The primary water use in the Kings Basin is for irrigation purposes. The major water users in the Kings Basin include FID, CID, and AID that jointly hold rights and deliver roughly 65% of the total water of the Kings River. The major source of supply is the natural flow of the Kings River or the water stored in Pine Flat Dam and water from Friant-Kern and Delta-Mendota canals. The surface water supplies are supplemented by groundwater pumping during times when surface water is not available for diversion. Upper Kings Basin, with a total area of 585 thousand acres, has approximately 440 thousand acres of agricultural area. In contrast, Lower Kings Basin, with a total area of 335 thousand acres, has approximately 280 thousand

acres of agricultural area. Approximately 61% of Kings Basin agricultural area is in Upper Kings Basin and 39% in Lower Kings Basin. However, it is estimated that more than 50% of Kings Basin agricultural groundwater pumping is in Lower Kings Basin.

Urban demands are a smaller percentage of the overall water use in the Kings Basin and most municipal supplies are obtained through groundwater pumping. The cities of Fresno, Clovis, Orange Cove, and Friant treat surface water at surface water treatment plants and which do not rely exclusively on groundwater.

2.1.3 GROUNDWATER SYSTEM

The general movement of groundwater in the Kings Basin is from the northeast to the southwest direction from the Upper Kings Basin into Lower Kings Basin. Despite the availability of surface water for irrigation use, the long-term reliance on groundwater has caused significant overdraft on the basin. Average groundwater levels in Kings Basin have dropped by approximately 34 feet during the past 40 years, and continue to decline. The current average depth to water is 25 to 50 feet in AID, 50 to 75 feet in eastern areas of CID, 100 to 150 feet in western areas of CID, and 75 to 100 feet in western areas of FID. However, depth to water is greater in Fresno SOI (125 to 150 feet) and RCWD (225 to 250 feet). There are two water level depressions in Kings Basin; one beneath the Fresno/Clovis metropolitan area, and the second larger and deeper depression generally in the area of the Raisin City Water District.

The primary drivers contributing to the changes in groundwater levels and overdraft are:

- high reliance on groundwater for all demands in much of the western parts of Kings Basin;
- urban development and reliance on groundwater once lands are converted to urban use from agricultural uses; and
- groundwater pumping to meet agricultural water demand when surface water diversions are inadequate to fully meet the crop water requirements.

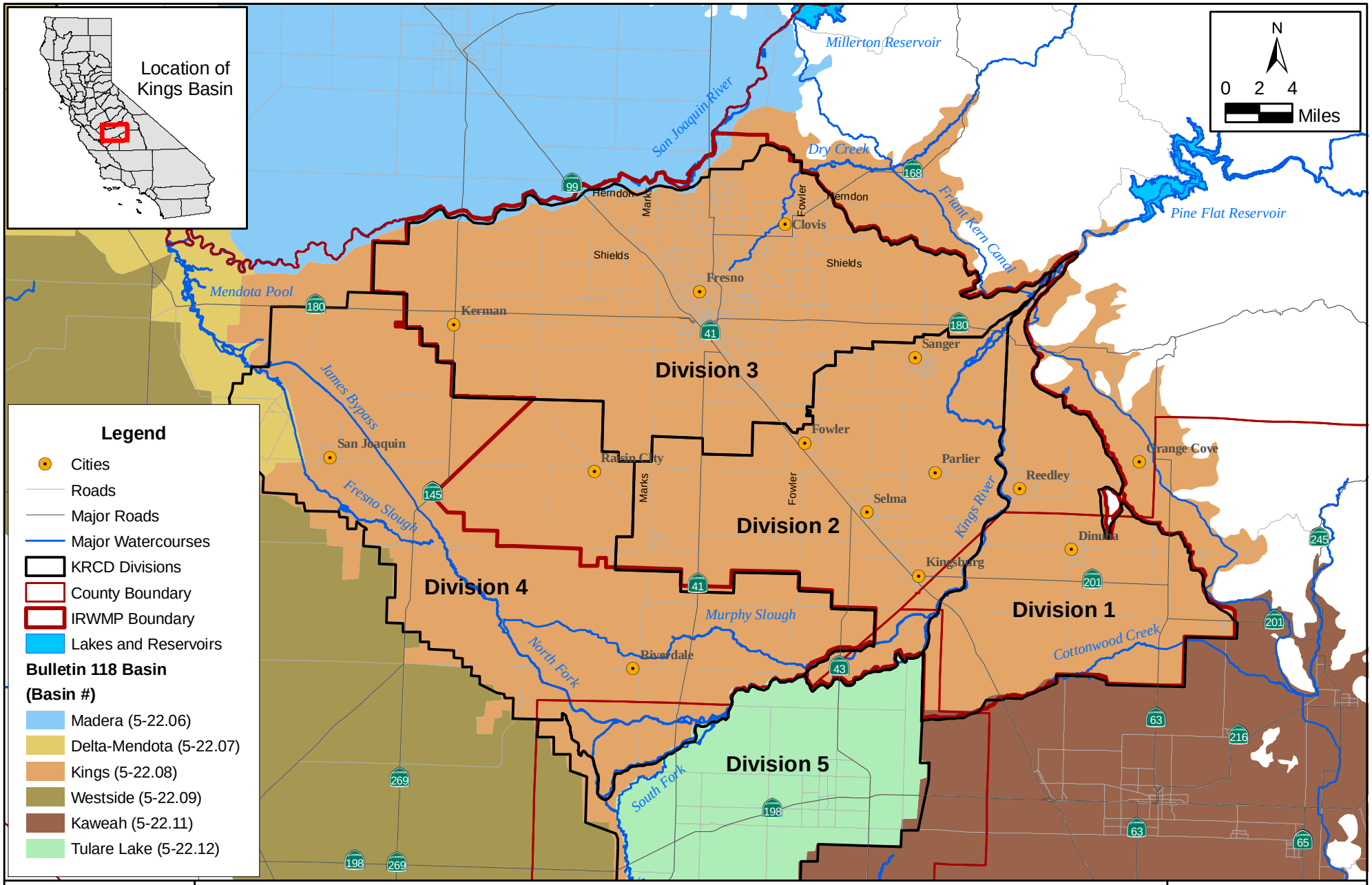
The cities of Fresno and Clovis have constructed surface water treatment plants that allow for use of surface water in-lieu of groundwater pumping and have recharged the groundwater for about 3.5 decades. This water management strategy leaves groundwater in storage and this will help recovery of the water table.

2.2 MODEL BOUNDARY

The model boundary, as shown in Figure 2-2, extends beyond the Kings groundwater basin area in the west and east to include the Mendota Pool area, Tranquility Irrigation District, and

urban and agricultural areas in the foothills. The model area extends about 50 miles from west to east and about 35 miles from north to south. The model area includes the Fresno-Clovis metropolitan and other urban areas, two major streams (Kings River and San Joaquin River), several major water distribution canals, and several small creeks.

The focus of the data collection and analysis effort as related to Kings IGSM development was limited to the IRWMP region (Figure 2-2). However, due to geologic and hydrologic interconnection of the IRWMP area and other areas, the readily available data on the neighboring areas outside the IRWMP area was also collected to facilitate the development of the Kings IGSM. The IRWMP area includes AID, CID, FID, and RCWD.



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Groundwater Basin, IRWMP, and KRCD Divisions Boundaries

Kings IGSM Model Development and Calibration

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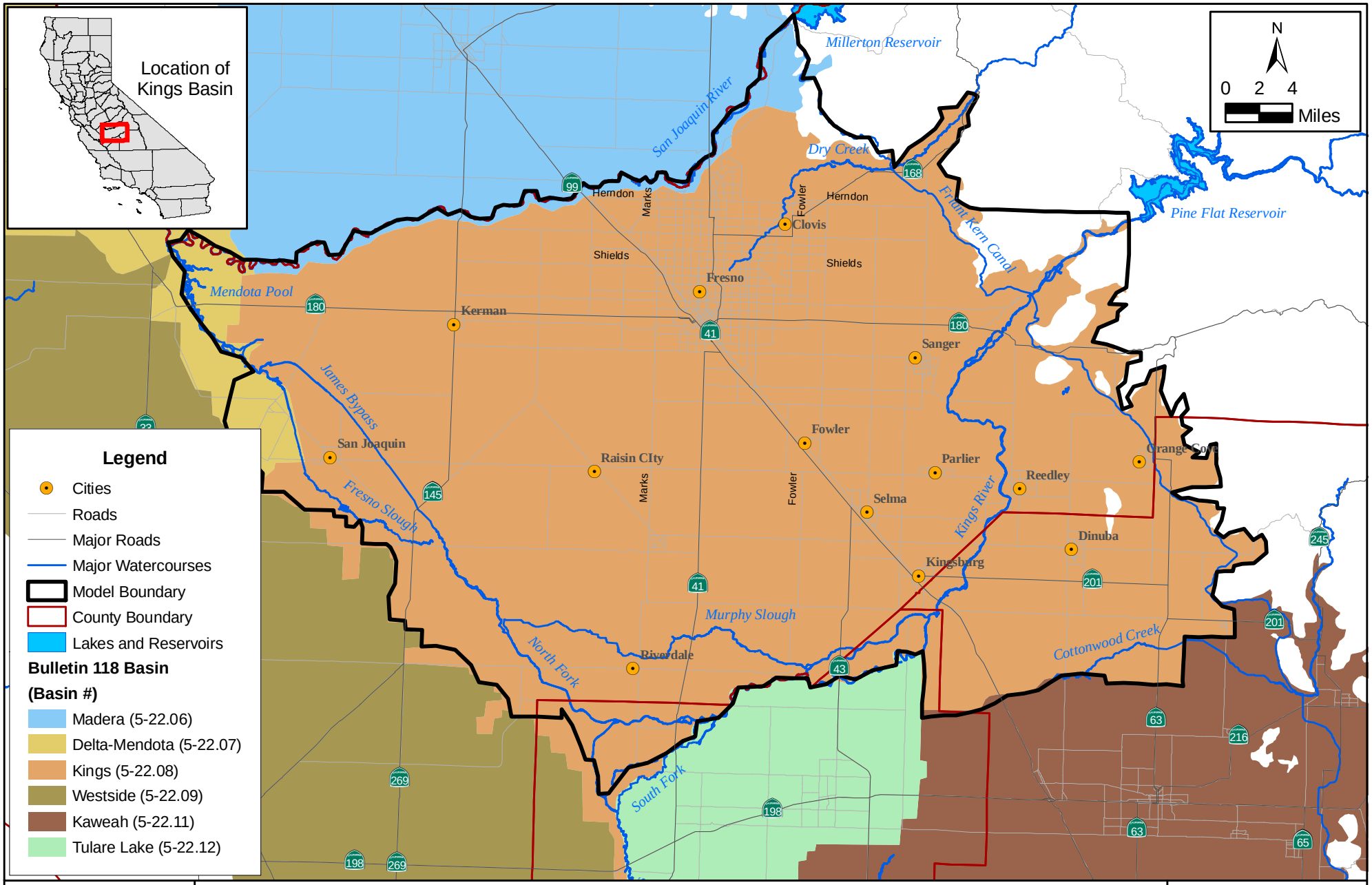
Figure 2-1



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Groundwater Basin and Model Boundaries

Kings IGSM Model Development and Calibration

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Figure 2-2

SECTION 3 MODEL DATA REQUIREMENTS

This section describes the categories of data utilized to develop the Kings IGSM. A summary of input data used in the Kings IGSM is presented in Table 3-1. The data is organized into the following categories:

- Model characterization data;
- Geohydrology and geography data;
- Hydrology and climatology data;
- Land use and crop data;
- Water supply and demand data;
- Aquifer parameter data;
- Initial conditions data; and
- Boundary conditions data.

Model characterization data is described in Section 4. Other data categories are described in Section 5.

3.1 KEY DATA SOURCES

The key data sources used in the development of the Kings IGSM are listed below:

1. **Local Sources:**
   a. Kings River Water Association (KRWA);
   b. City of Fresno
   c. City of Clovis;
   d. County of Fresno;
   e. Fresno Irrigation District (FID);
   f. Consolidated Irrigation District (CID);
   g. California State University – Fresno (CSUF);
   h. Alta Irrigation District Integrated Groundwater and Surface water Model (AIDIGSM);
   i. Alta Irrigation District (AID)
   j. Kings River Conservation District (KRCD);
   k. Fresno Metropolitan Flood Control District (FMFCD); and
   l. Kenneth D. Schmidt and Associates;
2. **State Agencies:**
   a. Department of Water Resources (DWR);
   b. University of California, Davis (UCD);
   c. Central Valley Groundwater and Surface water Model (CVGSM)
   d. California Irrigation Management Information System (CIMIS); and

e. Department of Health Services (DHS);

3. **Federal Agencies:**
   a. U.S. Bureau of Reclamation (USBR);
   b. U.S. Geological Survey (USGS);
   c. National Climatic Data Center (NCDC);
   d. U.S. Army Corps of Engineers (Corps); and
   e. U.S. Natural Resource Conservation Service (NRCS).

3.2 SIMULATION TIME PERIOD

The IGSM is a dynamic simulation model that simulates groundwater flow and stream flow for a continuous period of time. A time period, 1964–2004, was selected based on discussions with TAD Work Group. The features of the time period include:

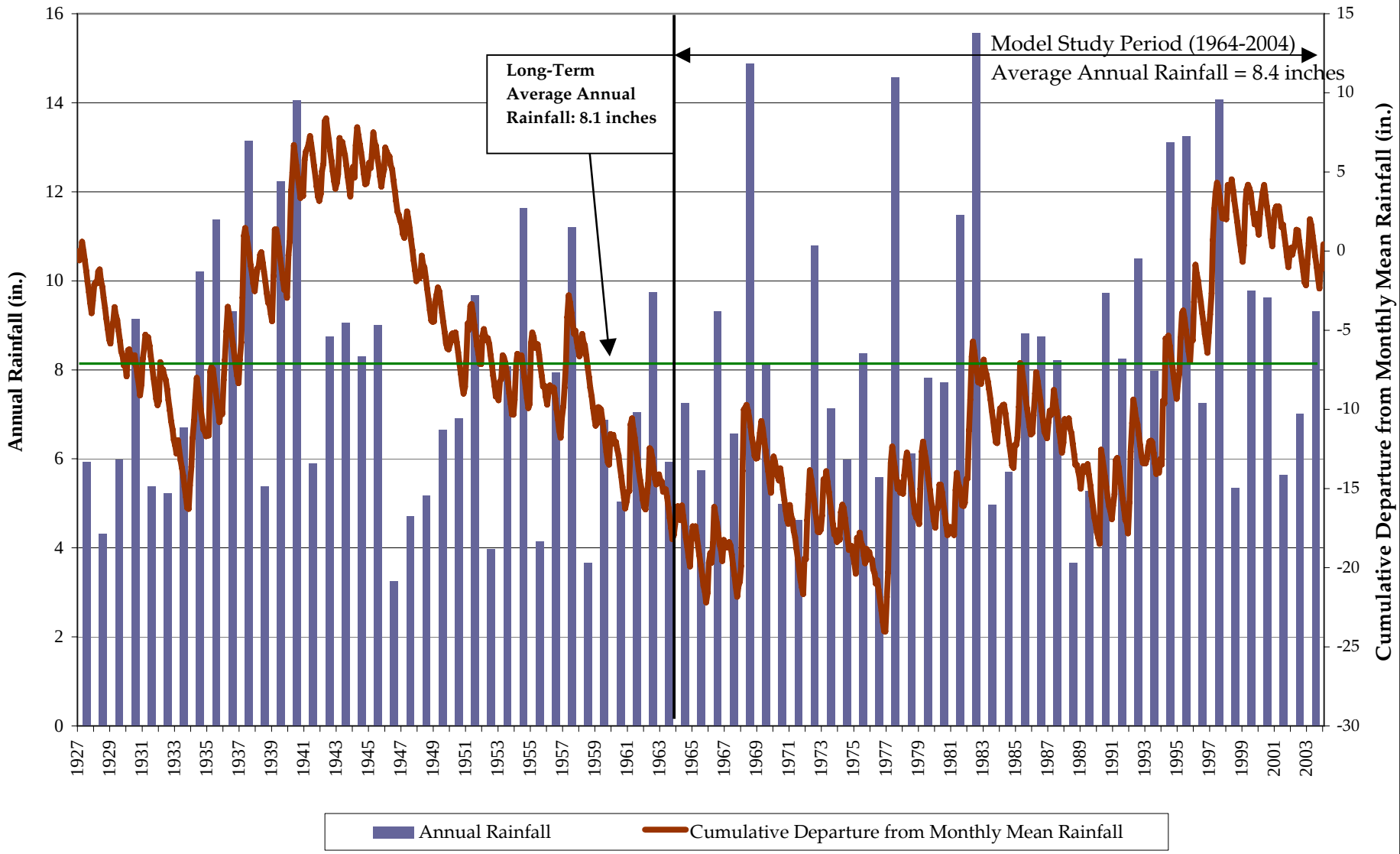
- 1964 is the beginning of the Pine Flat Reservoir operation under contemporary guidelines (KRWA, 1997);
- Beginning of Friant-Kern Canal water deliveries to FID;
- Reasonable amount of data is available for this time period;
- A long (41-year) period that provides a reasonable basis for calibration of the model;
- The inclusion of wet, dry, normal, and extreme conditions of the regional hydrology in the basin, such as the 1976–1977 drought, and 1983 flood; and
- Significant changes in land and water use in the model area.

Figure 3-1 shows the annual rainfall total at Hanford, California for the 1927–2004 hydrologic period. Based on the isohyetal maps (based on U.S. Weather Service Data), the Hanford gage reasonably represents the long-term rainfall trends in the basin. Figure 3-1 indicates that the 77-year average annual rainfall (1927-2004) is 8.1 inches in the valley floor, while the average annual rainfall during the 41-year model simulation period (1964-2004) is 8.4 inches. The figure also shows the cumulative departure from average annual rainfall for Hanford station. This chart provides rainfall trend information in the valley floor, as the periods with falling cumulative departure curve represent dry conditions, and those with rising trends represent wet conditions. It is apparent that while the early part of modeling period is relatively average rainfall conditions, the latter part is relatively wet. At the same time, there are short-term dry and extreme dry conditions such as 1976-77 and 1987-92. Model simulations during these dry periods will assist in evaluation of potential project impacts for water supply reliability during drought conditions. On the other hand, the modeling analysis during relatively wet hydrologic periods, such as 1969 and 1983 can assist in evaluation of potential runoff capture and water availability for short-term and long-term conjunctive use opportunities. Kings River flow closely follows the rainfall trend in the valley floor. Table 3-2 shows rainfall averages for several selected hydrologic periods.

Table 3-1. Summary of Input Data used in the Model

Data Group	Data Item	Data Characteristics		Data Sources
		Spatial Scale	*Time Scale*	
Model Characterization	Element configuration	Element	Invariant	LAFCO, USGS, CASIL
	Node coordinates	Node	Invariant	LAFCO, USGS, CASIL
	Stream configuration	Stream node	Invariant	CASIL, FID, CID, AID
	Subregion definition	Element	Invariant	LAFCO, USGS, CASIL
Hydrogeology and Geography	Stratigraphy	Node	Invariant	USGS, DWR, Brown & Caldwell
	Stream cross-sections	Stream node	Invariant	USGS, CVGSM, CID IGSM, AID IGSM
	Drainage pattern	Element	Invariant	CASIL
	Well locations	Well	Invariant	City of Fresno, City of Clovis
	Well construction	Well	Invariant	City of Fresno, City of Clovis
	Well sizes/capacities	Well	Invariant	City of Fresno, City of Clovis
Hydrology and Climatology	Rainfall	Gaging station	Daily	NOAA, CIMIS
	Rainfall distribution	Element	Invariant	CASIL
	Soil classification	Element	Invariant	NRCS
	Evapotranspiration	Subregion	Monthly	CIMIS
	Upstream inflow	Stream node	Daily	USBR, DWR, KRWA
Land Use	Land use distribution	Element	Survey years	DWR, KRCD
	Crop acreage	Subregion	Annual	DWR, AgComm
Water Use	Surface water diversion	Subregion	Monthly	KRWA, FID, CID, AID
	Diversion locations	Subregion	Invariant	KRWA, FID, CID, AID
	Groundwater pumping	Subregion	Monthly	City of Fresno, City of Clovis, FID
	Pumping distribution	Element	Invariant	FID, CID, AID
	Urban water use	Subregion	Monthly	City of Fresno, City of Clovis, KRCD
	Canal facilities/layout	Element	Invariant	KRCD, KRWA, FID, CID, AID
Parameter Data	Hydraulic conductivity	Node	Invariant	USGS, FID, Ken Schmidt, David Cehrs
	Stream bed parameters	Stream node	Invariant	USGS, CVGSM, CID IGSM, AID IGSM
	Specific yield	Node	Invariant	KRCD, Ken Schmidt, David Cehrs
	Storage coefficient	Node	Invariant	Ken Schmidt, David Cehrs
	Runoff curve number	Subregion	Invariant	NRCS
	Soil percolation parameter	Subregion	Invariant	NRCS
Other	Initial conditions	Node	Invariant	DWR, Ken Schmidt
	Boundary conditions	Node	Invariant, daily	DWR
	Recharge facilities	Element	Invariant	FID, CID, AID, FMFCD
	Well hydrographs	Well	Monthly	DWR, Ken Schmidt
	Groundwater levels	Well, regional contours	Monthly	DWR, KRCD, Ken Schmidt
	Artificial recharge	Element	Monthly	FID, KRCD

AGComm = Agricultural Commissioner for Fresno County
AID = Alta Irrigation District
CASIL = California Spatial Information Library
CID = Consolidated Irrigation District
CIMIS = California Irrigation Management Information System
CVGSM = Central Valley Groundwater and Surface Water Model
DWR = Department of Water Resources
FID = Fresno Irrigation District
FMFCD = Fresno Metropolitan Flood Control District
KRCD = Kings River Conservation District
KRWA = Kings River Water Association
LAFCO = Local Agency Formation Commission for Fresno County and Tulare County
NOAA = National Oceanic and Atmospheric Administration
NRCS = Natural Resource Conservation Service
USBR = United States Bureau of Reclamation
SGS = United States Geologic Survey



Data Source: NOAA Hanford Station (43747)

Hanford Station Rainfall Data

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Figure 3-1

Table 3-2. Rainfall Averages for Different Hydrologic Periods

Hydrologic Period	Years	Average Rainfall (in/yr)
Long-Term Average	1928 - 2004	8.05
Model Period	1964 - 2004	8.41
Short Dry Period	1976 - 1977	6.98
Extended Dry Period	1987 - 1992	7.32
Short Wet Period	1982 - 1983	13.53
Extended Wet Period	1995 - 1998	11.93

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SECTION 4 MODEL CHARACTERIZATION

The Kings IGSM model is physically characterized by the following data groups:

- Subregion Definition;
- Model Grid;
- Nodal Coordinates; and
- Surface Hydrology Configuration.

4.1 SUBREGION DEFINITION

Water and land use management in the model area is represented in the Kings IGSM by subdividing the model area into 32 management areas called subregions (Figure 4-1). The Kings IGSM uses subregions to enable independent analysis of water budgets and hydrologic conditions for each management area. In addition, the subregions allow for the proper development of model input data, especially water supply and demand data, which are generally available in terms of water districts or irrigation districts. The Kings IGSM subregions represent urban areas sphere of influence, individual water districts, irrigation districts, or other organized and/or unorganized areas within the model. The names of the Kings IGSM model subregions, their representative areas, and criteria for selecting the boundaries of the subregion are presented in Table 4-1.

The general criteria used to configure the Kings IGSM subregions include:

- Boundaries of Water Agencies;
- Boundaries of Municipalities;
- Administrative Boundaries; and
- Principal Hydrologic and Hydrogeologic Features.

Specific criteria used to define the Kings IGSM subregions are:

- IRWMP Area;
- Urban Spheres-of-Influence; and
- City of Fresno Pressure Zones.

Specific criteria are described below.

4.1.1 IRWMP PLAN AREA

Kings IGSM subregions were configured to provide geographic coverage similar to administrative boundaries of members of the Upper Kings Basin IRWMP. FID and CID subregions were further divided into FID East and West and CID East and West where

Highway 99 crosses FID and CID, respectively. AID was divided into three subregions AID West, East, and North where the Kings County Line and the Union Pacific Railroad tracks cross AID.

4.1.2 URBAN SPHERES-OF-INFLUENCE AND PRESSURE ZONES

Kings IGSM subregions in the Fresno Metropolitan Area were configured using spheres-of-influence (SOI) boundaries of the Cities of Fresno, and Clovis. Fresno sphere-of-influence is further divided into eight subregions using boundaries of five pressure zones of municipal water distribution system in Fresno (Subregions 7, 8, 10,11, and 12), Pinedale County Water District (Subregion 9), Bakman Water Company (Subregion 13), and California State University of Fresno (Subregion 14). Figure 4-2 illustrates the Kings IGSM subregions in Fresno SOI and Clovis SOI.

4.2 MODEL GRID

A two-dimensional, finite element grid was developed for the entire model area, as shown in Figure 4-3. The model area is subdivided into a series of triangular and quadrilateral elements. The grid shape allows the model to reasonably reflect the physical features in the model area. The Kings IGSM model grid consists of 4,689 elements and 4,266 nodes. The model area covers approximately 1,627 square miles, with an average element size of about 222 acres and minimum and maximum sizes of 9 acres and 965 acres, respectively (Table 4-2). The subregions are defined by a collection of finite elements of the model grid, as shown in Figure 4-3. The model grid was developed using a finite element mesh generation software and in coordination with and review by the TAD Work Group.

The general features of the model grid are:

- Model boundary matches the hydrogeologic and hydrologic boundaries of the underlying Kings groundwater basin;
- Grid orientation follows regional groundwater flow streamlines;
- Grid orientation follows the course of significant streams;
- Model elements are smaller in the IRWMP Area;
- Model elements are smaller in the groundwater depression area in the western part of the model area; and
- Model elements are smaller in the urban areas (Figure 4-4).

The specific features of the model grid in the Fresno SOI (Figure 4-5) are:

- Subregion boundaries match the boundaries of:
  - Fresno pressure zones;

  - Pinedale County Water District;
  - Bakman Water Company; and
  - Fresno State.
- Grid orientation follows the course of major canals in Fresno and Clovis area; and
- Model elements are smaller in Fresno SOI than the neighboring agricultural areas.

4.3 NODAL COORDINATES

The model uses the Universal Transverse Mercator (UTM) projection, Zone 11N coordinates, and North American Datum of 1983 for the x-y coordinates of the nodes. The list of connecting nodes for each element was developed by mesh generation software. Two independent sets of sequential numbers were used for nodes and elements identification. These node and element numbers are used in specifying model input data.

4.4 SURFACE HYDROLOGY CONFIGURATION

The Kings IGSM provides simulation of flows and stream-aquifer interaction for two major rivers and nine creeks. The rivers and creeks are:

- Kings River between Pine Flat and Mendota Pool
- San Joaquin River between Friant Dam and Mendota Pool
- Little Dry Creek
- Dry Creek
- Redbank Creek
- Fancher Creek
- Holland Creek
- Watoke Creek
- Wooten Creek
- Sand Creek
- Cottonwood Creek

There are also fourteen major canals that are simulated in the Kings IGSM as part of the surface water flow system:

- Alta Canal
- Consolidated Canal
- C-K Canal
- Lone Tree Canal
- Fowler Switch Canal
- Gould Canal
- Enterprise Canal
- Fresno Canal
- Mill Canal
- Dry Creek Canal
- Fancher Creek Canal
- Herndon Canal
- Herndon-Brawley Canal
- Murphy Slough Canal

The deliveries of eight additional canals (Crescent Canal, Grant Canal, A Ditch Canal, Island Canal, Summit Lake Canal, Liberty Canal, Stinson Canal, and James Canal) are included in the Kings IGSM, but the flows in these canals are not simulated. Since the surface water deliveries

to the south are not used in the model area, they are considered as exports from the model area. These are flows in and deliveries from the following facilities:

- Lakelands Canal,
- Peoples Canal,
- Last Chance Canal,
- Lemoore Canal, and
- South Fork of Kings River

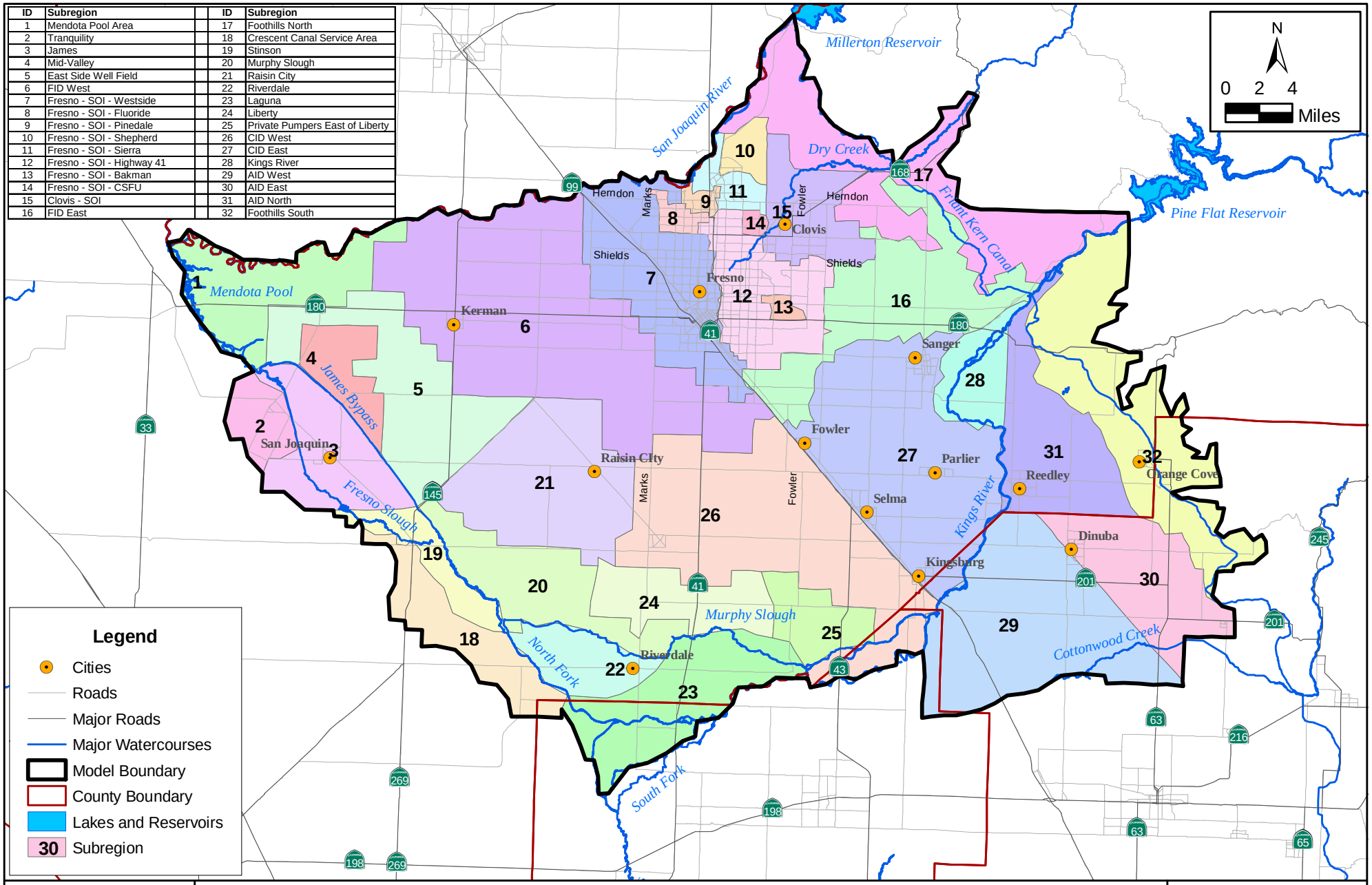
Figure 4-6 shows the location of the simulated rivers and creeks. The location of these physical features is based on GIS mapping available from the California Spatial Information Library (www.gis.ca.gov).

4.4.1 STREAM REACH CONFIGURATION

The surface water flow system is modeled by using 1-dimensional line elements along the stream courses. Each stream course simulated in the Kings IGSM is comprised of stream nodes, which correspond to groundwater nodes. A stream reach is defined by a series of sequential stream nodes. There are 78 stream reaches and 790 stream nodes that represent the stream courses listed above. The stream reaches are shown in Figure 4-6 and the names of the stream reaches are listed in Table 4-3.

The Kings IGSM uses stream reaches for streamflow accounting. Criteria commonly used for delineating stream reaches are locations of confluences, inflow locations, dam locations, outflow locations, subregions boundaries and/or administrative boundaries. Additional criteria can include the relative importance of the reach to a particular study, and stream reach gains or losses to local aquifer.

ID	Subregion	ID	Subregion
1	Mendota Pool Area	17	Foothills North
2	Tranquility	18	Crescent Canal Service Area
3	James	19	Stinson
4	Mid-Valley	20	Murphy Slough
5	East Side Well Field	21	Raisin City
6	FID West	22	Riverdale
7	Fresno - SOI - Westside	23	Laguna
8	Fresno - SOI - Fluoride	24	Liberty
9	Fresno - SOI - Pinedale	25	Private Pumpers East of Liberty
10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South



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Model Subregions

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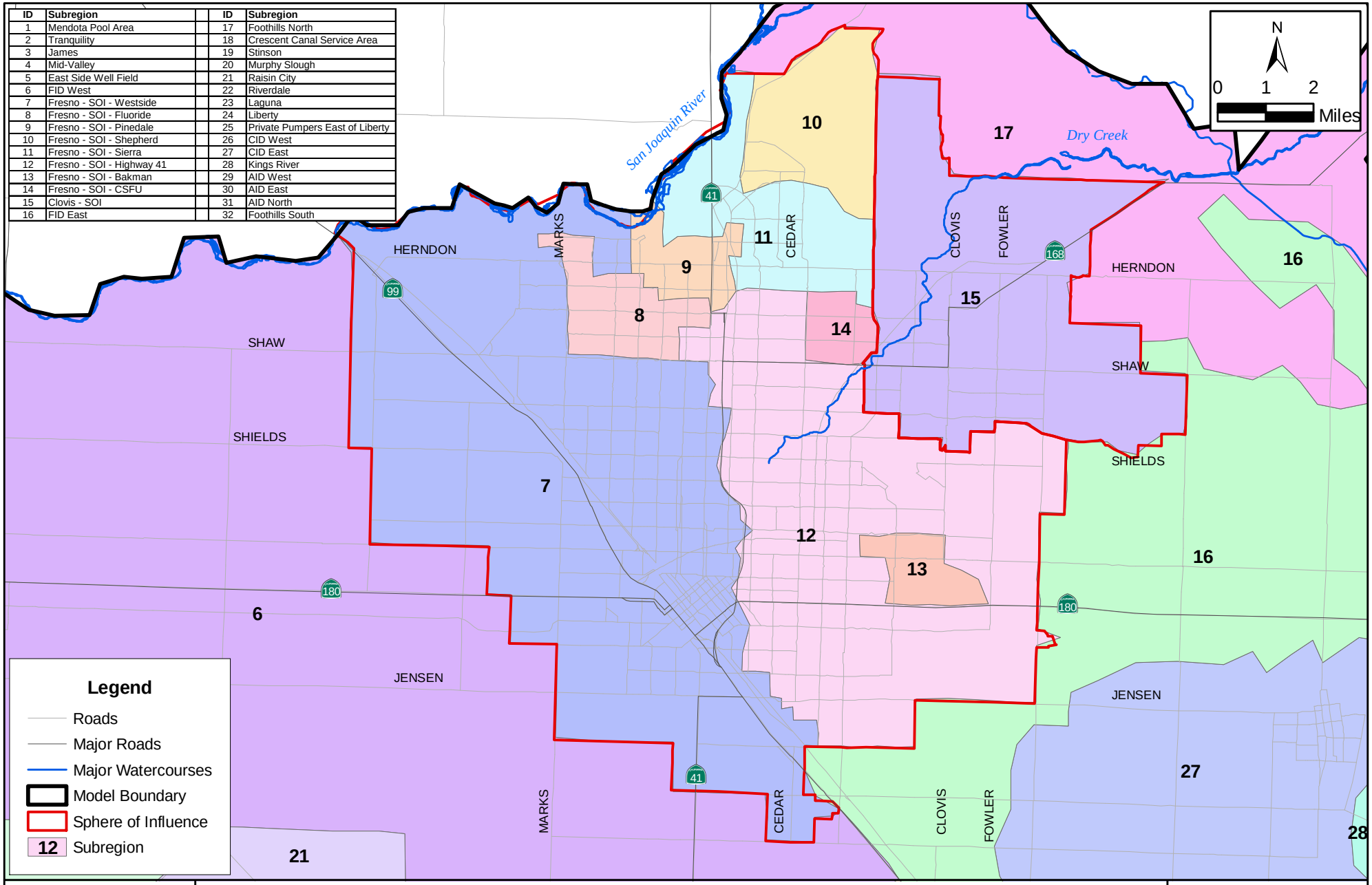
Figure 4-1

Table 4-1. Subregion Attributes

Subregion Number	Name	Criterion			Area	
		Sphere of Influence	IRWMP	District	Acres	Sq. Miles
1	Mendota Pool Area		No		33,239	52
2	Tranquility		No	Tranquility I.D.	10,431	16
3	James		No	James I.D.	28,196	44
4	Mid-Valley		No	Mid-Valley W.D.	13,483	21
5	East Side Well Field		No		44,193	69
6	FID West		Yes	Fresno I.D.	111,970	175
7	Fresno - SOI - Westside	City of Fresno	Yes		44,399	69
8	Fresno - SOI - Fluoride	City of Fresno	Yes		3,070	5
9	Fresno - SOI - Pinedale	City of Fresno	Yes	Pinedale W.D.	2,036	3
10	Fresno - SOI - Shepherd	City of Fresno	Yes		5,202	8
11	Fresno - SOI - Sierra	City of Fresno	Yes		6,229	10
12	Fresno - SOI - Highway 41	City of Fresno	Yes		27,869	44
13	Fresno - SOI - Bakman	City of Fresno	Yes	Bakman W.C.	1,651	3
14	Fresno - SOI - CSFU	City of Fresno	Yes		1,312	2
15	Clovis - SOI	City of Clovis	Yes		20,322	32
16	FID East		Yes	Fresno I.D.	48,167	75
17	Foothills North		No		59,406	93
18	Crescent Canal Service Area		No		23,230	36
19	Stinson		No	Stinson W.D.	12,155	19
20	Murphy Slough		No	Murphy Slough W.D.	30,870	48
21	Raisin City		Yes	Raisin City W.D.	49,502	77
22	Riverdale		No	Riverdale I.D.	15,966	25
23	Laguna		No	Laguna I.D.	38,629	60
24	Liberty		No	Liberty W.D.	21,499	34
25	Private Pumpers East of Liberty		No		13,875	22
26	CID West		Yes	Consolidated I.D.	86,963	136
27	CID East		Yes	Consolidated I.D.	76,202	119
28	Kings River		Yes	Kings River W.D.	14,676	23
29	AID West		Yes	Alta I.D.	67,425	105
30	AID East		Yes	Alta I.D.	32,728	51
31	AID North		Yes	Alta I.D.	34,733	54
32	Foothills South		No		62,075	97



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5	East Side Well Field	21	Raisin City
6	FID West	22	Riverdale
7	Fresno - SOI - Westside	23	Laguna
8	Fresno - SOI - Fluoride	24	Liberty
9	Fresno - SOI - Pinedale	25	Private Pumpers East of Liberty
10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South

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Model Subregions in Fresno and Clovis

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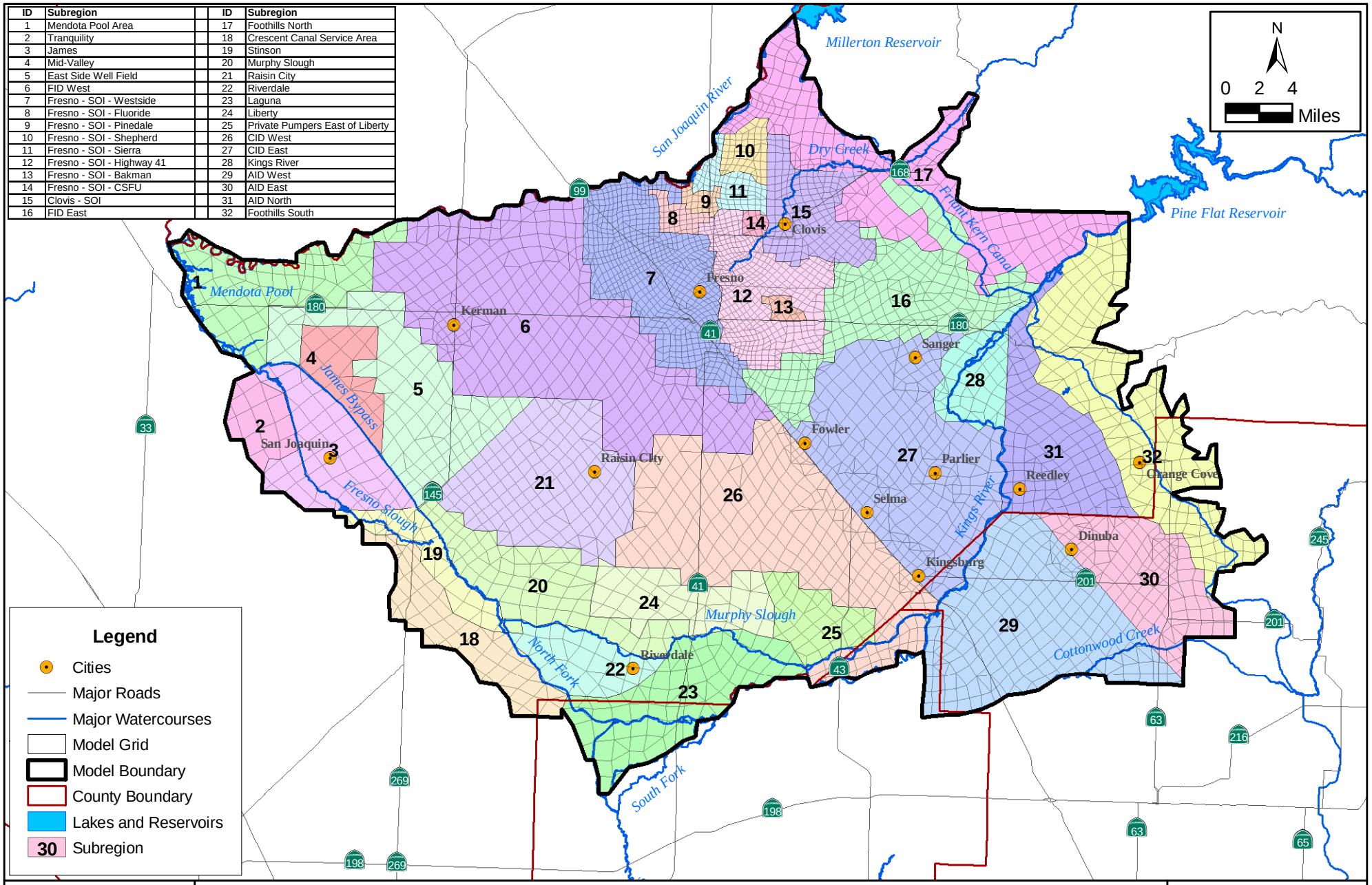
Figure 4-2



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11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South

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Model Grid

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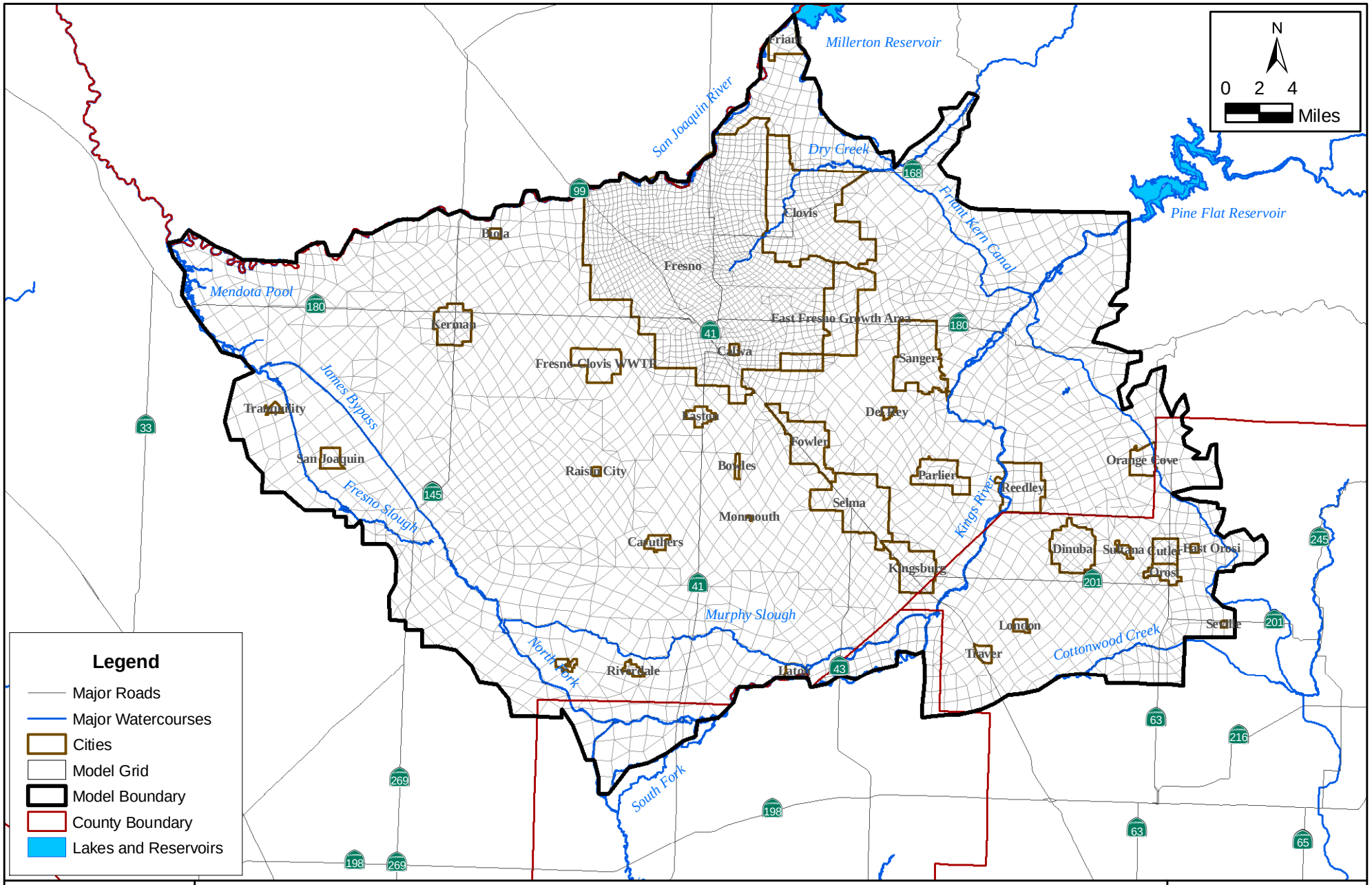
Figure 4-3

Table 4-2. Kings IGSM Grid Statistics

Statistic	Area						
	AID	CID	FID	Clovis SOI	Fresno SOI	Others	Total Model Area
# of Nodes	482	581	657	220	1,395	1,335	4,266
# of Elements	495	604	639	197	1,447	1,307	4,689
# of Layers	3	3	3	3	3	3	3
Min. Element Size (acres)	24	24	17	13	9	28	9
Max. Element Size (acres)	543	713	654	181	191	965	965
Average Element Size (acres)	272	270	251	103	63	361	222
Total Area (sq. miles)	211	255	250	32	143	737	1,628



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Model Grid Refinement for Urban Areas

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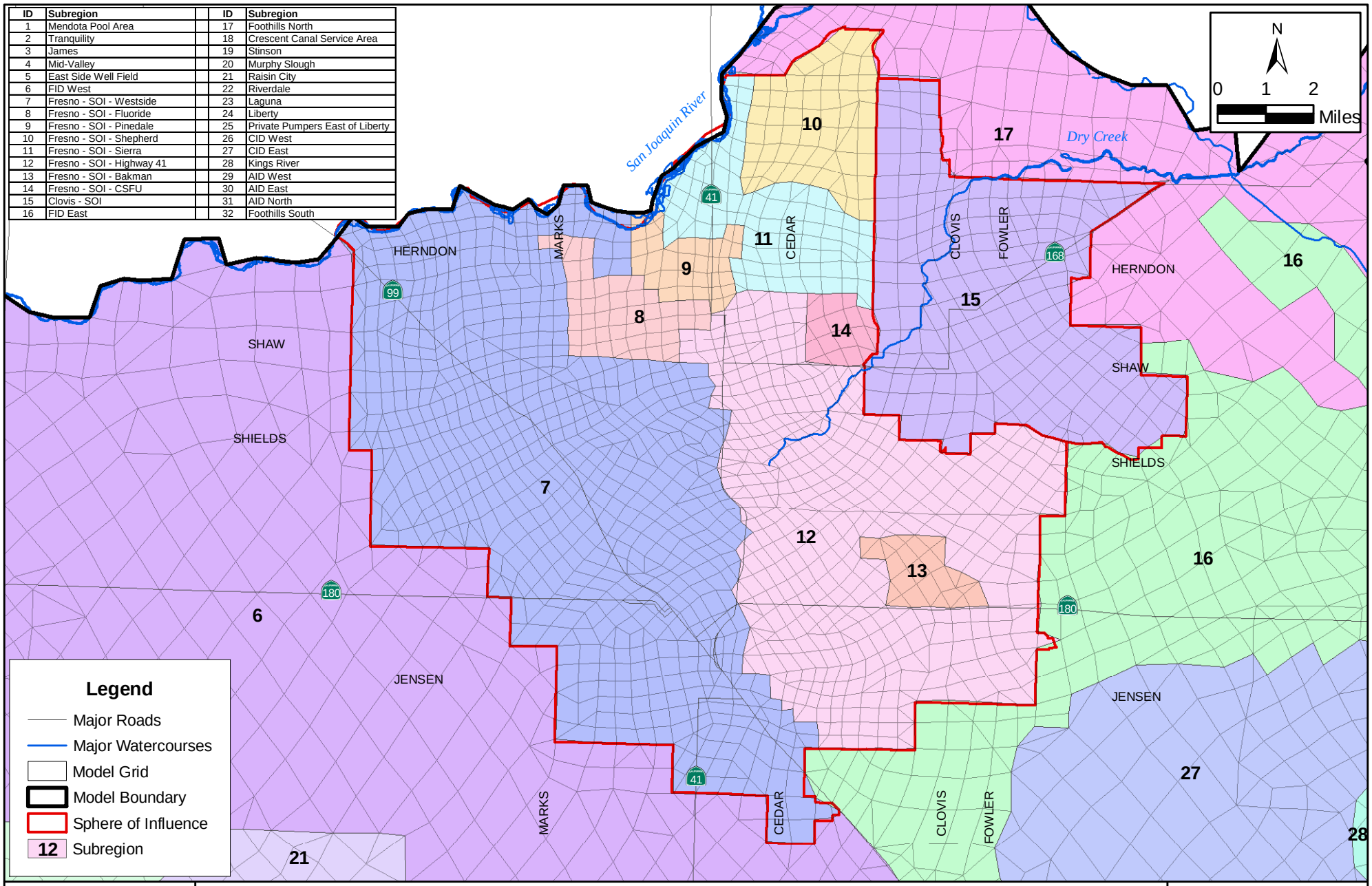
Figure 4-4



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10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South

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Model Grid Refinement for Fresno SOI

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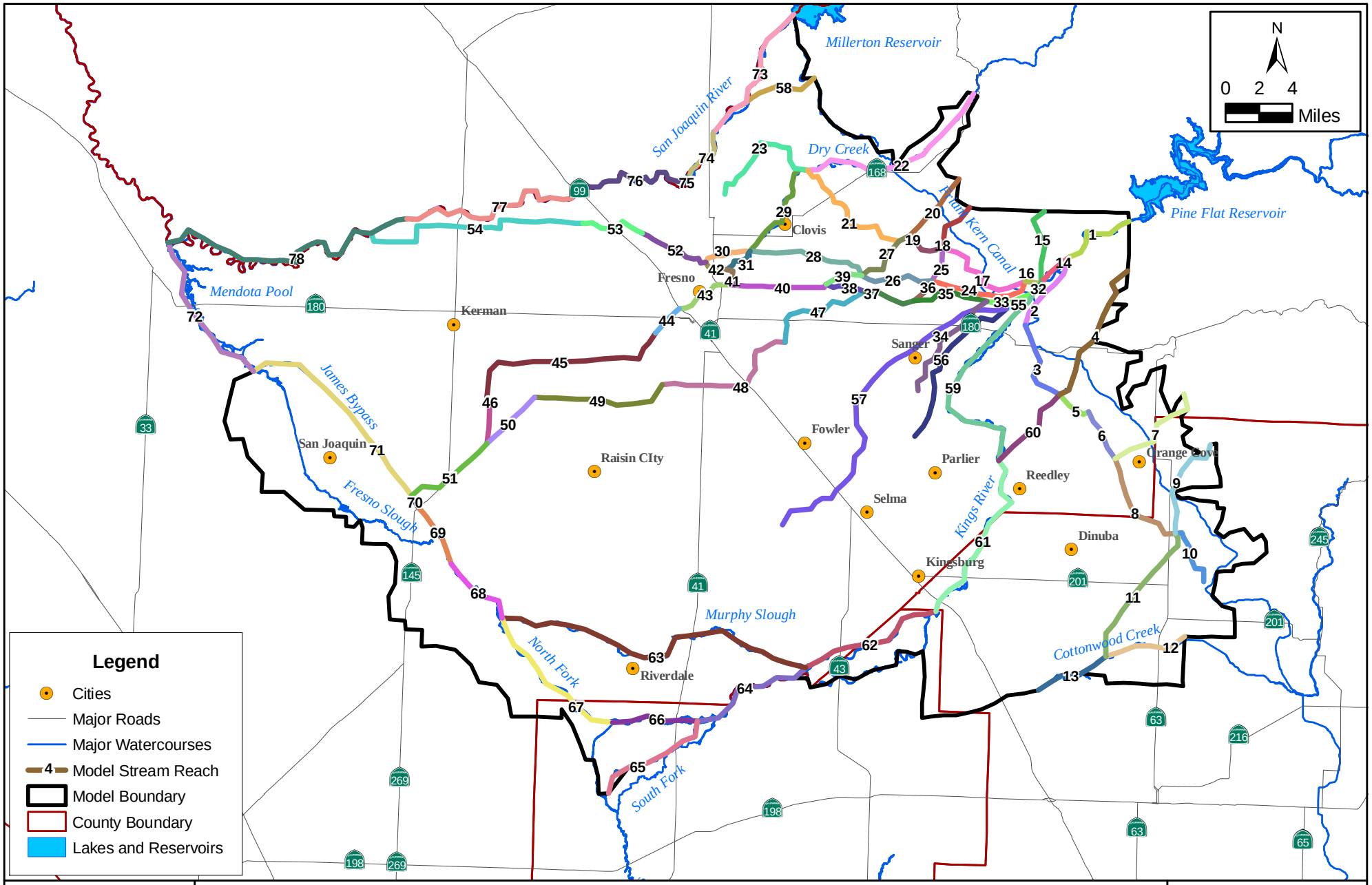
Figure 4-5



WRIME

Model Surface Water System

Kings IGSM Model Development and Calibration

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Figure 4-6

Table 4-3. Kings IGSM Stream Reaches

Stream Reach	Name	Begin	End	Segment Length (miles)
Kings River Reaches				
1	Kings River	Pine Flat	Alta Weir	4.8
14	Kings River	Alta Weir	Gould Weir	2.3
32	Kings River	Gould Weir	Fresno Weir	0.7
59	Kings River	Fresno Weir	Watoke Creek Confluence	14.3
61	Kings River	Watoke Creek Confluence	Peoples Weir	11.3
62	Kings River (Cole Slough)	Peoples Weir	Murphy Slough Weir	8.9
63	Murphy Slough	Murphy Slough Weir	North Fork Kings River near Stinson Weir	20.0
64	Kings River	Murphy Slough Weir	Island Weir	7.9
65	South Fork Kings River	Island Weir	Southern Model Boundary	7.5
66	North Fork Kings River	Island Weir	Crescent Weir	5.2
67	North Fork Kings River	Crescent Weir	Stinson Weir	9.6
68	North Fork Kings River	Stinson Weir	Conjeo Ave	4.8
69	North Fork Kings River	Conjeo Ave	James Weir	4.0
70	James Bypass	James Weir	McMulin Grade	0.7
71	James Bypass	McMulin Grade	Mendota Pool	13.3
72	Mendota Pool	James Bypass	San Joaquin River	9.9
Total Length (not including reach 63 & 65)				97.7
San Joaquin River Reaches				
58	Little Dry Creek	Foothills Model Boundary	San Joaquin River	4.6
73	San Joaquin River	Friant Dam	Madera County 10th Ave	9.1
74	San Joaquin River	Madera County 10th Ave	Madera County Road 40 1/2	3.4
75	San Joaquin River	Madera County Road 40 1/2	Madera County Road 40	0.6
76	San Joaquin River	Madera County Road 40	Hwy 99	7.9
77	San Joaquin River	Hwy 99	Madera County Road 24	12.4
78	San Joaquin River	Madera County Road 24	Kings River Confluence	17.3
Total Length (not including reach 58)				50.8
AID Reaches				
2	76 Channel	Kings River	Alta Canal Headgate	5.0
3	Alta Canal	Alta Canal Headgate	Watoke Creek	5.3
4	Watoke Creek	Foothills Model Boundary	Alta Canal	9.1
5	Alta Canal	Watoke Creek	Alta East Branch Canal	2.2
6	Alta East Branch Canal	Alta Canal	Wooten Creek	3.3

Stream Reach	Name	Begin	End	Segment Length (miles)
7	Wooten Creek	Foothills Model Boundary	Alta Canal	6.6
8	Alta East Branch Canal	Wooten Creek	Sand Creek	6.4
9	Sand Creek	Foothills Model Boundary	Alta East Branch Canal	6.6
10	Alta East Branch Canal	Sand Creek	End of Canal	4.0
11	Sand Creek	Alta East Branch Canal	Cottonwood Creek	8.9
12	Cottonwood Creek	Foothills Model Boundary	Sand Creek Confluence	5.0
13	Cottonwood Creek	Sand Creek Confluence	Southern Model Boundary	4.6
60	Watoke Creek	Alta Canal	Kings River	5.6
CID Reaches				
34	Lone Tree Canal	Fresno Canal	End of Canal	7.3
55	Consolidated Canal	Fresno Weir	C&K Canal and Fowler Swich Headgates	1.9
56	C&K Canal	C&K Canal and Fowler Swich Headgates	End of Canal	10.4
57	Fowler Swich	C&K Canal and Fowler Swich Headgates	End of Canal	21.3
FID Reaches				
15	Holland Creek	Foothills Model Boundary	Kings River	4.8
16	Gould Canal	Gould Weir	Enterprise Canal Headgate	1.0
17	Enterprise Canal	Enterprise Canal Headgate	Fancher Creek	6.4
18	Fancher Creek	Foothills Model Boundary	Enterprise Canal	3.2
19	Enterprise Canal	Fancher Creek	Redbank Creek	2.4
20	Redbank Creek	Foothills Model Boundary	Enterprise Canal	4.5
21	Enterprise Canal	Redbank Creek	Dry Creek	8.6
22	Dry Creek	Foothills Model Boundary	Enterprise Canal	12.2
23	Enterprise Canal	Dry Creek	End of Canal	8.0
24	Gould Canal	Enterprise Canal Headgate	Fancher Creek	6.1
25	Fancher Creek	Enterprise Canal	Gould Canal	2.1
26	Gould Canal	Fancher Creek	Redbank Creek	4.4
27	Redbank Creek	Enterprise Canal	Gould Canal	4.1
28	Gould Canal	Redbank Creek	Dry Creek	7.2
29	Dry Creek	Enterprise Canal	Gould Canal	6.7
30	Gould Canal	Dry Creek	End of Canal	2.9
31	Gould Extension	Gould Canal	Herdon Canal	2.0

Stream Reach	Name	Begin	End	Segment Length (miles)
33	Fresno Canal	Fresno Weir	Lone Tree Canal	2.9
35	Fresno Canal	Lone Tree Canal	Fancher Creek	4.6
36	Fancher Creek	Gould Canal	Fresno Canal	1.6
37	Fresno Canal	Fancher Creek	Fancher Creek and Mill Canal Headgates	3.1
38	Mill Canal	Fancher Creek and Mill Canal Headgates	Redbank Creek Confluence	2.4
39	Redbank Creek	Gould Canal	Mill Canal	2.3
40	Mill Canal	Redbank Creek Confluence	Dry Creek and Herndon Canal Headgates	5.7
41	Herdon Canal	Dry Creek and Herndon Canal Headgates	Gould Extension Confluence	1.2
42	Herdon Canal	Gould Extension Confluence	Gould Canal Confluence	1.4
43	Lower Dry Creek	Dry Creek and Herndon Canal Headgates	Lower Dry Creek and Houghton Headgates	3.6
44	Lower Dry Creek	Lower Dry Creek and Houghton Headgates	Marks Ave	2.1
45	Lower Dry Creek	Marks Ave	American Ave	12.5
46	Lower Dry Creek	American Ave	McMulin Grade	2.8
47	Fancher Creek	Fancher Creek and Mill Canal Headgates	Central Canal	6.7
48	Central Canal	Fancher Creek	Central Wasteway	9.2
49	Central Wasteway	Central Canal	McMulin Grade	8.3
50	McMulin Grade	Central Wasteway	Lower Dry Creek Confluence	3.9
51	McMulin Grade	Lower Dry Creek Confluence	Kings River	5.8
52	Herdon Canal	Gould Canal Confluence	Herdon Headgate at Brawley	4.4
53	Herdon Canal	Herdon Headgate at Brawley	Garfield Ave	4.0
54	Herdon Canal	Garfield Ave	San Joaquin River	14.4

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SECTION 5 MODEL INPUT DATA

This section describes the sources of data and methodology used to analyze and prepare data for input into the Kings IGSM. The model input data is organized into the following categories:

- Geohydrology and geography;
- Hydrology and climatology;
- Land use;
- Water use;
- Parameter;
- Initial Conditions; and
- Boundary Conditions.

Each of these data categories is described below.

5.1 GEOHYDROLOGY/GEOGRAPHY DATA

The geohydrology and geography data that were used as input data in the Kings IGSM are briefly described below. The detailed description of the development of the model geology data is presented in the *Hydrogeologic Investigation Technical Memorandum (TM)* (Brown and Caldwell, 2006).

The following primary data are described in more detail in this Section:

- Stratigraphy Data,
- Stream Channel Geometry, and
- Surface Drainage Pattern.

5.1.1 STRATIGRAPHY DATA

Thickness of the model layers representing the aquitards and aquifers of Kings Basin were developed from the hydrostratigraphic sections developed and presented in *Hydrogeologic Investigation TM* (Brown and Caldwell, 2006). The hydrogeologic investigation was based on primarily on previous hydrogeologic studies and lithologic and geophysical logs. A major study examined was Geology, Hydrology, and Water Quality in the Fresno Area, California by R.W. Page and R.A. LeBlanc (1969). Information on the subsurface deposits was interpreted mainly from well drillers logs and geophysical logs. DWR San Joaquin District provided over 500 geophysical logs and over 3000 driller's logs for review.

Driller's logs provided location, total depth, and a brief description of the deposits. Geophysical logs included downhole measurements of spontaneous potential (SP), electrical

resistivity, gamma, and/or caliper. Primarily resistivity and SP logs were used for the *Hydrogeologic Investigation*. Regional cross sections were developed to correlate the stratigraphic units and define the elevations of hydrostratigraphic layers in the subsurface. A database of layer elevations was compiled from the cross sections and used to generate elevation contour maps for the bottom of each layer.

Based on the Hydrogeologic Investigation (Brown and Caldwell, 2006), data collected as part of the development of the Kings IGSM, and the recommendation of the TAD Work Group, the aquifer system in Kings Basin is modeled as a 2-layer aquifer system with a confining bed between top and bottom layers. The bottom model layer was further divided into two layers (Model Layers 2 and 3). The model layers correspond to:

- Older Alluvium above E-Clay (Model Layer 1),
- E-Clay and the local confining beds (Confining Layer),
- Older Alluvium below E-Clay (Model Layer 2), and
- Upper parts of the Continental Deposits (Model Layer 3).

Model Layer 3 represents the active pumping zone in the upper parts of the Continental Deposits.

The Kings IGSM input data for geologic characterization of the groundwater basin includes the stratigraphic description of the underlying aquifers at every model node. This includes ground surface elevation, and thickness of the aquifers and aquitards at each of the 4,266 nodes of the Kings IGSM. Model layers were compared with several geologic cross sections developed by Kenneth D. Schmidt and Associates (Kenneth D. Schmidt and Associates, 1992 and 2004) for Fresno/Clovis Metropolitan Areas. Based on comments obtained from Kenneth D. Schmidt and Associates, model layer elevations were refined in southeast area of Fresno.

Four cross-sections are developed, based on model data, to represent the geologic conditions in the model. The locations of two regional and two Fresno area geologic cross-sections are shown in Figure 5-1 and the cross-sections are shown in Figures 5-2 through 5-5. These cross sections were reviewed by Kenneth D. Schmidt and Associates and represents the changes recommended by Kenneth D. Schmidt and Associates.

5.1.1.1 Ground Surface Elevation and Layer Thickness Data

A Digital Elevation Model (DEM) was obtained from the California Spatial Information Library. The DEM contains land surface elevation data at 1-second (30-meter) resolution (elevation data is taken on a grid at 30-meter spacing). The DEM data was used to develop the Kings IGSM ground surface elevation data. Figure 5-6 shows the ground surface elevation contours.

The thickness of layers 1 through 3 is shown in Figures 5-7 through 5-9. The thickness of aquitard between layers 1 and 2 (E Clay) is shown in Figure 5-10. E Clay aquitard is mainly present in the western half of the Basin and becomes thinner from west to east.

5.1.1.2 Well Depth Data

Groundwater production occurs at various depths throughout the model area. In order to develop a detail understanding of the spatial and depth distribution of groundwater pumping for agricultural and rural domestic water use, geophysical logs and e-logs were obtained from the DWR database. This database included two sets of data (i) a database with scanned images of well logs, and (ii) a database with electronic interpretation of well logs as digitized by the USGS in cooperation with the DWR. There are 15,129 wells with bottom depth information available from these sources. Figure 5-11 presents the distribution of these well logs by townships in the model area. The distribution of depth of agricultural and rural domestic wells in the model area is shown in Figure 5-12. Most of the wells are drilled to depths of 100 to 250 feet, however, significant numbers of wells are drilled deeper than 300 feet. The depths of the wells in Upper Kings Basin are usually less than 300 feet (Figures 5-12a-d). In contrast, the wells in Lower Kings Basin are significantly deeper. Most of the wells in Raisin City Water District are deeper than 300 feet. Some James Irrigation District wells are deeper than 800 feet.

5.1.2 FRESNO WELL DATA

Municipal wells in the model area are usually deeper than the agricultural wells. The well depth distribution of the agricultural and municipal wells in the spheres of influence for the cities of Fresno and Clovis are shown in Figures 5-13a-b. Agricultural wells in Fresno area are mostly shallower than 200 feet, while the municipal wells are mostly 200-600 feet deep. Agricultural and municipal wells in the Clovis sphere of influence follow a similar well depth distribution pattern. Information pertaining to Fresno and Clovis municipal wells is summarized in Table 5-1 and detailed information is presented in Appendix A. While most municipal wells (289 wells) pump from model layer 1, only 71 wells pump from model layers 2 and 3. The locations and approximate construction dates of Fresno and Clovis municipal wells are shown in Figure 5-14. Monthly pumping record of each municipal well in Fresno is available for 1980 to present. Monthly pumping record of municipal wells in Clovis is available for 1983 to present. Only total pumping record is available for the 1964-1979 period for Fresno and 1964-1982 period for Clovis. The construction dates of Fresno and Clovis municipal wells were used to determine the active wells during this period. The total pumping rates were distributed to the active wells using the 1980 pumping ratios.

Table 5-1. Fresno and Clovis Municipal Wells

Well Information	Fresno			Clovis		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Well Capacity (gpm)	250	3,600	1,260	500	2,700	1,182
Well Depth (feet)	115	810	366	100	715	408
Top Perforation Depth (feet)*	50	470	184	80	400	204
Bottom Perforation Depth (feet)*	77	800	343	100	700	397

* Although most wells have multiple perforated intervals, the top and bottom of perforation represents the top and bottom of the production zone for modeling purposes.

5.1.3 STREAM RATING TABLES

Stream rating tables provide the stage discharge relationships, which are used to calculate the stream stage and the stream aquifer interaction in the Kings IGSM. Stream channel cross-sections, flow rating tables, and wetted perimeter rating tables were collected as part of the development of the Kings IGSM. The sources of the stream cross-section data are:

- AID IGSM Model,
- CID IGSM Model, and
- CVGSM Model.

Eight stream rating tables were developed that represent the rating tables of the rivers and canals in the Kings IGSM. The rating tables are for small, medium, and major canals and creeks, Upper Kings River, Lower Kings River, and San Joaquin River (Table 5-2). A rating table from Table 5-2 was assigned to the stream nodes of each of the Kings IGSM stream reaches. Table 5-3 presents the Kings IGSM stream reaches and the corresponding rating tables and streambed hydraulic conductivities. A map of Kings IGSM reaches is presented in Figure 4-6.

5.1.4 SURFACE DRAINAGE PATTERN

Surface drainage patterns are used in the Kings IGSM to route runoff from rainfall or return flows from irrigation to the appropriate stream node. The drainage patterns are generally a function of the overall topography, but may be modified by man-made drains or canals. The drainage patterns for the Kings IGSM were determined using the DEM of the model area and the drainage patterns of the AID IGSM and CVGSM models. A more detailed drainage pattern was developed for the Fresno and Clovis areas by using the drainage patterns of the flood control basins of the FMFCD. Based on the natural drainage direction trends, each element was assigned a stream node to which runoff drains.

In general, the drainage pattern for the model area is from east to west or towards the Kings River. The surface drainage pattern used in the Kings IGSM is shown in Figure 5-15. Elements that drain to a common node are depicted in a common color in Figure 5-15.

5.2 HYDROLOGY/CLIMATOLOGY DATA

This section summarizes the general hydrology and climatology data collected for the Kings IGSM simulation period (1964-2004). Descriptions of the hydrologic/climatologic data included in the Kings IGSM are organized as follows:

- Rainfall Data;
- Rainfall Distribution;
- Soil Classification Data;
- Evapotranspiration Data; and
- Streamflow Data.

5.2.1 RAINFALL DATA

Rainfall is a significant component of the hydrologic system being modeled in the Kings IGSM. Ten stations were selected to provide rainfall data for the Kings IGSM. These stations were selected since the period of record was sufficient and there was sufficient geographic distribution from the selected stations. A list of the rainfall stations included in the Kings IGSM is provided in Table 5-4 and their locations and the associated model areas, as developed based on Thiesen polygons, are shown in Figure 5-16. These stations were selected to capture rainfall variations throughout the model area. The rainfall data were analyzed for accuracy before the input data for the Kings IGSM were prepared.

Table 5-4. Kings IGSM Rainfall Gaging Stations

No.	Station	Data Source	Period of Record	Percent Days without Data (1964-2004)	Annual Average (1964-2004) (inches/year)
1	Westlands*	CIMIS	1992-present	70	9.4
2	Five Points	NOAA	1948-present	8	7.7
3	Madera	NOAA	1978-present	3	12
4	Hanford	NOAA	1927-present	2	8.4
5	Visalia **	NOAA	1927-present	1	10.6
6	Fresno YIA	NOAA	1948-present	0	10.9
7	Parlier	CIMIS	1983-present	48	12.1
8	Orange Cove	NOAA	1931-1990	41	13.4
9	Friant GC	NOAA	1948-present	1	14.3
10	Pine Flat	NOAA	1965-present	4	19.3

* Westlands is not used in the model due to a relatively short period of record.

** Visalia is only used to estimate missing records and is not directly used in the model

Rainfall in the model area is characterized by a marked seasonal distribution with little or no rainfall in the summer months, with most rainfall occurring during the winter months, as shown for the Fresno Station in Figure 5-17. Figure 3-1 shows the annual rainfall and the cumulative departure from mean rainfall for the period of record and calibration period at Hanford Station. The long-term rainfall average for this station is 8.1 inches per year.

5.2.2 RAINFALL DISTRIBUTION

The Kings IGSM allows specifying variable rainfall at each of the finite elements of the model in order to capture the spatial distribution of rainfall in the model area. The rainfall at each element is computed from two parameters: (1) an assigned rainfall station for each element; and (2) a weighting factor for each element based on the long-term average annual rainfall value at the element, obtained from long-term rainfall isohyetal maps. The weighting factor for an element is the ratio of the long-term average annual rainfall value at the element to the average annual recorded rainfall at the corresponding rainfall station.

Average annual rainfall contours for a sixty-year period (1900-1960) had been prepared for Kings Basin (Department of Water Resources, 1997). These contours were used to develop the weighting factor for each of the Kings IGSM element. The long-term average annual rainfall distribution in the model area is shown in Figure 5-18.

5.2.3 SOIL CLASSIFICATION DATA

Rainfall entering the model area is routed to direct runoff or infiltration. Direct runoff is drained into local streams or rivers. Rainfall in excess of direct runoff infiltrates into the root zone. The allocation between runoff and infiltration is related to the magnitude of rainfall and retention parameters that depend upon soil types, land use, and land management practices.

The rainfall-runoff module of the Kings IGSM uses the modified NRCS, formerly the Soil Conservation Service (SCS), equations to compute runoff from rain. This requires specification of hydrologic soil groups for each element of the model grid. The soil survey data of the model area was used to develop the hydrologic soil group data.

5.2.3.1 Available Soils Data

Five soil surveys, published by NRCS, were used to characterize the soils within the Kings IGSM study area. The survey areas and publication dates are as follows:

- Western Fresno County (12/7/2004);
- Eastern Fresno County (1/20/2005);

- Kings County (12/15/2005);
- Western Tulare County (12/29/2004); and
- Central Tulare County (1/11/2005).

The NRCS developed digital mapping of the soil surveys, which are available through the USDA –NRCS Soil Data Mart (http://soildatamart.nrcs.usda.gov). The Soil Data Mart digital soils mapping is currently available for the entire Kings IGSM model area. Data from these digital soil surveys, as downloaded in June 2006, were incorporated into the Kings IGSM to classify the model elements based on hydrologic soil groups.

5.2.3.2 Soils Data in Kings IGSM

The soil types identified in the soil survey data are associated with four hydrologic soil groups according to their runoff potential and infiltration characteristics. Table 5-5 lists the hydrologic soil groups and their runoff characteristics.

Table 5-5. Hydrologic Soils Groups

Hydrologic Soil Group	Runoff Characteristics	IGSM Hydrologic Soil Group Value
A	Low runoff potential: mainly sands and gravel that are deep and well to excessively drained; high transmissivity.	1
B	Low to moderate runoff potential: soils of moderately fine to moderately coarse textures; moderately deep and drained; medium transmissivity.	2
C	Moderate to high runoff potential: soils of moderately find-to-find texture, with an impeding clay layer; low transmissivity.	3
D	High runoff potential: mainly clay soils with a high swelling potential, shallow soils over nearly impervious materials and soil with high permanent water table; poor transmissivity.	4

The three county soil surveys were used to develop the hydrologic soil group data for each of the Kings IGSM elements. Because each model element may contain several soil types with different hydrologic soil group classifications, a composite hydrologic soil group value was estimated for each model element based on the percentage of each soil type present in that element weighted by their associated hydrologic soil group value, as shown in column 3 of Table 5-5. The hydrologic soil group value for each model element is shown in Figure 5-19.

5.2.4 POTENTIAL EVAPOTRANSPIRATION DATA

Evapotranspiration (PET) is the measurement of amount of water loss due to soil evaporation and consumptive use of crops. The rate of PET varies by crop type, time of year, and geographic location. Potential ET is the maximum amount of consumptive use by crop, if sufficient water were available in the soil environment.

PET data are provided in the Kings IGSM as potential ET rates varying by (1) crop type, (2) month, and (3) model subregion. The following sources were used to compile and quality control the PET data for the model:

- CIMIS ET Data;
- AID IGSM Model;
- CVGSM Model;
- Potential Monthly ET for the Southern San Joaquin Valley (DWR);
- Estimated ET for San Joaquin Valley (DWR, Bulletin 113); and
- Technical Analysis and Data Work Group (TAD Work Group).

The PET data used in Kings IGSM for nine crop types is presented in Table 5-6.

Table 5-6. Potential Evapotranspiration (ET) Data Used in Model

Crop	Potential Evapotranspiration (inches)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Grain	-	0.8	4.2	6.8	6.5	0.6	-	-	-	-	-	-	18.9
Rice	-	-	-	2.4	7.5	9.6	10.0	8.5	5.7	2.2	-	-	45.9
Field	-	-	0.5	1.3	3.6	7.3	8.5	5.6	2.1	0.6	0.3	-	29.8
Alfalfa	-	-	3.8	5.5	7.4	8.0	8.1	7.2	5.2	3.4	-	-	48.7
Pasture	-	-	2.0	3.0	4.1	4.7	5.1	4.6	3.1	1.8	0.7	-	29.2
Truck	-	-	-	1.3	4.2	6.5	4.3	3.5	1.0	0.5	0.3	-	21.6
Deciduous	-	-	1.8	3.3	5.6	6.4	7.0	6.3	4.1	2.6	1.0	-	38.1
Citrus	-	-	2.0	3.0	4.8	5.1	5.2	4.6	3.3	2.5	-	-	30.5
Vineyards	-	-	-	2.1	4.4	5.7	6.1	5.3	2.6	0.5	-	-	26.7

5.2.5 STREAMFLOW DATA

Two primary sources of streamflow data are the USGS and the KRWA. The USGS data were obtained from the web site http://water.usgs.gov/usa/nwis/sw. KRWA data was digitally provided to WRIME by KRWA. There are several stream gaging stations in the study area, some of which are now discontinued. All past and current stream gaging stations are listed in

Table 5-7. The locations of the stream gaging stations listed in Table 5-7 are shown in Figure 5-20.

Table 5-7. Streamflow Gaging Stations in Model Area

Station Characteristics			Period of Record	
Name	Source	Station ID	From	To
Friant Kern Canal at Friant, CA	USGS	11250000	3/22/1949	9/30/2005
San Joaquin River Below Friant, CA	USGS	11251000	10/1/1907	9/30/2005
Madera Canal at Friant, CA	USGS	11249500	10/1/1948	9/30/2005
Little Dry Creek Near Friant, CA	USGS	11251500	10/1/1941	9/30/1956
Little Dry Creek at Mouth Near Friant, CA	USGS	11251600	10/1/1956	9/30/1961
San Joaquin River at Herndon, CA	USGS	11252500	4/1/1895	9/30/1901
San Joaquin River Near Biola, CA	USGS	11253000	10/1/1952	9/30/1961
San Joaquin River Near Mendota, CA	USGS	11254000	10/1/1939	9/30/2005
Kings River Below Pine Flat Dam, CA	USGS	11221500	1/1/1954	10/4/1990
Kings River at Piedra, CA	USGS	11222000	10/1/1895	9/30/1959
Mill Creek Near Piedra, CA	USGS	11221700	10/1/1957	9/30/1994
James Bypass (Fresno Slough) Near San Joaquin, CA	USGS	11253500	10/1/1947	9/30/2005
Sand Creek Near orange Cove, CA	USGS	11212000	10/1/1944	9/30/1984
Cottonwood Creek Near Elderwood, CA	USGS	11211790	2/10/1971	12/30/1984
Cottonwood Creek Above Collier Creek Near Elderwood, CA	USGS	11211785	1/1/1985	9/30/1994
Kings River Below Pine Flat Dam, CA	KRWA	NA	1/1/1990	1/1/2005
Mill Creek Near Piedra, CA	KRWA	NA	1/1/1995	1/1/2005
Peoples Weir	KRWA	NA	10/1/1963	9/30/2004
Lemoore Weir	KRWA	NA	10/1/1963	9/30/2004
Army Weir	KRWA	NA	10/1/1963	9/30/2004
Island Weir	KRWA	NA	10/1/1963	9/30/2004
Crescent Weir	KRWA	NA	10/1/1963	9/30/2004
Stinson Weir	KRWA	NA	10/1/1963	9/30/2004
James Weir	KRWA	NA	10/1/1963	9/30/2004

The Kings IGSM requires daily streamflow data at the boundary of the model. The stream flow gages in and near the model area were evaluated for proximity to the model boundary, length-of-record, and time interval for which data is available to determine the suitability of including them in the Kings IGSM. The stream flow gages that are at the model boundary were selected to provide inflows to the Kings IGSM; other stream gage stations were selected for use during model calibration of stream flows. The stream flow gages selected for inclusion to the Kings IGSM database are listed in Table 5-7.

5.2.5.1 Analysis of Stream Flow Data

The Kings IGSM requires a complete set of daily flow records at the most upstream river nodes, as the rivers enter the model boundary. Daily flow records for the following systems are collected, and when missing, estimated.

5.2.5.1.1 Kings River

The stream inflow data for the Kings River was developed by combining 1964-1990 daily stream flow data from the USGS and 1991-2004 daily stream flow data from the KRWA. The stream inflow from the Kings River is the release from the Pine Flat Dam as measured at the USGS gaging station located approximately one-half mile downstream of the dam. Kings River daily stream flow data is available for the entire model simulation period. Figure 5-21 shows the annual volume of inflow of the Kings River into the model area. Figure 5-21 shows annual streamflow of Kings River out of the model area.

5.2.5.1.2 Mill Creek

The stream inflow from the Mill Creek, a tributary to the Kings River below Pine Flat Dam, is included in the Kings IGSM. The period of record at this gage is complete for the model simulation period. The stream inflow data for the Mill Creek was obtained from KRWA.

5.2.5.1.3 Hughes Creek

The Hughes Creek is not gaged at the boundary of the Kings IGSM. Hughes Creek stream flow is the estimated daily average discharge of Hughes Creek and the other ungaged tributaries between Pine Flat Dam and Piedra. It has been determined by the KRWA that the runoff from these tributaries is approximately 12.2% of Mill Creek stream flow.

5.2.5.1.4 San Joaquin River

San Joaquin River daily stream inflow data is available from USGS for the entire model simulation period. Figure 5-22 shows the annual volume of inflow of the San Joaquin River into the model area.

5.2.5.1.5 Ungaged Small Tributaries

There are sixteen small, ungaged, watersheds in the foothills area east of the model area. These watersheds drain into the Kings Basin area, however, no complete record is available for most

of the tributaries. Flows from the ungaged watersheds are calculated based on the flows from Hughes Creek and Mill Creek.

5.3 LAND USE AND CROP DATA

The Kings IGSM requires two sets of input files for land use: (1) spatial distribution of land use by model elements; and (2) annual crop acreage by model subregions. Both the land use distribution data and crop acreage data are described below.

5.3.1 LAND USE DATA

The DWR conducts land use surveys by county in order to estimate the changing land and water use patterns. The surveys are completed about every five to seven years for an individual county. Land use data for Fresno, Kings and Tulare Counties were obtained from the DWR in electronic format for recent years. The survey years for each county differ from one another. KRCD has recently digitized hard copies of the 1972 Fresno County and 1970 Tulare County land use surveys. The DWR land use survey data that was collected for Kings IGSM development is listed in Table 5-8.

Table 5-8. Land Use Surveys Used in the KingsIGSM

Area	Year of Survey
Fresno County	1958, 1968, 1972*, 1979, 1986*, 1994*, 2000*
Kings County	1991*, 1996*, 2003*
Tulare County	1958, 1970*, 1978, 1985, 1993*, 1999*

* Available as GIS shape files

The data from the land use surveys of Table 5-8 was incorporated into the Kings IGSM database. The digitally available land use information was mapped to each of the Kings IGSM finite elements. The Kings IGSM elemental land use distribution data requires four general land use categories:

- Agricultural Areas;
- Urban Areas, including commercial, industrial, rural residential, urban landscaping, and urban vacant lands;
- Undeveloped/Native Vegetation, including lands designated as idle; and
- Riparian Vegetation.

Overall, the native vegetation and agricultural areas dominate the general land use in the Kings IGSM. The 2000 land use distribution for the entire Kings IGSM study area and the Fresno/Clovis Metropolitan area are shown in Figures 5-23 and 5-24. Figure 5-25 shows the 1964 and 2004 land use data summary for the entire model area and the Fresno SOI,

respectively. Based on these figures, agricultural lands in the model area increased from 68% to 74% of the total area over the 41-year simulation period, while agricultural area decreased from 43% to 18% in the Fresno SOI area. Urban lands in the model area increased from 5% to 13% of the total area, while urban area in the Fresno SOI area increased from 35% to 76%. The native/vacant land reduced from 26% to 12% and from 22% to 6% in the entire model area and Fresno SOI, respectively.

5.3.2 CROP DATA

Irrigated crop acreage data for the Fresno, Kings and Tulare Counties were obtained from three sources:

- Detailed Analysis Units (DAU) surveys;
- DWR land use surveys (described above); and
- Fresno County Agricultural Commissioner's Annual Reports.

The DAUs that fall within the Kings IGSM area are #233 through #240, excluding #238 which lies south of the Kings River (Figure 5-26). The DWR land use surveys provide the crop distribution and acreage for specific survey years. The Agricultural Commissioner's reports consist of annual countywide agricultural production data based on harvested acreages. These reports were used to verify the land use and crop data.

The annual crop data for the Kings IGSM study area was developed based on the GIS and DAU data. The acreages for individual crop types were aggregated into nine (9) consistent and common crop type categories, as shown in Figure 5-27. Land use trends (1965 to 2004) in model area and Fresno SOI are shown respectively in Figure 5-28. Tables 5-9 and 5-10 list crop acreages in each Kings IGSM subregions for 1964 and 2004. Crop distribution summary (1964 and 2004) in model area and Fresno SOI are shown respectively in Figures 5-29.

The Kings IGSM also simulates urban acreage. Urban acreage has increased from 49,000 acres in 1964 to about 135,000 acres in 2004. The urban growth is centered on several existing urbanized areas in the eastern part of the model area mainly in the Fresno SOI and Clovis SOI.

5.4 WATER SUPPLY AND WATER USE DATA

The agricultural and urban areas identified in the land use analysis above are the primary areas of water use within the Kings IGSM model area. Agriculture is the single largest user of water in the model area. Other than Fresno Metropolitan Area, urban areas are small relative to the agricultural area and their corresponding water use is smaller. The primary sources of water supply for agriculture are surface water and groundwater. In general, groundwater is used by those agricultural areas that do not have access to surface water, or in years when surface water

supplies are scarce due to hydrologic conditions. Groundwater has been the primary source of water supply in urban areas, to-date. However, the cities of Fresno and Clovis have also been using surface water since 2004 when the new surface water treatment plant was completed. This section describes the water supply and water use data and estimates within the Kings IGSM model area, including:

- Surface Water Delivery;
- Agricultural Water Use;
- Urban Water Use;
- Groundwater Pumping;
- Groundwater Recharge; and
- Reclaimed Water.

5.4.1 SURFACE WATER DELIVERY

The Kings IGSM model area includes several organized water and irrigation districts, which receive substantial amounts of surface water for agricultural purposes and municipal use. The primary sources of surface water in the model area are Kings River, San Joaquin River, and CVP water. The surface water diversion data were obtained from KRWA, USBR, and FID.

5.4.1.1 Kings River

KRWA and its member agencies provide Kings River water for irrigation use on nearly 20,000 farms in portions of Fresno, Kings and Tulare counties. All KRWA member agencies are public districts or canal companies. KRCD and KRWA oversee the Kings River. KRCD deals with flood control, power, on-farm water management and groundwater development. KRWA oversees Kings River entitlements and deliveries using a schedule of water rights and entitlements that has been in effect for about half a century. There are 28 member agencies or units of the Kings River Water Association. Thirteen are public agencies and 15 are mutual water companies. KRWA member units include:

1. Alta Irrigation District
2. Burrel Ditch Company
3. Clark's Fork Reclamation District
4. Consolidated Irrigation District
5. Corcoran Irrigation District
6. Crescent Canal Company
7. Empire West Side Irrigation District
8. Fresno Irrigation District
9. John Heinlen Mutual Water Company
10. James Irrigation District
11. Kings River Water District
12. Laguna Irrigation District
13. Last Chance Water Ditch Company
14. Lemoore Canal and Irrigation Company
15. Liberty Canal Company
16. Liberty Mill Race Company

17. Lovelace Water Corporation
18. People's Ditch Company
19. Reed Ditch Company
20. Riverdale Irrigation District
21. Southeast Lake Water Company
22. Stinson Canal and Irrigation Company
23. Stratford Irrigation District
24. Tranquility Irrigation District
25. Tulare Lake Basin Water Storage District
26. Tulare Lake Canal Company
27. Tulare Lake Reclamation District No. 761
28. Upper San Jose Water Company

Kings River water is diverted based on the schedules of water diversions. There are 12 such schedules, one for each month of the year (KRWA, 2007). They all detail exactly how much water each of the KRWA member units is entitled to receive and divert based on each day's calculated natural flow (the amount of water that would have been in the river if there weren't any dams). Based on the schedule, the KRWA's staff determines exactly the amount of water each unit is entitled to receive. Every year KRWA publishes the daily record of Kings River water deliveries to its member agencies. The daily records are available as hard copies for the most years of the Kings IGSM simulation period, however, only monthly records are available in electronic form. The electronic monthly records of Kings River diversions for KRWA units in the model area were obtained from KRWA for the 1964-2004 simulation period. The electronic records were analyzed and checked against the hard copy records for consistency and accuracy. The missing electronic data was obtained from the hard copy records.

Numerous weirs are used to control diversions into the specific canals for water districts or ditch companies. Diversions for AID, FID, and CID occur at the Cobbles Weir, Gould Weir, and Fresno Weir. Figure 5-30 shows the annual diversions from Kings River. Monthly diversion data for the KRWA units that divert water from Kings River in the model area is included in the Kings IGSM.

5.4.1.1.1 Surface Water Distribution within KRWA Units

Monthly distribution of Kings River water within all of the KRWA units is not well documented and is not readily available. However, available reports and data and communications with AID, CID, and FID personnel were used to determine the distribution patterns of Kings River water within the IRWMP area.

AID uses 4 major canals and 10 secondary canals to distribute Kings River water in its service area. The major canals have capacities of 70-120 cfs while the smaller secondary canals have capacities of 30-35 cfs. These 14 canals are included in AID subregions of Kings IGSM.

Three major canals, Fowler Switch Canal, C& K Canal, and Lone Tree Canal, distribute water in CID. The surface water service area map of CID was used to specify the distribution of Kings River water within CID subregions of Kings IGSM.

5.4.1.1.2 Surface Water Distribution within FID and Fresno/Clovis Areas

Kings River water is delivered to FID via Fresno Canal and Gould Canal. These canals branch into several smaller canals within FID. Gould Canal divides into Enterprise and Gould canals in the vicinity of Kings River. Enterprise Canal goes north and serves the Clovis and the surrounding areas. Gould Canal goes west and serves areas south of Clovis and east of Fresno. Fresno Canal goes west and branches into Fancher Creek Canal, Mill Canal, Dry Creek Canal, Herndon Canal, and Herndon/Brawly Canal. Hardcopy records of headgate diversions at major FID canals were obtained from FID and entered into Excel worksheets. The major canals of FID are simulated in Kings IGSM. The record of internal diversions of FID canals and the surface water service area map was used to specify the distribution of Kings River water within FID, Clovis, and Fresno subregions of Kings IGSM.

5.4.1.2 Friant-Kern Canal Deliveries

Most of San Joaquin River water is released from Millerton Lake reservoir into Friant-Kern Canal and Madera Canal. Friant-Kern Canal passes through the two foothills subregions of the Kings IGSM model area and runs south towards southern areas of the Central Valley. Friant-Kern Canal delivers water to:

- Foothills North Subregion:
  - Fresno County Water Works District No. 18,
  - Garfield Water District, and
  - International Water District;
- Foothills South Subregion:
  - Orange Cove Irrigation District, and
  - City of Orange Cove;
- FID Canals:
  - Gould Canal, and
  - Kings River.

Water delivered into Kings River is released upstream of Fresno Weir and is diverted out of Kings River via Fresno Canal. Fresno Canal diversions shown in Figure 5-30 include Friant-Kern deliveries into Kings River. Friant-Kern Canal deliveries into Kings IGSM model area are presented in Figure 5-31.

5.4.1.3 Central Valley Project Deliveries

Four districts at the northwestern section of Kings IGSM model area receive CVP water. These districts are as follows:

- James Irrigation District (Subregion #3),
- Tranquility Irrigation District (Subregion #2),
- Mid-Valley Water District (Subregion #4), and
- Fresno Slough Water District (Subregion #1).

Only 40% of Fresno Slough Water District is located within Kings IGSM model area and CVP delivery to this district was reduced proportionately. CVP deliveries into Kings IGSM model area are presented in Figure 5-31.

5.4.1.4 Canal Losses and Water Deliveries

A portion of the diverted water in each canal is lost to evaporation and seepage before it reaches the farms in the service area of the canal. An average of 15% losses is assumed for each canal. Surface water deliveries to each Kings IGSM subregion is equal to the diversion quantities reported by KRWA minus the canal losses. Table 5-11 summarizes the annual surface water deliveries to Kings IGSM model area. The annual surface water delivery for Kings Basin, with an average of 1,043,000 AF, ranges from about 318,000 AF in 1977 to 1,521,000 AF in 1967.

5.4.2 AGRICULTURAL WATER USE

5.4.2.1 Agricultural Water Demand

Agricultural water demand is calculated by using the Consumptive Use model component of the Kings IGSM. The consumptive use of a crop is the amount of water required to satisfy ET demand of the crop, which includes evaporation and transpiration loss from crop foliage and adjacent soils. The portion of the consumptive use that is met by irrigation water is called the consumptive use of applied water (CUAW). The agricultural water demand is equal to CUAW divided by the irrigation efficiency. The irrigation efficiency data for the model subregions were estimated based on the irrigation efficiency data included in DWR Bulletin 160-03 and with those used in the AIDIGSM and CVGSM models, and on the input from local stakeholders. These irrigation efficiency data were incorporated into the Kings IGSM database to compute agricultural water demand.

The estimated annual agricultural demand in Kings Basin ranges from a minimum of about 1,890,000 AF in 1983 to a maximum of about 2,411,000 AF in 1984 and averages about

2,224,000 AF/yr over the 1964-2004 study period, as shown in Table 5-12 and Figure 5-32. The annual variability in agricultural demand results from changes in crop acreage and crop mix and in hydrologic conditions.

5.4.2.2 Agricultural Groundwater Pumping

Groundwater pumping to meet agricultural water needs in each subregion is estimated as the balance of monthly agricultural water demand estimates in that subregion and the surface water deliveries for irrigation to that subregion. The estimated annual agricultural groundwater pumping in Kings Basin ranges from a minimum of about 959,000 AF in 1967 to a maximum of about 2,229,000 AF in 1977 and averages about 1,623,000 AF over the 1964-2004 study period, as shown in Table 5-13 and Figure 5-33.

5.4.2.3 Additional Agricultural Recharge

Depending on availability, monthly surface water deliveries to each subregion at times exceeds the estimated agricultural water demand. This excess water is applied to agricultural lands and results in additional groundwater recharge. Therefore, total agricultural water delivery is equal to sum of (1) total surface water delivery to meet agricultural demand and provide additional recharge and (2) agricultural groundwater pumping. The estimated annual agricultural water use is presented in Table 5-14 and Figure 5-32. Annual agricultural water use in Kings Basin ranges from a minimum of about 2,339,000 AF in 1976 to a maximum of about 3,021,000 AF in 1996 and averages about 2,666,000 AF.

5.4.3 URBAN WATER USE - AREAS OUTSIDE FRESNO METROPOLITAN AREA

The records of municipal water use in several cities outside Fresno Metropolitan Area are not complete for the model simulation period (Table 5-15). When pumping data were not available, the urban groundwater use was estimated to be the product of the per capita water use factor and the population of the urban area. Annual per capita water use factors are available from DWR for selected cities from 1980 to 2004. For 1964-1979 an average of 1980-2004 per capita water use factor was used. Cities without per capita water use data were assigned values from nearby cities with similar populations. Population data is available from the U.S. Census Bureau and the Department of Finance. Linear interpolation was used to estimate the missing data between years with population data. For years beyond the population data, a 2.5% growth rate was used to estimate the population of the urban areas.

Table 5-15. Annual Groundwater Pumping Data Availability

Urban Areas	Period of Annual Groundwater Pumping Record
Fresno SOI	
City of Fresno	1964 – 2004
Pinedale	2000-2004
Backman	2000-2004
CSUF	2000-2004
Clovis SOI	1964 – 2004
Malaga	1990 – 2003
Mendota	1990 – 2003
Sanger	1980 – 2003
Selma	1980 – 2003 excluding 1989
Kingsburg	1991 - 2003
Parlier	2001 – 2003
Riverdale	1992 - 2003
San Joaquin	1991 – 2003
Reedley	1980 – 2003
Dinuba	1991 – 2003
Orange Cove	1990 - 2003

5.4.4 URBAN WATER USE - FRESNO METROPOLITAN AREA

Annual municipal water use data for cities of Fresno and Clovis is available for the most of the years in simulation period. However, individual well pumping data for cities of Fresno and Clovis is only available for 1980-2004 and 1983-2004 periods, respectively. Well construction date data was used to determine the active wells for the years that no well pumping data is available. The pumping proportions of 1980 (for Fresno) and 1983 (for Clovis) were used to divide the annual pumping data by each well. Figure 5-14 illustrates the temporal and spatial distribution of Fresno and Clovis municipal wells.

Annual urban water use for various model areas for the 1964-2004 simulation period is provided in Table 5-16 and Figure 5-34. Annual urban water use in Kings Basin, with an average of 167,000 AF, ranges from 96,000 AF in 1964 to 265,000 AF in 2003. Table 5-17 and Figure 5-34 present annual urban water use by model subregions for Fresno SOI and Clovis SOI. The increase in urban water use reflects the increase in population and corresponding urban acreage.

5.4.5 GROUNDWATER PUMPING

Urban water demand, supplied by groundwater pumping, was added to the estimated agricultural groundwater pumping to determine the total groundwater pumping for each

model subregion. Table 5-18 and Figure 5-33 present annual groundwater pumping in various model areas for the 1964-2004 simulation period.

5.4.6 INTENTIONAL GROUNDWATER RECHARGE IN FRESNO METROPOLITAN AREA

Significant volumes of surface water are recharged at various recharge ponds and streams at the eastern parts of model area. The source of water for these recharge operations is mainly water diverted from Kings River. Recharge operations at Fresno Metropolitan Area occur mostly at Leaky Acres ponds and FMFCD ponds (Figure 5-35). Surface water has been recharged at Leaky Acres since 1972 at rates ranging from a minimum of about 9,000 AF/year in 1988 to a maximum of about 27,000 AF/year in 1992 (Figure 5-36). Recharge at FMFCD ponds started in 1980 at a rate of about 7,000 AF/year and gradually increased to more than 22,000 AF/year in the last ten years (Figure 5-36). During 1996 and 2000, recharge rates of more than 35,000 AF/year has occurred at FMFCD ponds. Leaky Acres ponds are used throughout the year with most of the recharge occurring from March to July (Figure 5-37). In contrast, FMFCD ponds are only available from late March to early October when the ponds are not needed for flood control operations.

5.4.7 RECLAIMED WATER IN FRESNO METROPOLITAN AREA

Municipal wastewater from cities of Fresno and Clovis, and industrial wastewater from some of the food processing plants in Fresno Metropolitan Area at a rate of about 80,000 AF/year is treated at Fresno-Clovis Regional Wastewater Treatment Facility. Wastewater is treated at this plant and directed mostly to percolation ponds where it percolates down into the aquifer. There are dozens of reclamation wells at this facility that pump out groundwater. The reclaimed water is pumped into FID canals of Dry Creek Canal that runs through the facility and Haughton Canal that is located north of the facility. These canals transfer the reclaimed water downstream for agricultural use. About 5% to 10% of treated wastewater is directly used at agricultural land at and in the vicinity of the facility. Figure 5-38 show the annual flow rates of Fresno-Clovis Regional Wastewater Treatment Facility. This chart shows (a) the quantity of plant outflow used for irrigation purposes in the vicinity of the facility, (b) the quantity of groundwater pumped by reclamation wells, and (c) net quantity of plant outflow that percolates down into the aquifer. The total treated wastewater that is sent to the percolation ponds is equal to sum of items (b) and (c). Evaporation from percolation ponds is assumed to be negligible for calculating the net percolation rates.

5.5 AQUIFER PARAMETER DATA

The geology and hydrogeology of the Kings Groundwater Basin have been investigated in the last several decades. Several reports on the Basin provide regional information on the geology, hydrogeology, aquifer characteristics, and storage capacity of the aquifer system in the study area.

An important database of aquifer parameters was provided by Kenneth D. Schmidt and Associates (2006). This database contains numerous measured aquifer transmissivity values from wells throughout the model area. Table 5-19 shows the transmissivity values that were reported by Kenneth D. Schmidt and Associates, number of wells tested at each site, the corresponding Kings IGSM layer, thickness of aquifer at the test site, and calculated hydraulic conductivities. The approximate locations of these aquifer test sites are shown in Figure 5-39. Hydraulic conductivity estimates presented in Table 5-19 are indicative of a highly permeable aquifer.

An important feature of the hydrogeology of Kings Basin is presence of several paleochannel deposits in eastern parts of the Basin. These paleochannels, with varying depths, have higher hydraulic conductivities and act as conduits for groundwater flow. Delineation of these paleochannels in Kings IGSM is based on studies conducted by Dr. David Cehrs (Cehrs, 2007).

The Kings IGSM uses a larger finite element grid, called parametric grid, to specify the spatial variation of aquifer parameters in the model area. The aquifer parameters are provided for each layer at the control points (i.e., nodes) of this parametric grid and an interpolation scheme is used to internally calculate aquifer parameter values at model nodes, which are used in the solution of finite element equations of groundwater flow. The parametric grid facilitates the mapping of regional hydrogeologic parameters to the model nodes. Figure 5-40 shows the parametric grid used in the Kings IGSM. The reported ranges of values of aquifer parameters are used in the Kings IGSM as initial estimates and are further refined during the model calibration. The maps of calibrated values of hydraulic conductivity are presented in Section 6.5.

5.6 INITIAL CONDITIONS DATA

The calibration period for the Kings IGSM is 1964–2004. The groundwater elevation at each node for each aquifer layer at the initial time of simulation provides the starting conditions for the groundwater flow simulation in the Kings IGSM. The initial groundwater levels for the Kings IGSM were developed based on observed water level data between September 1 to October 31 of 1963 and September 1 to October 31 of 1965 from the 542 wells identified in

Figure 5-41. The initial groundwater elevation at each node of the Kings IGSM was developed by applying bilinear interpolation to observed water level data. A contour map of initial groundwater levels is shown in Figure 5-42.

5.7 BOUNDARY CONDITIONS DATA

The boundary conditions are specified in the Kings IGSM at all boundary nodes to account for both surface and subsurface flows through the model boundary. There are five types of boundary conditions that can be specified in the Kings IGSM:

- Specified flux;
- Fixed head;
- General head (the flux depends on the specified head value outside the model area);
- Head-discharge rating table; and
- Mountain or ungaged watershed inflows.

The boundary conditions for the Kings IGSM were developed for the boundaries of the model area and for areas tributary to the model area. The boundaries of the groundwater model include:

- Northern Boundary along the San Joaquin River;
- Western Boundary along the Fresno Slough;
- Western Boundary along the western boundaries of Tranquility, James ID, Stinson, Crescent, and Laguna subregions;
- Southern Boundary along the Kings River;
- Southern Boundary along the AID West and AID East subregions; and
- Inflow from mountain watersheds in the foothills that drain into the Kings IGSM study area.

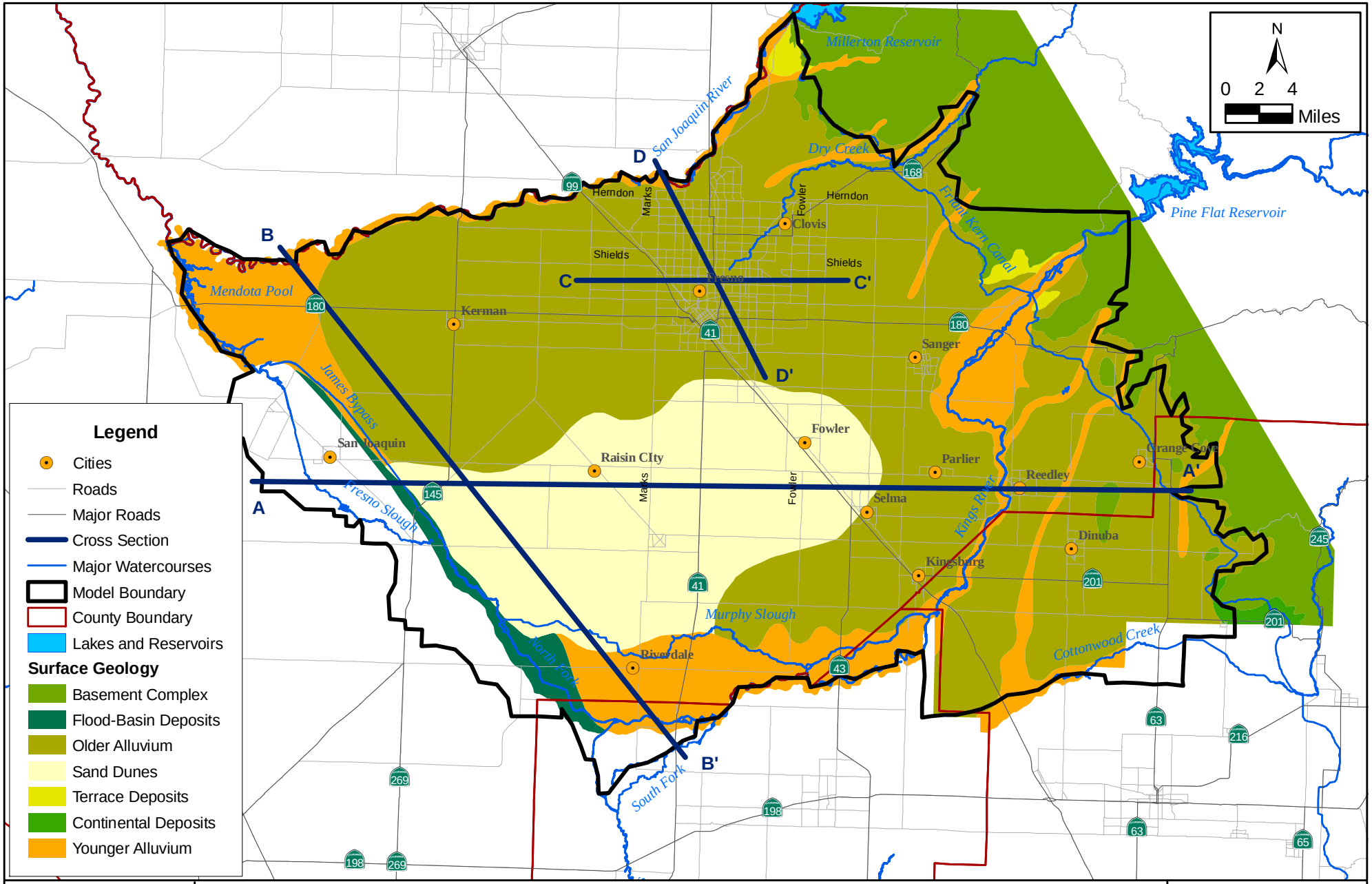
General head boundary condition is used for all model layers at the northern, western, and southern boundaries. Small watershed boundary condition is used for the eastern boundary of the Kings IGSM.

5.7.1 GENERAL HEAD BOUNDARY CONDITIONS

General head boundary conditions were assigned to northern, western, and southern boundaries of the Kings IGSM. This boundary condition requires that groundwater levels to be specified outside the model area at a short distance from the boundary. Time dependent general heads at 0.5 miles from the boundary nodes were estimated from representative groundwater level measurements based on data from DWR records. Figure 5-43 shows the general head boundary nodes of the Kings IGSM.

5.7.2 UNGAGED WATERSHED BOUNDARY CONDITIONS

There are sixteen small, ungaged, watersheds located in the foothills along the eastern boundary of the model. These watersheds are ungaged or do not have a complete period of record (Cottonwood Creek, Sand Creek, and Little Dry Creek) and drain into the Kings IGSM model area and are included in the Kings IGSM to account for ungaged surface flow and subsurface flow into the model area. The locations of these watersheds are shown on Figure 5-44. Table 5-20 presents basic data on the ungaged watersheds. Mill Creek watershed is gaged and Hughes Creek flows are calculated based on Mill Creek flows. Flow from Mill Creek and Hughes Creek is added to Kings River flow in the Kings IGSM and these two watersheds are not simulated as small watershed boundary condition.



WRIME

Model Cross-Section Locations and Surface Geology

Kings IGSM Model Development and Calibration

Source: USGS Groundwater in the Fresno Area, California, 1977

July 2007

Figure 5-1

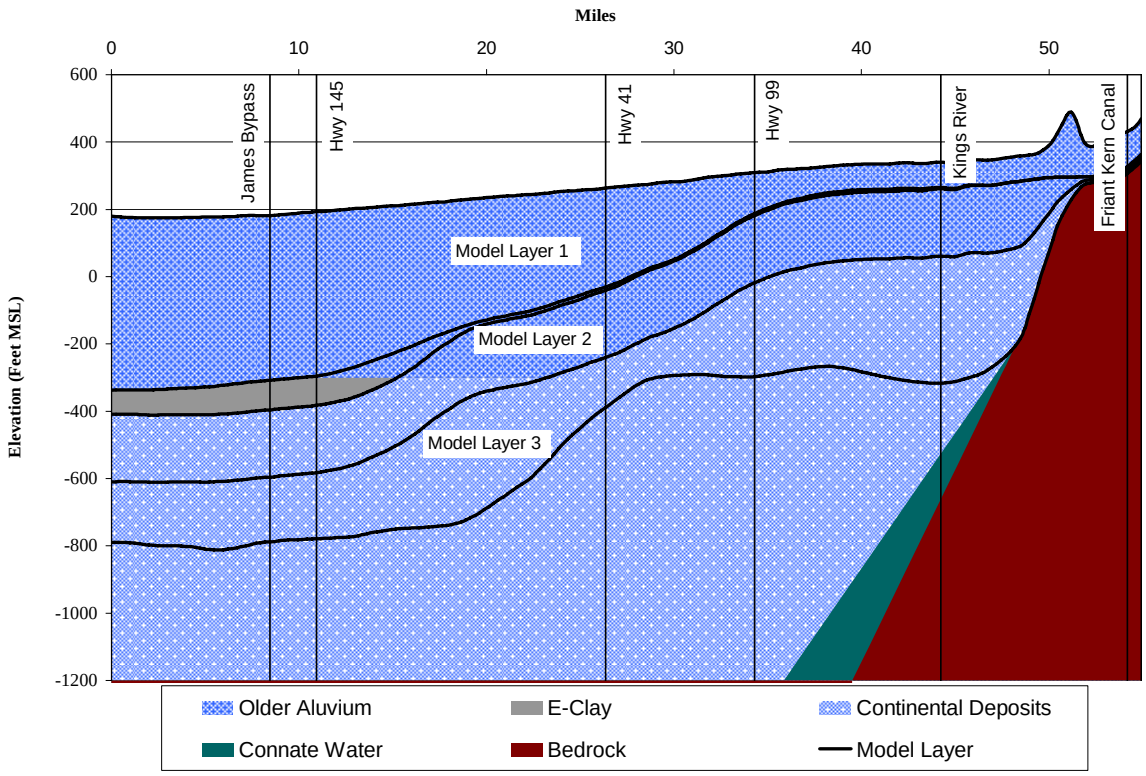


Figure 5-2. Model Cross Section A-A′

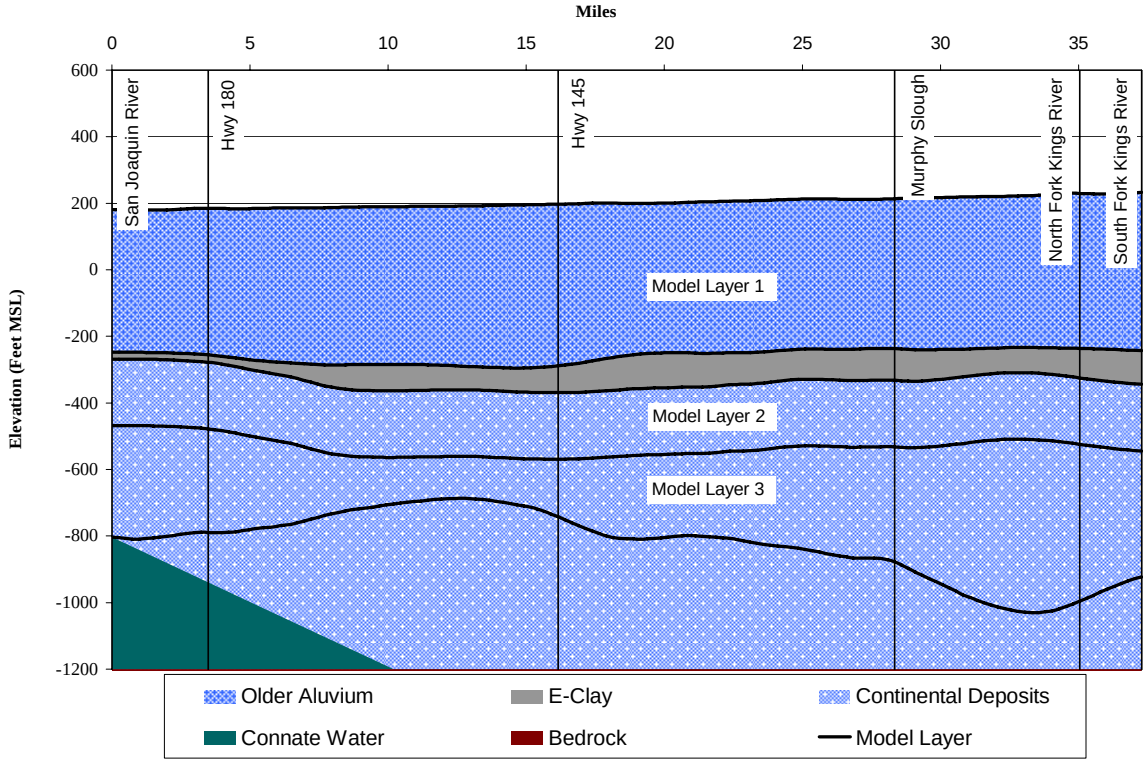


Figure 5-3. Model Cross Section B-B′

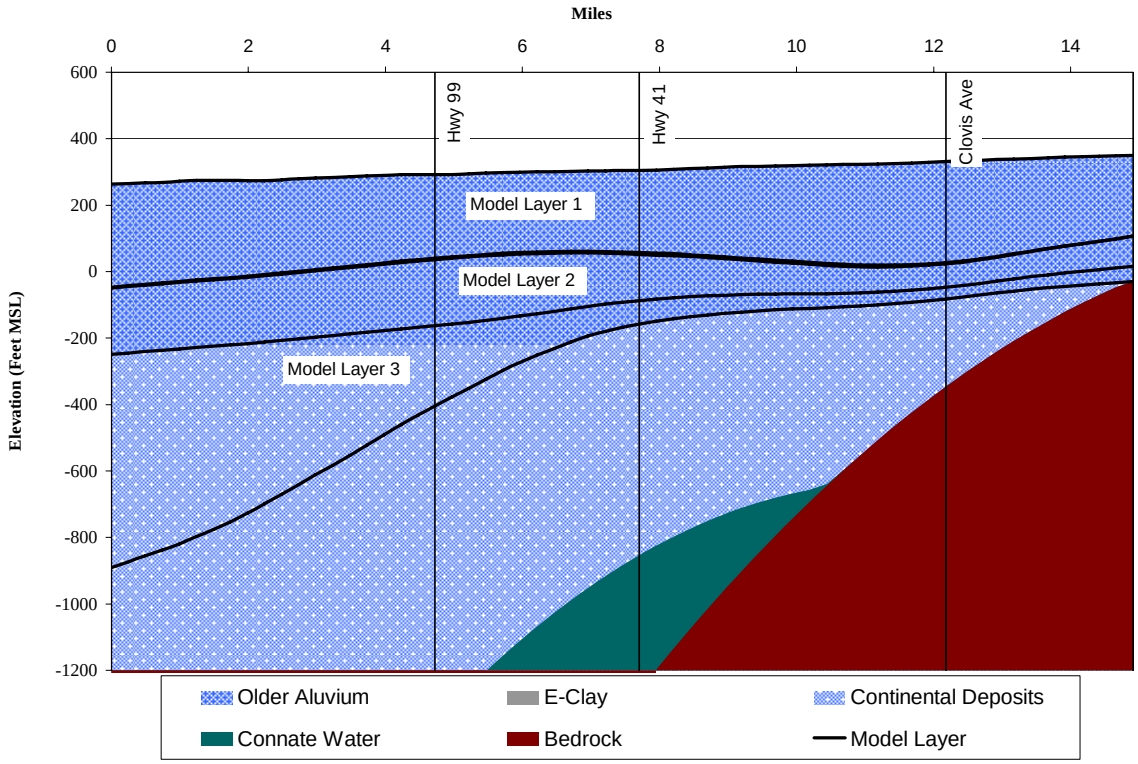


Figure 5-4. Model Cross Section C-C′

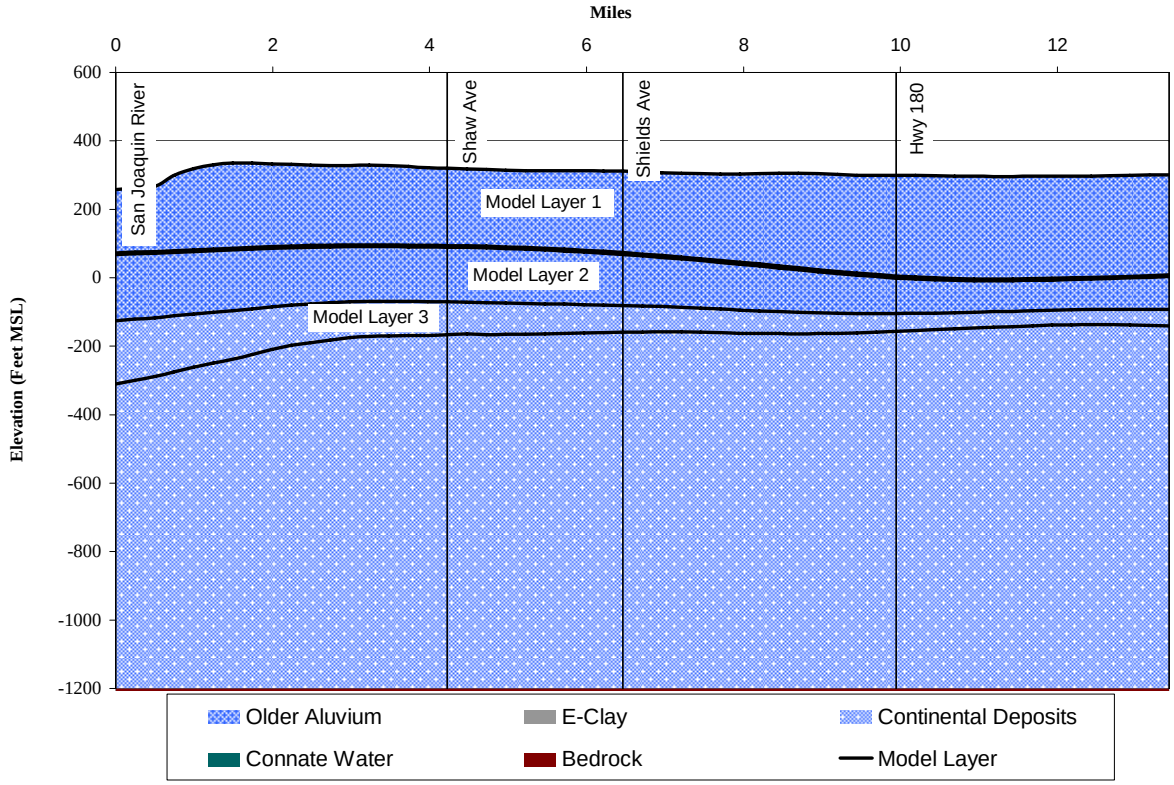
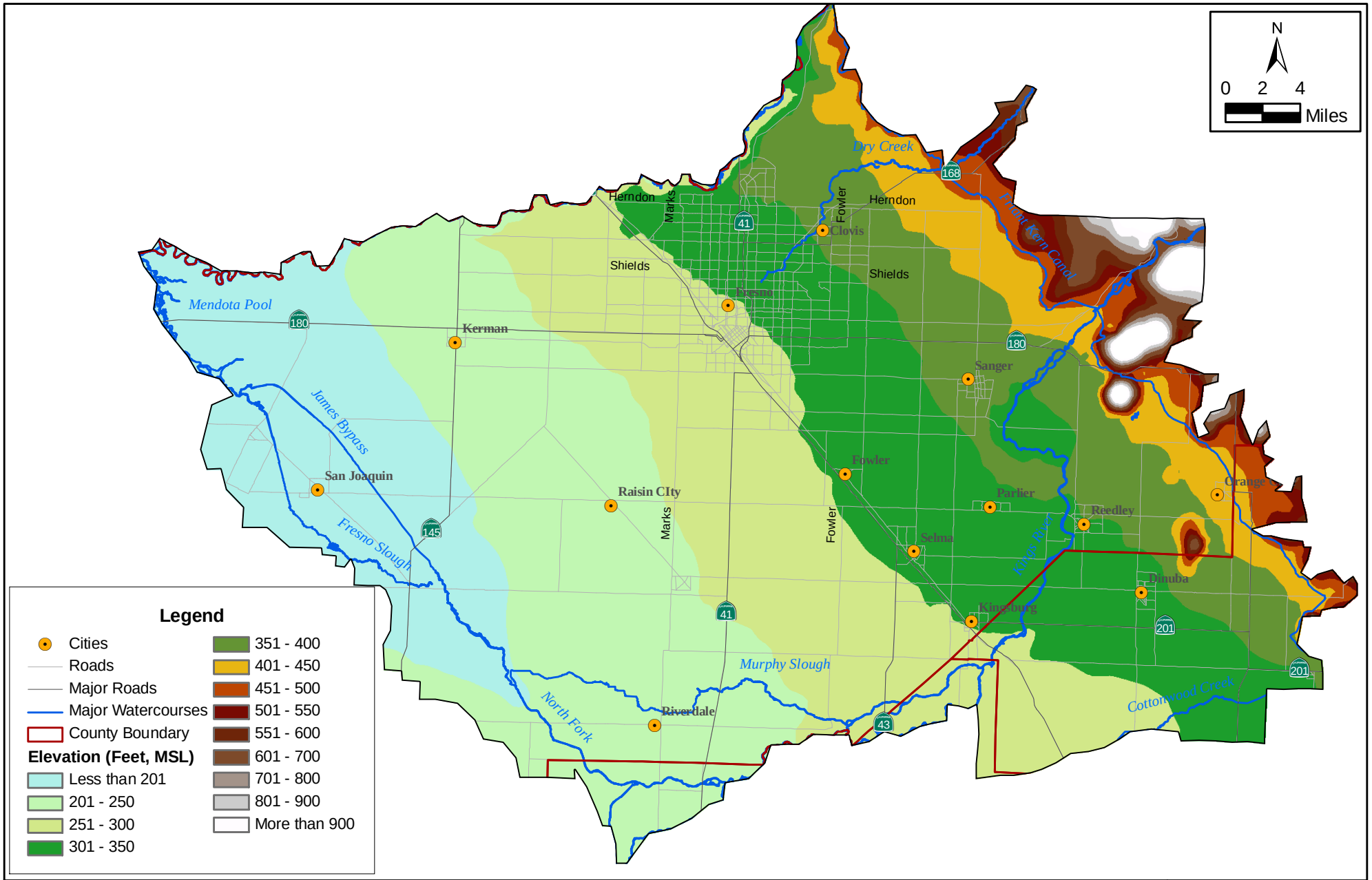


Figure 5-5. Model Cross Section D-D′



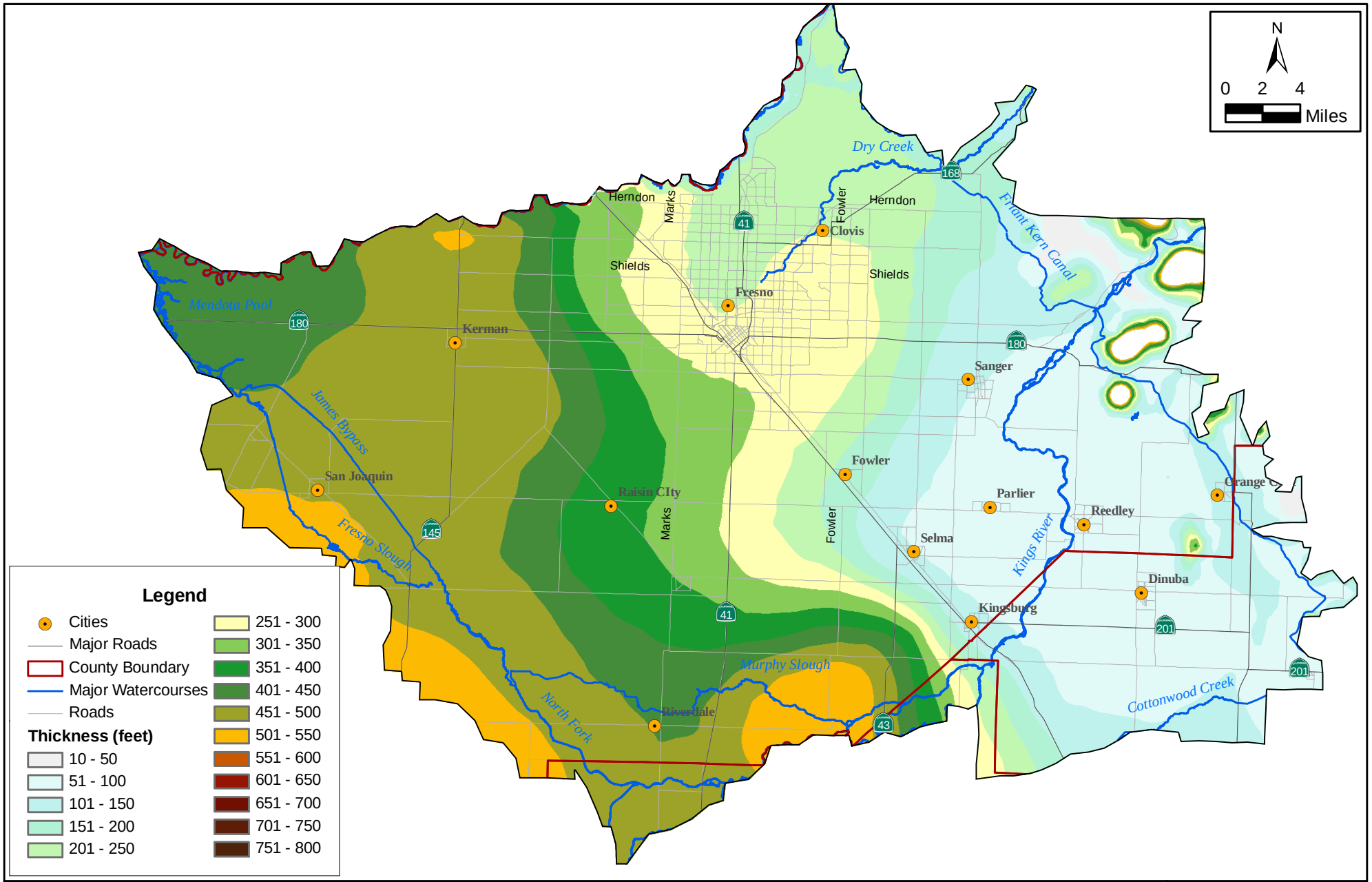
Ground Surface Elevation

Kings IGSM Model Development and Calibration

Source: 30-meter DEM, CalSil, 1997

July 2007

Figure 5-6



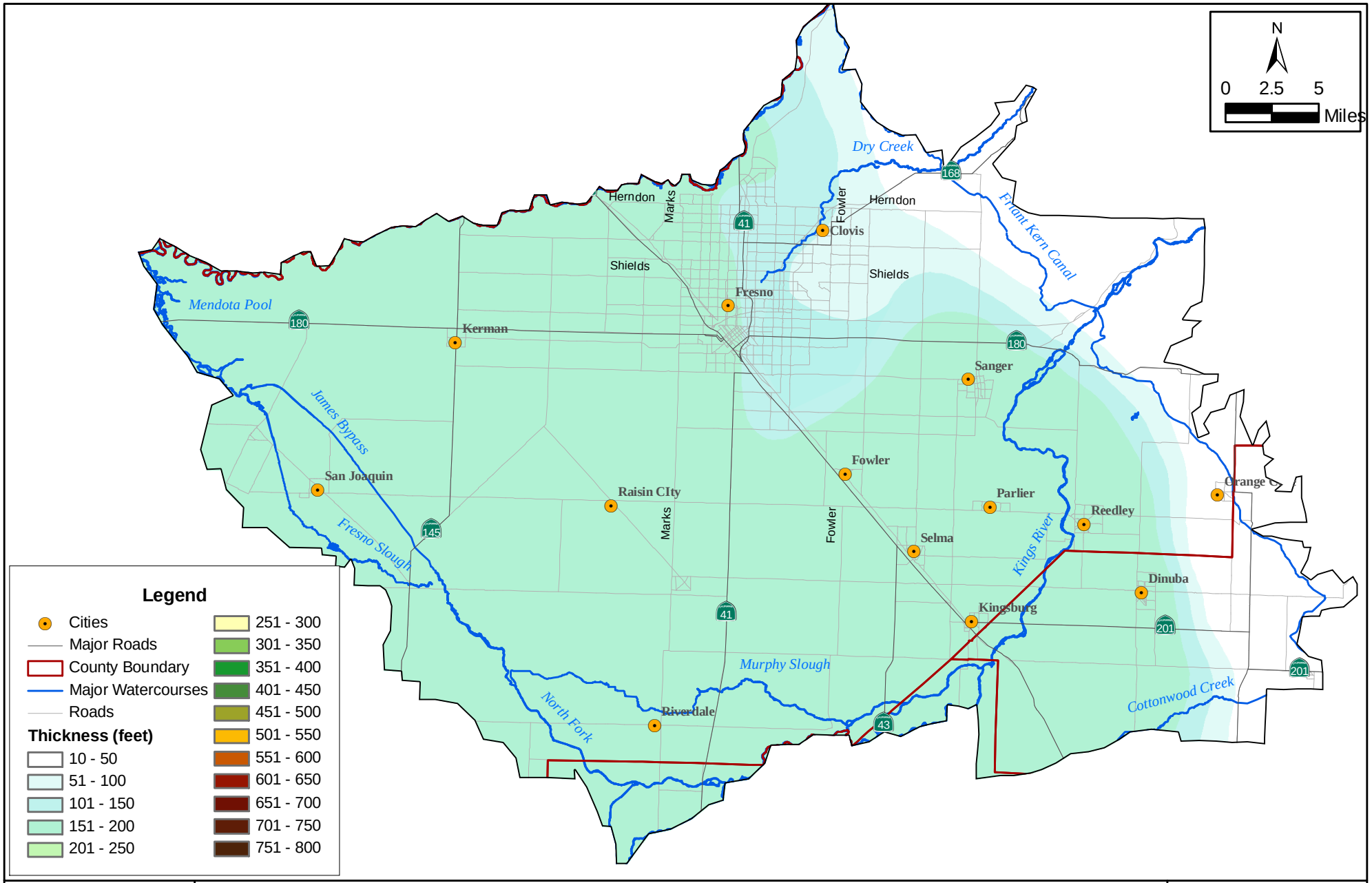
WRIME

Thickness of Model Layer 1

Kings IGSM Model Development and Calibration

July 2007

Figure 5-7



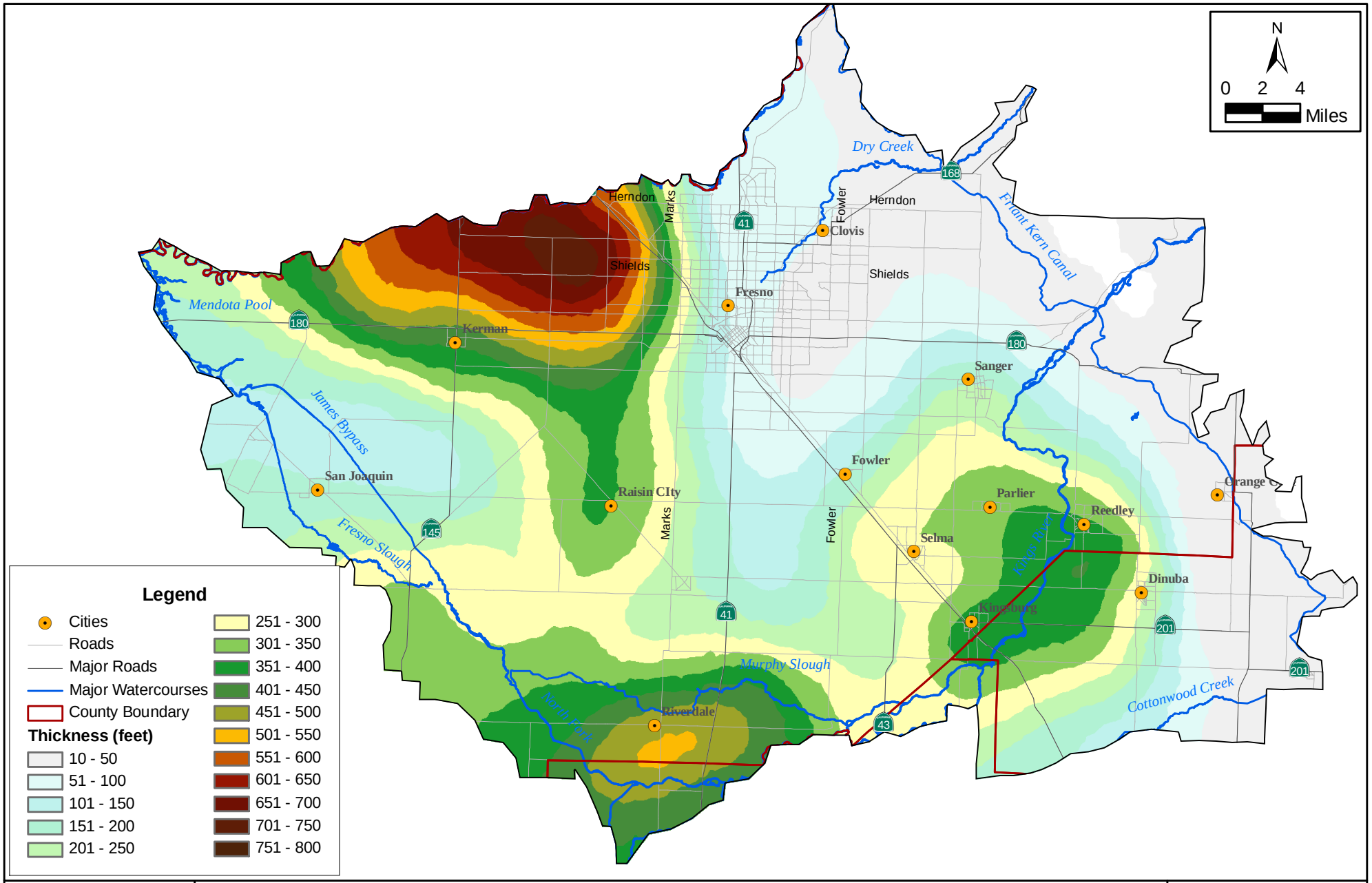
WRIME

Thickness of Model Layer 2

Kings IGSM Model Development and Calibration

July 2007

Figure 5-8

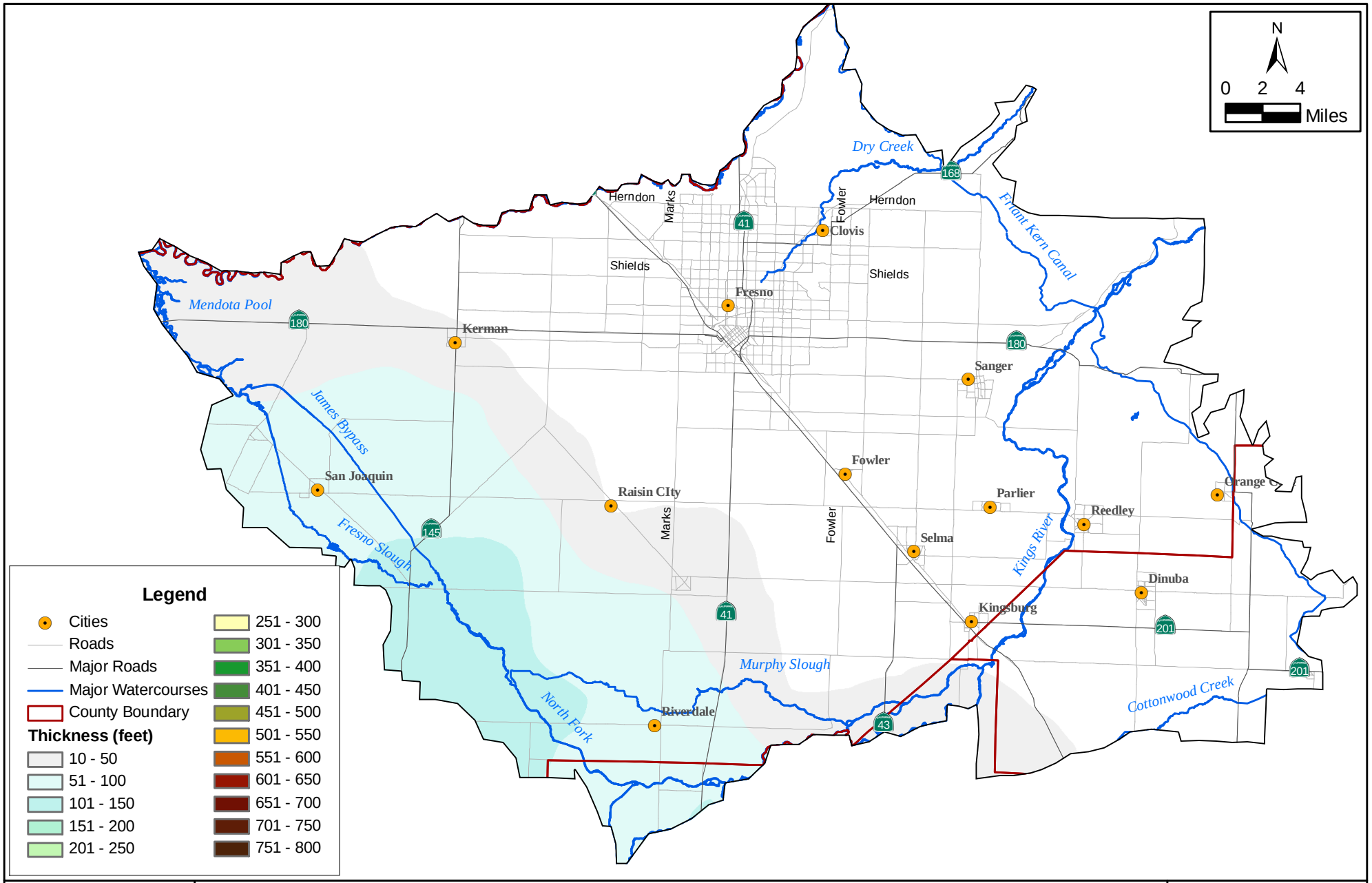


Thickness of Model Layer 3

Kings IGSM Model Development and Calibration

July 2007

Figure 5-9



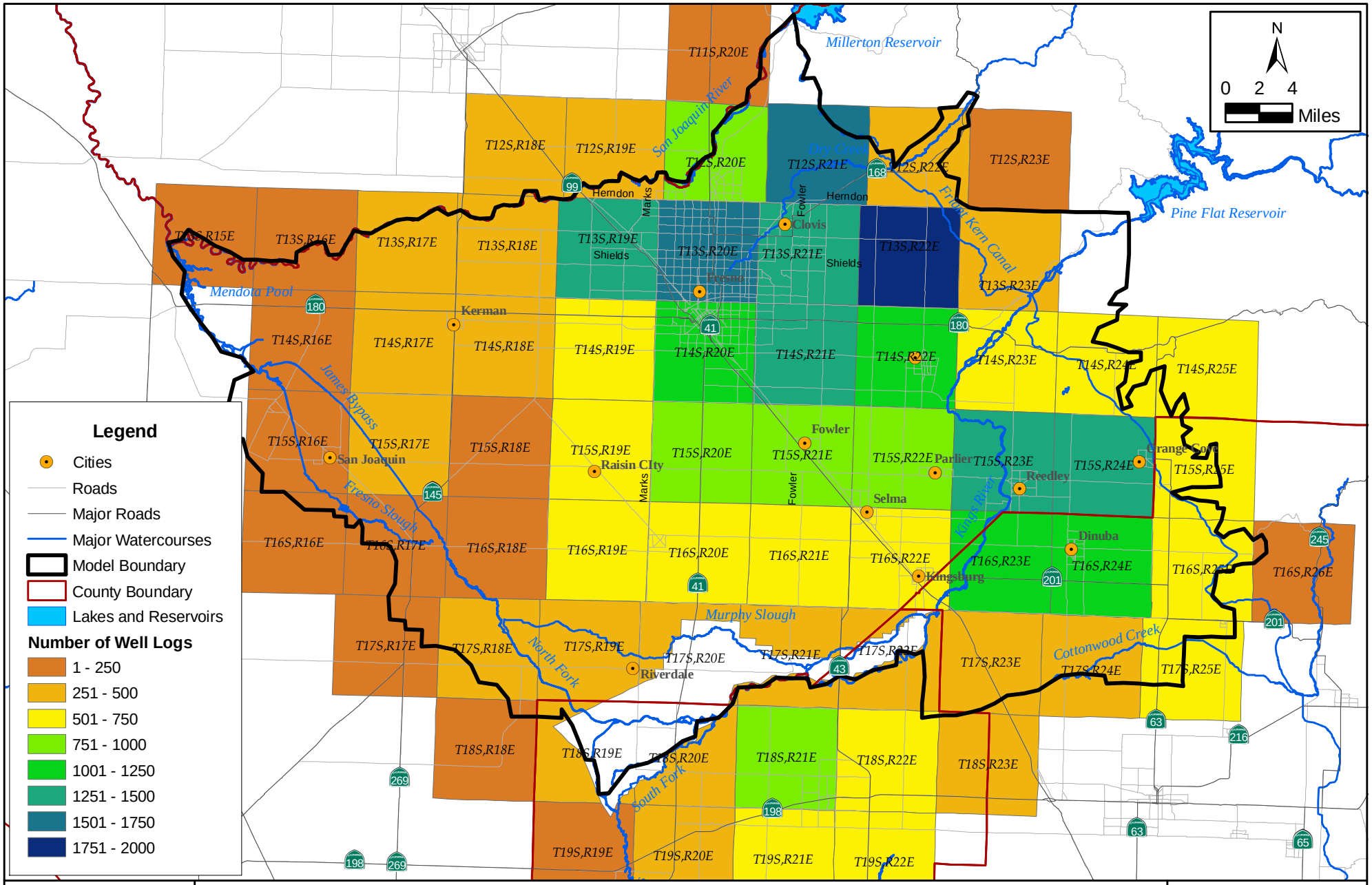
WRIME

Thickness of Aquitard

Kings IGSM Model Development and Calibration

July 2007

Figure 5-10



WRIME

Distribution of Well Logs Used for Model Development

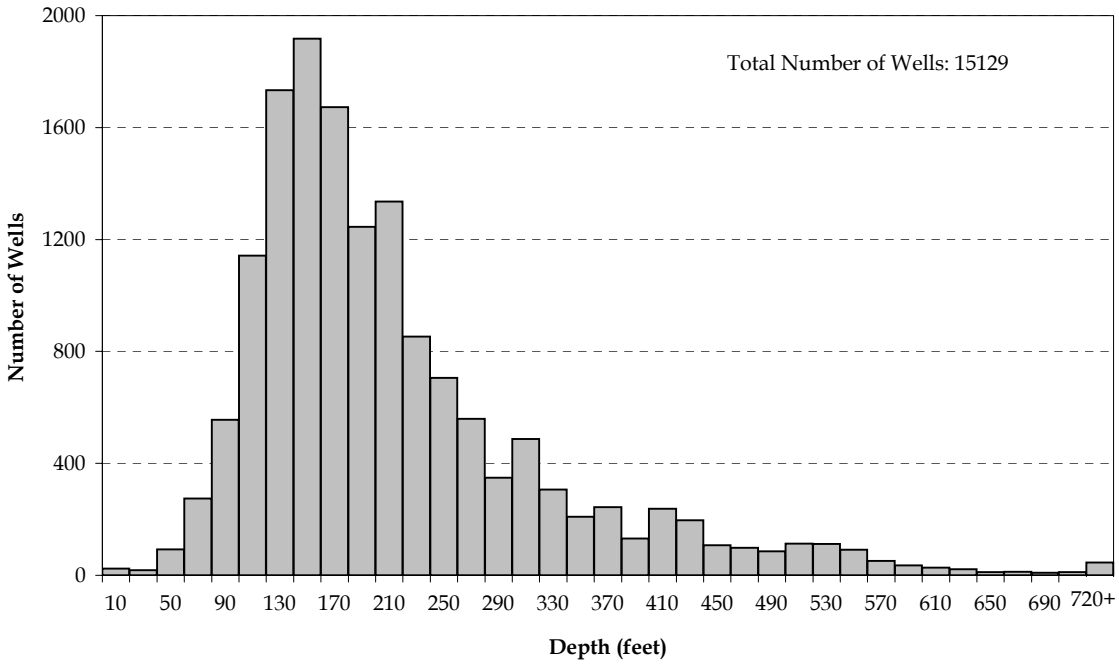
Kings IGSM Model Development and Calibration

July 2007

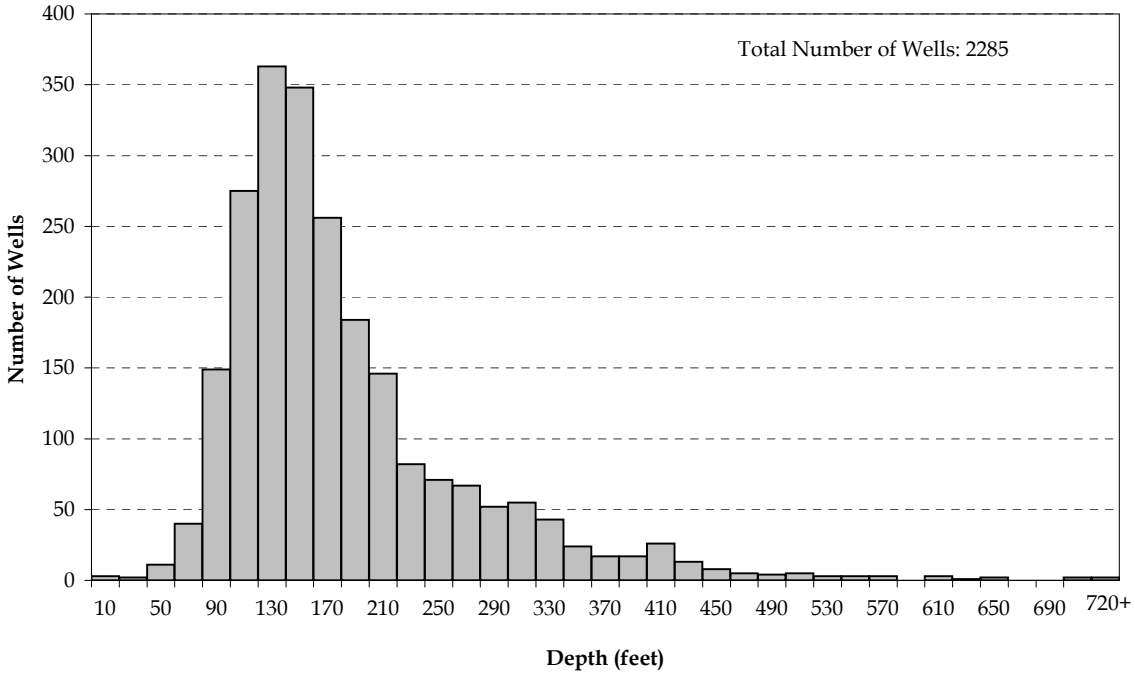
Figure 5-11

Source: DWR Well Log Database
Number in italics is the Township & Range

Model Agricultural and Rural Domestic Wells

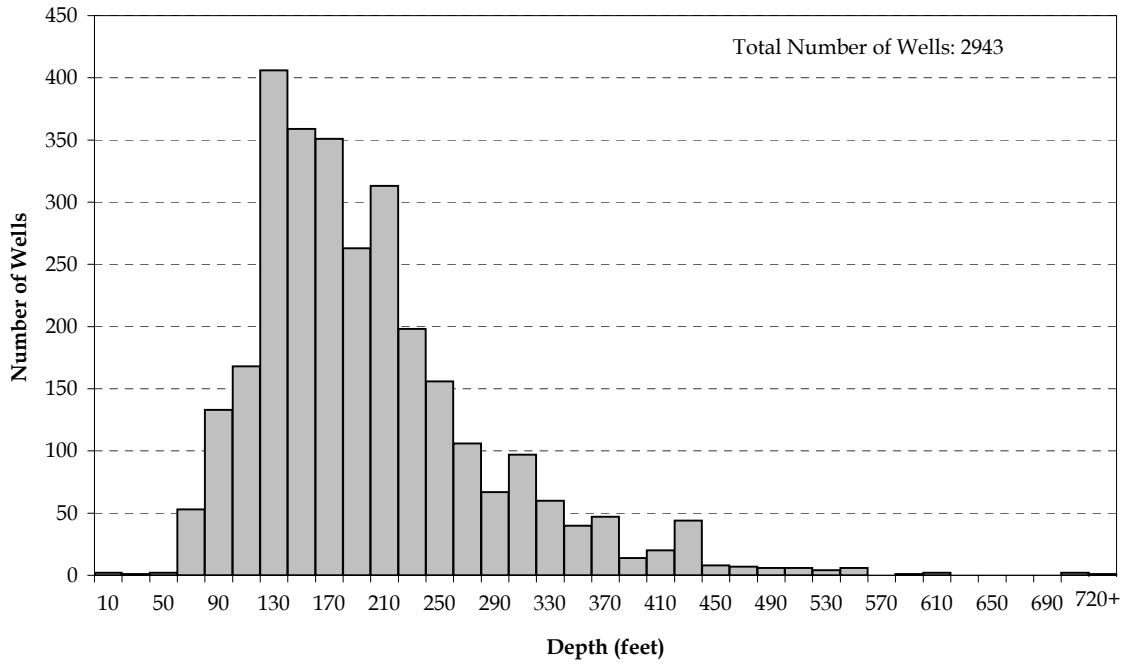


FID Area Agricultural and Rural Domestic Wells

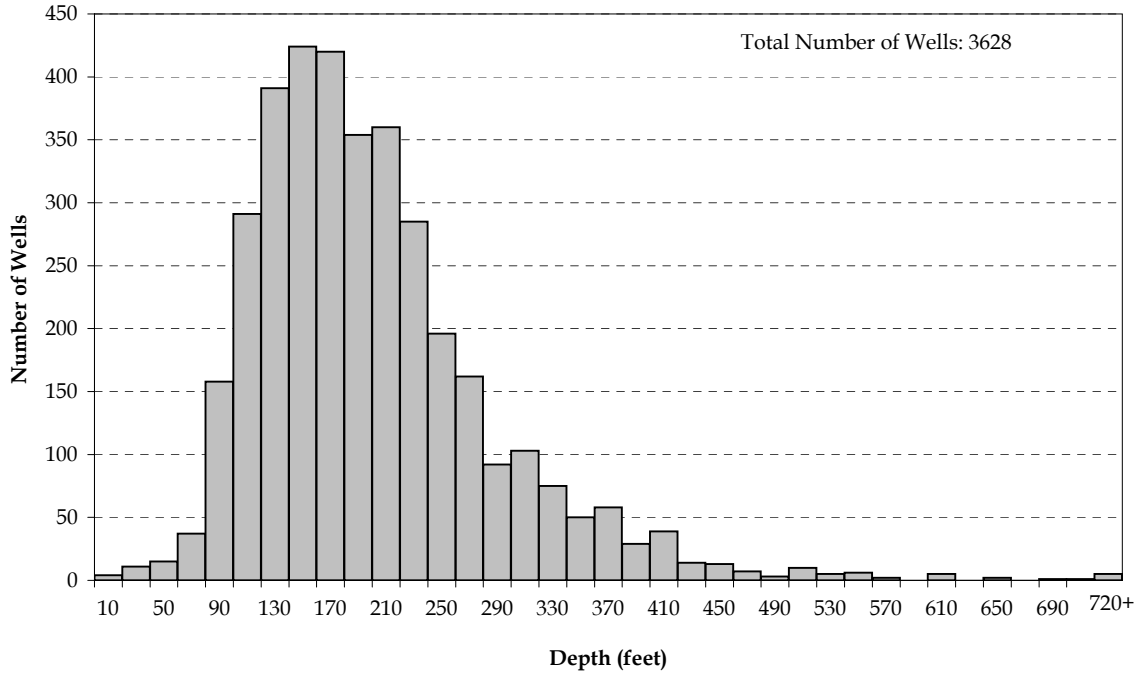


ωRIME	**Depth Distribution of Wells Used for Modeling in Model Area and FID Area**	July 2007
		Figure 5-12a

CID Area Agricultural and Rural Domestic Wells

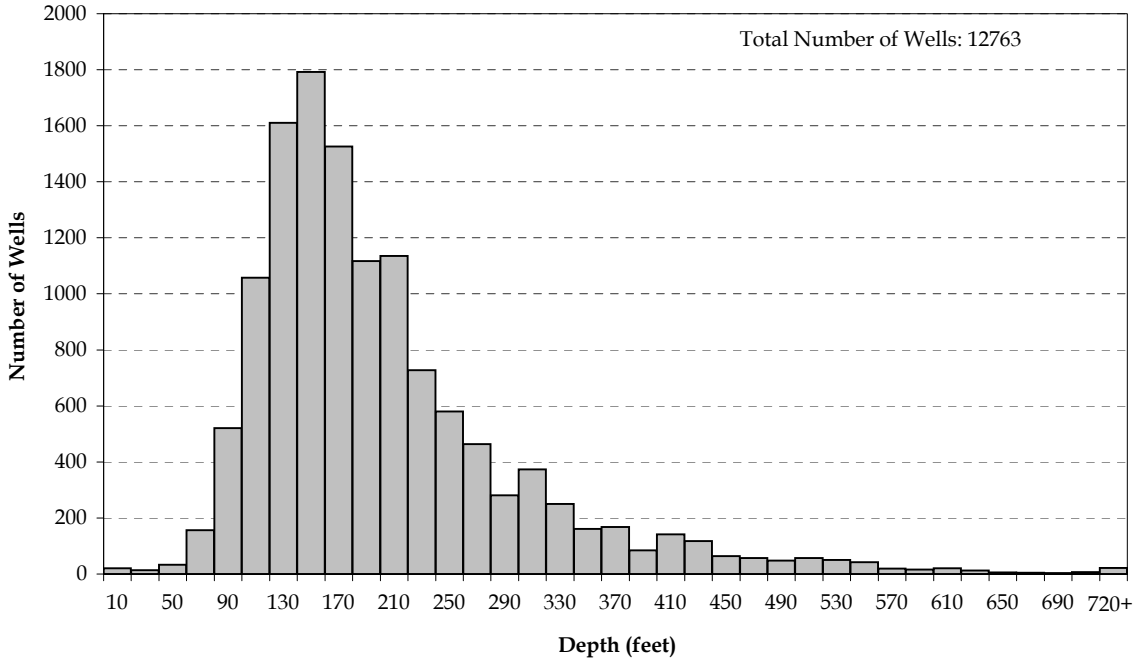


AID Area Agricultural and Rural Domestic Wells

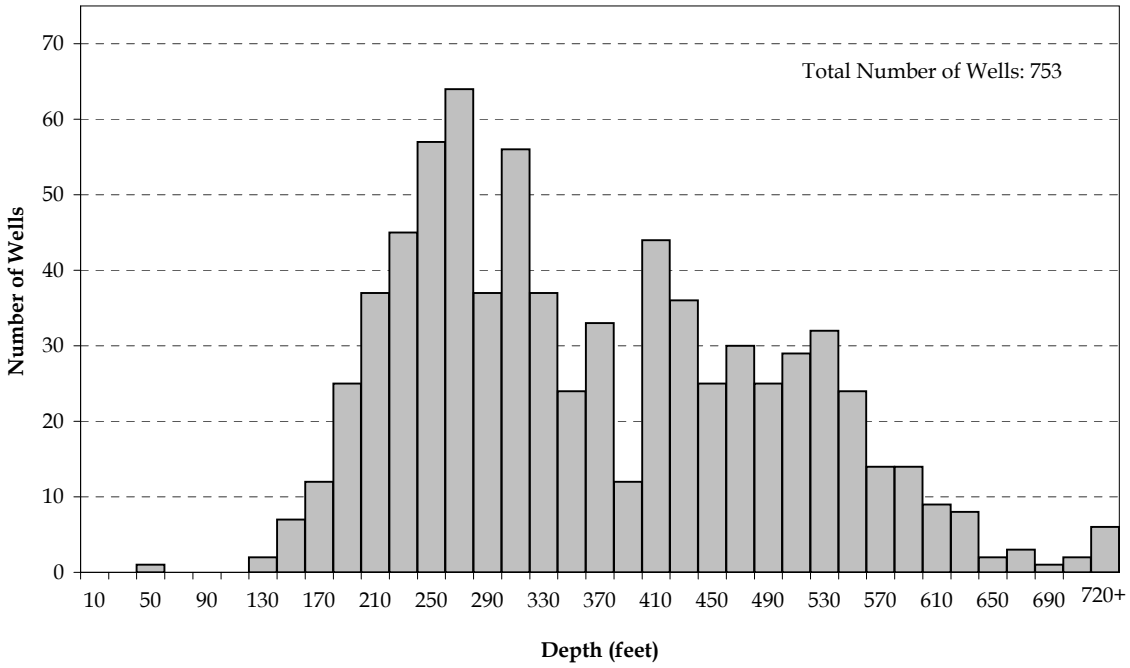


ωRIME	**Depth Distribution of Wells Used for Modeling in CID Area and AID Area**	July 2007
		Figure 5-12b

IRWMP Area Agricultural and Rural Domestic Wells

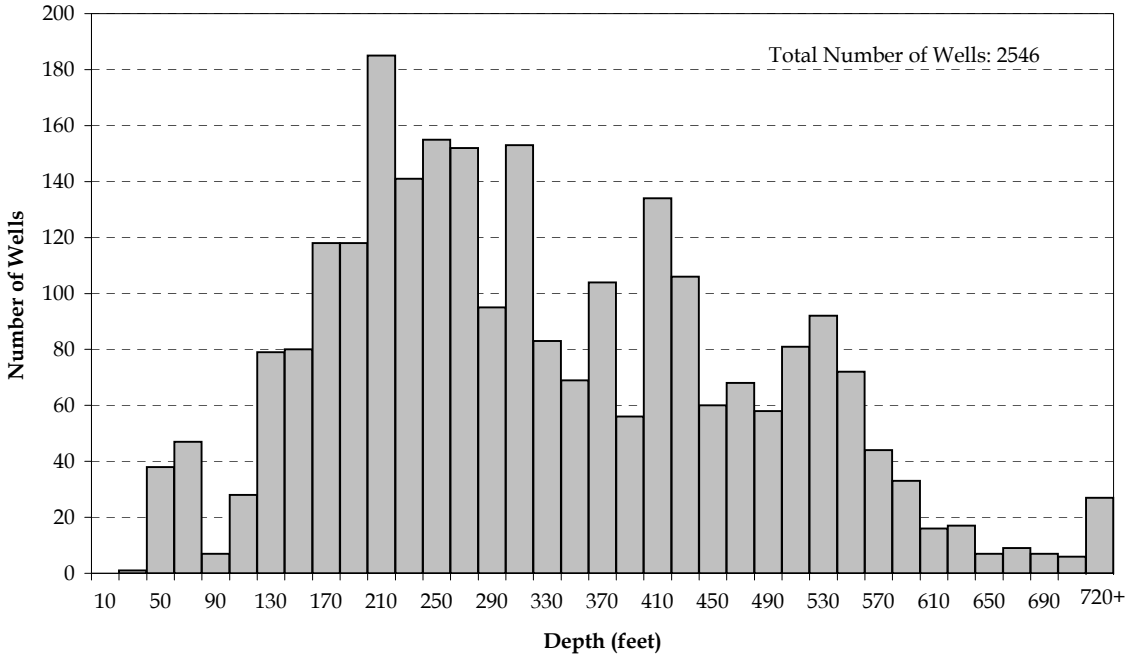


RCWD Area Agricultural and Rural Domestic Wells

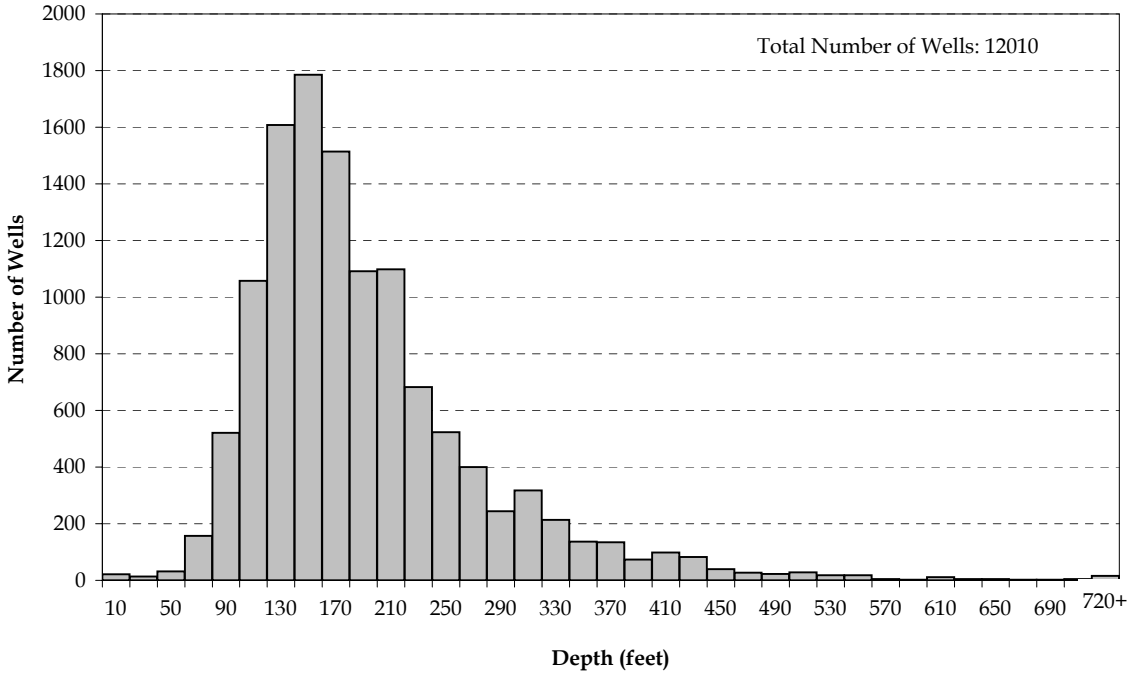


ωRIME	**Depth Distribution of Wells Used for Modeling in IRWMP Area and RCWD Area**	July 2007 Figure 5-12c

Lower Basin Area Agricultural and Rural Domestic Wells

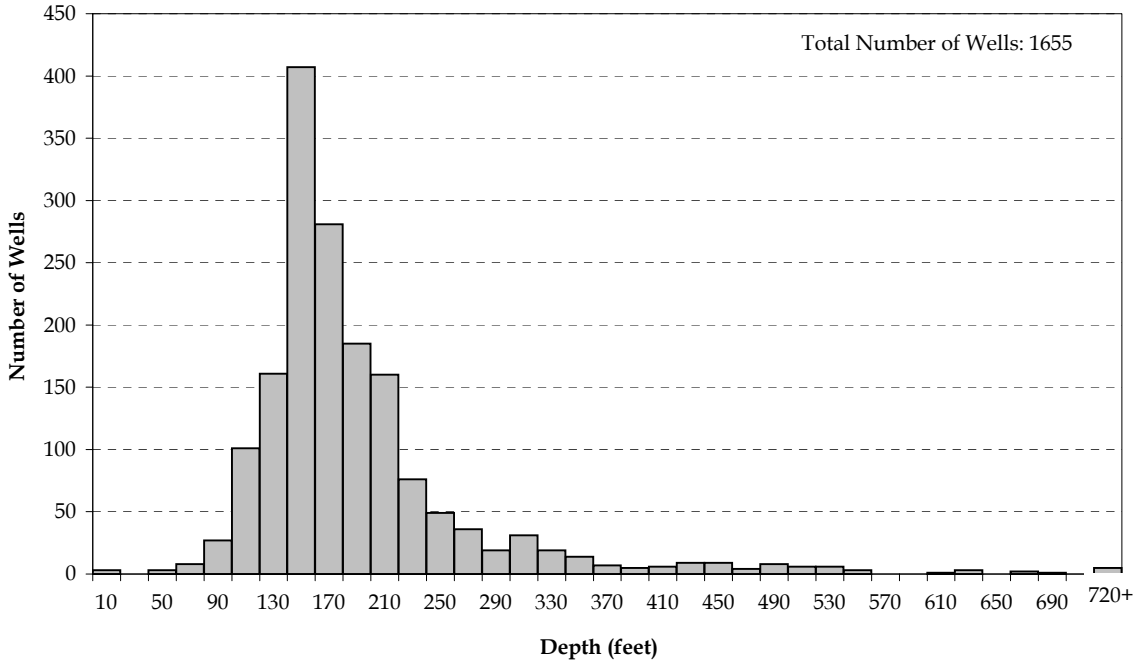


Upper Basin Area Agricultural and Rural Domestic Wells

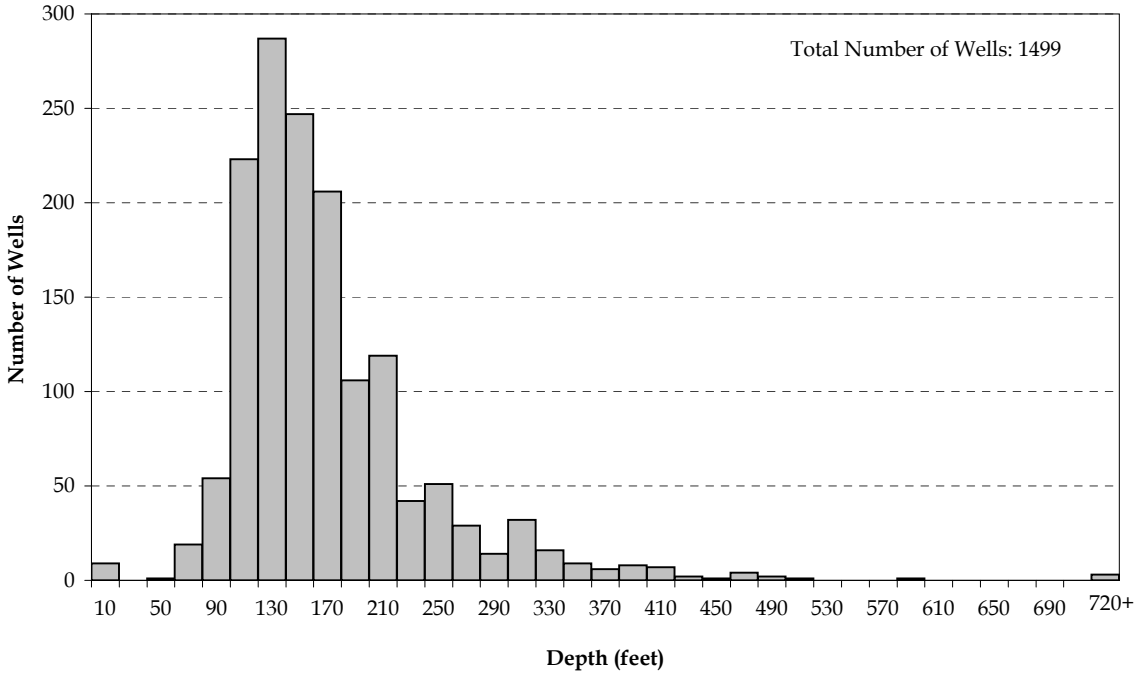


ωRIME	**Depth Distribution of Wells Used for Modeling in Lower Basin Area and Upper Basin Area**	July 2007
		Figure 5-12d

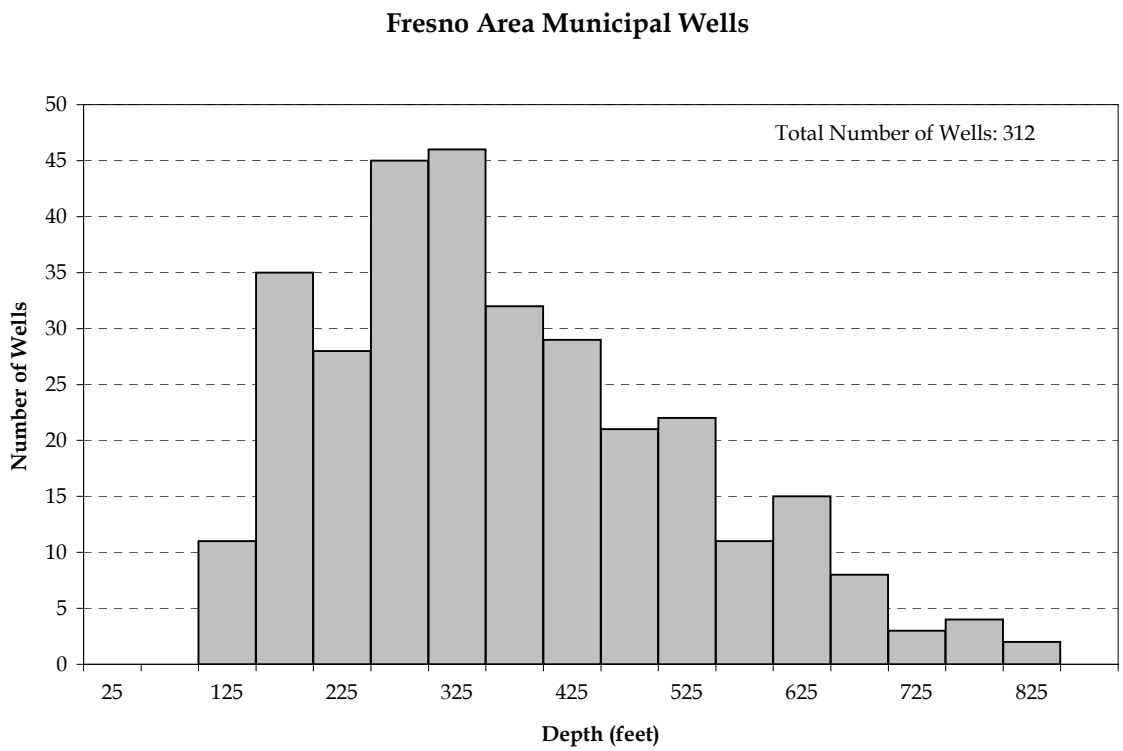
Fresno SOI Area Agricultural and Rural Domestic Wells

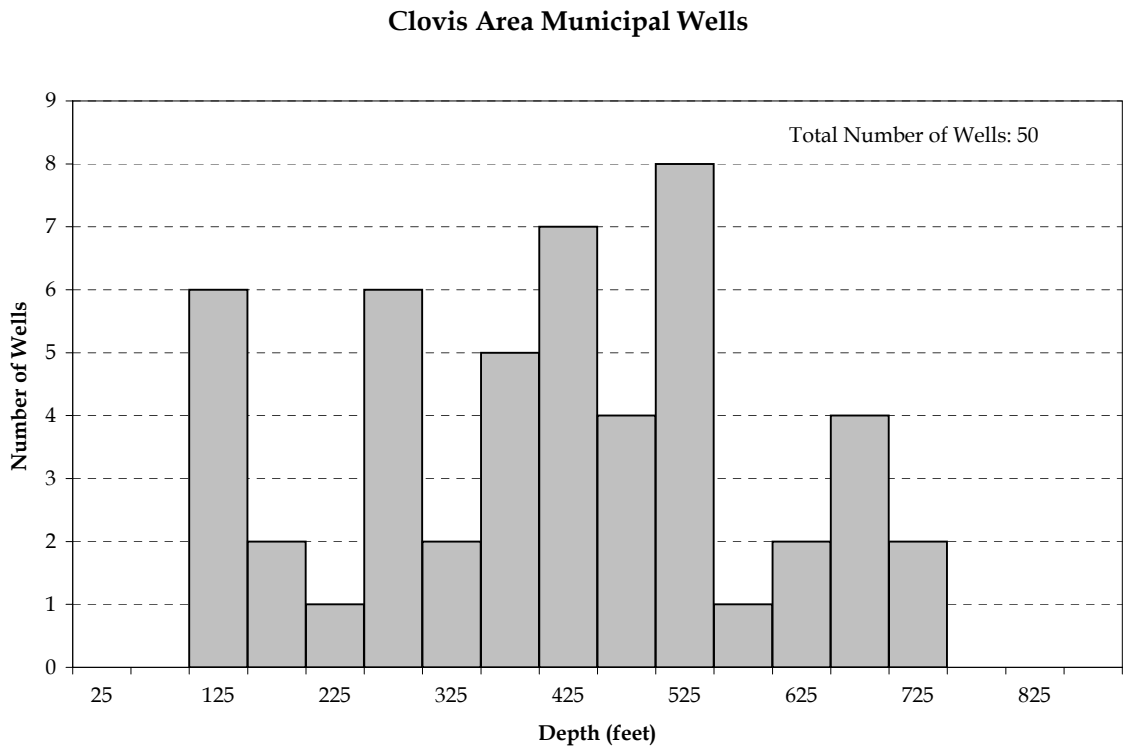


Clovis Area Agricultural and Rural Domestic Wells

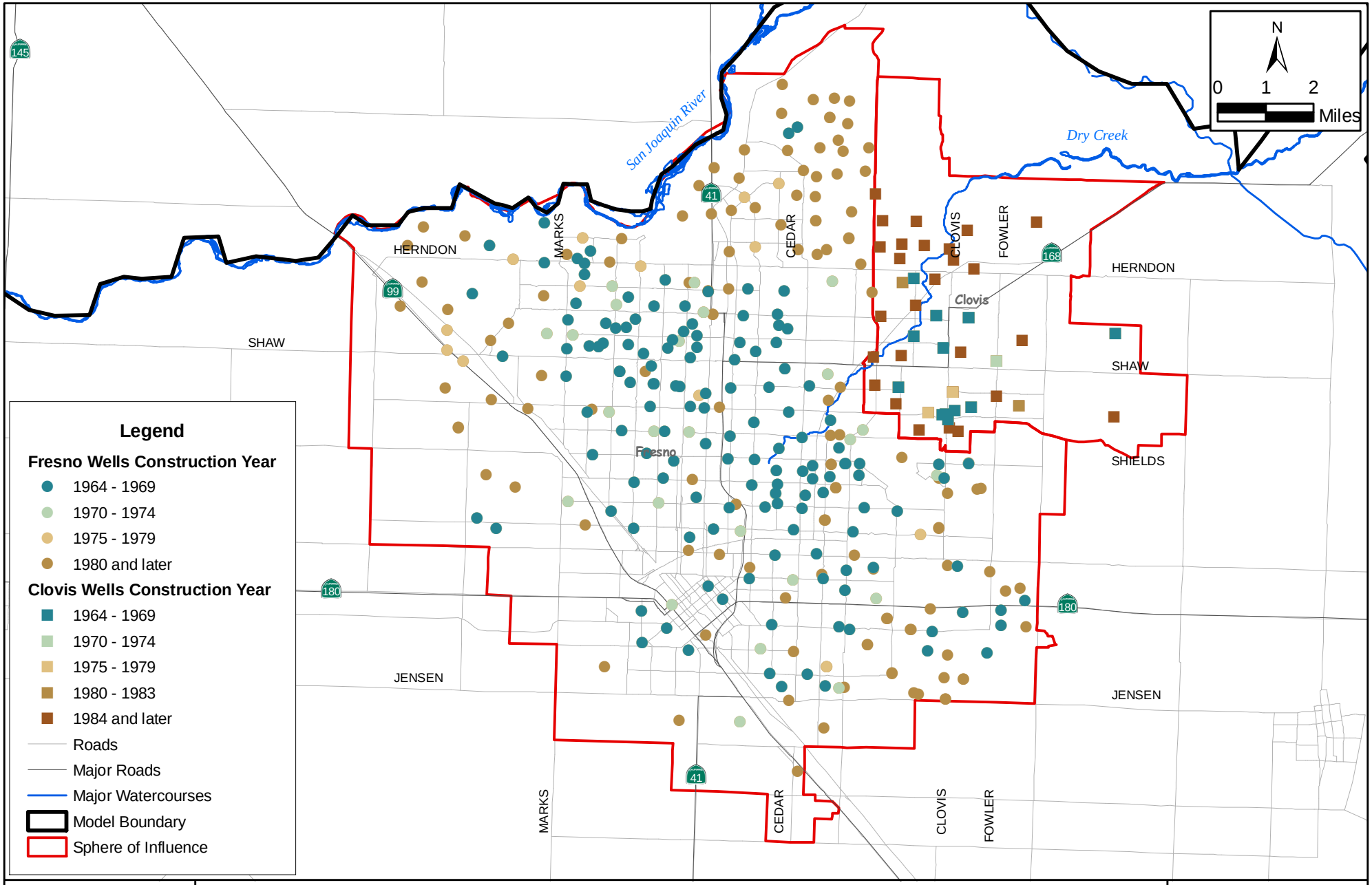


ωRIME	**Depth Distribution of Wells Used for Modeling in Fresno SOI Area and Clovis Area**	July 2007
		Figure 5-13a





ωRIME	**Depth Distribution of Wells Used for Modeling in Fresno Area and Clovis Area**	July 2007
		Figure 5-13b



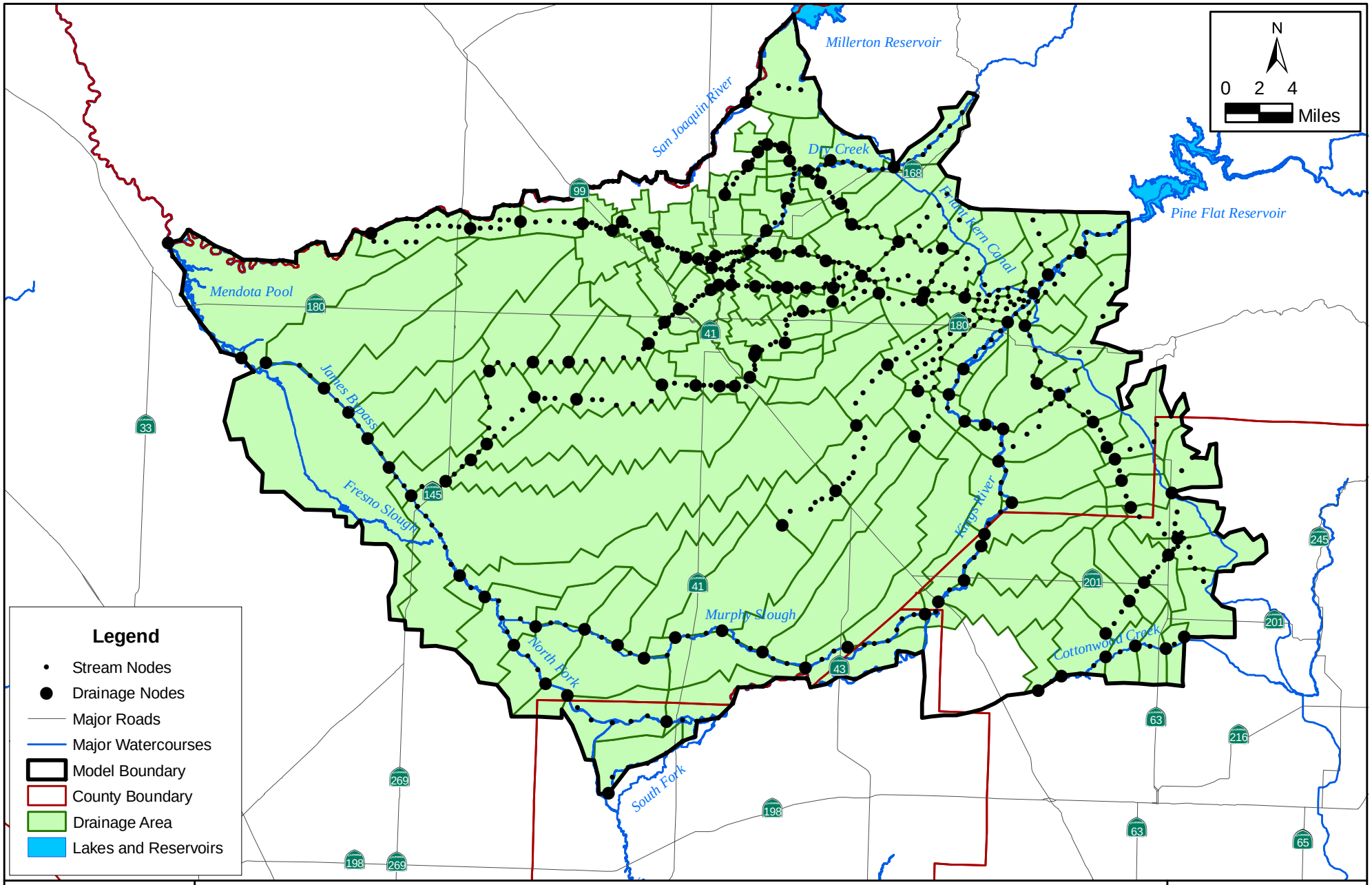
WRIME

Fresno and Clovis Municipal Wells

Kings IGSM Model Development and Calibration

July 2007

Figure 5-14



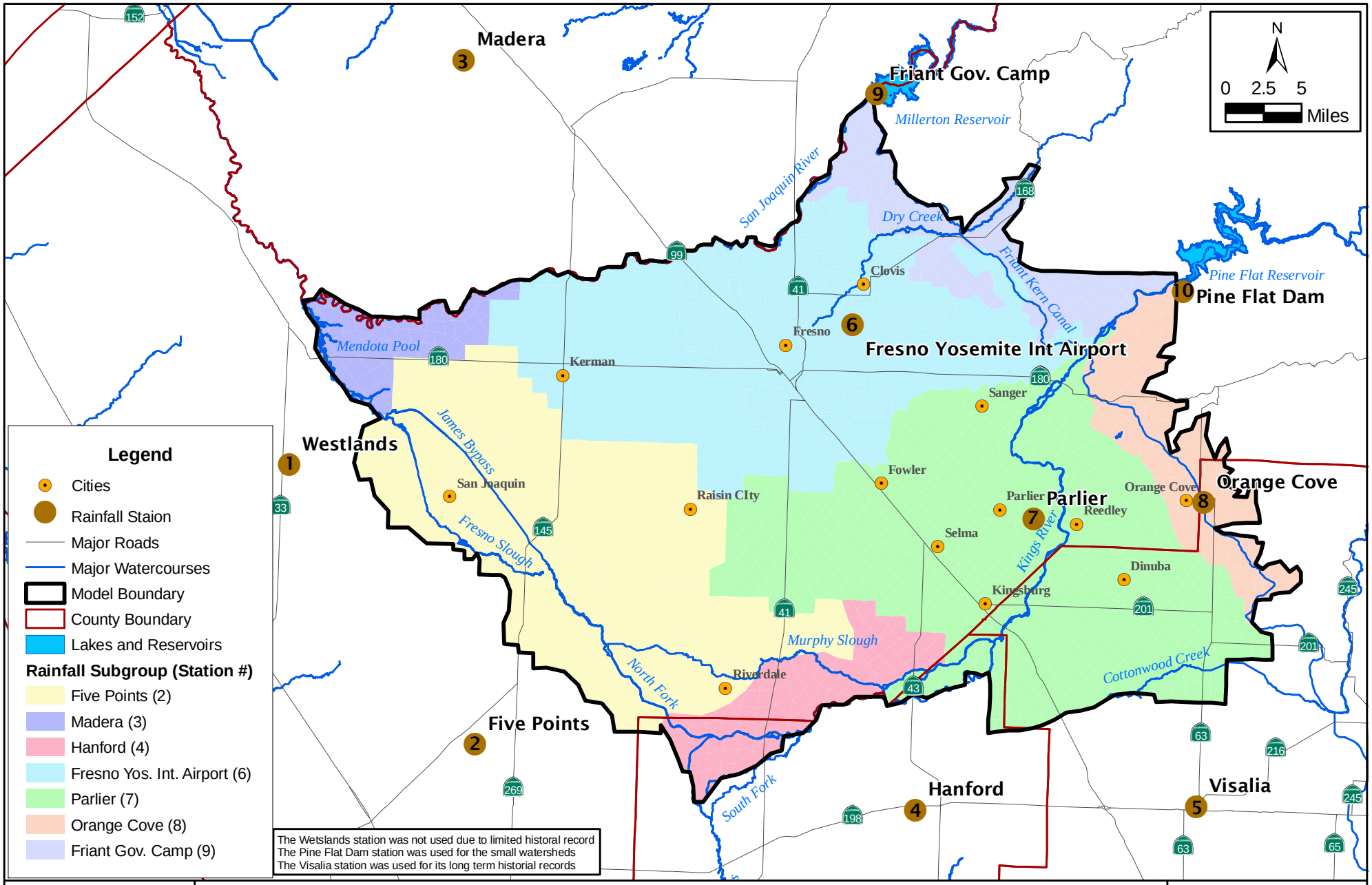
WRIME

Model Drainage Pattern

Kings IGSM Model Development and Calibration

July 2007

Figure 5-15



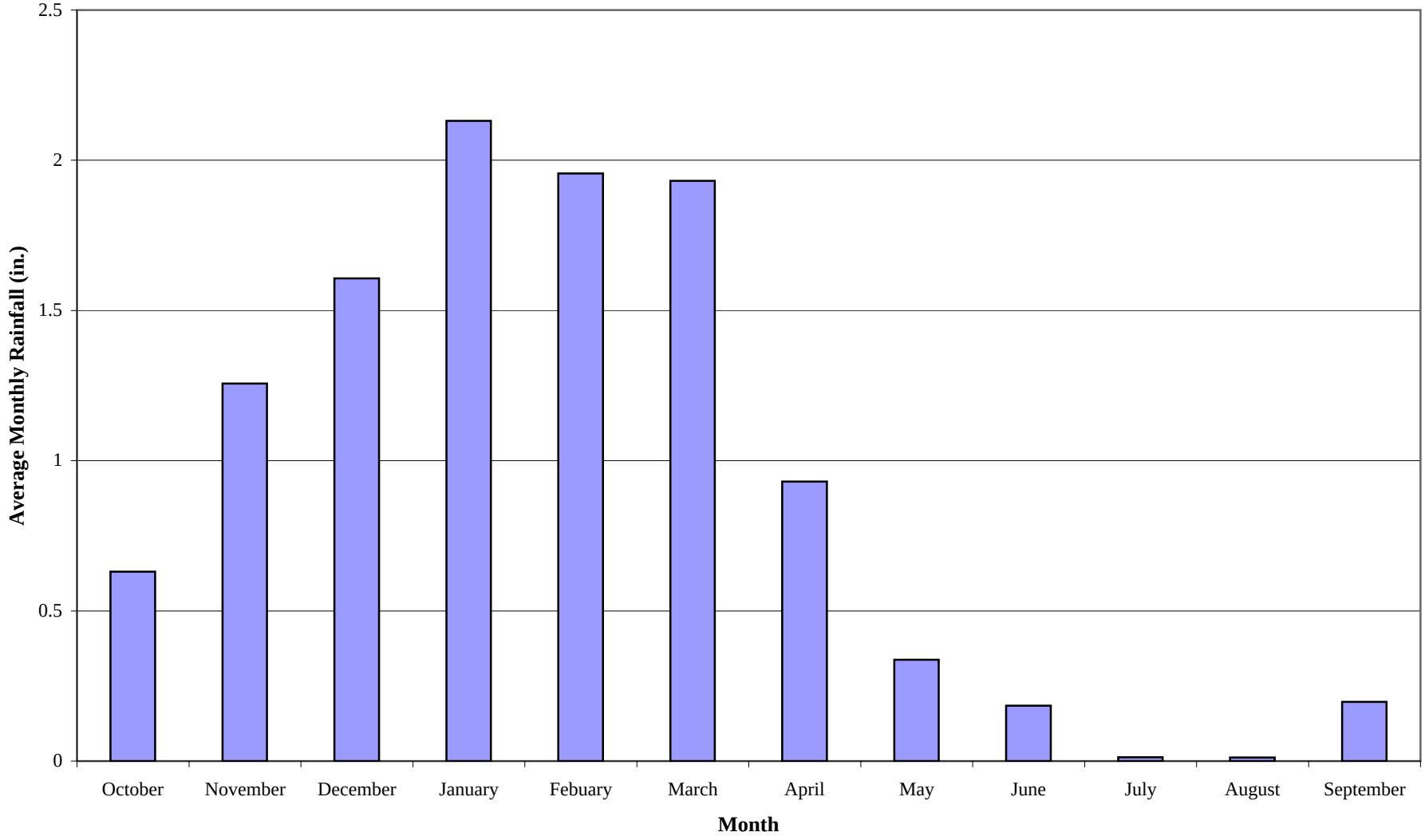
WRIME

Rainfall Stations in Model Area

Kings IGSM Model Development and Calibration

July 2007

Figure 5-16

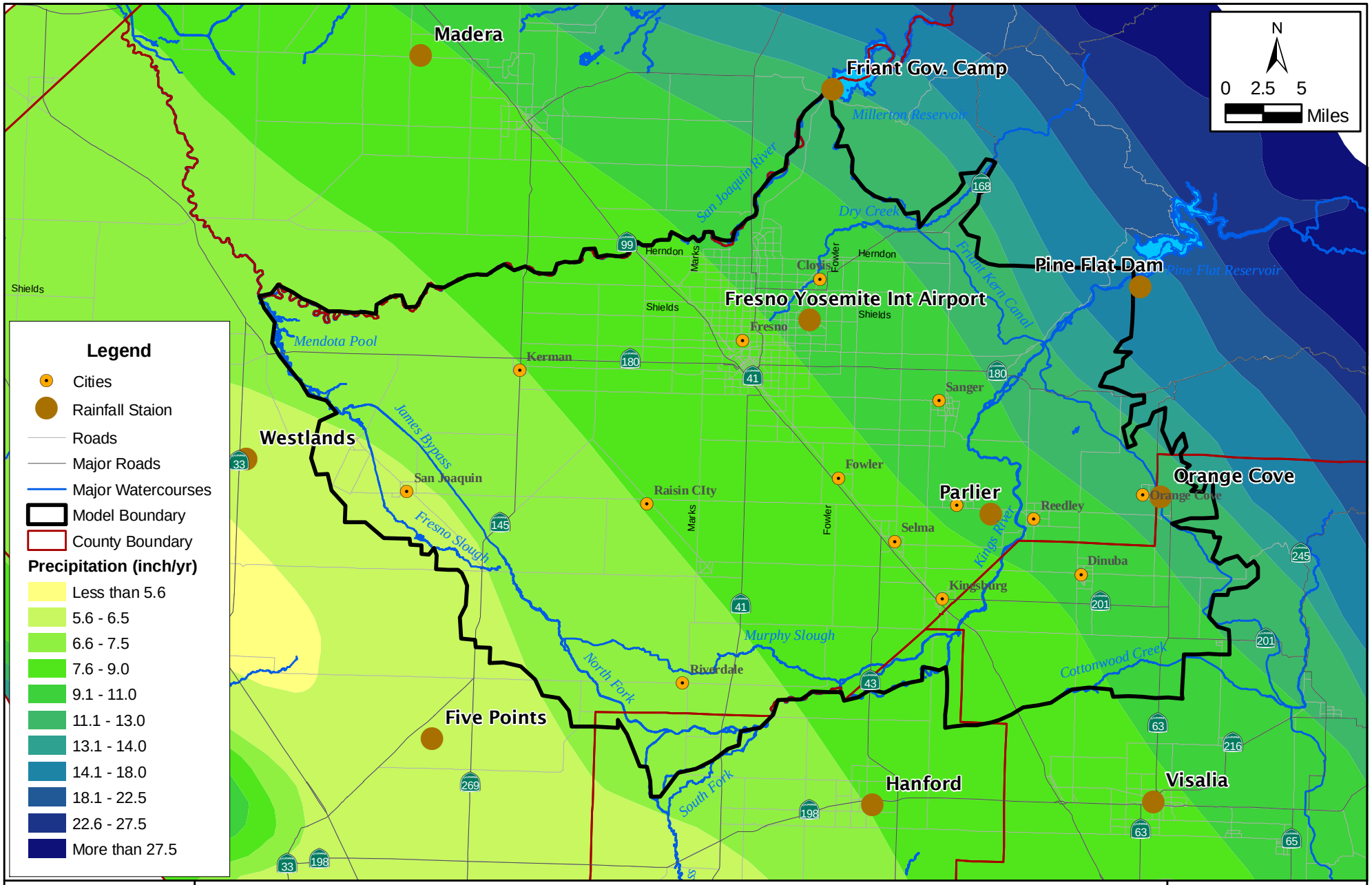


Average Monthly Rainfall for Fresno Yosemite International Airport Station
Water Years 1964 - 2004

Kings IGSM Model Development and Calibration

July 2007

FIGURE 5-17



WRIME

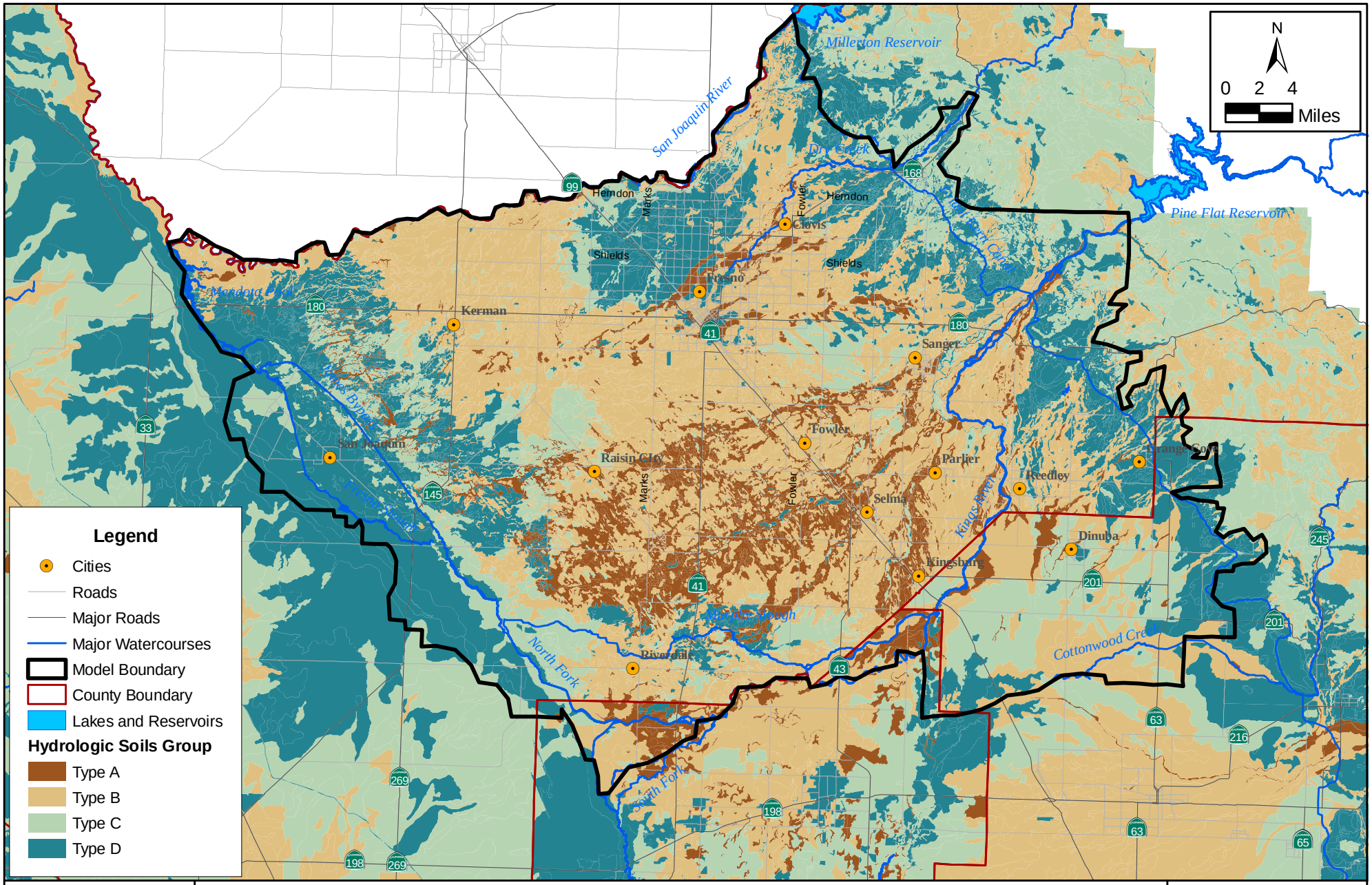
Average Annual Rainfall Distribution in Model Area

Kings IGSM Model Development and Calibration

Source: DWR (1997), Based on U.S. Weather Service Data from 1900 to 1960

July 2007

Figure 5-18



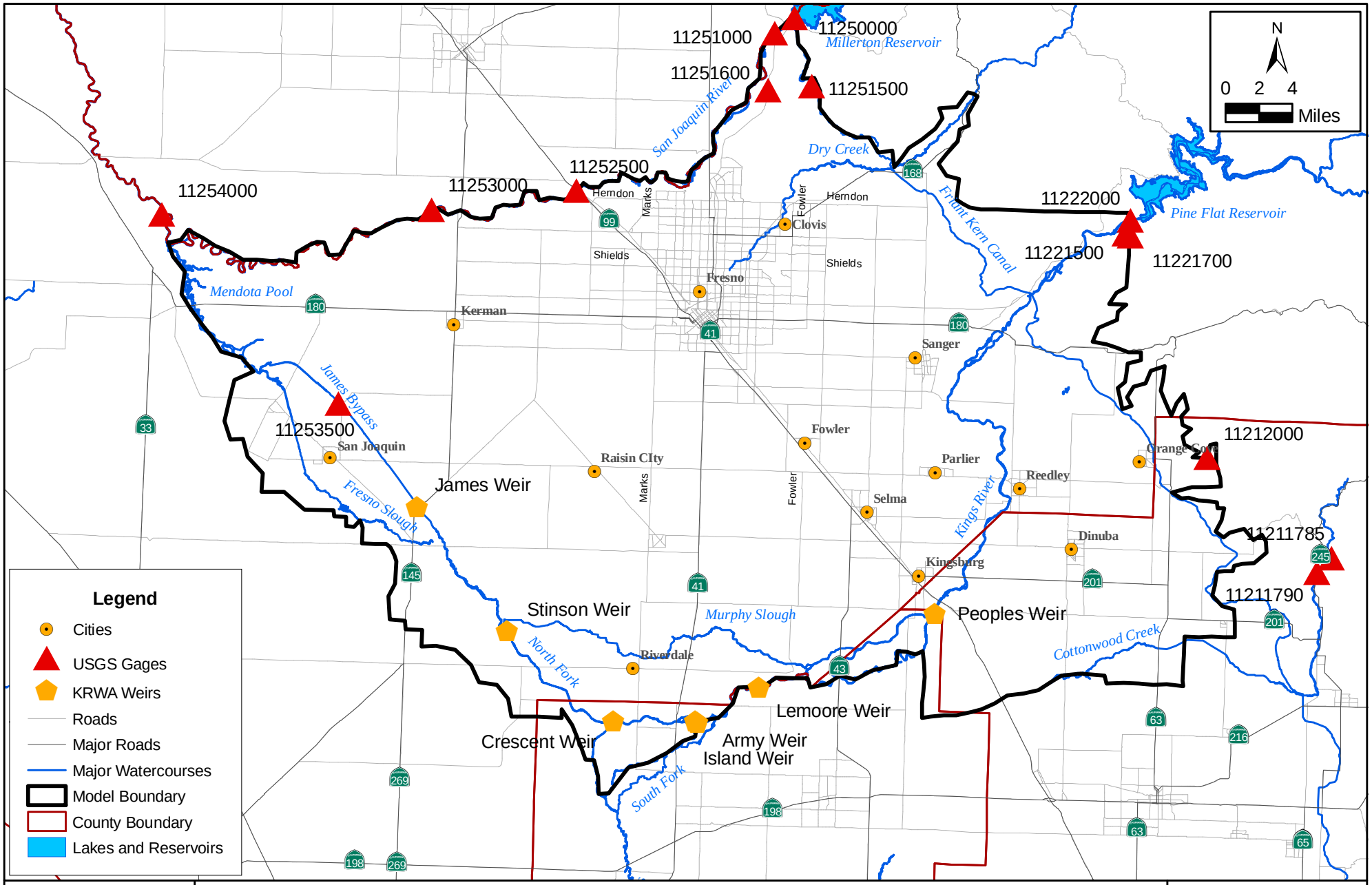
Hydrologic Soil Groups in Model Area

Kings IGSM Model Development and Calibration

Source: USDA NRCS Soil Data MART, 2006

July 2007

Figure 5-19



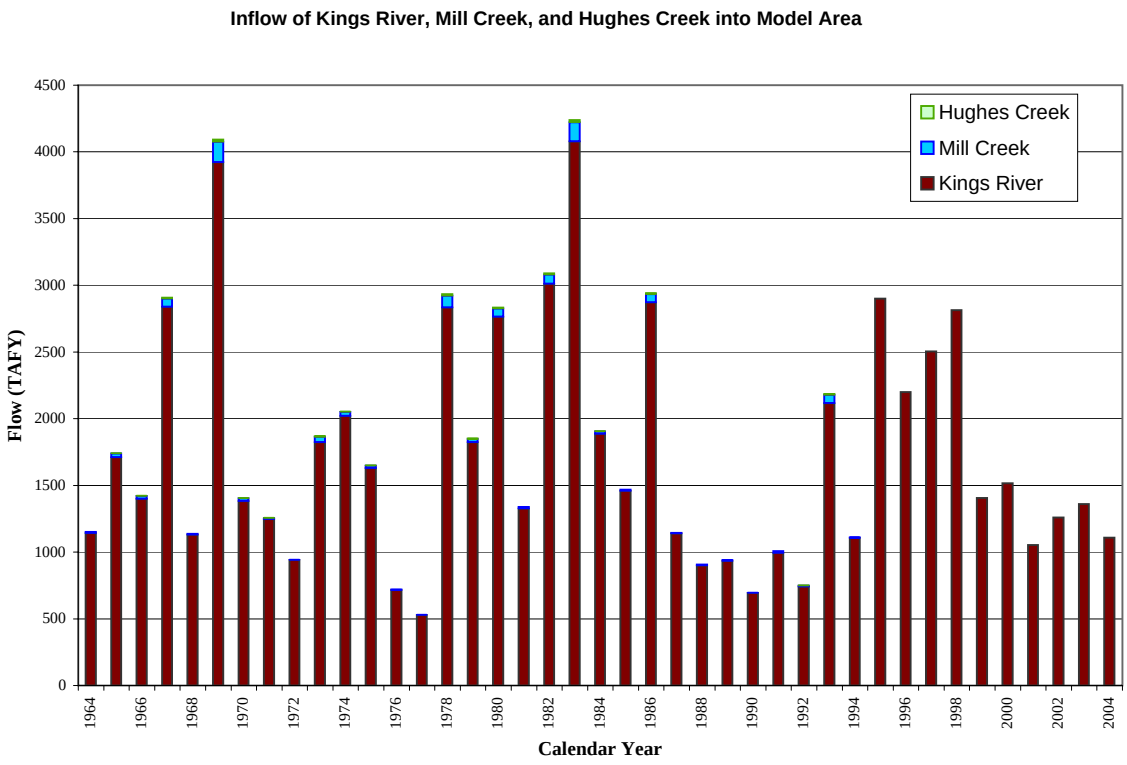
RIME

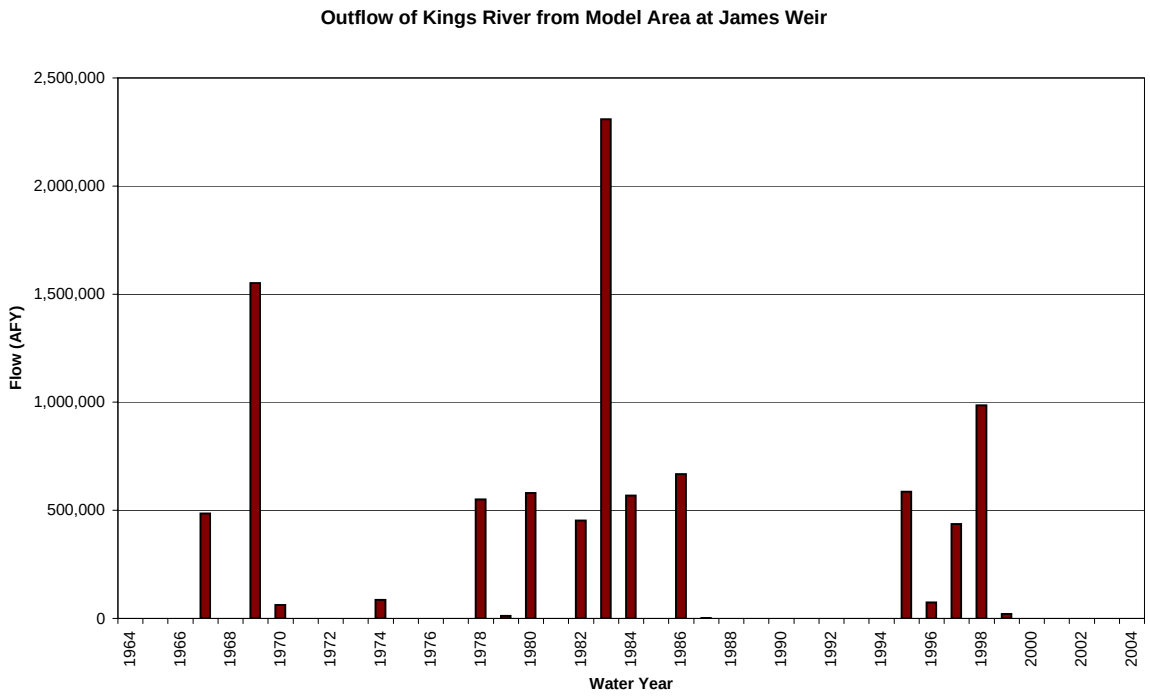
Streamflow Stations in Model Area

Kings IGSM Model Development and Calibration

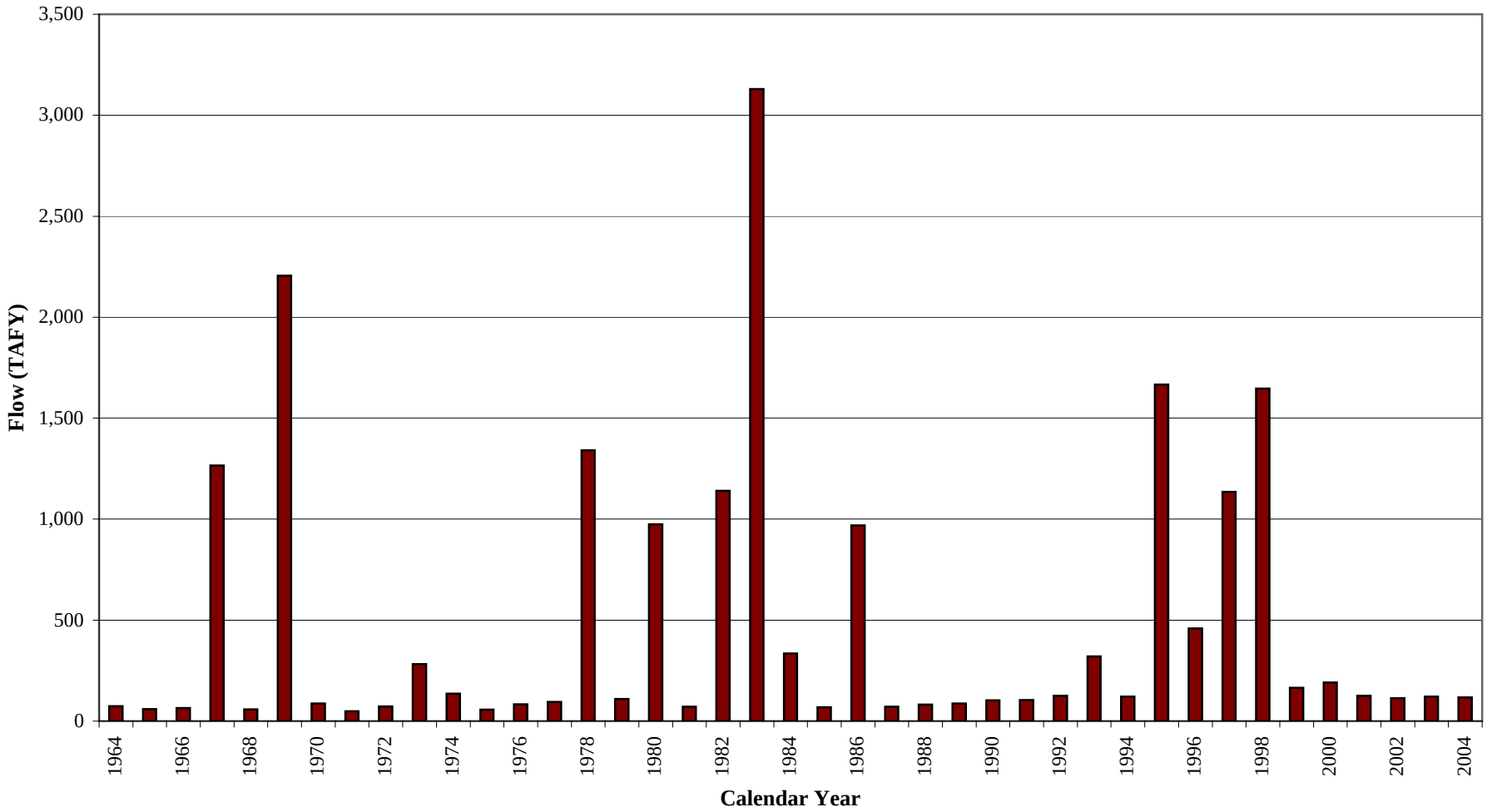
July 2007

Figure 5-20

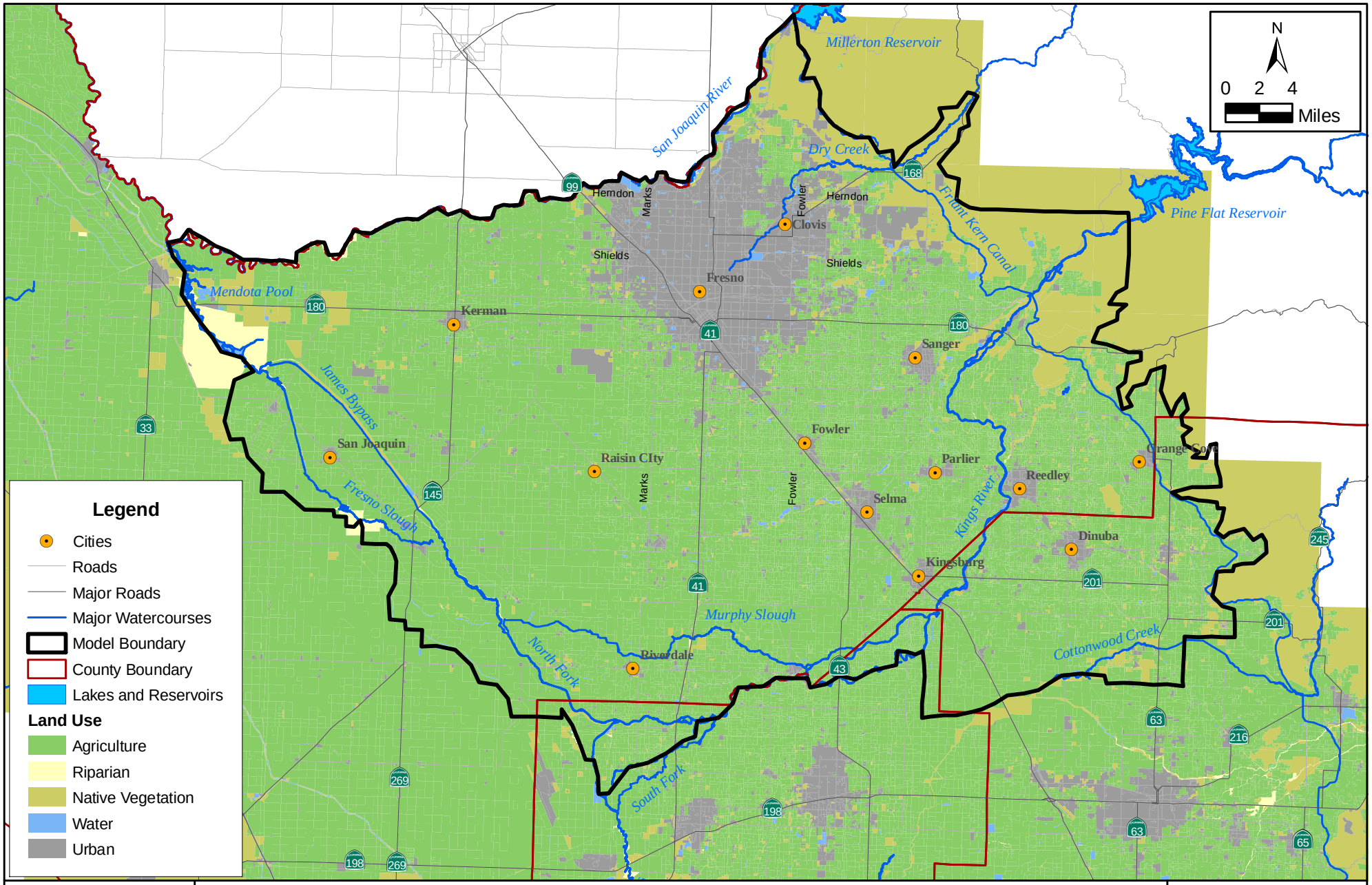




WRIME	**Inflow of Kings River, Mill Creek, and Hughes Creek into Model Area and Outflow of Kings River from Model Area at James Weir** Kings IGSM Model Development and Calibration	July 2007 Figure 5-21



WRIME	**San Joaquin River Flow Below Friant Dam** Kings IGSM Model Development and Calibration	July 2007 FIGURE 5-22

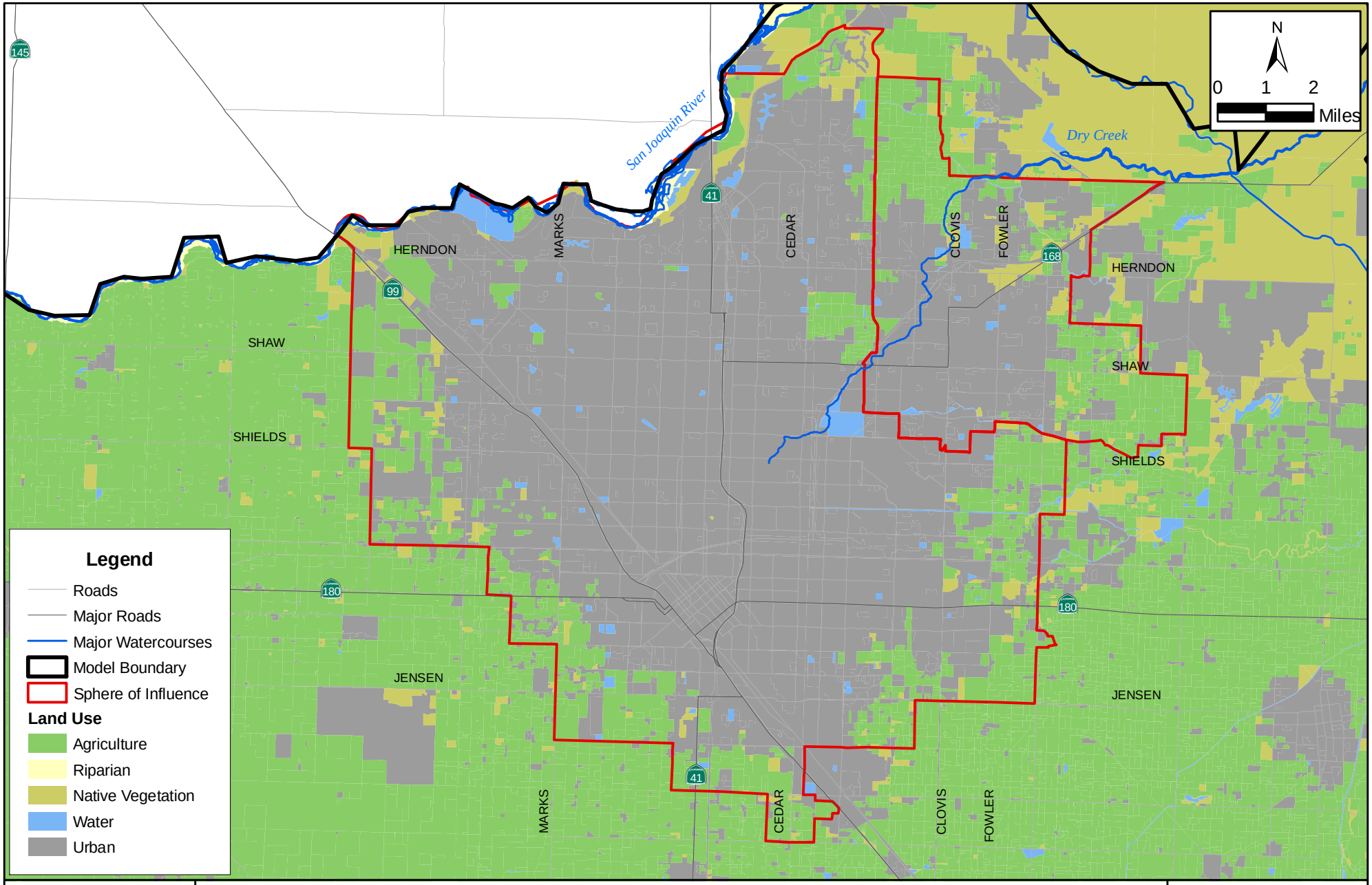


2000 Land Use Distribution in the Model Area

Kings IGSM Model Development and Calibration

July 2007

Figure 5-23



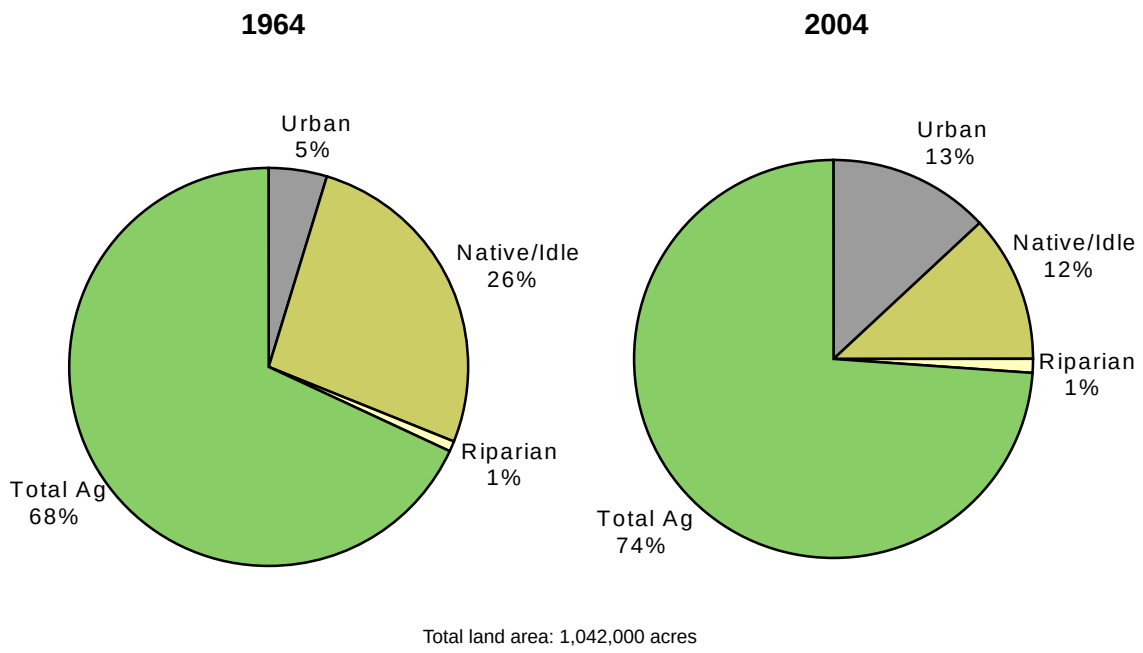
WRIME

2000 Land Use Distribution in Fresno and Clovis

Kings IGSM Model Development and Calibration

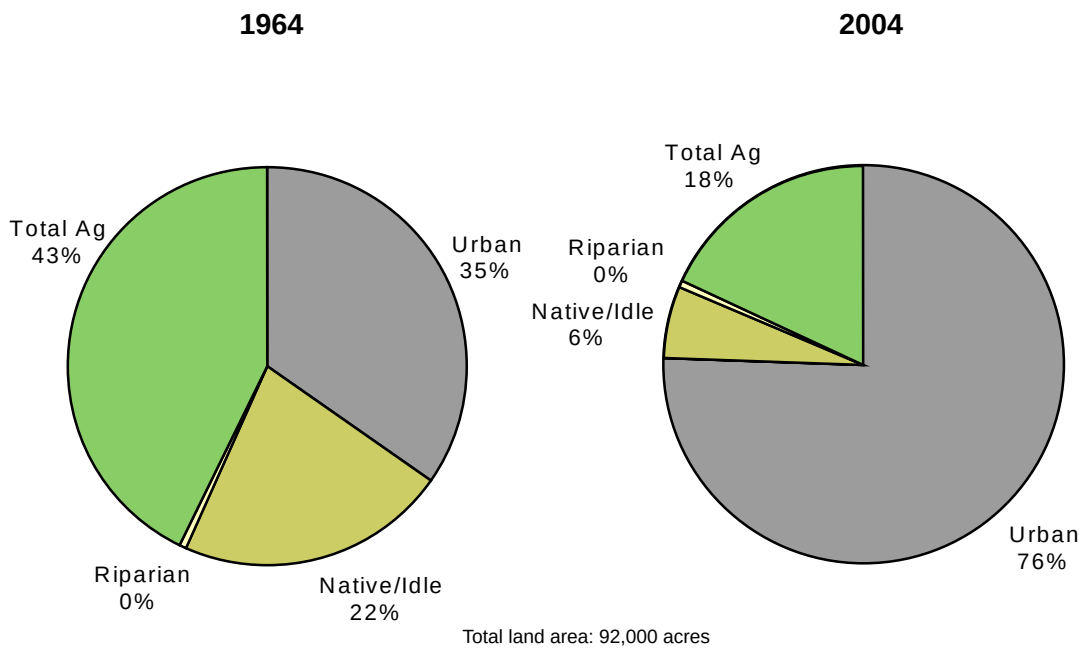
July 2007

Figure 5-24



Total land area: 1,042,000 acres

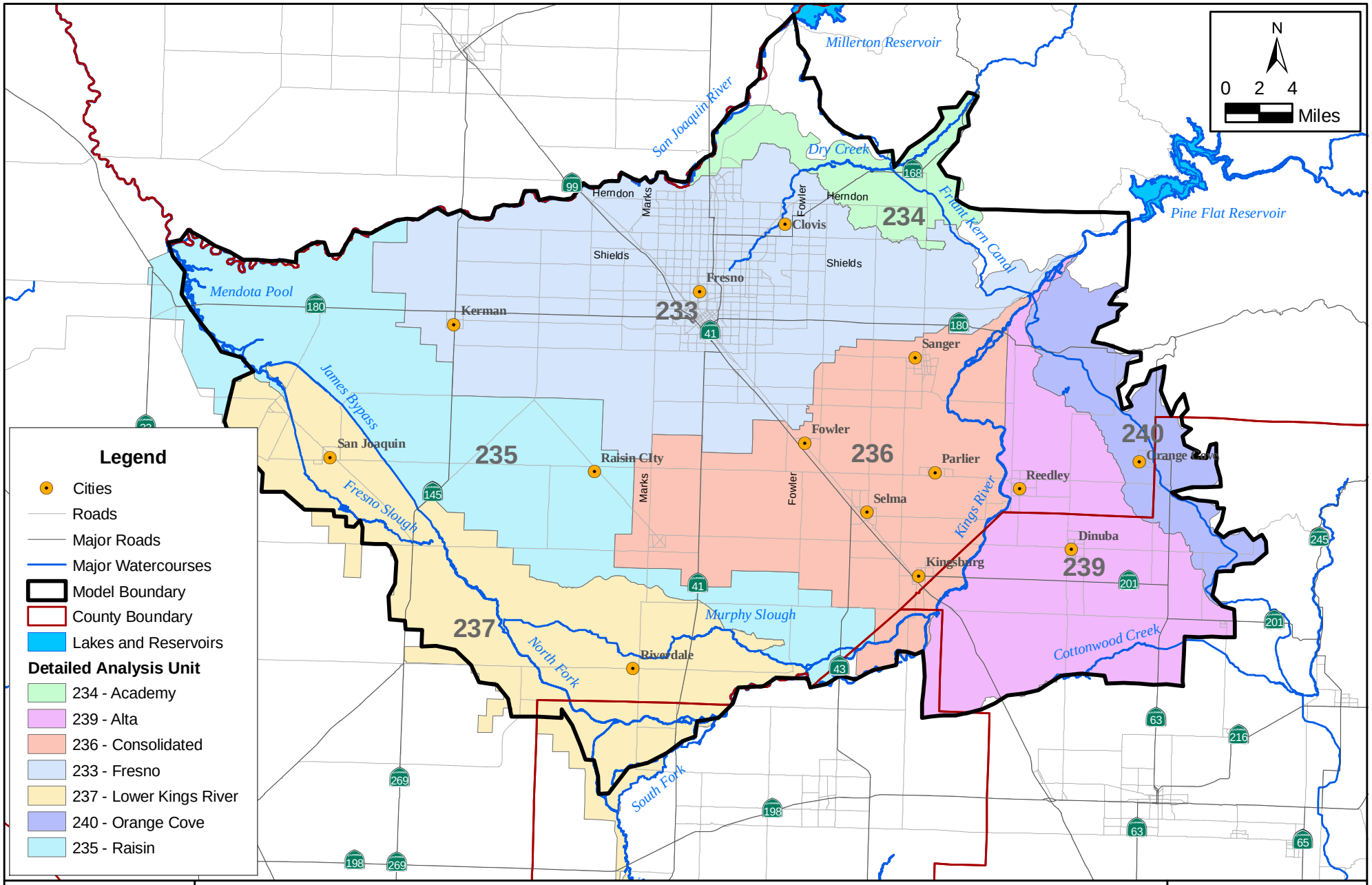
Model Area



Total land area: 92,000 acres

Fresno Sphere of Influence

ωRIME	**1964 and 2004 Land Use in Model Area and Fresno Sphere of Influence**	July 2007
		Figure 5-25



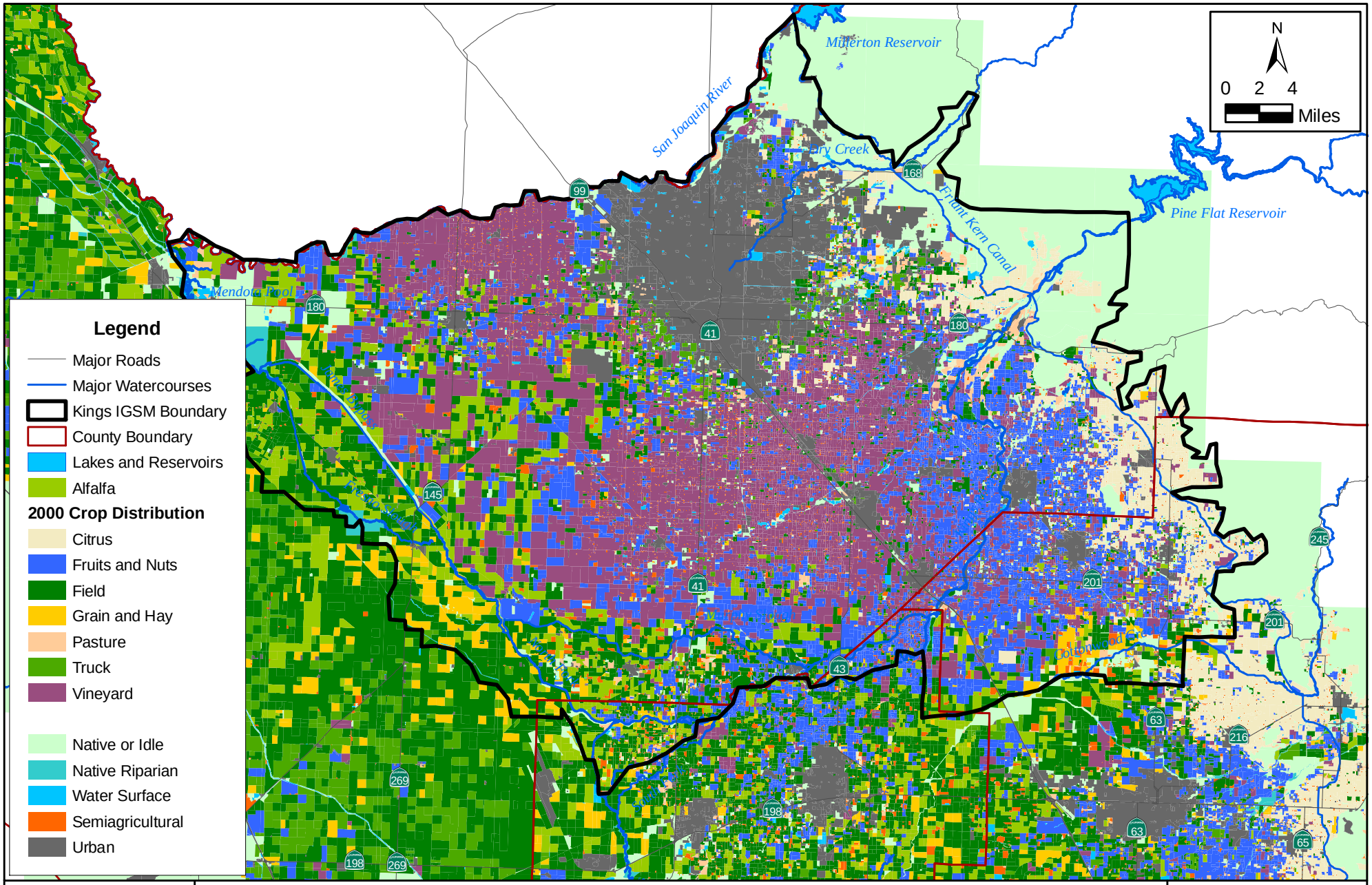
WRIME

Detailed Analysis Units (DAUs) in Model Area

Kings IGSM Model Development and Calibration

July 2007

Figure 5-26



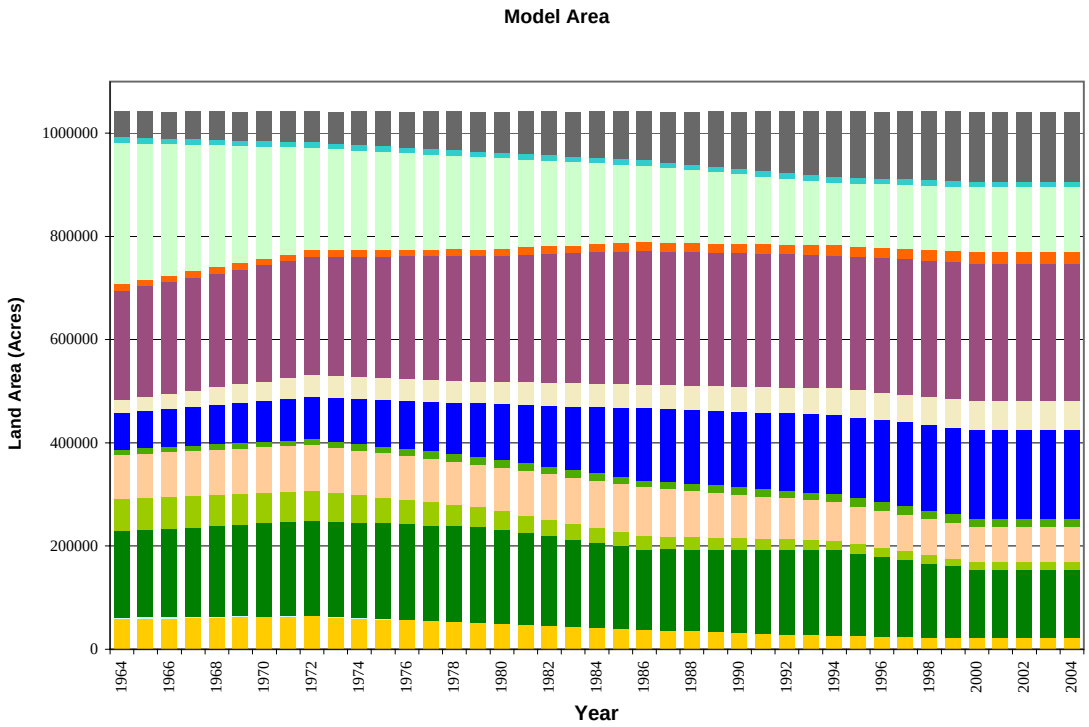
ωRIME

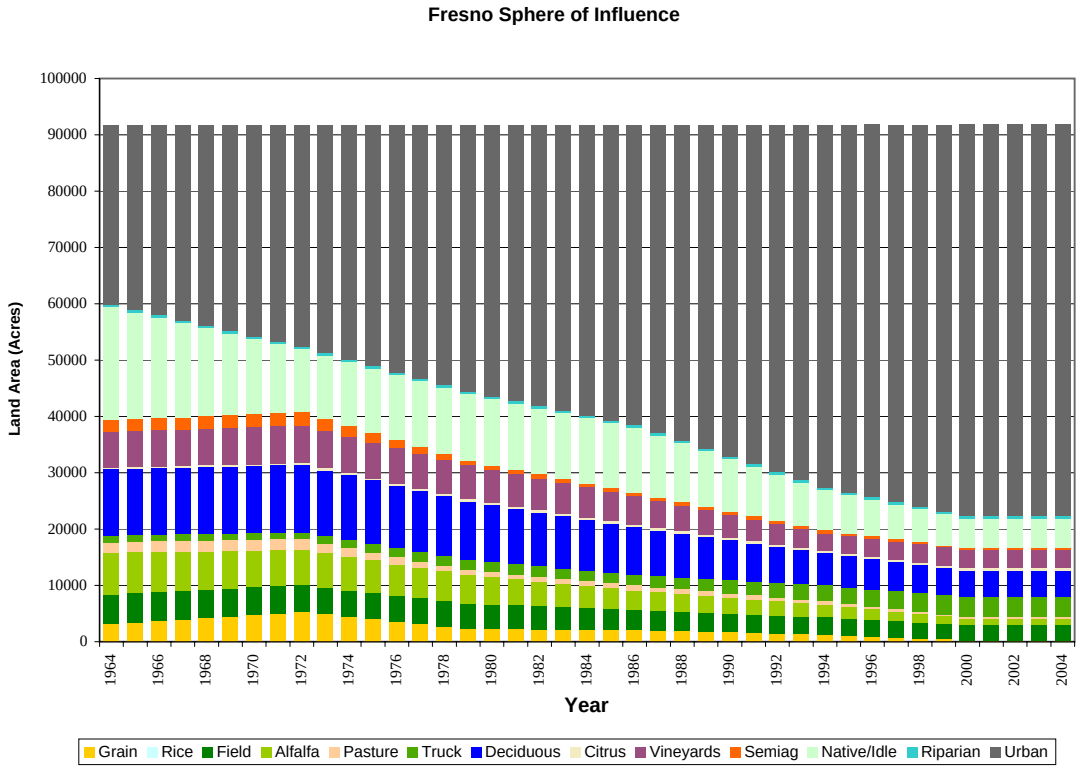
2000 Crop Distribution in the Model Area

Kings IGSM Model Development and Calibration

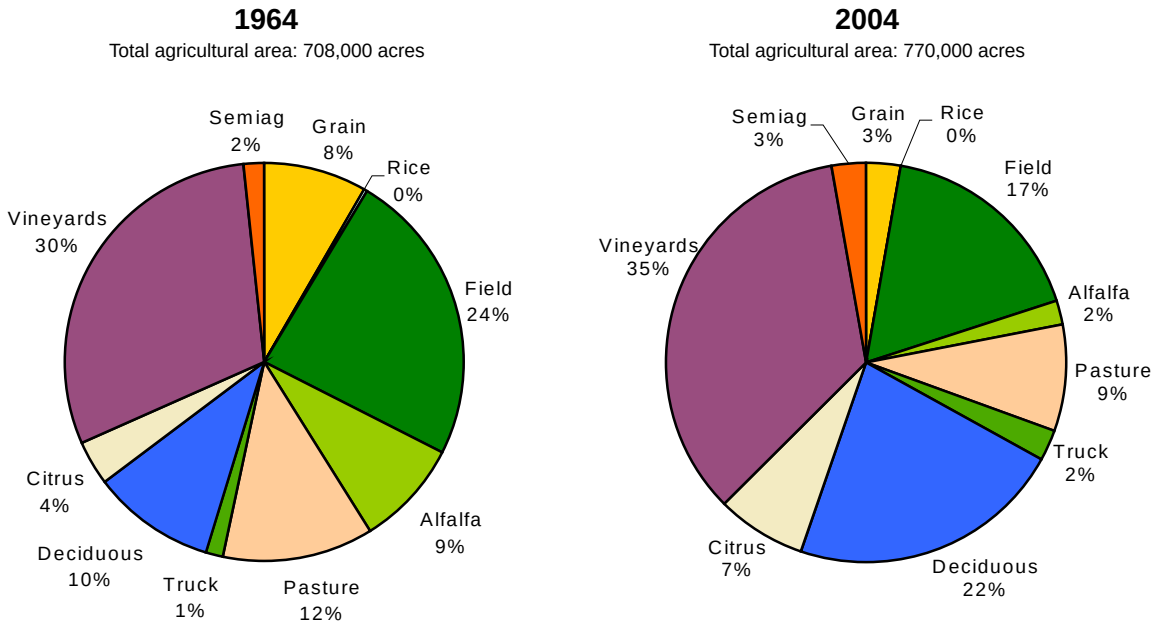
July 2007

Figure 5-27

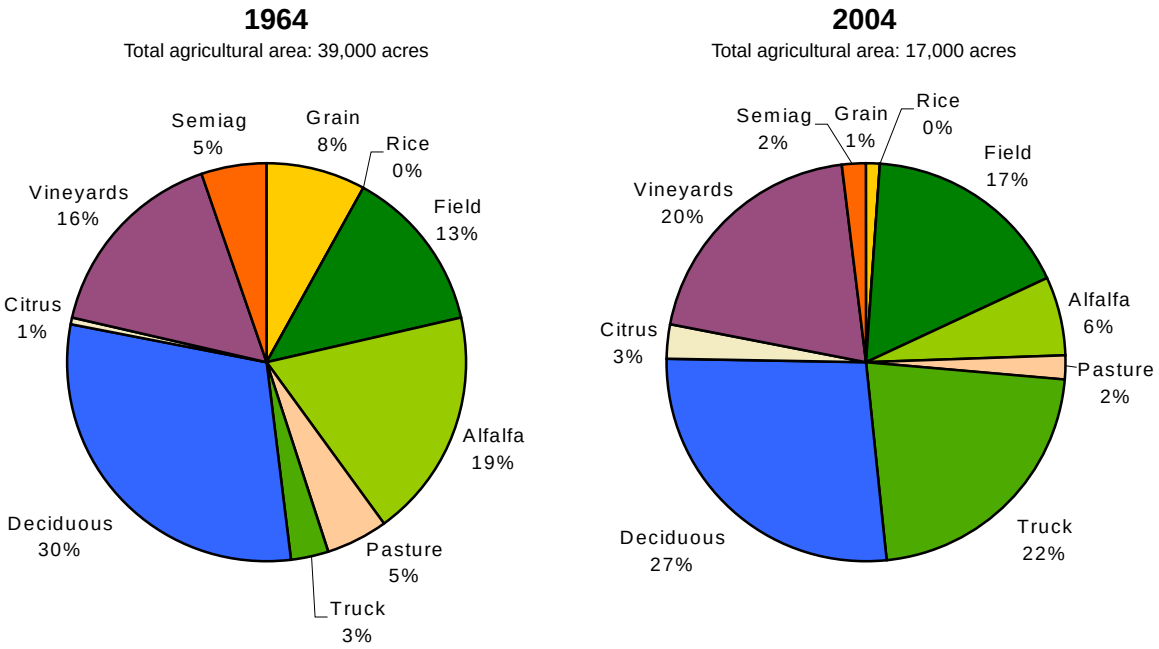




ωRIME	**Land Use Trends** Kings IGSM Model Development and Calibration	July 2007 Figure 5-28

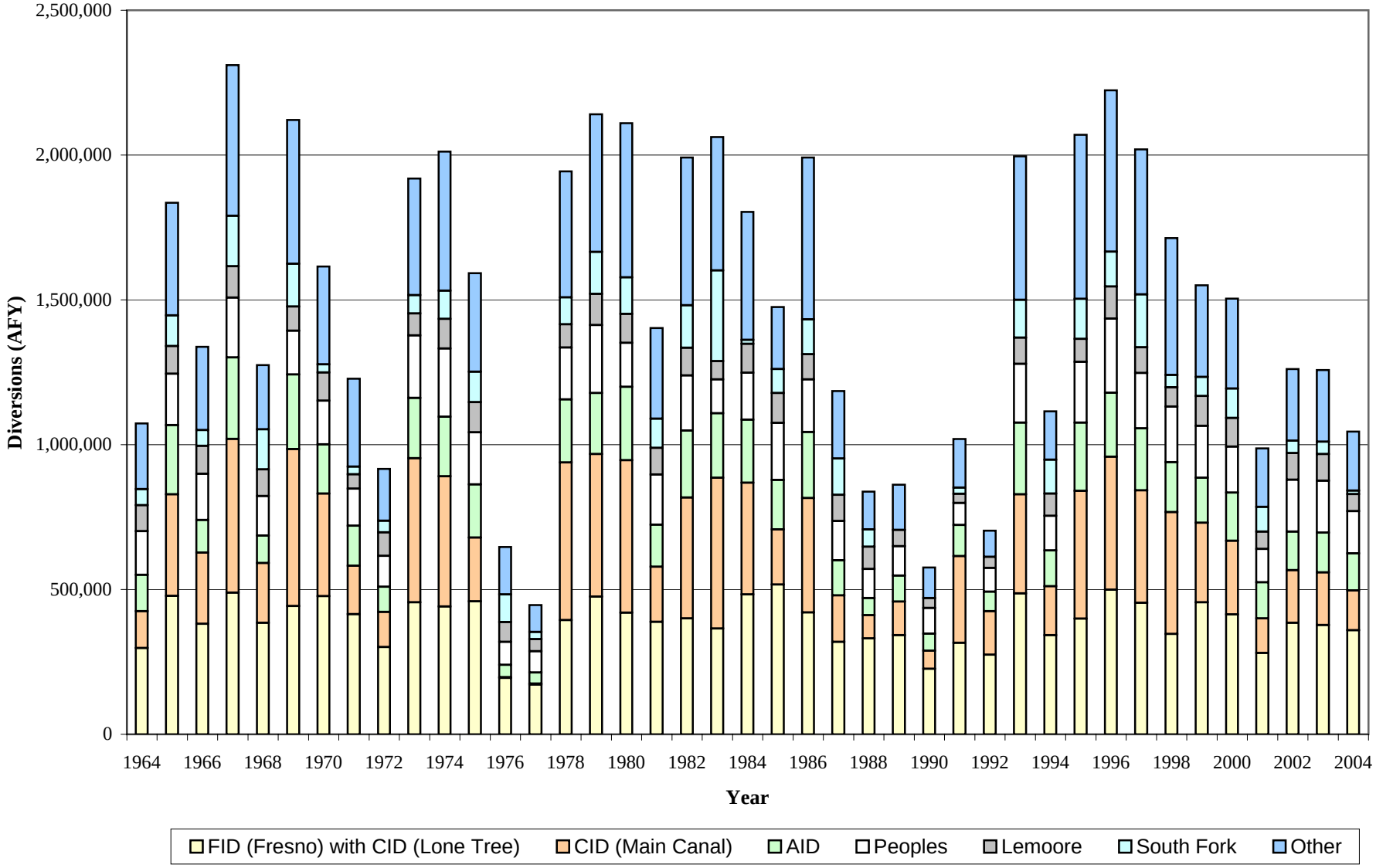


Model Area



Fresno Sphere of Influence

WRIME	**1964 and 2004 Crop Distribution in Model Area and Fresno Sphere of Influence**	July 2007
		Figure 5-29



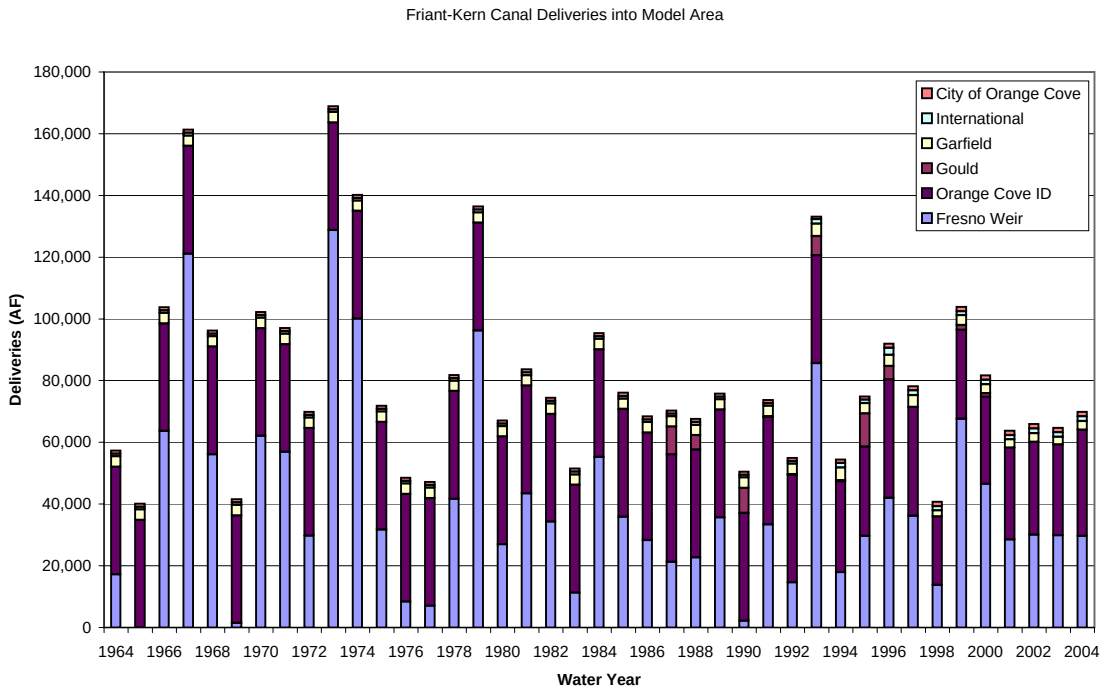
ωRIME

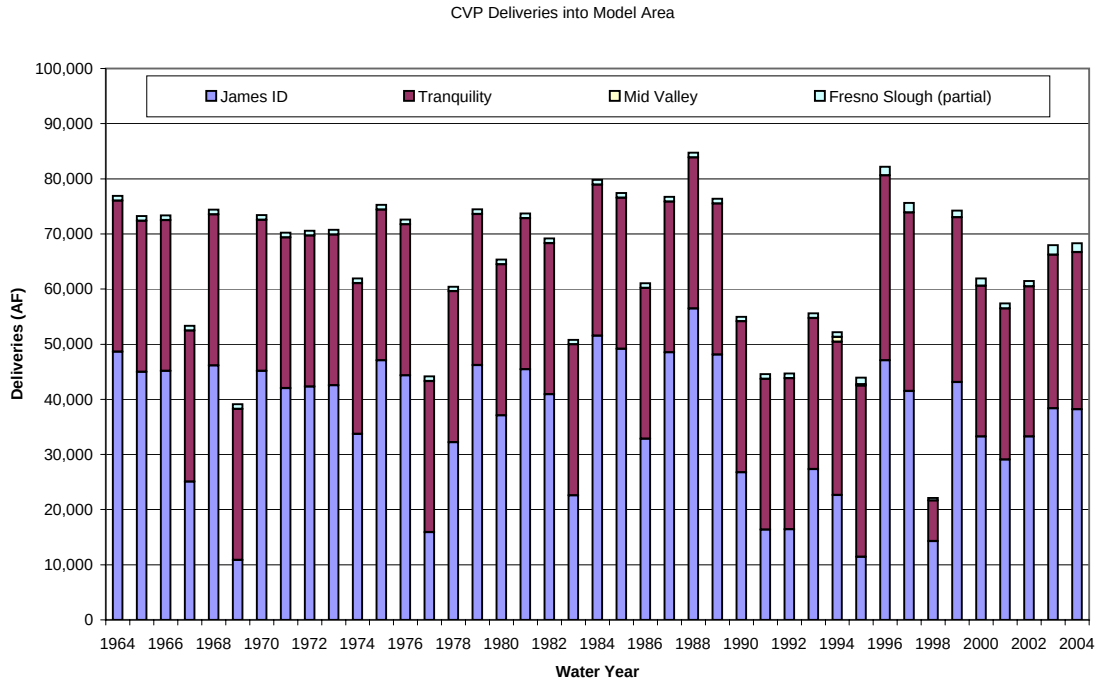
Kings River Diversions

Kings IGSM Model Development and Calibration

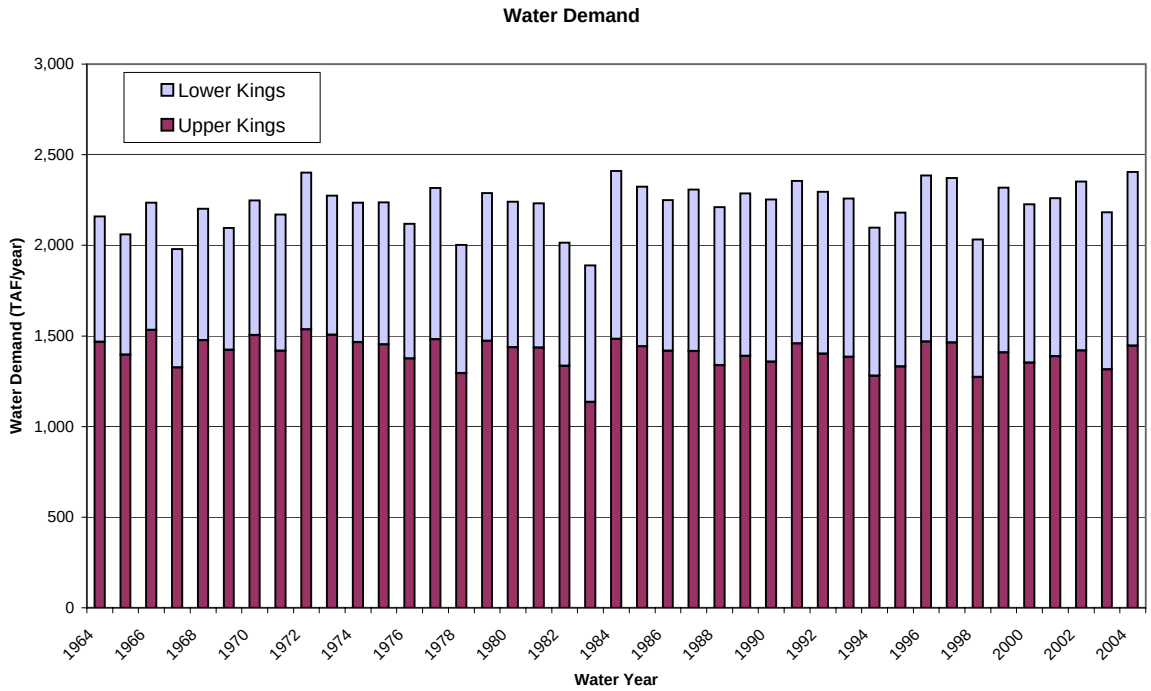
July 2007

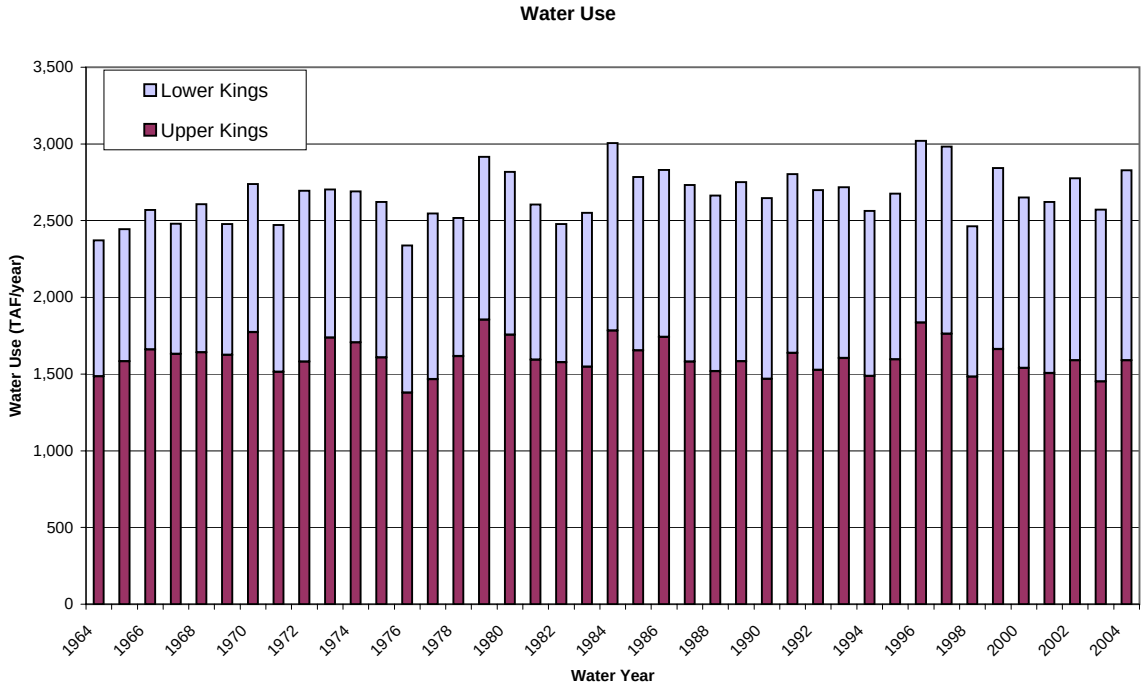
FIGURE 5-30



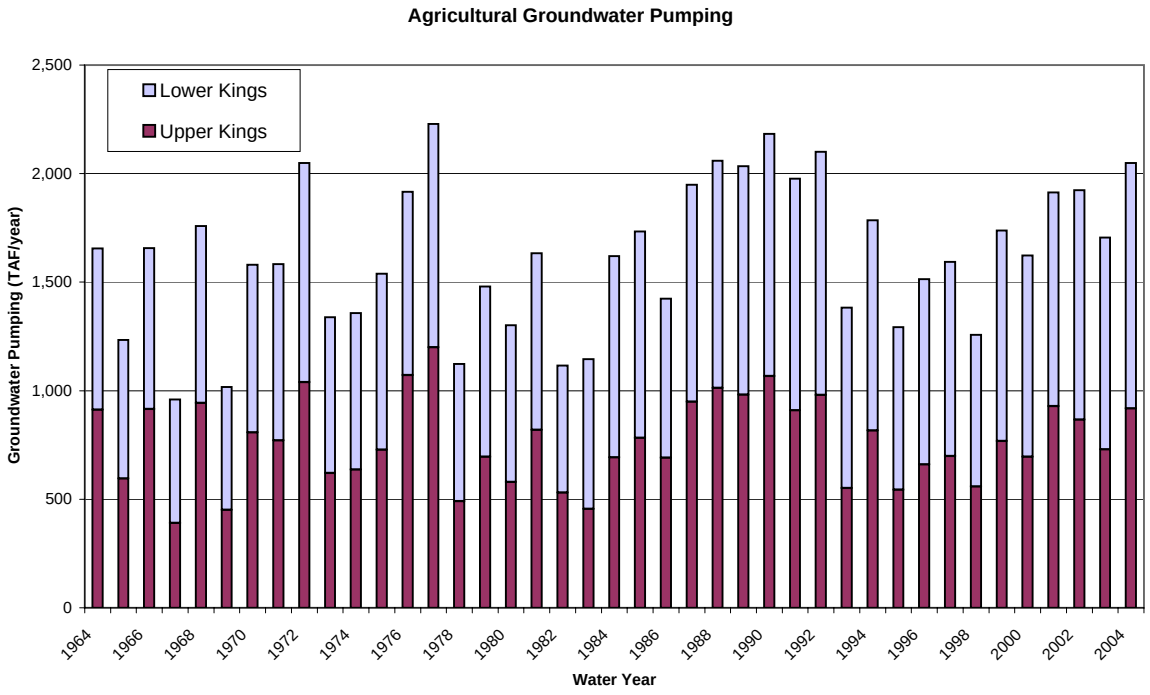


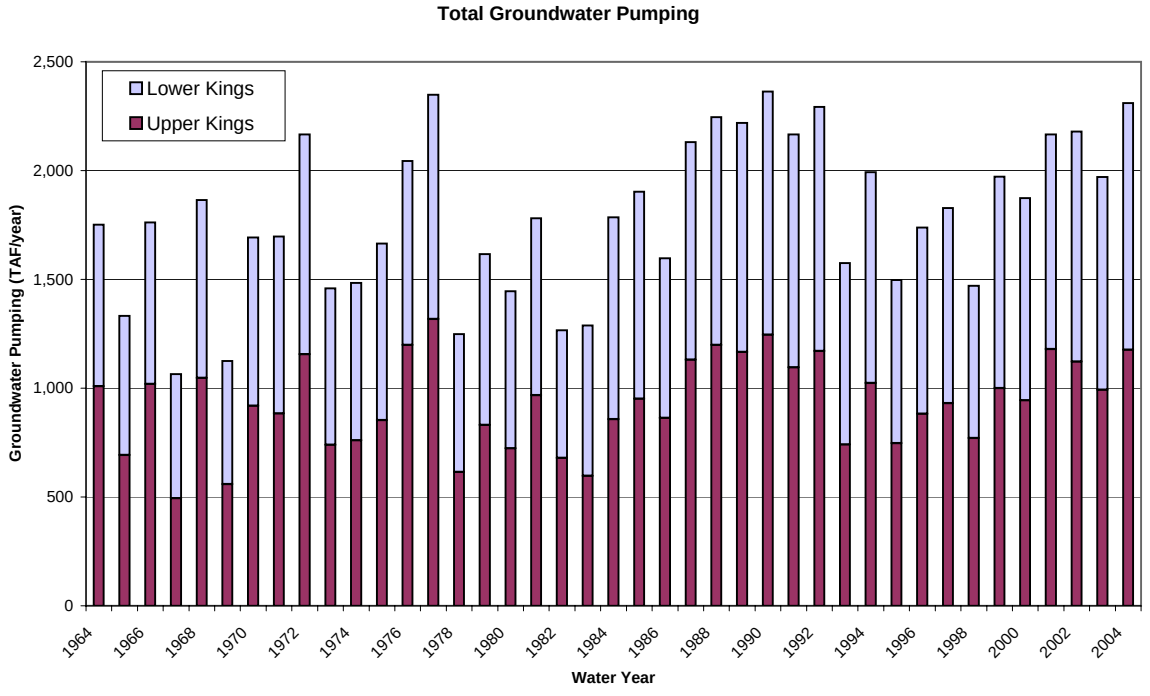
ωRIME	**Import Deliveries** Kings IGSM Model Development and Calibration	July 2007 Figure 5-31



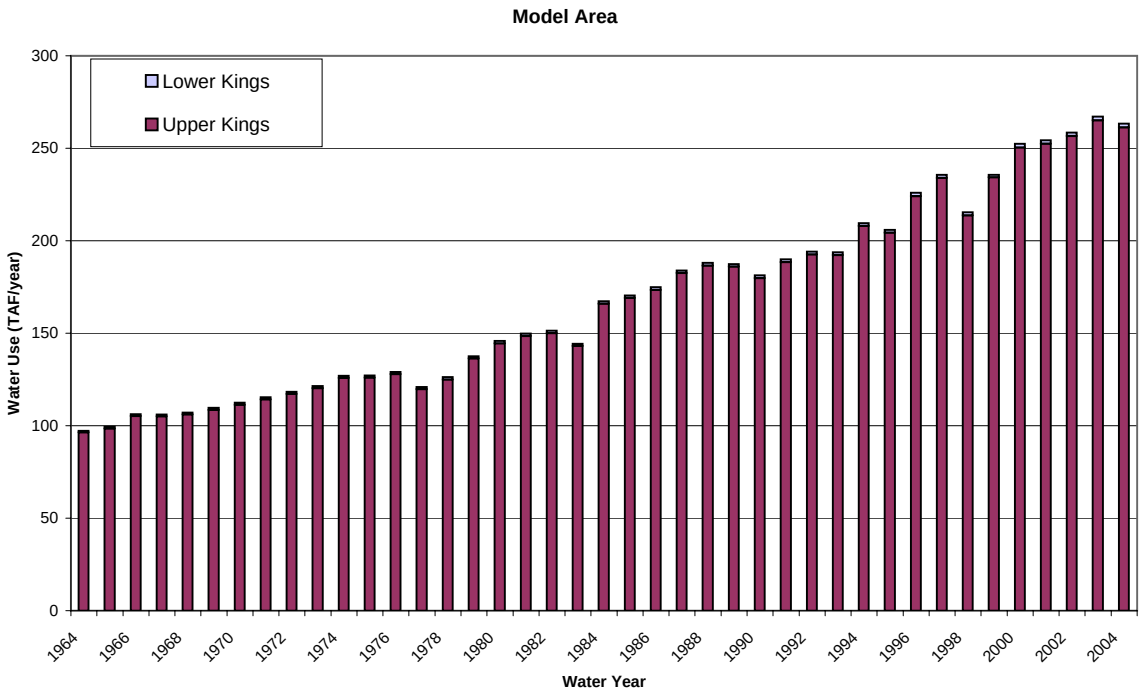


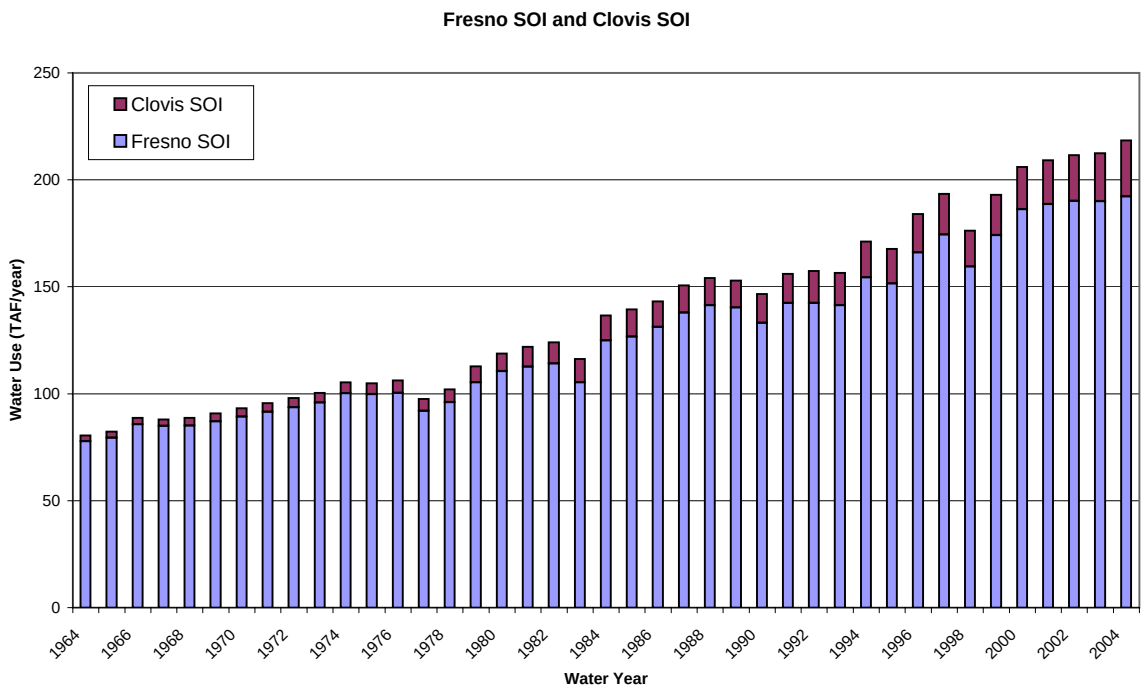
ωRIME	**Estimated Agricutural Water Demand and Use in Kings Basin** Kings IGSM Model Development and Calibration	July 2007 Figure 5-32



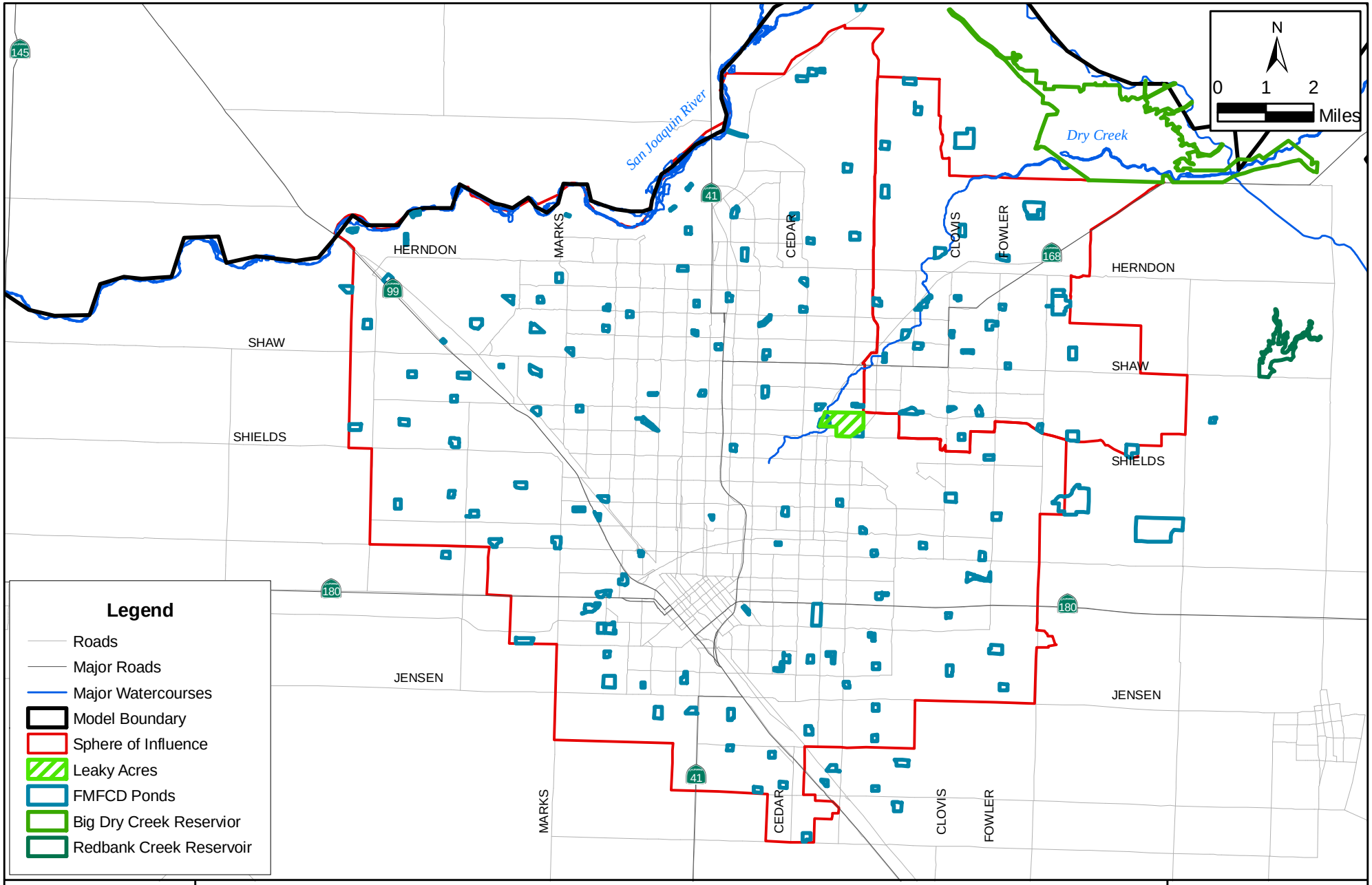


ωRIME	**Estimated Groundwater Pumping in Kings Basin**	July 2007
	Kings IGSM Model Development and Calibration	Figure 5-33





ωRIME	**Estimated Urban Water Use** Kings IGSM Model Development and Calibration	July 2007 Figure 5-34



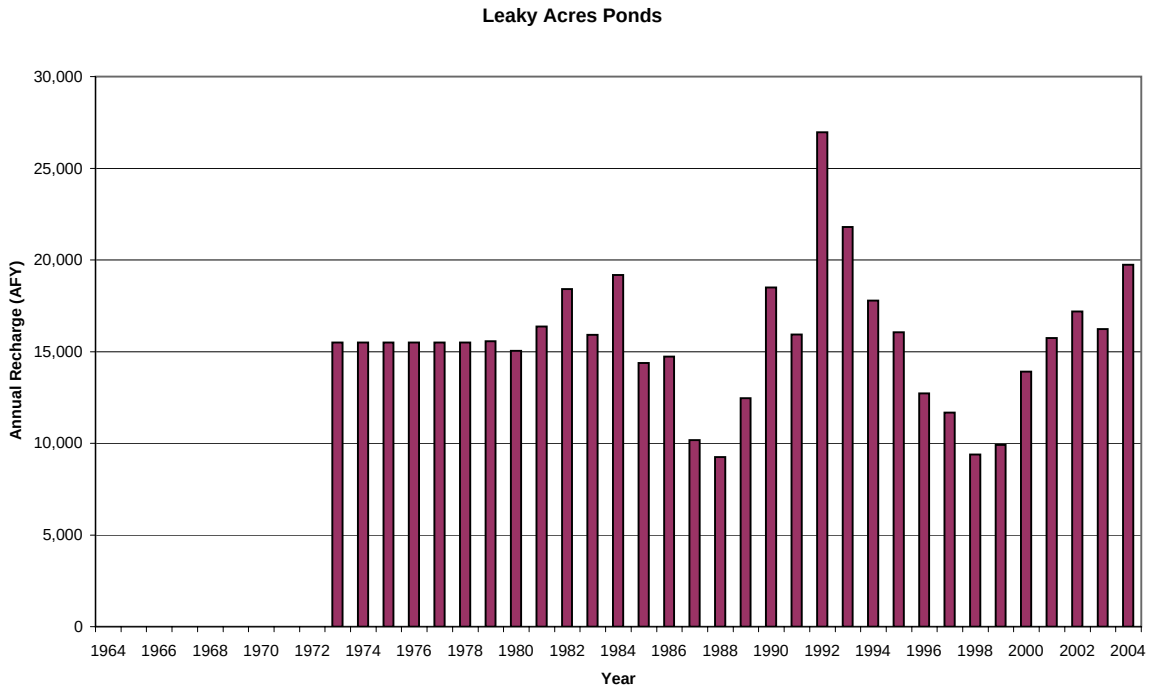
WRIME

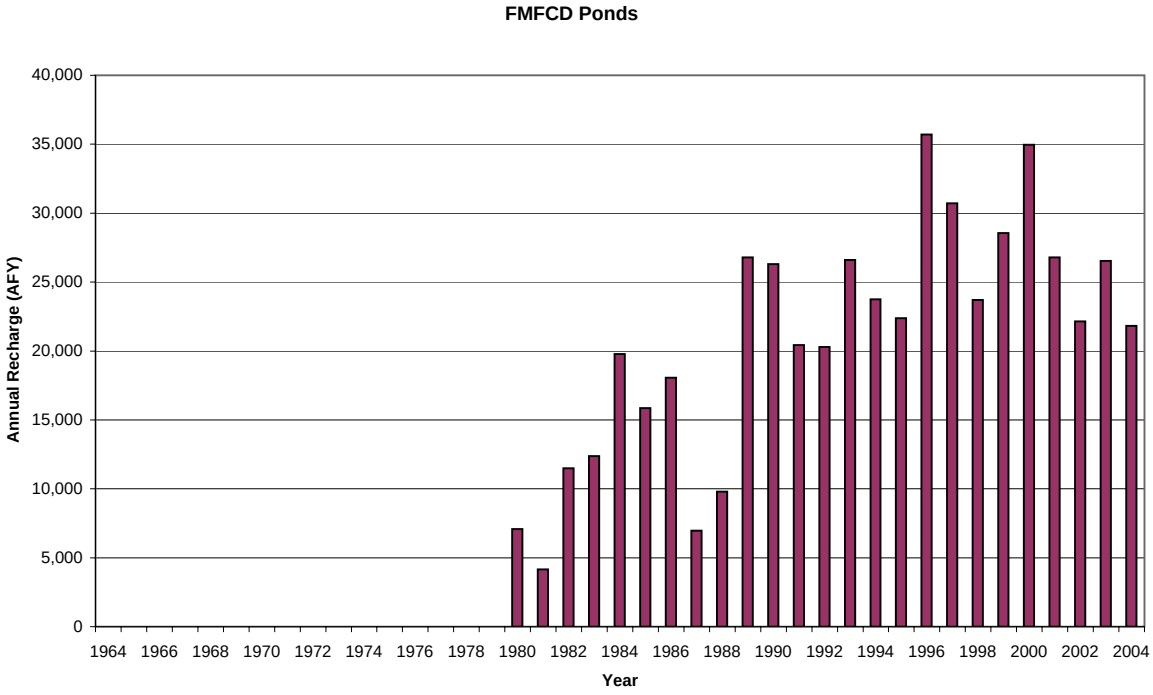
Fresno & Clovis Area Recharge Ponds

Kings IGSM Model Development and Calibration

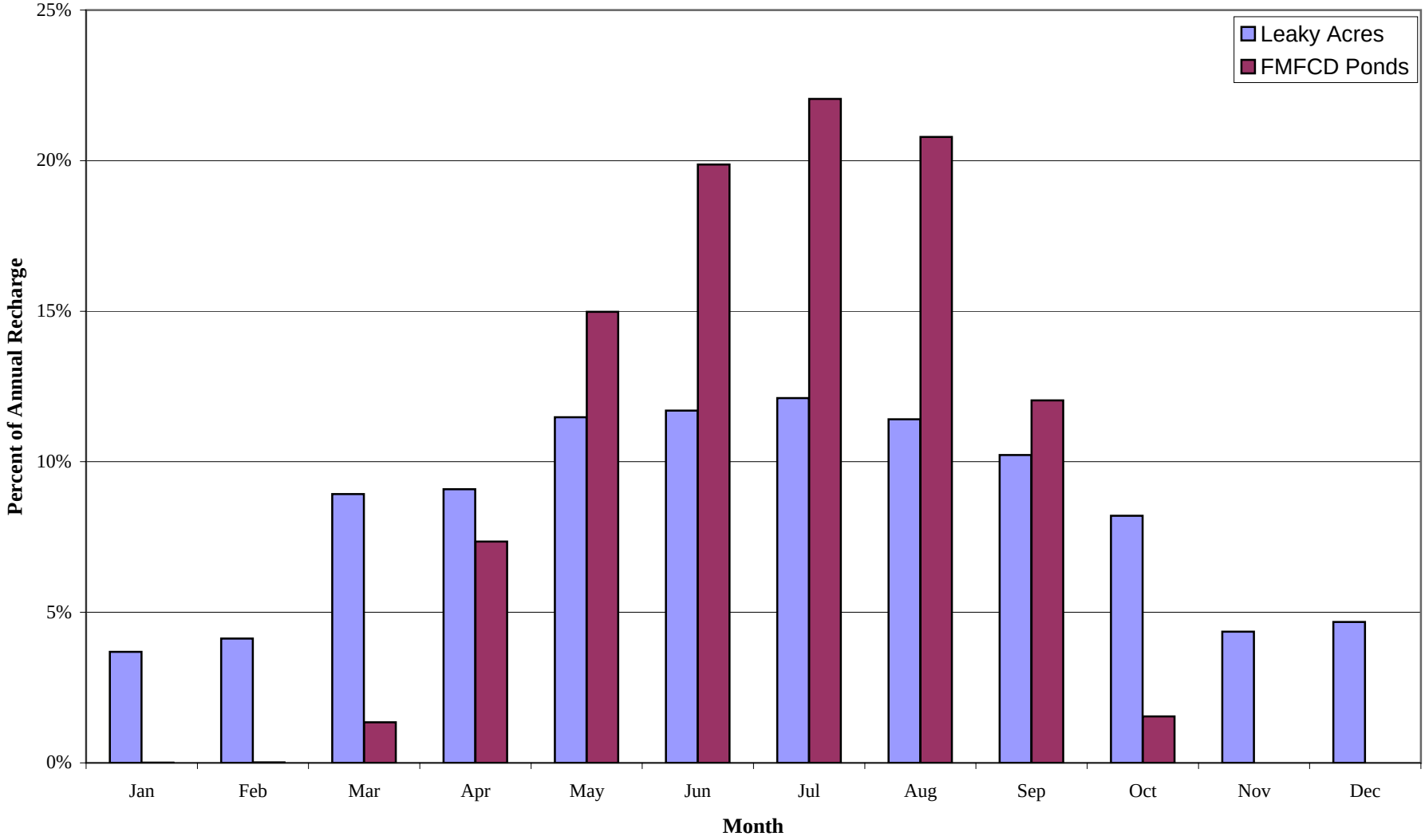
July 2007

Figure 5-35





ωRIME	**Recharge at Spreading Basins** Kings IGSM Model Development and Calibration	July 2007 Figure 5-36

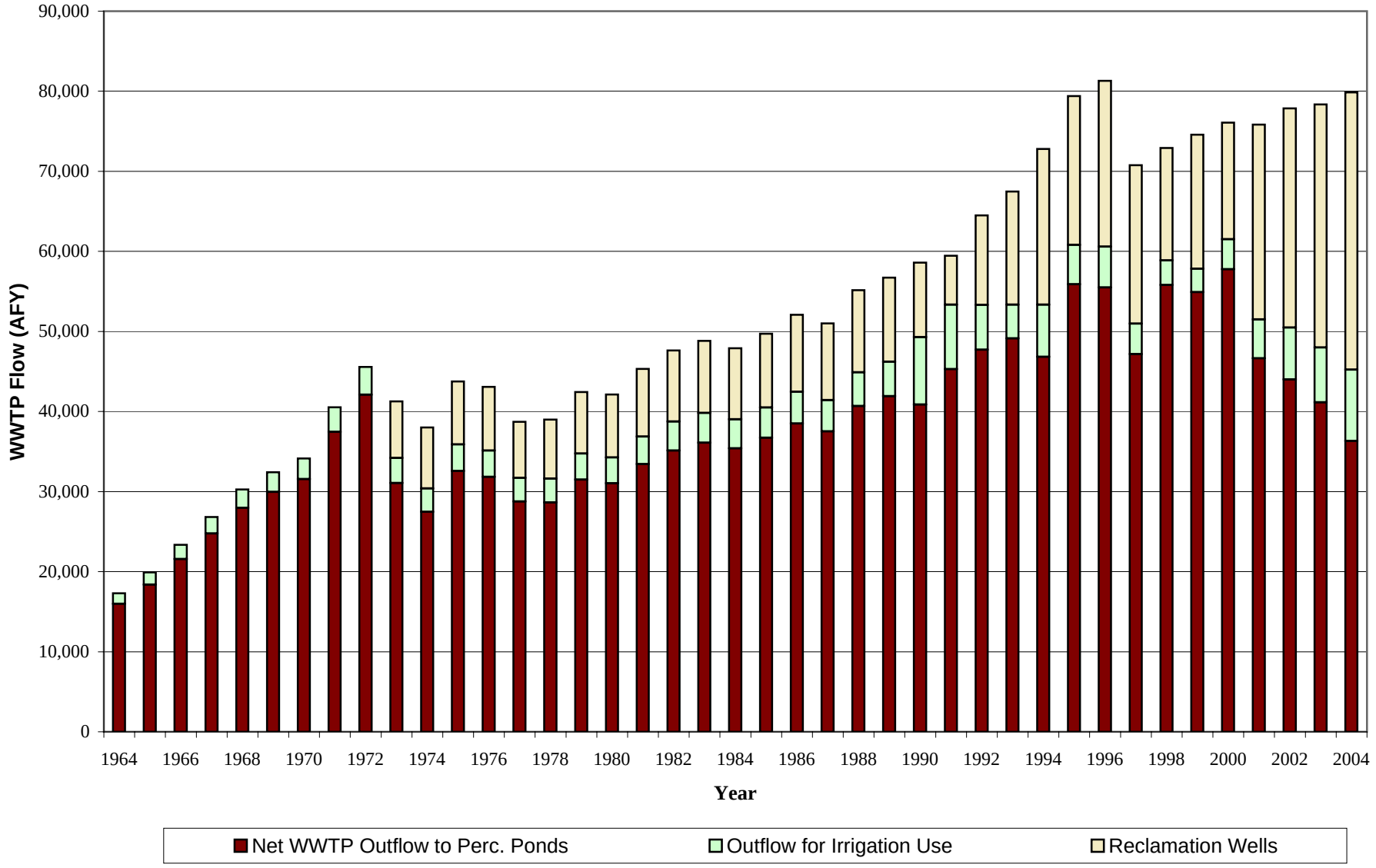


Monthly Distribution of Recharge at Leaky Acres and FMFCD Ponds

Kings IGSM Model Development and Calibration

July 2007

FIGURE 5-37



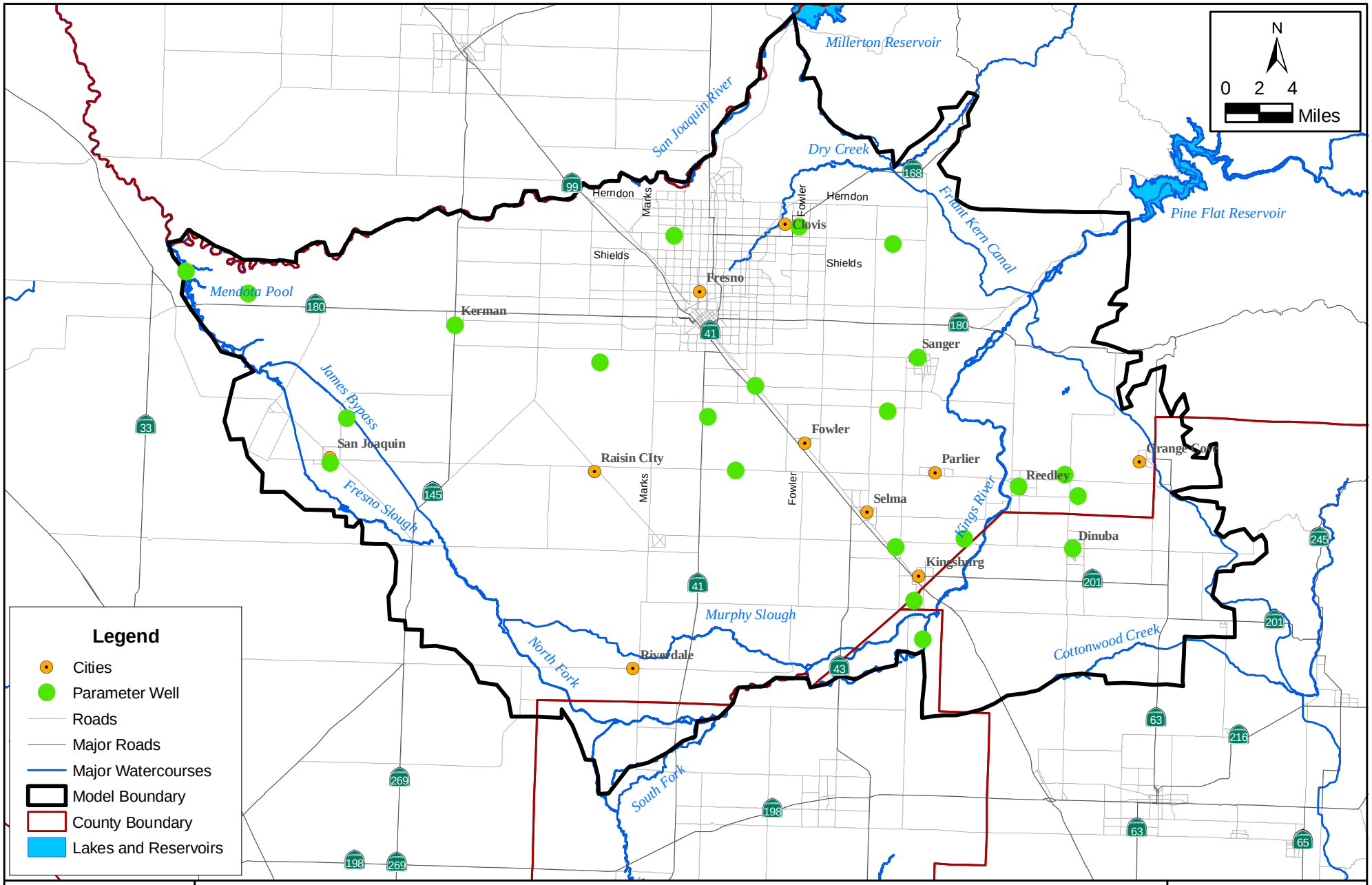
WRIME

Fresno-Clovis Regional WWTP Flow

Kings IGSM Model Development and Calibration

July 2007

FIGURE 5-38

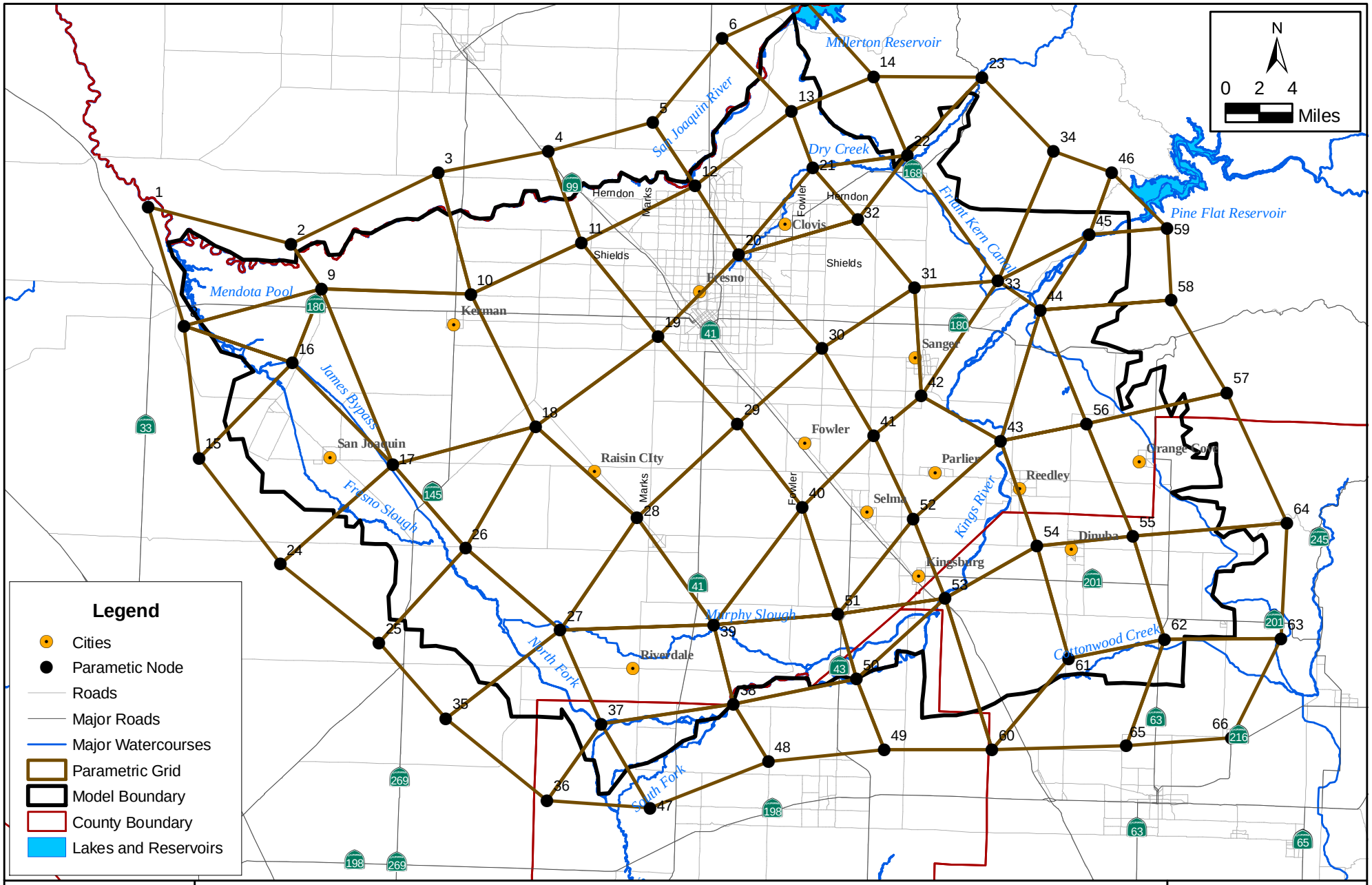


Parameter Wells

Kings IGSM Model Development and Calibration

July 2007

Figure 5-39



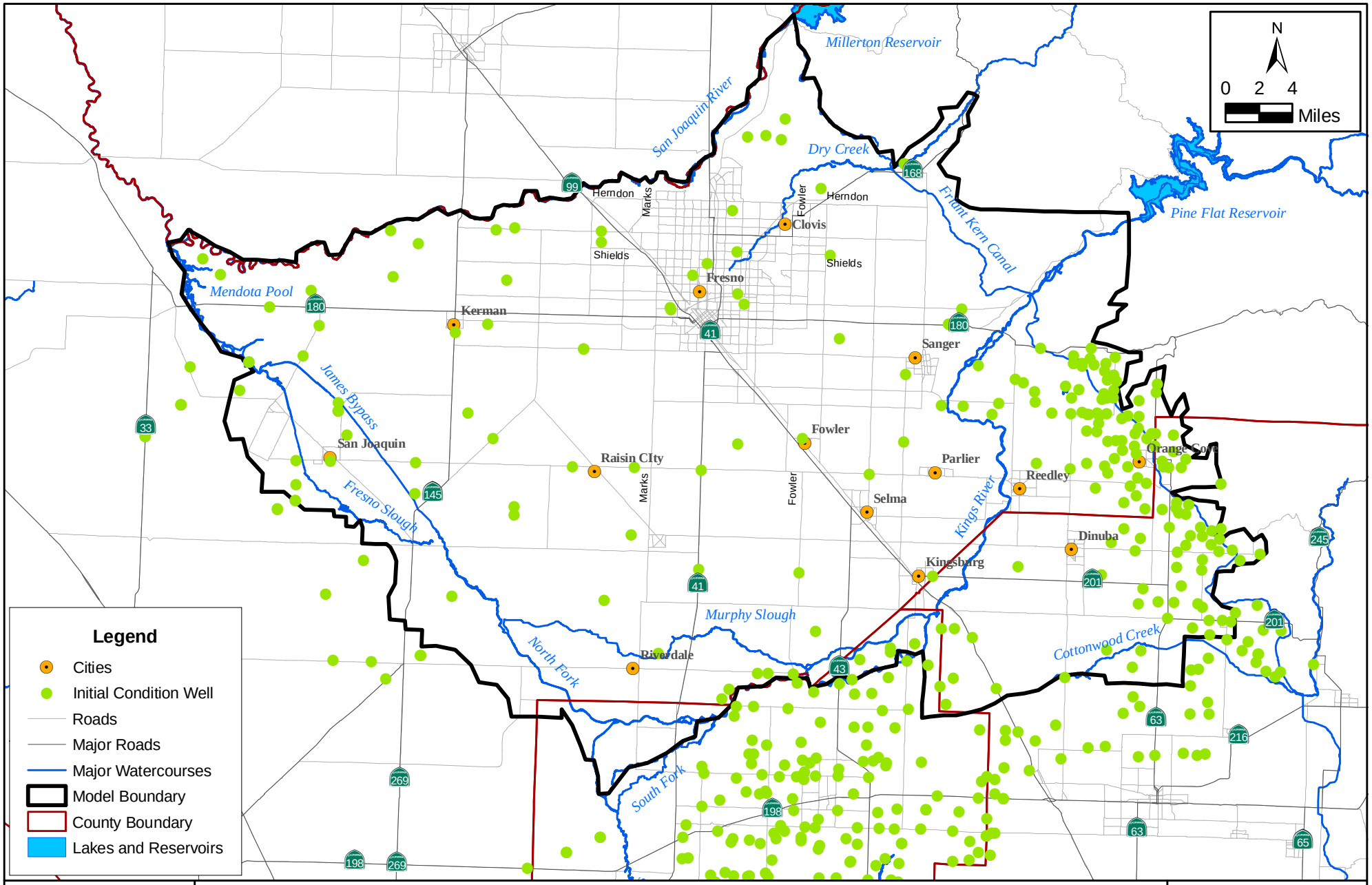
WRIME

Model Parametric Grid

Kings IGSM Model Development and Calibration

July 2007

Figure 5-40

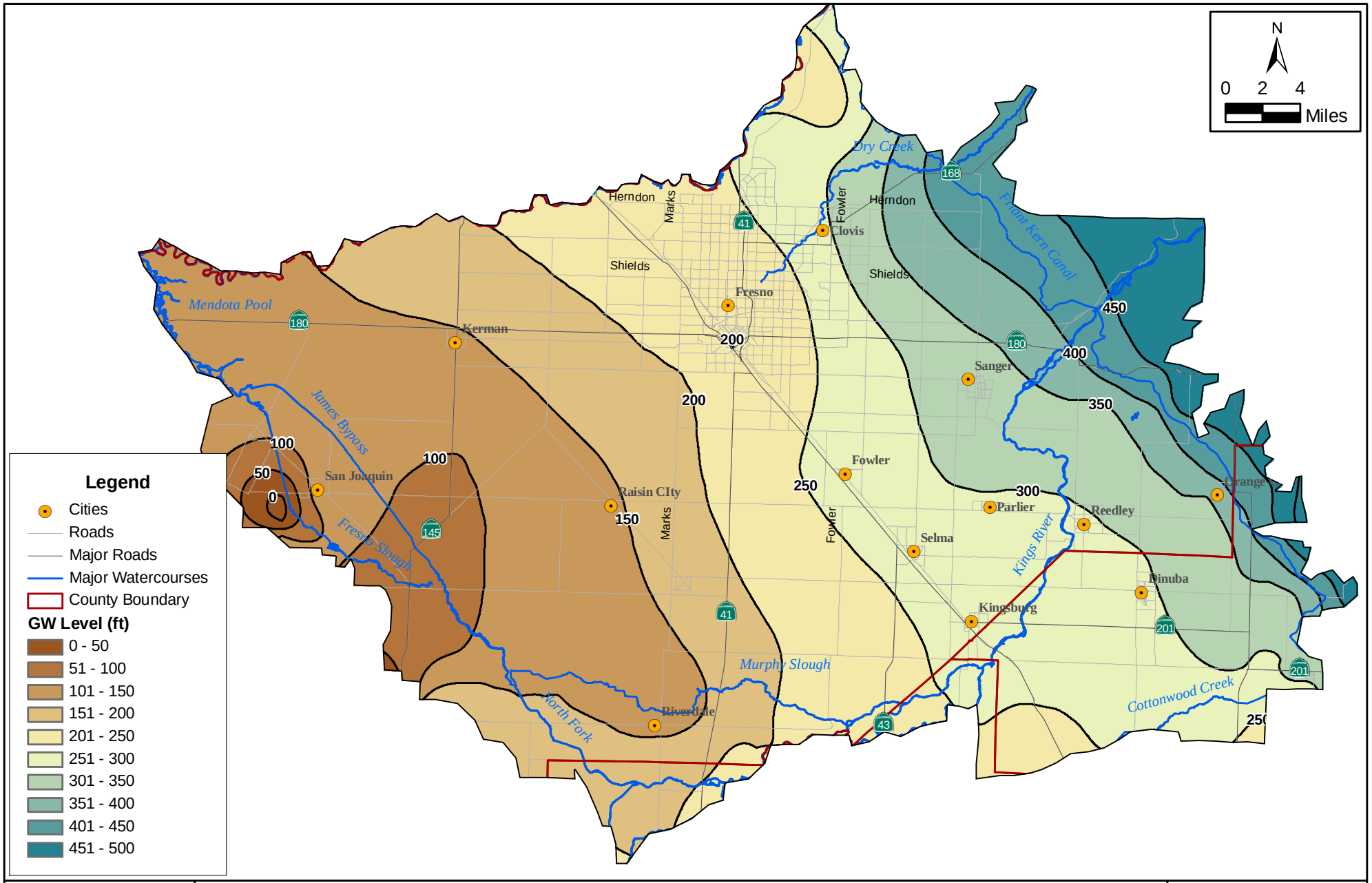


Wells Used for Initial Conditions

Kings IGSM Model Development and Calibration

July 2007

Figure 5-41

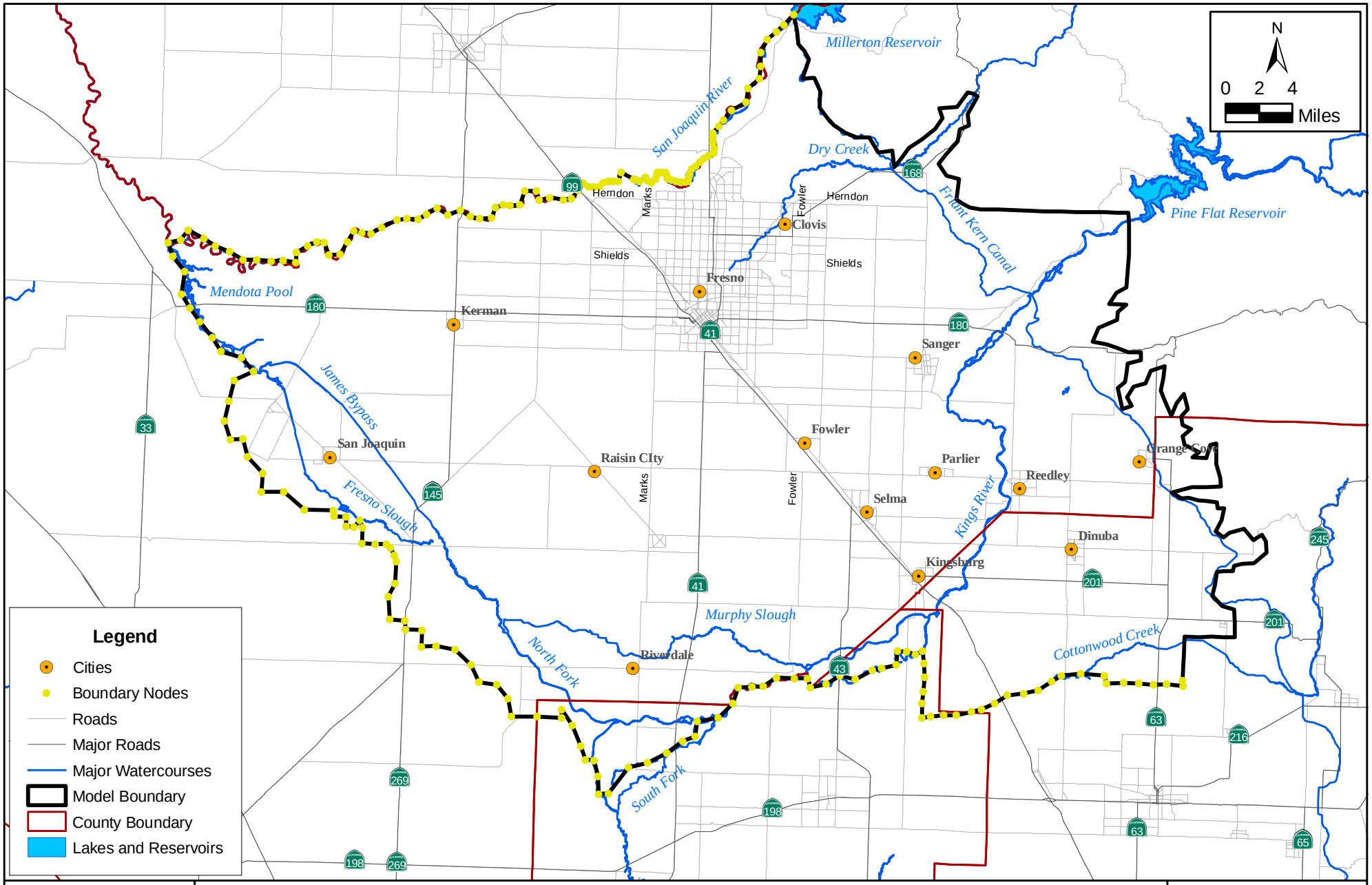


Initial Condition Groundwater Levels

Kings IGSM Model Development and Calibration

July 2007

Figure 5-42



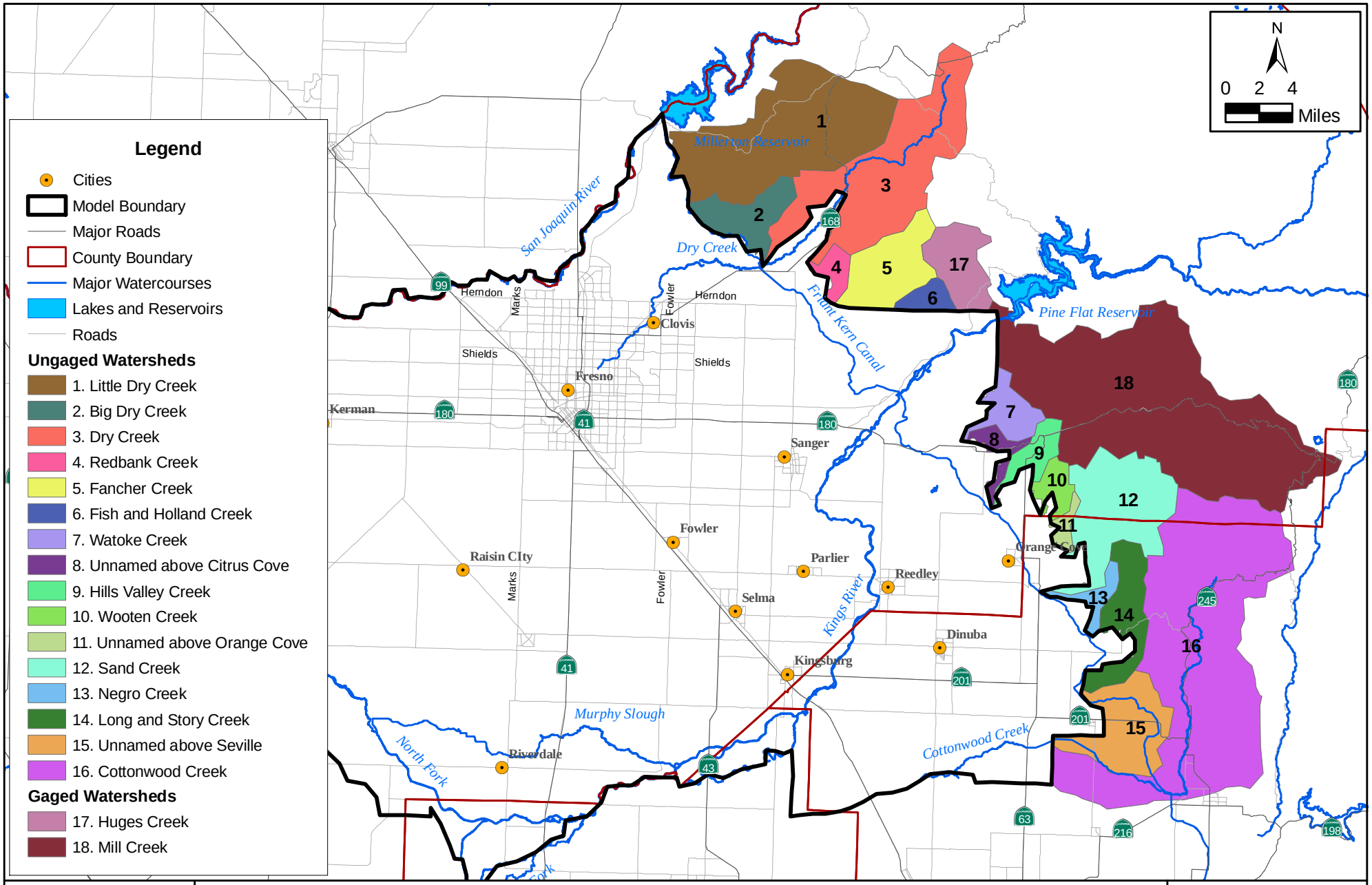
WRIME

General Head Boundary Nodes

Kings IGSM Model Development and Calibration

July 2007

Figure 5-43



Eastern Boundary Small Watersheds

Kings IGSM Model Development and Calibration

July 2007

Figure 5-44

Table 5-2. Streamflow Rating Tables

Cross Section	Reach Type	Depth (ft)	Wetted Perimeter (ft)	Discharge (cfs)
1	Small Canal	0	0	0
		1	27	10.8
		1.4	29.1	21.7
		2.4	33.6	54.2
		3.4	37.9	108.5
		5.1	46.4	216.9
2	Medium Canal	0	0	0
		1.5	31.9	25.2
		2.1	35.6	50.5
		3.3	43.1	126.2
		4.7	50.4	252.4
		6.7	60.5	504.7
3	Major Canal	0	0	0
		2.2	56.2	50
		2.9	61.4	100
		4.2	72.4	250
		5.7	82.4	500
		7.8	95.7	1,000
4	Small Creek	0	0	0
		1.2	27	10.8
		1.8	29.1	21.7
		2.9	33.6	54.2
		4.1	37.9	108.5
		5.1	46.4	216.9
5	Medium Creek	0	0	0
		2.4	28.4	26.1
		3.2	32.1	50.5
		5	39.8	129.8
		6.9	48.1	257
		9.6	8260	523.1
6	Major Creek	0	0	0
		1.7	57.4	110.4
		2.5	61.4	220.8
		4	69.8	551.9
		5.7	79.5	1,103
		9.3	5830	2,350
7	Upper Kings	0	0	0
		2.5	136.2	625
		3.5	170.5	1,250
		5.3	196.8	3,125
		7.1	221	6,250
		9.9	241.6	12,500
8	Lower Kings	0	0	0
		5	189.4	625
		6.4	218.3	1,250
		10	298.4	3,125
		14.6	310.3	6,250
		19.5	323	12,500

Table 5-3. Stream Reach Types and Hydraulic Parameters

Reach	Name	Reach Type	Streambed Hydraulic Conductivity (ft/day)	Streambed Thickness (ft)
1	Kings River Pine Flat to Alta Weir	7	1	5
2	76 Channel	3	0.5	1
3	Alta Canal	3	0.5	1
4	Upper Watoke Creek	2	0.5	1
5	Alta Canal Below Watoke Creek	3	0.5	1
7	Alta East Branch	2	0.5	1
8	Wooten Creek	4	0.5	1
6	Alta East Branch Below Wooten Creek	2	0.5	1
9	Upper Sand Creek	5	0.5	1
10	Alta East Branch Below Sand Creek	1	0.5	1
11	Lower Sand Creek	4	0.5	1
12	Cottonwood Creek	6	0.5	1
13	Cottonwood Creek Below Sand Creek	6	0.5	1
14	Kings River Alta Weir to Gould Weir	7	1	5
15	Holland Creek	4	0.5	1
16	Gould Canal off Gould Weir	3	0.5	1
17	Enterprise Canal	2	0.5	1
18	Fancher Creek above Enterprise	2	0.5	1
19	Enterprise Canal Below Fancher Creek	2	0.5	1
20	Redbank Creek above Enterprise	4	0.5	1
21	Enterprise Canal Below Redbank Creek	2	0.5	1
22	Dry Creek above Enterprise	6	0.5	1
23	Enterprise Canal Below Dry Creek	1	0.5	1
24	Gould Canal	3	0.5	1
25	Fancher Creek Between Enterprise and Gould	5	0.5	1
26	Gould Canal Below Fancher Creek	2	0.5	1
27	Redbank Creek Between Enterprise and Gould	4	0.5	1
28	Gould Canal Below Redbank Creek	2	0.5	1
29	Dry Creek between Enterprise and Gould	6	0.2	1
30	Gould Canal Below Dry Creek	2	0.2	1
31	Gould Extension (Dry Creek)	6	0.2	1
32	Kings River Gould Weir to Fresno Weir	7	1	5
33	Fresno Canal	3	0.5	1
34	Lone Tree Canal	2	0.5	1
35	Fresno Canal Lone Tree to Fancher Upstream	3	0.5	1
36	Fancher Creek Between Gould and Fresno	5	0.5	1
37	Fresno Canal Fancher Upstream to Fancher Downstream	2	0.5	1
38	Fresno Canal Below Fancher Creek	2	0.5	1
39	Redbank Creek between Gould and Fresno	4	0.5	1
40	Mill Canal	2	0.5	1

Reach	Name	Reach Type	Streambed Hydraulic Conductivity (ft/day)	Streambed Thickness (ft)
41	Herdon Canal between Gould Extension and Mill	6	0.2	1
42	Herdon Canal Between Gould and Dry	2	0.2	1
43	Lower Dry Creek Below Mill Canal	6	0.2	1
44	Lower Dry Creek in Westside	6	0.5	1
45	Lower Dry Creek in FID West	6	0.5	1
46	Lower Dry Creek in Eastside	6	0.5	1
47	Fancher Creek below Fresno Canal	5	0.5	1
48	Central Canal	2	0.5	1
49	Central Wasteway	2	0.5	1
50	Mc Mulin Grade above Dry Creek Inflow	2	0.5	1
51	Mc Mulin Grade below Dry Creek Inflow	2	0.5	1
52	Herdon Canal Gould to Headgate	2	0.2	1
53	Herdon Canal in Westside below Headgate	1	0.5	1
54	Herdon Canal in FID West	1	0.5	1
55	Consolidated Canal	3	0	1
56	C&K Canal	2	0.5	1
57	Fowler Switch	2	0.5	1
58	Little Dry Creek	6	0.5	1
59	Kings River Fresno Weir to Watoke Creek	7	1	5
60	Lower Watoke Creek	5	0.5	1
61	Kings River Watoke Creek to Peoples Weir	8	1	1
62	Kings River Peoples Weir to Murphy Slough	8	1	1
63	Murphy Slough	3	0.5	1
64	Kings River Murphy Slough to Island Weir	8	1	1
65	South Fork Kings River	8	1	1
66	North Fork Island Weir to Crescent Weir	8	1	1
67	North Fork Crescent Weir to Stinson Weir	8	1	1
68	North Fork Stinson to James Bypass	8	1	1
69	James Bypass	8	1	1
70	James Bypass James Weir to Mc Mulin Grade	8	1	1
71	James Bypass Below Mc Mulin Grade	8	1	1
72	Mendota Pool	8	1	1
73	San Joaquin River - Foothills N	8	2	1
74	San Joaquin River - Sierra	8	2	1
75	San Joaquin River - Pinedale	8	2	1
76	San Joaquin River - Westside	8	2	1
77	San Joaquin River - FIDW	8	2	1
78	San Joaquin River – Mendota	8	2	1

Table 5-9. 1964 Land Use Acreage by Model Subregion

Sub-region	Kings Basin	Name	Grain	Rice	Field	Alfalfa	Pasture	Truck	Deci-duous	Citrus	Vine-yards	Semi ag	Total Ag	Urban	Native/ Idle	Riparian	Total
6	Upper	FID West	1,192	0	33,365	3,310	15,733	1,530	3,917	125	44,727	1,220	105,121	1,429	4,995	422	111,967
7	Upper	Fresno - Westside	685	0	3,211	3,546	707	1,051	7,337	49	2,852	986	20,427	14,001	9,824	146	44,398
8	Upper	Fresno - Fluoride	6	0	18	67	0	0	702	0	0	11	807	1,761	500	0	3,069
9	Upper	Fresno - Sierra_B	77	0	0	105	0	0	353	0	11	0	547	834	620	34	2,036
10	Upper	Fresno - Shepherd	1,077	0	179	724	24	0	471	39	529	212	3,257	137	1,806	0	5,202
11	Upper	Fresno - Sierra_A	616	0	109	1,953	107	0	955	0	100	181	4,025	492	1,435	276	6,229
12	Upper	Fresno - Highway 41B	430	0	1,367	865	896	152	1,784	118	2,746	568	8,927	13,623	5,318	0	27,868
13	Upper	Fresno - Highway 41C	87	0	60	31	99	0	96	0	0	19	394	849	407	0	1,651
14	Upper	Fresno - Highway 41A	158	0	288	102	96	0	91	8	160	56	962	184	165	0	1,312
15	Upper	City of Clovis	1,074	0	778	4,893	565	66	4,726	543	953	103	13,701	2,510	4,109	0	20,322
16	Upper	FID East	1,549	0	2,125	5,820	1,249	250	5,914	3,190	13,752	499	34,350	1,160	12,656	0	48,167
26	Upper	CID West	107	0	10,148	1,715	5,532	747	7,442	44	51,241	986	77,964	1,061	7,890	44	86,961
27	Upper	CID East	124	0	1,290	1,178	172	368	13,014	348	44,770	635	61,901	4,405	9,508	385	76,200
28	Upper	Kings River W.D.	131	0	617	3,304	122	650	2,012	16	2,900	52	9,808	24	4,685	156	14,675
29	Upper	AID West	4,199	0	15,203	10,227	3,762	897	4,768	235	13,108	1,143	53,543	596	12,993	290	67,424
30	Upper	AID East	1,529	0	5,602	1,745	97	835	3,011	2,736	7,187	617	23,363	1,788	7,575	0	32,728
31	Upper	AID North	476	0	1,610	1,234	2,220	587	7,263	1,762	10,197	302	25,653	1,518	7,247	313	34,732
Upper Kings Basin Subtotal			**13,517**	**0**	**75,970**	**40,819**	**31,381**	**7,133**	**63,856**	**9,213**	**195,233**	**7,590**	**444,750**	**46,372**	**91,733**	**2,066**	**584,941**
1	Lower	Mendota Pool Area	2,380	0	5,002	2,255	4,115	20	458	0	596	216	15,045	100	11,605	6,488	33,238
2	Lower	Tranquility I.D.	2,602	1,394	4,893	31	151	0	0	0	0	53	9,125	160	1,126	19	10,431
3	Lower	James I.D.	7,842	1,172	12,861	0	2,166	10	47	0	0	99	24,199	266	3,322	407	28,195

Sub-region	Kings Basin	Name	Grain	Rice	Field	Alfalfa	Pasture	Truck	Deci-duous	Citrus	Vine-yards	Semi ag	Total Ag	Urban	Native/ Idle	Riparian	Total
4	Lower	Mid-Valley W.D.	129	0	1,919	1,923	1,372	0	0	0	685	37	6,067	0	7,415	0	13,483
5	Lower	East Side Well Field	569	0	8,574	2,996	10,033	12	184	0	3,178	619	26,167	104	17,809	110	44,192
18	Lower	Crescent Canal Serv. Area	9,922	0	7,772	0	2,395	400	6	0	0	40	20,539	164	2,437	89	23,230
19	Lower	Stinson W.D.	6,583	0	3,678	0	506	0	0	0	0	0	10,769	127	1,132	126	12,155
20	Lower	Murphy Slough	2,954	0	7,093	762	5,488	296	0	0	2,402	195	19,192	48	11,353	275	30,869
21	Lower	Raisin City W.D.	1,407	0	11,807	1,551	11,877	444	178	0	4,693	598	32,558	213	16,728	0	49,501
22	Lower	Riverdale I.D.	5,206	0	3,928	1,130	2,161	0	155	0	0	167	12,748	379	2,763	74	15,965
23	Lower	Laguna I.D.	1,965	0	11,414	4,288	6,944	293	999	0	48	1,102	27,057	479	10,840	251	38,628
24	Lower	Liberty W.D.	1,042	0	4,676	1,011	4,610	232	426	0	1,070	290	13,357	27	8,112	0	21,498
25	Lower	East of Liberty W.D.	200	0	3,536	1,238	2,564	101	821	0	1,293	215	9,972	26	3,874	0	13,874
Lower Kings Basin Subtotal			**42,801**	**2,566**	**87,153**	**17,185**	**54,382**	**1,808**	**3,274**	**0**	**13,965**	**3,631**	**226,795**	**2,093**	**98,516**	**7,839**	**335,259**
17	Foothills	Foothills North	2,177	0	1,271	2,613	420	37	2,175	1,451	836	359	11,342	279	47,374	409	59,405
32	Foothills	Foothills South	619	0	3,207	753	238	1,064	1,943	14,764	2,134	547	25,273	757	36,030	13	62,074
Foothills Subtotal			**2,796**	**0**	**4,478**	**3,366**	**658**	**1,101**	**4,118**	**16,215**	**2,970**	**906**	**36,615**	**1,036**	**83,404**	**422**	**121,479**
Total			**59,114**	**2,566**	**167,601**	**61,370**	**86,421**	**10,042**	**71,248**	**25,428**	**212,168**	**12,127**	**708,160**	**49,501**	**273,653**	**10,327**	**1,041,679**

Table 5-10. 2004 Land Use Acreage by Model Subregion

Sub-region	Kings Basin	Name	Grain	Rice	Field	Alfalfa	Pasture	Truck	Deci-duous	Citrus	Vine-yards	Semi ag	Total Ag	Urban	Native/ Idle	Riparian	Total
6	Upper	FID West	249	0	9,787	903	6,515	2,404	15,430	497	63,528	3,076	102,388	6,634	2,522	422	111,967
7	Upper	Fresno - Westside	56	0	1,268	544	73	2,251	3,098	37	1,767	138	9,232	32,424	2,596	146	44,398
8	Upper	Fresno - Fluoride	0	0	0	0	0	0	9	0	0	0	9	3,024	36	0	3,069
9	Upper	Fresno - Sierra_B	0	0	0	0	0	0	17	0	0	0	17	1,851	133	34	2,035
10	Upper	Fresno - Shepherd	0	0	42	0	0	84	315	141	451	14	1,047	3,363	792	0	5,202
11	Upper	Fresno - Sierra_A	0	0	23	149	0	0	140	0	4	10	327	4,960	666	276	6,228
12	Upper	Fresno - Highway 41B	73	0	1,236	221	160	1,154	774	268	899	140	4,926	21,958	984	0	27,867
13	Upper	Fresno - Highway 41C	0	0	0	0	0	132	50	0	0	2	197	1,466	0	0	1,651
14	Upper	Fresno - Highway 41A	77	0	225	160	78	30	113	9	212	0	904	392	16	0	1,312
15	Upper	City of Clovis	22	0	646	644	91	681	2,874	763	280	272	6,275	12,164	1,883	0	20,320
16	Upper	FID East	249	14	3,763	2,568	90	1,854	5,129	9,083	10,579	569	33,898	6,168	8,101	0	48,167
26	Upper	CID West	123	0	2,985	436	1,069	878	12,933	358	58,871	2,683	80,338	3,599	2,981	44	86,960
27	Upper	CID East	0	0	4,329	235	88	515	21,884	1,543	34,826	991	64,410	9,579	1,825	385	76,200
28	Upper	Kings River W.D.	0	0	1,667	2,241	66	88	4,769	196	1,427	148	10,601	306	3,611	156	14,675
29	Upper	AID West	4,189	0	8,165	978	4,560	837	25,909	1,392	11,715	2,733	60,477	2,737	3,919	290	67,424
30	Upper	AID East	1,000	0	2,752	605	817	354	9,374	6,656	4,187	1,071	26,816	3,273	2,639	0	32,728
31	Upper	AID North	30	0	1,160	1,241	59	297	14,771	4,053	3,882	777	26,272	3,907	4,242	313	34,732
Upper Kings Basin Subtotal			**6,068**	**14**	**38,048**	**10,925**	**13,666**	**11,559**	**117,589**	**24,996**	**192,628**	**12,624**	**428,134**	**117,805**	**36,946**	**2,066**	**584,935**
1	Lower	Mendota Pool Area	206	0	2,936	993	4,550	0	3,686	0	4,674	326	17,371	651	8,728	6,488	33,238
2	Lower	Tranquility I.D.	46	0	6,836	0	2,395	519	59	0	0	139	10,070	408	0	19	10,431
3	Lower	James I.D.	251	0	14,584	19	7,905	2,301	852	0	424	323	26,660	588	541	407	28,195

Sub-region	Kings Basin	Name	Grain	Rice	Field	Alfalfa	Pasture	Truck	Deci-duous	Citrus	Vine-yards	Semi ag	Total Ag	Urban	Native/ Idle	Riparian	Total
4	Lower	Mid-Valley W.D.	644	0	3,662	27	2,939	0	1,416	15	3,327	240	12,270	123	1,090	0	13,483
5	Lower	East Side Well Field	890	0	8,082	45	6,544	641	6,693	21	14,666	1,072	38,655	1,822	3,605	110	44,191
18	Lower	Crescent Canal Serv. Area	5,878	0	13,901	4	1,583	718	0	0	0	58	22,141	219	780	89	23,230
19	Lower	Stinson W.D.	3,146	0	4,281	0	2,546	92	21	0	0	5	10,091	356	319	1,389	12,155
20	Lower	Murphy Slough	917	0	6,832	117	5,725	303	5,115	0	10,003	932	29,944	204	445	275	30,868
21	Lower	Raisin City W.D.	418	0	5,963	15	6,102	638	10,341	0	23,588	1,260	48,324	514	662	0	49,501
22	Lower	Riverdale I.D.	1,398	0	7,600	434	3,424	0	259	10	330	944	14,399	707	785	74	15,965
23	Lower	Laguna I.D.	1,239	0	14,911	1,401	6,290	320	6,945	11	1,190	2,147	34,453	1,221	2,702	251	38,628
24	Lower	Liberty W.D.	74	0	1,158	9	1,084	110	8,549	6	9,005	657	20,651	278	568	0	21,498
25	Lower	East of Liberty W.D.	0	0	2,221	61	1,940	70	4,874	42	4,050	435	13,692	121	60	0	13,874
Lower Kings Basin Subtotal			**15,107**	**0**	**92,967**	**3,125**	**53,027**	**5,712**	**48,810**	**105**	**71,257**	**8,538**	**298,721**	**7,212**	**20,285**	**9,102**	**335,257**
17	Foothills	Foothills North	168	0	529	460	24	398	1,413	4,090	368	202	7,651	8,384	42,960	409	59,405
32	Foothills	Foothills South	233	0	927	621	77	119	2,999	27,021	2,827	663	35,487	1,431	25,143	13	62,074
Foothills Subtotal			**401**	**0**	**1,456**	**1,081**	**101**	**517**	**4,412**	**31,111**	**3,195**	**865**	**43,138**	**9,815**	**68,103**	**422**	**121,479**
Total			**21,576**	**14**	**132,471**	**15,131**	**66,794**	**17,788**	**170,811**	**56,212**	**267,080**	**22,027**	**769,993**	**134,832**	**125,334**	**11,590**	**1,041,671**

Table 5-11. Annual Surface Water Delivery (TAF/Year)

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1964	107	127	235	30	21	287	51	572	0	145	145	717
1965	204	291	379	41	21	442	50	987	0	225	225	1,211
1966	96	224	277	74	21	372	53	745	0	169	169	914
1967	239	477	357	92	31	480	46	1,242	0	279	279	1,521
1968	80	182	294	69	21	385	51	698	0	151	151	849
1969	219	482	365	43	25	433	39	1,174	0	288	288	1,462
1970	144	315	340	92	27	459	46	964	0	194	194	1,158
1971	117	150	353	44	31	428	47	743	0	147	147	890
1972	74	110	221	64	21	307	52	542	0	103	103	645
1973	177	428	348	93	28	469	43	1,117	0	246	246	1,364
1974	175	399	343	82	27	452	44	1,070	0	264	264	1,333
1975	156	214	393	43	26	462	47	879	0	205	205	1,084
1976	37	13	179	21	14	214	43	307	0	116	116	423
1977	33	16	148	18	12	178	41	267	0	51	51	318
1978	185	486	307	80	29	415	39	1,125	0	269	269	1,394
1979	179	431	410	60	34	503	45	1,159	0	277	277	1,436
1980	215	481	318	90	30	438	43	1,177	0	339	339	1,516
1981	124	175	354	48	27	430	45	773	0	200	200	973
1982	196	361	376	44	26	446	42	1,046	0	317	317	1,363
1983	189	457	324	60	27	411	34	1,091	0	316	316	1,407
1984	185	345	378	110	32	520	40	1,090	0	296	296	1,386
1985	145	175	384	101	28	513	38	872	0	179	179	1,051
1986	194	355	336	101	28	464	38	1,051	0	356	356	1,406
1987	103	144	254	74	19	347	37	631	0	153	153	784

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1988	50	70	293	37	19	349	36	506	0	99	99	605
1989	76	115	275	73	21	369	41	601	0	116	116	717
1990	49	54	211	38	14	262	36	402	0	62	62	464
1991	91	244	281	48	30	359	33	728	0	98	98	826
1992	57	136	249	54	15	317	37	546	0	53	53	600
1993	210	311	377	89	25	491	41	1,052	0	283	283	1,335
1994	105	150	316	39	23	378	38	671	0	108	108	779
1995	200	396	360	39	23	422	33	1,051	0	333	333	1,384
1996	188	407	452	53	30	535	43	1,174	0	332	332	1,507
1997	182	357	406	46	29	482	44	1,065	0	324	324	1,389
1998	146	377	313	34	21	367	34	925	0	281	281	1,206
1999	132	244	409	46	25	480	40	895	0	210	210	1,105
2000	141	237	357	41	24	423	43	844	0	184	184	1,028
2001	106	114	262	31	21	315	41	577	0	132	132	709
2002	113	143	360	38	20	418	48	722	0	132	132	854
2003	117	149	352	37	19	408	48	721	0	146	146	867
2004	109	136	320	37	21	378	49	672	0	107	107	779
Long-term Average (64-04)	**138**	**256**	**324**	**57**	**24**	**405**	**42**	**841**	**0**	**202**	**202**	**1,043**
Recent 10-yr (95-04)	**144**	**256**	**359**	**40**	**23**	**423**	**42**	**865**	**0**	**218**	**218**	**1,083**
Extended Dry Period (87-92)	**71**	**127**	**260**	**54**	**20**	**334**	**37**	**569**	**0**	**97**	**97**	**666**
Short Dry Period (76-77)	**35**	**15**	**163**	**20**	**13**	**196**	**42**	**287**	**0**	**84**	**84**	**371**
Extended Wet Period (95-98)	**179**	**384**	**383**	**43**	**26**	**452**	**39**	**1,054**	**0**	**318**	**318**	**1,371**
Short Wet Period (82-83)	**193**	**409**	**350**	**52**	**27**	**429**	**38**	**1,069**	**0**	**316**	**316**	**1,385**

Table 5-12. Annual Estimated Agricultural Water Demand (TAF/Year)

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1964	332	441	458	142	56	656	38	1,467	103	588	692	2,159
1965	315	439	429	126	51	606	37	1,396	102	563	665	2,061
1966	352	473	466	141	58	665	41	1,532	111	592	703	2,235
1967	297	424	408	115	46	570	35	1,325	105	549	654	1,979
1968	342	467	442	134	54	629	39	1,477	113	613	726	2,203
1969	329	455	428	124	50	602	37	1,423	108	565	673	2,097
1970	349	480	451	132	54	637	39	1,505	120	622	742	2,247
1971	332	444	426	127	52	605	37	1,418	122	630	752	2,170
1972	367	485	452	138	55	645	40	1,536	138	728	865	2,402
1973	352	488	450	126	51	628	39	1,506	126	643	769	2,275
1974	345	477	439	119	48	607	37	1,466	127	644	770	2,236
1975	343	472	435	120	47	601	37	1,454	126	657	783	2,237
1976	327	438	414	113	47	574	36	1,375	115	630	744	2,120
1977	372	468	434	119	49	602	40	1,482	136	700	835	2,317
1978	311	420	387	99	42	528	35	1,294	116	593	709	2,002
1979	362	473	439	110	47	596	40	1,472	135	682	816	2,289
1980	350	462	435	105	46	585	40	1,437	133	672	804	2,241
1981	357	462	429	102	44	575	42	1,436	127	670	797	2,233
1982	324	429	410	92	41	543	39	1,335	104	575	679	2,014
1983	252	345	388	83	36	507	31	1,135	123	631	755	1,890
1984	380	466	448	99	45	591	47	1,484	151	777	927	2,411
1985	367	467	433	90	40	563	46	1,443	140	742	881	2,324
1986	359	456	435	85	39	558	45	1,419	136	695	831	2,250
1987	363	450	436	84	38	558	46	1,417	140	750	891	2,307
1988	342	424	415	80	36	530	43	1,338	139	734	873	2,211

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1989	365	451	419	75	34	529	45	1,390	142	756	897	2,287
1990	360	435	411	73	33	518	45	1,358	143	752	895	2,253
1991	382	471	449	74	34	557	47	1,458	145	751	897	2,355
1992	359	456	441	69	31	542	44	1,401	146	747	893	2,295
1993	367	465	418	63	28	509	44	1,385	145	729	874	2,259
1994	332	404	412	62	28	502	42	1,279	133	685	818	2,097
1995	357	447	403	56	25	484	43	1,332	141	707	848	2,180
1996	415	496	424	59	26	510	48	1,468	148	769	917	2,386
1997	391	485	453	61	27	542	46	1,463	151	757	908	2,371
1998	344	440	378	49	21	448	41	1,273	126	633	759	2,032
1999	381	467	435	57	24	516	44	1,409	151	760	910	2,319
2000	362	461	415	51	22	488	42	1,352	147	727	874	2,226
2001	388	471	415	51	21	487	43	1,388	149	722	871	2,259
2002	382	480	436	54	23	513	44	1,419	155	778	933	2,352
2003	360	447	397	49	21	467	42	1,316	146	722	867	2,183
2004	394	486	443	55	23	522	45	1,447	159	798	958	2,404
Long-term Average (64-04)	**353**	**455**	**428**	**92**	**39**	**558**	**41**	**1,408**	**132**	**684**	**816**	**2,224**
Recent 10-yr (95-04)	**377**	**468**	**420**	**54**	**23**	**498**	**44**	**1,387**	**147**	**737**	**885**	**2,271**
Extended Dry Period (87-92)	**362**	**448**	**428**	**76**	**35**	**539**	**45**	**1,394**	**142**	**749**	**891**	**2,285**
Short Dry Period (76-77)	**350**	**453**	**424**	**116**	**48**	**588**	**38**	**1,429**	**125**	**665**	**790**	**2,219**
Extended Wet Period (95-98)	**377**	**467**	**415**	**57**	**25**	**496**	**44**	**1,384**	**142**	**717**	**858**	**2,242**
Short Wet Period (82-83)	**288**	**387**	**399**	**88**	**38**	**525**	**35**	**1,235**	**114**	**603**	**717**	**1,952**

Table 5-13. Annual Estimated Agricultural Groundwater Pumping (TAF/Year)

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1964	236	288	303	84	0	387	2	913	139	604	743	1,656
1965	126	209	184	75	0	260	1	596	138	500	638	1,233
1966	256	290	289	78	0	367	2	915	150	591	741	1,656
1967	78	89	162	60	0	222	2	390	141	428	569	959
1968	261	315	288	77	0	365	2	943	152	664	816	1,759
1969	112	117	142	76	0	218	4	452	145	419	565	1,016
1970	221	268	242	74	0	316	3	808	162	611	773	1,581
1971	214	280	196	80	0	275	2	771	164	647	811	1,583
1972	291	356	304	86	0	390	2	1,039	185	825	1,010	2,049
1973	175	186	184	74	0	258	2	621	170	549	718	1,339
1974	170	170	201	88	7	295	2	636	170	551	722	1,358
1975	187	251	163	119	6	289	2	729	170	641	810	1,539
1976	345	322	263	128	9	400	4	1,071	154	690	844	1,916
1977	394	342	310	137	10	456	7	1,199	183	847	1,030	2,229
1978	135	111	162	73	5	240	5	491	156	476	631	1,123
1979	201	213	167	107	5	279	3	696	181	603	785	1,480
1980	164	129	201	77	5	283	5	580	178	544	722	1,302
1981	244	257	196	112	6	314	5	820	170	643	813	1,633
1982	142	143	128	108	4	241	5	531	140	445	585	1,116
1983	95	105	149	99	4	251	5	456	166	523	689	1,145
1984	195	197	192	81	16	289	13	693	202	724	926	1,619
1985	232	263	183	77	17	277	11	783	188	763	951	1,734
1986	170	190	239	67	13	320	12	691	183	550	733	1,424
1987	271	297	264	81	23	368	14	950	189	810	999	1,949
1988	346	268	244	98	43	385	14	1,013	186	860	1,046	2,059

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1989	298	301	254	84	35	372	11	982	190	861	1,052	2,034
1990	362	288	274	95	34	403	14	1,067	192	924	1,116	2,183
1991	338	213	241	89	11	341	17	909	195	873	1,068	1,977
1992	350	251	256	81	30	366	13	980	197	924	1,120	2,100
1993	159	192	126	58	7	191	9	551	195	637	832	1,383
1994	268	226	204	92	18	314	9	817	179	789	968	1,785
1995	158	142	140	80	12	232	12	544	190	558	748	1,292
1996	225	201	131	89	6	226	9	660	199	654	854	1,514
1997	211	225	161	86	7	254	8	698	203	693	895	1,594
1998	198	139	131	73	8	211	10	558	169	530	699	1,257
1999	249	263	154	83	8	245	11	768	203	768	971	1,738
2000	219	224	156	84	5	245	8	696	197	730	927	1,623
2001	290	321	222	83	6	311	6	929	201	784	985	1,914
2002	275	304	189	82	12	283	5	867	208	848	1,056	1,923
2003	237	284	121	75	9	204	5	730	196	780	976	1,705
2004	274	330	219	84	6	309	4	918	214	917	1,132	2,049
Long-term Average (64-04)	**229**	**233**	**203**	**86**	**9**	**299**	**7**	**767**	**178**	**678**	**855**	**1,623**
Recent 10-yr (95-04)	**234**	**243**	**162**	**82**	**8**	**252**	**8**	**737**	**198**	**726**	**924**	**1,661**
Extended Dry Period (87-92)	**328**	**270**	**256**	**88**	**29**	**373**	**14**	**983**	**192**	**876**	**1,067**	**2,050**
Short Dry Period (76-77)	**370**	**332**	**286**	**133**	**9**	**428**	**6**	**1,135**	**168**	**769**	**937**	**2,073**
Extended Wet Period (95-98)	**198**	**177**	**141**	**82**	**8**	**231**	**10**	**615**	**190**	**609**	**799**	**1,414**
Short Wet Period (82-83)	**119**	**124**	**138**	**103**	**4**	**246**	**5**	**493**	**153**	**484**	**637**	**1,131**

Table 5-14. Annual Estimated Agricultural Water Use (TAF/Year)

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1964	342	416	538	115	21	674	53	1,485	139	749	888	2,373
1965	329	501	563	117	21	701	51	1,582	138	724	862	2,444
1966	352	514	566	152	21	740	54	1,660	150	761	910	2,570
1967	317	565	518	152	31	702	48	1,632	141	708	849	2,481
1968	341	497	582	147	21	750	52	1,641	152	815	967	2,607
1969	331	599	508	119	25	651	44	1,626	145	707	853	2,478
1970	365	583	582	166	27	775	49	1,772	162	805	966	2,739
1971	331	430	549	124	31	704	49	1,514	164	795	959	2,473
1972	365	466	526	150	21	697	54	1,582	185	928	1,113	2,694
1973	352	614	532	167	28	727	45	1,738	170	795	965	2,703
1974	344	569	544	170	33	747	45	1,706	170	815	985	2,691
1975	343	465	556	162	32	751	49	1,608	170	846	1,015	2,623
1976	381	335	442	149	24	614	47	1,378	154	806	961	2,339
1977	427	358	458	155	22	635	47	1,467	183	898	1,081	2,548
1978	320	598	469	153	33	655	43	1,617	156	745	901	2,517
1979	380	645	577	167	38	782	48	1,854	181	881	1,062	2,917
1980	379	609	519	167	35	720	47	1,756	178	883	1,061	2,818
1981	367	432	550	161	32	743	50	1,593	170	843	1,013	2,606
1982	339	504	504	152	30	687	48	1,577	140	762	902	2,479
1983	285	562	473	158	31	662	38	1,547	166	839	1,005	2,552
1984	380	541	570	191	48	809	52	1,783	202	1,020	1,223	3,006
1985	377	438	568	178	45	790	50	1,655	188	943	1,130	2,785
1986	363	545	575	168	41	784	50	1,742	183	906	1,088	2,830
1987	374	441	518	154	42	715	51	1,580	189	963	1,152	2,733
1988	396	338	538	135	62	735	50	1,519	186	959	1,146	2,664
1989	375	416	529	156	56	741	52	1,583	190	977	1,167	2,751

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1990	412	342	485	133	48	666	50	1,469	192	986	1,178	2,648
1991	429	458	522	137	41	700	50	1,637	195	971	1,166	2,803
1992	407	387	505	134	44	683	49	1,526	197	977	1,174	2,700
1993	368	503	503	146	32	682	49	1,603	195	920	1,115	2,718
1994	373	376	520	131	42	692	46	1,488	179	897	1,076	2,564
1995	358	538	499	120	35	654	45	1,595	190	891	1,081	2,676
1996	413	608	583	142	36	761	52	1,835	199	987	1,186	3,021
1997	393	582	567	133	36	735	52	1,763	203	1,016	1,219	2,982
1998	344	516	444	107	28	579	45	1,484	169	811	980	2,464
1999	381	507	562	129	34	725	51	1,663	203	978	1,180	2,844
2000	361	461	513	126	29	668	50	1,540	197	914	1,111	2,651
2001	396	436	485	115	27	626	48	1,505	201	916	1,117	2,622
2002	388	447	550	120	32	702	53	1,589	208	980	1,188	2,777
2003	354	433	472	111	28	612	52	1,451	196	926	1,121	2,572
2004	383	466	539	121	28	688	52	1,589	214	1,025	1,239	2,828
Long-term Average (64-04)	**366**	**489**	**527**	**144**	**33**	**704**	**49**	**1,608**	**178**	**880**	**1,057**	**2,666**
Recent 10-yr (95-04)	**377**	**499**	**521**	**122**	**31**	**675**	**50**	**1,601**	**198**	**944**	**1,142**	**2,744**
Extended Dry Period (87-92)	**399**	**397**	**516**	**142**	**49**	**706**	**50**	**1,553**	**192**	**972**	**1,164**	**2,716**
Short Dry Period (76-77)	**404**	**347**	**450**	**152**	**23**	**625**	**47**	**1,423**	**168**	**852**	**1,021**	**2,443**
Extended Wet Period (95-98)	**377**	**561**	**523**	**125**	**34**	**682**	**48**	**1,669**	**190**	**926**	**1,116**	**2,786**
Short Wet Period (82-83)	**312**	**533**	**488**	**155**	**31**	**674**	**43**	**1,562**	**153**	**800**	**953**	**2,515**

Table 5-16. Annual Estimated Urban Water Use (TAF/Year)

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1964	6	6	2	78	3	83	1	95	0	1	1	96
1965	6	6	2	79	3	85	1	98	0	1	1	99
1966	6	6	2	86	3	91	1	104	0	1	1	105
1967	6	6	2	85	3	90	1	104	0	1	1	105
1968	6	7	2	85	4	91	1	105	0	1	1	106
1969	6	7	2	87	4	93	1	107	0	1	1	109
1970	7	7	2	89	4	96	1	110	0	1	1	111
1971	7	7	3	91	4	98	1	113	0	1	1	114
1972	7	7	3	94	4	101	1	116	0	1	1	117
1973	7	8	3	96	4	103	1	119	0	1	1	120
1974	8	8	3	100	5	108	1	125	0	1	1	126
1975	8	8	3	100	5	108	1	125	0	1	1	126
1976	8	8	3	100	6	109	1	127	0	1	1	128
1977	8	9	3	92	5	100	1	119	0	1	1	120
1978	8	9	3	96	6	105	1	124	0	1	1	125
1979	9	9	3	105	7	116	1	135	0	1	1	136
1980	9	10	3	110	8	122	2	143	0	1	1	145
1981	10	11	3	113	9	125	2	147	0	1	1	148
1982	10	10	3	114	10	127	2	149	0	1	1	150
1983	10	11	3	105	11	119	2	142	0	1	1	143
1984	11	13	3	125	12	140	2	165	0	1	1	166
1985	11	13	3	127	13	143	2	168	0	1	1	169
1986	11	13	3	131	12	146	2	172	0	1	1	173
1987	11	14	3	138	13	154	2	181	0	1	1	182
1988	12	14	4	141	13	158	2	185	0	1	1	187

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1989	12	14	4	140	13	157	2	184	0	1	1	186
1990	12	14	4	133	13	150	2	178	0	1	2	180
1991	12	13	4	142	14	160	2	187	0	2	2	188
1992	13	15	4	142	15	162	2	191	0	2	2	193
1993	13	15	4	141	15	161	2	191	0	2	2	192
1994	13	16	4	154	17	176	2	206	0	2	2	208
1995	13	16	4	152	16	172	2	203	0	2	2	204
1996	14	17	4	166	18	188	2	222	0	2	2	224
1997	15	17	4	174	19	198	2	232	0	2	2	234
1998	13	16	4	159	17	180	2	212	0	2	2	214
1999	15	18	4	174	19	197	2	233	0	2	2	234
2000	16	19	5	186	20	212	2	248	0	2	2	250
2001	16	18	5	189	20	215	2	250	0	2	2	252
2002	16	19	5	190	21	217	2	255	0	2	2	257
2003	24	19	5	190	23	218	2	263	0	2	2	265
2004	16	18	5	192	26	223	2	259	0	2	2	261
Long-term Average (64-04)	**11**	**12**	**3**	**127**	**11**	**141**	**2**	**166**	**0**	**1**	**1**	**167**
Recent 10-yr (95-04)	**16**	**18**	**5**	**177**	**20**	**202**	**2**	**238**	**0**	**2**	**2**	**240**
Extended Dry Period (87-92)	**12**	**14**	**4**	**140**	**13**	**157**	**2**	**184**	**0**	**1**	**2**	**186**
Short Dry Period (76-77)	**8**	**9**	**3**	**96**	**6**	**105**	**1**	**123**	**0**	**1**	**1**	**124**
Extended Wet Period (95-98)	**14**	**17**	**4**	**163**	**17**	**185**	**2**	**217**	**0**	**2**	**2**	**219**
Short Wet Period (82-83)	**10**	**11**	**3**	**110**	**10**	**123**	**2**	**145**	**0**	**1**	**1**	**147**

Table 5-17. Annual Urban Water Use by Model Subregions for Fresno SOI and Clovis SOI (TAF/Year)

Year	F-West	Flouride	Shepherd	Sierra	Highway 41	Pinedale	Bakman	CSUF	Clovis SOI	Fresno	Fresno SOI	Fresno & Clovis SOI
	1	2	3	4	5	6	7	8	9	1-5	1-8	1-9
1964	32	2	1	4	6	29	1	3	3	45	78	80
1965	33	2	1	4	6	30	1	3	3	45	79	82
1966	35	3	1	4	6	32	1	3	3	49	86	89
1967	35	3	1	4	6	32	2	3	3	48	85	88
1968	35	2	1	4	6	32	2	4	4	48	85	89
1969	36	3	1	4	6	32	2	4	4	49	87	91
1970	37	3	1	4	6	33	2	4	4	51	89	93
1971	37	3	1	4	7	34	2	4	4	52	91	96
1972	38	3	1	4	7	34	2	4	4	53	94	98
1973	39	3	1	4	7	35	2	4	4	54	96	100
1974	41	3	1	5	7	37	2	5	5	57	100	105
1975	41	3	1	4	7	37	2	5	5	56	100	105
1976	41	3	1	4	7	37	2	5	6	56	100	106
1977	37	3	1	4	6	33	3	5	5	51	92	97
1978	39	3	1	4	7	35	3	5	6	53	96	102
1979	43	3	1	5	7	38	3	5	7	59	105	113
1980	45	3	1	5	8	40	3	6	8	62	110	119
1981	45	3	2	5	8	41	3	6	9	63	113	122
1982	46	3	2	5	8	41	3	6	10	64	114	124
1983	42	3	2	5	7	38	3	6	11	59	105	116
1984	50	4	2	6	9	45	4	6	12	70	125	137
1985	51	4	2	6	9	46	4	6	13	71	127	139
1986	53	4	2	6	9	48	4	6	12	74	131	143
1987	56	4	2	6	10	50	4	6	13	78	138	151
1988	58	4	2	6	10	52	4	6	13	80	141	154
1989	58	4	2	6	10	51	4	6	13	80	140	153
1990	55	4	2	6	9	48	4	6	13	76	133	147
1991	59	4	2	6	10	52	4	6	14	81	142	156
1992	59	4	2	6	10	52	4	6	15	81	142	157
1993	59	4	2	6	10	51	4	6	15	81	141	157
1994	65	4	2	7	11	56	4	6	17	89	154	171
1995	63	4	2	7	11	55	4	6	16	87	152	168

	F-West	Flouride	Shepherd	Sierra	Highway 41	Pinedale	Bakman	CSUF	Clovis SOI	Fresno	Fresno SOI	Fresno & Clovis SOI
1996	69	5	2	7	12	61	4	6	18	95	166	184
1997	73	5	2	8	12	64	4	7	19	100	174	193
1998	66	5	2	7	11	58	4	7	17	91	159	176
1999	73	5	2	8	12	64	4	7	19	100	174	193
2000	78	5	2	9	13	69	4	7	20	107	186	206
2001	79	6	2	9	14	70	4	7	20	109	189	209
2002	80	6	2	9	14	70	4	7	21	109	190	211
2003	79	6	2	9	14	70	4	7	23	109	190	212
2004	80	6	2	9	14	71	4	7	26	111	192	218
Long-term Average (64-04)	**52**	**4**	**2**	**6**	**9**	**46**	**3**	**5**	**11**	**72**	**127**	**138**
Recent 10-yr (95-04)	**74**	**5**	**2**	**8**	**13**	**65**	**4**	**7**	**20**	**102**	**177**	**197**
Extended Dry Period (87-92)	**57**	**4**	**2**	**6**	**10**	**51**	**4**	**6**	**13**	**79**	**140**	**153**
Short Dry Period (76-77)	**39**	**3**	**1**	**4**	**7**	**35**	**3**	**5**	**6**	**54**	**96**	**102**
Extended Wet Period (95-98)	**68**	**5**	**2**	**7**	**12**	**59**	**4**	**6**	**17**	**93**	**163**	**180**
Short Wet Period (82-83)	**44**	**3**	**2**	**5**	**8**	**40**	**3**	**6**	**10**	**62**	**110**	**120**

Table 5-18. Annual Total Groundwater Pumping (TAF/Year)

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1964	241	294	305	162	3	470	3	1,008	139	605	744	1,752
1965	131	216	186	155	3	344	2	693	138	501	639	1,332
1966	262	297	291	164	3	458	3	1,020	150	592	742	1,762
1967	84	95	164	145	3	312	3	494	141	429	570	1,064
1968	267	322	290	162	4	456	3	1,048	152	665	817	1,865
1969	118	124	145	163	4	311	6	559	145	420	566	1,125
1970	227	275	244	164	4	412	4	918	162	612	774	1,692
1971	221	287	198	171	4	374	3	884	164	649	813	1,697
1972	298	363	307	180	4	491	3	1,155	185	826	1,011	2,166
1973	182	193	187	170	4	361	3	740	170	550	720	1,459
1974	177	178	204	188	12	403	3	761	170	553	723	1,483
1975	195	259	166	219	12	397	3	854	170	642	812	1,665
1976	353	331	265	229	15	509	6	1,198	154	691	846	2,044
1977	403	350	313	229	15	557	8	1,318	183	848	1,031	2,349
1978	144	120	165	169	11	345	6	615	156	477	633	1,248
1979	209	222	170	213	12	395	4	831	181	605	786	1,617
1980	173	139	204	187	13	405	6	723	178	545	723	1,446
1981	254	268	199	225	15	439	7	967	170	644	814	1,781
1982	152	154	131	222	14	368	7	680	140	446	586	1,266
1983	105	116	152	204	14	370	6	597	166	525	691	1,288
1984	206	209	196	206	28	429	14	858	202	725	928	1,785
1985	243	276	187	203	29	419	13	951	188	765	952	1,903
1986	181	203	242	199	25	466	14	863	183	551	734	1,598
1987	282	311	268	219	35	522	16	1,131	189	812	1,001	2,131
1988	357	282	248	239	56	543	16	1,198	186	861	1,048	2,246

Year	AID	CID	FID	Fresno SOI	Clovis SOI	FID Area (FID, Fresno SOI, Clovis SOI)	KRWD	Upper Kings Subtotal	RCWD	Other Lower Kings	Lower Kings Subtotal	Kings Basin
1989	310	315	257	224	48	529	13	1,166	190	863	1,053	2,219
1990	374	302	278	228	48	554	15	1,245	192	926	1,118	2,363
1991	350	227	245	231	25	501	19	1,096	195	875	1,070	2,166
1992	362	266	260	223	45	528	15	1,171	197	925	1,122	2,293
1993	171	207	131	199	22	352	11	742	195	639	834	1,575
1994	281	242	209	246	35	490	11	1,024	179	791	969	1,993
1995	171	158	144	232	28	404	14	747	190	559	749	1,496
1996	239	218	136	255	24	414	11	882	199	656	855	1,738
1997	226	242	165	261	26	452	10	930	203	694	897	1,828
1998	211	156	135	232	24	392	12	770	169	532	700	1,471
1999	264	281	158	257	27	443	13	1,000	203	770	972	1,973
2000	235	243	161	271	25	457	10	944	197	732	929	1,873
2001	306	339	228	272	26	526	9	1,179	201	786	987	2,166
2002	291	323	195	272	33	500	7	1,122	208	850	1,058	2,180
2003	261	304	126	264	32	422	7	993	196	782	978	1,971
2004	291	348	224	276	33	532	6	1,177	214	919	1,134	2,311
Long-term Average (64-04)	**239**	**245**	**207**	**213**	**21**	**440**	**8**	**933**	**178**	**679**	**857**	**1,790**
Recent 10-yr (95-04)	**249**	**261**	**167**	**259**	**28**	**454**	**10**	**975**	**198**	**728**	**926**	**1,901**
Extended Dry Period (87-92)	**339**	**284**	**259**	**227**	**43**	**529**	**15**	**1,168**	**192**	**877**	**1,069**	**2,236**
Short Dry Period (76-77)	**378**	**341**	**289**	**229**	**15**	**533**	**7**	**1,258**	**168**	**770**	**938**	**2,196**
Extended Wet Period (95-98)	**212**	**193**	**145**	**245**	**26**	**415**	**12**	**833**	**190**	**610**	**801**	**1,633**
Short Wet Period (82-83)	**129**	**135**	**141**	**213**	**14**	**369**	**7**	**639**	**153**	**485**	**638**	**1,277**

Table 5-19. Aquifer Parameter Data

Approximate Location	Well # or location Description	Well Model Layer (From IGSM)	Thickness of Aquifer (From IGSM)	Reported Average Transmissivity (gpd/foot)	Calculated K (ft/day)
James ID	Well #C-81	1	80	62,000	103
Mendota	New Well	1	46	70,000	202
Caruthers	Well #3	N/A	N/A	N/A	N/A
Malaga	Test #6	2	116	41,500	48
Selma	Well #13	2	200	N/A	N/A
Raisin City	Test Well	2	200	N/A	N/A
Kingsburg	Test Well #16	2	200	N/A	N/A
San Joaquin	Well #5	1	107	41,000	51
Mendota	2 Wells	1	39	57,000	197
Cartuthers	Alvina Elementary	2	200	N/A	N/A
Selma	Selma School	1	57	N/A	N/A
Bowles	Pacific Union School	1	60	39,400	88
Dinuba	Alta School	2	200	6,300	4
Dinuba	Kings Canyon High School	2	200	3,600	2
Dinuba	7 Wells	2	200	31,883	21
Laton	Conejo School	1	39	N/A	N/A
Easton	Washington Colony School	1	58	37,000	85
Kingsburg	Clay Elementary School	2	200	49,000	33
Kerman	4 Wells	1	73	79,500	146
	1 Well	2	200	11,000	7
South CID	Apex Ranch	1	34	112,500	438
Kingsburg	Irrigation Well	2	200	170,500	114
Kingsburg	Well #15	2	200	114,000	76
Del Rey	Two Wells	2	200	49,750	33
Malaga	Well #7	2	142	N/A	N/A
Sanger	5 Wells	2	200	65,160	44
Clovis	2 Wells	1	56	32,475	77
	16 Wells	2	91	55,666	82
Reedley	Great Western School	2	200	N/A	N/A
Reedley	4 Wells	2	200	68,500	46

Approximate Location	Well # or location Description	Well Model Layer (From IGSM)	Thickness of Aquifer (From IGSM)	Reported Average Transmissivity (gpd/foot)	Calculated K (ft/day)
FID East	Quail Lake Estates - 2 Wells	2	75	15,050	27
Fresno/Clovis WWTF	22 Wells	1	59	120,000	271
Fresno	Well #CRR 1	1	107	135,000	169
	Well #79	1	88	220,000	334
	Well #96	2	154	76,000	66
	Well #44a	2	200	250,000	167
	Well #133	2	155	62,000	54
	Well #158	2	200	142,000	95
	Well #160	2	200	218,000	146
	Well #161	1	84	176,000	281
	Well #169	2	200	144,000	96
	Well #192	1	80	298,000	497
	Well #198	2	198	194,000	131
	Well #044A	2	200	250,000	167
	Well #63	2	77	109,000	190
	Well #79	2	200	220,000	147
	Well #96	2	153	76,000	66
	Well #132	2	152	100,000	88
	Well #133	2	153	62,000	54
	Well #134	2	140	55,000	52
	Well #139	2	200	113,000	76
	Well #140	2	154	39,000	34
	Well #160	2	200	253,000	169
	Well #8A	2	117	68,000	78
	Well #21	2	131	35,000	36
	Well #22	2	110	16,000	19
	Well #23	2	105	13,000	17
	Well #24	2	97	75,000	103

Table 5-20. Ungaged Watersheds Characteristics

Watershed	Area (Sq Miles)	Area (Acres)	Associated Rainfall Station	Avg Annual Rainfall at station (in)	Long term Average Isohyte Value (in)	Rainfall Weighting Factor	Field Capacity	Total Porosity	Root Depth of Natural Vegetation	Percolation Parameter	Curve Number	Recession Coefficient
Little Dry Creek	65.0	41,576	9	13.89	15.9	1.14	0.12	0.08	3	1	80	0.002
Big Dry Creek	14.0	8,953	9	13.89	13	0.94	0.12	0.08	3	1	80	0.002
Dry Creek	58.2	37,246	9	13.89	19.1	1.38	0.12	0.08	3	1	80	0.002
Redbank Creek	4.6	2,940	10	19.47	13.2	0.68	0.12	0.08	3	1	80	0.002
Fancher Creek	20.0	12,790	10	19.47	15.9	0.82	0.12	0.08	3	1	80	0.002
Fish and Holland Creek	4.6	2,916	10	19.47	17.5	0.90	0.12	0.08	3	1	80	0.002
Watoke Creek	9.3	5,967	10	19.47	16.9	0.87	0.125	0.08	4	1.25	81	0.0005
Unnamed above Citrus Cove	4.6	2,952	10	19.47	13.9	0.71	0.125	0.08	4	1.25	81	1
Hills Valley Creek	6.9	4,411	8	12.59	15.9	1.26	0.125	0.08	4	1.25	74	1
Wooten Creek	5.6	3,610	8	12.59	14.6	1.16	0.125	0.08	4	1.25	73	1
Unnamed above Orange Cove	2.8	1,812	8	12.59	13.8	1.10	0.125	0.08	4	1.25	82	1
Sand Creek	34.7	22,212	8	12.59	17	1.35	0.125	0.08	4	1.25	75	0.5
Negro Creek	4.7	3,007	8	12.59	13.2	1.05	0.125	0.08	4	1.25	81	0.0025
Long and Story Creek	16.5	10,574	8	12.59	14.1	1.12	0.125	0.08	4	1.25	79	0.01
Unnamed above Seville	24.3	15,581	8	12.59	12.3	0.98	0.125	0.08	4	1.25	65	0.00001
Cottonwood Creek	126.5	80,986	8	12.59	16.3	1.29	0.125	0.08	4	1.25	65	0.00001

SECTION 6 MODEL CALIBRATION

Model calibration can be defined as "a process that uses a model to achieve a match between the recorded (i.e., historical) and simulated distribution(s) of dependent variable(s) by choosing a range of possible values of the independent variable(s)" (AWWA, 2001). In a hydrologic modeling situation such as the Kings IGSM, the challenge is to solve the inverse problem, that is, the distribution of the dependent variable (such as groundwater elevation) is known and measurable, while the distribution of the independent variable (such as hydraulic conductivity of an aquifer) can be estimated within a range of possible values. In such a situation, the independent variables are adjusted for model calibration and these variables are called model '*parameters*'. For example, in the Kings IGSM, the most important model parameters are the aquifer properties such as hydraulic conductivity, specific yield, specific storage, and leakance.

It should be noted that "a calibrated groundwater model provides 'best' or 'most reasonable' estimates of such model parameters, which are then used to predict the future response of a dependent variable (such as groundwater elevation) under a changed land use or water use plan" (AWWA, 2001).

The purpose of this section is to present the process used to calibrate the Kings IGSM. This section is organized as follows:

- Calibration Process,
- Calibration Data,
- Calibration Targets,
- Calibration Steps, and
- Calibration Results.

6.1 CALIBRATION PROCESS

The purpose of model calibration is to evaluate the scientific adequacy of the model in representing a physical system and to corroborate scientific hypotheses that are already established through data analyses and field observations. A well-calibrated model built on actual values of parameters, is capable of representing the physical system and is suitable for use in the analysis of water management planning.

The model calibration begins after the data development and input are complete. The intent of calibration is to compare model output with observed conditions and values and to adjust model parameters so that simulated conditions reasonably represent observed conditions.

The model calibration can be considered a systematic process, which includes the following series of activities:

1. Set calibration targets;
2. Calibrate to overall water budgets for the model area;
3. Calibrate simulated groundwater levels to observed groundwater levels;
4. Compare calibration performance with the calibration targets established in Step 1; evaluate and refine the calibration targets with reference to the available data, modeling and data assumptions, and potential use of the models;
5. Calibrate simulated streamflows to the observed streamflows; and
6. Conduct additional refinements to calibration as necessary.

A detailed process diagram for the model calibration is shown in Figure 6-1.

6.2 CALIBRATION DATA

The Kings IGSM is calibrated to the following observed records:

a. Regional groundwater levels for specific years;
b. Long-term groundwater levels; and
c. Streamflow Data.

More detail description is provided below.

6.2.1 REGIONAL GROUNDWATER LEVEL CONTOURS

Simulating groundwater level contours for Fall 1977, Spring 1983, and Spring 2004 were developed representing dry, wet, and average hydrologic conditions, respectively. These contour maps illustrate the distribution of the average of simulated heads of model layers 1 and 2. The measured groundwater level data used for comparison with the simulated groundwater level contour maps are based on the DWR Water Data Library (WDL) information with numerous wells in the model area with known coordinates. Figure 6-2 shows the location of the DWR wells in the vicinity of Kings Basin. Data from these wells were compared with the simulated head contour maps.

6.2.2 LONG-TERM GROUNDWATER LEVELS

To calibrate the model to long-term trends in groundwater levels and short-term, seasonal, groundwater level fluctuations, a series of wells from the DWR well inventory as well as the data from City of Fresno were selected. The information pertaining to the calibration wells is summarized in Table 6-1.

6.2.2.1 Basin-wide Model Calibration Wells

As mentioned in Section 6.2.1, the DWR has been monitoring groundwater level data and publishing the data in the WDL over the past several decades. The criteria to select calibration wells from among more than 10,000 wells was primarily based on the length of the period of record and availability of information on well location, depth, and perforation data. The criteria were applied so that there was sufficient geographic coverage with calibration wells with emphasis for IRWMP and the Upper Kings basin area. The selected wells had more than 60 measurements during the simulation period, with at least one measurement prior to October 1963 and one after October 2000. Wells with construction data were selected for use as calibration wells. A total of 157 wells were selected as shown in Figure 6-3. 135 of these wells are outside the City of Fresno SOI, and 22 are within the Fresno SOI. In addition to the 22 wells within the Fresno SOI, the City of Fresno data was also used as described in Section 6.2.3.

6.2.3 CITY OF FRESNO CALIBRATION WELLS

The City of Fresno has been collecting groundwater level data from 250 of their supply wells since 1940s and recently from 150 monitor wells.

Production Wells Monitoring - City of Fresno collects water level measurements from monitoring and municipal wells within Fresno sphere of influence. These measurements report water level data that provides reasonable temporal coverage for most of the model simulation period. Most recent data are available in electronic form; however, historical data are available as hardcopy water level hydrographs from Kenneth D. Schmidt and Associates. The hydrographs were provided by Kenneth D. Schmidt and Associates, and were digitized and imported into Excel worksheets. These well water level measurements were used for model calibration in the Fresno SOI area. The location of these wells is shown in Figure 6-4a.

Monitor Wells - City of Fresno has installed more than 150 nested monitor wells within Fresno SOI to measure water levels at various depths. At the time of this study, only Spring 2006 water level data is available for most of these monitor wells. These are used to improve the understanding of spatial distribution of groundwater levels, and vertical gradients between the aquifer layers in the Fresno area. Analysis of this data reveals that the head difference between layers 1 and 2 is only about 1-5 feet in areas west of Highway 41. However, the head difference in layers 1 and 2 increases toward east of Highway 41, to the tune of 10 to 20 feet (Figure 6-4b). The highest water level differences are observed in the monitor wells east of the airport. The general pattern and spatial distribution of head differences are used to calibrate the leakance parameters in the model. Kenneth D. Schmidt and Associates also provided water level and direction of flow maps for two layers.

6.2.4 STREAM FLOW DATA

There are several stream flow gages at the model boundary and inside model area (Table 5-7 and Figure 5-20). The Kings IGSM requires daily stream inflow data at the boundary of the model. The stream flow gages that are at the model boundary were selected to provide inflows to the Kings IGSM. Other stream gage stations inside the model area were selected for use during model calibration of stream flows. The stream flow gages selected for Kings IGSM calibration are listed in Table 6-2 and their locations are shown in Figure 6-5.

Table 6-2. Model Calibration Streamflow Gages

Name	Model Stream Node
Kings River below Peoples Weir	594
Kings River below Lemoore Weir	630
Kings River below Army Weir	636
North Fork below Island Weir	644
North Fork below Crescent Weir	650
North Fork below Stinson Weir	660
Kings River at Reedley Narrows	569
James bypass at (before) KRWA	671
James bypass at KRWA	672

6.3 CALIBRATION TARGETS

Calibration targets are typically designed to set specific calibration targets that are numerically measurable. The calibration targets for the Kings IGSM are summarized in Table 6-3. These targets are based on an evaluation of available data in the basin and in discussions with the TAD Work Group. It should be noted that the calibration targets are often refined and revised as data, assumptions, water budget, and additional information are further evaluated during the model development and calibration process. The calibration performance of the Kings IGSM will be evaluated with reference to these targets.

Table 6-3. Calibration Performance Targets

Criterion	Target
Mean absolute residual between simulated and observed groundwater levels	15 feet
Percent of simulated water levels within 20 feet of observed groundwater levels	75%
Percent of simulated water levels within 10 feet of observed groundwater levels	60%

6.4 CALIBRATION STEPS

Model calibration for the Kings IGSM consisted of the following steps:

1. Water Budget Calibration;
2. Groundwater Calibration; and
3. Streamflow Calibration.

Each step is discussed below.

6.4.1 WATER BUDGET CALIBRATION

This step of model calibration is intended to ensure that the model is properly representing the key hydrologic components of the groundwater basin. The Kings IGSM simulates the movement of the primary sources of water coming into and leaving the basin, including rainfall, streamflows, applied water, consumptive use, and subsurface flows. The model outputs that are reviewed and refined during this stage of calibration include annual and monthly water budgets for groundwater, streamflow, soil moisture, and land and water use for the entire model area and selected subregions. The key components for each of these water budgets are listed in the Table 6-4.

Table 6-4. Water Budget Components

	Budgets			
	Groundwater	**Streamflow**	**Soil Moisture**	**Water Use**
Components	Deep Percolation	Upstream Flow	Rainfall	Agricultural Use
	Stream Recharge	Rainfall Runoff	Irrigation Applied Water	Urban Use
	Boundary Flows	Gain from Groundwater	Evapotranspiration	Pumping
	Pumping	Diversions	Direct Runoff	Diversions
	Change in Storage	Return Flows	Return Flow	Imports
		Downstream Flow	Percolation	Shortages

Some of the key model data and/or parameters that are adjusted during this phase include soil moisture parameters (field capacity, soil hydraulic conductivity, SCS curve numbers, and root zone depth); boundary conditions; water use data; and streambed parameters (hydraulic conductivity and thickness). An important piece of data in this stage of calibration is typically the water use data, including the location, amount, and timing of surface water diversion and groundwater pumping.

6.4.2 GROUNDWATER LEVEL CALIBRATION

This step of model calibration involves adjustment of the hydrogeologic parameters to obtain a reasonable fit between the observed and simulated groundwater levels. The groundwater level calibration is performed in two stages:

1. The initial groundwater level calibration effort is focused on conforming to the regional scale, i.e., the simulated groundwater level contours are compared with the historic groundwater level contours for selected years. This step ensures that overall groundwater flow directions are representative of the field conditions. In the Kings IGSM, the following years were selected for regional groundwater level calibration: 1977, 1983, and 2000. These years were selected because they represent dry, wet, and average conditions in the model area.
2. The focus of the final groundwater level calibration is the local calibration wells; comparisons are made between the historic time series observations at each calibration well and the corresponding simulated time series groundwater levels. In the Kings IGSM, 240 calibration wells were selected for the purpose of local water level calibration. These wells were selected, in general, to provide a broad geographic coverage of the entire Kings IGSM area, and in particular, to enable comparison of local water levels in the focus areas of the present study. These focus areas include the IRWMP area and the City of Fresno.

During this phase of calibration, adjustments are made to aquifer parameters, including: hydraulic conductivity, specific storage, specific yield, and leakance between aquifer layers.

6.4.3 STREAMFLOW CALIBRATION

The streamflows are calibrated by comparing the historical time series data at selected stream gages within the model area with corresponding simulated streamflows. The streamflow calibration is focused on achieving a level of model accuracy that will provide a reasonable agreement between the simulated and observed streamflow measurements throughout the study area. This step ensures that the overall streamflow amounts are representative of the field conditions. During this phase of calibration, adjustments are made to model streambed parameters, including streambed thickness, hydraulic conductivity, and amounts of water returned to the aquifer system. For calibrating the Kings IGSM, simulated streamflows were compared with observed data from 6 streamflow gages within the model area.

6.5 CALIBRATION RESULTS

The Kings IGSM was calibrated in accordance with the calibration methodology described above. The performance of the Kings IGSM calibration exceeded the initial target that were set and discussed above.

The aquifer parameter values of the calibrated Kings IGSM are presented in Table 6-5. The maps of calibrated hydraulic conductivity are presented in Figures 6-6 and 6-7. Hydraulic conductivity is generally higher in Upper Kings Basin. The presence of several paleochannels with higher hydraulic conductivities could be seen in eastern parts of AID, KRWD, and Clovis (Figure 6-6). These paleochannels direct flow of groundwater from foothills to Kings Basin. The major Kings River paleochannel, with a width of approximately 10 miles, could be observed in the middle of Upper Kings Basin, extending from east of Sanger to areas west of Highway 41. Highest hydraulic conductivities in layer 1 could be observed south of Kingsburg where Kings River has high losses to groundwater. Figure 6-7 illustrates the higher hydraulic conductivity areas in Fresno/Clovis metropolitan area. The higher conductivities are associated with coarser paleochannel deposits of the San Joaquin River. High yielding municipal wells in the vicinity of downtown Fresno indicate the presence of higher hydraulic conductivities.

Table 6-5. Kings IGSM Range of Aquifer Parameter Values

Parameter	Range of Parameter Values		
	Layer 1	Layer 2	Layer 3
Horizontal Hydraulic Conductivity (feet/day)	1 - 425	0.1 - 200	0.1 - 25
Transmissivity (feet^2/day)	270 - 200,000	2.5 – 20,000	1 – 19,000
Storage Coefficient[1] (unit less)	–	0.00037 – 0.015	0.00037 – 0.056
Specific Yield (%)	15	12	–
Leakance[2] (1/day)	–	7.5×10^{-5} – 0.05	–

1. Specific storage * layer thickness.
2. Ratio of confining bed hydraulic conductivity to its thickness.

The Kings IGSM calibration results are presented below under the following categories:

- Water Budget;
- Groundwater Level:
  - Regional Groundwater Levels; and
  - Local Groundwater Levels;
- Streamflow.

6.5.1 WATER BUDGET

The Kings IGSM output results are summarized in the following water budgets analysis.

- Land and Water Use Budget,
- Soil Moisture Budget,
- Stream Reach Budget, and
- Groundwater Budget.

The budget tables can be generated by the model in either monthly or annual time steps for the period of simulation. The average annual water budget results for the Kings Basin, Upper Kings Basin, Lower Kings Basin, and Fresno SOI for water years 1964–2004 are discussed below.

6.5.1.1 Land and Water Use Budget

The land and water use budget demonstrates the balance between water supply and water demand in the study area. Calculation of this balance ensures that the model is properly representing the key hydrologic components of the study area. This balance includes agricultural and urban land use, agricultural and urban water demand, and overall water supply, consisting of surface water supply and groundwater pumping. The average annual simulated land and water use budget for water years 1964–2004 is presented in Table 6-6. Urban demand in Kings Basin is mostly due to urban areas in Upper Kings Basin. However, only 63% (1,410 TAF per year) of Basin's agricultural demand is in Upper Kings Basin. Based on Table 6-6, the total water demand in Kings Basin is approximately 2,800 TAF per year. This water demand is met by approximately 2,850 TAF per year of water supply consisting of 1,050 TAF per year of surface water supply and 1,800 TAF per year of groundwater pumping. The surface water supply to the model area consists of the surface water diversion plus imports minus exports and losses. Table 6-6 indicates that there are approximately 120 TAF per year of losses through the canal system in the form of recoverable losses (seepage from canals) and non-recoverable losses (evaporation from canals). Table 6-6 also shows an apparent imbalance between the long-term average annual water demands and water supplies. This is shown in the Shortage/Surplus column; the negative number indicates shortage and positive number indicates surplus. The shortage or surplus is typically due to mismatch in the timing between the monthly demand and supply patterns and inaccuracies in estimates of agricultural demand. The average shortage for Fresno SOI is 12 TAF per year. There is a surplus of 136 TAF per year for Upper Kings Basin while Lower Kings Basin has a shortage of 184 TAF per year. There is an average of 49 TAF per year shortage or 1.8% of total demand for Kings Basin. It may also be noted that the average agricultural water delivery in the model area is 3.5 acre-feet per acre. The average urban water delivery is 2.0 acre-feet per acre.

Goal of the water budget analysis is to develop a balance system between demand and supply. To the extent that data accuracy allows, care has been implemented to balance the agricultural demand and agricultural supply; as well as urban demand and supply. However, given the resolution of monthly data for the period 1964-2004 as well as uncertainty in the surface water delivery data and estimates of groundwater pumping, there are inaccuracies in the water budget between demand and supply.

6.5.1.2 Soil Moisture Budget

The Kings IGSM incorporates a soil moisture accounting system to track the hydrologic processes within the soil zone. The components of the soil moisture budget for agricultural, urban, and undeveloped areas as simulated by the Kings IGSM are: rainfall; irrigation applied water; crop consumptive use during growing season; actual ET during the entire year; direct runoff due to rainfall; return flow from agricultural and outdoor urban water use; and deep percolation. Higher rates of direct runoff are expected in urban areas because of higher fraction of impervious areas. Deep percolation in the agricultural and urban areas is primarily due to the rainfall and irrigation applied water; whereas in the undeveloped areas, deep percolation is mainly from rainfall.

The average annual soil moisture budget for water years 1964–2004 is presented in Table 6-7. The soil moisture budget is presented by agricultural, urban and undeveloped (native vegetation) areas, as sources of water supply may be different for each land use area.

Average annual deep percolation in agricultural areas is about 12.2 inches per year for Kings Basin. This annual percolated water is primarily from irrigation applied water (about 36.7 inches) and from rainfall (8.9 inches). The amount of deep percolation in urban areas (6.7 inches per year), which is primarily due to outdoor use and turf irrigation, is less than that in the agricultural areas. The annual average ET in the agricultural areas of Kings Basin is 32.5 inches; about 80 percent of this amount was for crop consumptive use during growing season.

6.5.1.3 Stream Budget by Reach

The major components of water budget by stream reach are: upstream flow; runoff from mountain watersheds; direct runoff from rain; gain and loss due to stream-aquifer interaction; surface water diversions; and downstream outflow. There are 14 stream reaches for Kings River and 6 stream reaches for San Joaquin River simulated in the Kings IGSM. These reaches are shown in Figure 4-6 and defined in Table 4-3. Figures 6-8 and 6-9 show the summary and detailed schematics of the Kings IGSM representation of Kings River stream and diversion system. Average annual quantities of surface water flows in and out of Upper Kings Basin and Lower Kings Basin are presented in Figure 6-8. Figure 6-9 presents the average annual quantities of diversions and annual graphs of major components of Kings River stream and diversion system.

Surface water inflow into Upper Kings Basin is 1,855 TAF per year and consists of 1,738 TAF per year of Pine Flat Reservoir releases and inflows from Mill and Hughes creeks and Friant-Kern Canal. Kings River gains approximately 22 TAF per year from groundwater in Upper Kings Basin and looses 189 TAF per year to groundwater in Lower Kings Basin. Diversions in

Upper Kings Basin (1,156 TAF per year) are significantly higher than Lower Kings Basin diversions (145 TAF per year). Kings River outflow from Upper Kings Basin is approximately 730 TAF per year. Kings River outflow from Lower Kings Basin includes 250 TAF per year of stream flow to Mendota Pool area and 185 TAF per year of stream flow and diversions to south.

The level of detail on the data available for San Joaquin River is much less than the Kings River. Nevertheless, the long-term average release from Millerton Reservoir into San Joaquin River is approximately 475 TAF per year. San Joaquin River at the northern boundary of Kings IGSM has an annual average simulated loss to groundwater of 95 TAF/year. Note that this loss is simulated based on the stream-aquifer interaction at the boundary nodes. The calculated groundwater heads at the boundary nodes are subject to boundary conditions, as such they reflect the groundwater conditions outside the model area to the extent that data is available and assumptions are valid. Therefore, the estimated losses from San Joaquin River, or any other river along the model boundary, reflect the total estimated losses/gains. There is an annual average of 13 TAF per year of diversions from San Joaquin River.

6.5.1.4 Groundwater Budget

Kings IGSM incorporates the major hydrologic processes that affect the flow of groundwater in the model area. The primary components of the groundwater budget are as follows:

- Inflows:
  - Deep percolation from irrigation applied water and rainfall;
  - Recharge due to stream seepage;
  - Recharge from other sources such as irrigation canals and recharge ponds;
  - Subsurface boundary inflows from outside model area; and
  - Subsurface inflows from adjacent subregions.
- Outflows:
  - Groundwater pumping;
  - Subsurface outflows to adjacent subregions; and
  - Boundary outflows.

The average annual groundwater budget for water years 1964–2004 is presented in Table 6-8. Schematic representation of the groundwater budgets for Fresno SOI, Upper Kings Basin, Lower Kings Basin, and Kings Basin representing the average annual groundwater budget for the water years 1964 to 2004 and the maps of these areas are presented in Figure 6-10a and 6-10b, respectively. The budget table shows that the primary sources of aquifer recharge are deep percolation of irrigation water and rainfall, gain from streams and canals, and recharge ponds. During the simulation period of 1964-2004, groundwater storage in Kings Basin decreased by an annual average of about 162 TAF per year resulting from desaturation of model

layer 1 by 116 TAF per year and reduction of storage in confined model layers 2 and 3 by 46 TAF per year. Figures 6-11 through 6-13 show the annual and cumulative changes in groundwater storage for water years 1964-2004 for Fresno SOI, Upper Kings Basin, Lower Kings Basin, and Kings Basin, respectively.

Subsurface flow from Foothill Subregions into the Kings Basin is 62 TAF per year. Total boundary inflow from northern, western, and southern model boundaries into Kings Basin is 76 TAF per year. Subsurface flow from Upper Kings Basin to Lower Kings Basin is approximately 260 TAF/year and mainly flows toward the groundwater depression area in the vicinity of RCWD. The subsurface flow from FID and Clovis SOI into Fresno SOI is 65 TAF per year.

The groundwater budget presented in Figure 6-10 suggests that the average change in storage during 1964 to 2004 has been 160 TAF per year. Approximately 20% of change in storage in Upper Kings Basin is due to change in storage in Fresno resulting from high urban groundwater pumping in Fresno SOI. Groundwater storage loss in Lower Kings Basin is higher than the storage loss in Upper Kings Basin (Figure 6-10).

6.5.2 GROUNDWATER LEVEL CALIBRATION

The calibration of the Kings IGSM to the observed groundwater levels is performed in two stages:

1. Calibration to the regional observed groundwater levels at specific times; and
2. Calibration to the long-term trends and seasonal fluctuations of groundwater levels at specific well locations during the period of observation.

The goal of this stage of calibration is to achieve a reasonable agreement between the simulated and observed groundwater levels at as many of the calibration wells as possible with the main focus on groundwater wells located within the Upper Kings Basin and Fresno SOI. Aquifer parameters, such as hydraulic conductivity, specific storage, specific yield, and leakance parameters, are modified throughout the model area to achieve the calibration targets.

6.5.2.1 Regional Water Levels

In order to evaluate the performance of the Kings IGSM during dry, average, and wet hydrologic conditions, the following periods were selected to calibrate regional groundwater levels:

- Fall 1977, representing dry hydrologic conditions;
- Spring 1983, representing wet hydrologic conditions; and
- Spring 2004, representing average hydrologic conditions.

The Kings IGSM simulated groundwater levels for Fall 1977, Spring 1983, and Spring 2004 are presented in Figures 6-14 through 6-16, respectively. These figures also show observed groundwater levels at the monitoring locations. The simulated groundwater elevation trends, flow directions, and groundwater gradients generally match the measured data. Simulated groundwater levels in FID and CID areas for the three hydrologic periods are within the calibration targets. The simulated groundwater levels in AID for Fall 1977 are higher than the measured levels. A better match between simulated and measured values in AID is observed for Spring 1983. The simulated heads for Fall 1977 are higher than the measured data in the groundwater level depression area in Lower Kings Basin. Lower accuracy of model for simulation of groundwater levels in dry hydrologic conditions is due to low resolution of available agricultural groundwater pumping data.

Simulated groundwater levels in Fresno Metropolitan Area for Fall 1977, Spring 1983, and Fall 2000 are presented in Figures 6-17 through 6-19. The figures indicate that, in general, the model simulates the groundwater elevation trends, flow directions, and slope of the groundwater levels reasonably well. The figures also show the development of groundwater level depression area in Fresno SOI. The distribution of simulated groundwater levels for Fall 1977 is not as accurate as for Spring 1983 and Fall 2004. This is due to lack of pumping data for individual Fresno wells prior to 1980 and the potential inaccuracies in method of estimation of pumping for Fresno municipal wells.

The major source of differences between simulated and observed groundwater levels are:

- Lack of vertical leakance data;
- Unknown 3 layer groundwater level data outside of City of Fresno;
- Model assumptions in assignment of agricultural groundwater pumping to model layers;
- Deficiencies in the municipal wells pumping quantities and location data;
- Errors in the measurements of the observed groundwater levels; and
- Insufficient recovery time during water level measurements at the active production wells between shut down and measurement.

The differences between simulated and observed values are acceptable and meet the calibration performance targets of Table 6-3.

6.5.2.2 Local Groundwater Levels

The second stage of calibration of the groundwater levels is to use the observed groundwater level measurements at specific wells. Simulated groundwater elevations at 240 wells were compared with corresponding observed values for long-term trends as well as seasonal fluctuations. The locations of the calibration wells are presented in Figures 6-3 and 6-4. The

comparisons of monthly simulated and observed values over an extended period of time provide information on the overall model performance during the simulation period.

The results of this calibration stage indicate that the Kings IGSM reasonably simulates the long-term hydrologic responses at the local wells under various hydrologic conditions. Appendix B presents the simulated and observed groundwater levels at 240 calibration wells and Figures 6-20 to 6-25 show a subset of those hydrographs. Elevations of model layers, screen intervals and associated model layers for the calibration wells are presented in Table B-1.

Calibration wells 127 and 146 are located in AID area (Figure 6-20). The simulated groundwater levels reasonably match with the observed water levels except for Well 146 during the extended dry period of 1986-1994. Lack of agricultural pumping data and stratigraphy in this area of the Kings IGSM could have affected the groundwater level simulation at Well 146.

Calibration wells 104 and 119 are located in CID area (Figure 6-21). The simulation of groundwater levels reasonably represents the observed measurements for these wells. For Well 104, the Kings IGSM simulated water levels are lower than observed maximum measurements. Well 104 is located in the vicinity of CID recharge ponds and lack of data associated with recharge rates could have affected the groundwater level simulation in Well 104.

Calibration wells 33 and 70 are located in FID area (Figure 6-22). Simulated groundwater levels in Wells 33 and 70 reasonably represent the observed measurements. However, the simulated water levels for Well 33 are lower during 1988-1944 period. Lack of agricultural pumping data in this area of the Kings IGSM could have affected the groundwater level simulation in Well 33.

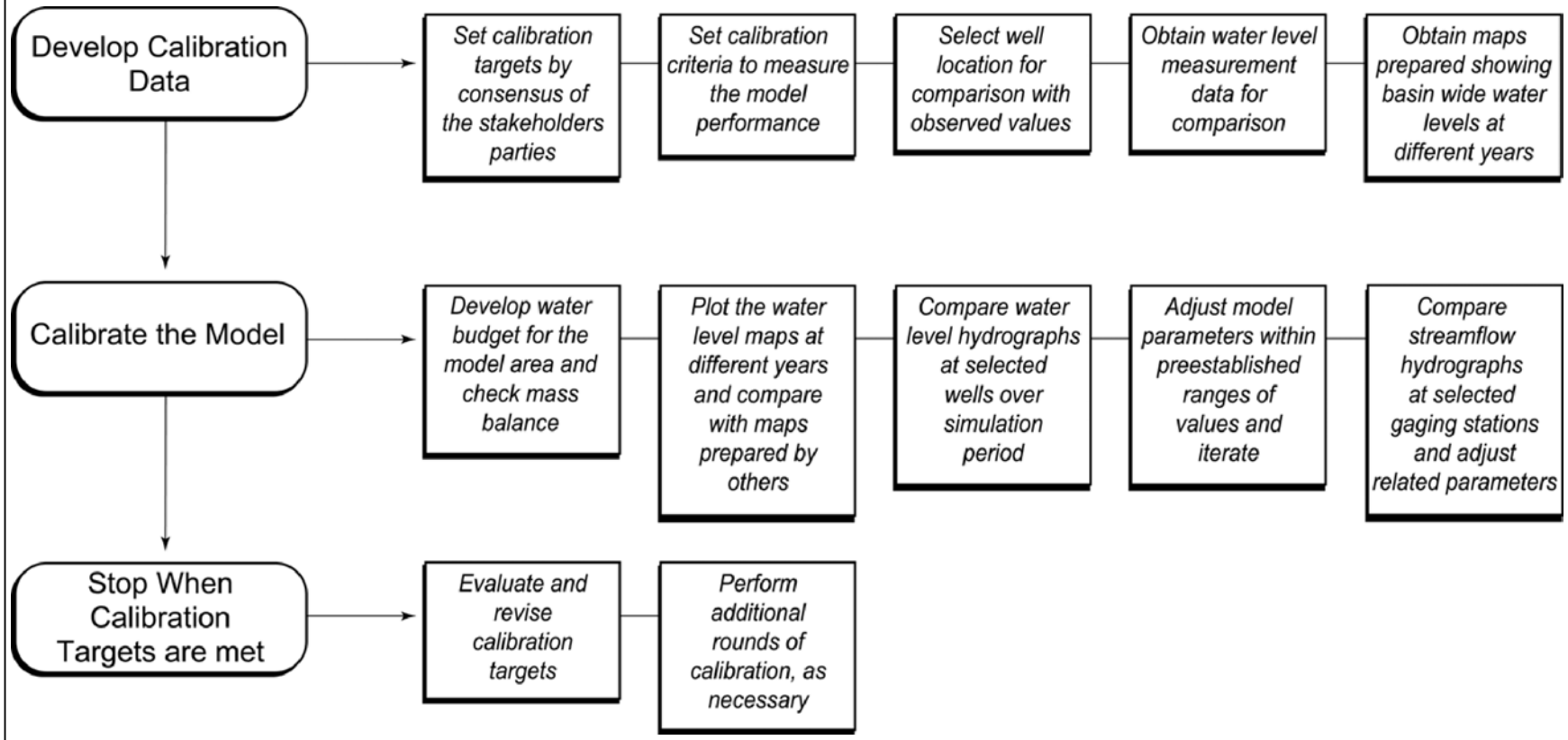
Calibration wells 227, 235, and 226 are located in Fresno SOI area (Figures 6-23 and 6-24). Simulated groundwater levels reasonably represent the observed measurements. Water level measurements from City of Fresno monitoring wells indicate that water levels in layer 2 are lower than water levels in layer 1 for areas east of Highway 41. Simulated groundwater levels for Well 226 represent similar head differences between layers 1 and 2.

Figures 6-26 through 6-28 show the histograms of residuals between the simulated and observed groundwater levels in Fresno SOI, Upper Kings Basin, and Lower Kings Basin. Figure 6-27 shows that in Upper Kings Basin, approximately 73% of the simulated values in Kings Basin fall within 10 feet of the observed values, and approximately 93% of the simulated groundwater levels are within 20 feet of the observed values. Similarly, approximately 82% of the simulated values in Fresno SOI fall within 10 feet of the observed values, and approximately 97% of the simulated groundwater levels are within 20 feet of the observed values. Higher resolution of data in Fresno SOI resulted in significantly less deviation between simulated and observed groundwater levels.

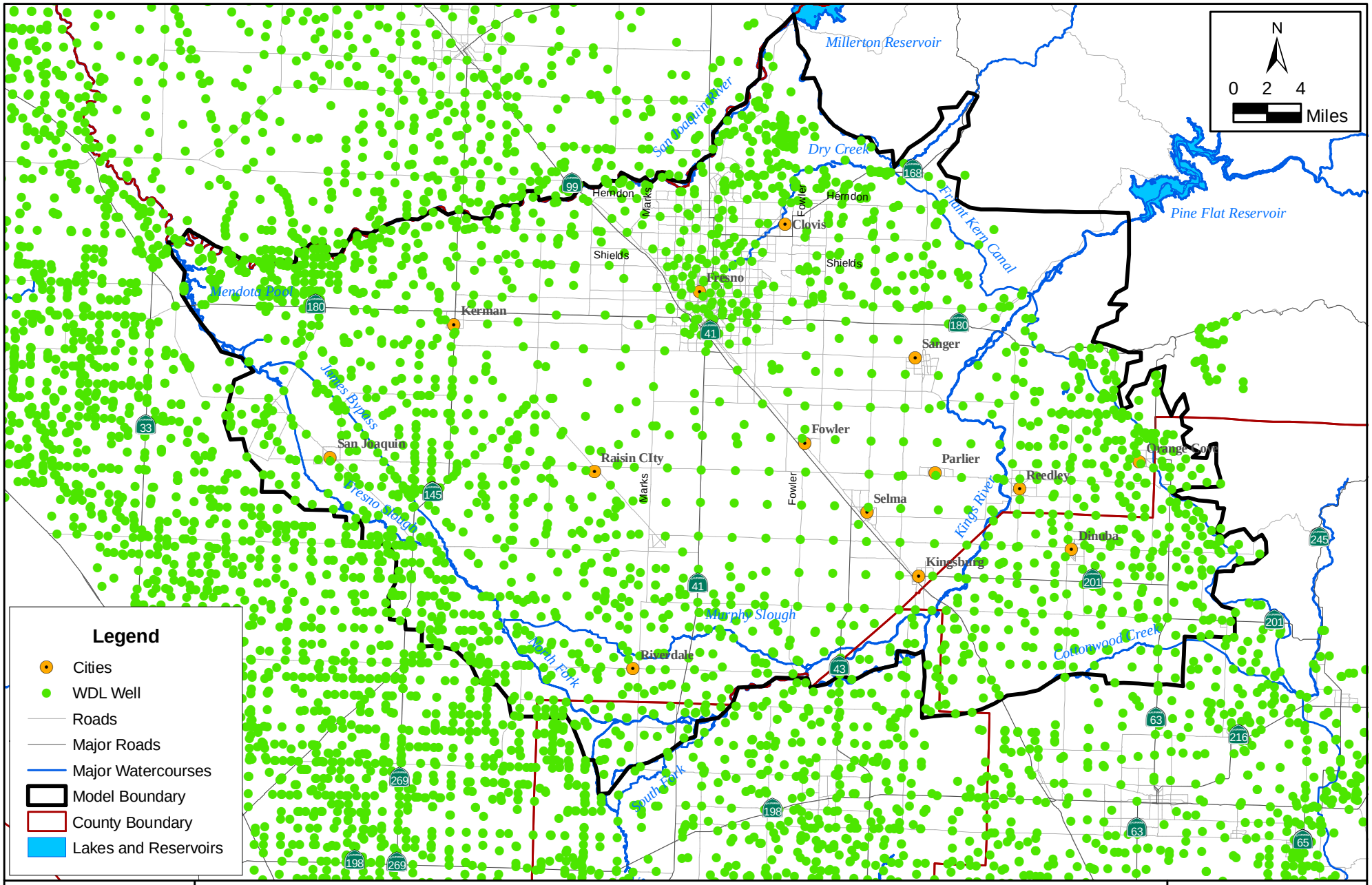
6.5.3 STREAMFLOW CALIBRATION

The Kings IGSM simulates the streamflow in several major rivers and creeks in the model area, including the Kings River and the San Joaquin River. The model also simulates the interaction between the stream and the aquifer system on a daily time step. The streamflow simulation is based on water balance at every stream node along each reach. Based on a water balance calculation along a stream reach, the downstream flow for each stream node is calculated for every time step. Calibration of the simulated streamflows is performed by comparing them with recorded streamflows at the locations of stream gages of Table 6-2 and Figure 6-5. The simulated and observed streamflow hydrographs for Kings River flows below Peoples and James weirs are shown in Figures 6-29 and 6-30. Figures 6-31 and 6-32 show exceedance charts for Kings River below these weirs. These figures show a reasonable simulation of the flows in Kings River.

Kings River streamflow is measured at several weirs. The Peoples and James weirs were selected for streamflow calibration. Flow measured at Peoples weir represents the Kings River streamflow from Upper Kings Basin into Lower Kings Basin. Flow measured at James weir approximately represents the Kings River streamflow out of Lower Kings Basin. Simulated streamflows below Peoples weir reasonably matches observed flows greater than 100 cfs. The simulated streamflows are higher than observed records for observed flows less than 100 cfs. This is in part due to inaccuracies in the surface water return flow estimates, riparian pumping from the river, and discrepancies between monthly diversion data and daily operation of canal headgates. Simulated streamflows below James weir matches observed flows greater than 1,000 cfs. The simulated flows are higher than measured flows for observed flows below 1,000 cfs. This discrepancy is most likely due to inaccuracies in surface water return flow and discrepancies between monthly diversion data and daily operation of canal headgates.



ωRIME	**Model Calibration Process** Kings IGSM Model Development and Calibration	July 2007 Figure 6-1

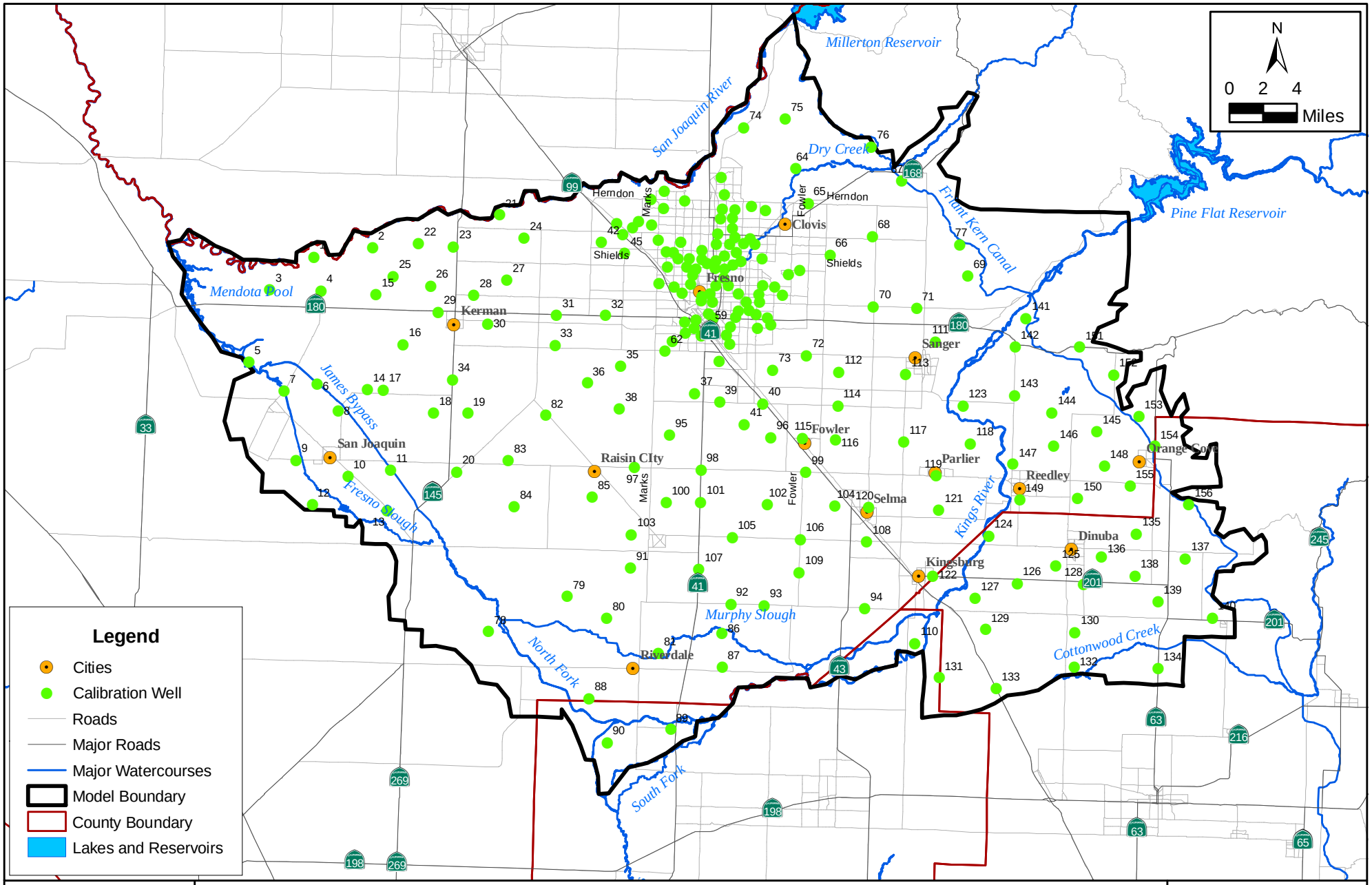


DWR Water Data Library Wells in Kings Basin

Kings IGSM Model Development and Calibration

July 2007

Figure 6-2



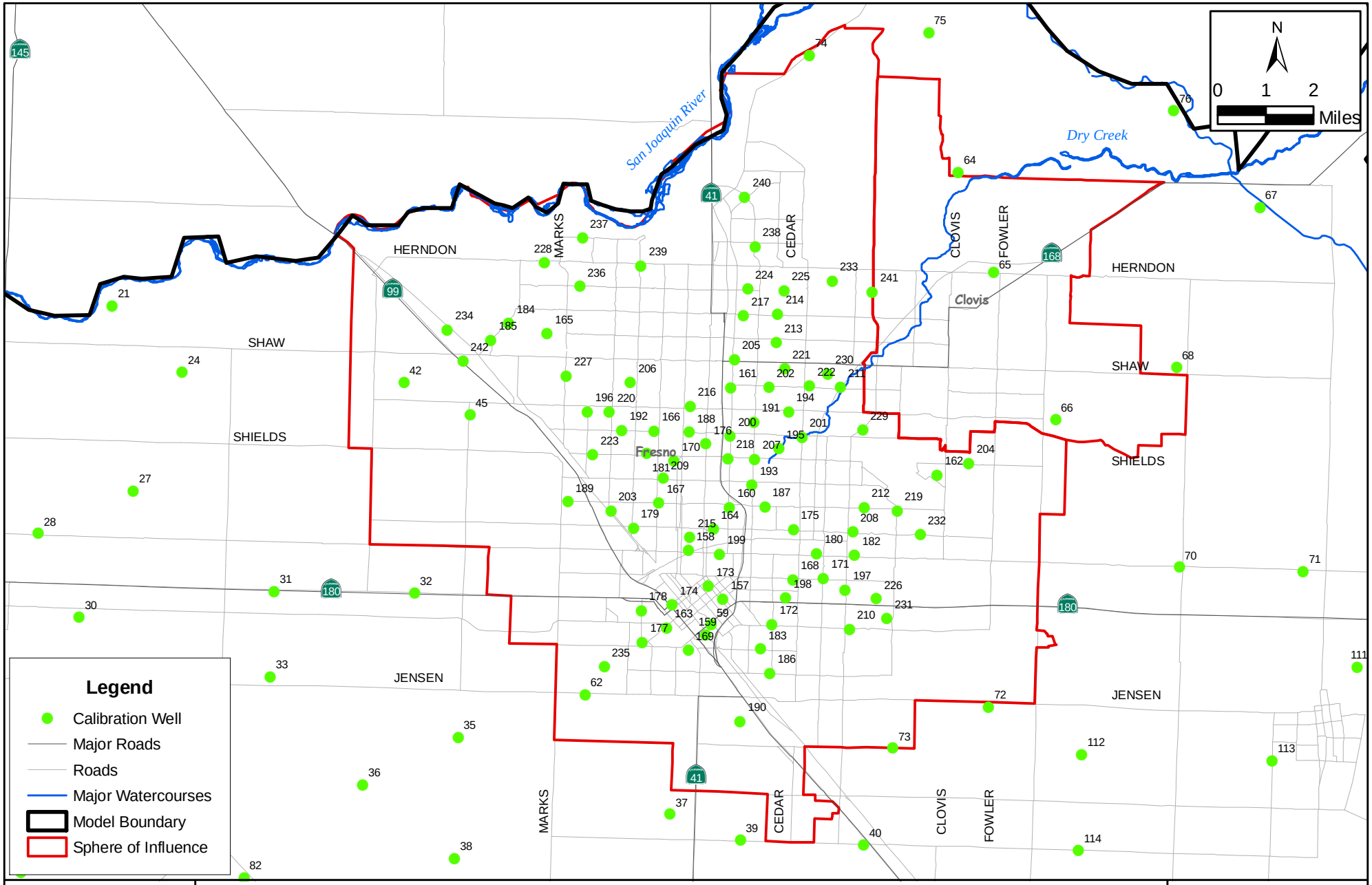
Calibration Wells

Kings IGSM Model Development and Calibration

Note: Fresno and Clovis Calibration Wells are labled in Figure 6-4

July 2007

Figure 6-3

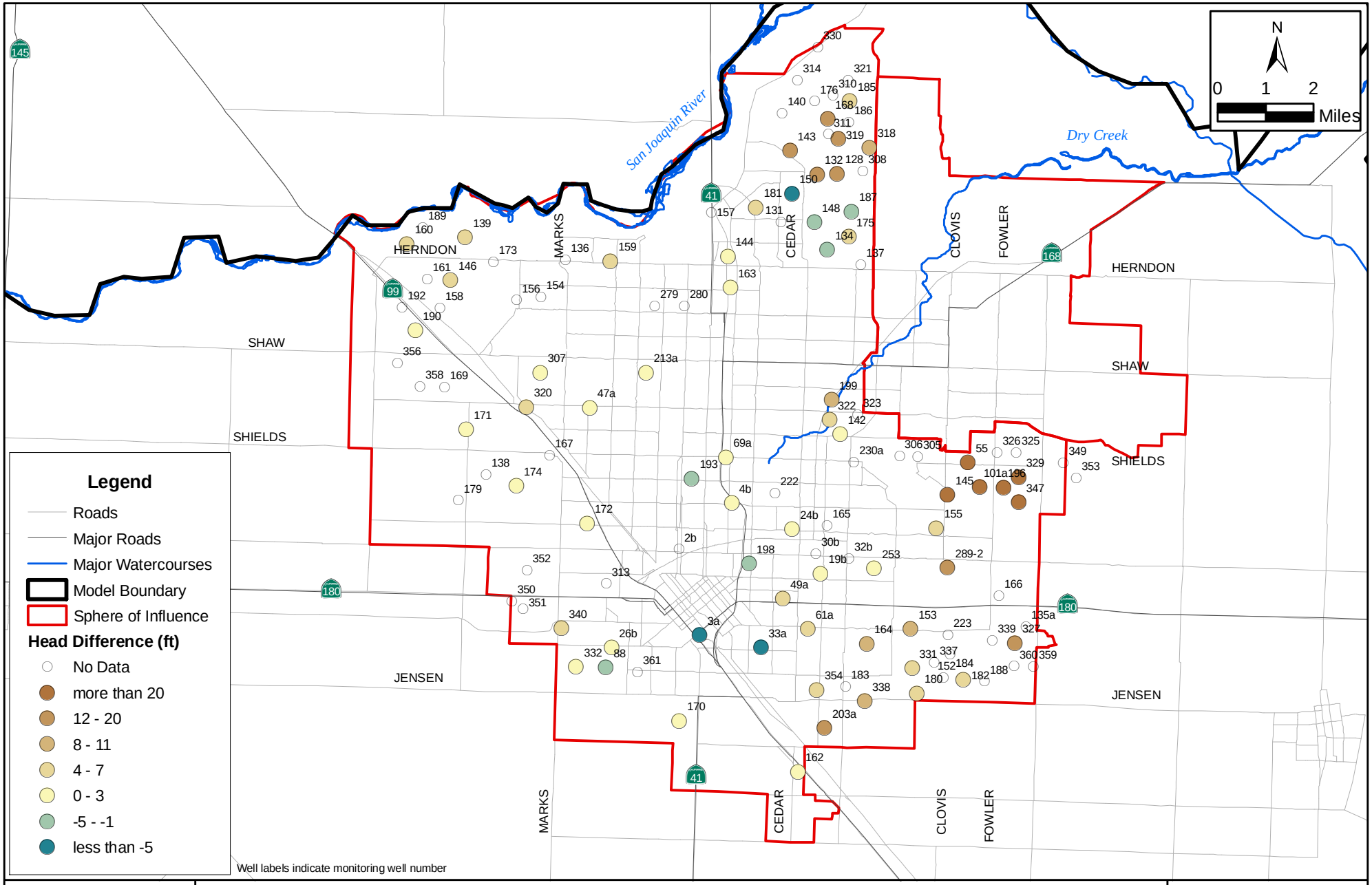


Calibration Wells in Fresno and Clovis

Kings IGSM Model Development and Calibration

July 2007

Figure 6-4a

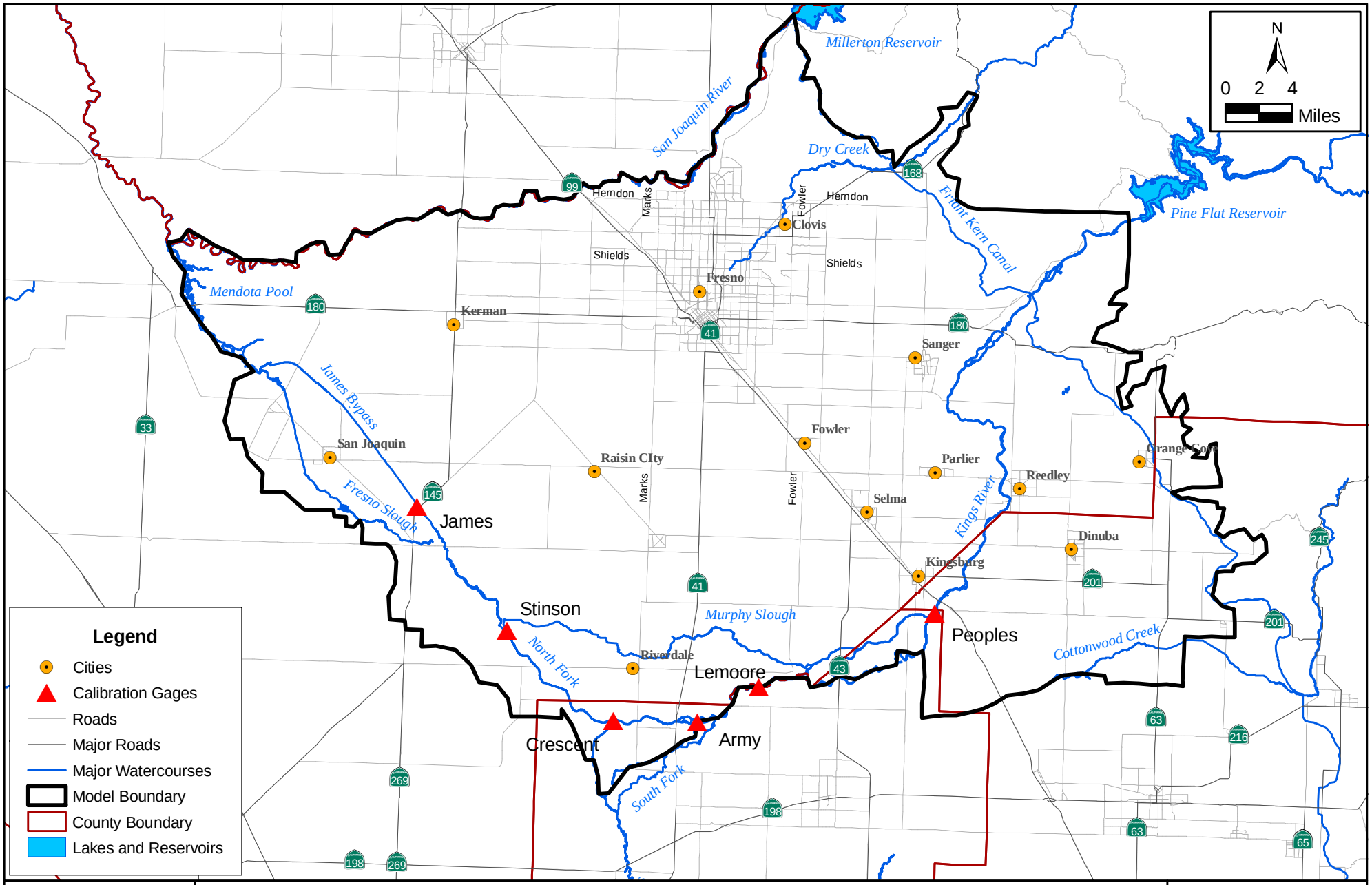


Head Difference in Fresno Monitor Wells (Layer 1 minus Layer 2)

Kings IGSM Model Development and Calibration

July 2007

Figure 6-4b

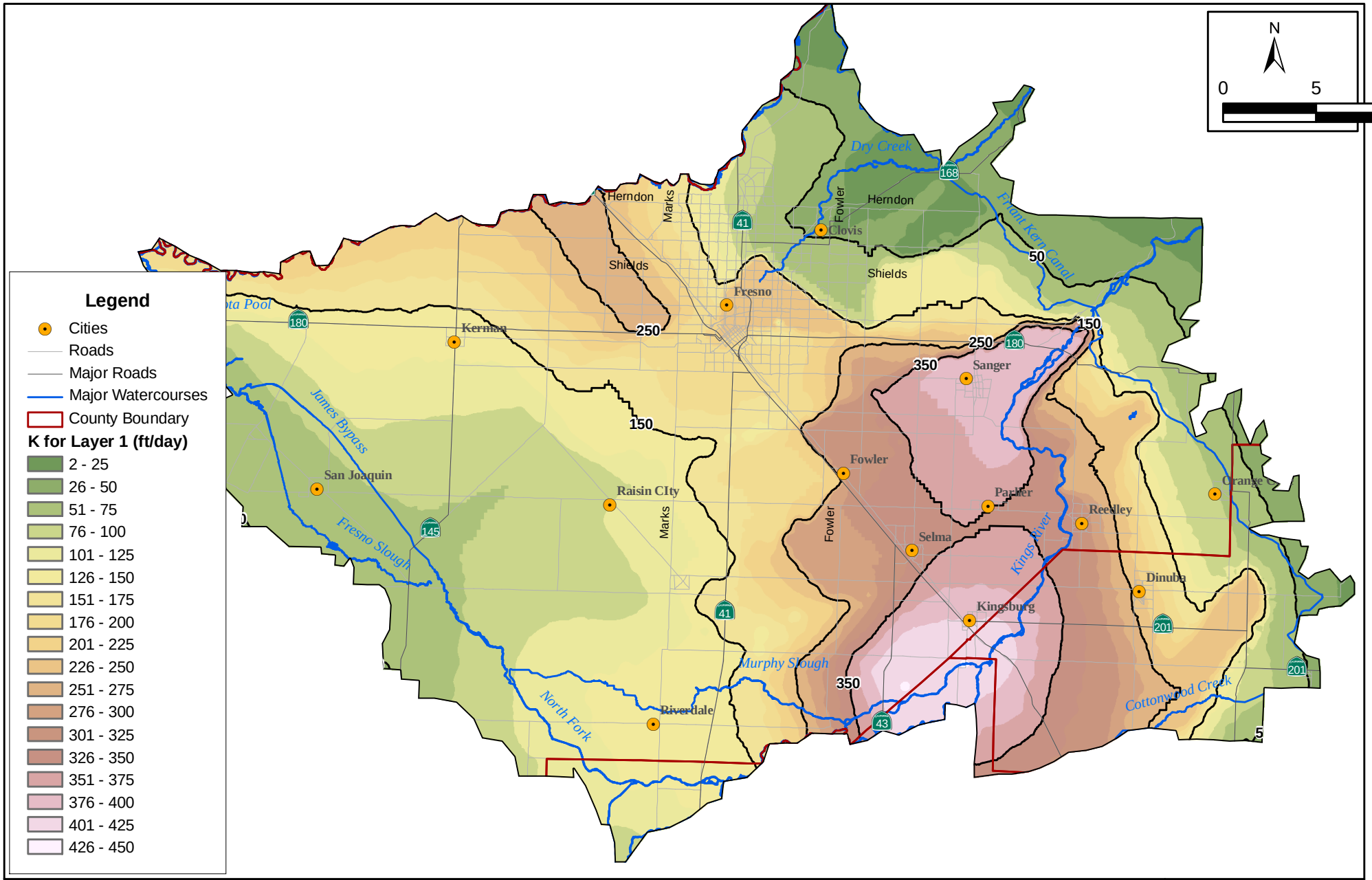


Calibration Streamflow Gages

Kings IGSM Model Development and Calibration

July 2007

Figure 6-5

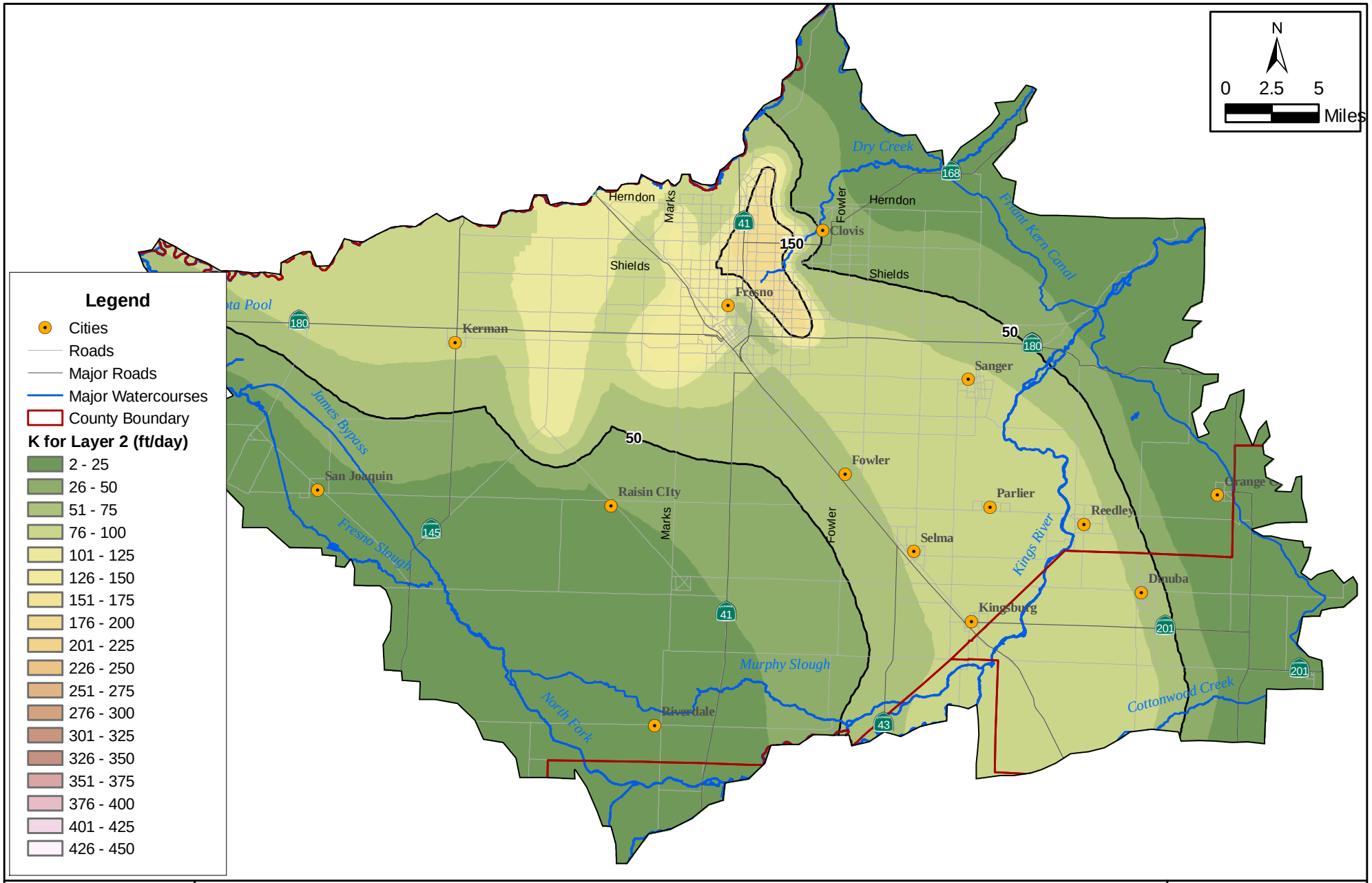


Calibrated Hydraulic Conductivity for Model Layer 1

Kings IGSM Model Development and Calibration

July 2007

Figure 6-6



Calibrated Hydraulic Conductivity for Model Layer 2

Kings IGSM Model Development and Calibration

July 2007

Figure 6-7

Figure 6-8. Kings Basin IGSM Representation of Kings River Stream and Diversion System

(All values are in TAF/Year; average for water years 1964 to 2004)

Historical Calibration

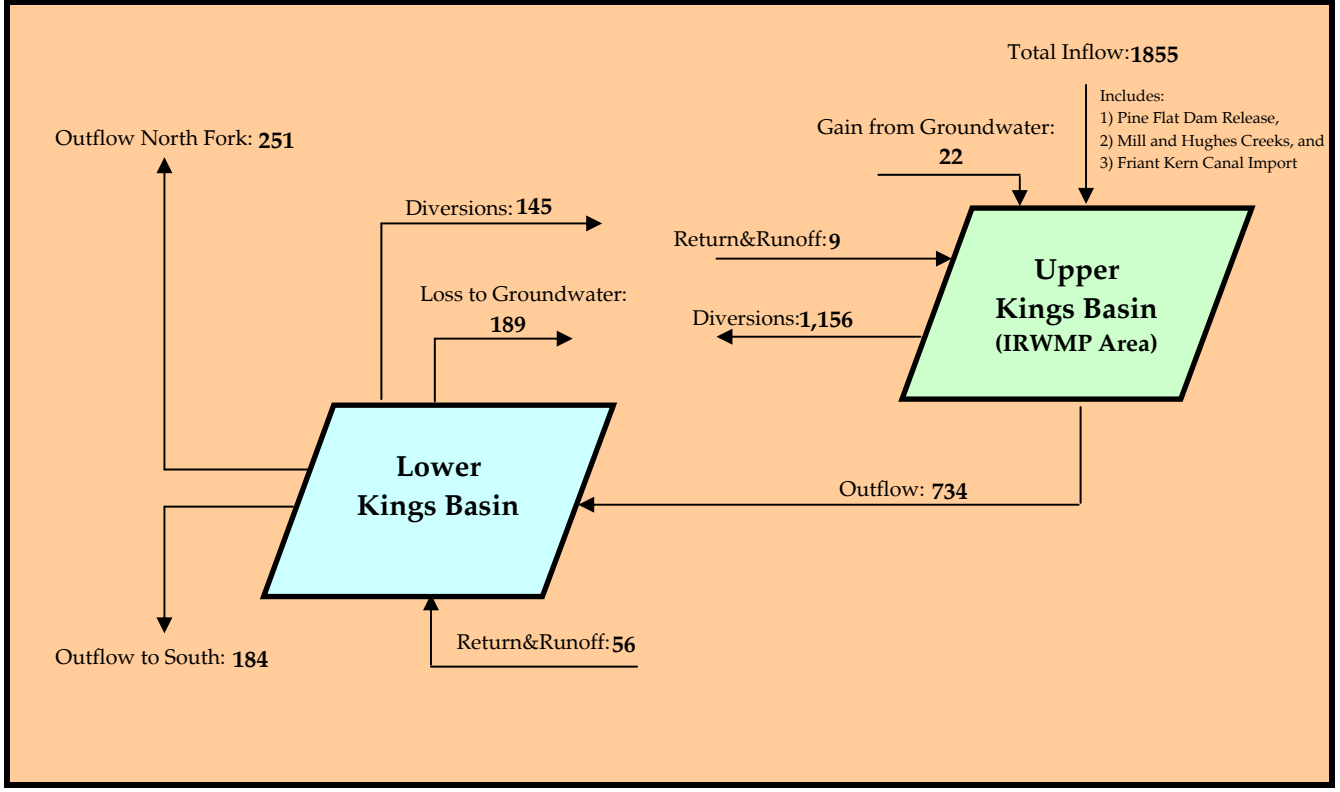
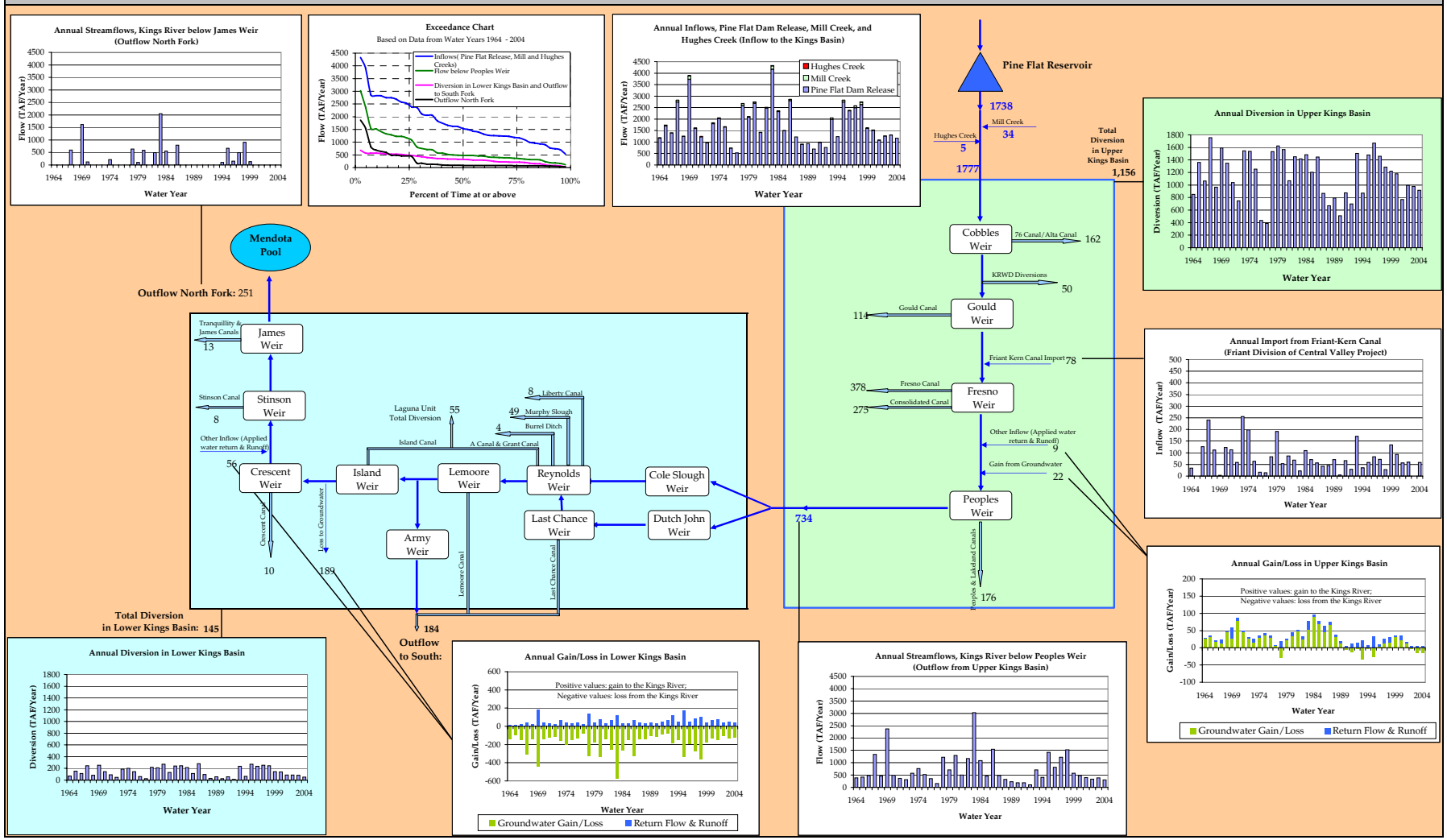
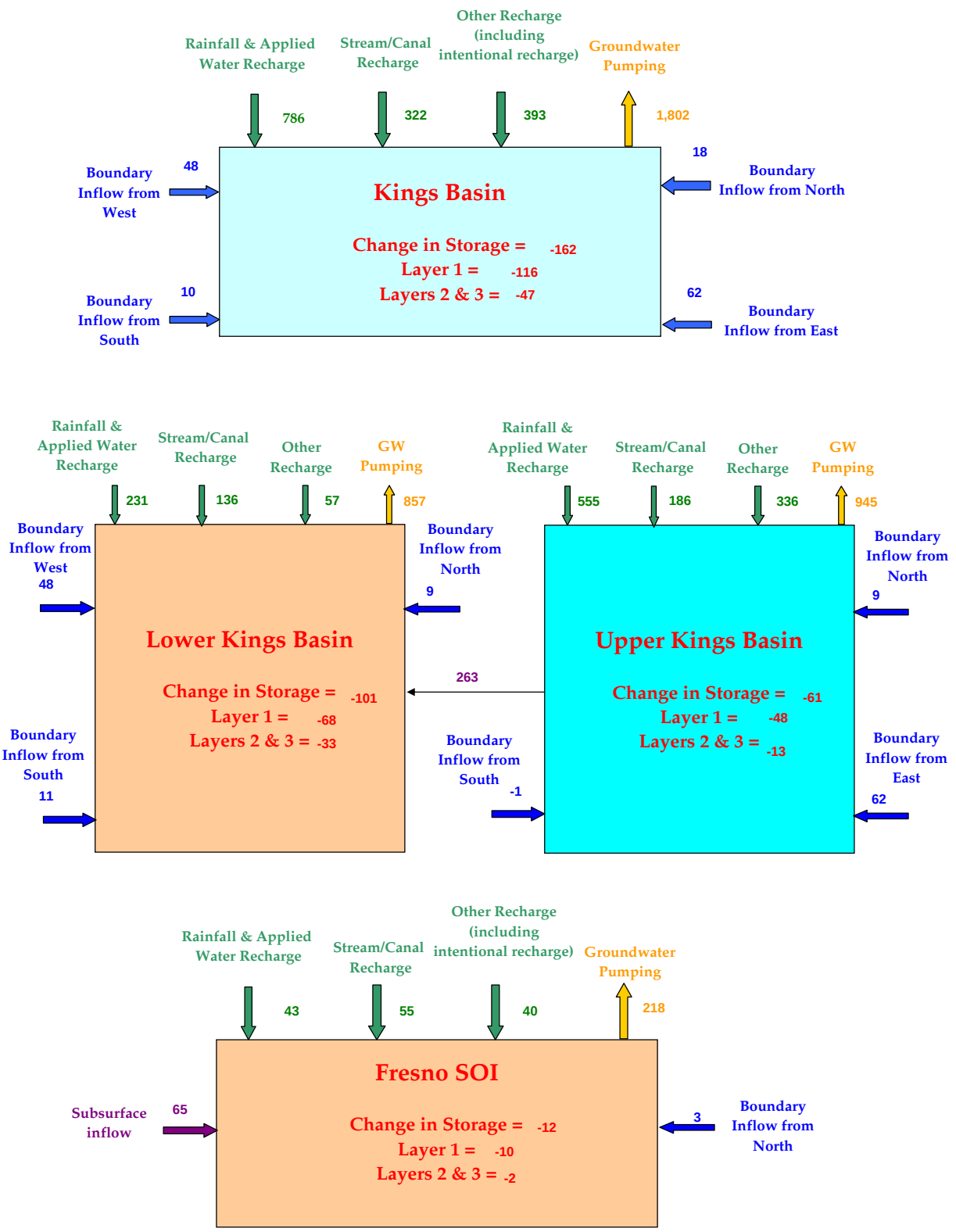


Figure 6-9. Kings Basin IGSM Detailed Representation of Kings River Stream and Diversion System

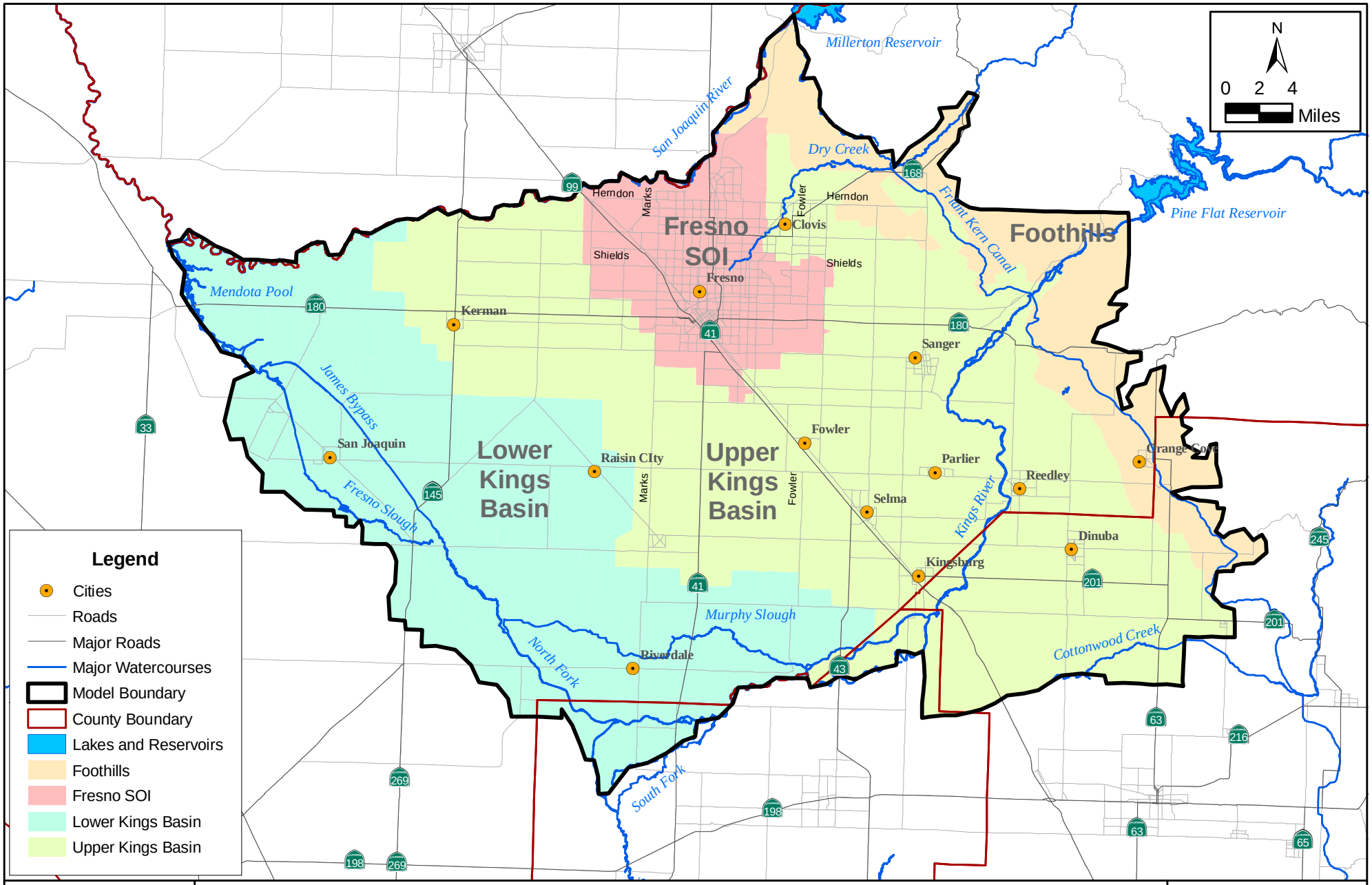
(All values are in TAF/Year; average for water years 1964 to 2004)

Historical Calibration





RIME	**Average Annual Groundwater Budget 1964 - 2004 (TAF/yr)** Kings IGSM Model Development and Calibration	October 2007 Figure 6-10a



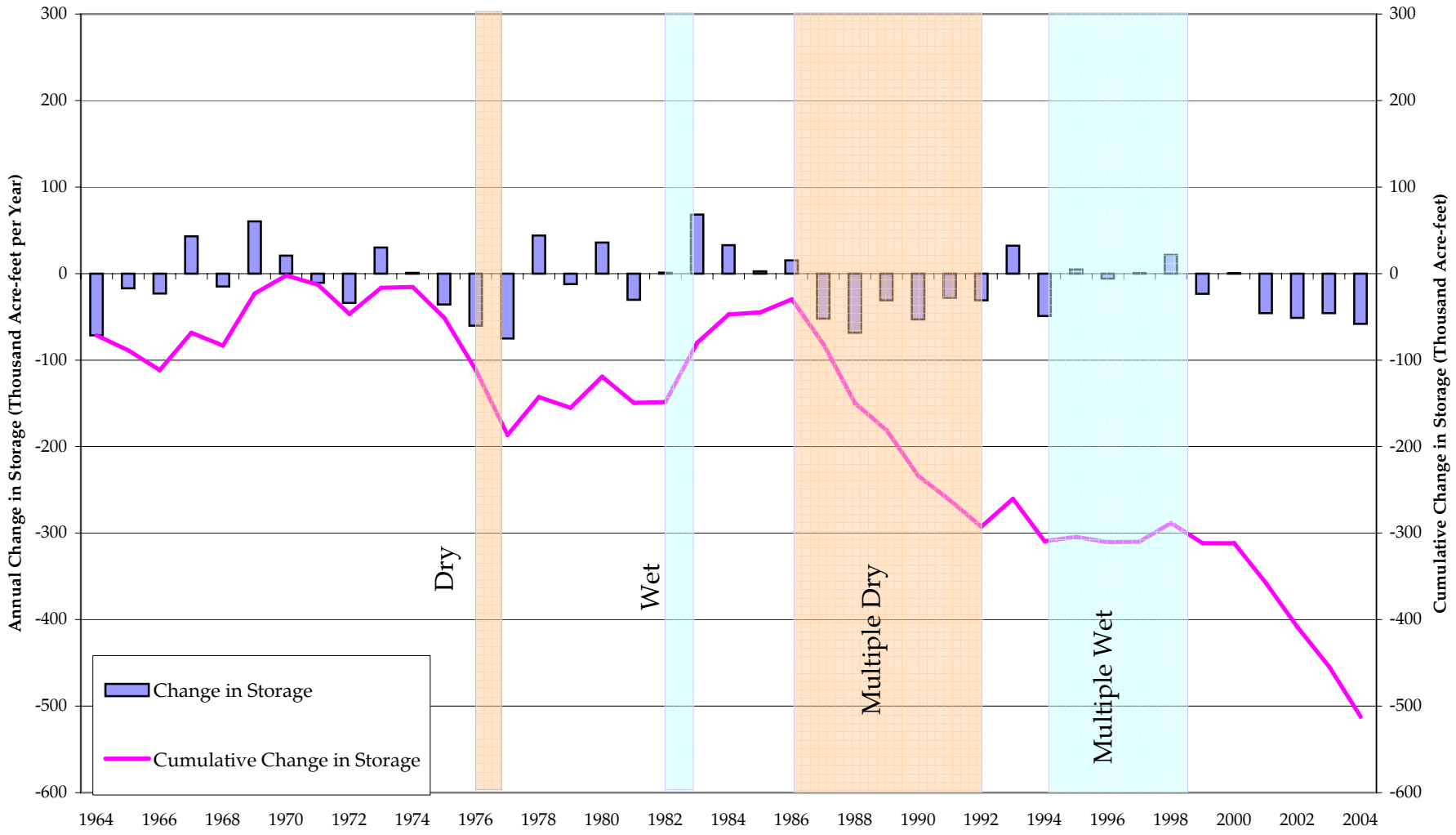
RIME

Locations of Groundwater Budget Areas

Kings IGSM Model Development and Calibration

July 2007

Figure 6-10b

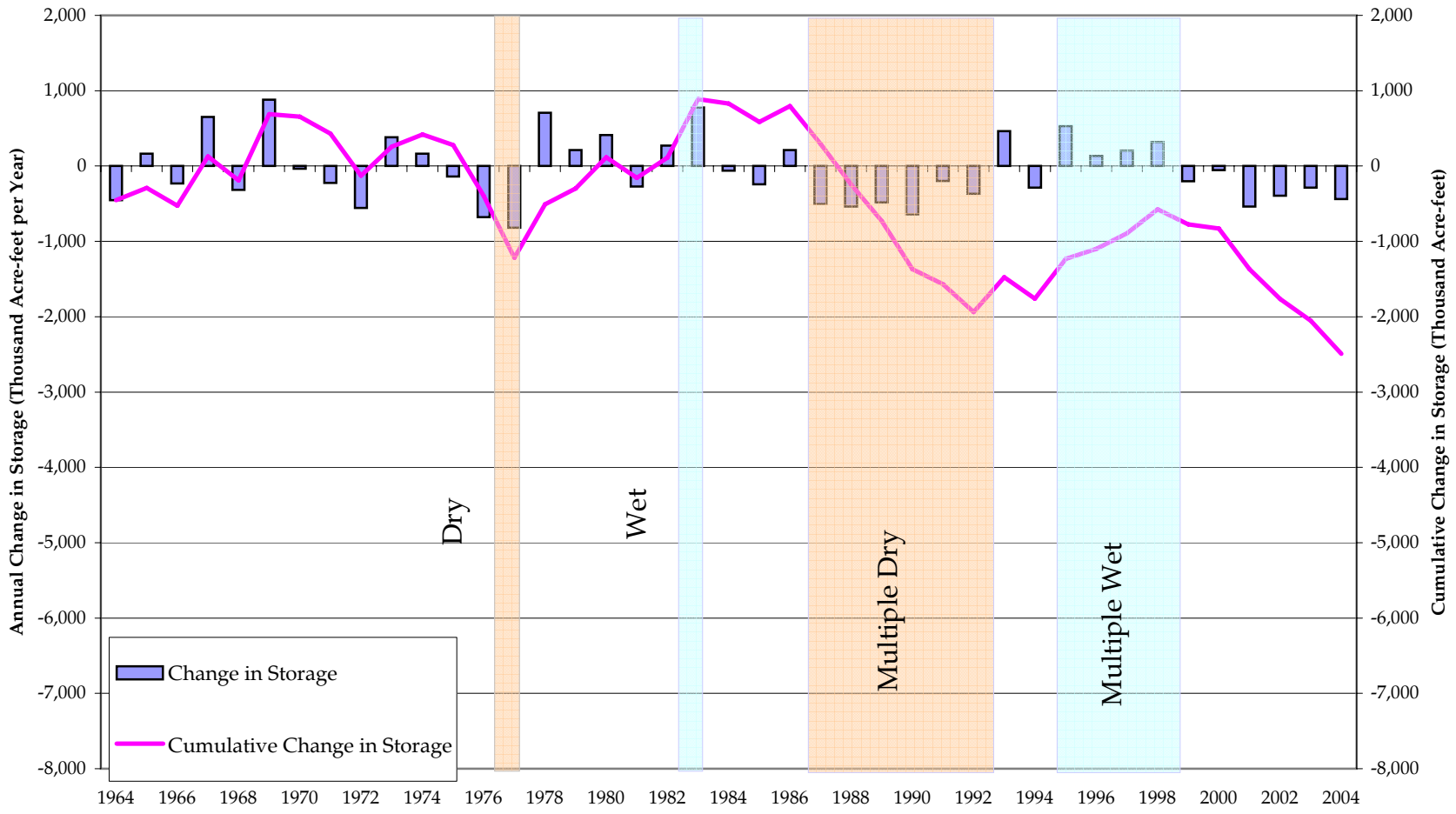


Change in Storage in Fresno SOI (Sum of 3 Model Layers)

Kings IGSM Model Development and Calibration

July 2007

FIGURE 6-11

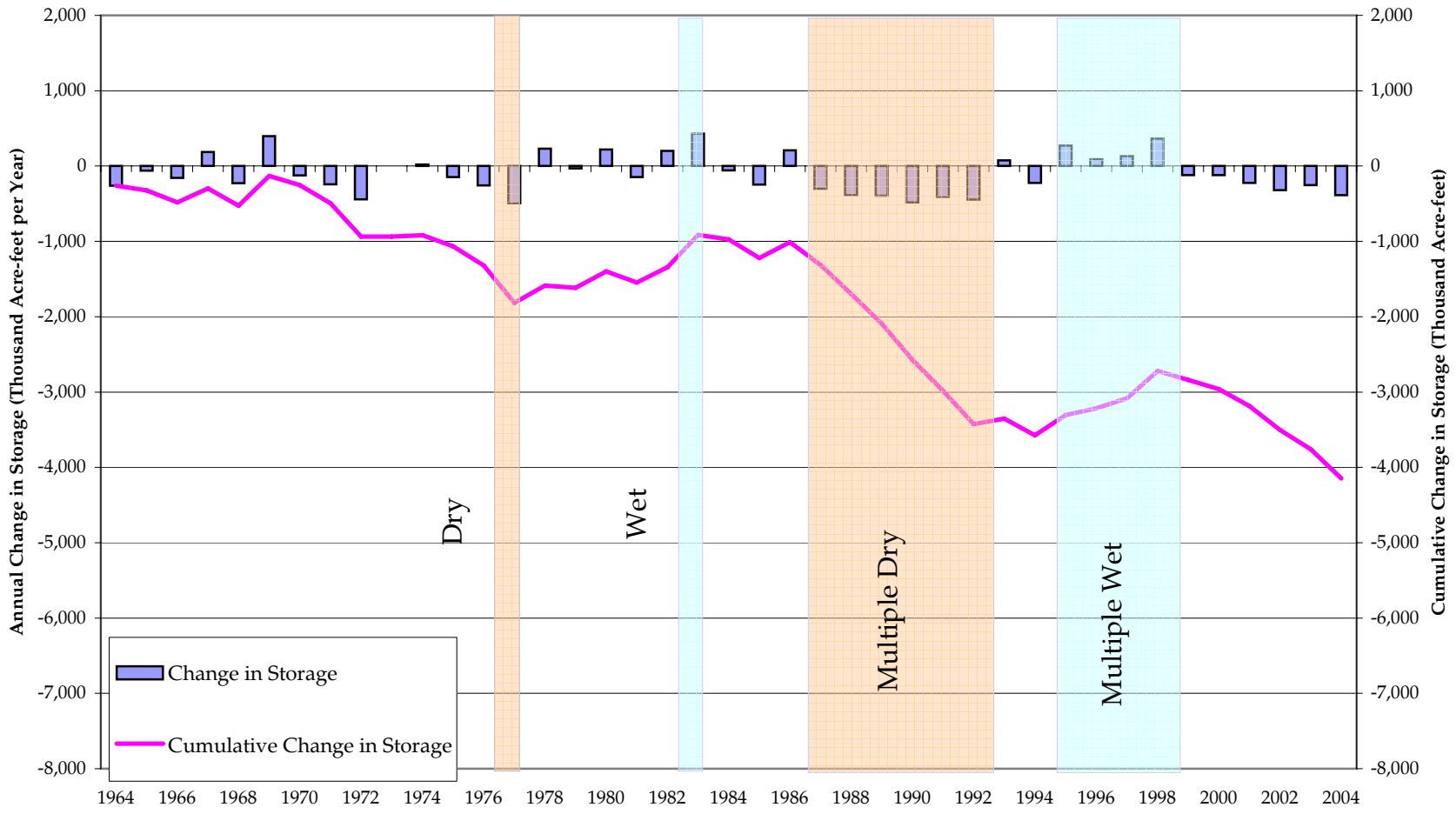


Change in Storage in Upper Kings Basin (Sum of 3 Model Layers)

Kings IGSM Model Development and Calibration

July 2007

FIGURE 6-12a

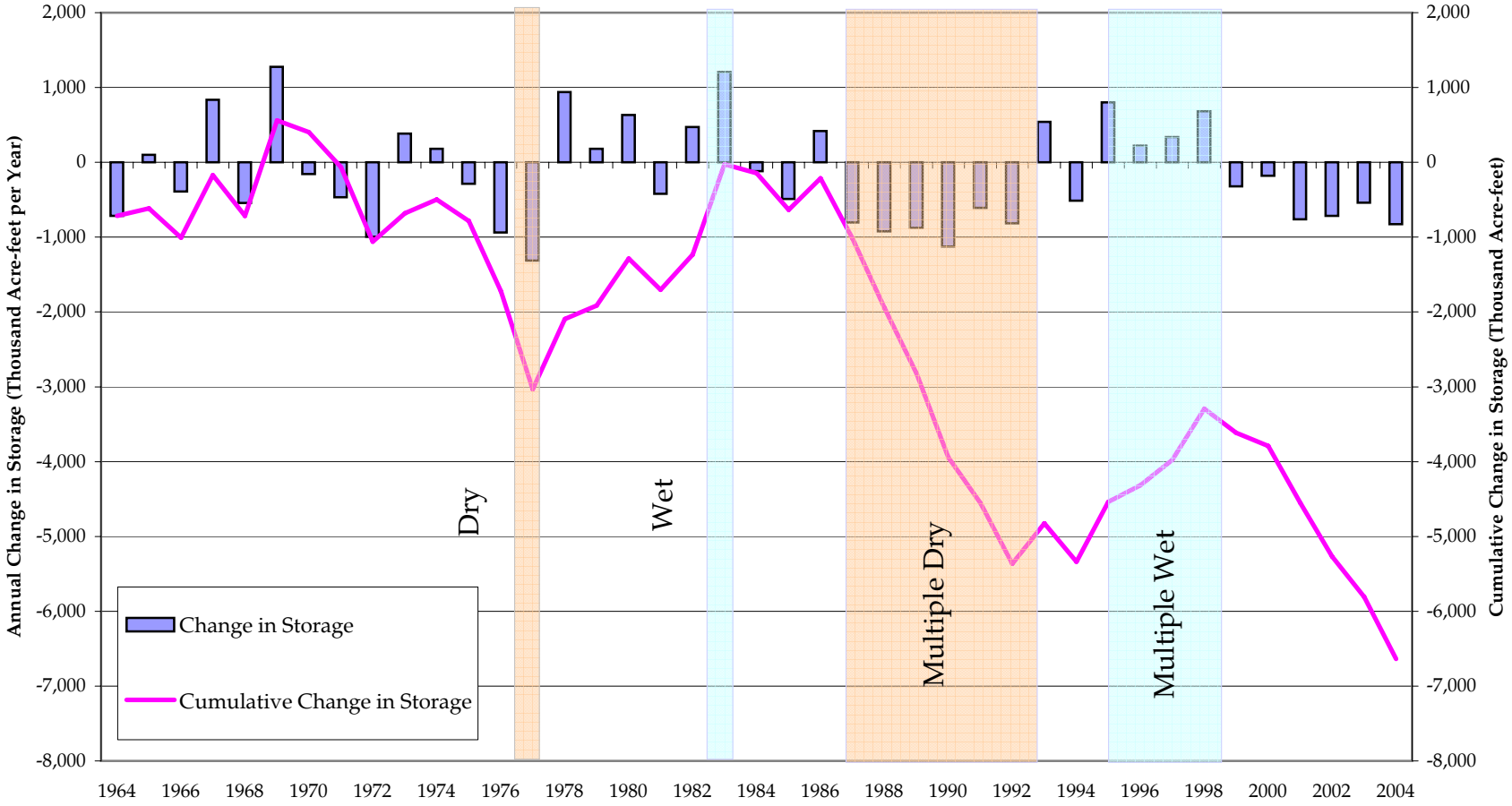


Change in Storage in Lower Kings Basin (Sum of 3 Model Layers)

Kings IGSM Model Development and Calibration

July 2007

FIGURE 6-12b

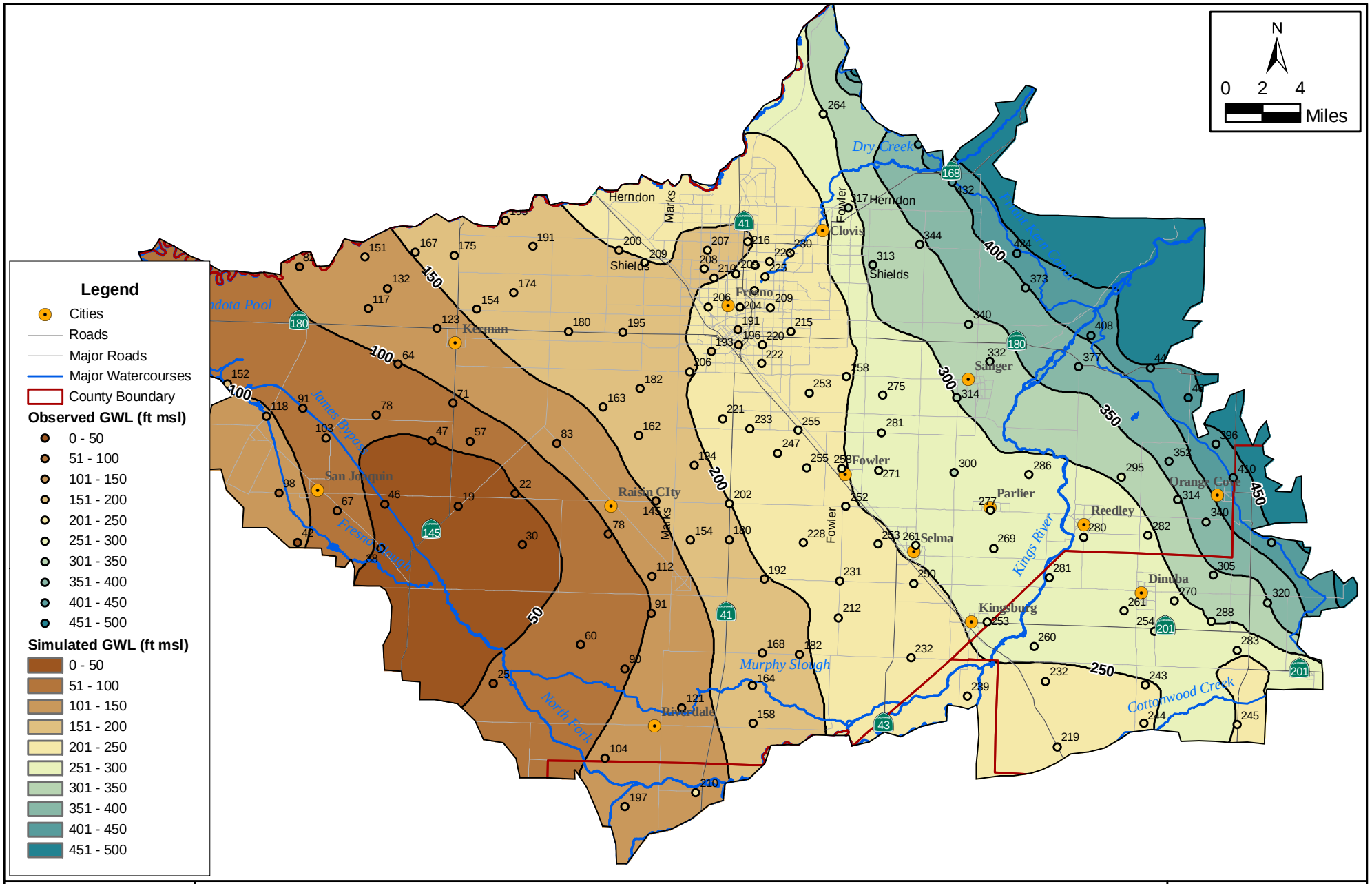


Change in Storage in Kings Basin (Sum of 3 Model Layers)

Kings IGSM Model Development and Calibration

July 2007

FIGURE 6-13



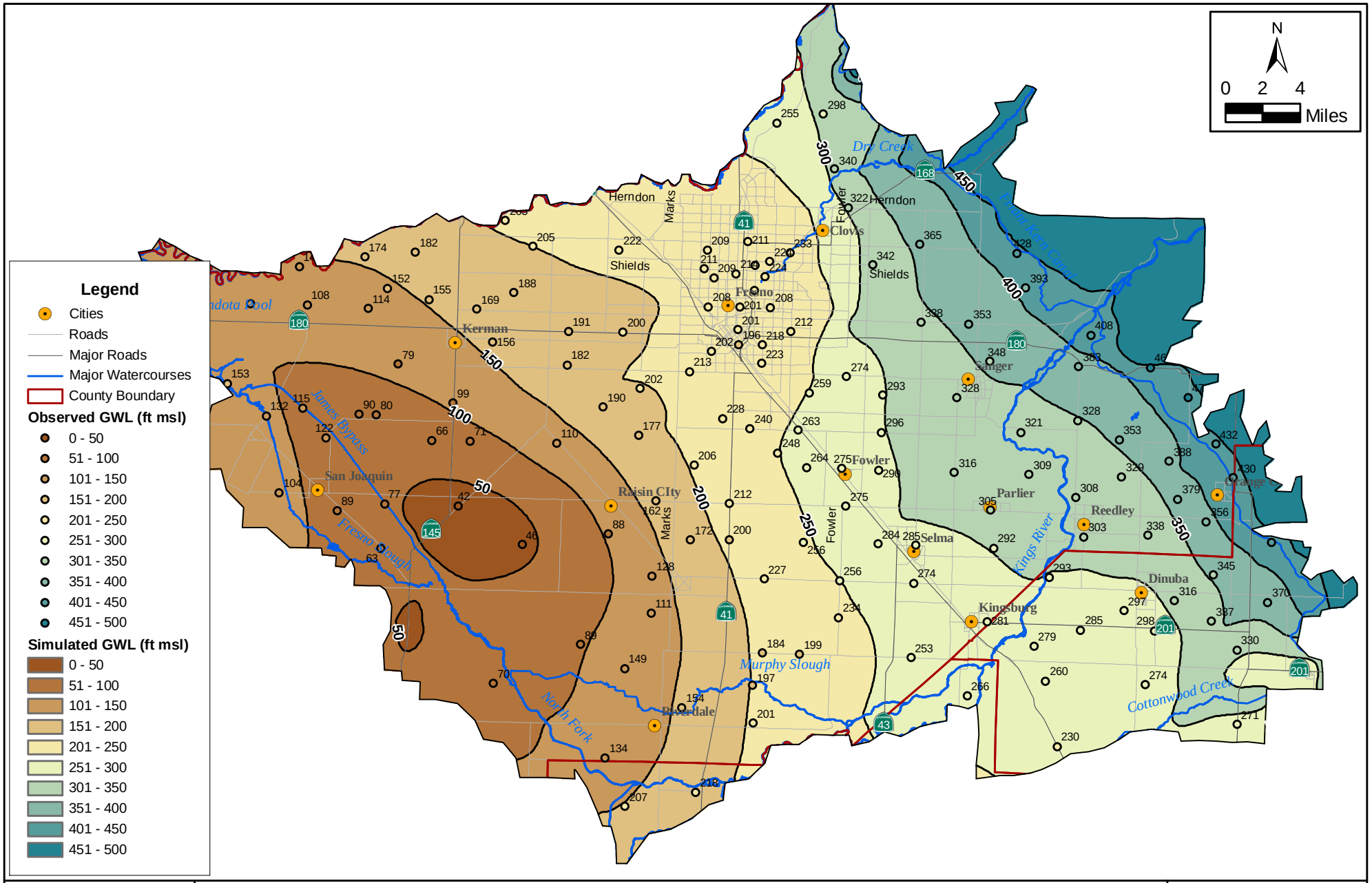
Observed and Simulated Groundwater Levels (Fall 1977 - Dry Conditions)

Kings IGSM Model Development and Calibration

Simulated groundwater levels are an average of model layers 1 and 2

July 2007

Figure 6-14



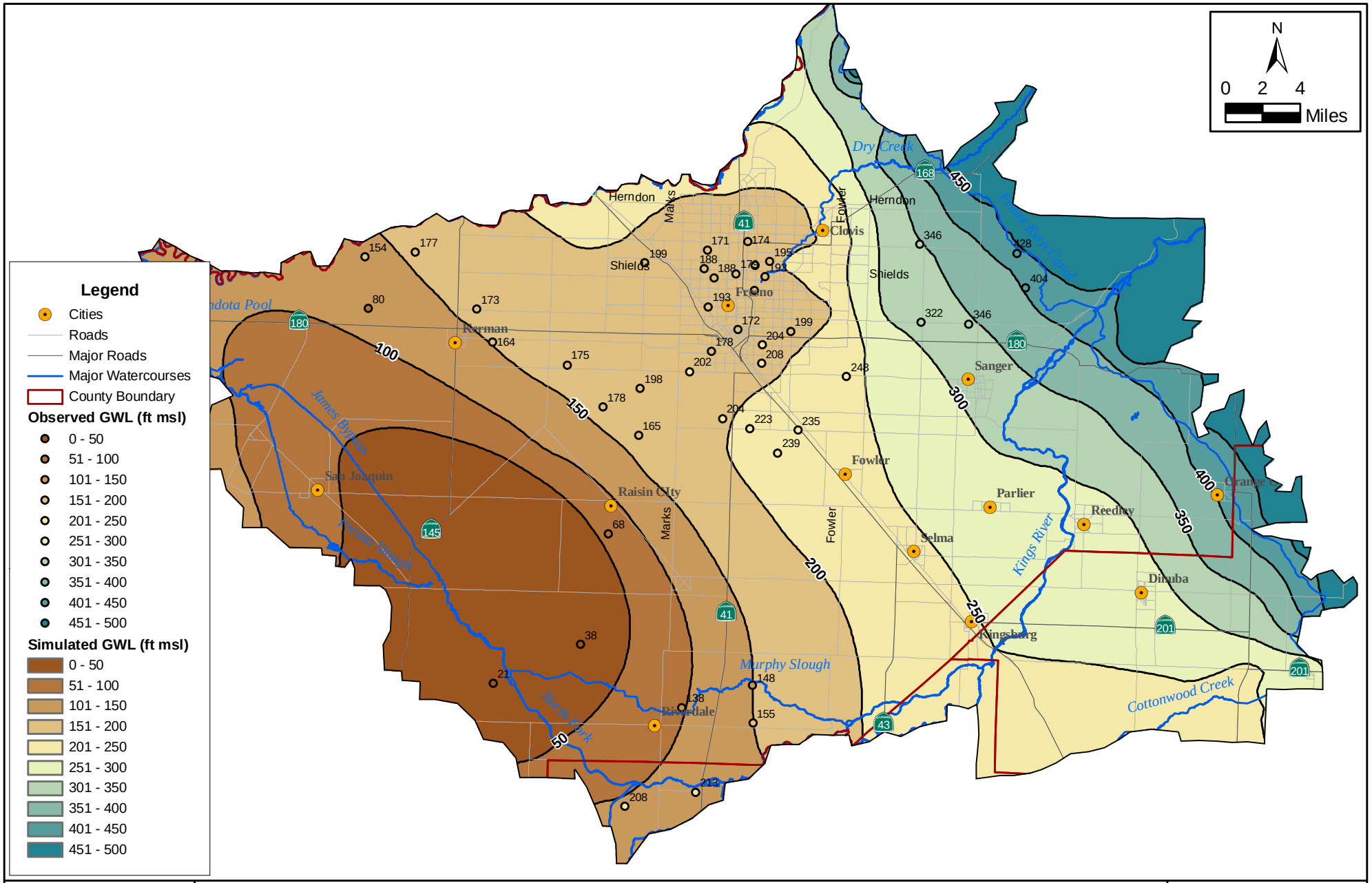
Observed and Simulated Groundwater Levels (Spring 1983 - Wet Conditions)

Kings IGSM Model Development and Calibration

Simulated groundwater levels are an average of model layers 1 and 2

July 2007

Figure 6-15



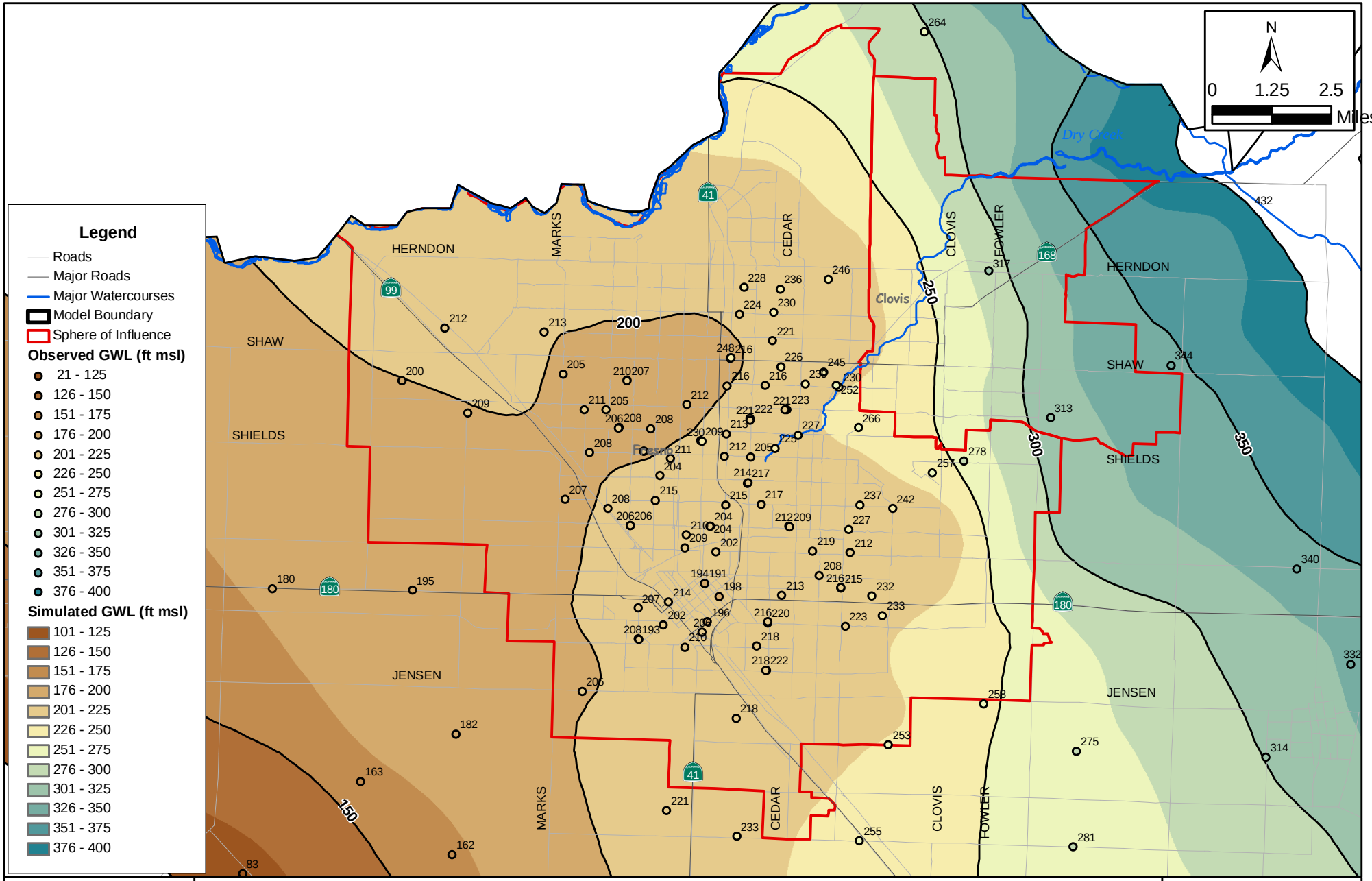
Observed and Simulated Groundwater Levels (Spring 2004 - Normal Conditions)

Kings IGSM Model Development and Calibration

Simulated groundwater levels are an average of model layers 1 and 2

July 2007

Figure 6-16



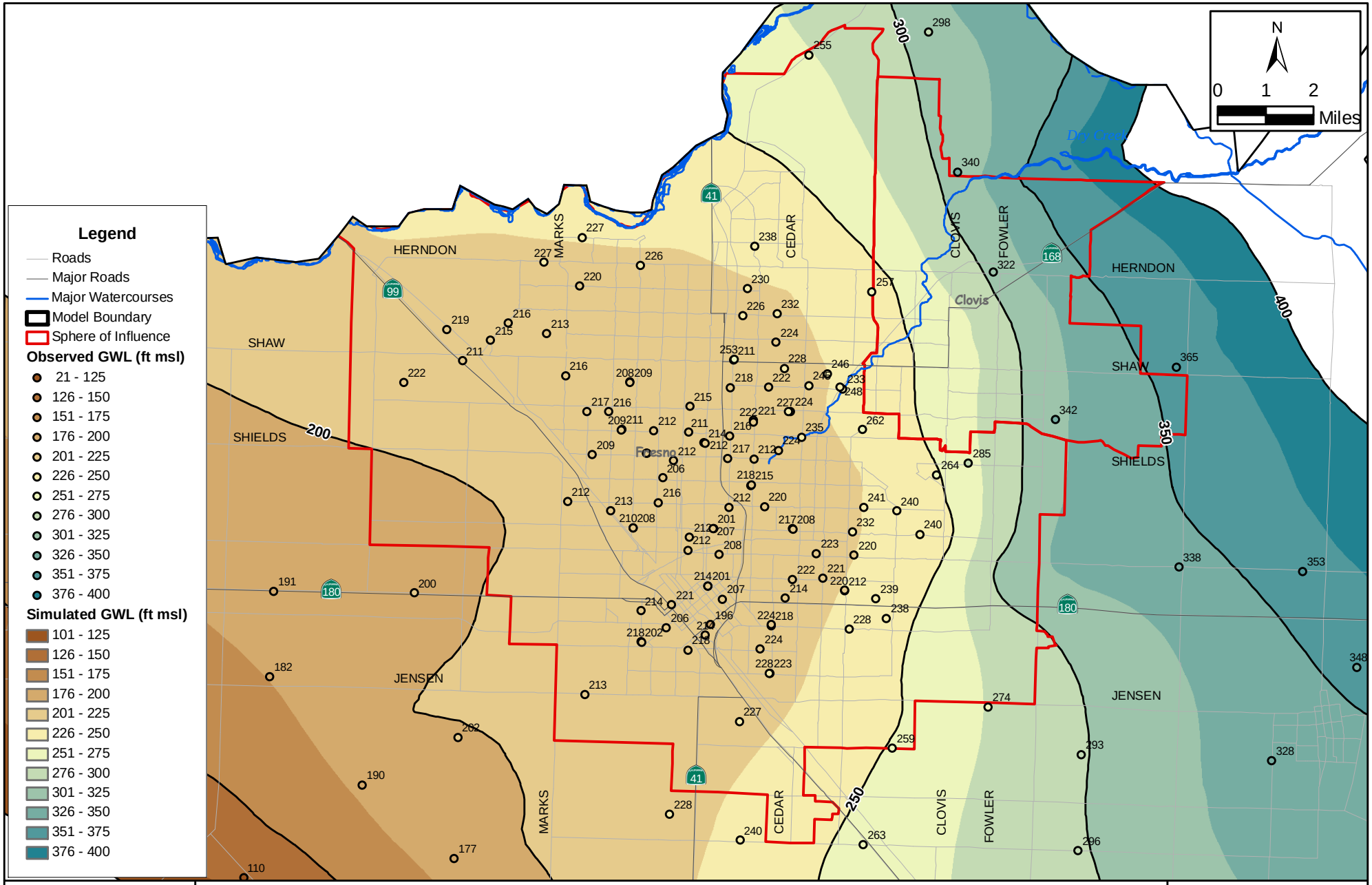
Observed and Simulated Groundwater Levels in Fresno (Fall 1977 - Dry Conditions)

Kings IGSM Model Development and Calibration

Simulated groundwater levels are an average of model layers 1 and 2

July 2007

Figure 6-17



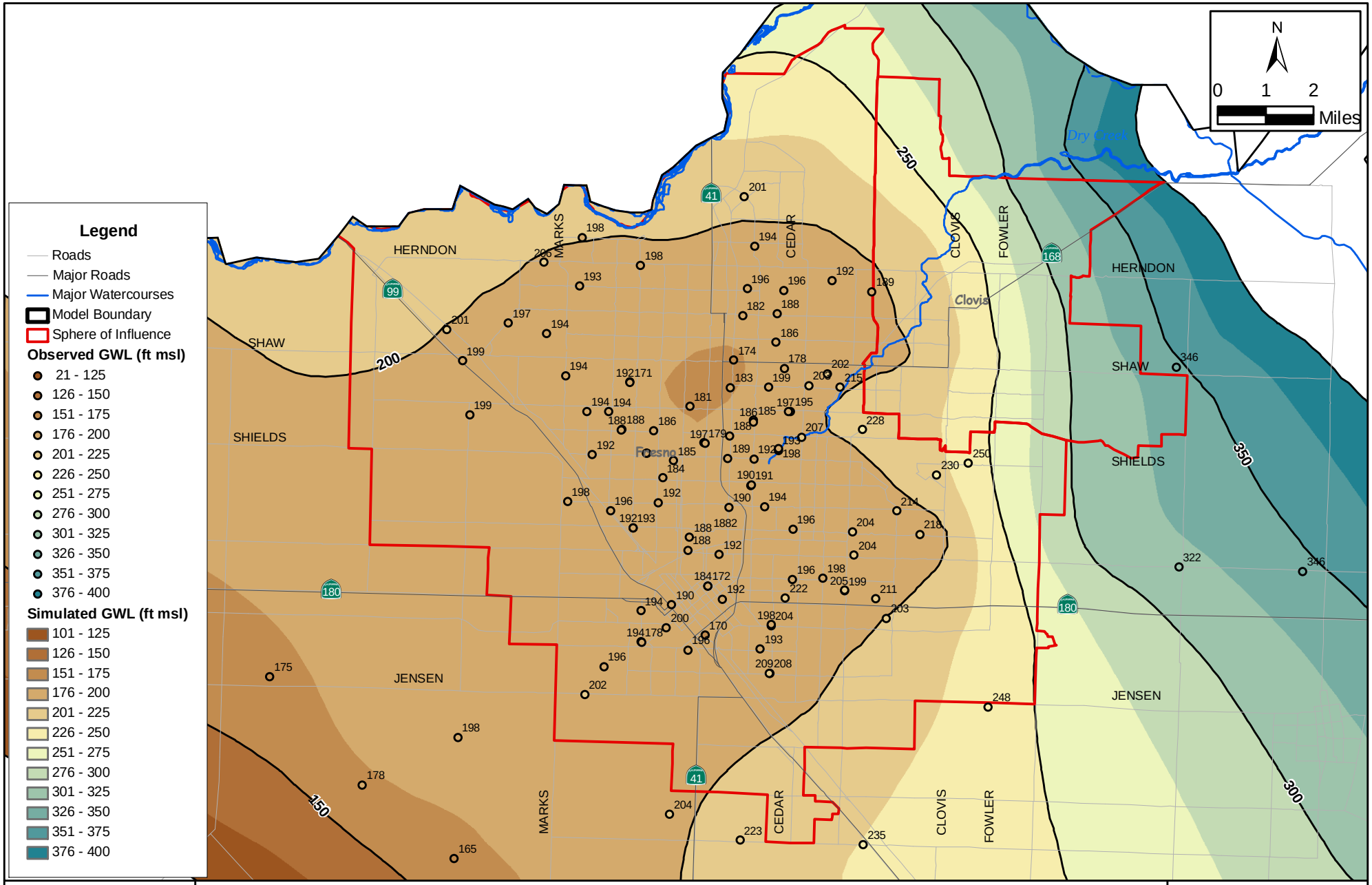
Observed and Simulated Groundwater Levels in Fresno (Spring 1983 - Wet Conditions)

Kings IGSM Model Development and Calibration

Simulated groundwater levels are an average of model layers 1 and 2

July 2007

Figure 6-18



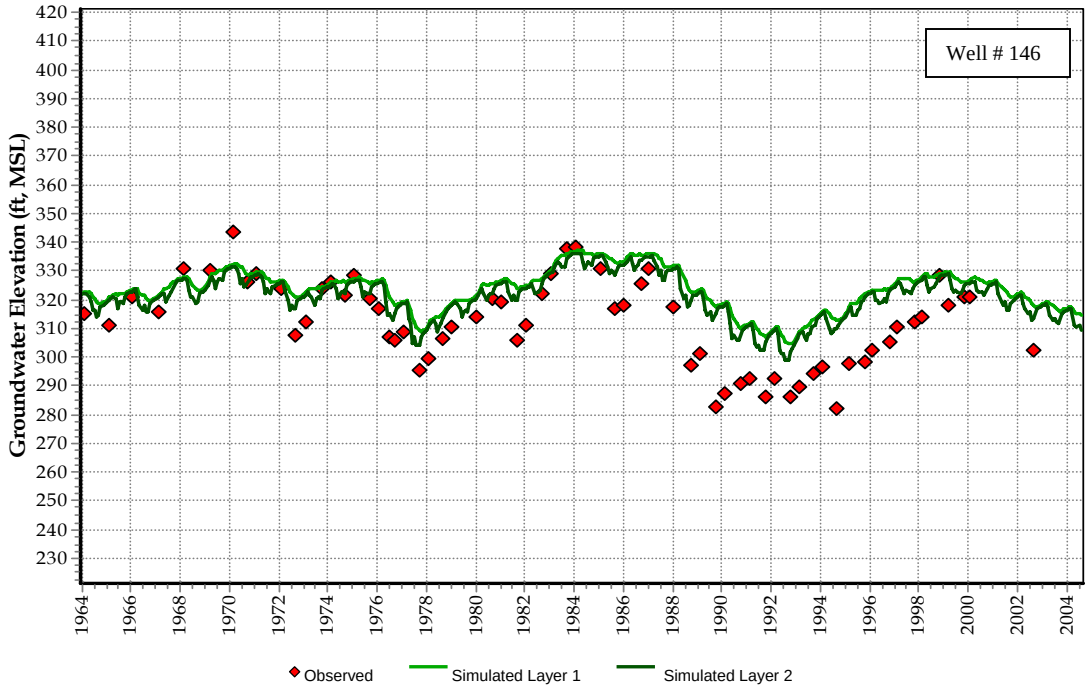
Observed and Simulated Groundwater Levels in Fresno (Spring 2004 - Normal Hydrology)

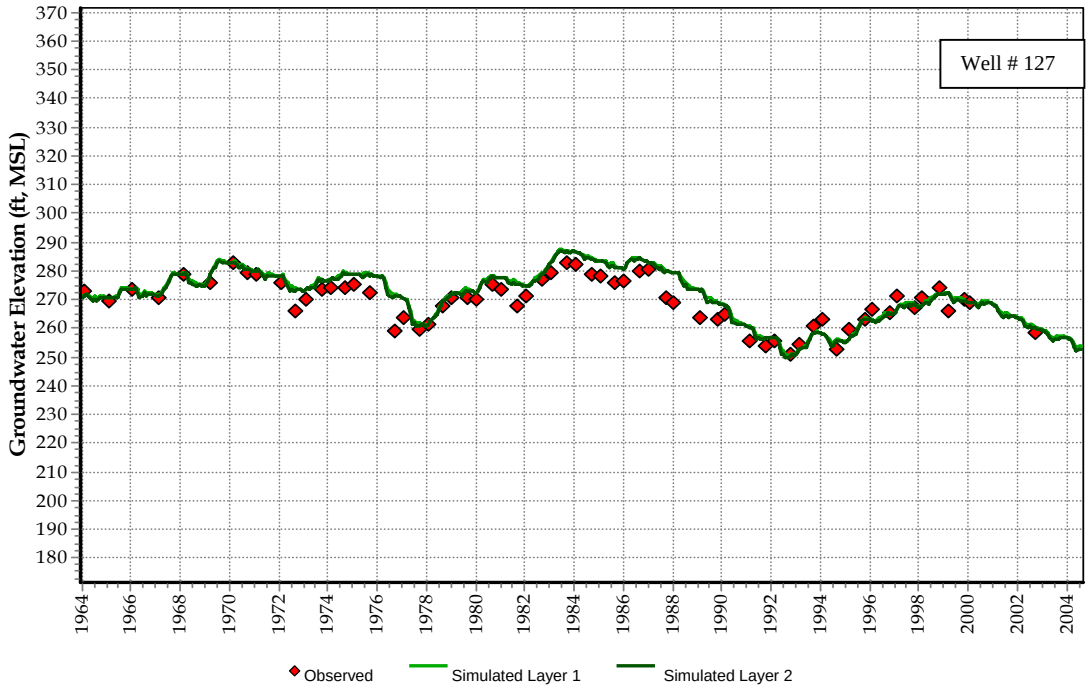
Kings IGSM Model Development and Calibration

Simulated groundwater levels are an average of model layers 1 and 2

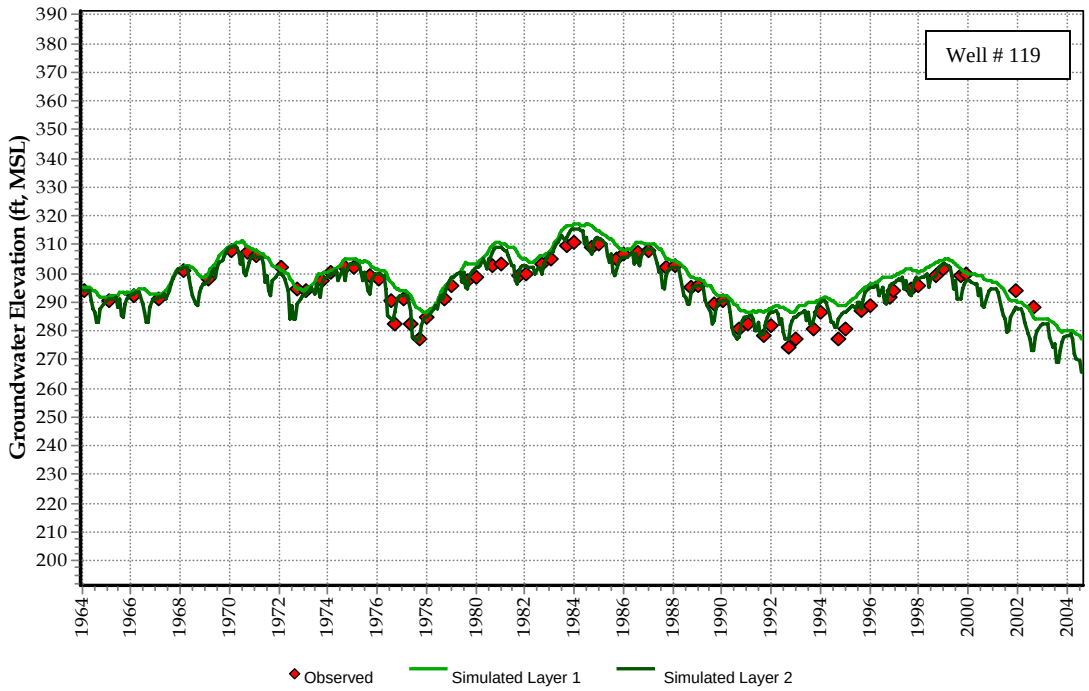
July 2007

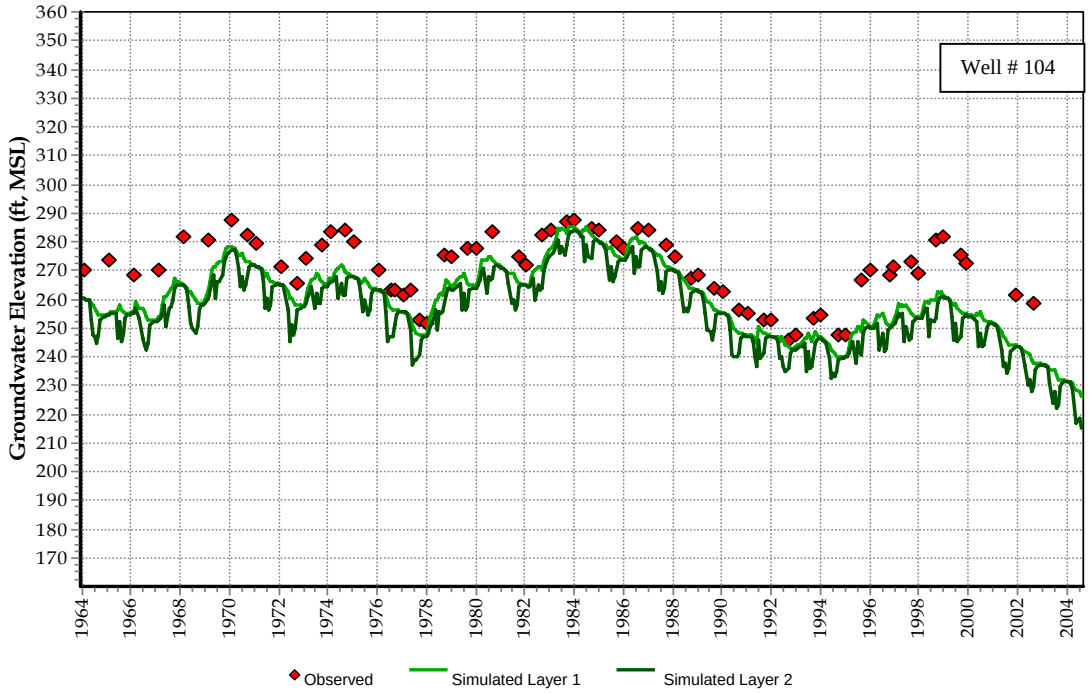
Figure 6-19



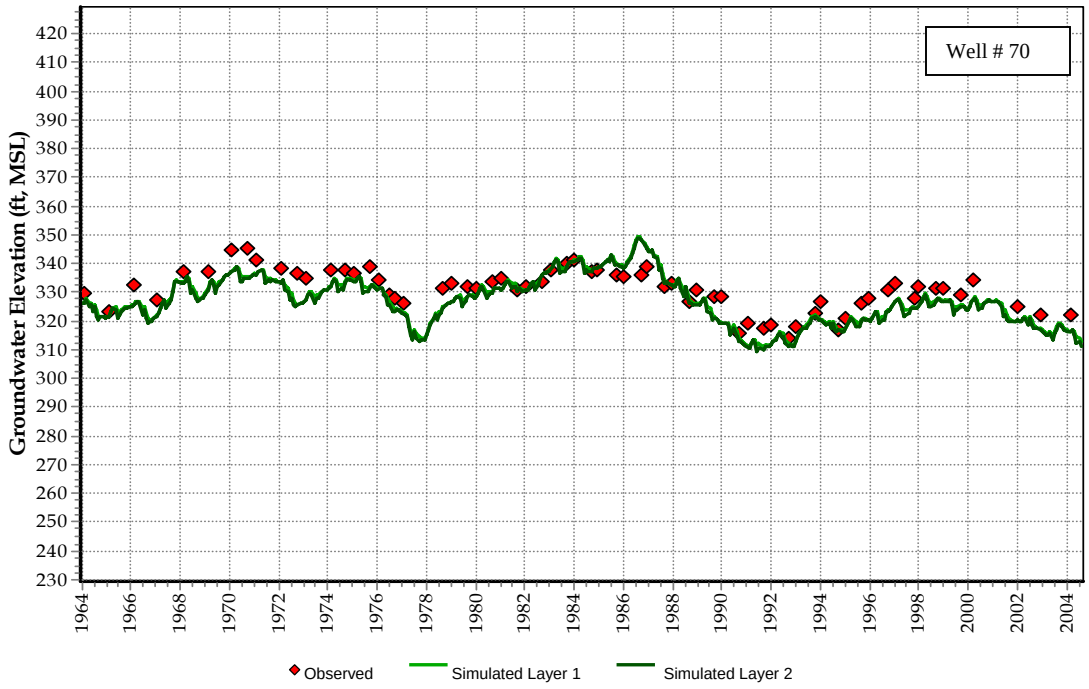


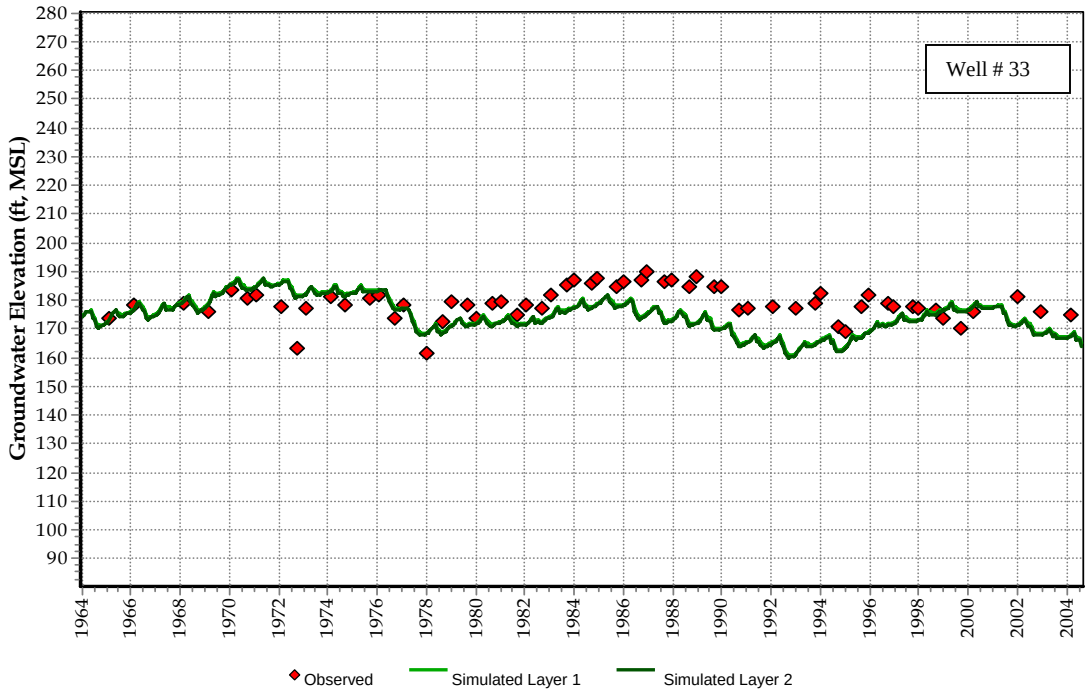
RIME	**Representative Hydrograph for AID** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-20**



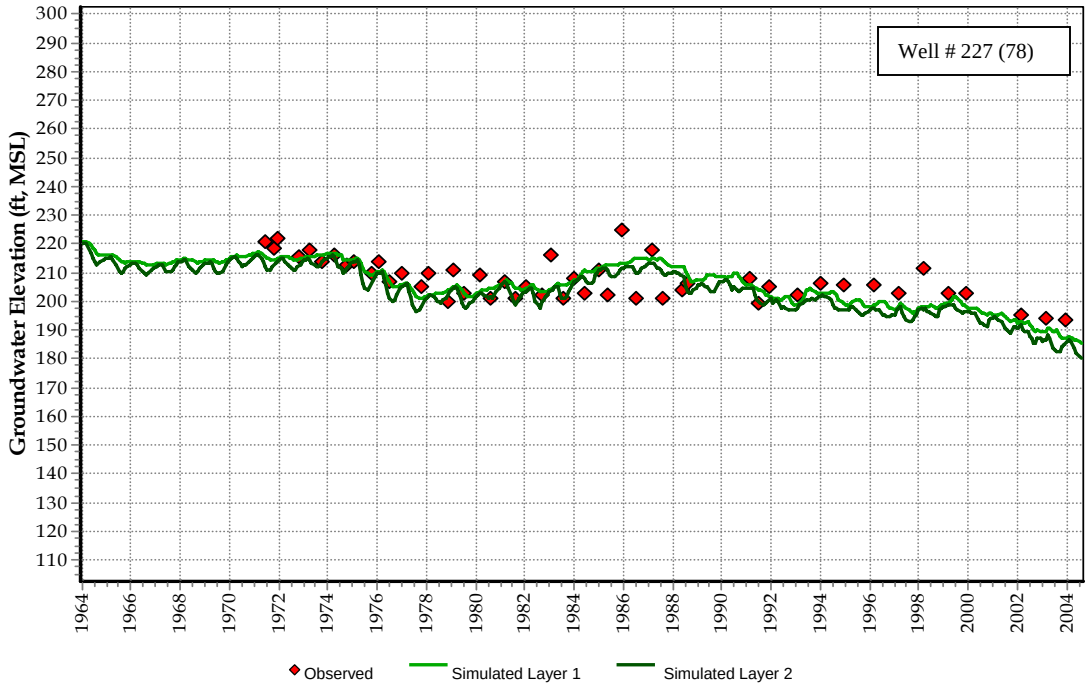


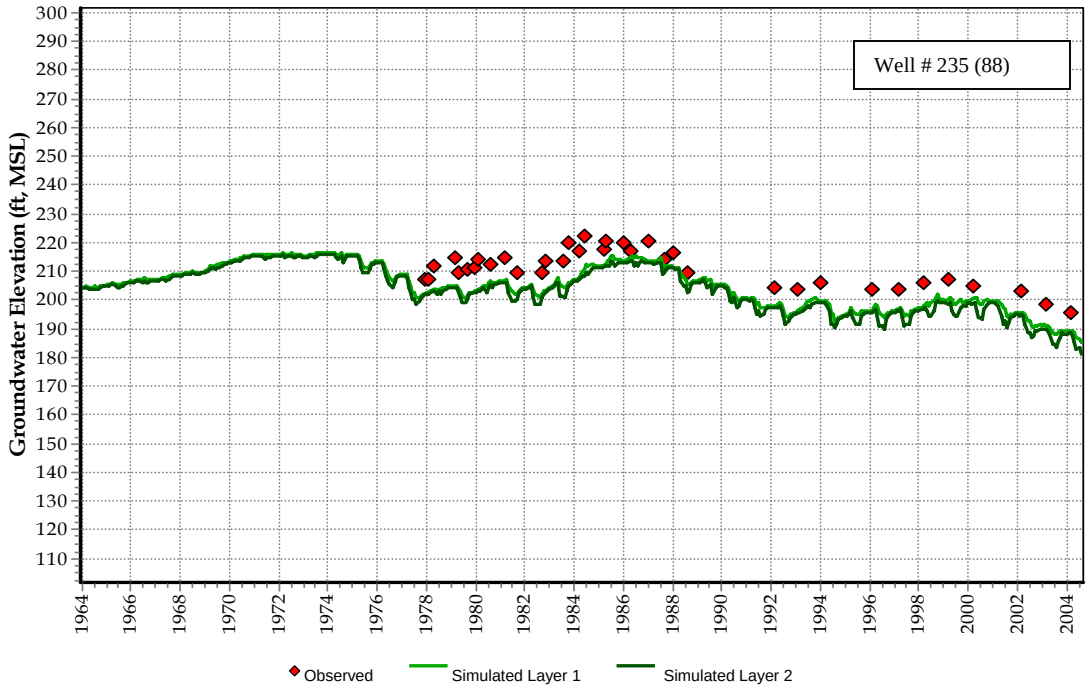
RIME	**Representative Hydrograph for CID** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-21**



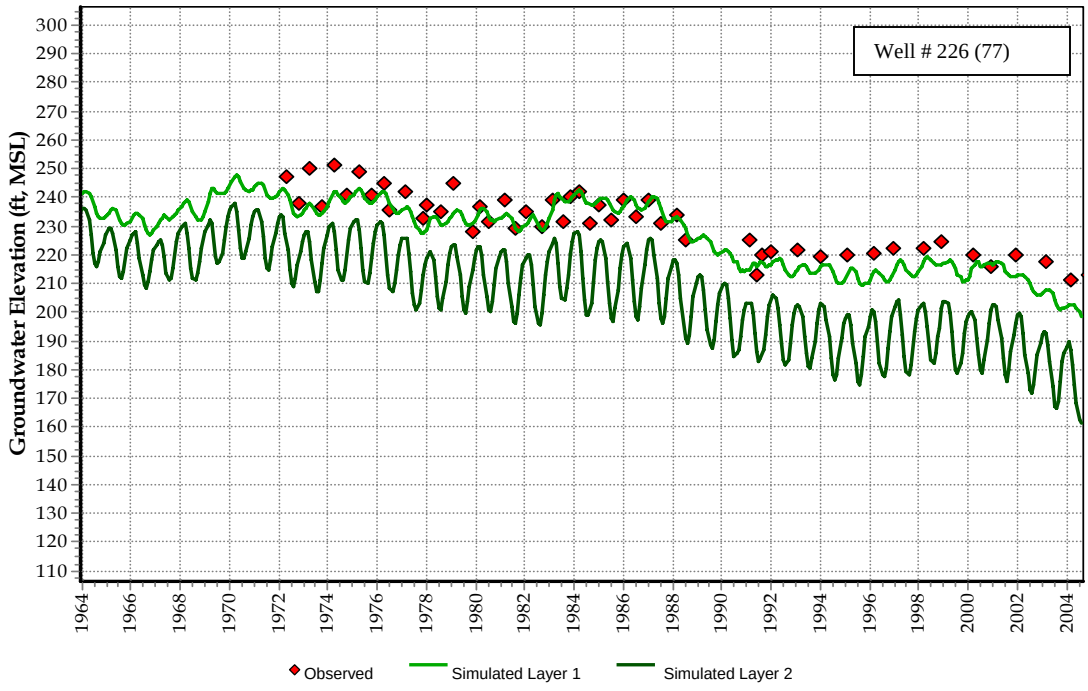


RIME	**Representative Hydrograph for FID** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-22**

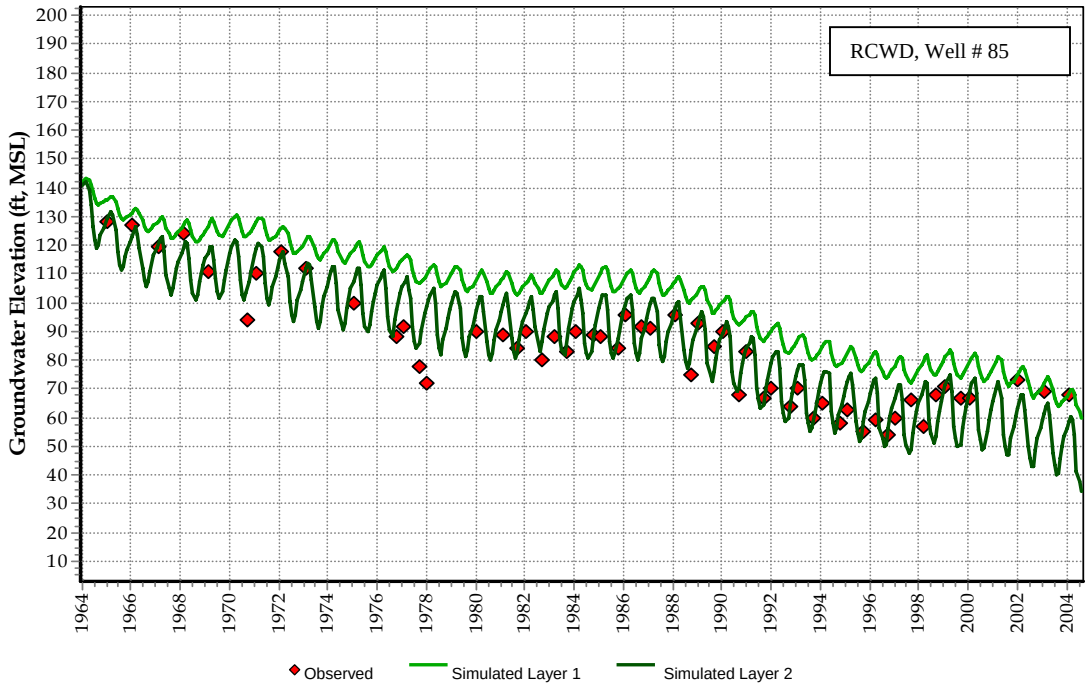


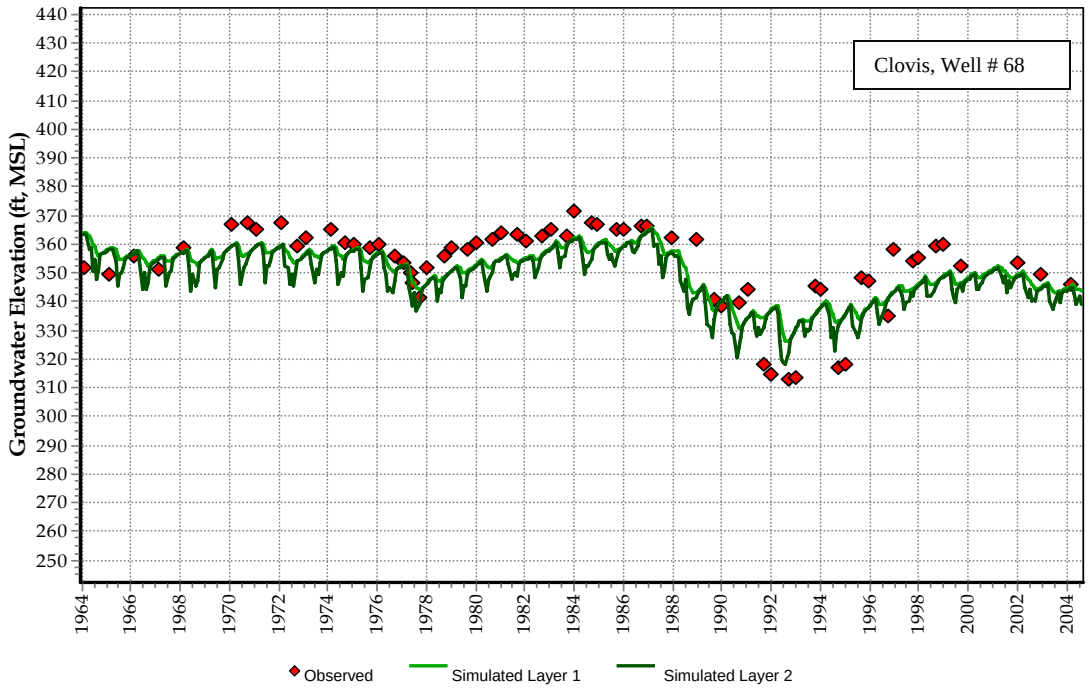


RIME	**Representative Hydrograph for Fresno** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-23**

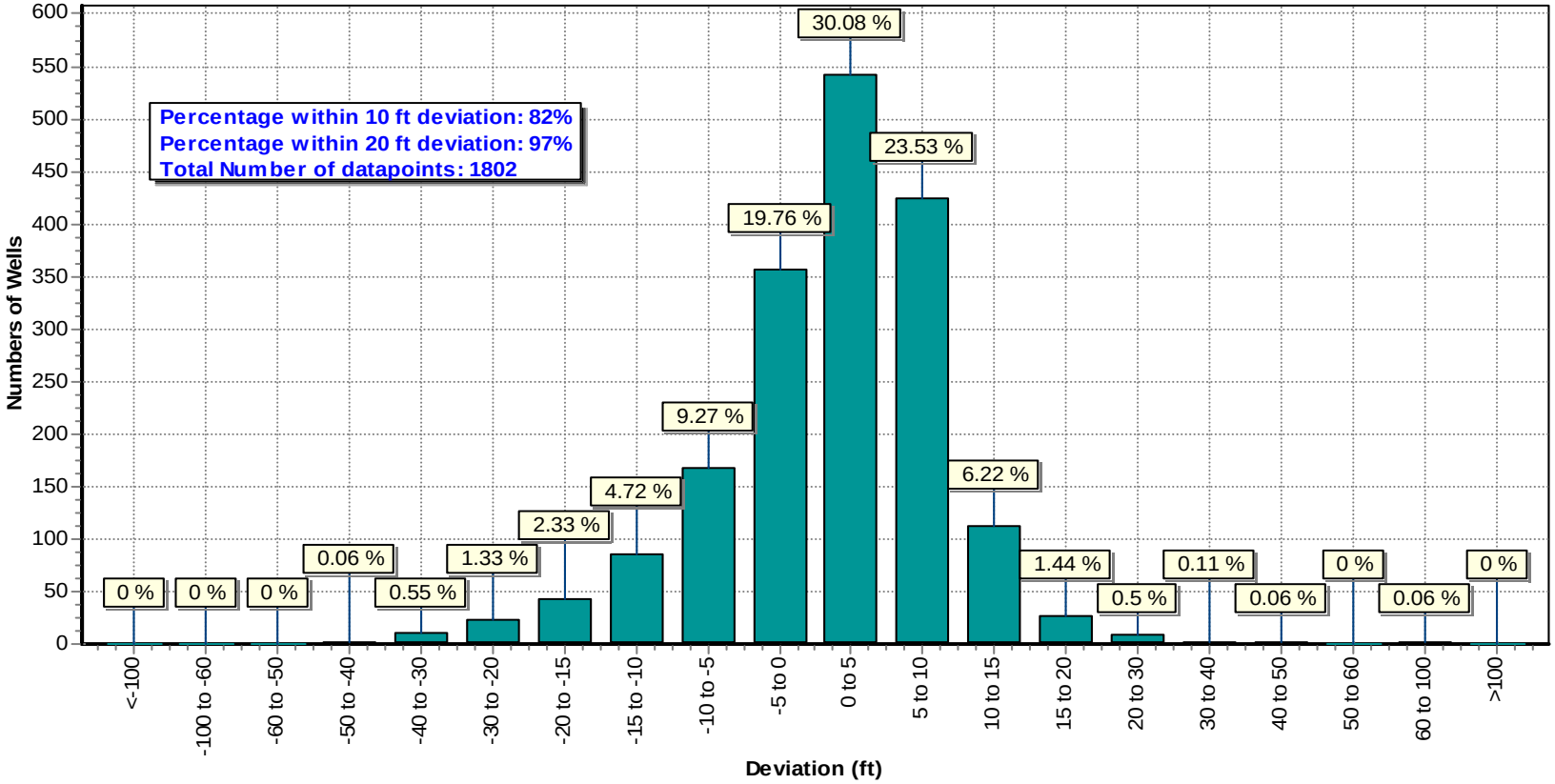


RIME	**Representative Hydrograph for Fresno** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-24**

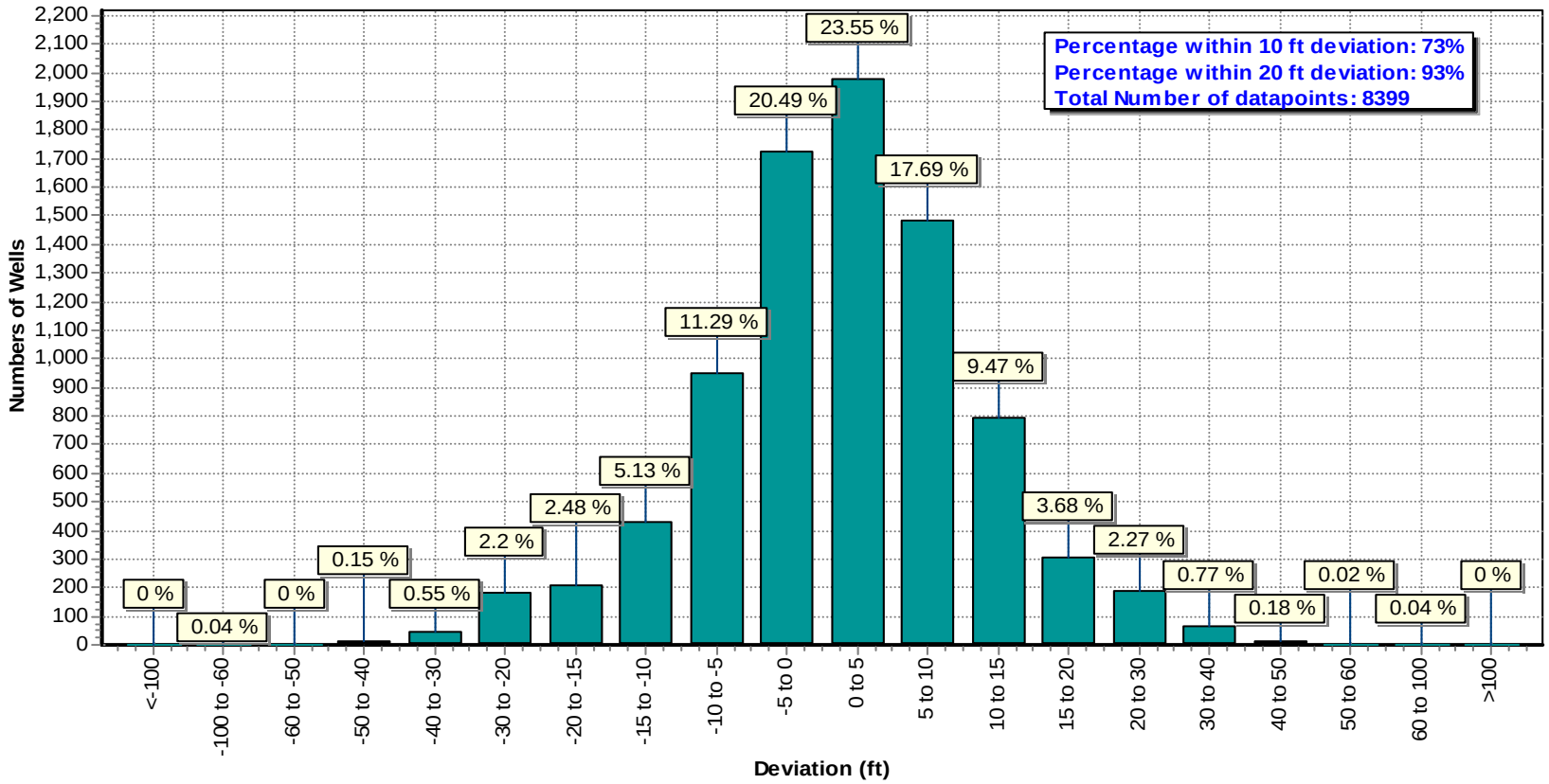




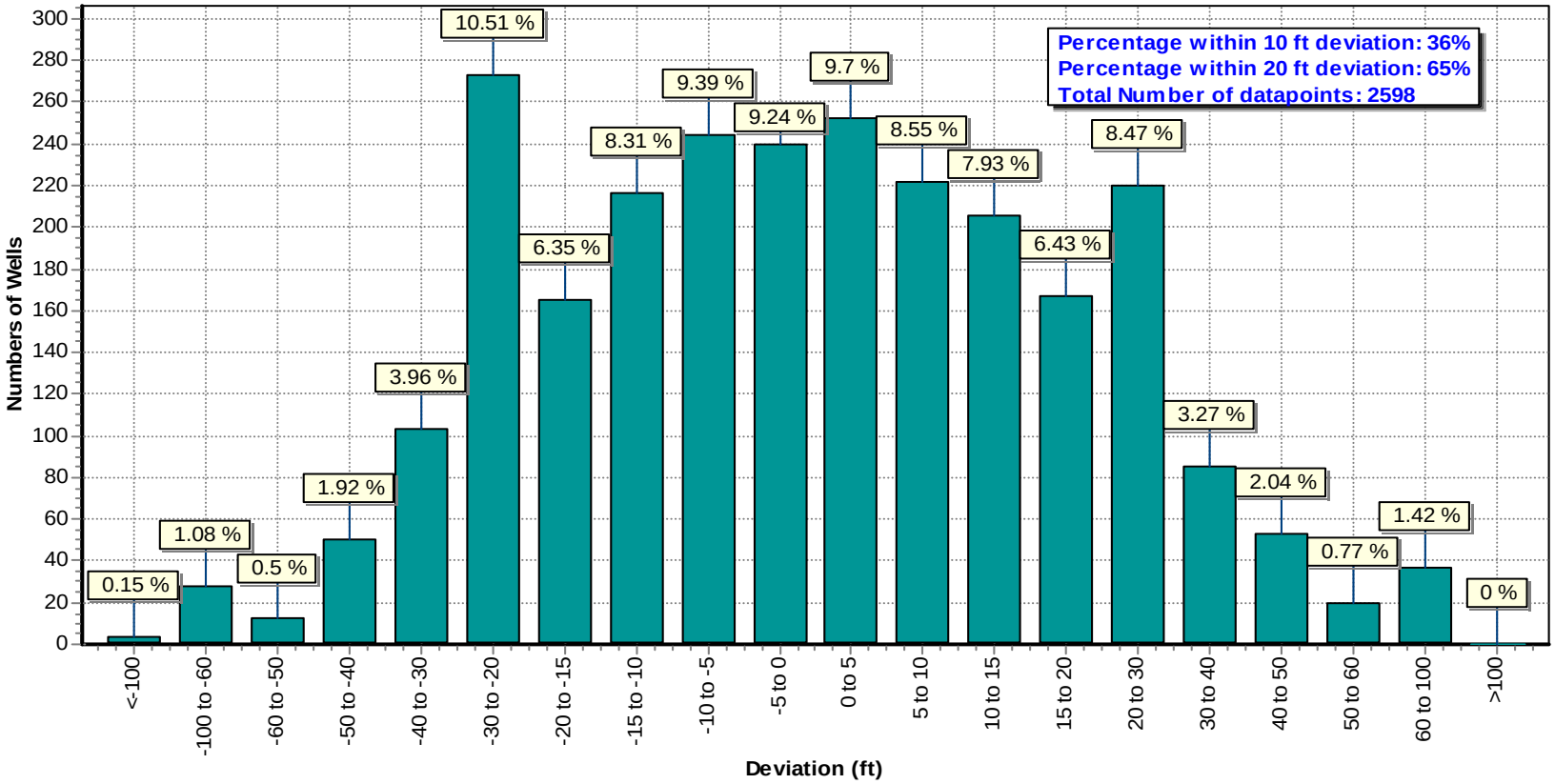
RIME	**Representative Hydrograph for RCWD and Clovis** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-25**



ORIME	**Histogram of Deviations between Simulated and Observed Groundwater Levels in the Fresno SOI** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-26**



RIME	**Histogram of Deviations between Simulated and Observed Groundwater Levels in the Upper Kings Basin** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-27**



RIME	**Histogram of Deviations between Simulated and Observed Groundwater Levels in the Lower Kings Basin** Kings IGSM Model Development and Calibration	**July 2007** **FIGURE 6-28**

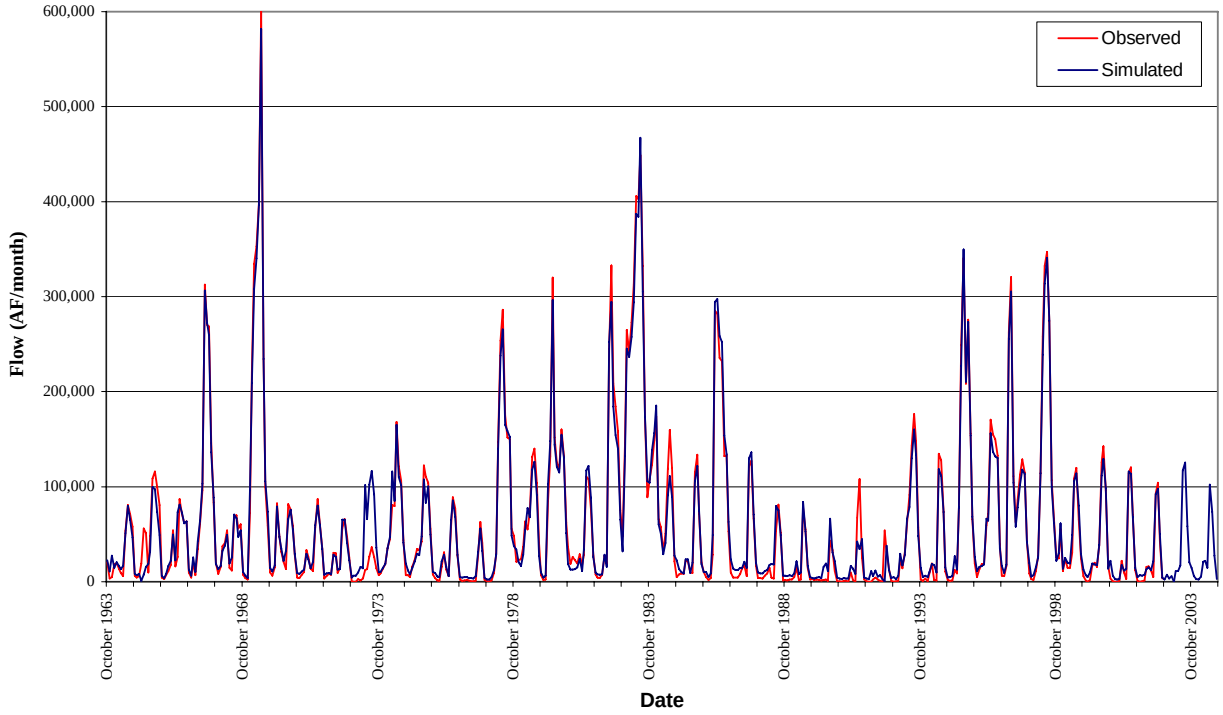


Figure 6-29. Simulated and Observed Kings River Hydrograph Below Peoples Weir

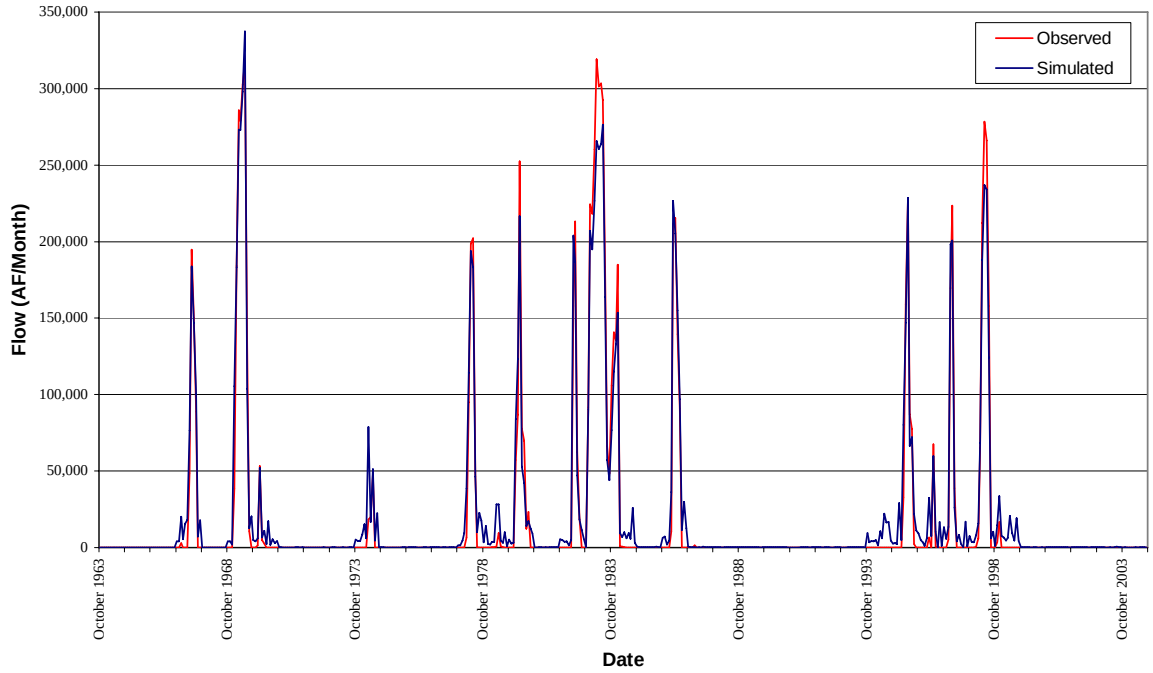


Figure 6-30. Simulated and Observed Kings River Hydrograph Below James Weir

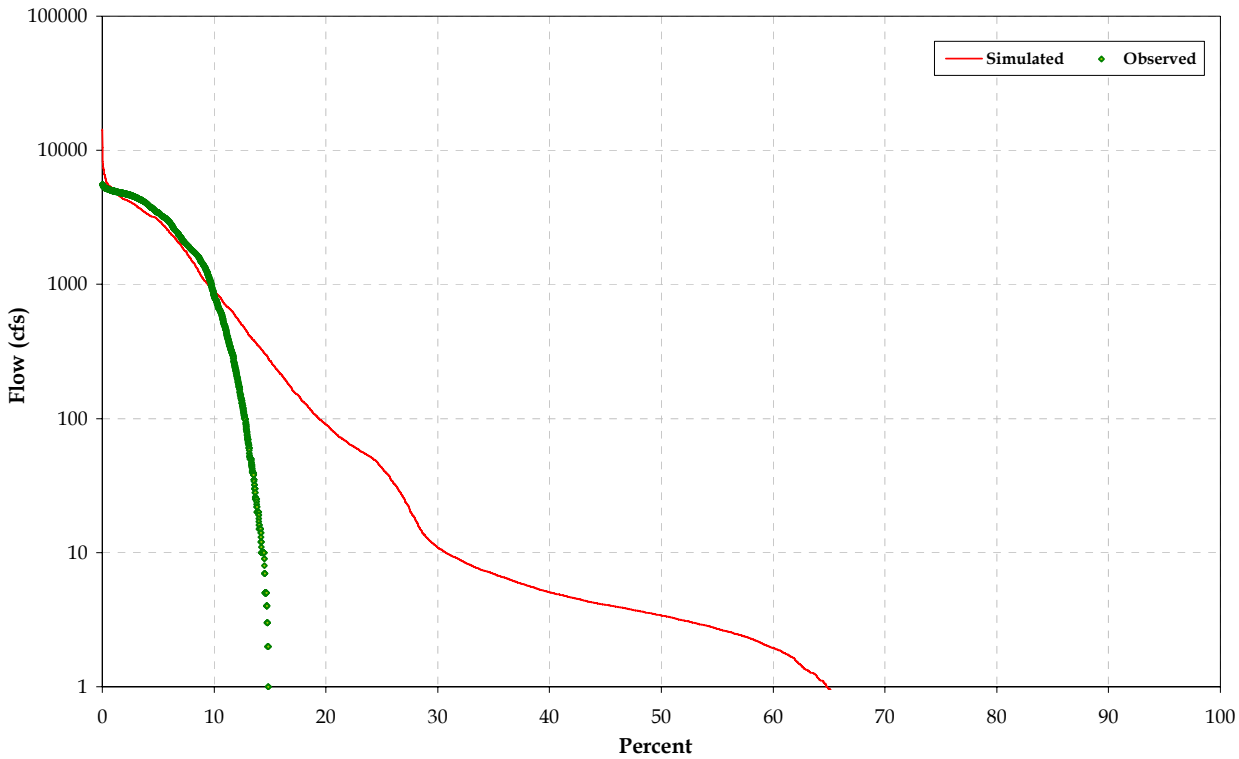


Figure 6-31. Exceedance Chart for Kings River Below James Weir

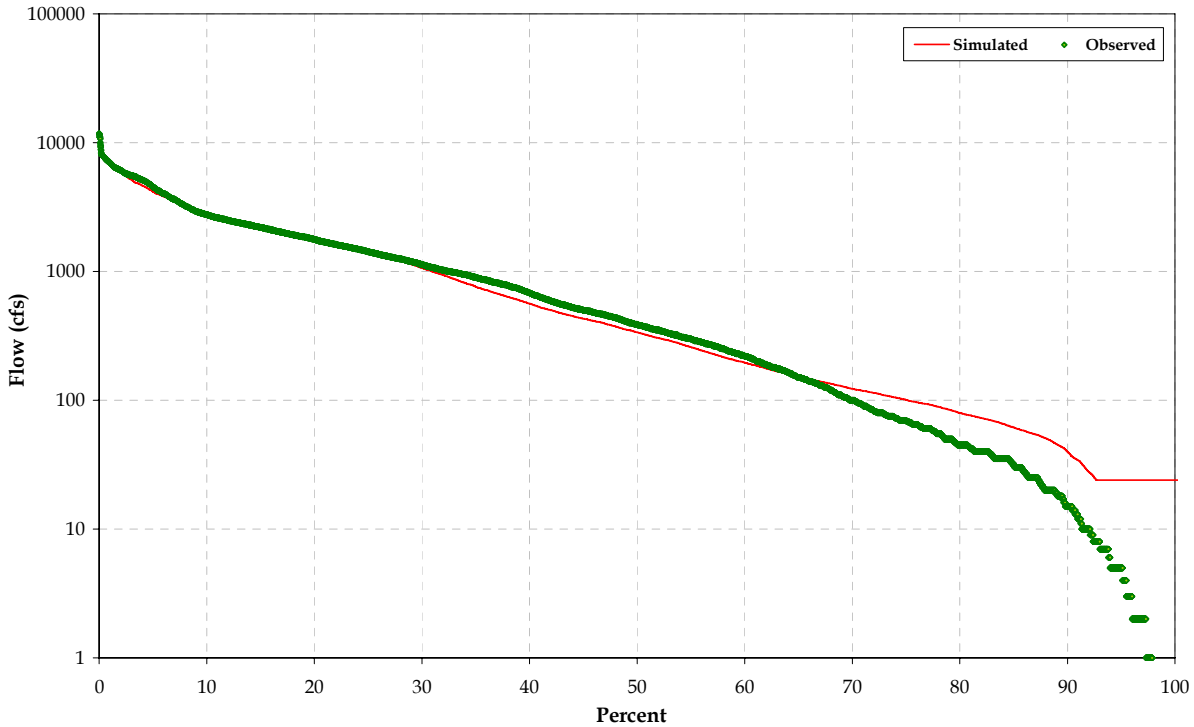


Figure 6-32. Exceedance Chart for Kings River Below Peoples Weir

Table 6-1a. Model Calibration Wells – DWR Wells

Well ID	Model Well ID	Well ID	Model Well ID	Well ID	Model Well ID
13S16E27C01M	1	13S20E27J01M	53	16S20E14A01M	105
13S17E19H01M	2	13S20E32L02M	54	16S21E15D01M	106
14S16E06A01M	3	13S20E34M01M	55	16S20E22N01M	107
14S16E03A01M	4	13S20E35H02M	56	16S22E18A01M	108
14S15E25H01M	5	14S20E03M01M	57	16S21E22N01M	109
14S16E35M01M	6	14S20E01J01M	58	17S22E11P01M	110
14S16E33N01M	7	14S20E10M01M	59	14S22E14B01M	111
15S16E12C01M	8	14S20E08R01M	60	14S21E25D01M	112
15S16E28A02M	9	14S20E11F01M	61	14S22E22N01M	113
15S16E25R01M	10	14S20E19B01M	62	15S21E02A01M	114
15S17E28K01M	11	14S20E14F01M	63	15S21E15D01M	115
16S16E02M01M	12	12S21E20Q01M	64	15S21E14A01M	116
16S17E04P01M	13	12S21E33P01M	65	15S22E16A01M	117
14S17E31R01M	14	13S21E23D01M	66	15S23E07R01M	118
14S17E05D01M	15	12S22E29H01M	67	15S22E23R01M	119
14S17E21A01M	16	13S22E07R01M	68	15S22E32N01M	120
14S17E32R01M	17	13S23E30C01M	69	15S22E36P01M	121
15S17E11A01M	18	14S22E06A01M	70	16S22E23R01M	122
15S18E07A02M	19	14S22E03B01M	71	14S23E31P01M	123
15S18E30L01M	20	14S21E22D01M	72	16S23E09E01M	124
13S18E09B01M	21	14S21E29D01M	73	16S24E19C01M	125
13S17E22B01M	22	12S20E11K02M	74	16S23E27H01M	126
13S17E24A01M	23	12S21E07A02M	75	16S23E32B01M	127
13S18E15J01M	24	12S22E18M01M	76	16S24E29A02M	128
13S17E33D01M	25	13S22E13A01M	77	17S23E09B01M	129
13S17E35L01M	26	17S18E09R01M	78	17S24E08A01M	130
13S18E34D01M	27	16S19E32P01M	79	17S22E25A01M	131
13S18E32N01M	28	17S19E10A01M	80	17S24E20A01M	132
14S17E11A01M	29	17S20E20D01M	81	17S23E27L01M	133
14S18E08J01M	30	15S18E12B01M	82	17S25E18R01M	134
14S19E07D01M	31	15S18E22P02M	83	16S24E12D02M	135
14S19E04R01M	32	16S18E03J01M	84	16S24E16H01M	136
14S18E13R01M	33	15S19E33Q01M	85	16S25E17H01M	137
14S17E36A01M	34	17S20E11J01M	86	16S24E23J01M	138
14S19E22R01M	35	17S20E24N01M	87	16S25E31C01M	139
14S19E33D01M	36	17S19E34N01M	88	16S25E34Q01M	140
14S20E33F01M	37	18S20E09M01M	89	14S23E02E01M	141
15S19E03J01M	38	18S19E14E01M	90	14S23E15C01M	142
14S20E34R01M	39	16S19E26A01M	91	14S23E34B01M	143
15S21E06C01M	40	17S20E01C01M	92	14S23E36R01M	144
15S20E12F01M	41	17S21E05C01M	93	15S24E09B01M	145
13S19E16K01M	42	17S22E05C01M	94	15S23E12R01M	146

Well ID	Model Well ID	Well ID	Model Well ID	Well ID	Model Well ID
13S20E10Q01M	43	15S20E17D01M	95	15S23E22B01M	147
13S20E17F01M	44	15S21E17D01M	96	15S24E22D01M	148
13S19E23E01M	45	15S19E24N01M	97	15S23E35D01M	149
13S20E20E01M	46	15S20E28A01M	98	15S24E32C01M	150
13S20E13J01M	47	15S21E27D01M	99	14S24E17C01M	151
13S20E23B01M	48	16S20E06A01M	100	14S24E22L01M	152
13S20E22A01M	49	15S20E34N01M	101	14S24E35R01M	153
13S20E20R01M	50	16S21E06A01M	102	15S24E12R01M	154
13S20E21J01M	51	16S19E14A01M	103	15S24E26B01M	155
13S20E23Q01M	52	15S21E35R01M	104	15S25E33D01M	156

Table 6-1b. Model Calibration Wells - Fresno Wells

Well ID	Model Well ID		Well ID	Model Well ID
1A	157		51	200
2A	158		52	201
3	159		53	202
4A	160		54	203
5A	161		55	204
8A	162		56	205
9A	163		57	206
10A	164		58	207
11A	165		59	208
12A	166		60	209
13A	167		61	210
14A	168		62	211
16A	169		63	212
17	170		64	213
19A	171		65	214
20	172		66	215
21A	173		67	216
22A	174		68	217
24A	175		69	218
25	176		70	219
26A	177		71	220
27A	178		72	221
28A	179		73	222
30A	180		74	223
31	181		75	224
32	182		76	225
33A	183		77	226
34A	184		78	227
35A	185		79	228
36	186		80	229
37	187		81	230
38A	188		82	231
39A	189		84	232
40A	190		85	233
41	191		87	234
42	192		88	235
43	193		90	236
45	194		91	237
46	195		92	238
47	196		93	239
48	197		94	240
49	198		95	241
50	199		105	242

Table 6-6. Average Annual Simulated Water Use Budget (Water Years 1964 – 2004, AF/Year)

Area	Area (ac)		Agricultural							Urban				Other Recharge (Leaky, FMFCD Ponds, etc)	Shortage (-), Surplus (+)
	Ag	Urban	Demand	Supply		Canal Losses		Additional Recharge	Unit Water Use (AF/AC)	Demand	Supply		Unit Water Use (AF/AC)		
				GW	SW	Recov.	Non-Recov				GW	SW			
Fresno SOI	28,500	52,200	91,900	86,700	83,100	23,200	2,800	16,000	3.8	131,400	131,400	0	2.5	23,800	12,000
Upper Kings Basin	444,300	83,600	1,407,600	766,600	938,000	87,100	9,100	273,500	3.8	178,700	178,700	0	2.1	62,800	-135,600
Lower Basin including RCWD	282,700	4,400	816,100	855,300	227,100	23,000	2,000	57,000	3.1	1,400	1,400	0	0.3	0	184,400
Kings Basin	727,000	88,000	2,223,600	1,621,900	1,163,100	110,100	11,100	330,600	3.5	180,100	180,100	0	2.0	62,800	48,800

Table 6-7. Average Annual Simulated Soil Moisture Budget (Water Years 1964 – 2004, Inches/Year)

Area	Agricultural Area							Municipal Area						Undeveloped Area			
	Rainfall	Irrigation Applied Water	Crop Consumptive Use	ET	Direct Runoff	Return Flow	Deep Percolocation	Rainfall	Water Use	ET	Direct Runoff	Return Flow	Deep Percolation	Rainfall	ET	Direct Runoff	Deep Percolation
Fresno SOI	9.6	38.9	29.4	35.6	1.1	0.3	11.5	9.4	33.1	16.5	5.9	1.9	4.4	9.7	7.8	0.6	1.3
Upper Kings Basin	9.6	38.0	26.8	33.1	0.5	0.2	13.7	9.6	27.8	14.4	5.4	1.4	6.9	10.5	7.5	0.6	2.4
Lower Basin including RCWD	7.7	34.7	25.9	31.4	0.7	0.3	9.8	7.6	3.9	5.5	3.3	0.0	2.7	7.8	6.5	0.4	0.9
Kings Basin	8.9	36.7	26.5	32.5	0.6	0.3	12.2	9.5	26.6	13.9	5.3	1.3	6.7	9.2	7.0	0.5	1.7

Table 6-8. Average Annual Simulated Groundwater Budget (Water Years 1964 – 2004, AF/Year)

Area	Inflow						Outflow	Change in Storage
	Deep Percolation	Gain From Stream and Canals	Recharge	Boundary Inflow	Subsurface Inflow	Total	Groundwater Pumping	Inflow minus Outflow
Fresno SOI	42,700	55,200	39,900	3,000	64,800	205,600	218,000	-12,500
Upper Kings Basin	555,200	185,700	336,300	10,800	-203,500	884,500	945,300	-60,800
Lower Basin including RCWD	230,500	136,000	57,000	69,000	263,100	755,600	856,700	-101,100
Kings Basin	785,700	321,700	393,300	79,800	59,600	1,640,200	1,802,000	-161,900

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SECTION 7 SENSITIVITY ANALYSIS

Sensitivity analysis is an important step in the model development process. It is defined as "the study of distribution of dependent variables (e.g., groundwater elevations in a groundwater model) in response to changes in the distribution of independent variables, initial conditions, boundary conditions, and physical parameters" (AWWA, 2001). In general, a sensitivity analysis of an integrated groundwater and surface water model is performed for the following purposes:

- To test the robustness and stability of the model by establishing tolerance within which the model parameters can vary without significantly changing the model results;
- To understand the impact of inaccuracies in input data on model results (e.g., how model results can change because of a 10% error in the estimation of agricultural pumping); and
- To develop an understanding of the relative sensitivity of the components of the hydrologic cycle and data, so that an effective data collection and monitoring plan can be developed.

7.1 METRICS OF SENSITIVITY ANALYSIS

A sensitivity analysis was performed using the Kings IGSM to assess the sensitivity of model results to specific model parameters and input data. Two different metrics were selected to measure the sensitivity of the Kings IGSM. A sensitivity metric is a single number derived from the Kings IGSM model results and has a unique value for each model run corresponding to a given set of data or parameter value. The sensitivity metrics used in the study are:

- Average groundwater elevation in study areas, and
- Average root mean square (RMS) error aggregated from selected calibration wells.

Average groundwater elevation in study areas is defined as a three-way average of simulated groundwater elevations at model nodes. The average is taken over:

- Layers,
- Nodes, and
- Time.

This can be mathematically expressed by:

$$\overline{H} = \frac{1}{M}\sum_{k=1}^{M} H_k$$

and,

$$H_k = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{L}\sum_{j=1}^{L} h_j\right]_i^k$$

where,

M	total number of simulation time steps,
H_k	average head in the model area at k-th time step,
N	number of model nodes,
L	number of model layers in aquifer,
h_j	groundwater elevation at layer j, and
i, j, k	are indices for node, layer, and time, respectively.

The average RMS error at selected calibration wells is defined as the average of individual RMS error at each calibration well. The RMS error at a calibration well is defined as follows:

$$RMS_w = \sqrt{\left\{\frac{1}{N_o}\sum_{k=1}^{No}[h_{k,w}^{o} - h_{k,w}^{s}]^2\right\}}$$

where,

N_0	is the number of observations at well k,
$h_{k,w}^{o}$	is the observed groundwater elevation at time step k, at well w,
$h_{k,w}^{s}$	is the simulated groundwater elevation at time step k, at well w.

7.2 RESULTS OF KINGS IGSM SENSITIVITY ANALYSIS

7.2.1 SELECTED PARAMETERS

Sensitivity analyses were performed for the Kings IGSM for the following model parameters and input data.

- Hydraulic conductivity,
- Specific yield,
- Storage coefficient,
- Streambed hydraulic conductivity for:
  - Kings River,
  - San Joaquin River, and

- Canals
- Groundwater pumping, and
- Leakance between model layers 1 and 2.

7.2.2 IMPACT AREAS

The sensitivity analysis was performed model-wide over the entire basin. However, the impacts of the sensitivity analysis were evaluated in thirteen impacts areas. These impacts areas are:

1. FID West
2. FID East
3. City of Fresno
4. City of Clovis
5. CID West
6. CID East
7. Raisin City WD
8. AID West
9. AID East
10. AID North
11. IRWMP Area
12. Lower Basin
13. Kings Basin

Kings IGSM nodes were selected within each impact area and an evaluation of groundwater levels were conducted for each area. Calibration wells were selected from each impact area for the RMS error evaluation.

The results of the sensitivity analysis for the IRWMP Area, Lower Basin, and Kings Basin are presented in Figures 7-1 through 7-8. The results of the sensitivity analysis for other impact areas are presented in Appendix C.

7.2.3 HYDRAULIC CONDUCTIVITY

The results are presented with reference to the calibrated Kings IGSM model, using the corresponding value as the reference value for the average groundwater level. For example, the average groundwater level in a particular sensitivity analysis impact area was shown as difference from the corresponding value for the calibration run; in other words, the average groundwater level in the impact area for the calibration run of the Kings IGSM was subtracted from the corresponding value for each sensitivity run of the Kings IGSM. Figure 7-1 indicates that if the estimated hydraulic conductivity is twice the calibration value in the entire basin, the range of the change in average groundwater levels in the Kings Basin is 10 to 14 feet higher than that of in calibration.

The RMS error for the main impact areas calibration wells was also shown as a relative value with reference to the corresponding value for the calibration run; that is, the RMS error value for each sensitivity run of the Kings IGSM was divided by the corresponding value for the calibration run. For example, Figure 7-1 shows that the RMS error values increase for all

hydraulic conductivity values other than those used in the calibration run of the Kings IGSM. This implies the calibrated hydraulic conductivity value provides the minimum RMS error for the evaluation wells at the main impact areas.

7.2.4 SPECIFIC YIELD

The sensitivity of the Kings IGSM to changes in specific yield of layer 1 (unconfined aquifer) is presented in Figure 7-2. If the specific yield is reduced by half over the entire basin, the range of the change in average groundwater levels in the main impact areas will be 1 to 1.5 feet lower than that of in calibration. If the specific yield is doubled, the range of the change in average groundwater levels will be 0.2 feet lower to 0.75 feet higher than that of in calibration.
Figure 7-2 shows that the RMS error remains relatively unchanged as specific yield values are increased and the RMS error increases in the main impact areas as specific yield values are decreased.

7.2.5 SPECIFIC STORAGE

The sensitivity of the Kings IGSM to changes in specific storage of layers 2 and 3 is presented in Figure 7-3. It can be seen from the figure that reducing specific storage by one order of magnitude results in 3.5 feet lower groundwater level in Kings Basin and slight increase in RMS value. Increasing specific storage by one order of magnitude results in about 9.5 feet higher groundwater level in Kings Basin and slight increase in RMS values. Further increase in specific storage has little additional impact on average groundwater levels and RMS values.

7.2.6 STREAMBED HYDRAULIC CONDUCTIVITY

7.2.6.1 Kings River

The sensitivity of the Kings IGSM to changes in streambed hydraulic conductivity of Kings River is presented in Figure 7-4. It can be seen from the figure that a reduction of streambed hydraulic conductivity to one fourth of the calibrated value over the entire basin results in 6 feet lower groundwater level. When streambed hydraulic conductivity values are increased five times the groundwater levels in the Kings Basin is about 5 feet higher than that of in calibration. For the impact area evaluation wells, there is little change in the RMS error when Kings River streambed hydraulic conductivity is changed from 0.25 to 5 times of the calibrated value.

7.2.6.2 San Joaquin River

The sensitivity of the Kings IGSM to changes in streambed hydraulic conductivity of San Joaquin River is presented in Figure 7-5. It can be seen from the figure that a reduction of streambed hydraulic conductivity to one fourth of the calibrated value over the entire basin results in 5 feet lower groundwater level. When streambed hydraulic conductivity values are increased five times the groundwater levels in the Kings Basin is about 2 feet higher than that of in calibration. For the impact area evaluation wells, there is little change in the RMS error when Kings River streambed hydraulic conductivity is changed from 0.25 to 5 times of the calibrated value.

7.2.6.3 Canals

The sensitivity of the Kings IGSM to changes in streambed hydraulic conductivity of canals is presented in Figure 7-6. It can be seen from the figure that a reduction of streambed hydraulic conductivity to one fourth of the calibrated value over the entire basin results in one foot lower groundwater level. When streambed hydraulic conductivity values are increased five times the groundwater levels in the Kings Basin is about 3 feet higher than that of in calibration. For the impact area evaluation wells, there is little change in the RMS error when Kings River streambed hydraulic conductivity is changed from 0.25 times of the calibrated value and the RMS error increases in Kings Basin as canals bed hydraulic conductivity values are increased.

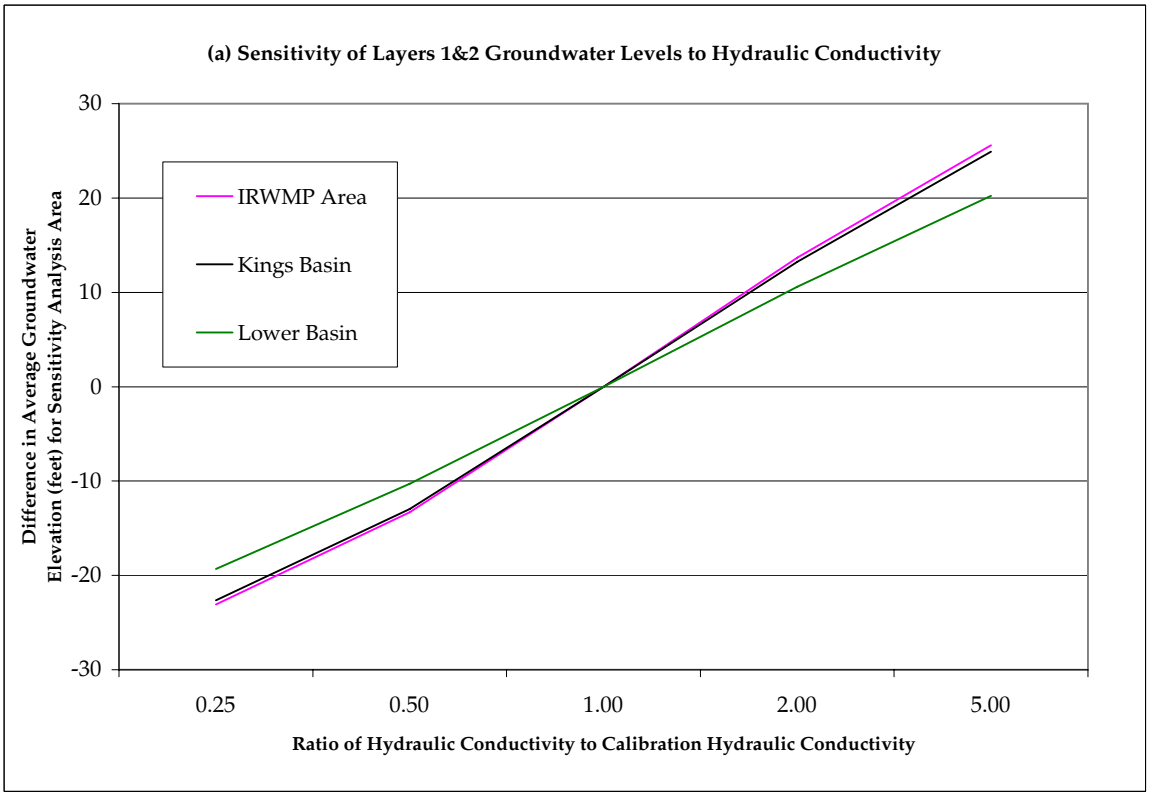
7.2.7 GROUNDWATER PUMPING

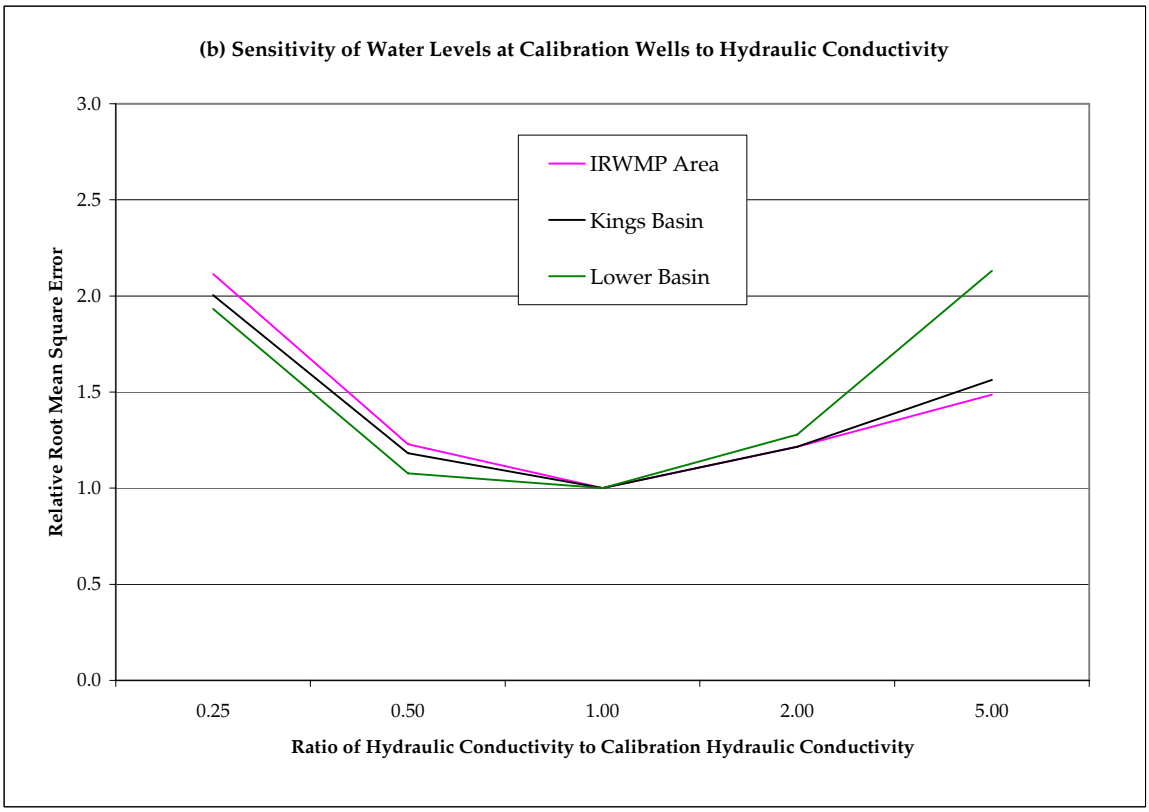
The sensitivity of the Kings IGSM to changes in groundwater pumping is shown in Figure 7-7. It can be seen from the figure that a reduction of groundwater pumping to 0.8 times of the calibrated value over the entire basin results in 22 feet higher groundwater levels. When groundwater pumping is increased by 1.2 times of the calibrated value, the change in average groundwater levels in Kings Basin is 24 feet lower. For the impact area evaluation wells, any changes in pumping result in higher RMS error values.

7.2.8 LEAKANCE

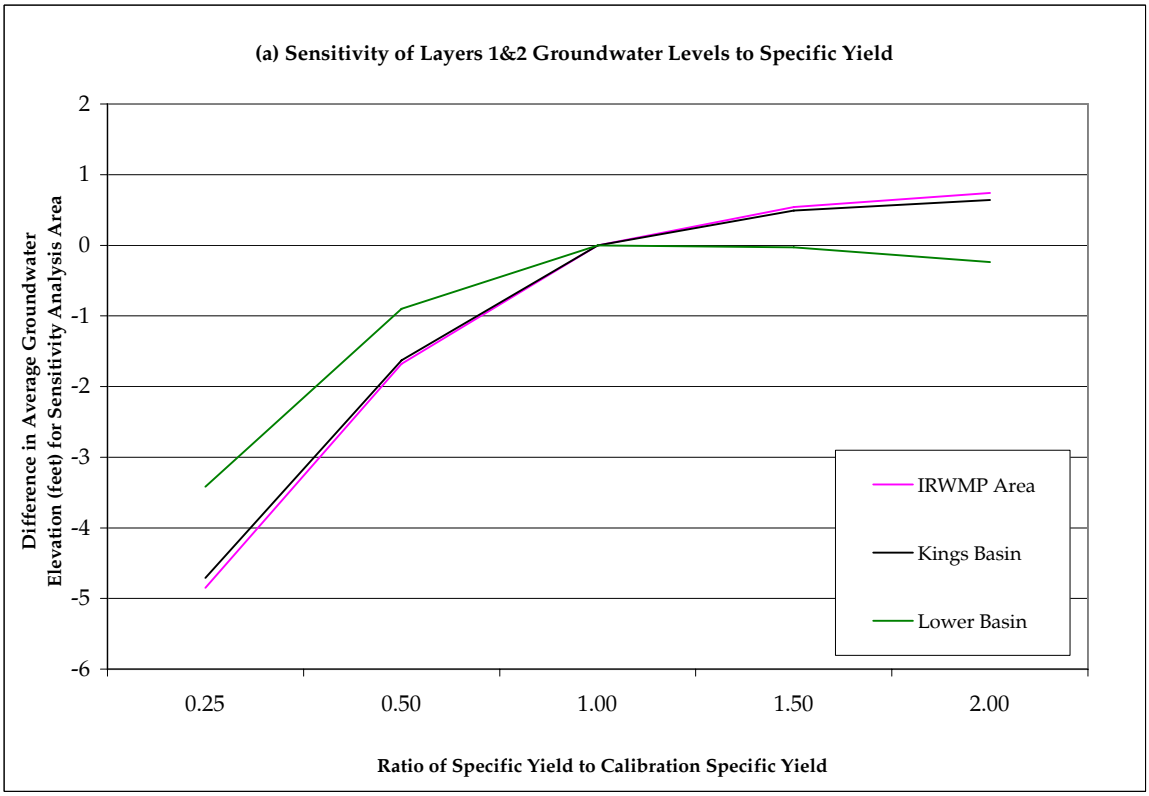
The sensitivity of the Kings IGSM to changes in leakance between layers 1 and 2 is shown in Figure 7-8. It can be seen from the figure that in response to reductions in leakance, the average groundwater levels in the Kings Basin decrease by 22 feet. The increase in leakance by 5 times of the calibrated value results in 8 feet higher groundwater levels. The RMS error values increase because of changes in leakance.

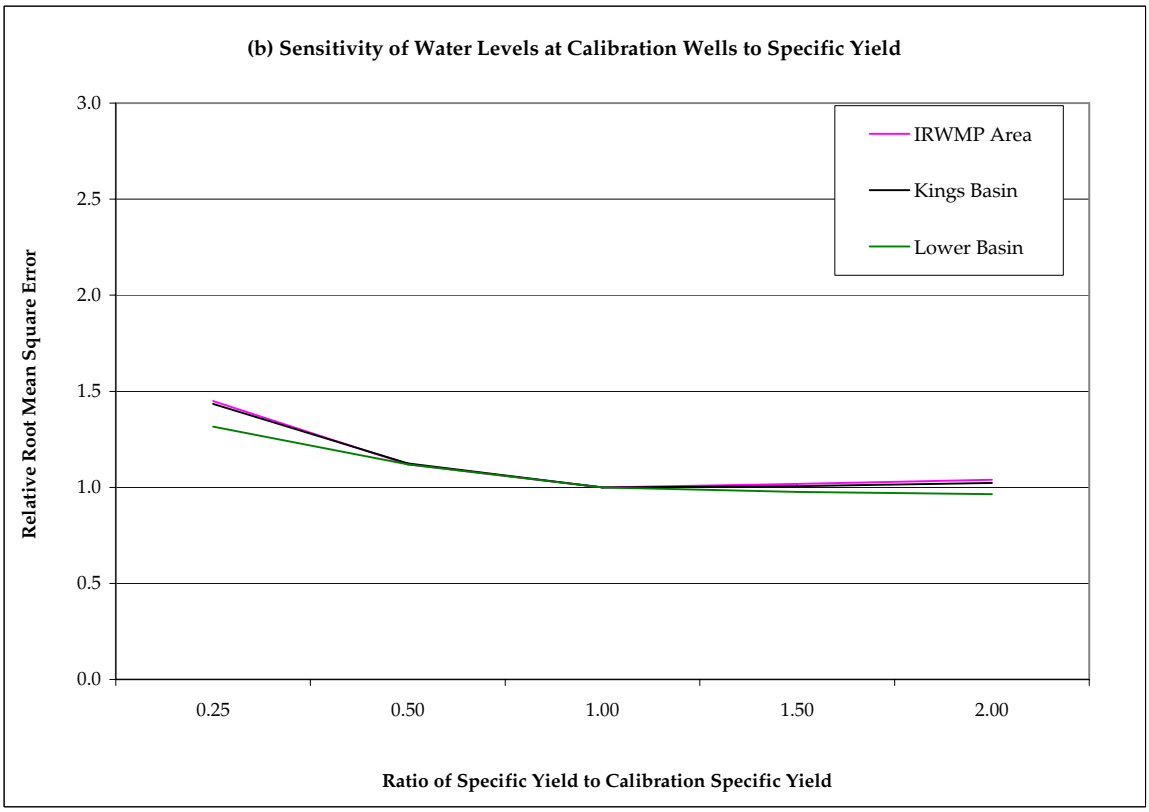
The results of the sensitivity analysis for the Kings IGSM indicate that the model is a stable model and the system responds in the expected manner because of changes in aquifer parameters and input data.



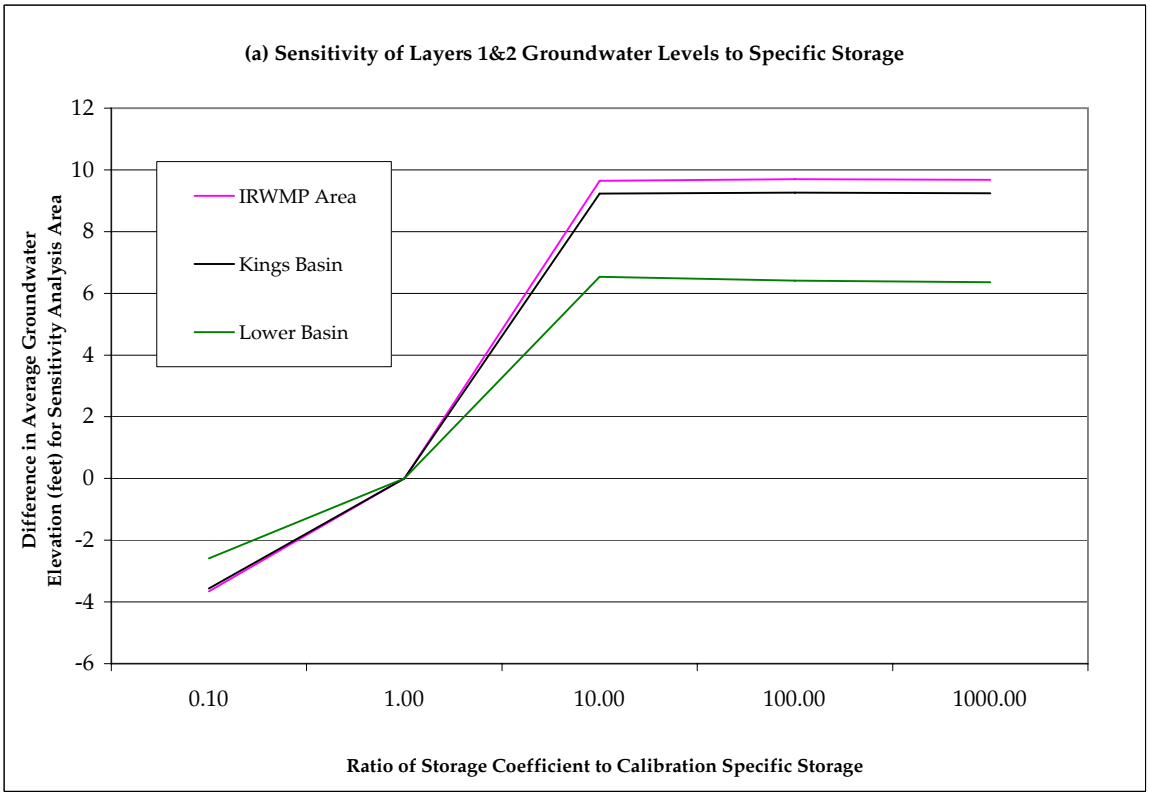


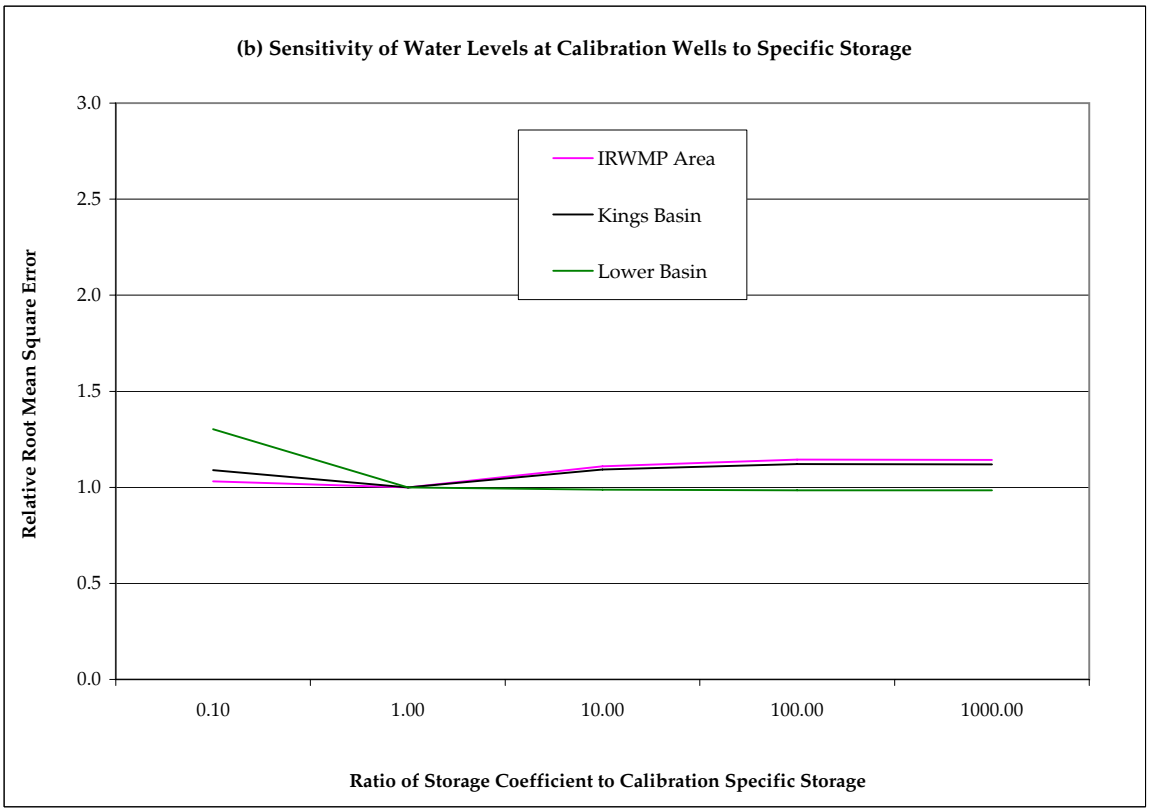
RIME	**Sensitivity Analysis in Selected Areas to Hydraulic Conductivity**	July 2007
	Kings IGSM Model Development and Calibration	FIGURE 7-1



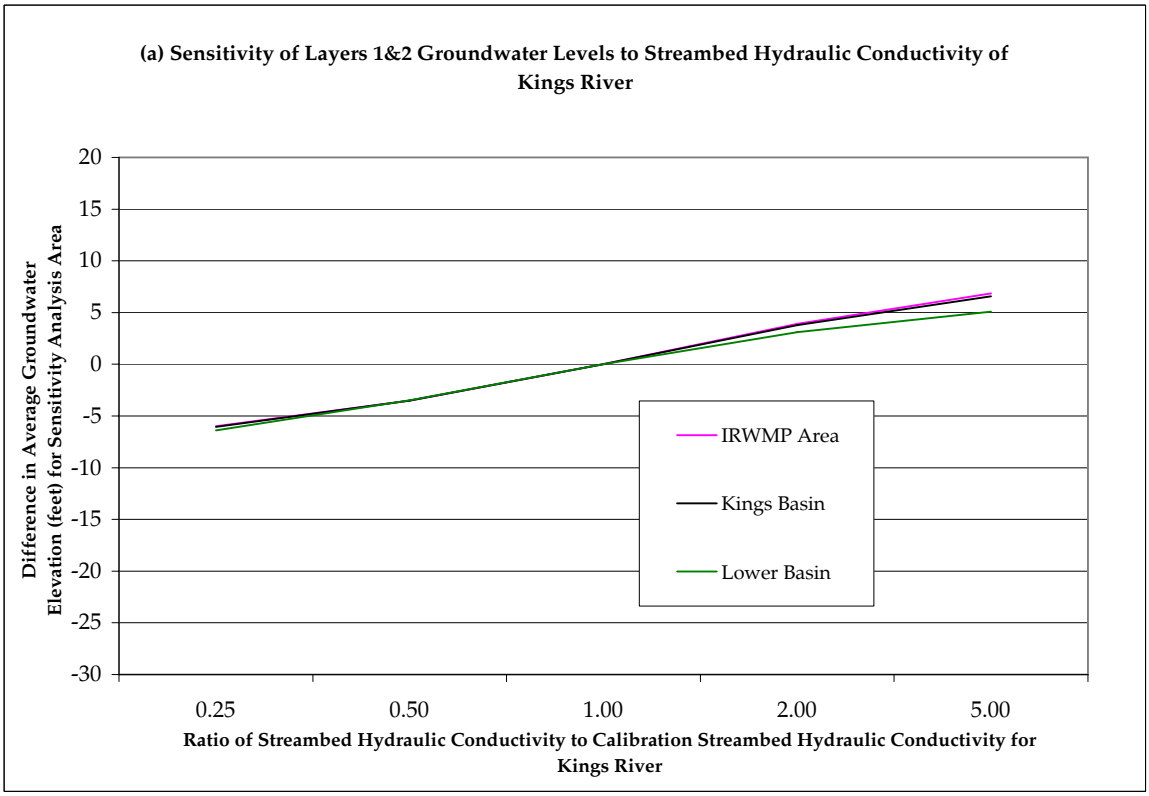


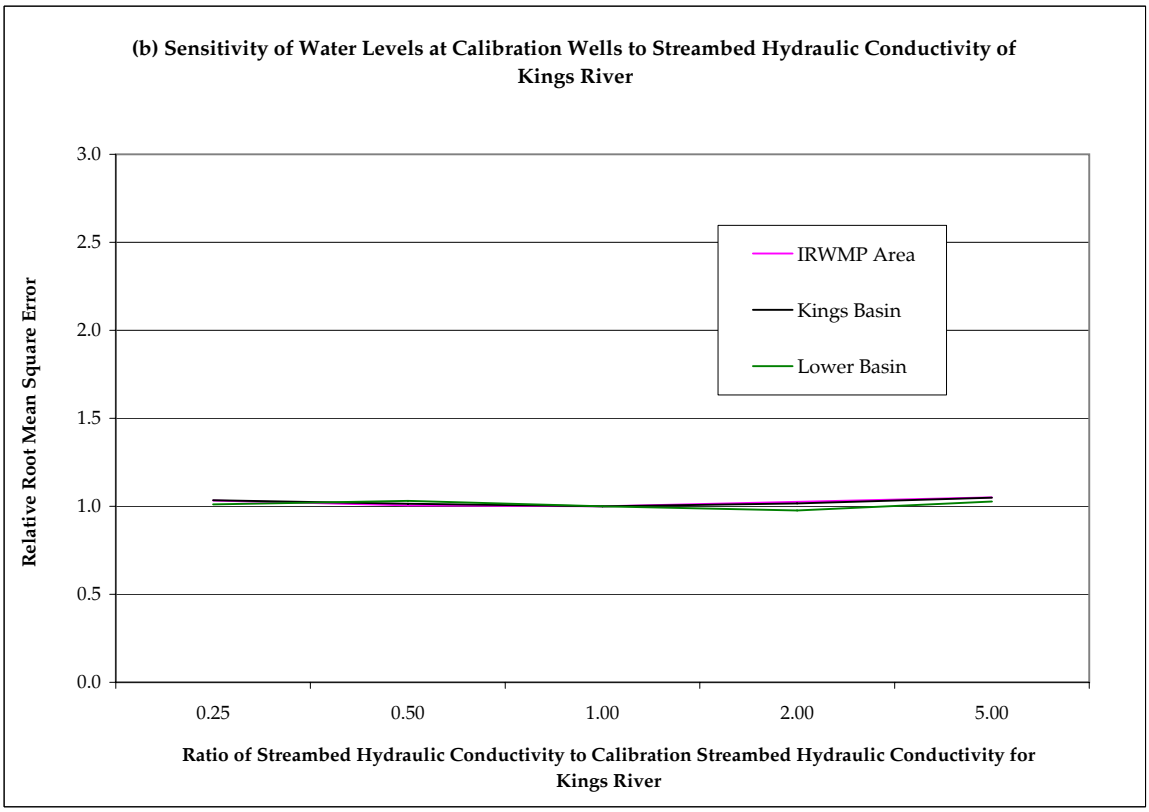
RIME	**Sensitivity Analysis in Selected Areas to Specific Yield**	July 2007
	Kings IGSM Model Development and Calibration	FIGURE 7-2



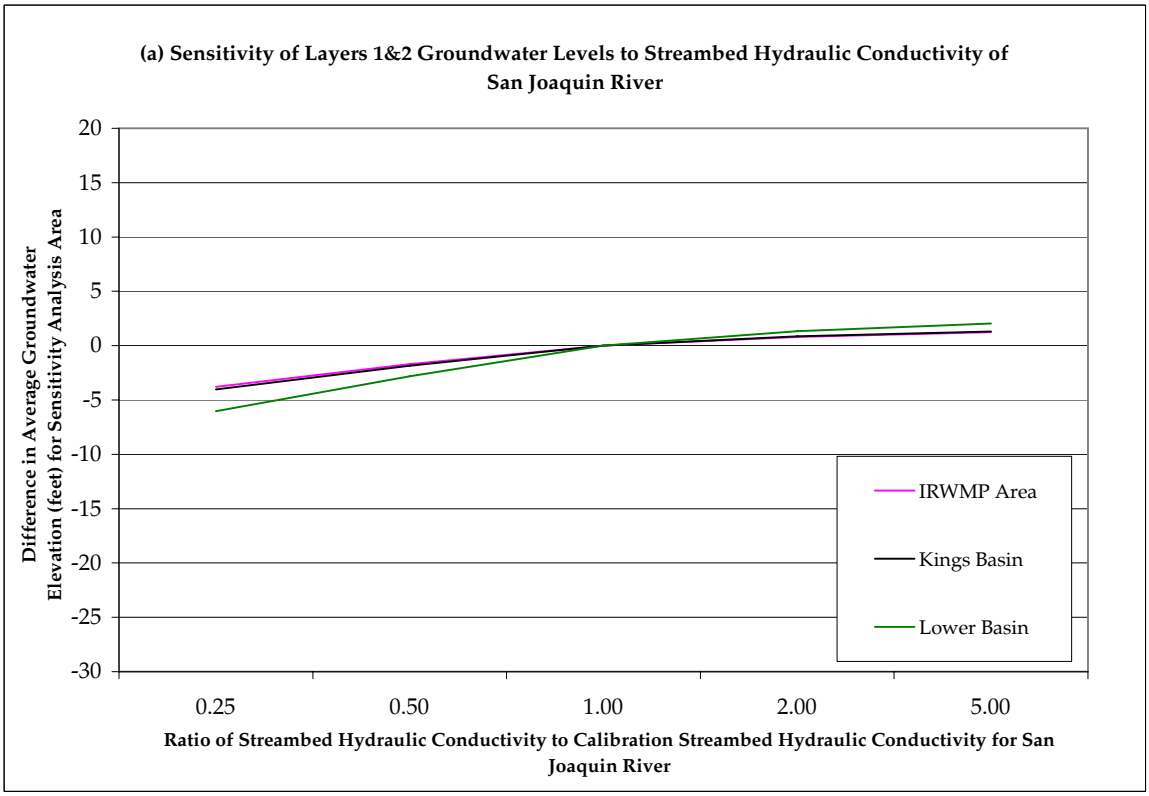


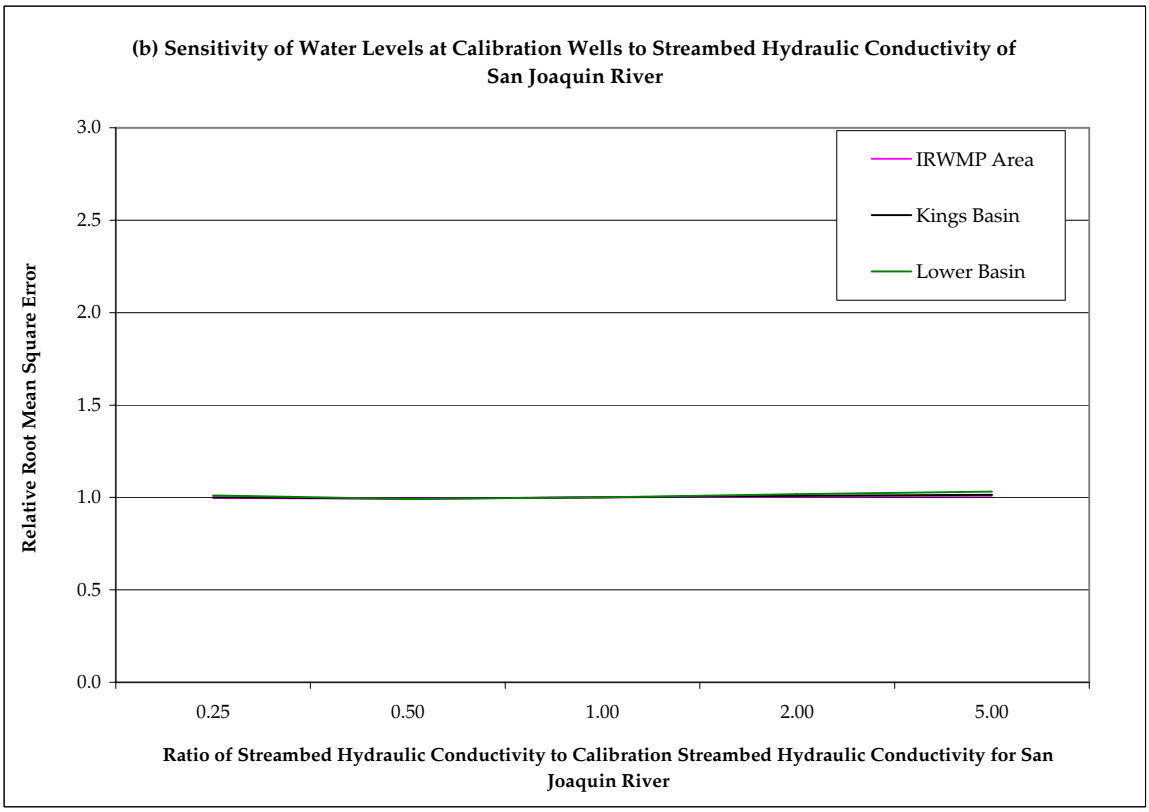
WRIME	**Sensitivity Analysis in Selected Areas to Specific Storage** Kings IGSM Model Development and Calibration	July 2007 FIGURE 7-3





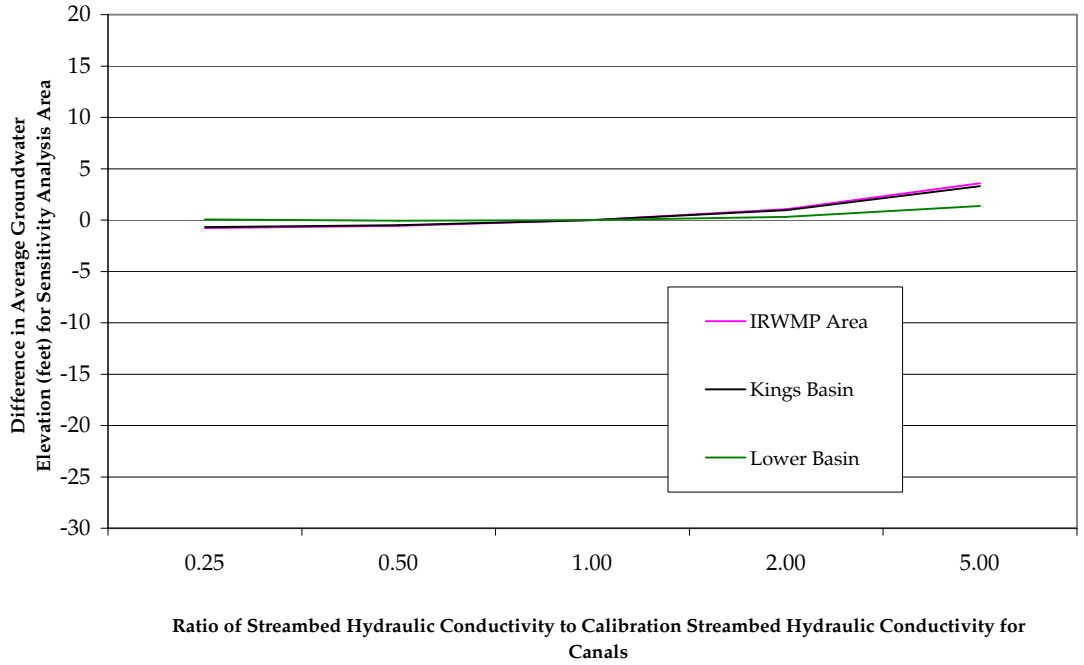
WRIME	**Sensitivity Analysis in Selected Areas to Streambed Hydraulic Conductivity (Kings River)** Kings IGSM Model Development and Calibration	July 2007 FIGURE 7-4



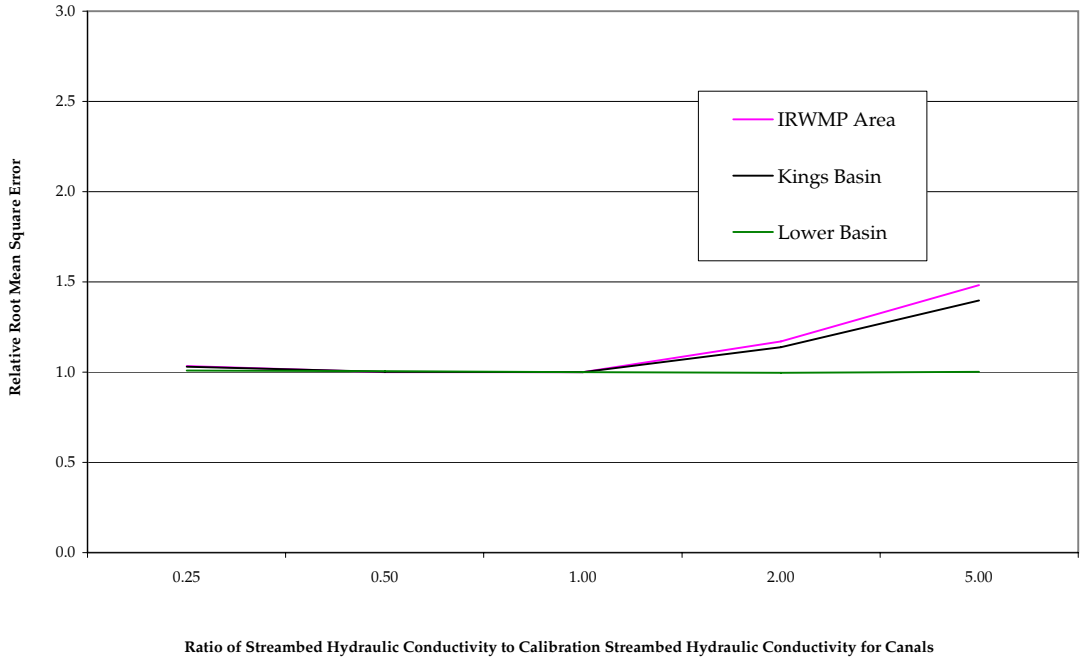


WRIME	**Sensitivity Analysis in Selected Areas to Streambed Hydraulic Conductivity (San Joaquin River)** Kings IGSM Model Development and Calibration	July 2007 FIGURE 7-5

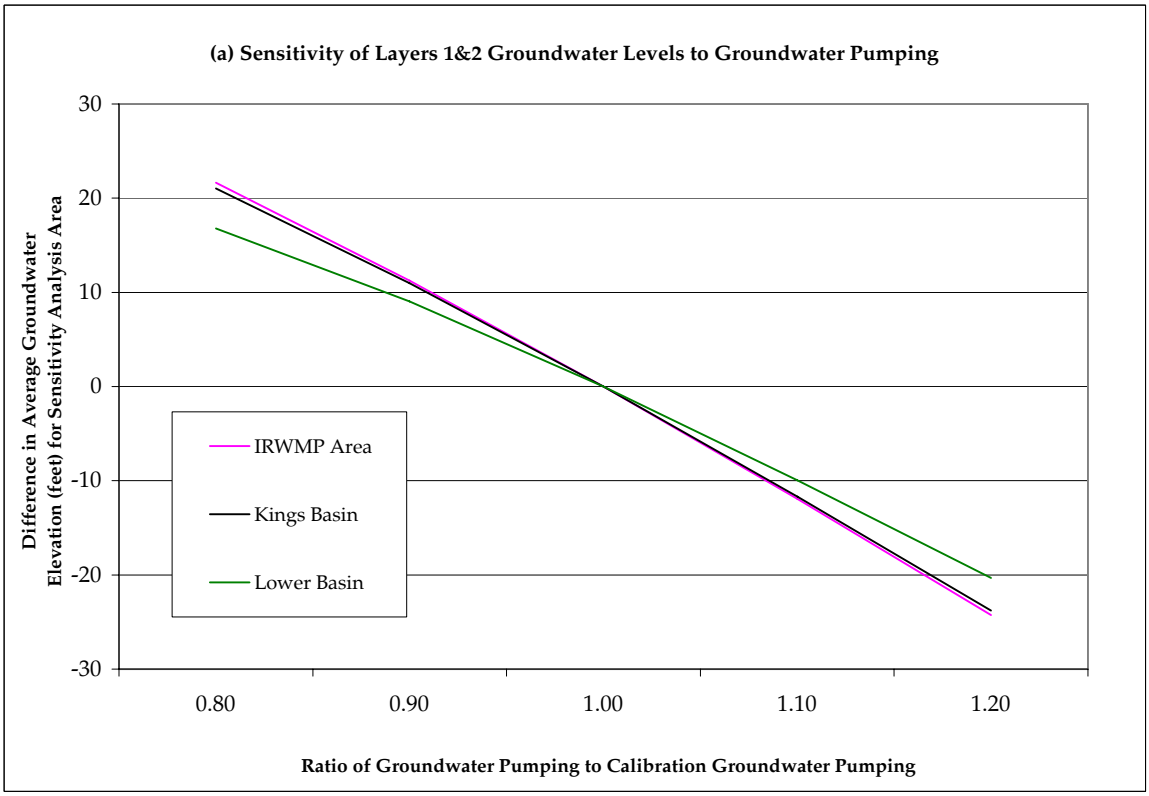
(a) Sensitivity of Layers 1&2 Groundwater Levels to Streambed Hydraulic Conductivity of Canals

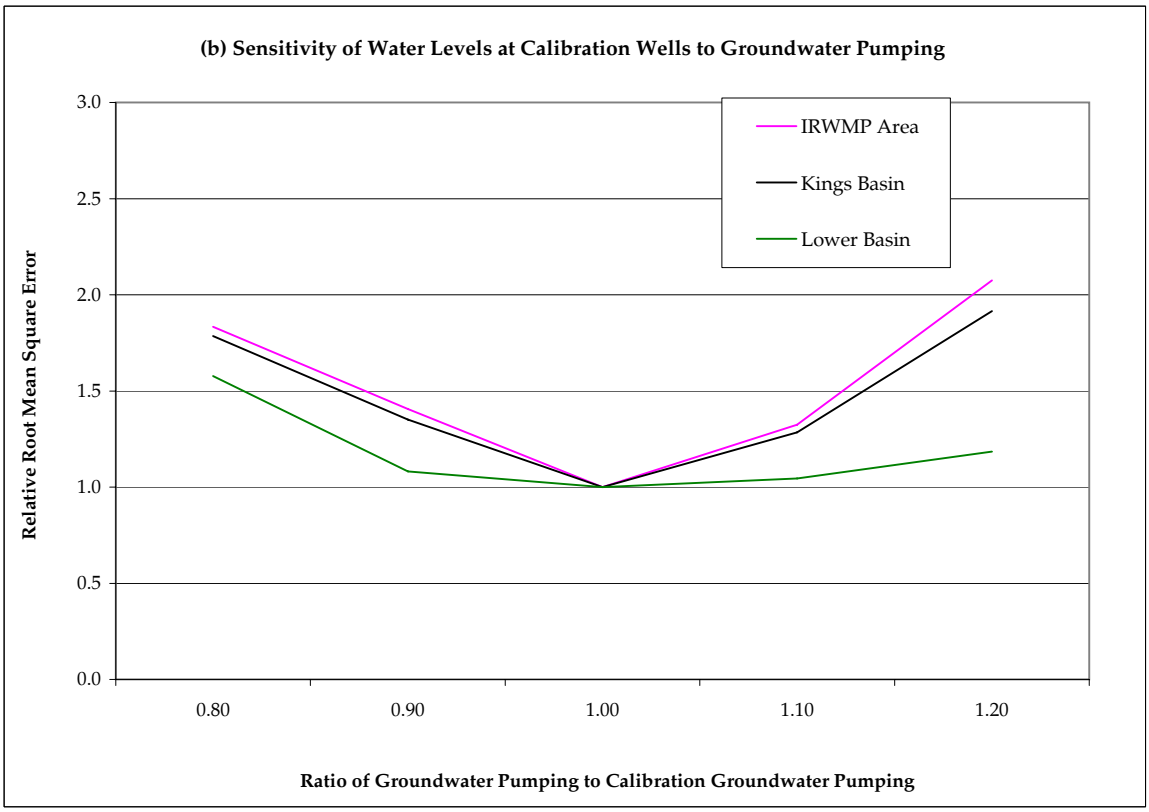


(b) Sensitivity of Water Levels at Calibration Wells to Streambed Hydraulic Conductivity of Canals

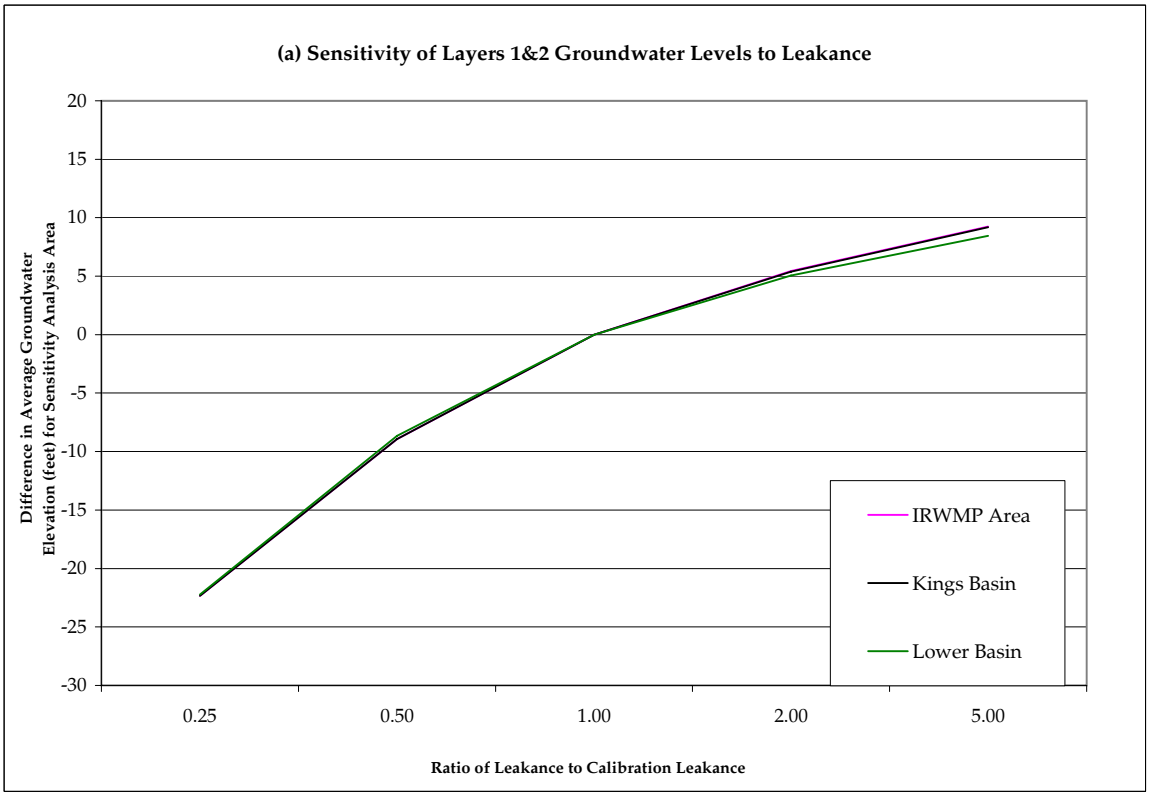


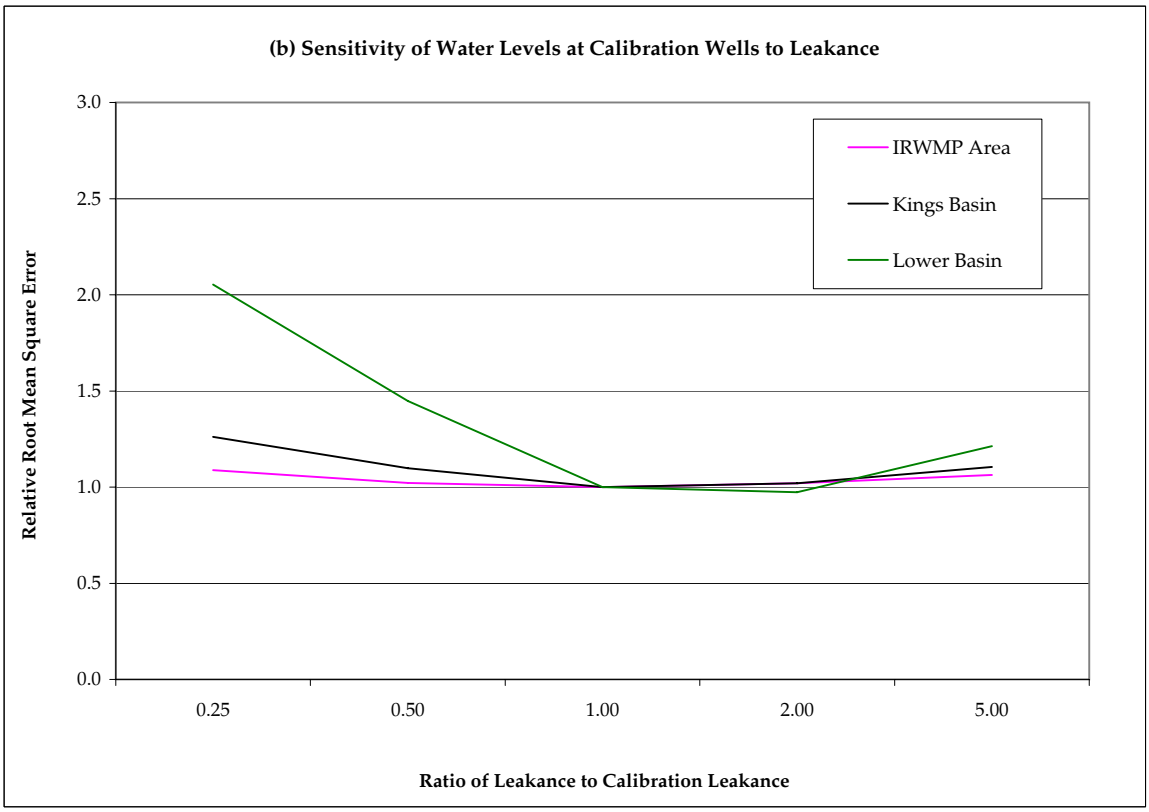
WRIME	**Sensitivity Analysis in Selected Areas to Streambed Hydraulic Conductivity (Canals)** Kings IGSM Model Development and Calibration	July 2007 FIGURE 7-6





RIME	**Sensitivity Analysis in Selected Areas to Groundwater Pumping**	July 2007
	Kings IGSM Model Development and Calibration	FIGURE 7-7





WRIME	**Sensitivity Analysis in Selected Areas to Leakance** Kings IGSM Model Development and Calibration	July 2007 FIGURE 7-8

SECTION 8 SUMMARY AND RECOMMENDATIONS

8.1 SUMMARY

The Kings IGSM is a comprehensive hydrologic model, which simulates both groundwater flow and stream flow including stream-aquifer interactions. The model simulates the historical hydrology on a daily time step for the 41-year simulation period from 1964–2004. This simulation period was selected because 1964 is the beginning of the Pine Flat Reservoir operation under contemporary guidelines; it includes wet, dry, normal, and extreme conditions of the regional hydrology, availability of reasonable amount of data for this time period.

The Kings IGSM was calibrated on the basis of four key criteria:

1. water budgets;
2. regional groundwater trends;
3. local groundwater elevations at 240 calibration wells distributed throughout the model area; and
4. stream flow hydrographs at 2 stream gaging stations.

The water budgets were developed for 32 model subregions, which corresponded to water districts and irrigation districts in the model area, as wells for Fresno SOI, Upper Kings Basin, Lower Kings Basin, and Kings Basin.

In order to assess the sensitivity of model results to specific model parameters and input data, a sensitivity analysis was conducted using the Kings IGSM by evaluating two different error metrics: average groundwater elevation in selected impact areas and average RMS error aggregated from selected calibration wells in the impact areas. The results of the sensitivity analysis indicates that the model is most sensitive to the uncertainties in the following data and parameters:

- Groundwater pumping, and
- Hydraulic conductivity.

As such, the recommendations include steps to improve on these data and information for future improvements to the model.

8.2 POTENTIAL APPLICATION OF KINGS IGSM

The Kings IGSM was developed and calibrated to support the planning analysis required for development of the Upper Kings Basin IRWMP project. The TAD Work Group of Upper Kings

Basin Water Forum provided the necessary technical review, guidance, and coordination during the model development and calibration process. The Kings IGSM is expected to be used extensively for water resources planning and management in the Kings Basin. KRCD will continue to coordinate the use and application of the model and the TAD Work Group.

The Kings IGSM is currently being used for evaluating the Upper Kings Basin IRWMP's scenarios of Future Without Project conditions. It is anticipated that the Kings IGSM will be used to further support the Water Forum in sizing capital projects and evaluating the IRWMP alternatives once these are firmly defined. The analysis of project alternatives will support the program or project level environmental evaluations that are needed to comply with the CEQA and/or NEPA.

Other stakeholders in the Kings Basin may also benefit by model analysis conducted as part of the IRWMP development or by using the Kings IGSM when it is necessary to quantify benefits or impacts of proposed actions. Contemporary examples of the model applications within the Kings Basin include:

- The City of Fresno use of the model to support the development of the Metro Plan, a capital facilities plan for the city. The Kings IGSM will be used to size projects, compare alternatives benefits and impacts, and support the preparation of any required program or project level environmental documents.
- Analysis of the groundwater impacts of the power plant being proposed by KRCD to support the permit application to the California Energy Commission.

The Kings IGSM may also be applied to any circumstances which require quantification of project or program benefit and effects and comparison of alternatives, such as the impacts of changes in land and water use conditions, impacts of proposed facilities, and changes to the surface water and/or groundwater conditions.

Other examples of model application can be:

- Impacts of projects on the Streamflow conditions, and water supplies for the purposes of fisheries, and other wildlife habitat;
- Quantification of basin yield, and means to reduce the overdraft conditions;
- Benefits distribution of the historical facilities and operations;
- Benefits distribution of the proposed facilities and changes in operations;
- Quantification of effects of conservation programs, and possible changes to the distribution facilities, such as lining of canals, and reduction in leakage in municipal distribution systems;
- Planning, evaluation, and design of conjunctive use and recharge facilities;
- Water supply reliability studies;
- Evaluation of effects of water exchange programs; and
- Evaluation of effects of river re-operation programs.

The Kings IGSM does not currently include water quality modeling capabilities or operational modeling of the Pine Flat Reservoir or major CID, FID, or AID distribution systems. The model, however, provides the fundamental data and information framework, as well appropriate level of spatial and temporal details for future development of additional features, such as the water quality simulation and river/reservoir operations. The development of these additional capabilities may be potential future improvement to the Kings IGSM.

8.3 MODEL LIMITATIONS

A numerical model is an approximate mathematical representation of the physical conditions in the field. Unfortunately, field data on all model components are not equally available or reliable. Therefore, reasonable assumptions are made during the model development process regarding missing data and information on the physical system. These approximations and assumptions lead to the model's inability to exactly replicate the historical observations at all locations at all times. The differences between field observations and model simulations can be, in a loose sense, termed "modeling errors." Truly speaking, these are the limitations of the model. It is very important to understand these limitations or "sources of errors" before a numerical model, such as the Kings IGSM, is applied to conduct evaluation of water management alternatives. These limitations of the Kings IGSM are discussed below under the subheadings modeling errors, input data errors, and measurement errors.

8.3.1 MODELING ERRORS

The Kings IGSM represents physical processes occurring in nature by a series of mathematical approximations. Due to the randomness associated with the governing physical processes, both in their phenomenological description and in their quantification, it is not possible to develop a complete mathematical description of the physical world without introducing certain simplifying assumptions. These simplifying assumptions provide us with the Darcy's equation and the governing differential equation of groundwater flow that are universally used in all groundwater models, including the Kings IGSM. These equations are valid on a representative equivalent volume (Bear, 1979), which are characterized by the level of spatial discretization (i.e., the size of the finite elements) in the Kings IGSM. On the other hand, data are available on a much larger scale, such as a water district or irrigation district. As a consequence, the Kings IGSM is able to predict hydrologic responses on a macro scale basis by replicating regional historical trends; certain discrepancies in simulated streamflows and groundwater levels are expected on a local scale.

8.3.2 INPUT DATA ERRORS

Input data used in the Kings IGSM represents the best information available at the time of this study. Missing data were estimated by (i) statistical methods, (ii) engineering judgment, and (iii) inference from other sources. The estimation of data necessarily leads to certain limitations in the developed model. These potential limitations of the Kings IGSM associated with input data errors are provided below.

8.3.2.1 Generic Data Estimation Errors

Estimation errors associated with any input data have effects on Kings IGSM results. As discussed previously, the data used in developing the Kings IGSM input files were available in different temporal and spatial scales with different degrees of reliability. These limitations of the input data combine to produce discrepancies between simulated results and observed values.

8.3.2.2 Groundwater Pumping Data Estimation Error

Groundwater pumping is one of the most critical sets of input data that affect the response of the Kings IGSM model area. Agricultural water use accounts for about most of the water use in the Kings IGSM model area. Groundwater pumping data and the distribution of pumping in the area are not recorded except for municipal pumping. In the absence of field data, agricultural groundwater pumping was estimated by the Kings IGSM on the basis of crop water requirements and other related information obtained from previous studies. Estimation errors in the pumping data are believed to have contributed to some of the discrepancies between observed and simulated results by the Kings IGSM.

8.3.2.3 Model Simulation Capabilities in Major Geographic Areas

This section provides the context on the simulation capabilities and limitations of the calibration and application of the Kings IGSM in major geographic areas that included the Upper Kings Basin, Fresno SOI, and Lower Kings Basin.

For the areas in Upper Kings Basin there was very good agreement of simulated groundwater levels with observed measurements for majority of wells. The simulated groundwater elevation trends, flow directions, and groundwater gradients generally match the measured data. However, the wells located closer to foothills show some discrepancy between simulated and observed measurements. This is suspected to be related to low resolution of the stratigraphy data in the foothills area.

The simulated groundwater levels in AID for dry hydrologic conditions are higher than the measured levels. This may be due to low resolution of available agricultural groundwater pumping data.

Higher resolution of data in Fresno SOI resulted in significantly less deviation between simulated and observed groundwater levels. In general, the model simulates the groundwater elevation trends, flow directions, and slope of the groundwater levels reasonably well.

Lower Kings Basin was not the focus area for model development and calibration and only readily available data was used. Therefore, some deficiencies in simulation results for the Lower Kings Basin are expected.

8.3.3 MEASUREMENT ERRORS

The Kings IGSM calibration performance should be evaluated on the basis of both the availability and quality of historical streamflow data at gage stations and groundwater levels at observation wells.

The water level measurements data are sometimes influenced by nearby pumping and, therefore, do not necessarily represent regional water level conditions; sometimes the reported water levels include measurement errors. Measurements taken from municipal wells are quite frequently taken too soon after well shutdown and, thus, the groundwater level measurements reflect a well in recovery instead of the regional groundwater level. The recorded measurement at a well is on a specific day within a month. In contrast, the corresponding simulated groundwater level is an average value over an entire layer or multiple layers and is the end-of-month value. In addition to the above, the perforations of wells are often estimated in the Kings IGSM because of lack of data or insufficient data. Due to these differences in how the observed values are measured and how the simulated values are computed, differences of model results with observations at local wells are expected.

8.4 RECOMMENDATIONS

The following actions are recommended to improve the capability of Kings IGSM to simulate the regional surface water and groundwater conditions in the model area more accurately.

Agricultural Groundwater Pumping – Conduct a field survey for agricultural pumping wells to provide better estimates of agricultural groundwater pumping quantity and distribution data and thus improve model simulation results.

Irrigation Districts Surface Water Distribution Data – Collect and incorporate surface water distribution data within each irrigation district. This data would allow for a better characterization of surface water and agricultural groundwater pumping distribution within each subregion.

Foothills Stratigraphy Data – Conduct additional hydrogeologic studies to obtain better information for model layer thickness in foothills area and eastern parts of AID, FID and Clovis. Availability of such information would allow more accurate simulation of water levels in AID during extended dry periods and an improved simulation of water levels in eastern parts of FID and Clovis.

Improved Upper Kings Stratigraphy – Local clay layers associated with older alluvium in eastern parts of Kings Basin act as local confining layers. Where these local clay layers are present, a head difference is observed between layers 1 and 2. Availability of this data would allow more accurate simulation of water levels in eastern parts of Kings Basin.

San Joaquin River Operations – The operations of Millerton Reservoir and the Friant Unit of the Central Valley Project could change significantly as a direct result of the implementation of the San Joaquin River restoration program. Observation of stream loses, groundwater responses, and the effects of flow variations would help ensure that the model is able to respond to the changes and future updates to the model would benefit.

Refinements in the Lower Kings Basin– Although the development of Kings IGSM required attention to the coverage, data development, analysis, and quality control for the areas in the Lower Kings Basin, the focus of calibration was in the Upper Kings Basin and the IRWMP area. Many areas in the Lower Basin show reasonable calibration to the regional groundwater levels, as well as long-term trends in observed groundwater levels. However, there are areas that require more attention to the details in both input data, such as agricultural pumping rates and locations, as well as calibration of aquifer parameters. It is recommended that additional resources be allocated to refine the model in both the Lower Kings Basin, as this part of the basin is hydraulically and operationally connected to the Upper Kings groundwater Basin.

Refinements in the Foothills Areas– The Foothills areas are currently included in the Kings IGSM. However, the geologic and hydrogeologic data is not as detail as the remaining of the basin. This is primarily due to lack of data and information for this area. Since the data and information in the Foothills was limited, the focus of calibration was in the Upper Kings Basin and the IRWMP area. Many areas in the Foothills show reasonable calibration to the trends and seasonal fluctuations in observed groundwater levels, however, there are areas that require more attention to the details in both input data, such as agricultural pumping rates and locations, depth and perforation of wells, and geologic conditions, as well as calibration of aquifer parameters. Some of the areas in the Foothills consist of fractured rock environment,

which requires additional details on data, as well as numerical modeling schemes. It is recommended that additional resources be allocated to collect and analyze geologic and groundwater data in the Foothills area, with subsequent refinements in the Kings IGSM.

Integration of River/Reservoir Operations – As the operations of the groundwater system is closely integrated with the operations of the Kings river and San Joaquin river systems, it is recommended to develop a strategy to integrate the operations of the groundwater and surface water systems. This can be attained by development of external programs to simulate the operations of the river systems and combining them with the Kings IGSM, or by development of river/reservoir modules within the Kings IGSM.

Development of Water Quality Model – The simulation of non-point sources of pollution in the groundwater basin is one of the major goals of the development of a comprehensive hydrologic model. The Kings IGSM flow model is currently well calibrated and can serve as a framework for the development of the Water Quality Model. Therefore, it is recommended to lay out specific strategies and actions for development of the Water Quality Model for the Kings Basin.

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