Kern Delta Water District
Agricultural Water Management Plan

60312278 **December 2015**

Kern Delta Water District

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List of Acronyms and Abbreviations

AEWSD	Arvin-Edison Water Storage District
AF	acre-feet
AWMP	Agricultural Water Management Plan
BVWSD	Buena Vista Water Storage District
CASGEM	California Statewide Groundwater Elevation Monitoring
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CWC	California Water Code
District	Kern Delta Water District
DWR	California Department of Water Resources
ET	Evapotranspiration
ET_c	Crop Evapotranspiration
Et_o	Reference Evapotranspiration
EWMP	Efficient Water Management Practice
GSA	Groundwater Sustainability Agency
GWMP	Groundwater Management Plan
HMWD	Henry Miller Water District
HWY	Highway
ID4	Improvement District No. 4 of the Kern County Water Agency
ILRP	Irrigated Lands Regulatory Program
ITRC	Irrigation Training and Research Center
KCWA	Kern County Water Agency
KDWD	Kern Delta Water District
KWB	Kern Water Bank
M&I	Municipal and Industrial
MCL	Maximum Contaminant Level
MOU	Memorandum of Understanding
MWD	Metropolitan Water District of Southern California
NOAA	National Oceanographic and Atmospheric Administration
NWKRCD	North West Kern Resource Conservation District
RRBWSD	Rosedale-Rio Bravo Water Storage District
RWQCB	State Regional Water Quality Control Board
SBX7-7	Steinberg Water Conservation Act of 2009
SBVMWD	San Bernardino Valley Municipal Water District
SGMA	Sustainable Groundwater Management Act
SWP	State Water Project
TDS	Total Dissolved Solids
UWMP	Urban Water Management Plan
WAP	Kern River Water Allocation Plan, Kern Delta Water District
WWTP	Wastewater Treatment Plant

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Section 1: Plan Preparation and Adoption

The California Water Code requires that agricultural water suppliers providing water to 10,000 or more irrigated acres prepare and adopt an Agricultural Water Management Plan (AWMP, Plan), which is submitted to the California Department of Water Resources (DWR). The Plan is required to describe and evaluate water deliveries and uses, sources of supply, water quality, water delivery measurements, water rates and charges, water shortage allocation policies, and reasonable and practical efficient water management practices. In accordance with Water Code §10852, adoption of an AWMP and implementation of efficient water management practices (EWMPs) as defined in §10608.48 is required in order for an agricultural water supplier to be eligible for a water grant or loan administered by the State.

The Kern Delta Water District (KDWD, District) AWMP has been prepared in accordance with the requirements of SBX7-7 (Water Conservation Act of 2009) and following the recommendations in "A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2015 Agricultural Water Management Plan" (Guidebook) published by the DWR. The format of the Plan follows the suggested organization in Section 3 of the Guidebook.

1.01 Description of Previous Water Management Activities

Law

Describe previous water management activities (§10826(d)).

The KDWD initially prepared a Groundwater Management Plan (GWMP) under AB3030 in 1996. The District Board of Directors subsequently adopted a GWMP Update on October 15, 2013 which included the following Basin Management Objectives:

- Mitigate overdraft,
- Preserve groundwater quality,
- Manage groundwater storage,
- Avoid further inelastic land subsidence,
- Updater District monitoring programs, and
- Coordinate groundwater management activities with other agencies.

1.02 Coordination Activities

Law

An agricultural water supplier required to prepare a plan pursuant to this part shall notify each city or county within which the supplier provides water supplies that the agricultural water supplier will be preparing the plan or reviewing the plan and considering amendments or changes to the plan. The agricultural water supplier may consult with, and obtain comments from, each city or county that receives notice pursuant to this subdivision (§10821(a)).

Prior to adopting a plan, the agricultural water supplier shall make the proposed plan available for public inspection, and shall hold a public hearing on the plan. 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 (§10841).*

KDWD is located on the south side of metropolitan Bakersfield in the County of Kern. The District encompasses portions of both City and unincorporated County land. The Kern County Water Agency (KCWA) serves as the contracting entity with the DWR for the District's State Water Project (SWP) supply. **Table 1** summarizes the efforts KDWD has taken to involve appropriate agencies and the general public in the District's planning process. Copies of notices are included in **Appendix A**.

The public hearing was held on December 15, 2015. Accordingly, notice was provided as follows:

- Letter to City and County on August 26, 2015,
- Letter to Interested Parties (see **Table 1**) on August 26, 2015,
- Notice in local newspaper on December 1, 2015 and December 8, 2015 (per Gov. Code 6066 – 2 weeks in advance of hearing),
- Posted Draft AWMP at District Office on December 1, 2015 (2 weeks prior to hearing), and
- Drafts of the plan were submitted to the entities that requested such drafts (see **Table 1)**.

Table 1. Summary of Coordination, Adoption, and Submittal Activities

Potential Interested Parties	Notified of AWMP Preparation	Requested Copy of Draft	Commented on Draft/Action Taken by Supplier	Notified of Public Meetings	Attended Public Meetings	Copy of Adopted AWMP/ Amendment Sent
City of Bakersfield	8/26/2015					12/23/2015
Kern County	8/26/2015					12/23/2015
Kern County Water Agency						12/23/2015
Arvin-Edison Water Storage District	8/26/2015					12/23/2015
Wheeler Ridge-Maricopa Water Storage District	8/26/2015					12/23/2015
Henry Miller Water District	8/26/2015					12/23/2015
California State Library						12/23/2015
DWR						12/23/2015
Bakersfield Californian				12/1/2015 12/8/2015		
Kern County Library						12/23/2015
California Water Service Company						12/23/2015
Lamont PUD						12/23/2015
Greenfield CWD						12/23/2015
Kern County LAFCO						12/23/2015
DWR Website						12/23/2015

1.03 AWMP Adoption, Submittal, and Availability

Law

> *After the hearing, the plan shall be adopted as prepared or as modified after the hearing (§10841).*
>
> *Amendments to, or changes in, the plan shall be adopted and submitted in the manner set forth in Article 3 (commencing with Section 10840) (§10820(b)).*
>
> *An agricultural water supplier shall submit to the entities identified in subdivision (b) a copy of its plan no later than 30 days after the adoption of the plan. Copies of amendments or changes to the plans shall be submitted to the entities identified in subdivision (b) within 30 days after the adoption of the amendments or changes (§10843(a)).*
>
> *Not later than 30 days after the date of adopting its plan, the agricultural water supplier shall make the plan available for public review on the agricultural supplier's Internet Web site (§10844(a)). An agricultural water supplier that does not have an Internet Web site shall submit to the department not later than 30 days after the date of adopting its plan, a copy of the adopted plan in an electronic format. The department shall make the plan available for public review on the department's Internet Web site (§10844(b)).*

KDWD Agricultural Water Management Plan was adopted by the District at a Public Hearing / Regular Meeting of the Board of Directors on December 15, 2015. The intent of the Public Hearing was to gather input from interested persons and entities. At the meeting, both written comments and verbal comments were considered by the Board of Directors. After careful review of any received comments, the Plan was adopted with modifications as required in response to the comments received at the public hearing. A copy of the resolution adopting the AWMP is included in **Appendix B**.

The Plan will be submitted to the appropriate entities per §10843(b) (see **Table 1**) no later than January 14, 2016, which is within 30 days of adoption by the District. The District will submit an electronic version of the AWMP to the DWR for posting on the DWR website since the District does not have a website.

1.04 AWMP Implementation

Law

> *An agricultural water supplier shall implement the plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan, as determined by the governing body of the agricultural water supplier (§10842).*

The District has developed an implementation schedule for EWMPs as described in **Section 7** of this Plan.

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Section 2: Description of District and Service Area

Law

Describe the agricultural water supplier and the service area, including all of the following:

1. *Size of the service area.*
2. *Location of the service area and its water management facilities.*
3. *Terrain and soils.*
4. *Climate.*
5. *Operating rules and regulations.*
6. *Water delivery measurements or calculations.*
7. *Water rate scheduling and billing.*
8. *Water shortage allocation policies (§10826a).*

2.01 Background and Physical Characteristics

Irrigated agriculture was first developed in the area that would become the KDWD in the late 1800s when enterprising settlers drained the swamps, sloughs, and lakes that covered the land. Unlined canal systems were constructed within the future District area, which now provide water deliveries to the service areas of five former canal companies (Kern Island, Buena Vista, Stine, Farmers, and Eastside) with Kern River diversion rights. The District was formed by concerned landowners in December 1965 in accordance with the provisions of California Water District Law (Division 13 of the Water Code). The objectives of the District were to provide a public entity to contract with the KCWA for a supplemental supply from the SWP and to protect the area's existing rights to Kern River water.

The District's contract with the KCWA was executed in 1972. In 1976, the District acquired the water rights and facilities of the five former canal systems through an agreement with the City of Bakersfield. In addition to its Kern River and SWP supplies, the District has made occasional purchases of water from the Central Valley Project (CVP) through deliveries to the Kern River from the Friant-Kern Canal. Irrigation deliveries to lands within the District are also made with wastewater treatment plant effluent, but not through District facilities. Irrigation demands in excess of the District's water deliveries are met through groundwater pumping.

The KDWD boundaries include approximately 128,960 acres. According to the District's GWMP Update, approximately 107,600 acres were developed as irrigated agriculture. The actual irrigated acreage varies from year to year depending on the number of acres fallowed. Of the 107,600 acres developed as irrigated agricultural lands, about 92,000 acres were irrigated in 2013. Municipal and Industrial (M&I) development in the District is estimated to cover approximately 16,900 acres. The District's water supply sources, size and formation date are summarized in **Table 2**. The District does not expect changes to the size of its service area.

Table 2. Water Supplier History and Size	
Date of Formation	**December 1965**
Source of Water	
Local Surface Water (Kern River)	✓
Local Groundwater	✓
Treated Effluent	✓
USBR (when available)	✓
SWP (via KCWA)	✓
Service Area Gross Acreage	**128,960 acres**
Service Area Developed as Irrigated Agriculture	**107,600 acres**
Service Area Irrigated Acreage (2013)	**92,000 acres**
Source: KDWD Supplemental Water Supply Study, August 2000 KDWD Groundwater Management Plan Update	

2.02 Location of the Service Area

The KDWD is located southerly of the City of Bakersfield and the Kern River in the Southern San Joaquin Valley. As shown on **Figure 1**, the District is bordered by KCWA Improvement District No. 4 (ID4) on the north, Arvin Edison Water Storage District (AEWSD) on the east, Wheeler Ridge-Maricopa Water Storage District (WRMWSD) on the south, and the Kern Water Bank (KWB), Henry Miller Water District (HMWD), Buena Vista Water Storage District (BVWSD), and McAllister Ranch Irrigation District on the west. The City of Bakersfield’s boundaries include a portion of the District.

Approximately 89,210 of the District’s acres are within the utility service areas of the five canal systems and about 35,620 acres are classified as non-utility areas. The remaining lands are major rights of way for State and County roads and canals. The District and canal service area boundaries are shown on **Figure 2**. The canal service area boundaries include lands located outside of the District’s boundaries.

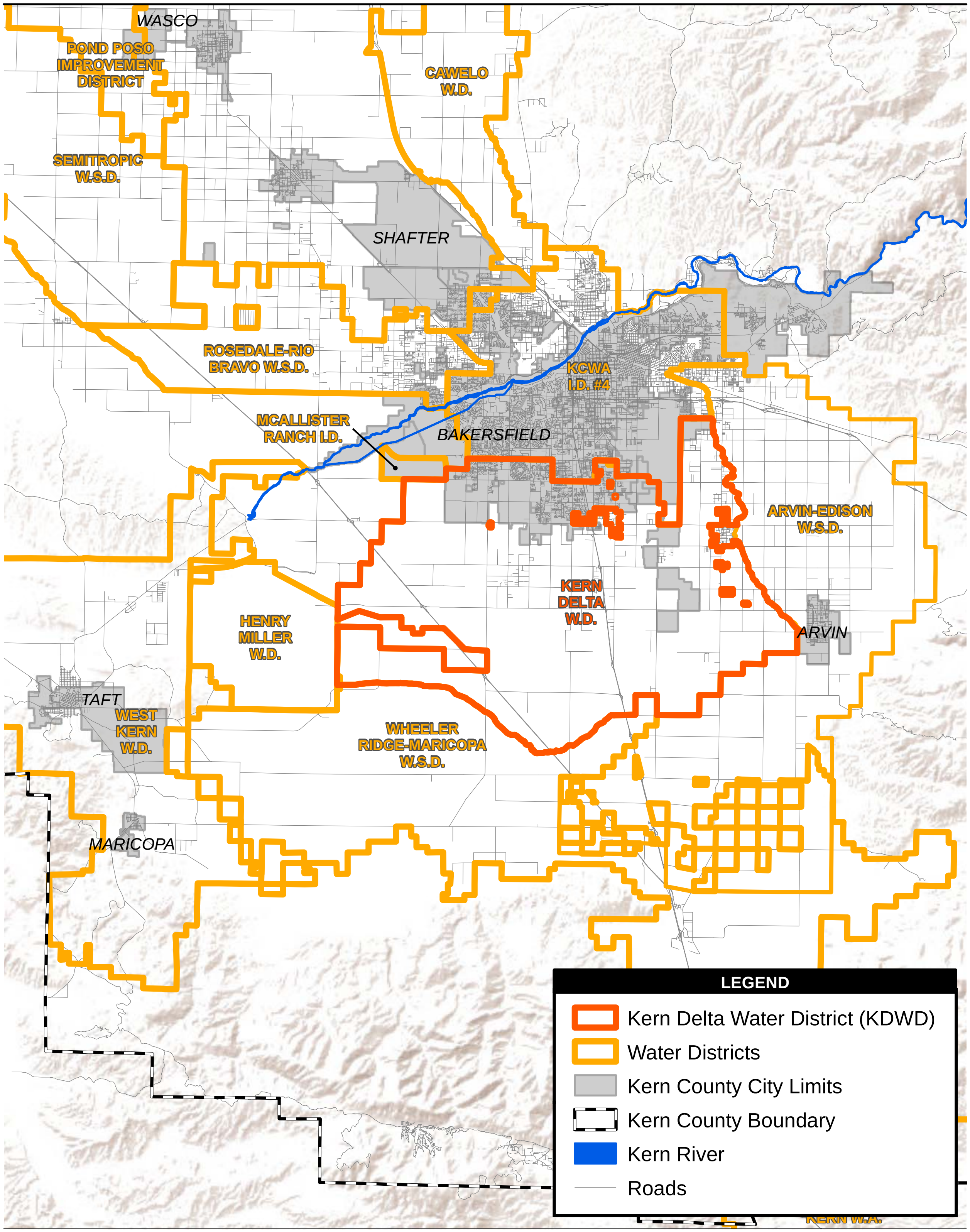
2.03 Water Management Facilities

The District’s water management facilities including canals, laterals, groundwater recharge basins, and District owned wells are also shown on **Figure 2**. Brief descriptions of the facilities are included below.

Water Conveyance and Delivery System

The District’s gravity water conveyance and delivery system consists primarily of unlined canals and laterals located within the utility service areas. Short reaches of canals and laterals within the urban area have been concrete lined or pipelined as a part of development projects. The total length of canals and laterals is approximately 150 miles (see **Table 3**). The District has maintained the majority of its canals as unlined in order to preserve the groundwater recharge benefits that result from seepage through the unlined canal bottoms. The District does not operate any agricultural drains.

The District’s main canals, from west to east, are the Buena Vista Canal, Stine Canal, Farmers Canal, Kern Island Canal (including the main canal and the Central Branch), and the Eastside Canal. These canals are connected to regional facilities operated by others (the Kern River Canal, Carrier Canal, and the Arvin-Edison Intake Canal), which allow the various surface water supplies to be diverted into the District.



Sources: Esri, USGS, NOAA; AECOM 2014

7 3.5 0 7 Miles

Scale: 1:443,520; 1 inch = 7 miles

Figure 1
District Location and Adjacent Water Districts

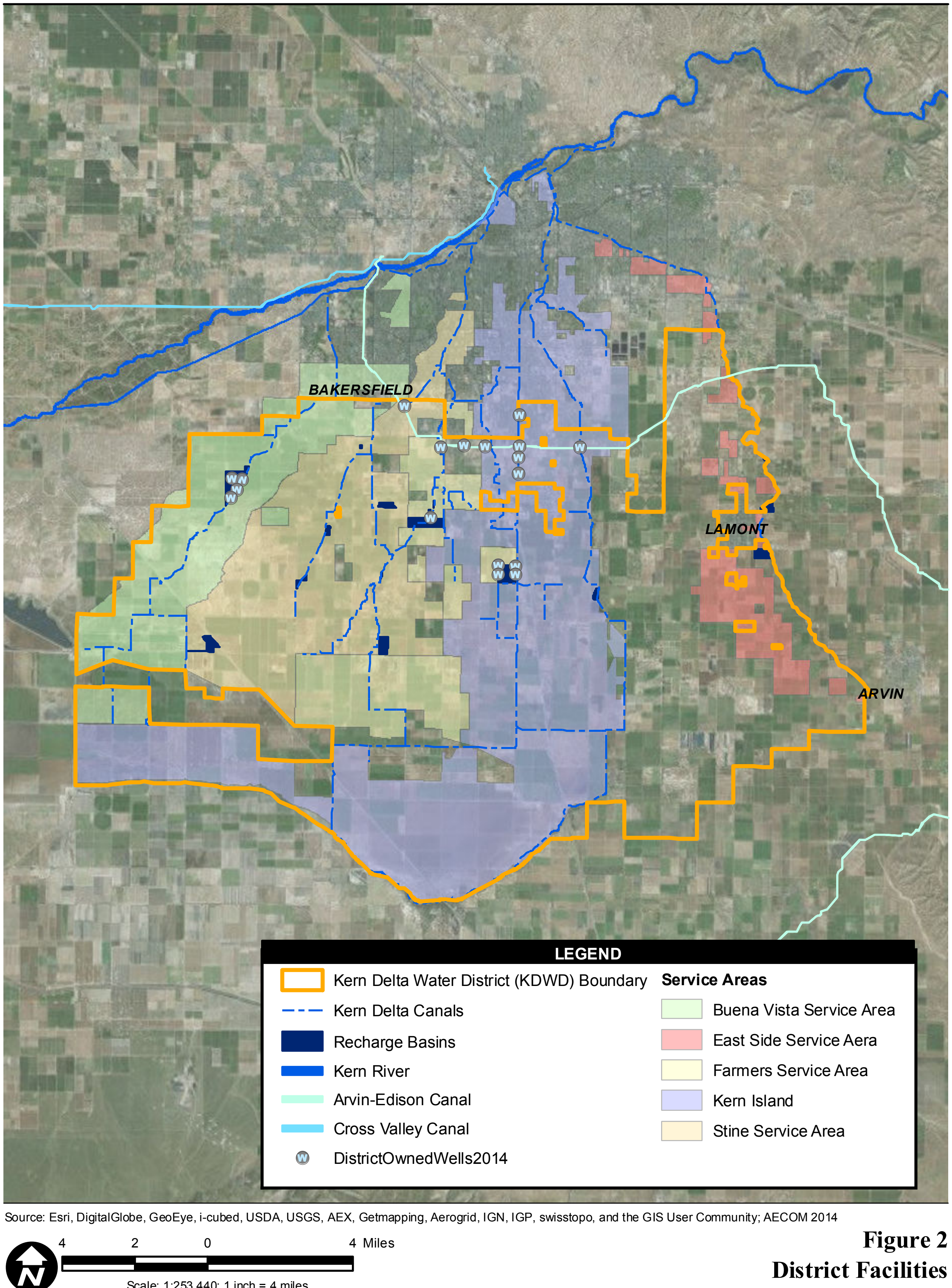


Figure 2
District Facilities and Service Areas

Table 3. Water Conveyance and Delivery System	
System Used	**Number of Miles**
Unlined Canal	127
Lined Canal	4
Pipelines	11
Drains	0
Total	**142**
Source: KDWD	

Groundwater Recharge Basins

The District's system also includes approximately 814 acres of groundwater recharge basins that were constructed beginning in 2003 as a part of the District's groundwater banking project with the Metropolitan Water District of Southern California (Metropolitan). When not needed for the Metropolitan program, these basins are available for the District's use for recharge of its excess surface water supplies. The characteristics of the District's groundwater recharge basins are summarized in **Table 4**.

Table 4. Groundwater Recharge Basins				
Recharge Basin	**Service Area**	**Size (acres)**	**Average Infiltration Rate (ft/day)**	**Average Annual Recharge Capacity (AF)**
Destefani	Buena Vista	215	0.43	34,000
Pit	Stine	72	0.20	5,000
Dairy	Stine	40	0.45	6,500
Ramero	Farmers	169	0.45	28,000
Stonefield	Stine	80	0.45	13,000
Kern Island	Kern Island	160	0.45	26,000
Di Giorgio	Eastside	78	0.30	8,500
Total		**814**	**0.41**	**121,000**
Source: KDWD Groundwater Management Plan Update				

Isabella Reservoir Rights

As a part of the KDWD purchase of Kern River rights from the City of Bakersfield, the District acquired storage rights in Isabella Reservoir. The storage rights vary from month to month based on a rule curve. The maximum storage limits and the end of year carryover limits for each service area are shown in **Table 5**. KDWD can also use a portion of BVWSD's storage space per the terms of the SWP exchange agreement with BVWSD (maximum carryover of 6,000 AF).

Table 5. KDWD Isabella Reservoir Storage Rights		
Service Area	**Maximum Storage (AF)**	**Carryover (AF)**
Kern Island	18,000	2,500
Buena Vista	11,000	1,500
Stine	9,000	1,500
Farmers	6,000	1,500
Total	44,000	7,000
Source: KDWD Supplemental Water Supply Study, 2000		

District Owned Wells

KDWD has constructed or purchased 18 wells to recover banked groundwater as a part of its banking program with Metropolitan. These wells may be used by the District to supplement surface water deliveries to its landowners in dry years. The wells are located adjacent to recharge basins in the Kern Island and Buena Vista service areas and near the Arvin-Edison Canal (operated by the AEWSD) in the northern portion of the District. Individual well capacities range from about 1,800 gallons per minute (gpm) to 4,500 gpm. The total annual recovery capacity of the wells is estimated to be 94,000 acre-feet per year.

Tailwater/Spill Recovery Systems

The District does not operate any tailwater/spill recovery systems. Individual growers may operate their own systems (see **Table 6**).

Table 6. Tailwater/Spill Recovery System	
System	**Yes/No**
District Operated Tailwater/Spill Recovery	No
Grower Operated Tailwater/Spill Recovery	Yes
Source: KDWD	

2.04 Terrain and Soils

The KDWD is situated near the southern “horseshoe” end of the San Joaquin Valley, with the Sierra Nevada Mountains to the east, the Tehachapi Mountains to the south, and the Temblor Range to the west. Elevations in the District slope gently from a maximum elevation of approximately 415 feet in the northeast to a minimum of 285 feet in the southwest. The topography allows for gravity operation of the District’s canals and laterals. The District has allowed storm water drainage facilities operated by the City of Bakersfield and County of Kern to connect to the District’s canal facilities in a number of locations. It is estimated that the quantity of storm water entering the District’s canal facilities averages about 800 acre-feet/year.

The soils in the District are the result of deposits from the Kern River which during historic flood stages overflowed into the District and terminated in the former Kern Lake bed in the southern portion of the District. The soils in the northern and central portions of the District are primarily coarse-grained sediments (sands), while those in the lower Kern Island Service Area, including the former Kern Lake bed area, are primarily fine-grained deposits (silts and clays) as shown in **Figure 3**.

The District's recharge basins have been located within the higher percolation areas with the coarse-grained soils. The lands overlying the silt and clay deposits may have issues related to the area's perched groundwater table. The perched groundwater tends to be high in salts (TDS) and can interfere with crop growth. Many landowners in these areas utilize tile drains to lower the water table and allow for continued farming of the land. The perched water from these drains is blended with other sources of supply and reused for irrigation.

2.05 Climate

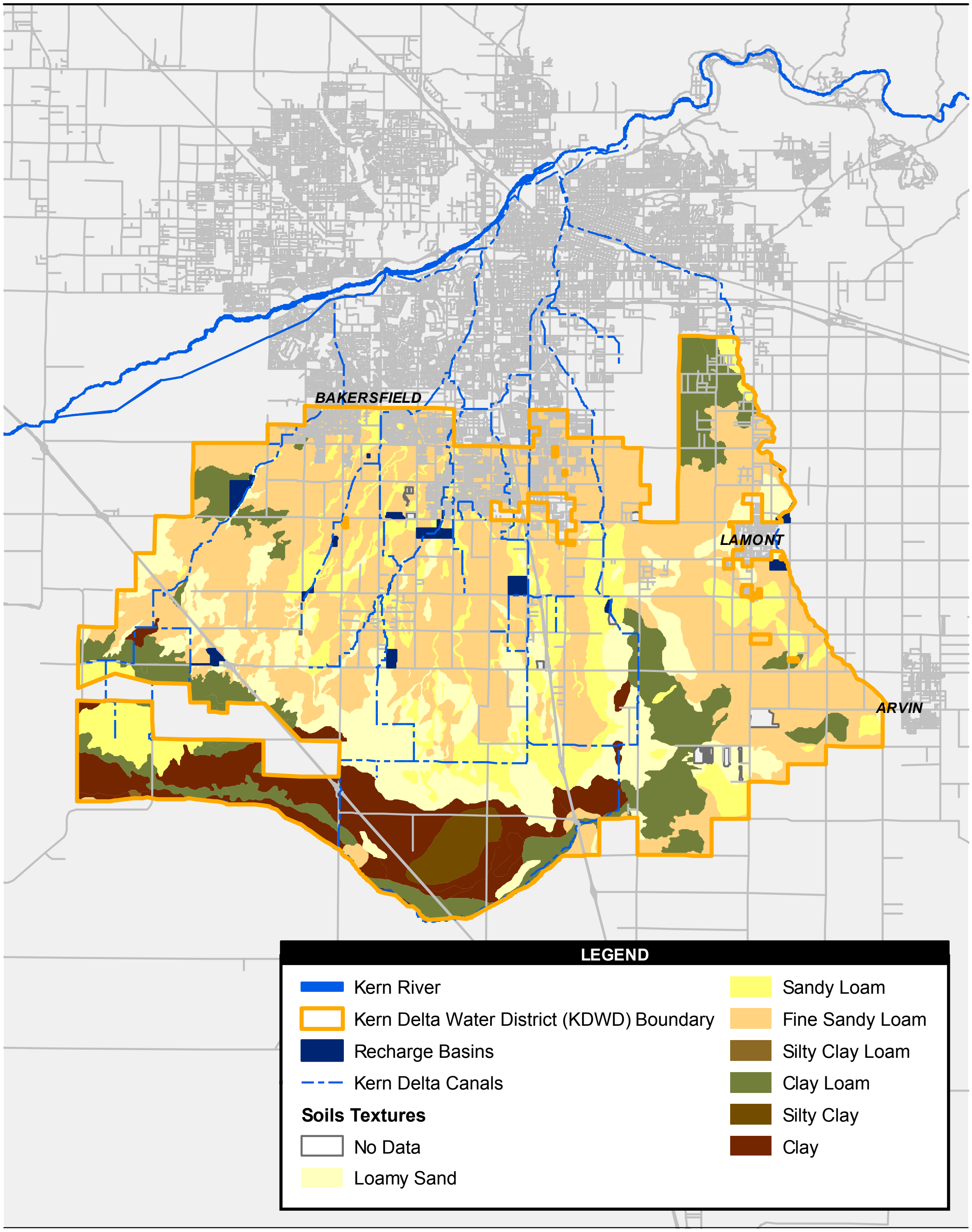
The local climate is characterized by hot, dry summers and cooler, more humid winters. The Bakersfield area enjoys clear, sunny days for more than half of the year. Minimum temperatures often drop below 40 degrees Fahrenheit during the winter. Summers are hot with most days exceeding 90 degrees Fahrenheit. Annual precipitation in the area averages approximately 6 inches and rain occurs primarily during the period from November through April. Fog is common in the winter and may last for several weeks at a time.

Local climate data for the City of Bakersfield as recorded at the Western Regional Climate Center NOAA Cooperative Center (Bakersfield WSO ARPT) for the period from 1937 to 2013 is presented in summary form in **Table 7**. More detailed climate data is included in **Table 8**.

Table 7. Summary Climate Characteristics

Climate Characteristic	Value
Average Annual Precipitation (inches)	6.16 inches
Monthly Minimum Precipitation (Avg. July) (inches)	0.01 inches
Monthly Maximum Precipitation (Avg. February) (inches)	1.16 inches
Average Annual Minimum, Average Month Temperature (January) (°F)	52.7 °F Annual, 38.5 °F January
Average Annual Maximum, Average Month Maximum Temperature (July) (°F)	77.8 °F Annual, 98.6 °F July

Source: Western Region Climate Center (http://www.wrcc.dri.edu/) Yrs. 1937-2013. Bakersfield WSO ARPT



Source: Kern County; USDA SSURGO; AECOM 2014

4 2 0 4 Miles

Scale: 1:253,440; 1 inch = 4 miles

Figure 3
Soil Texture Map

KDWD

Path: C:\GIS\KDWD\Fig3_SoilTexture.mxd, 12/11/2014, steinb

Table 8. Detailed Climate Characteristics*				
Month/Time	**Average Precipitation, Inches[1]**	**Average Reference Evapotranspiration (Et_o), Inches[2]**	**Average Minimum Temperature[1], °F**	**Average Maximum Temperature[1], °F**
January	1.04	2.63	38.5	57.4
February	1.16	2.74	42.1	63.6
March	1.12	4.84	45.4	69.0
April	0.67	6.18	49.7	75.7
May	0.21	8.41	56.6	84.2
June	0.07	9.39	63.3	92.1
July	0.01	8.99	69.2	98.6
August	0.04	8.52	67.7	96.7
September	0.10	6.27	63.1	91.0
October	0.30	4.36	54.0	80.5
November	0.59	2.54	44.1	67.3
December	0.85	1.80	38.5	57.8
Wet Season**	5.43	20.73	43.1	65.1
Dry Season**	0.73	45.94	62.3	90.5
Annual	6.16	66.67	52.7	77.8

Source:
[1]Western Region Climate Center (http://www.wrcc.dri.edu/) Yrs. 1937-2013. Bakersfield WSO ARPT
[2]DWR California Irrigation Management Information System (CIMIS). Arvin-Edison Station #125
Notes:
**Wet season is November through April. Dry Season is May through October

2.06 Operating Rules and Regulations

The District amended its "Rules and Regulations for the Sale and Distribution of Water" on April 21, 2015 (attached as **Appendix C**). These rules require at least 24 hour notice for requested water delivery or shutoff. A grace period for water overruns of up to four hours is included. Information on the operation of the District's delivery system and lead times is presented in **Tables 9 and 10**.

Table 9. Supplier Delivery System		
Type	**Check if Used**	**Percent of System Supplied**
Arranged Demand	✓ (24 Hr. Notice)	100 Percent
Rotation	✓	Only during shortages

Source: KDWD "Rules and Regulations for the Sale and Distribution of Water"

Table 10. Actual Lead Times	
Operations	**Hours/Days**
Water Orders	24 hours / 1 day
Water Shut-Off	24 hours / 1 Day
Grace Period (Water Shut-Off)	4 Hours
Source: KDWD "Rules and Regulations for the Sale and Distribution of Water"	

Kern River Utility Water may be prorated during times of shortage based on: (1) anticipated total deliverable water to specific areas within the District Service Areas, (2) total acres within those Areas, (3) acres owned or operated by each customer within those Areas, and (4) any other equitable factors deemed necessary and appropriate by the District. During periods of water shortage, the District may deliver Utility Water on a rotational basis. The rotation may cause growers to go several days or weeks between deliveries.

Allocation of the District's SWP supplies is governed by Resolution No. 2009-05 and the "2nd Amendment to the 1974 Plan for Water Allocation and Procedure for Setting State Water Tolls" according to the following process:

1. The Board of Directors shall have the option to sell up to 2,000 acre-feet/year of Kern Delta's State Water Project (SWP) contractual water supply out-of-district but within Kern County.

2. The annual SWP contractual water supply, less any water sold out-of-district pursuant to Paragraph 1, shall be allocated as follows:

    a) 12,500/30,000 to Eastside Utility lands and Eastside Area Non-Utility lands capable of receiving service from the Eastside Canal or the Central Branch of the Kern Island Canal.

    b) 17,500/30,000 to Stine, Farmers, and Buena Vista Utility lands and Non-Utility lands lying west of the Kern Island Central Canal that are capable of receiving service.

3. Specific allocations to individual service areas shall be determined based on the following guidelines:

    a) 20% of the amounts allocated to the Eastside and Westside Areas shall be reserved to cover seepage losses within the District's canals. The remaining 80% of the Eastside and Westside Area supplies shall be allocated to individual District consumers.

    b) Water will be allocated to Eastside Area consumers (utility and non-utility) on an equal acre-foot per acre basis.

    c) The Westside Area supply shall be allocated to Stine, Farmers, and Buena Vista Utility consumers and Westside Non-Utility consumers, i.e., located west of Highway 99, capable of receiving service in amounts such that the total water deliveries to each area (based on projected long term average Utility Water deliveries and available SWP supply for that year) shall be equal in terms of acre-feet per acre.

A summary of the District's water allocation policy is given in **Table 11**.

Table 11. Water Allocation Policy

	(Check if applicable)			Allocation	
Basis of Water Allocation	**Flow**	**Volume**	**Seasonal Allocations**	**Normal Year**	**Percent of Water Deliveries (%)**
Area within the service area		✓		✓	100
Amount of land owned		✓		✓	100
Seepage Losses		✓		✓	20[1]
Other (Out-of-District)		✓		✓	2,000 AF max[2]

Source: KDWD "Rules and Regulations for the Sale and Distribution of Water"
KDWD "Proposed Second Amendment to 1974 Plan for Water Allocation"

Note: [1]Percentage of SWP supply reserved to cover canal seepage loss.
[2]Option to sell up to 2,000 acre/feet/year of SWP supply out-of-district within Kern County

2.07 Water Delivery Measurements

Water delivery measurements are made as described in the KDWD Water Deliveries Report, July 2014 (included as **Appendix D**). The District utilizes two types of measurement devices: overpour weirs and meters (manual and automated). The measurement devices are read and reported daily by District staff.

Weirs that are used by the District for water measurement are constructed and maintained to conform to the requirements of fixed-blade, thin-walled rectangular weirs, as defined in the "Water Measurement Manual" published by the United States Department of the Interior, Bureau of Reclamation, in order to provide accurate measurements. The method of measurement has also been standardized by the District to eliminate potential sources of error. Measurements are taken at a distance between four and six times the head above the weir at approximately the center of the canal's flow path.

Waterman Type C-10 canal gates are a primary source of measurement and are used throughout the District at both major diversions and at individual farmer turnouts and delivery points. Farmer turnouts have pipe risers or stilling wells installed behind the headwall. Water delivery measurements at these locations are based on differential head readings, gate opening height, and gate size. Other metering devices used by the District include:

- Doppler ultrasonic and depth sensor – used in partially full pipelines and open canals,
- EchoFlo ultrasonic sensor – installed in canals upstream of fixed-blade overpour weirs, used in conjunction with weirs to measure flow in canals, and
- Propeller meters – used in pipelines flowing full.

The KDWD periodically reviews the condition of its measurement devices as a part of its routine maintenance program. A summary of the District's water delivery measurement devices is given in **Table 12** along with typical levels of accuracy.

Table 12. Water Delivery Measurements			
Measurement Device	**Frequency of Calibration (Months)**	**Frequency of Maintenance (Months)**	**Estimated Level of Accuracy (%)**
Orifices (meter gates)	As needed	As needed	+/- 5 to 10%
Propeller Meters	Per Mfr. Rec.	Per Mfr. Rec.	+/- 2%
Weirs	As needed	As needed	+/- 5 to 10%
Doppler UltraSonic & Depth Sensor[1]	Per Mfr. Rec.	Per Mfr. Rec.	+/- 1%
EchoFlo Ultrasonic Sensor[2]	Per Mfr. Rec.	Per Mfr. Rec.	+/- 0.2%

Source: KDWD Water Deliveries Report, July 2014
[1]For measurement of flow within district canals and pipelines
[2]Installed upstream of fixed-blade overpour weirs. Used in conjunction with weirs to determine flow rates within a canal reach

2.08 Water Rate Schedules and Billing

KDWD charges a combination of annual assessments on a per acre basis and a water rate per acre foot of deliveries. The assessment charges vary based on District Service Area and development type. Water rates are different for Utility Water and SWP supplies. Rates for SWP supplies also vary by District Service Area. Water rates are billed monthly per the District's "Rules and Regulations". The water rates are uniform, they do not increase or decrease based on the quantity of water used.

The District's assessment charges and water rates for 2014 are summarized in **Table 13**.

Table 13. 2014 Water Rate Basis			
Water Charge Basis	**Check if Used**	**Percent of Water Deliveries (%)**	**Description**
Volume of Water Delivered	✓	100	Rates vary based upon water type and District Service Area, See Below:
		Service Area:	**Rate:**
		KDWD Utility Water:	$17.00/ac-ft
		Eastside SWP Water:	$61.77/ac-ft
		Kern Island East of 99 SWP Water:	$40.40/ac-ft
		Kern Island West of HWY 99 SWP Water:	$46.23/ac-ft
		Stine and Farmers SWP Water:	$42.07/ac-ft
		Buena Vista SWP Water	$40.53/ac-ft
Land Assessment	✓	100	Rates vary based upon District Service Area and development type, See Below:
		Service Area:	**Rate (per acre):**
		Annual Assessment Admin. Charge:	$4.34
		Eastside Assessment Charge:	$2.97
		Farmers Assessment Charge:	$4.67
		Stine Assessment Charge:	$5.48
		Buena Vista Assessment Charge:	$5.21
		Kern Island Assessment Charge:	$2.21
		South Fork Assessment Charge:	$0.85
		City Sewer Plant Assessment Charge:	$0.85
		Remaining Irrigated Land Assessment Charge:	$6.31
		Undeveloped Lands Assessment Charge:	$0.85
		Commercial / Residential Assessment Charge:	$6.31
Equalization (Standby)	✓	100	Rates vary based upon District Service Area, See Below:
		Service Area:	**Rate (per acre):**
		Eastside Equalization Charge:	$7.31
		Buena Vista Equalization Charge:	$9.55
		Kern Island Equalization Charge:	$6.55
Source: KDWD Note: Rates are subject to change.			

2.09 Drought Management and Water Shortage Allocation Policies

The District's water shortage allocation procedures are discussed in **Section 2.06 - Operating Rules and Regulations.** Available water supplies are prorated based on area within the applicable Service Area as summarized in **Table 14**.

Table 14. Decreased Water Supplies Allocations	
Allocation Method	**Check if used**
Area in Service Area	✓
Source: KDWD Rules and Regulations.	

Landowners in the District pump groundwater to cover shortages in surface water supplies. The KDWD may also pump District wells to provide additional surface supplies to landowners. The District may shut off deliveries or refuse to make deliveries if private facilities are not reasonably maintained or if wasteful use of delivered water occurs (see **Table 15**).

Table 15. Enforcement Methods of Allocation Policies	
Enforcement Method	**Check if used**
Water Shut-off	✓
Source: KDWD Rules and Regulations.	

The District's conjunctive use program operations have been developed to maximize its surface water supplies and help to maintain sustainable groundwater quality and quantity and allow the District to continue to rely on its groundwater supplies during times of drought. In its GWMP, the District identifies Groundwater Basin Management Measures that it will follow in order to protect and sustain its groundwater and surface water supplies. These are included in **Section 5.04 – Water Supply Reliability.**

Section 3: Description of the Quantity of Water Uses (Demands)

Law

Describe water uses within the agricultural water supplier's service area, including all of the following:

A. Agricultural.
B. Environmental.
C. Recreational.
D. Municipal and Industrial.
E. Groundwater Recharge.
F. Transfers and Exchanges.
G. Other water uses (§10826b).

3.01 Basis for Reporting Water Quantities

KDWD's water usage varies from year to year based on a number of factors including cropping patterns, fallowed acreage, precipitation, and available surface water supplies. Due to this variation, three types of representative years (wet, normal, and dry) are used as the basis for reporting water use quantities in this report. The characteristics of the selected representative years - 2008 (normal), 2011 (wet) and 2013 (dry) - are given in **Table 16**. These year types are approximations and were selected primarily based on Kern River hydrology.

Table 16. Representative Year

	2008	2011	2013
Representative year(s) based upon	Normal Year	Wet Year	Dry Year
First month of representative year	January	January	January
Last month of representative year	December	December	December
Final SWP Allocation (Percent)	35%	80%	35%
Kern River Runoff (Percent of Average)	72%	190%	29%

Source:
Kern River Annual Reports
Department of Water Resources, State Water Project. http://www.water.ca.gov/swpao/deliveries.cfm

3.02 Agricultural Water Use

Annual agricultural water use within the District for the representative years 2008, 2011, and 2013 is shown in **Table 17**. Water usage varies based on the cropping pattern and hydrologic conditions.

Table 17. Annual Agricultural Water Use (AF)

Source	Representative Year		
	2008 – Normal	2011 – Wet	2013 – Dry
Agricultural Water Supplier Delivered			
Surface Water (SWP)	8,205	15,531	8,299
Surface Water (Kern River)	138,724	137,473	81,139
Reclaimed Water (City WWTP Effluent)[1]	18,000	18,000	18,000
Other Water Supplies Used			
Groundwater (District Wells[2])	10,534	-	20,519
Effective Precipitation[3]	25,236	34,096	26,162
Groundwater (Private[4])	104,380	93,910	143,140

Source: KDWD, Annual Kern River Reports
[1]Estimated average effluent deliveries to lands within KDWD
[2]Pumping from District owned groundwater wells
[3]Effective precipitation based on annual precipitation and net irrigated acreage.
[4]Estimate of pumping from private wells based on difference in water supplies and total applied water demands in Tables 18A – 18C.

Groundwater pumping from private wells shown in **Table 17** is estimated based on the applied water needs for the agricultural cropping patterns for each representative year as determined in **Tables 18A through 18C**. Agricultural cropping patterns for the representative years 2008, 2011 and 2013 have been tabulated from permit data from the Kern County Agricultural Commissioner's website. Crop evapotranspiration (Crop ET) values in these tables are based on data from the Cal Poly Irrigation Technology Research Center (ITRC) as modified for typical Kern County operations (modified scenario surfdrywb15). The Kern Groundwater Authority is currently reviewing an alternative approach for the determination of consumptive use based on a surface energy balance using satellite thermal imagery (ITRC-METRIC). If this method is adopted, the consumptive use values in this report may be reviewed relative to the new methodology.

Estimates of applied water demands assume an average irrigation efficiency of 80 percent per the District's GWMP Update. Irrigation efficiencies within the District range from about 76 percent to 92 percent with the highest values in the areas of low permeability soils where tile drains allow for reuse of perched water for irrigation. The 20 percent return flows provide for leaching requirements, seedbed preparation, and weather variations. Total crop water needs are calculated based on net irrigated acreage (assumed to be 95% of total acreage to account for non-irrigable areas of parcels) multiplied by the applied water demand for each crop.

Multiple crop acreage from the Kern County Agricultural Commissioner's data for each representative year is shown in **Table 20**. The crop acreages in **Tables 18A through 18C** are based on the crop with the highest water usage. The consumptive use estimates from the ITRC for the typical multiple crop scenarios in the District are nearly the same as those for the higher water use crop. Total crop water needs for 2014 and 2015 would be similar to those shown for 2013 in **Table 18C**.

Table 18A. Agricultural Crop Data For 2008[1]				
Crop	**Total Acreage**	**Crop ET[2] (AF/Ac)**	**Applied Water Demand (AF/Ac)[3]**	**Total Crop Water Needs (AF)[4]**
Alfalfa	31,840	3.96	4.95	149,740
Wheat	6,740	1.29	1.61	10,320
Corn/Sorghum	22,530	2.25	2.81	60,190
Cotton	11,290	2.37	2.96	31,790
Grape	5,300	2.22	2.78	13,990
Carrot/Cabbage	3,420	1.45	1.81	5,890
Tomato	3,100	1.71	2.14	6,310
Misc. Grains	1,340	1.29	1.61	2,050
Almond	1,740	3.71	4.64	7,650
Potato	1,550	2.76	3.45	5,070
Onion	830	1.33	1.66	1,310
Misc. Field	2,310	1.99	2.49	5,450
Pasture and Grass	890	3.94	4.93	4,190
Other[5]	300	3.11	3.89	1,130
TOTALS	**93,180**			**305,080**

Source: Kern County website
[1]Based on best available data and rounded to nearest 10 acres and AF.
[2]Crop ET from Cal Poly ITRC (modified surfdrywb15)
[3]Based on irrigation efficiency of 80%
[4]Calculated based on net irrigated acreage at 95% of total acreage (to account for non-irrigable areas) and applied water demand
[5]Includes miscellaneous fruit, nuts, and nursery

Table 18B. Agricultural Crop Data For 2011[1]				
Crop	**Total Acreage**	**Crop ET[2] (AF/Ac)**	**Applied Water Demand (AF/Ac)[3]**	**Total Crop Water Needs (AF)[4]**
Alfalfa	26,920	3.96	4.95	126,570
Wheat	6,640	1.29	1.61	10,170
Corn/Sorghum	21,580	2.25	2.81	57,660
Cotton	15,120	2.37	2.96	42,540
Grape	5,670	2.22	2.78	14,960
Carrot/Cabbage	2,590	1.45	1.81	4,460
Tomato	1,910	1.71	2.14	3,870
Misc. Grains	1,890	1.29	1.61	2,900
Almond	2,640	3.71	4.64	11,640
Potato	2,000	2.76	3.45	6,560
Onion	780	1.33	1.66	1,230
Misc. Field	3,740	1.99	2.49	8,830
Pasture and Grass	1,260	3.94	4.93	5,910
Other[5]	460	3.11	3.89	1,710
TOTALS	**93,200**			**299,010**

Source: Kern County website
[1]Based on best available data and rounded to nearest 10 acres and AF.
[2]Crop ET from Cal Poly ITRC (modified surfdrywb15)
[3]Based on irrigation efficiency of 80%
[4]Calculated based on net irrigated acreage at 95% of total acreage (to account for non-irrigable areas) and applied water demand
[5]Includes miscellaneous fruit, nuts, and nursery

Table 18C. Agricultural Crop Data For 2013[1]				
Crop	**Total Acreage**	**Crop ET[2] (AF/Ac)**	**Applied Water Demand (AF/Ac)[3]**	**Total Crop Water Needs (AF)[4]**
Alfalfa	24,250	3.96	4.95	114,050
Wheat	6,870	1.29	1.61	10,530
Corn/Sorghum	25,200	2.25	2.81	67,330
Cotton	10,990	2.37	2.96	30,930
Grape	5,740	2.22	2.78	15,120
Carrot/Cabbage	2,790	1.45	1.81	4,800
Tomato	1,940	1.71	2.14	3,930
Misc. Grains	750	1.29	1.61	1,140
Almond	6,030	3.71	4.64	26,570
Potato	960	2.76	3.45	3,140
Onion	340	1.33	1.66	530
Misc. Field	2,770	1.99	2.49	6,540
Pasture and Grass	1,990	3.94	4.93	9,310
Other[5]	910	3.11	3.89	3,340
TOTALS	**91,530**			**297,260**

Source: Kern County website
[1]Based on best available data and rounded to nearest 10 acres and AF.
[2]Crop ET from Cal Poly ITRC (modified surfdrywb15)
[3]Based on irrigation efficiency of 80%
[4]Calculated based on net irrigated acreage at 95% of total acreage (to account for non-irrigable areas) and applied water demand
[5]Includes miscellaneous fruit, nuts, and nursery

Table 19. Irrigated Acres			
	Representative Year		
	2008 – Normal	**2011 – Wet**	**2013 – Dry**
District Irrigable Area	107,600	107,600	107,600
Total Irrigated Acres[1]	93,180	93,200	91,530

Source: KDWD, KDWD Groundwater Management Plan Update
[1]From Tables 18A, 18B, and 18C

Table 20. Multiple Crop Information			
Cropping Method	**Representative Year**		
	2008 – Normal	**2011 – Wet**	**2013 – Dry**
Single Cropped Acres[1]	66,970	63,590	64,600
Multiple-cropping[1]	26,210	29,610	26,930

[1]From crop permit data from the Kern County Agricultural Commissioner's website

3.03 Environmental Water Use

The District's groundwater banking program agreement with Metropolitan provides for groundwater recharge for environmental purposes off of the Buena Vista Canal. The property was purchased by KDWD in 2009 and basins were constructed in 2010. Deliveries to these basins are summarized in **Table 21**. Deliveries were made even in 2013 (a dry year). The District does not supply water to wetlands, vernal pools or wildlife refuges.

Table 21. Environmental Water Uses (AF)

Environmental Resources	Representative Year		
	2008 – Normal	2011 – Wet	2013 – Dry
Groundwater Recharge (Metropolitan Program)	-	540	60
TOTAL	**-**	**540**	**60**

Source: KDWD
Note: Property was purchased by KDWD in 2009 and basins constructed in 2010.

3.04 Recreational Water Use

There are no recreational uses that are supported by the District's surface water supplies. There are several privately owned small artificial lakes that rely on pumped groundwater. This water usage for these private lakes is assumed to be small relative to other groundwater pumping and has not been included.

3.05 Municipal and Industrial Water Use

The District does not supply water directly for municipal and industrial water uses. The urbanized area within the District consists of approximately 16,900 acres and includes land within the City of Bakersfield and the small communities of Weedpatch and Pumpkin Center. Portions of the communities of Greenfield and Lamont lie within the District boundaries, while the remaining portions are islands of exclusion within the District's boundaries.

The City of Bakersfield area is supplied by a combination of groundwater and treated surface water (from KCWA, ID4 treatment plants). The other urban areas rely on groundwater for their water supply. Estimates of groundwater pumping for the urban areas within the KDWD boundary is presented in **Table 22**. The values shown are 14-year averages (1998- 2011) as included in the District's GWMP Update. Groundwater pumping for M&I usage outside of those listed in **Table 22** is assumed to be small in relation to other groundwater pumping and has not been estimated.

Table 22. Municipal/Industrial Groundwater Pumping (AF)			
Municipal / Industrial Entity	Representative Year[1]		
	2008 – Normal	2011 – Wet	2013 – Dry
City of Bakersfield	7,003	7,003	7,003
Lamont Public Utility District	4,693	4,693	4,693
Greenfield County WD	1,920	1,920	1,920
TOTAL	**13,616**	**13,616**	**13,616**

Source: KDWD Groundwater Management Plan Update
[1]14 year average from 1998-2011

3.06 Groundwater Recharge Use

While deliveries for groundwater recharge are generally only made in wet or above normal years, the District provides groundwater recharge in every year through seepage from unlined canals. A summary of the District's groundwater recharge deliveries for the representative years is given in **Table 23**. Total deliveries as a part of groundwater banking programs are included in **Section 3.07**.

Table 23. Groundwater Recharge Water Uses (AF)			
Location/ Groundwater Basin	Representative Year		
	2008 – Normal	2011 – Wet	2013 – Dry
District Recharge Ponds (for KDWD)	-	10,773	-
District Recharge Ponds (for others)		80,224	
District Canal Seepage Recharge[1]	44,468	97,792	34,486
TOTAL	**44,468**	**188,789**	**34,486**

Source: KDWD, Annual Kern River Reports
[1]Larger quantities are available in wetter years.

3.07 Transfer and Exchange Use

The KDWD has groundwater banking program/exchange agreements with Metropolitan and the San Bernardino Valley Municipal Water District (SBVMWD) which allows the agencies to the recharge up to 50,000 acre-feet per year, with a limit of 250,000 acre-feet of total groundwater in storage. Deliveries under these programs are assessed an 11% operational loss at the point of delivery to the District. Water is returned to the agencies by either water exchanges or direct delivery of pumped groundwater. Until water is returned, it remains in storage in the groundwater basin to the benefit of KDWD and its landowners.

Exchange program operations for the representative years are shown in **Table 24**. The District has entered into various other operational exchanges that help to maximize the efficient use of its water supplies. The District's SWP contract deliveries are made through an exchange with BVWSD where KDWD's SWP supplies are delivered to BVWSD in exchange for BVWSD's Kern River supplies. These exchange deliveries are addressed in **Section 4.01**.

Table 24. Transfers and Exchanges Water Uses (AF)					
From What Agency	**To What Agency**	**Type of Transfer of Exchange**	**2008 – Normal**	**2011 - Wet**	**2013 - Dry**
MWD	KDWD	Banking program delivery	-	60,139	-
KDWD	MWD	Banking program return	8,402	-	10,000
SBVMWD	KDWD	Banking program delivery	-	30,000	-
KDWD	SBVMWD	Banking program return	-	-	1,500
Source: KDWD					

3.08 Other Water Use

The District does not have any other significant water uses.

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Section 4: Description of Quantity and Quality of the Water Resources

Law

Describe the quantity and quality of water resources of the agricultural water supplier, including all of the following:

1. *Surface water supply,*
2. *Groundwater supply,*
3. *Other water supplies,*
4. *Source water quality monitoring practices,*
5. *Water uses within the agricultural water supplier's surface area,*
6. *Drainage from the water supplier's service area (10826(b)).*

4.01 Water Supply Quantity

The KDWD's main sources of supply are surface water (both local and imported) and groundwater. These supplies are managed conjunctively by the District in an effort to maximize the beneficial use of these supplies. A description of the quantities of these supplies is included below.

A. Surface Water Supply

As discussed in **Section 2.01**, KDWD's Kern River diversion rights (for the former Kern Island, Buena Vista, Stine, Farmers, and Eastside canal companies) were acquired in 1976. Diversions are based on the river stage and the priority of each water right as summarized in **Table 25**. Current Kern River supplies have been reduced as a result of litigation that placed caps on the District's entitlement for various rights in certain months. The District estimates that its average long-term Kern River water supply will be about 202,000 acre-feet per year. Restrictions on the District's Kern River entitlement supply are summarized in **Table 26**.

The KDWD's contract for SWP water provides for a maximum entitlement of 25,500 acre-feet per year. Through an exchange agreement with BVWSD, the District's SWP supplies are delivered to BVWSD in exchange for an equal quantity of BVWSD supplies in the Kern River. In recent years, court imposed pumping restrictions on the deliveries of SWP water south of the Sacramento-San Joaquin River Delta have resulted in reductions in the District's SWP supplies. In the District's GWMP Update, it was estimated that 50 percent of the District's SWP contract supply will be available on average.

Purchases of water from the CVP (Section 215 floodwater), SWP Article 21, lower Kern River rights, and other sources are made when available and advantageous to the District. The District has also received water supplies from Metropolitan and SBVWMD as a part of its groundwater banking programs.

The District's water supplies from the above sources for the representative years are shown in **Table 27**.

Table 25. KDWD Kern River Water Rights				
Service Area	**Right (cfs)**	**River Stage (cfs)**	**Diversion Priority**	**Appropriation Date**
Kern Island	300	0-300	1	12/1/1869
	56	3,106-3,162	26	
Buena Vista	80	330-410	4	7/19/1870
	90	2,416-2,526	22	
Stine	150	550-700	7	12/12/1872
Farmers	150	730-880	9	4/28/1873
Eastside	83/300th of Kern Island			6/30/1921
Source: KDWD GWMP Update				

Table 26. Kern River Entitlement Caps from Court Decisions						
Service Area	**January (AF)**	**August (AF)**	**September (AF)**	**October (AF)**	**November (AF)**	**December (AF)**
Kern Island	8,493	-	-	6,989	3,375	2,050
Buena Vista	347	-	-	-	236	191
Stine	-	-	583	1,380	22	12
Farmers	-	610	268	-	-	207
Source: KDWD GWMP Update						

Table 27. Surface Water Supplies (AF)			
Source	**Representative Year**		
	2008 - Normal	**2011 - Wet**	**2013 - Dry**
Kern River	182,343	228,107	115,348
SWP Contract	9,054	21,227	8,576
Lower River Purchase	-	1,462	-
MWD Program	-	60,139	-
SBVMWD Program	-	30,000	-
TOTAL	**191,397**	**340,935**	**123,924**
Source: KDWD, Annual Kern River Reports			

B. Groundwater Supply

The KDWD is located in the Kern County Subbasin of the San Joaquin Valley Groundwater Basin (DWR Basin No. 5-22.14). The subbasin covers more than 3,000 square miles and is the source of groundwater for numerous other districts, cities, agencies, and private landowners. Details about the subbasin are provided in **Table 28**.

Table 28. Groundwater Basins

Basin Name	Size (Sq. Mi.)	Usable Capacity (AF)	Safe Yield (AF/Yr)
Kern County Subbasin	3,040	40,000,000	Unknown

Source: DWR San Joaquin District Kern County Groundwater Basin Information: http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/5-22.14.pdf

Additional information on the groundwater basin is provided in the District's GWMP Update which has been attached as **Appendix E**. Information about the preparation and adoption of the GWMP is given in **Table 29**.

Table 29. Groundwater Management Plan

Written By	Todd Engineers
Year	2013
Is Appendix Attached?	Yes. Appendix E

Source: KDWD

The location of the District's wells and groundwater recharge areas are shown on **Figure 2** and described in **Section 2.03**. Groundwater recharge operations are summarized in **Table 23** in **Section 3.06**. Information regarding the District's groundwater banking program operations in provided in **Section 3.07**. Estimated groundwater pumping within the District for the representative years is shown in **Table 30**.

Table 30. Groundwater Supplies (AF)

Source	Representative Year			Anticipated Changes
	2008 - Normal	2011 - Wet	2013 - Dry	
District Well Pumping	10,534	-	20,519	unknown
Municipal Pumping[1]	13,616	13,616	13,616	unknown
Private Pumping[2]	104,380	93,910	143,140	unknown
TOTAL	**128,530**	**107,526**	**177,275**	unknown

Source: KDWD, KDWD GWMP Update
[1]From Table 22
[2]From Table 17

The Sustainable Groundwater Management Act (SGMA) was signed by the Governor on September 16, 2014 and includes requirements for the formation of local groundwater sustainability agencies (GSAs) that will assess local groundwater conditions. These GSAs will adopt groundwater sustainability plans. The impacts that this legislation will have on groundwater pumping within the District is unknown at this time.

The District is a member of the Kern Groundwater Authority (Authority) which was formed with the purpose to develop a groundwater management plan for the Kern County Subbasin. The District also participates in California Statewide Groundwater Elevation Monitoring (CASGEM) program and provides information on groundwater levels within the District to the DWR.

C. Other Water Supplies

Reclaimed wastewater treatment plant effluent from City of Bakersfield Wastewater Treatment Plants No. 2 and No. 3 is used to irrigate limited lands within the KDWD. The average quantity of reclaimed wastewater applied to agricultural lands within the District is estimated to be about 18,000 acre-feet per year. Changes in urban water management planning legislation that encourages reuse of recycled water may decrease this supply in the future. However, the recycled water may be used for urban irrigation within the District thereby reducing the future municipal pumping requirements.

D. Drainage

The District does not operate drainage facilities. Landowners, especially in the perched water areas, may operate tile drains and reuse drainage flows for irrigation.

4.02 Water Supply Quality

The quality of KDWD’s groundwater and surface water supplies is described in the following sections.

A. Surface Water Supply

KDWD’s surface water is primarily from the Kern River and is of excellent quality. KCWA ID4 reports on the quality of surface water from the Kern River, Friant-Kern, and SWP through the Aqueduct in their annual Report on Water Conditions. Kern River water quality data from the most recent Report on Water Conditions for parameters of concern for agricultural supplies are presented in **Table 31**. The complete table of Source Water Quality from the 2014 Report on Water Conditions has been included in **Appendix F.**

Table 31. Kern River Water Supply Quality		
Parameter	**Units**	**2014**
Total Dissolved Solids (TDS)	mg/L	126
Calcium	mg/L	19.6
Boron	mg/L	0.25
Arsenic	mg/L	0.006
Magnesium	mg/L	3.76
Potassium	mg/L	2.46
Sodium	mg/L	23.7
Chloride	mg/L	9.68
Sulfate (SO_4)	mg/L	25.5
Nitrate (NO_3)	mg/L	ND
Source: KCWA ID4 – Report on Water Conditions 2014		

B. Groundwater Supply

Groundwater quality in the KDWD is generally of very good quality and suitable for agricultural use. A detailed description of the District's groundwater quality is included in the GWMP Update in **Appendix E**. A summary of KDWD's groundwater quality follows.

Concentrations of TDS in groundwater were found to range from about 140 mg/l in the north-central portion of the District to about 1,600 mg/l in the southwestern portion of the District (in the Buena Vista Dry Lake area). In general, TDS values in the District's groundwater were in the range of about 200-500 mg/l. Nitrate concentrations in the samples included in the GWMP Update ranged from less than 0.4 mg/l to 26 mg/l. No samples were found to have concentrations of Nitrate in excess of the primary maximum contaminant level (MCL) of 45 mg/l. Boron concentrations were found to be less than 0.6 mg/l. Sodium concentrations were found to range between 13 and 154 mg/l. Higher sodium concentrations were found in the southeastern and southwestern portions of the District. The GWMP Update concluded that there were no areas or constituents of concern indicated by the available groundwater data. A summary of groundwater quality data from the GWMP Update is given in **Table 32**.

Table 32. Groundwater Water Supply Quality		
Parameter	**Units**	**Range**
TDS	mg/L	200-500[1]
Sodium	mg/L	13-154
Boron	mg/L	<0.6
NO_3	mg/L	<0.4 – 26
Source: KDWD GWMP Update. [1]General range.		

C. Other Water Supplies

The quality of the wastewater treatment plant effluent used for irrigation is monitored by the State Regional Water Quality Control Board (RWQCB). Groundwater quality in the area of disposal is monitored by the RWQCB as well.

D. Drainage

The District does not operate any drains and does not monitor water quality of privately operated drain water facilities.

4.03 Source Water Quality Monitoring Practices

ID4 monitors the quality of the District's surface water sources and includes this information in its annual Report on Water Conditions. The District monitors groundwater quality in District wells periodically. Four District wells were sampled in 2013.

The District is a member of the Kern River Watershed Coalition Authority which was formed to serve as the coordinator and coalition (third party) under the Irrigated Lands Regulatory Program (ILRP). The ILRP required the monitoring of discharges from irrigated lands to waters of the State. On September 19, 2013, the Central Valley Regional Water Quality Control Board (Regional Board) adopted new waste discharge requirements as a part of the ILRP for the Tulare Lake Basin area. The Kern River Watershed Coalition Authority will serve as the clearinghouse for information provided by individual growers and participating Districts. Groundwater quality monitoring may become a part of this program.

Section 5: Water Accounting and Water Supply Reliability

Law

Describe the quantity and quality of the agricultural water supplier, including all of the following:

7. *Water accounting including all of the following:*
   a. *Quantifying the water supplier's supplies*
   b. *Tabulation water uses*
   c. *Overall water budget (10826(b)).*

5.01 Quantifying Water Supplies

Table 33 is a summary of the District's water supplies for the representative years. Effective precipitation has been calculated based on the precipitation for the representative years and an average net irrigated acreage of 90,000 acres.

Table 33. Water Supply Quantities for Representative Years (AF)

Source	2008 - Normal	2011 - Wet	2013 - Dry
Kern River[1]	182,343	228,107	115,348
SWP[1]	9,054	21,227	8,576
WWTP Effluent[2]	18,000	18,000	18,000
Banking Programs[1]	-	90,139	-
Lower River Purchase[1]	-	1,462	-
Effective Precipitation[3]	25,236	34,096	26,162
District Well Pumping[4]	10,534	-	20,519
Private Pumping (Ag)[4]	104,380	93,910	143,140
TOTAL (Rounded)	**349,550**	**486,940**	**331,750**

Notes:
[1]From Table 27
[2]Estimate
[3]Based on annual precipitation and net irrigated acreage.
[4]From Table 17

5.02 Tabulating Water Uses

Applied water usage for the KDWD as calculated in **Tables 18A through 18C** is presented in **Table 34**.

Table 34. Applied Water (AF)			
	Representative Year		
	2008 – Normal	2011 – Wet	2013 – Dry
Applied Water* (from Tables 18A through 18 C)	305,080	299,010	297,260
Note: * Water delivered to agricultural customers from all sources			

The District does not operate surface or subsurface drains which allow for water to leave the District as shown in **Table 35**.

Table 35. Quantify Water Leaving the District (AF)			
Drain Water	Representative Year		
	2008 – Normal	2011 – Wet	2013 – Dry
Surface drain water leaving the service area	N/A	N/A	N/A
Subsurface drain water leaving the service area	N/A	N/A	N/A
Note: The District does not operate surface or subsurface drains.			

There are no irrecoverable losses from the District (see **Table 36**).

Table 36. Irrecoverable Water Losses (AF)			
Drain Water	Representative Year		
	2008 – Normal	2011 – Wet	2013 – Dry
Flows to saline sink	N/A	N/A	N/A
Flows to perched water table	N/A	N/A	N/A
Notes: There are no flows to saline sinks and flows to perched water table are not irrecoverable water losses but are used for irrigation.			

The District's water uses for the representative years are summarized in **Table 37**. M&I uses are not included since those demands are met by M&I pumping. Banking program return water use is also not included since these returns were made by exchange of surface supplies that were not included in **Table 33**.

Table 37. Quantify Water Use (AF)			
Water Use	**Representative Year**		
	2008 – Normal	**2011 – Wet**	**2013 – Dry**
Crop Water Use (from Tables 18A through 18C)			
1 Crop Evapotranspiration	244,050	239,210	237,830
2 Leaching and cultural practices	61,030	59,800	59,430
Conveyance & Storage System			
3 Conveyance seepage (from Table 23)	44,468	97,792	34,486
Environmental Use (Consumptive)			
4 Environmental use (from Table 21)	-	540	60
Municipal and Industrial[1]	NA	NA	NA
Outside the District[2]	NA	NA	NA
Conjunctive Use			
5 Groundwater recharge (from Table 23)	-	90,997	-
TOTAL (rounded)	**349,550**	**486,880**	**331,800**

Note:
[1]M&I usage is not applicable since demands are met by M&I pumping.
[2]Banking program return not included since return was made by exchange of surface supplies not delivered to the District and not included in Table 33.

5.03 Overall Water Budget

Table 38 is a summary of the overall District water budgets for the representative years. Total water supplies are approximately equal to total water uses since private groundwater pumping is used to make up the shortfall in surface water supplies.

Table 38. Budget Summary (AF)			
Drain Water	Representative Year		
	2008 – Normal	2011 – Wet	2013 – Dry
Subtotal of Water Supplies (Table 33)	349,550	486,940	331,750
Subtotal of Water Uses (Table 37)	349,550	486,880	331,800
Difference*	-	60	-50
Notes: *Calculated from line 2 subtracted from line 1			

5.04 Water Supply Reliability

Factors that could affect the reliability of the District's future water supplies include the following:

- Catastrophic earthquake or flood events which result in damage to the facilities providing water supplies to the District,
- Long-term drought conditions which result in a reduction of water supplies available to the District,
- Legislative or legal decisions that result in a reduction of water supplies available to the District,
- Land subsidence which limits groundwater storage capacity,
- Land use changes that result in increased water demands, or
- Climate change (see **Section 6**).

The District's conjunctive use program operations have been developed to maximize its surface water supplies while helping to maintain sustainable groundwater quality and quantity. The District will adjust its operations and investigate new opportunities that will help it to meet the goals of its conjunctive use program and adapt to changes in the available water supplies in the future. The DWR's *California Water Plan Update 2009* includes as Chapter 5 Managing an Uncertain Future. This document emphasizes that "water management must be dynamic, adaptive, and durable" due to the many uncertainties in and risks to California's future water supplies. The document recommends planning to anticipate change by evaluating uncertainties and assessing risks.

The District identifies and discusses a number of Groundwater Basin Management Measures that it will follow in order to protect and sustain its groundwater and surface water supplies in its GWMP Update. These measures include the following:

- Continue groundwater recharge operations with high quality surface supplies when available,
- Protect and preserve existing groundwater recharge areas,

- Maintain groundwater levels to reduce land subsidence,
- Update the District's groundwater level and quality monitoring program, and
- Coordinate groundwater management activities with other Agencies, specifically:
    - CASGEM Monitoring Cooperative Group with BVWSD and Rosedale-Rio Bravo Water Storage District (RRBWSD)
    - Resolution with AEWSD to cooperatively pursue beneficial groundwater management activities
    - Joint project with AEWSD to construct infrastructure to allow water to be conveyed across district boundaries more efficiently
    - Groundwater banking agreements with Metropolitan and SBVMWD
    - Agreements with City of Bakersfield and Greenfield County Water District (and others) to enhance groundwater recharge for the benefit of municipal pumpers
    - Provision of SWP water via KCWA through exchange agreements with BVWSD
    - Participation in regional out-of-district banking projects including the Pioneer Project operated by KCWA
    - Cooperating with KDWD customers and the RWQCB (in compliance with the ILRP).

In addition to the above, the District is now a member of the Kern Groundwater Authority and the Kern River Watershed Authority which may also provide coordination of groundwater management activities and resources. KDWD will be part of the program to purchase Lower River water supplies (from the Kern River) when they are available in the future.

KDWD's ongoing maintenance program provides for inspection of and repairs to its conveyance and delivery facilities so that any problems are addressed quickly and result in minimal impacts to the District's operations. The District will continue to assess the stability of its levees and will evaluate the risks to its facilities from flood events and earthquakes.

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Section 6: Climate Change

Law

Include an analysis, based on available information, of the effect of climate change on future water supplies (10826(c)).

It is not known what effect climate change may have on the District's future water supplies. As discussed in the previous section on Water Supply Reliability, the District will need to be flexible in its operations and adjust to the changing water supplies over time. In Chapter 5 of the *California Water Plan Update 2009*, the following potential water supply impacts from climate change were identified:

- California's snowpack is decreasing with increasing winter temperatures,
- Warmer temperatures and decreasing snowpack result in more winter runoff and less spring/summer runoff,
- Larger precipitation events could be expected with warmer temperatures in some areas,
- Sea level rise could disrupt Sacramento-San Joaquin River Delta water exports should levees fail,
- Plant evapotranspiration would increase with higher temperatures,
- Storage, transport, and treatment of water involves the use of substantial amounts of energy which can release greenhouse gas emissions that contribute to climate change.

A Climate Change and Vulnerability Assessment Technical Memorandum was completed and submitted as an addendum to the Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan (Kern IRWMP) in September 2014 (included as **Appendix G**). The Technical Memorandum included the following Kern Region Climate Change Projections:

- Changing hydrology and the resultant impacts to conjunctive use operations due to a shift from snow to rain precipitation,
- Higher wildfire risk due to warmer, drier conditions and the associated impacts on water quality and flooding,
- Fluctuations in temperature resulting in longer and drier conditions and the associated impacts on water quality and flooding,
- Longer and more severe multi-year droughts,
- Greater summer water demand from all categories of users, and
- Impacts to habitats and species.

Suggested regional adaptation strategies are discussed in Section 1.5 of the Technical Memorandum. The Basin Management Measures and strategies identified in **Section 5.04** of this Plan are consistent with the regional climate change adaptation strategies.

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Section 7: Water Use Efficiency Information

7.01 EWMP Implementation and Reporting

Law

> *(Include) a report on which efficient water management practices have been implemented and are planned to be implemented, an estimate of the water use efficiency improvements that have occurred since the last report, and an estimate of the water use efficiency improvements estimated to occur five and 10 years in the future. If an agricultural water supplier determines that an efficient water management practice is not locally cost effective or technically feasible, the supplier shall submit information documenting that determination (10608.48(d)).*

The California Water Code establishes Efficient Water Management Practices (EWMPs), two of which are identified as critical and fourteen are identified as conditional. Implementation of critical EWMPs is required for all agricultural water suppliers. Conditional EWMPs are required to be implemented only if they are locally cost-effective and technically feasible. Documentation as to the feasibility of the non-implemented measures is required.

Table 39 summarizes the EWMPs and the status of the District's implementation of the measures.

Table 39. Report of EWMPs Implemented/Planned
(Water Code §10608.48(d), §10608.48 (e), and §10826 (e))

EWMP No.*	EWMP	Current Status	Description of EWMP Implementation
Critical EWMPs			
1	*Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2) (10608.48(b)).*	Implemented	All deliveries to District customers are measured using either metered or gated turnouts (see Section 2.07 and Appendix D).
2	*Adopt a pricing structure for water customers based at least in part on quantity delivered (10608.48(b)).*	Implemented	Water pricing is based on the volume of water delivered (see Section 2.08 and Appendix C).
Conditionally Required EWMPs (locally cost-effective and technically feasible EWMPs)			
1	*Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.*	Implemented	The District contributes to the North West Kern Resource Conservation District (NWKRCD) which provides technical assistance to landowners to allow them to make the best use of their land and irrigation water. Landowners are encouraged to take advantage of the NWKRCD services.

Table 39. Report of EWMPs Implemented/Planned (Water Code §10608.48(d), §10608.48 (e), and §10826 (e))			
EWMP No.*	**EWMP**	**Current Status**	**Description of EWMP Implementation**
2	*Facilitation of use of available recycled water that otherwise would not be used beneficially, meets health and safety criteria, and does not harm crops or soils. The use of recycled urban wastewater can be an important element in overall water management.*	Implemented	Recycled urban wastewater is currently used for agricultural irrigation within the District.
3	*Facilitate the financing of capital improvements for on-farm irrigation systems.*	Partially Implemented	Landowners are able to receive technical assistance regarding improvements to on-farm irrigation systems through the NWKRCD.
4	*Implement an incentive pricing system that promotes one of the following goals (A) more efficient water use at the farm level such that it reduces waste, (B) conjunctive use of groundwater, (C) Appropriate use of groundwater recharge, (D) Reduction in problem drainage (E) Improved management of environmental resources (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.*	Implemented	The KDWD has established a pricing structure for surface water that is tied directly to the quantity of surface water used. This promotes the efficient use of water supplies since customers have to pay for all water deliveries. SWP supplies are priced so that those supplies will be utilized in-lieu of groundwater pumping.
5	*Expand line or pipe distribution systems, construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance, and reduce seepage.*	Partially Implemented	Most of the District's irrigation deliveries are supplied through unlined canals and ditches which allow for groundwater recharge through seepage losses. The District considers this a benefit and does not have plans to expand canal lining or pipelining. Some reaches of the canals and ditches have been lined or pipelined as urban development has encroached into the District service area.
6	*Increase flexibility in water ordering by, and delivered to, water customers within operational limits.*	Implemented	The District has increased its flexibility in water ordering and deliveries through the supplies and facilities available from its groundwater banking programs, including groundwater recharge basins and District owned wells.
7	*Construct and operate supplier spill and tail-water systems.*	Not Implemented	The District does not operate spill and tail-water systems. Due to water quality concerns, landowner spill and tail-water is not allowed in the KDWD delivery system.

Table 39. Report of EWMPs Implemented/Planned (Water Code §10608.48(d), §10608.48 (e), and §10826 (e))			
EWMP No.*	**EWMP**	**Current Status**	**Description of EWMP Implementation**
8	*Increase planned conjunctive use of surface water and groundwater within the supplier service area.*	Implemented	The District has increased its conjunctive use activities through the implementation of its groundwater banking, environmental recharge, and surface water exchange programs. The District has extended canals to serve additional customers.
9	*Automate canal control devices.*	Not Implemented	While the KDWD has automated many of its metering devices, the KDWD does not have any automated canal control devices.
10	*Facilitate or promote customer pump testing and evaluation.*	Implemented	The District encourages the use of PG&E or pump companies for customer well pump testing and evaluations.
11	*Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.*	Planned Implementatio n	The District plans to designate a staff member to serve as the Water Conservation Coordinator.
12	*Provide for the availability of water management services to water users. These services may include, but are not limited to, all of the following: A. On-farm irrigation and drainage system evaluations, B. Normal year and real-time irrigation scheduling and crop evapotranspiration information, C. Surface water, groundwater, and drainage water quantity and quality data, D. Agricultural water management educational programs and materials for farmers, staff, and the public.*	Implemented	These services are available to KDWD customers through the District and the agencies that it supports. The NWKRCD provides on-farm evaluations, irrigation scheduling information is available through the California Irrigation Management System (CIMIS), and the KCWA provides water management educational programs and materials. Surface and groundwater quality data is available from the District, the KCWA and the California DWR. The District encourages the use of these services.
13	*Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional change to allow more flexible water deliveries and storage.*	Implemented	The District works with the KCWA, Friant Water Users, and Kern River interests to execute water exchanges that allow for more flexible water deliveries and storage.
14	*Evaluate and improve the efficiencies of the supplier's pumps.*	Implemented	The KDWD routinely evaluates the condition and efficiency of its existing pumps as a part of its on-going maintenance program.
Notes: *Conditional EWMP numbers correspond to Water Code §10608.48(c)			

7.02 Documentation for Non-Implemented EWMPs

For non-implemented conditional EWMPs, a determination must be made that the EWMP is not locally cost effective or technically feasible. The non-implemented EWMPs for the KDWD are summarized in **Table 40**.

Table 40. Non-Implemented EWMP Documentation
(Water Code §10608.48(d), §10608.48 (e), and §10826 (e))

EWMP #	Description	*(check one or both)* Technically Infeasible	Not Locally Cost-Effective	Justification/Documentation
5	Expand lining or pipelining		X	Unlined canals provide groundwater recharge benefits to the District service area that would be lost by canal lining or pipelining. Lining the 127 miles of the District's unlined canals would not be cost effective. Short sections of canals have been lined or pipelined as a part of urban development projects. This practice will continue where it is feasible with the District's operations.
7	Supplier spill and tail-water systems	X	X	Tail-water systems are operated by individual customers. The District does not want potentially poor quality water to enter its canals and create water quality issues for its customers.
9	Automate canal controls		X	It is not believed that installation of automatic canal controls would result in significant water savings. Due to the length of canals and the size of the District's service area, implementation of an automated canal control system would not be cost effective at this time.

Source: KDWD

Section 8: Supporting Documentation

8.01 Description of Water Measurement Best Professional Practices

The District's water measurement methods and quality control procedures are described in the Water Deliveries Report, July 2014 included as **Appendix D**.

8.02 Device Corrective Action Plan

The District assesses the condition and performance of the measurement devices as a part of its on-going maintenance program. The District follows the procedures in SBx7-7 Compliance for Agricultural Irrigation Districts prepared by the ITRC and attached as **Appendix H** in the implementation of its flow meter testing and calibration program.

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Section 9: References

1. AECOM, Engineering Report Setting Forth a Proposed 2nd Amendment to 1974 Plan for Water Allocation and Procedure for Setting Water Tolls, January 2009.
2. Boyle Engineering Corporation, Kern Delta Water District Supplemental Water Supply Study, August 2000.
3. California Department of Water Resources, California Water Plan Update 2009, Chapter 5.
4. California Department of Water Resources, A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2015 Agricultural Water Management Plan.
5. ESA, Kern Delta Water District, Kern River Allocation Plan Draft EIR, November 2011.
6. Irrigation Training and Research Center, SBx7-7 Compliance for Agricultural Water Districts, 2012.
7. Kennedy/Jenks Consultants, Climate Change and Vulnerability Assessment submission as an addendum to Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan, September 8, 2014.
8. Kern County Water Agency Improvement District No. 4, 2014 Report on Water Conditions.
9. Kern Delta Water District, Rules and Regulations for the Sale and Distribution of Water, Adopted 1/19/2010 amended 4/21/15.
10. Kern Delta Water District, Water Deliveries Report, July 2015.
11. City of Bakersfield, Kern River Annual Reports.
12. Todd Engineers, Kern Delta Water District, Kern River Water Allocation Plan, September 2011.
13. Todd Engineers, Final Groundwater Management Plan Update, Kern Delta Water District, October 11, 2013.

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Appendix A: Coordination Documentation

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PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P.O. BOX 440
BAKERSFIELD, CA 93302

Ad Number:	14023137	**PO #:**	**#: 60312278.0001**
Edition:	1TBC	**Run Times**	**2**
Class Code	Legal Notices		
Start Date	12/1/2015	**Stop Date**	12/8/2015
Billing Lines	23	**Inches**	138.92
Total Cost	$ 279.92	**Account**	1BOY50
Billing Address	AECOM 5001 E. COMMERCENTER DR. SUITE 100 BAKERFIELD,CA 93309		

AECOM
5001 E. COMMERCENTER DR. SUITE 100
BAKERFIELD, CA 93309

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 12/1/15
12/8/15

ALL IN YEAR 2015

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

[signature]

DATED AT BAKERSFIELD CALIFORNIA DEC 08 2015

Solicitor I.D.: 0

First Text
NOTICE OF PUBLIC HEARING KERN DELTA WAT

Ad Number 14023137

NOTICE OF PUBLIC HEARING

KERN DELTA WATER DISTRICT

2015 AGRICULTURAL WATER MANAGEMENT PLAN

NOTICE IS HEREBY GIVEN that, pursuant to California Water Code section 10841, Kern Delta Water District (District) will hold a public hearing on December 15, 2015, at the hour of 1:30 p.m., at the District offices located at 501 Taft Highway, Bakersfield California to consider and determine whether the District shall adopt an agricultural water management plan. Written comments should be submitted to the District, to the attention of L. Mark Mulkay, District Manager no later than 4:30 p.m. on December 14, 2015. During the hearing, the District will receive oral and written comments before making a decision.

L. Mark Mulkay, General Manager

Kern Delta Water District

December 1, 8, 2015

14023137

AECOM

AECOM
5001 E. Commercenter Drive
Suite 100
Bakersfield, CA 93309
www.aecom.com

661 283 2323 tel
661 395 0359 fax

August 26, 2015

Mr. Steven C. Collup
Arvin-Edison Water Storage District
P.O. Box 175
Arvin, CA 93203-0175

Kern Delta Water District
Agricultural Water Management Plan 2015 – Notification of Draft AWMP for Review

Dear Mr. Collup:

In accordance with the California Water Code Section 10841, you are being notified that the Kern Delta Water District has prepared a draft Agricultural Water Management Plan. A public hearing will at 1:30 PM, December 15, 2015 at the District offices located 501 Taft Highway, Bakersfield California to consider and determine whether the District shall adopt an agricultural water management plan.

Enclosed is a CD-ROM containing an electronic (PDF) copy of the draft report. If you would like to consult with or provide comments to the District during this process, please let us know. Thank you.

Sincerely,

Daniel S. Cronquist, P.E.

cc. Mark Mulkay, General Manager, KDWD

AECOM

AECOM
5001 E. Commercenter Drive
Suite 100
Bakersfield, CA 93309
www.aecom.com

661 283 2323 tel
661 395 0359 fax

August 26, 2015

Ms. Roberta Gafford
City of Bakersfield - City Hall North
City Clerk's Office
1600 Truxtun Avenue
Bakersfield, CA 93301

Kern Delta Water District
Agricultural Water Management Plan 2015 – Notification of Draft AWMP for Review

Dear Ms. Gafford:

In accordance with the California Water Code Section 10841, you are being notified that the Kern Delta Water District has prepared a draft Agricultural Water Management Plan. A public hearing will at 1:30 PM, December 15, 2015 at the District offices located 501 Taft Highway, Bakersfield California to consider and determine whether the District shall adopt an agricultural water management plan.

Enclosed is a CD-ROM containing an electronic (PDF) copy of the draft report. If you would like to consult with or provide comments to the District during this process, please let us know. Thank you.

Sincerely,

Daniel S. Cronquist, P.E.

cc. Mark Mulkay, General Manager, KDWD

AECOM
5001 E. Commercenter Drive
Suite 100
Bakersfield, CA 93309
www.aecom.com
661 283 2323 tel
661 395 0359 fax

August 26, 2015

Mr. Joe Lutje
Henry Miller Water District
P.O. Box 9759
Bakersfield, CA 93389

Kern Delta Water District
Agricultural Water Management Plan 2015 – Notification of Draft AWMP for Review

Dear Mr. Lutje:

In accordance with the California Water Code Section 10841, you are being notified that the Kern Delta Water District has prepared a draft Agricultural Water Management Plan. A public hearing will at 1:30 PM, December 15, 2015 at the District offices located 501 Taft Highway, Bakersfield California to consider and determine whether the District shall adopt an agricultural water management plan.

Enclosed is a CD-ROM containing an electronic (PDF) copy of the draft report. If you would like to consult with or provide comments to the District during this process, please let us know. Thank you.

Sincerely,

Daniel S. Cronquist, P.E.

cc. Mark Mulkay, General Manager, KDWD

AECOM

AECOM
5001 E. Commercenter Drive
Suite 100
Bakersfield, CA 93309
www.aecom.com

661 283 2323 tel
661 395 0359 fax

August 26, 2015

Ms. Mary Bedard
Kern County Clerk
1115 Truxtun Ave
Bakersfield, CA 93301

Kern Delta Water District
Agricultural Water Management Plan 2015 – Notification of Draft AWMP for Review

Dear Ms. Bedard:

In accordance with the California Water Code Section 10841, you are being notified that the Kern Delta Water District has prepared a draft Agricultural Water Management Plan. A public hearing will at 1:30 PM, December 15, 2015 at the District offices located 501 Taft Highway, Bakersfield California to consider and determine whether the District shall adopt an agricultural water management plan.

If you would like a copy of the plan, please email me at daniel.cronquist@aecom.com or call at (661) 283-2331. If you would like to consult with or provide comments to the District during this process, please let us know. A copy of the draft report is being provided separately to the Kern County Planning Department.

Thank you.

Sincerely,

Daniel S. Cronquist, P.E.

cc. Mark Mulkay, General Manager, KDWD

AECOM

AECOM
5001 E. Commercenter Drive
Suite 100
Bakersfield, CA 93309
www.aecom.com

661 283 2323 tel
661 395 0359 fax

August 26, 2015

Ms. Lorelei Oviatt
Kern County Planning Department
2700 M Street, Suite 100
Bakersfield, CA 93301-2370

Kern Delta Water District
Agricultural Water Management Plan 2015 – Notification of Draft AWMP for Review

Dear Ms. Oviatt:

In accordance with the California Water Code Section 10841, you are being notified that the Kern Delta Water District has prepared a draft Agricultural Water Management Plan. A public hearing will at 1:30 PM, December 15, 2015 at the District offices located 501 Taft Highway, Bakersfield California to consider and determine whether the District shall adopt an agricultural water management plan.

Enclosed is a CD-ROM containing an electronic (PDF) copy of the draft report. If you would like to consult with or provide comments to the District during this process, please let us know. Thank you.

Sincerely,

Daniel S. Cronquist, P.E.

cc. Mark Mulkay, General Manager, KDWD

AECOM
5001 E. Commercenter Drive
Suite 100
Bakersfield, CA 93309
www.aecom.com

661 283 2323 tel
661 395 0359 fax

August 26, 2015

Mr. Robert J. Kunde, PE
Wheeler Ridge-Maricopa Water Storage District
12109 Highway 166
Bakersfield, CA 93313-9630

Kern Delta Water District
Agricultural Water Management Plan 2015 – Notification of Draft AWMP for Review

Dear Mr. Kunde:

In accordance with the California Water Code Section 10841, you are being notified that the Kern Delta Water District has prepared a draft Agricultural Water Management Plan. A public hearing will at 1:30 PM, December 15, 2015 at the District offices located 501 Taft Highway, Bakersfield California to consider and determine whether the District shall adopt an agricultural water management plan.

Enclosed is a CD-ROM containing an electronic (PDF) copy of the draft report. If you would like to consult with or provide comments to the District during this process, please let us know. Thank you.

Sincerely,

Daniel S. Cronquist, P.E.

cc. Mark Mulkay, General Manager, KDWD

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Appendix B: Resolution of Plan Adoption

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BEFORE THE BOARD OF DRIECTORS
OF THE
KERN DELTA WATER DISTRICT

IN THE MATTER OF: **RESOLUTION NO. 2015-09**

ADOPTION OF THE KERN DELTA WATER DISTRICT AGRICULTURAL WATER MANAGEMENT PLAN

WHEREAS, Part 2.8 (commencing with § 10800) of Division 6 of the California Water Code, otherwise known as the Agricultural Water Management Planning Act, requires this District to prepare, adopt, and implement an agricultural Water Management Plan; and

WHEREAS, notice as required by Water Code §10821 has been provided to the City of Bakersfield and the County of Kern regarding the proposed adoption of an agricultural water management plan for the Kern Delta Water District, and

WHEREAS, a draft Agricultural Water Management Plan has been prepared; and

WHEREAS, notice of a public hearing to consider the adoption of the Agricultural Water Management Plan was published as required by Water Code §10841, and a public hearing was held pursuant thereto on 15 December, 2015;

WHEREAS, at the public hearing, the Kern Delta Water District Board of Directors considered oral and written comments, to the extent provided by the public.

NOW, THEREFORE, BE IT RESOLVED, and ordered by the Board of Directors as follows:

1. The foregoing is true and correct.

2. The Board of Directors hereby adopts the Agricultural Groundwater Management Plan, dated December 2015, in accordance with Part 2.8 of Division 6 of the California Water Code.

3. The Board of Directors hereby authorizes the General Manager to execute all documents, and take any other action necessary or advisable to carry out the purpose of this resolution.

All the foregoing being on the motion of Director Antongiovanni, seconded by Director Cerro and authorized by the following vote, namely:

AYES: Antongiovanni, Cerro, Cosyns, Frick, Kaiser, Tillema

NOES: None

ABSENT: Cosyns, Garone, Palla

ABSTAIN: None

I HEREBY CERTIFY that the foregoing resolution is the resolution of the Kern Delta Water District as duly passed and adopted by its Board of Directors at a legally convened meeting held on the 15th day of December, 2015.

WITNESS my hand and the official seal of said Board of Directors this 15th day of December, 2015.

Vice-President of the Board of Directors
KERN DELTA WATER DISTRICT

ATTEST:

Assistant Secretary of the Board of Directors
KERN DELTA WATER DISTRICT

Appendix C: KDWD Rules and Regulations

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ADOPTED 1/19/2010
AMENDED 4/21/2015

KERN DELTA WATER DISTRICT

RULES AND REGULATIONS FOR THE SALE AND DISTRIBUTION OF WATER

These Rules and Regulations are established by the Board of Directors pursuant to California Water Code section 35423 which provides, in pertinent part, that the District may establish, print, and distribute equitable rules and regulations for the sale and distribution of water. The District Board may change these Rules and Regulations, without prior notice, at their sole discretion.

APPLICABILITY OF RULES

General: All water service and deliveries and other activities pertaining to the use of water provided by the District shall be subject to these Rules and Regulations of the District.

DISTRICT FACILITIES

District Facilities: The District facilities, including any and all diversion works, canals, ditches, headgates, weirs and any other property owned by the District shall be operated and maintained solely by the District or its authorized agent, permittee, or subcontractor. Such facilities shall be under the exclusive control of the Manager or those employees whom the Manager has designated with authority. The Manager is hereby authorized to do all acts necessary and proper to enforce these Rules and Regulations.

Private Facilities: The operation and maintenance of private ditches, laterals, or other waterworks which are not the property of the District shall be undertaken by the individual or group of individuals who own or use such facilities (community ditches). At all times such facilities must be kept in reasonable repair and reasonably free from weeds and/or other obstructions and must be of sufficient capacity to carry the amount of water which is to be delivered by the District. The District reserves the right to refuse water delivery in the case of a facility or community ditch that, in the sole discretion of the District, is deemed to be not properly maintained.

Connections: All connections to District facilities shall be made in such a manner so as to prevent damage from occurring to the District's facilities, and so as to prevent water from customers' facilities from entering District facilities. Any connections to District facilities must be approved by the Manager of the District, or his designee. It is the responsibility of the customer to reach the District's canal right-of-way or easement with a suitable pipeline or ditch. In the event the customer is unable to obtain an appropriate easement for such pipeline, the District may, under terms and conditions acceptable to the District, assist in the acquisition of an appropriate easement. The District will install a turnout and pipe from the canal to the edge of the District's right-of-way or easement. For parcels of 40 acres or more, the District will pay for the aforementioned turnout and pipe at no cost to the customer. For parcels smaller than 40 acres, the customer or landowner will pay the fee.

Obstructions: No fences, gates, bridges, ditches, buildings, culverts, pipelines, roads, telephone poles, power poles, signs, vehicle parking, storage, any fertilizer tanks or tubs, trees, or any other obstructions shall be placed within, along, across, or upon any property or right-of-way of the District without the permission of the Manager and an encroachment permit from the District stating the conditions governing the obstruction. No fences, structures, rubbish, garbage or any other matter may be placed in, or allowed to be placed in or on any District canal or other District facility or property.

If any obstruction listed above, or any other similar obstruction necessitates maintenance or other remedial action being taken by the District, the customer, the landowner, or other responsible person shall, within ten (10) days of being notified of said expenses by mail, reimburse the District for any such cost of repairs or remedial actions.

APPLICATIONS FOR WATER

Applications: In order to obtain delivery of water, the owner of lands (or their agent) and the tenant or lessee of lands, (hereinafter referred to as "customer(s)") must complete, execute and file with the District, an application for water service which shall include the name and addresses of the landowner and tenant or lessee, a description of the land to be irrigated, and any other information required by the District. If the owner of lands is not available or not willing to execute the application for any reason, a copy of an executed lease agreement and Vesting Deed, for said land, will take the place of the owner's execution and the tenant/lessee must also provide the District a letter allowing the District to lien the tenant's or lessee's land in the District if the tenant/lessee become delinquent in their payments to the District. Application forms shall be provided by the District. The District may fix the date prior to which applications for water for the ensuing irrigation season are to be received, and may require a cash deposit at the time of application for each acre for which application is made.

Land Transfers: When land is sold, a change of tenant occurs, or title is otherwise transferred to another party, the District shall be under no obligation to deliver water to such lands until a new application for water service is properly completed and filed with the District.

Authority of Applicant: District shall not be obligated to provide water service pursuant to any application for water service, or otherwise, unless and until District is provided, upon request, verification acceptable to the District that applicant has authority to bind the landowner and/or tenant for charges associated with water deliveries by District and for any other charges or expenses associated with these Rules and Regulations. Any such verification shall be in the form prescribed by District.

DELIVERY

Delivery Orders: All orders for water delivery or shutoffs must be placed by the customer, or his designee, either by telephone, or in writing no later than 10:30 a.m., and twenty four (24) hours prior to the requested delivery or shutoff. Shutoff orders not placed within the minimum 24 hour period will be charged for a full 24 hour day for "Off Without Notice". Delivery shall be made as requested by customer, provided that sufficient water is available to permit such delivery and provided that the capacity of the District's facilities has not previously been committed to delivery of water to other customers. The District may require payment of water charges prior to the delivery of any water ordered. Water delivery problems must be called into the Dispatch office immediately. Problems turned in after the day of occurrence may not be acted upon. Customer shall be responsible for the payment of water ordered until the procedures and time requirements described above have been complied with.

Minimum Order: Customers must order a minimum of one half (1/2) cubic foot per second for at least twenty four (24) hours (1 acre foot). Delivery orders of less than this amount, or in amounts not readily measurable or controllable, will not be accepted or processed by the District. Any water ordered by a customer must be accepted by the customer on a continuous basis until the entire amount so ordered or deliverable has been delivered, unless the proper turn-off procedure and time requirements thereof have been complied with. All water shutoff times will be the same as the start time, unless previously specified by the customer and agreed upon by the District. There is a grace period for water overruns of up to four (4) hours, over four (4) hours will be charged one half (1/2) day, over six (6) hours will be charged for one (1) full day of water.

Non-acceptance: A customer who fails to accept delivery of water, which has been ordered, and which the District is prepared to deliver, shall be charged for the amount of water so ordered, unless the proper shutoff procedure and time requirements thereof have been complied with. In the event of breaks in private ditches, laterals, or other private water-carrying facilities, or other emergency circumstances or conditions where it becomes necessary for the customer to turn the delivered water back into the District's facilities, the District must be notified before the water is turned back to the District (Dispatch number is 661-834-4653 and is answered 24 hours a day, either by the Dispatcher or the answering service) and the District must consent to such return. The customer shall be responsible for any and all loss or damage caused by the turning back of water into the District's canal if said water causes any loss or damage. The customer shall not be responsible for payment of water not accepted if non-acceptance is the result of an unavoidable and unanticipated emergency. It is within the Manager's sole discretion to determine whether or not an unavoidable and unanticipated emergency situation has occurred.

Condition of Property: Customers must have their land and facilities in reasonable condition in order to care for and accept delivered water without undue waste or damage.

Reasonable care in applying the water must also be undertaken in order to eliminate excessive drainage.

Water Level: The District shall not be required to raise water levels to an excessive height in any canal or other facility of the District in order to provide water service to a customer.

Priority: At such times as the District's facilities are being used to capacity, water will be delivered as far as practicable to consumers on those canals in order of priority of water orders.

Split Heads: In the event two or more customers are supplied water through the same turnout ("split head"), the District may require that all customers being served by a combined turnout furnish to the District, in a form suitable to the District, an agreement executed by each customer which may include, among other provisions, terms regarding acceptance of water delivery through the turnout, granting of easements among the customers, and authorization for one individual to represent the others in all matters relating to delivery of water through the turnout. It is the customers' responsibility to make sure the water is divided appropriately.

Temporary Deliveries: Delivery of water for unscheduled, temporary, or special purposes may be made in the manner and upon such terms and conditions as are required by the Manager, or his designee.

Transferability: No water delivered or deliverable by District, or any rights that may pertain to such waters or to the delivery thereof may be permanently transferred from one customer to another or from one property to another. Monthly or annual transfers of District water service is permitted under the following circumstances and with approval from the Board or General Manager upon acceptable terms and conditions:

(a) Kern River Utility water shall only be delivered within the water right Service Area of origin, except during mandatory release.

(b) Balfour Guthrie, Bloomfield, or Eastside Contract water entitlements shall be delivered to their respective contract lands only.

(c) Transfers of Kern River prorations and/or service rights between eligible recipients may be permitted within the same Service Area. Transfers of State Water allocations are permitted within the District with no Service Area restrictions; however, the original State Water Rate will follow the State Water delivery.

(d) Transfers by the original allocatee into a pool established by the District for general reallocation are permitted.

(e) During proration periods, all transfers shall be subject to all of these Rules and Regulations and:

(1) Parties to the transfer will notify the Dispatcher. No water may be transferred without a written Transfer Agreement between the parties on file with the District.

(2) Payment for the transferred water will be the responsibility of the receiving party.

(3) From time to time the Board of Directors will review the status of unused allocations and, at their discretion, may recall such supplies as they deem to be prudent and practical.

(4) Transfers may not adversely affect the prorations or canal capacity of other Customers.

Exchanges: Exchanges may be permitted on a case by case basis subject to Manager's approval in emergency situations, and subject to Board approval under non-emergency conditions. The term "exchange" refers to the substitution of any water supply available to the District or any person for use by any person, provided however, the recipient pledges in good faith to repay the party or entity of origin at the earliest practical point in time. Any such exchange shall be conditioned upon terms and conditions deemed appropriate by the Manager or the Board.

District Well Water: District Well Water, produced by District owned wells, will not be available for use by individual customers.

Customer Well Water: District facilities may be used to transport such water upon terms and conditions deemed appropriate by the Manager, including but not limited to:

(a) Unused capacity is and is anticipated to be available in the District's facility.

(b) Prior to delivery into a District facility, Customer shall install a District approved flow meter, in addition to any other turn-in delivery facility deemed appropriate by the District, in accordance with District specifications. Cost of the meter and its installation will be paid by the Customer.

(c) Delivery of Customer Well Water into the District's facility may be terminated at any time, and without notice, by the District, in its sole discretion.

(d) Customer shall provide District ingress and egress to and from the groundwater well location site and any other areas deemed relevant by the District so as to account for and monitor the delivery of Customer Well Water to the facility.

(e) The Customer's well site may be labeled by the District for District reference purposes.

(f) Scheduling of the Customer's Well Water pump-in shall follow the same procedures as ordering for turnouts (See Rules and Regulations section "Delivery"). Customer shall provide the District Dispatch as much notice on a proposed well turn ON and/or turn OFF as possible, with a minimum notice of 24 hours.

(g) Customer, and NOT District personnel, shall operate the Customer's well. Customer shall only make flow changes upon prior approval of the District. The Customer shall call and notify the District Dispatch at the exact time of turn ON, turn OFF, or change in flow and provide a corresponding meter reading.

(h) Customer shall have the sole responsibility to maintain the well and related "turn-in" facilities (i.e. check oil, water levels, operate valves, etc.)

(i) District staff will endeavor to read meters daily, and upon each ON, OFF, or change of flow.

(j) District staff will endeavor to verify the meter is measuring accurately (i.e. full pipe flow). District may require the Customer to have the meter tested for accuracy and/or repaired/recalibrated, at Customer's expense.

(k) Customer Well Water may only be transported within the District's Groundwater Zone of Benefit of origin of said Well Water (Zone of Benefit may differ from the Service Area).

(l) Customers may only transport Customer Well Water in District facilities within a three mile radius of the well. The District's Wheeling Rate for this transportation is $2.50 per acre-foot, and is subject to change by the Board of Directors. If the District conveyance facility is not in operation, and if approved by the District, customers may transport Customer Well Water in District facilities (the three mile radius still applies). Customers must pay all costs and expenses through District facilities.

(m) Customers must provide annual water quality tests for Well Water pumped into District facilities. Constituents to be tested for will be determined by the District and will include at a minimum an Irrigation water quality test. The District may also require more frequent tests and a full Title 22 or other test(s) if District water is being delivered to another agency, or upon other circumstanced as determined by the District.

(n) The constituents of the water quality tests may change from time to time as determined by the District Manager.

(o) Customer shall indemnify, defend, and hold the District harmless from any and all claims and liability related to delivery of the Customer's Well Water quality into District facilities, including but not limited to any and all effects on water quality, and damages related to delivery into District facilities, upstream or downstream of the turn in.

(p) The Customer must enter into and sign the District's Well Water Pump-In Agreement.

CONTROL

Hazards:

(a) No customer shall use, cause to be used, or suffer to be used on lands located within the District, water distributed by the District in any manner which creates, or is likely to create, an unsafe or hazardous condition, and the District shall have the authority to immediately cease water deliveries where an unsafe or hazardous condition is known to exist, and the delivery will not restart until the District is satisfied that the condition has been rectified.

(b) If a violation of subparagraph (a) is found to exist, the District may discontinue service without notice if the unsafe or hazardous condition creates a clear and imminent danger to the public health, welfare, or safety such that immediate action is required in order to avert or mitigate said danger. Immediately thereafter, the District shall notify the customer of the reasons for the discontinuance and the corrective action which must be taken by the customer before service will be restored. Such notification shall be in writing and shall be personally served upon the customer or mailed to the customer at his last known address. A copy of such notice shall also be left in a conspicuous place on the affected premises. If the owner of the affected premises differs from the customer, a copy of such notice shall also be personally served upon the landowner or mailed to the landowner at his last known address.

(c) In all other cases in which a violation of subparagraph (a) is found to exist, the District may discontinue service after the District has given the customer at least five (5) days' written notice of such intention. Said notice shall include the reasons for the proposed action, a description of the corrective action which must be taken by the customer in order to avert discontinuance of service, and the date on which the District proposes to discontinue the service. A copy of such notice shall be personally served upon the customer or mailed to him at his last known address. A copy of such notice shall also be left in a conspicuous place on the affected premises. If the owner of the affected premises differs from the customer, a copy of such notice shall also be personally served upon the landowner or mailed to the landowner at his last known address.

Diversions: No water delivered by the District shall be diverted or allowed to be diverted by a customer at any time from lands within the District service area to lands outside of the District service area, from one improvement District to another, or to lands for which no application for water service has been filed with the District, without the prior consent of the Board of Directors.

Control Outside District Facilities: District shall not be responsible for the control, carriage, handling, use, disposal or distribution of water delivered to a customer whenever such water is outside of facilities then being owned, operated and maintained by District. Customer agrees to indemnify and shall hold harmless the District and its officers, agents, and employees from any and all loss, expenses, damage, liability, claims or causes of action of every nature whatsoever, for damage to or destruction of property of whatever nature, including District's property, or for injury to or death of persons, in any manner arising out of or incidental to the control, carriage, handling, use, disposal or distribution of water outside such facilities.

Drainage: Except for drains and water ways built, or formally accepted, by the District expressly for the conveyance of drainage water and/or storm water, no person will be allowed to drain irrigation or other water into or upon District-owned property or facilities, unless consent to such drainage has been obtained from the Manager. Such consent may only be given on a case-by-case basis.

Landowner Wheeling Rates: Upon terms and conditions acceptable to the Manager, an in-District landowner may bring outside surface water into the District for delivery in the District using District facilities. Kern Delta must review and approve the request on a case by case basis. If the canal is running and there is available capacity, the Wheeling Rate is $2.50 per acre-foot and no water losses (floated on District water). If the canal is dry, the Wheeling Rate is $2.50 per acre-foot for all water diverted into District facilities. All water losses associated with this wheeling becomes the property of the District for any legal use and/or purpose.

3rd Party Wheeling Rates (Non-District Landowner or Water User): Upon terms and conditions acceptable to the Manager, A 3rd party may wheel water in Kern Delta District facilities, if capacity is available, and under the following conditions:

(a) Kern Delta staff must review and approve the request.
(b) Administration fee of $1000.00. (Non-refundable)
(c) A $12.50 per acre-foot Wheeling Rate. (No water losses if the canal is operating)
(d) A $12.50 per acre-foot Wheeling Rate. (Plus water losses if the canal is dry) All water losses become the property of Kern Delta for any legal use and/or purpose.
(e) Kern Delta personnel will operate District facilities at all times.

WATER SHORTAGE

Water Shortage: In the event of actual or perceived water shortages, as determined by the District, the District may prorate the anticipated total deliverable amount of water among District customers. Proration may be calculated on a monthly basis or by using any other time period, and shall be calculated based upon (1) anticipated total deliverable water to specific areas within the District Service Areas, (2) total acres within those Areas, (3) acres owned or operated by each customer within those Areas, and (4) any other equitable factors deemed necessary and appropriate by the District.

LIABILITY

Negligence: The District shall not be liable for any damage caused by the negligence, carelessness, or intentional acts or omissions of any customer in the use of water, or for the failure on the Customer's part to maintain any ditch, lateral, or other facility not owned and controlled by the District. The Customer shall not be liable for any damage caused by the negligent act or omission of the District.

Water Availability: The District shall not be responsible or liable for any damage to crops resulting from insufficient water supply to the crops, regardless of the cause of the insufficiency.

Water Orders: Customer shall be responsible for any loss, damage, or expense caused by customer not using the full amount of water ordered by the customer.

Damage to District Facilities: If any damage whatsoever is done to District facilities by customers and/or their agents, including damage caused by moving farm equipment, livestock, or otherwise, it shall be the responsibility of the customer to pay for any such damage. District shall be entitled to make any necessary repairs and customer shall be responsible for paying the costs of any such repairs within ten (10) days of being notified by mail of such costs.

DISCLAIMER

The District may sell and distribute water for any legal purpose. Any water purchased by a customer shall be used for irrigation purposes only unless otherwise allowed in these Rules and Regulations or by other agreement. District waters include, but are not limited to, Kern River Water, State Water Project (SWP) water, well water, storm water runoff, exchange water, transferred water, and other 3rd party waters. Water furnished by the District is unfit for human consumption and may be unfit for other purposes, and is not warranted by the District. The District hereby expressly disclaims any and all warranties, including merchantability, either express or implied, as to the fitness or suitability of water for any purpose whatsoever. The District does not represent, express or imply as to the availability, condition, quantity, quality or suitability of water at any time for any purpose. The District does not represent, express, or imply as to the integrity, availability, capacity, condition, quality, or suitability of the District's facilities at any time or for any purpose.

The District treats canals, waters, and other District facilities with chemicals, herbicides, surfactants, and other materials. Customer assumes all risks associated with the use of said water and any consequences thereof, except for any negligent act of the District.

WATER RATES, BILLS, AND PAYMENT

Rates: Water rates, standby charges, equalization charges, and any other charges permitted by law shall be determined from time to time by the Board of Directors of the District.

Billing: Invoices for water service shall normally be mailed to the person designated in the application for water service no later than the tenth of each month for those water deliveries which occurred during the preceding month. Payments are to be made at the District offices, located at 501 Taft Highway, Bakersfield, California 93307, and must be paid upon receipt. All water bills must be paid no later than the last business day of the month the bill is issued.

Delinquent Accounts: A Water Account will be considered delinquent if billings and invoices are not paid in full on or before the last business day of the month in which the invoice was mailed to the Customer. Delinquent Water Accounts will be charged interest at the rate of 1.5% per month until paid. An Assessment Account will be considered delinquent if the Assessment is not paid in full on or before June 30th of the year assessed. Delinquent Assessment Accounts will be charged with a 10% penalty on the delinquency date and interest at the rate of 9% per year until paid. No water will be delivered to a customer if their water account becomes delinquent or the property assessments become delinquent.

Landowner Responsibility: The landowner is ultimately responsible for and shall be liable for all water charges and other costs invoiced by the District which have been incurred for water services, water deliveries, or otherwise incurred pursuant to these Rules and Regulations, or as allowed by law.

Requests Re: Equalization Charge: In the event a customer owns lands which are not farmed, nor intended to be farmed, nor anticipated to be farmed, but who is charged the District's Equalization Charge upon said non-farmed land, the customer may request of the District, prior to the imposition of such charge, in a form prescribed by the District, to have the equalization charge against said non-farmed property withdrawn and/or cancelled. The District may approve the request, in its sole discretion, upon such terms as it deems appropriate.

COMPLAINTS/ERRORS

Complaints: Complaints of any kind against the District must be made in writing to the Manager immediately after the acts complained of have occurred. Water delivery problems must be brought to the attention of the District by calling the Dispatch office immediately. Problems reported after the day of occurrence may not be acted upon.

Errors: All claims for errors in the measurement of water must be made in writing to the Manager within 30 days after the mailing of the invoice containing the error. If no claim is made within that time, the measurement as reported by the District personnel shall be the basis for the water charge.

FACILITY MODIFICATIONS

Customer Requests: Any customer desiring a structural change, realignment, or modification of any canal or District facility may petition the Board of Directors, in writing, for permission to make such change or realignment. Any such petition must be accompanied by a map showing the desired charges, and customer shall be required to pay for any such changes in advance. Any modifications or changes, if allowed by the District in its sole discretion, shall be conditioned upon terms and conditions acceptable to the District and shall, upon acceptance, become the property of the District.

TERMINATION OF SERVICES

Waste: Water delivery or services may be discontinued to any customer found to be wasting water either willfully, carelessly, or as a result of defective or inadequate ditches, laterals, pipelines, or inadequately prepared land or improper management, and said water delivery will not be resumed until such conditions are corrected to the satisfaction of the District. However, the customer shall in no way be relieved of any responsibility for payment of any charges or obligations by reason of such discontinuance of water service.

Violations of Rules and Regulations: Water delivery or services may be discontinued by the District for any violation of these Rules and Regulations by the customer. Water delivery will not be resumed until the customer complies with all the Rules and Regulations of the District. However, the customer shall in no way be relieved of any responsibility for payment of any charges or obligations by reason of such discontinuance of water service.

Maintenance: Water delivery or services may be discontinued by the District in order to perform maintenance, modifications, or construction of canals or other facilities or for any other necessary purpose(s), at any time or times. District facilities may be drained of water during shut down periods. Customers receiving usable water during a drain down will be charged normal and customary rates for water delivered. District staff may make arrangements to drain canals for maintenance or emergencies at no cost to customers or landowners.

Delinquency: Water delivery or services shall be discontinued to any customer or property for which there exists a delinquency in the payment of any charges or assessments. Water service shall be resumed only upon full payment of all delinquencies, including water charges, assessments, penalties, and interest.

Non-liability: In any event of water service termination, District shall not be responsible or liable for any damage occasioned by such discontinuance of water service.

ENFORCEMENT

Manager's Responsibility: The Manager of the District shall be responsible for the enforcement of these Rules and Regulations. Nothing in these Rules and Regulations are intended to, nor shall have the effect of limiting any rights granted the District under any laws of the State of California. The failure or refusal of the Manager to enforce any provision of these Rules and Regulations shall not constitute a waiver of the right to enforce any or all of the provisions contained herein at any subsequent time for the same violation or for any other.

Records: In administering these Rules and Regulations, the District will rely upon the Kern County Assessment Roll, last equalized, and upon District records regarding matters of title to land, addresses of landowners, authorizations, appointments, designations and the like filed with the District by a customer. These records shall be considered continuing representations upon which the District is entitled to rely unless and until the District has received actual written notice of any changes from the customer, the transferee, or the County of Kern.

Unauthorized Tampering: No person shall molest, tamper with, or interfere with structures, meters, or devices used for the delivery of water. In this connection, attention is directed to **California Penal Code section 592** which provides as follows:

"**(a)** Every person who shall, without authority of the owner or managing agent, and with intent to defraud, take water from any canal, ditch, flume, or reservoir used for the purpose of holding or conveying water for manufacturing, agricultural, mining, irrigating, generation of power, or domestic uses is guilty of a misdemeanor.

(b) If the total retail value of all the water taken is more than four hundred dollars ($400), or if the defendant has previously been convicted of an offense under this section or any former section that would be an offense under this section, or of an offense under the laws of another state or of the United States that would have been an offense under this section if committed in this state, then the violation is punishable by imprisonment in the county jail for not more than one year, or in the state prison.

ACCESS

Customer Property: The authorized agents or employees of the District shall have free access at all times to all lands irrigated from the District facilities, for the purpose of operation or maintenance of District facilities or for the purpose of examining the ditches and flows of water therein and for the further purposes of ascertaining the acreage of crops on lands irrigated or to be irrigated, or for any other purposes reasonably related to conducting District business or enforcing these Rules and Regulations.

District Facilities: No customer shall use or enter upon any District facilities, property, or rights-of-way without the express permission of the Manager. Prior to sampling or testing of District's water supplies in District facilities, an encroachment permit from the District stating the conditions governing the same shall be obtained. No chemicals may be added by customers, private parties, or their agents to waters within District facilities, rights-of-ways, or easements. Suitable measures to prevent back flow into the District's facilities shall be provided as required by the District.

MODIFICATION OF RULES

Board of Directors: These Rules and Regulations shall become effective when adopted by the Board of Directors of the District and may be amended or repealed, in whole or in part, from time to time within the sole discretion of the Board of Directors.

Special Conditions: The Board of Directors may authorize a temporary variance from these Rules and Regulations to meet any special conditions as deemed appropriate by the Board of Directors.

SEVERABILITY

Invalidity: If any provision of these Rules and Regulations, or the application thereof to any person or circumstance, is held invalid, the remainder of these Rules and Regulations and the application of its provisions to the same or other persons or circumstances shall not be affected thereby.

Captions: All captions accompanying these Rules and Regulations are for convenience and ease of reference and are not intended to limit the applicability of any rule or regulation.

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Appendix D: KDWD Water Deliveries Report, July 2015

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KERN DELTA WATER DISTRICT
WATER DELIVERIES REPORT

July 2015

Submitted to:

Kern Delta Water District
Board Members
501 Taft Highway
Bakersfield, CA 93307

Department of Water Resources
Water Use and Efficiency Branch
Agricultural Water Use Efficiency Unit
Attention: Fethi BenJemaa
VIA EMAIL: AgWUE@water.ca.gov

Prepared by:

Kern Delta Water District
501 Taft Highway
Bakersfield, CA 93307

State of California | The Natural Resources Agency | Department of Water Resources

Agricultural Aggregated Farm-Gate[1] Delivery Reporting Form for Article 2

Title 23, Division 2, Chapter 5.1, Article 2 of the CCR requires water supplier subject to the regulation to report to DWR the previous calendar year's aggregated farm gate delivery by July 31 of the subsequent year

1. Water Supplier Information

Name: Kern Delta Water District

Address: 501 Taft Highway
Bakersfield, California 93307

Phone Number: (661) 834-4656

Fax: (661) 836-1705

Total Number of Farm-Gates:

Number of Measured Farm-Gates:

Irrigated Acreage for Reporting Period:

Total Service Area Acreage:

2. Contact information

Name: Mark Mulkay

Title: General Manager

Address: 501 Taft Highway
Bakersfield, California 93307

Phone Number: (661) 834-4656

Fax: (661) 836-1705

E-mail: mark@kerndelta.org

Submittal date: 7/31/2015

Reporting year: 2014

3. Aggregated Farm-Gate Delivery Data[2]: (*provide monthly or bimonthly data, acre-feet*)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly Deliveries	7,218.90	9,222.12	17,507.80	17,121.18	20,189.09	29,659.58	19,209.02	16,773.48	8,930.86	6,491.98	7,054.41	2,313.06	161,691.48

	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Total
Bimonthly Deliveries							

4. Explanations, Comments and Best Professional Practices[3]:

PLEASE SEE ATTACHED REPORT

Note: An agricultural water supplier's total water use may be different from Aggregated Farm-Gate deliveries because measurement at these points may not account for other practices (such as groundwater recharge/conjunctive use, water transfers, wheeling to other agencies, urban use, etc).

1. "Farm-gate" means the point at which water is delivered from the agricultural water supplier's distribution system to each of its individual customers as specified in the Agricultural Water Measurement Regulation (Title 23, Division 2, Chapter 5.1, Article 2 of the CCR).
2. "Aggregated farm-gate delivery data" means information reflecting the total volume of water an agricultural water supplier provides to its customers and is calculated by totaling its deliveries to customers.
3. "Best Professional Practices" is defined in Title 23, Division 2, Chapter 5.1, Article 2 of the CCR, Section 597.2.

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1. INTRODUCTION

In order to ensure all customers in the Kern Delta Water District (District) service area receive the water supplies they require, and in accordance with SBx 7-7, the District has been and continues to implement measuring technologies with increased accuracy, enabling the District to supply all deliveries ordered by its customers. These technologies include standard canal measuring structures such as weirs as well as modern measuring technologies that measure flow rates through the use of Doppler and ultrasonic technologies. In recent years the District has been converting to wireless sensors, allowing for instantaneous access to and observation of flow rates measured throughout the its service area. Through the use of these technologies and measuring devices, the District has been able to accurately measure where water resources within its systems are at any time and, as a result, continues working towards optimizing the operations within its systems to allow for the optimal use of its resources.

As the District employs several metering technologies, it is necessary to provide specialized training regarding how to accurately work with each type of meter and to maintain each meter as required. District staff responsible for the measurement of flow rates in District facilities undergo extensive training regarding methodologies for obtaining and recording measurements, ensuring that these measuring devices both measure and are reported accurately. Additionally, each device is calibrated by the District Maintenance department at a minimum of the manufacturer's required interval in order to maintain accurate and precise measurements.

This report is intended to detail the measuring devices employed by the District as well as the methods of measurement and accuracy of each measuring technique used with by District staff for its deliveries. Also included in this report is a listing by month of the deliveries made to each gate within the Kern Delta Water District during the 2013 water year. This data is also presented in the condensed "Agricultural Aggregated Farm-Gate Delivery Reporting Format for Article 2" form provided by the State as stipulated in SBx 7 and included in Appendix B.

Detailed information regarding each of the measuring devices and their measurement methodologies and accuracies may be reviewed in its entirety through publications by the Department of the Interior: Bureau of Reclamation or by the individual manufacturer of the meters used within the District. A condensed description of each device along with any special provisions implemented specifically within the District service area is included herein.

2. BACKGROUND

The Kern Delta Water District was formed in December 1965, pursuant to the provisions of California Water District Law (Division 13 of the California Water Code) to consolidate water rights and provide area landowners with the ability to contract with the Kern County Water Agency for the delivery of supplemental imported water from the State Water Project.
The District supplies are obtained via three sources: water served in the District is primarily diverted from the Kern River with groundwater and State water supplemental to it. The District's service area includes 128,960 acres of primarily agricultural lands, south of the City of Bakersfield.

Between the years of 1972 to 1976, the District contracted with the KCWA to secure annual entitlement to State water; however, at the time the District did not have facilities to convey State water to its service area. The District did have access to Kern River water via canals owned by the Kern Island Water Company that ran through its service area. In 1972, the District entered into a water exchange agreement with the Buena Vista Water Storage District to trade its annual State water entitlement for an equal amount of Kern River Water. Soon thereafter, the District also entered into a water distribution agreement with the Kern Island Water Company for the use of its canals.

The Kern Island Water Company was formed in 1966 in accordance with a directive (Decision No. 71684) of the Public Utilities Commission. The formation of the Kern Island Water Company was the result of a merger of five canal companies: Kern Island Canal Company, Farmer's Canal Company, Stine Canal Company, Buena Vista Canal Company, and East Side Canal Company. These canal companies, with the exception of East Side Canal Company, had pre-1914 rights to divert water from the Kern River. Kern Island Water Company inherited all historical agreements for delivery and allocation of water held by the five canal companies.

The District acquired Kern Island Water Company in 1976 from the City of Bakersfield including all of its facilities and its historical water rights to diversions from the Kern River. The service areas of Kern Delta Water District and Kern Island Water Company largely overlapped.

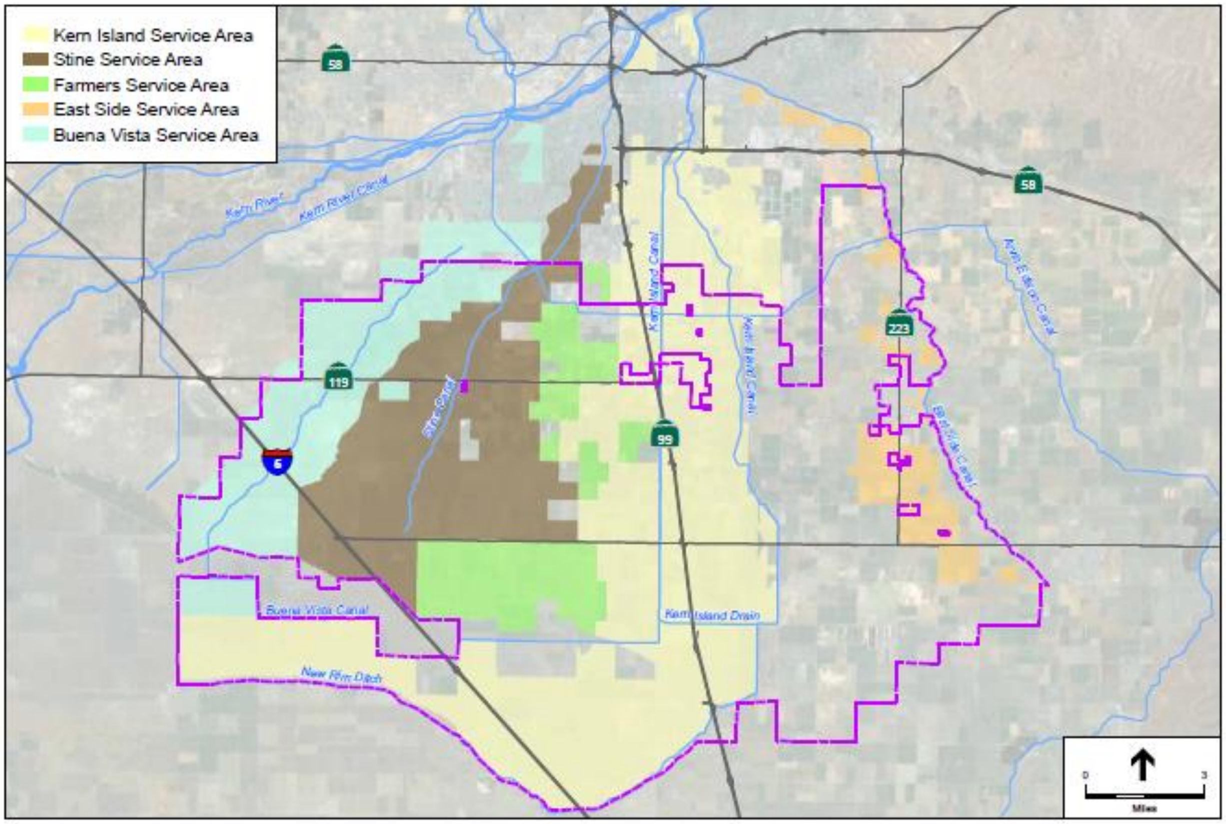

Figure 1: Kern Delta Water District Service Areas

Since the District's organization and acquisition of the Kern Island Water Company, water rights in California and the San Joaquin Valley have been a much debated and fought over resource. Considerable time and effort was spent during the early to mid 18th century refining measuring principles to be applied with the existing a structures in the canals; many of these structures are presently still in use for measuring diversions into District facilities.

This report is intended to summarize the methods of measurement employed by the District within its facilities. Also included in this report is a thorough breakdown of all deliveries to customers by delivery point by month and, as a supplement, the same deliveries totalized as requested by the Department of Water Resources.

3. MEASUREMENT DEVICES

The District utilizes two main methods for the measurement of water in its systems: standard overpour measurement facilities and meters (manual and automated). These measurement devices are read and reported daily by District staff.

3.1. WEIRS

Kern Delta Water District has an extensive weir system in its canals. These weirs are used as a primary means of regulating large flows through its facilities and consist of both fixed grade weirs and variable timber weirs. While District staff is very adept at calculating and regulating flow rates through timber weirs, it is recognized that these weirs are not an accurate means of measurement for the purposes of reporting deliveries; thus, the District only uses fixed grade weirs, thin-walled weirs to measure any flow rates diverted into its system and regulated within the District facilities. Following is a summary of the studies and analysis the District and other agencies have conducted to verify measurement accuracy through the use of weirs.

3.1.1. CONCRETE, FIXED GRADE WEIR:

Weirs, being some of the oldest canal structures still in existence, measure the flow of water in open canal channels within the District. Due to their lengthy use, several studies have been conducted on weirs to improve accuracy of measurements via their use. The District has incorporated and made use of one study in particular: the Kindsvater and Carter study and method of determining flow rates over weirs. This method, also used by the United States Department of the Interior Bureau of Reclamation, may be found in *The Water Measurement Manual* and a summary of which is included hereafter.

Weirs constructed and maintained within the District that serve as accurate measuring points are required to be maintained and, when necessary, rehabilitated so as to conform to the requirements of fixed blade, thin-walled rectangular weirs. These conditions are:

(a) The upstream face of the weir plates and bulkhead should be plumb, smooth, and normal to the axis of the channel.

(b) The entire crest should be level for rectangular and trapezoidal shapes, and the bisector of V-notch angles should be plumb.

(c) The edges of the weir opening should be located in one plane, and the corners should have proper specified angles.

(d) The top thickness of the crest and side plates should be between 0.03 and 0.08 inch (in).

(e) All weir plates should have the same thickness for the entire boundary of the overflow crest. If the plates are thicker than specified in condition (d), the plate edges shall be reduced to the required thickness by chamfering the downstream edge of the crest and sides to an angle of at least 45 degrees; 60 degrees is highly recommended for a V-notch to help prevent water from clinging to the downstream face of the weir.

(f) The upstream edges of the weir opening plates must be straight and sharp. Edges of plates require machining or filing perpendicular to the upstream face to remove burrs or scratches and should not be smoothed off with abrasive cloth or paper. Avoid knife edges because they are a safety hazard and damage easily.

(g) The bottom edge plates and fastener projection upstream should be located a distance of at least two measuring heads from the crest. If not, the plates must be inset flush with the upstream face of the supporting bulkhead, and the fasteners must be countersunk on the upstream pool side. Upstream faces of the plates must be free of grease and oil.

(h) The overflow sheet or nappe should touch only the upstream faces of the crest and side plates.

(i) Maximum downstream water surface level should be at least 0.2 foot (ft) below crest elevation. However, when measuring close to the crest, frequent observations are necessary to verify that the nappe is continually ventilated without waves periodically filling the under nappe cavity.

(j) To prevent the nappe from clinging to the downstream face of the weir, the head measurement should be greater than 0.2 ft. Conditions (d), (e), and (f) also help to prevent clinging. If measurements must be made at heads approaching this value for substantial periods, operators must ensure the head measuring system has commensurate precision with respect to needed accuracy and must continually check for clinging.

(k) The measurement of head on the weir is the difference in elevation between the crest and the water surface at a point located upstream from the weir a distance of at least four times the maximum head on the crest.

(l) Keep the approach to the weir crest free of sediment deposits. All the approach flow conditions as discussed in section 17 of chapter 2 of this manual apply. [1]

Upon verification that these conditions are met, each weir is then rated using the Kindsvater-Carter Method. The equation used to determine flow rate over the weir is:

$$Q = C_e L_e h_{1e}^{3/2}$$

[1] *The Water Measurement Manual*, United States Department of the Interior – Bureau of Reclamation, 2001.

Where: Q = discharge, cubic feet per second (ft^3/s)
e = a subscript denoting "effective"
C_e = effective coefficient of discharge, $ft^{1/2}/s$
$L_e = L + k_b$
$h_{1e} = h_1 + k_h$
k_b = a correction factor to obtain effective weir length
L = measured length of weir crest
B = average width of approach channel, ft
h_1 = head measured above the weir crest, ft
k_h = a correction factor with a value of 0.003 ft

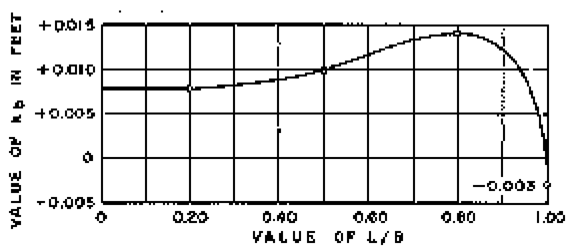

Figure 2: Value of width-adjustment factor from Georgia Institute of Technology tests (courtesy of American Civil Society of Engineers).

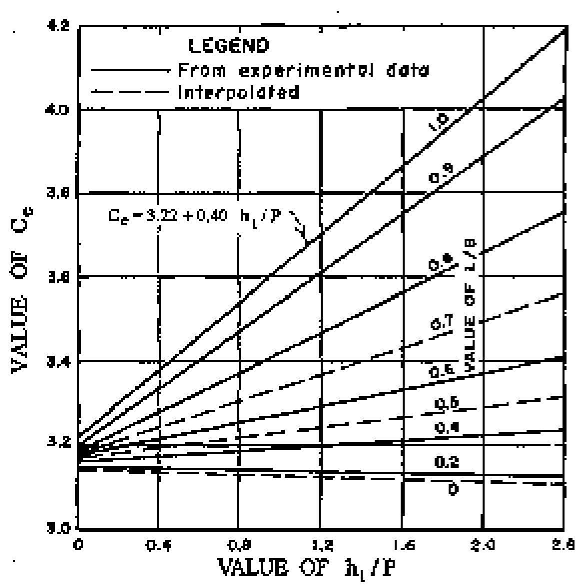

Figure 3: Effective coefficient of discharge, *C_e*, as a function of *L*/*B* and *h_1/p*, from Georgia Institute of Technology tests (courtesy of American Civil Society of Engineers).

The straight lines on Figure 2 have the equation form:

$$C_e = C_1 (h_1 / p) + C_2$$

where:

C_e = effective coefficient of discharge
C_1 = equation coefficient
h_1 = head on the weir (ft)
p = height of crest above approach invert (ft)
C_2 = equation constant

The District has also standardized measurement practices of thin-plate rectangular weirs. For a weir to provide an accurate source of flow rate measurement, the following conditions must be true (please note, other conditions are also necessary, but the primary sources of error within District service area are reflected by the conditions listed below):

1) Measurements must not be taken from the side of the canal or concrete box structure.
2) Measurements must be taken at a distance between four (4) to six (6) times the head (H) above the weir. (i.e. The water surface for a weir with one foot of head must be measured between four to six feet upstream of the weir).

Errors in measurement and calculation of flow rates over weirs are most often introduced through these two items.

Measurements cannot be taken from the sides of the canal or concrete box due to the reactions at the interface between the water surface and soil/concrete. The water velocities in these zones are slowed due to shearing forces and friction which cannot be accounted for in the traditional weir over pour calculation.

The greatest potential for error, however, is in the location the differential head measurement (head above the weir) is taken. Assuming steady flow and steady state conditions (typical for Kern Delta's service area) upstream of the weir, the water velocity and cross sectional area above the weir remains constant and uniform; however, beginning about four (4) to six (6) measuring heads upstream of the weir, and increasing in severity as the water approaches the weir, there is a contraction in the cross sectional area and increase in velocity. This results in a lower measured head as water approaches the weir crest, with a critical depth (lowest point in the water profile) occurring at the weir crest, before free-falling into the canal below the weir. Please note, per the Bureau's *Water Measurement Manual*, the formula widely used by water agencies including

Kern Delta requires that the head be measured at least four measuring heads upstream of the weir crest, before the change to the water profile due to approaching the weir occurs.

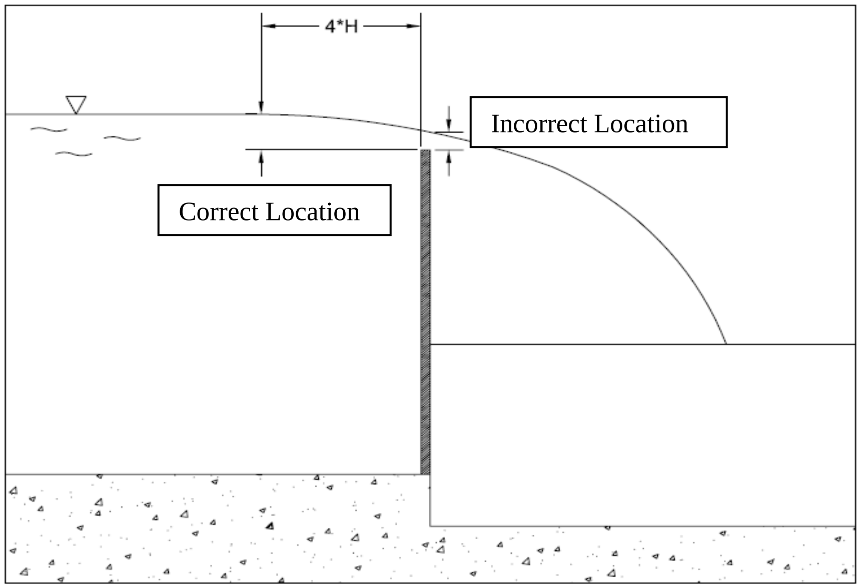

Figure 4: Typical Water Profile at a Sharp Crested Weir

In determining the flow rate over a weir, several variables (canal roughness, water turbulence, cross-sectional area vs. velocity, friction from air & other sources, etc.) are accounted for, based on the assumption that the water surface elevation is measured when the canal is still in a steady state and uniform condition. Measuring the water surface at the vena contracta introduces errors into the measured flow rates that result in measured flow rates being lower than the actual flow rates.

To illustrate the effects of these errors on the calculated flow rates in a specific example, and assuming a weir is to measured that has a weir crest length of 4’-6”, all conditions regarding the weir installation are correctly met, the tail water elevation is a minimum of two (2) feet below the weir crest, the following is the difference between the calculated flow rate (whose head is measured at the weir crest) and the actual flow rate.

Table 1: Calculated Flow Rates of Example Weir

Calculated Flow Rates (H, being measured at the weir crest)		
H (in)	Q - Perceived (cfs)	Q – Actual (cfs)
0	0.00	0.00
1	0.33	0.40
2	0.90	1.10
3	1.64	2.00
4	2.52	3.07
5	3.52	4.28
6	4.61	5.61
7	5.80	7.06
8	7.08	8.62

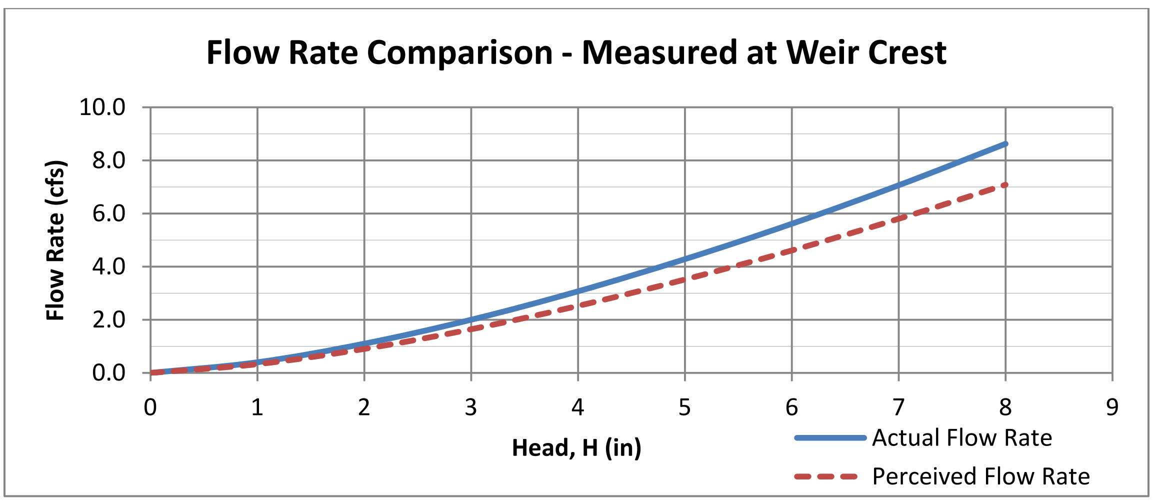

Figure 5: Perceived Flow Rate at Weir Crest vs. Actual Flow Rate

Based on the above discussion, District personnel record the head on each weir at a location approximately four (4) to six (6) measuring heads upstream of the weir. Measurements are also taken in (approximately) the centerline of the canal's flow path at the specified distance upstream from the weir.

3.2. FLOW METERS

Given the size of the District's service area and its limited staff, it has been deemed impractical to rely solely on fixed canal structures (such as weirs) that require staff to measure flow rates at several times a day in addition to regulating the canals and diversion points. The District has explored the possibilities of implementing several metering technologies that would allow for its staff to be able to take measurements faster, to be able to record measurements over time that could be read at the locations, and to record measurements and transmit them wirelessly back to the office for observation. Through trial and error, the District has found that a few metering technologies work best at points throughout its systems; following is a detailed breakdown of metering technologies that have been implemented within the District, as well as a description of each meter and its specific application.

3.2.1. CANAL AND DIVERSION GATES:

Figure 6: Waterman C-10 Canal Gate

C-10 canal gates are used extensively throughout the District at major diversions and at individual farmer turnouts and delivery points. The gates are specifically designed to be used on canal and pipeline systems which operate at low heads. In the District, they are installed in two manners: the first being a typical installation at the head of a pipeline delivery or measurement point, and the second location is against a concrete headwall that discharges into a canal. The first type of installation is very typical for farm turnouts. The District has hundreds of turnout structures with gates installed on them. These gates regulate water into pipeline systems that are installed by farmers and used to distribute the water within their systems. Often times these pipelines networks are very long, necessitating the installation of a pipe riser behind the gate and turnout structure that serves to provide a pressure/vacuum release and to measure the instantaneous differential head behind the gate: this differential head measurement, along with height of the gate opening are used to determine deliveries to the farmer. Other times, the pipeline is very short and empties into a stilling well where a booster pump sends it to the farmer's required location. In this situation, the differential head can be measured in the stilling well while accounting for any losses from friction in the pipe.

The second installation is unique to the District and specifically for the purpose of metering diversions into canals throughout the District. A headwall is placed in a canal just downstream of a major diversion with a fixed water surface. Should the water surface rise, the water will overtop the fixed structure in the canal lateral and travel into the lateral as designed. The headwall, however, has one to four C-10 gates installed on it which are opened to allow for a determined flow to pass through them into the main canal. Knowing the flow rates coming to this diversion point, and the flow passing through the gates, District staff knows exactly how much of its resources are being sent into the canal lateral at any time.

3.2.2. DOPPLER ULTRASONIC & DEPTH SENSOR:

One of the primary meters the District uses in partially full pipelines is a Doppler ultrasonic technology with a depth sensor. The Doppler technology allows for hundreds of measurements of water velocity – specifically, the debris, organisms or sediment being transported by the water – to be taken in the pipe and averaged to determine the true water velocity in the pipeline. These readings are taken over the entire cross section of the pipe, accounting for increased friction along the pipe walls and other factors traditional measuring cannot take into consideration. The meters are also equipped with a pressure sensor, capable of calculating the depth of water in the pipe. The meter, upon measuring the depth of the water based upon the hydrostatic water pressure, is programmed to determine the flow area in the pipe. Thus, the measurements of both area and velocity yield the flow rate through each of these pipes.

Figure 7: Mace Depth and Area Sensor

The District also makes use of these devices in its open canals. After programming the cross sectional area of the canal section the meter is installed in, the meter is able to measure the velocity of the water and the depth of water above it and, using this data, compute the flow rates in an open canal. The same also holds true for measuring weirs throughout the District.

The accuracy of the Doppler Ultrasonic technology is within 1% with velocities below ten (10) feet per second. None of the facilities within the District operate with velocities above this threshold.

3.2.3. ECHOFLO ULTRASONIC SENSOR:

The District has installed and currently uses several EchoFlo meters to monitor water depths throughout the District. These meters are installed in District canals upstream of fixed-blade overpour weirs and are used in conjunction with the weirs to determine flow rates through a given canal reach. Using several of these weirs in series, the District is able to effectively calculate the differential flow through each reach, thereby indicating the amount of water delivered to its customers at large diversion points.

The EchoFlo meter uses ultrasonic technology to transmit a signal out from the meter and, based upon the amount of time for that signal to be reflected and return to the meter, is able to determine the depth of water. In the case of fixed blade weirs, this can then be used to determine the head on the weir.

Figure 8: Mace EchoFlo Depth Sensor

These meters are mounted throughout the District in one of two methods. The first method utilizes a stilling well that is attached to the headwall of the weir structure. This stilling well has pipes that extend below the water surface, approximately twenty (20) feet upstream of the headwall, allowing for the stilling well's water surface to present an accurate representation of the energy grade line of the canal and is used to determine the head on the weir. The second method involves the use of a swing arm specifically designed for these meters. The arm extends out approximately twenty (20) feet and is locked in place upstream of the weir, providing the same water surface, free from obstructions and changes in the water surface due to approach conditions at the weir crest.

The EchoFlo meters have an accuracy of +/- 0.2%.

3.2.4. **PROPELLER METER**

The District has canal reaches that have been placed in pipeline for several reasons including the regulation of its supplies into retention basins as well as for overcrossings due to further expansion of the City of Bakersfield. These pipelines have given the District the opportunity to install propeller meters that measure instantaneous flow rates through the pipelines.

A few conditions must be met for these meters to function accurately: namely, water velocities must be within a specified range (100 to 75,000 gallons per minute), pipes must be flowing full – partial flow through pipes will not be measured accurately, the meters must be installed a certain distance away from entrances or exits to allow for the velocity profile to pass through the propeller perpendicular to the meter, and the water must be free from large debris and objects that might obstruct flow through the propeller.

Accuracy of the Propeller meters is within +/- 2% of the true flow rate and the repeatability of the measurements taken is within +/- 0.25%.

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Appendix E: KDWD Groundwater Management Plan Update

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Final

Groundwater Management Plan Update

Kern Delta Water District

October 11, 2013

Todd Engineers

Groundwater Management Plan Update

Kern Delta Water District

Final

October 11, 2013

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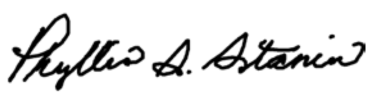

Phyllis Stanin

Vice President and Principal Geologist

FINAL
Groundwater Management Plan (GWMP) Update
Kern Delta Water District

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List of Acronyms

AFY – acre feet per year
AEWSD – Arvin-Edison Water Storage District
BVWSD – Buena Vista Water Storage District
Cal Water – California Water Service Company
CEQA – California Environmental Quality Act
cfs – cubic feet per second
COB – City of Bakersfield
District – Kern Delta Water District
DWR – (California) Department of Water Resources
ET - evapotranspiration
ft/day - feet per day
gpm – gallons per minute
GWMP – Groundwater Management Plan
ID4 –Improvement District No. 4 of the Kern County Water Agency
IRWMP – Integrated Regional Water Management Plan
KDWD – Kern Delta Water District
KCWA – Kern County Water Agency
KWB – Kern Water Bank
Metropolitan – The Metropolitan Water District of Southern California
mgd – million gallons per day
msl – mean sea level
NKWSD – North Kern Water Storage District
PAC – Project Advisory Committee for the Groundwater Management Plan Update – designated as the Kern Delta Water District Board of Directors
RWQCB – Central Valley Regional Water Quality Control Board (also Water Board)
SBVMWD - San Bernardino Valley Municipal Water District, also referred to as Valley MWD
SWP – State Water Project
SWRCB – State Water Resources Control Board
UWMP – Urban Water Management Plan
Valley MWD – San Bernardino Valley Municipal Water District
WAP – Kern River Water Allocation Plan, Kern Delta Water District
Water Board – Central Valley Regional Water Quality Control Board (also RWQCB)
WWTP – wastewater treatment plant

1 Introduction

For more than 130 years, groundwater and surface water have been used conjunctively in the Kern Delta Water District (KDWD or District) service areas. Canal companies dating back to the late 1800s have provided conveyance of Kern River water for agricultural irrigation. Significant quantities of conveyed water seep into the permeable bottoms of the unlined canals, providing recharge to the groundwater basin. Additional recharge occurs through irrigation in excess of crop consumptive use (referred to as return flows). Beginning in the early 1900s, groundwater has been developed to supplement surface water supply; groundwater demand has increased over time and currently represents more than one-half to about two-thirds (in dry years) of the District's total irrigation supply. Municipal groundwater demand has also increased within KDWD as the City of Bakersfield has expanded into the northern portions of the District.

This increasing reliance on groundwater highlights the need for continued and improved groundwater monitoring and management. This Groundwater Management Plan (GWMP) update is being prepared to assess current groundwater conditions and to coordinate the various groundwater and surface water management programs being implemented by KDWD.

The GWMP follows guidelines set forth in the Groundwater Management Planning Act (Assembly Bill AB 3030) promulgated in 1992, which allows local agencies to prepare and adopt GWMPs (California Water Code Sections 10750 through 10756). The GWMP is also in compliance with the 2002 Water Code amendments by Senate Bill (SB) 1938, which identified additional components to be included in a GWMP. Such a plan allows KDWD to address issues of groundwater recharge and storage, critical components for effective management of the District's water supply.

On June 19, 2012, the KDWD Board of Directors held a public hearing and adopted Resolution No. 2012-05, *Intention of the Kern Delta Water District to Update Its Groundwater Management Plan* (Appendix A). A draft GWMP Update was presented in a second public hearing on September 17, 2013. Comments from the District and Project Advisory Committee on the draft GWMP Update were incorporated into the Final GWMP Update. On October 15, 2013, the KDWD Board of Directors adopted the Final GWMP Update, including GWMP monitoring protocols (Appendix C), by Resolution 2013-05 in accordance with AB 3030 timelines. A copy of Resolution 2013-05, *Adoption and Implementation of the Kern Delta Water District Groundwater Management Plan Update*, is included with this document in Appendix B; the original executed resolution is on file at the District office.

1.1 Background

Since its formation in 1965, KDWD has conducted numerous groundwater management activities within its approximate 200-square mile boundary (Figure 1). Activities have been formalized in numerous water supply planning documents including its original GWMP (KDWD, 1996) and a 2010 amended GWMP and Agricultural Water Management Plan (KDWD, December2010). These plans are summarized in the following section.

1.1.1 Previous KDWD Groundwater Management Plans

KDWD first prepared a GWMP under AB3030 in 1996 to formalize ongoing groundwater management practices and support the continuation of local management. Specifically the plan provided the District with the information and tools needed to maintain and improve its overall water supply through conjunctive management. The primary Basin Management Objective was to preserve the utility of the local groundwater resources, both in quantity and quality, for beneficial uses in the District. Plan elements included groundwater replenishment through incidental recharge (in unlined canals) and in-lieu recharge through delivery of imported water. The plan also documented the District's groundwater monitoring program (KDWD, 1996).

In 2010, KDWD updated and amended its GWMP in combination with an Agricultural Water Management Plan (AWMP). The 2010 plan recognized the need to optimize monitoring in compliance with new legislation including SB 6, which contained certain requirements for water level monitoring, and SB 7, which contained requirements for agricultural water conservation/management. The overall goal of the 2010 plan was to assist with long-term, sustained productive and profitable agriculture within KDWD. Combined GWMP/AWMP objectives to achieve that goal included:

- Increase water use efficiency
- Increase water supply to the extent feasible given available surface supply
- Maintain the quality of groundwater and
- Encourage and support water management techniques that minimize salt and mineral build up in soils and groundwater.

The plan contained strategies to meet these objectives, which are reviewed and incorporated into this GWMP update as applicable. Key strategies involved specific actions for optimized monitoring of groundwater levels, water demand/use, and water quality; facilitation of basic water management strategies under SB 7; consideration of pricing incentives for water management; coordination and cooperation of water use efficiency and water conservation measures; and increasing importation, recharge and storage of available water. The amended plan also noted the need for a GWMP update to include a more detailed groundwater analysis and meet requirements of recent amendments to the California Water Code, which are included in this GWMP Update.

1.1.2 Current Update

This GWMP update is being developed to document ongoing management actions, address more fully the requirements of SB 1938, consider integration with regional water management plans (including the Tulare Lake Integrated Regional Water Management Plan (IRWMP)), and incorporate additional legislative requirements since the completion of the 2010 plan (including AB 359 regarding identification of recharge zones). Current groundwater conditions beneath the District are analyzed to provide context for the plan. The GWMP also includes a more detailed assessment of water demand/use in accordance with a specific management strategy identified in the 2010 GWMP.

1.2 Project Goal, Objectives, and Management Area

The goal of the project is to develop an updated GWMP that complies with recent legislation and recommends groundwater management and monitoring activities including documentation of those already being conducted by the District. To accomplish this goal, the following project objectives have been identified:

- Update the GWMP with requirements from SB 1938 and other legislative requirements
- Re-evaluate groundwater basin conditions and update Basin Management Objectives (BMOs)
- Coordinate groundwater management with other KDWD management plans and activities for surface water (local and imported) supply
- Coordinate groundwater management with regional water management conducted by others
- Cooperate with state and local agencies on management
- Update and adopt GWMP monitoring protocols.

The GWMP update establishes the Management Area as the 129,000 acres (approximately 200 square miles) within the KDWD boundary (Figure 1). This area is located within the Kern County subbasin of the larger San Joaquin Valley Groundwater Basin as defined by the California Department of Water Resources (DWR) (Figure 2). The GWMP recognizes that the Management Area covers only a portion of the contiguous groundwater basin and represents a shared resource also managed by other agencies, which also have prepared GWMPs. Through this GWMP update, KDWD meets its responsibilities for providing local groundwater management and monitoring for its portion of the underlying groundwater resource.

1.3 Public Participation

The KDWD Board of Directors (Board) has served an active role in preparation, oversight, and adoption of GWMPs and other management activities in the District. As users of the local water resources and representatives of the various service areas across the District, the Board has the responsibility for developing sustainable groundwater management policies for all beneficial uses. As such, they are serving as the GWMP Project Advisory Committee (PAC) for the GWMP update.

The public has been invited to participate in GWMP development. The Board formally invited public participation and included contact information on how to participate in the planning process at their June 2012 public meeting. At that meeting, the Board adopted Resolution 2012-05 providing a Notice of Intention to update its GWMP. The resolution included the contact information for public participation. The public was notified of the date, time, location, and subject of the meeting through publication of the meeting date and topic in the local newspaper. The Notice of Public Hearing and the adopted resolution of Notice of Intent are provided in Appendix A. The resolution was also provided to DWR for publication on their GWMP website.

The Draft GWMP Update was provided to the PAC/Board on June 13, 2013 for review and presented in a public hearing on September 17, 2013 for public comment and consideration. The Final GWMP Update was adopted by the Board on October 15, 2013 by Resolution 2013-05. As part of the GWMP Update, the monitoring plan and protocols, provided in Appendix C, were also adopted by the Board. The resolution and Notice of the Public Hearing are included in this document as Appendix B[1].

1.4 GWMP Organization

This document begins by presenting the purpose, goals, objectives, management area, and public participation process of the GWMP Update (Section 1). Section 2 provides a review of regional water management activities including adjacent GWMPs prepared by others and other planning documents potentially relevant to KDWD groundwater management objectives. Section 3 provides a description of current District operations and facilities and its ongoing water management activities, including conjunctive use. Section 4 provides an update of local groundwater conditions within the Management Area, including a detailed analysis of recent irrigation demand and estimated quantities of groundwater pumping. The ongoing programs in Section 3 and the groundwater evaluation in Section 4 provide the foundation for updated BMOs in Section 5. An assessment of various management strategies that could be used to achieve BMOs are discussed in Section 6, including a checklist of potential applicable strategies originally provided in AB 3030 and updated in SB 1938. Section 7 provides the components of the GWMP and presents an implementation schedule.

The KDWD monitoring program has been updated to better achieve BMOs and to monitor performance of the GWMP activities. Monitoring program details and protocols are provided in Appendix C. Resolutions, Notices of Public Hearings, and Proof of Publications are in Appendices A and B. An index to DWR required and recommended components of a GWMP is provided as Appendix D.

[1] A copy of the unsigned final resolution is provided in Appendix B. The original signed resolution was executed after the production of this document; the original is on file with the District and a copy is available on request.

2 Local Groundwater Management

Kern County is an area of both current and historical active groundwater management. In response, in part, to declining groundwater levels and regional overdraft, numerous water districts were formed in the 1960s to consolidate surface water rights and provide imported water supplies. During the next few decades, groundwater recharge and storage projects were developed across the region. In the 1990s, larger and more formalized banking projects were developed along the Kern River north and northwest of the District. Further, many local water districts engaged in groundwater replenishment activities for the benefit of in-district customers. Both banking and in-district replenishment projects have involved numerous participants and cooperation among local water districts and other water purveyors in the region.

Recently local water districts, including KDWD, have engaged in formal banking agreements with outside partners to recharge water in-district for later recovery. These arrangements have provided needed revenue for groundwater management infrastructure such as recharge basins. Because groundwater management activities by others have the potential to impact groundwater resources beneath the District, a summary is provided below of local and regional groundwater management activities adjacent or applicable to KDWD.

2.1 Neighboring GWMPs

Numerous Kern County water districts have prepared GWMPs, including two neighboring water districts, Arvin-Edison Water Storage District and Wheeler Ridge-Maricopa Water Storage District. These two plans have been reviewed to better understand groundwater conditions and management adjacent to KDWD and to ensure complementary management of the shared groundwater resource. GWMPs from adjoining districts are summarized below.

2.1.1 Arvin-Edison Water Storage District (AEWSD)

Arvin-Edison Water Storage District (AEWSD) is located east and south of KDWD and is about the same size in area (132,000 acres) and irrigated acreage (about 113,000 acres) (Figure 1). It was formed in the mid-1960s to provide imported water from the Federal Central Valley Project (CVP) to supplement groundwater for agricultural irrigation and to alleviate groundwater overdraft (estimated at about -126,000 AFY in 1964). Due to the variable nature of CVP water availability, AEWSD initiated recharge operations as early as 1966 to store excess imported water in the groundwater basin. Groundwater storage and conjunctive use activities were expanded in 1995 and 1997 through more formalized banking projects with Rosedale-Rio Bravo Water Storage District (RRBWSD) and The Metropolitan Water District of Southern California (Metropolitan), respectively.

In 2003, AEWSD prepared a GWMP to develop a coordinated and comprehensive approach to future groundwater evaluation and management (Provost & Pritchard, 2003). The GWMP identified 24 BMOs to be used as guiding principles for groundwater management actions. Most of the BMOs consisted of general guidelines such as maximizing surface water supplies in an economical manner, increasing conjunctive use, consideration of economical exchanges or banking arrangements with other agencies, avoidance of overdraft and subsidence, protection of groundwater quality, cooperation with local agencies, and continuation of groundwater monitoring. Components of the AEWSD GWMP are organized around the 12 elements provided in AB 3030 as potential items for inclusion in a GWMP. Key plan elements are summarized below:

- Minimize groundwater degradation (salinity) and limit migration of saline water through continued importation of high quality surface water for direct or in lieu recharge, management of groundwater extractions, and improved monitoring programs.
- Cooperate with the Wellhead Protection programs of other agencies with public water supply wells.
- Report groundwater contamination issues to the appropriate agency and cooperate and assist according to AEWSD's jurisdiction and authority.
- Comply with the Kern County Department of Health Services well ordinance by applying for well permits and properly abandoning AEWSD wells. Encourage landowners to convert usable wells to monitoring wells. Continue to maintain DWR Well Completion Reports for wells in AEWSD to facilitate evaluation of groundwater monitoring data.
- Work towards reduction and elimination of overdraft conditions by monitoring levels, subsurface inflow, and pumping; look for opportunities to reduce overdraft by participating in projects or activities that positively affect groundwater balance and are cost effective to implement.
- Continue to operate and manage existing groundwater replenishment facilities. Look for and evaluate opportunities to participate in projects or activities that further replenish groundwater.
- Continue current groundwater levels, storage and quality monitoring program. Update hydrographs annually and present to AEWSD Board of Directors. Update water quality mapping every 5 years.
- Manage extractions from AEWSD wells to balance groundwater on a district-wide basis. Manage indirectly extractions by landowners by providing surface water supplies and continuing the AEWSD conjunctive use program.
- Continue to participate in water transfers, water exchanges, water banking, and other water management arrangements that are mutually beneficial to the parties involved and are consistent with the BMOs in the GWMP. Evaluate potential projects that would involve the construction and operation of additional groundwater management facilities.
- Cooperate with various Federal, State, and local agencies with jurisdiction over various aspects of surface water and groundwater and participate in cooperative management of the Kern groundwater basin, while maintaining local control of AEWSD's groundwater resources.
- Review and comment on environmental documents related to land use plans affecting BMOs or AEWSD.
- Cooperate with agency studies on subsidence. Update elevations of critical benchmarks and structures when available as part of projects that require land surveying.

- Continue to work with agencies for mitigation of potential impacts on groundwater from changes in surface water flow, if any, as environmental documents are prepared. Monitor land use activities in ephemeral streams tributary to AEWSD. Report illegal discharges to the Regional Water Quality Control Board. Identify and oppose land uses or activities with potential to negatively impact groundwater quality.
- Continue relationships with other agencies in the basin involved in groundwater management including basin-wide planning efforts. Propose periodic meeting with overlapping and adjacent agencies for the purposes of coordinating groundwater management activities.
- Establish the Board of Directors as the GWMP Stakeholder Advisory Committee.
- Prepare annual Water Management Reports for the Board of Directors (presented on May 31st of each year).
- Conduct a re-evaluation every five years unless the Advisory Committee elects to forgo a re-evaluation.

In addition to these elements, the GWMP contains a 20-year planning horizon list of potential projects to improve surface water facilities, many of which also support groundwater replenishment and management (Table 8, Provost & Pritchard, 2003).

2.1.2 Wheeler Ridge-Maricopa Water Storage District (WRMWSD)

Wheeler Ridge-Maricopa Water Storage District (WRMWSD) borders KDWD on the south and consists of approximately 147,000 acres in the southernmost portion of the Kern County Groundwater Subbasin (Figure 1). WRMWSD prepared an AB 3030 GWMP in 2007, documenting their portfolio of water sources including private and District groundwater wells, State Water Project (SWP) water, and storage accounts in the Kern Water Bank, Berrenda Mesa Project, and Pioneer Project (Todd Engineers, 2007). The goal of the GWMP was to determine how best to integrate groundwater use with the other sources of water available to WRMWSD. To accomplish this goal, groundwater levels, flow and quality in the various subareas of the district were evaluated, including groundwater response to localized groundwater use across the area. BMOs identified in the plan are listed below:

- Prevent a return to historical overdraft
- Maintain groundwater quality
- Monitor water levels, water quality, and groundwater storage
- Estimate groundwater use and future demand
- Update progress on achieving BMOs

Strategies for groundwater management included the following actions:

- Optimize the integration of WRMWSD water sources
- Secure additional water sources, as necessary, to supplement current supplies
- Prepare a Groundwater Development Program
    - Evaluate perennial yield of the subareas
    - Implement a Well Maintenance Program for WRMWSD wells
    - Determine the need for additional wells
    - Operate the basin to support BMOs

- Improve coordination with Kern County well ordinances
  - Obtain copies of permits from County for new wells drilled in WRMWSD
  - Coordinate well abandonment activities in WRMWSD with the County
- Continue and improve groundwater monitoring
- Coordinate monitoring activities with other agencies
- Report progress on the GWMP annually and update the GWMP periodically
- Prepare an Integrated Water Resources Plan with neighboring agencies in the southern portion of the subbasin.

WRMWSD also conducts a water level monitoring program and coordinates with AEWSD on its monitoring programs (Provost & Pritchard, 2003).

2.2 Urban Water Management Plans (UWMPs)

Several water purveyors supplying municipal water are located adjacent to and within portions of KDWD as shown on Figure 3. Two of the larger municipal water suppliers, California Water Service Company (Cal Water) and the City of Bakersfield, have service areas that extend into the northern portion of KDWD. These purveyors have prepared Urban Water Management Plans (UWMPs) that compare current and future water supply sources and water demands as described below.

Cal Water serves a large portion of eastern Bakersfield and unincorporated lands adjacent to the City (encompassing about 49 square miles and a population of about 225,000 persons). Groundwater has historically supplied up to 80 percent of Cal Water's demands supplemented by surface and imported water. In 2011, Cal Water operated about 115 active wells, four of which are located within KDWD, with a total design capacity of 142,000 AFY. As per Cal Water's 2010 UWMP, their service area population is expected to increase by about 55 percent between 2010 and 2040 (Cal Water, 2011). Cal Water plans on reducing groundwater pumping during normal hydrologic years and replacing this supply with treated surface water. Cal Water now has additional treatment plant capacity to treat surface water and can expand these plants in the future when needed. Pumping is anticipated to be reduced from 44,000 AFY in 2010 to about 11,400 AFY in 2025 and then increase to 32,800 in 2040 (Cal Water, 2011).

The City of Bakersfield's Water System service area covers about 35 percent of the western portion of the Bakersfield (about 38 square miles) and provides water to a population of about 118,600 persons. Water sources include groundwater, Kern River water, and imported SWP water. The City has contracted with Cal Water to operate its water distribution system. Groundwater supply is pumped from approximately 50 active groundwater wells within City boundaries with about 12 active wells within KDWD boundaries. The City Water System population is estimated to increase from 130,600 in 2010 to about 183,900 by 2030 (City of Bakersfield, June 2012). The most recent UWMP for the City Water System is a 2007 Update to the 2005 UWMP (Stetson, 2007). Like Cal Water, the City anticipates using more treated surface water and less groundwater in the future due to new and expanded water treatment plants. The 2007 UWMP Update estimated that groundwater production would decrease from around 33,700 AFY in 2006 to 15,800 AFY in 2015 then slowly increase to 31,700 AFY by 2035 (Stetson, 2007). A 2010 UWMP is currently being prepared but not yet available.

2.3 General Plans

In addition to other GWMPs and UWMPs, additional planning documents for the area were reviewed. Cooperative and complementary actions relating to groundwater were identified for consideration in this GWMP update as discussed below.

2.3.1 City of Bakersfield

City's General Plan. The City's current general plan was adopted in 2002 (City of Bakersfield, December 2002). The plan estimates growth through 2022 and establishes a maximum extent of development. The City's 2002 General Plan update identified nine policies to address fundamental water resources issues:

1. Develop and maintain facilities for groundwater recharge in the planning area.
2. Minimize the loss of water to locations outside the planning area when water could otherwise be used for groundwater recharge to benefit local groundwater aquifers.
3. Support programs to convey imported water into the planning area (sources outside of the San Joaquin Valley basin).
4. Support programs and policies that assure continuance or augmentation of Kern River surface water supplies.
5. Work towards resolving the problem of groundwater resource deficiencies in the upland portions of the planning area.
6. Protect planning area groundwater resources from further quality degradation.
7. Provide substitute or supplemental water resources to areas already impacted by groundwater quality degradation by supporting facilities construction for surface water diversions.
8. Consider each proposal for water resource usage within the context of total planning area needs and priorities including water transport, groundwater recharge, flood control, recreational needs, riparian habitat preservation and conservation.
9. Encourage and implement water conservation measures and programs.

Kern River Flow and Municipal Water Program. The City has been developing a project to allow for more sustained flows in certain reaches of the Kern River, a project referred to as the Kern River Flow and Municipal Water Program (KRFMWP). The City recently prepared a Draft Environmental Impact Report (DEIR) for the project (City of Bakersfield, June 2012).The goal of the project is to increase Kern River channel flows to protect, increase, and enhance the City's water supply to meet current and future water demands (City of Bakersfield, June 2012). The proposed program would use existing facilities and infrastructure and would not require new construction. Under the program, water flow in the river could potentially increase downstream of the Calloway Weir in amounts up to approximately 160,000 AFY, depending upon hydrologic conditions (City of Bakersfield, June 2012).

According to the City, the increased flows would be from two potential sources:

- Up to 70,000 AFY, on average, of water from the City's pre-1914 appropriative Kern River water rights. This water has been used by local agricultural districts under long-term water supply agreements, which are expiring.

- An estimated average of up to 87,000 AFY of water, if available, through the City's application for unappropriated Kern River water with the State Water Resources Control Board (SWRCB).

2.3.2 Kern County Planning Commission

The Kern County General Plan (Kern County, 2009) also contains policies and implementation measures related to surface water and groundwater. Relevant policies include:

- Provide water related infrastructure in an efficient and cost effective manner.
- Ensure that water quality standards are met for existing users and future development.
- Ensure that adequate water storage, treatment, and transmission facilities are constructed concurrently with planned growth.
- Ensure that appropriate funding mechanisms for water are in place to fund the needed improvements resulting from growth and subsequent development.
- Encourage utilization of wastewater treatment facilities which provide for the reuse of wastewater.
- Encourage the development of the County's groundwater supply to sustain and ensure water quality and quantity for existing users, planned growth, and maintenance of the natural environment.
- Encourage utilization of community water systems rather than the reliance on individual wells.
- Review development proposals to ensure adequate water is available to accommodate projected growth.
- Discretionary projects shall analyze watershed impacts and mitigate for construction-related and urban pollutants, as well as alterations of flow patterns and introduction of impervious surfaces as required by the CEQA, to prevent the degradation of the watershed to the extent practical.
- New high consumptive water uses, such as lakes and golf courses, should require evidence of additional verified sources of water other than local groundwater. Other sources may include recycled stormwater or wastewater.

Implementation measures were developed for the various stated policies, several of which are included below:

- Develop guidelines for the protection of groundwater quality which will include comprehensive well construction standards and the promotion of groundwater protection for identified degraded watersheds (to be conducted by the County Health Services Department).
- Ensure maintenance and repair of existing water systems.
- Encourage effective groundwater resource management for the long-term benefit of the County through the following:
    - Promote groundwater recharge activities in various zone districts.
    - Support the development of Urban Water Management Plans and promote Department of Water Resources grant funding for all water providers.
    - Support the development of Groundwater Management Plans.

- Support the development of future sources of additional surface water and groundwater, including conjunctive use, recycled water, conservation, additional storage of surface water, and groundwater and desalination.

2.4 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County

KDWD participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County prepared by Kern County Water Agency (KCWA) (Kennedy/Jenks Consultants, 2011). As a member of the Regional Water Management Group (RWMG), KDWD executed a Participation Agreement and sponsored a joint project with AEWSD. That project involved improvements to the Arvin-Edison Intake Canal check structures and KDWD interties, which would increase operational efficiency.

The IRWMP Executive Committee ranked the project 13^{th} among more than 135 separate projects and incorporated it into the IRWMP. Although IRWMP funding was not available, KDWD and AEWSD constructed the project in 2012.

The project improves conveyance of water into and out of KDWD, facilitating water exchanges between the two districts. This efficiency increases the overall water supply including water available for recharge and banking. Additional project benefits include water quality improvements and floodplain management.

2.5 Agricultural Water Management

KDWD is currently working with regulators on improvements in management of agricultural water runoff. Some of these management strategies, including Best Management Practices (BMPs), were addressed in the previous GWMP (KDWD, December 2010). Future management strategies are focused on enhancing water for recharge while preserving groundwater quality and are consistent with goals and objectives of this GWMP Update, including Basin Management Objectives discussed in Section 5.

2.6 Groundwater Banking Areas

Several formal banking projects have been developed along the Kern River for groundwater recharge, storage, and subsequent recovery on behalf of others. Most of these projects are located within a few miles northwest of KDWD as shown on Figure 1 and listed below:

- Berrenda Mesa – KCWA
- Pioneer Project – KCWA
- COB 2800 – City of Bakersfield
- Kern Water Bank – Kern Water Bank Authority

An additional banking project is also planned for the McAllister Ranch ID area (Figure 1).

Also shown on Figure 1 are numerous additional recharge basins that have been constructed in water districts (e.g., Rosedale-Rio Bravo Water Storage District (RRBWSD), North Kern WSD, and AEWSD) that are not part of the four Kern River banking projects. These recharge facilities are used primarily for in-district groundwater replenishment, although several districts, including RRBWSD, AEWSD and KDWD, have also established formal in-district banking programs to store water for out-of-district parties. In addition to their in-district banking program, KDWD also participates in several of the Kern River banking projects by releasing river water to be conveyed to banking areas or through purchase of SWP water for banking. For example, KDWD is a participant in the Pioneer Project banking program through an agreement with KCWA. Additional information on KDWD water sources and water management programs is summarized in Section 3.

3 KDWD Operations and Management Programs

KDWD was formed in 1965 to provide a contracting agency for importing State Water Project (SWP) water through the Kern County Water Agency (KCWA) and to protect the existing Kern River water rights of the landowners within its boundaries. To provide context for the GWMP, a brief description of the District and its current operations, facilities, and management programs are summarized below.

3.1 Kern Delta Water District

KDWD boundaries encompass approximately 129,000 acres, about 107,635 of which contain irrigated agriculture (ESA, 2012). The area within the KDWD boundaries includes 89,212 acres within the historical utility service areas of five former canal companies and about 35,615 acres in non-utility areas. Figure 4 shows KDWD boundaries and the canal service areas. Lands within the KDWD boundary but outside of a service area are the non-utility lands. As shown on Figure 4, the canal service areas extend to the north beyond the KDWD boundary. Major roads and rights-of-way cover approximately 4,133 acres within KDWD, leaving about 124,867 acres (typically rounded to 125,000 acres) available for agriculture or other development. These areas are summarized in the following table.

Table 1
In-District Areas
Kern Delta Water District

Land Description	Area (acres)
Service Areas	
Kern Island	40,359
Buena Vista	14,408
Stine	19,817
Farmers	9,789
Eastside	4,839
Service Area Total	89,212
Non-Utility Areas	35,615
Rights-of-Way	4,133
Total	128,960

Reference: Boyle, 2000

3.2 Water Sources

KDWD manages three primary water sources – local surface water, groundwater, and imported water – conjunctively for beneficial uses in the District. Surface water rights on the Kern River are provided to agricultural customers to supplement groundwater pumping by individual landowners. The District also pumps groundwater for supplemental supply through District wells. In addition, KDWD has secured imported SWP water rights and obtains other water sources as available through various contracts and exchanges. These sources are described below.

3.2.1 Kern River Water

KDWD acquired Kern River water rights (and related facilities) of the Kern Island Water Company in 1976 through a series of transactions. Tenneco West, Inc. (successor-in-interest to the Kern County Land Company) sold its Kern River water rights, Isabella storage rights, water transportation and distribution facilities, and other assets to the City of Bakersfield. Bakersfield, concurrently, sold the portion of these assets that served the Kern Island Water Company to KDWD. In January 1977, KDWD assumed control of these assets and facilities and began delivery of Kern River water to landowners (City of Bakersfield, et al, 1976).

In KDWD, specific diversion rights on the Kern River are associated with the service areas. Diversions are based on the river stage and the diversion priority of each water right holder as summarized in Table 2.

Table 2
Kern River Water Rights - Kern Delta Water District

Service Area	Right (cfs)	River Stage (cfs)	Diversion Priority	Appropriation Date
Kern Island	300	0-300	1	12/1/1869
	56	3,106-3,162	26	
Buena Vista	80	330-410	4	7/19/1870
	90	2,416-2,526	22	
Stine	150	550-700	7	12/12/1872
Farmers	150	730-880	9	4/28/1873
Eastside	83/300th of Kern Island		-	6/30/1921

Diversions of river flow occur on a daily basis through a cooperative effort and are recorded at measurement stations along rivers and canals. The First Point of measurement lies upstream of the diversion points for the “First Point diverters”, which include KDWD, City of Bakersfield, and North Kern Water Storage District (NKWSD). The First Point measurement station upstream on the Kern River is shown on Figure 1. Allocated water not used by any First Point diverter can be used by others with downstream water rights (BVWSD, 2007).

In 1995, NKWSD initiated water rights litigation against KDWD over how Kern River water was allocated among the First Point diverters (NKWSD v. KDWD, Tulare County Supreme Court Case No. 96-172919). The final determination, after appeal, was a forfeiture of a portion of the Kern Island water rights during January, October, November, and December and a portion of junior water rights for other service areas during January, August, September, October, November and December (Vartabedian Appeal Opinion, 2007). Although KDWD water rights have always had maximum monthly volume caps, the judgments resulted in further reductions for certain months. Current entitlement monthly caps for the service areas are summarized below.

Table 3
Entitlement Caps Resulting from Court Decisions
Kern Delta Water District

Service Areas	January (acre-feet)	August (acre-feet)	September (acre-feet)	October (acre-feet)	November (acre-feet)	December (acre-feet)
Kern Island	8,493	-	-	6,989	3,375	2,050
Buena Vista	347	-	-	-	236	191
Stine	-	-	583	1,380	22	12
Farmers	-	610	268	-	-	207

The cap restrictions reduced KDWD's long-term average Kern River water supply from about 251,775 acre-feet per year (AFY) to about 201,943 AFY, based on average river conditions recorded from 1997 through 2007. In its 2012 Kern River Water Allocation Plan (WAP), KDWD identified a series of prioritized management actions for use of the full Kern River entitlement including moving water among service areas, providing water to meet underserved demand, and increasing the amount of groundwater recharge (Todd Engineers, September 2011).

3.2.2 Groundwater

Landowners in both utility and non-utility areas within KDWD augment surface water supplies with groundwater: more than 1,000 wells have been drilled within the District boundary (KCWA, 2011). Wells are used primarily for irrigation where surface water deliveries are limited. Groundwater is also used for non-irrigation agriculture, including dairies, and for municipal and industrial (M&I) uses. In addition, KDWD pumps a relatively small amount of groundwater from District-owned wells to supplement surface water deliveries. The total amount of pumping within the District is unknown, but is estimated to range between about 200,000 AFY and 300,000 AFY. Pumping is especially critical in service areas with more limited Kern River diversion rights, such as Buena Vista, Stine, Farmers, and Eastside, or the non-utility areas without any diversion rights (Figure 4) (Boyle, 2001). Additional analyses of groundwater pumping locations and amounts are provided in Section 4 of this GWMP update.

3.2.3 State Water Project (SWP) Water

In 1972, KDWD contracted with KCWA to receive 30,000 AFY of SWP water imported into the county via the California Aqueduct (KDWD, 1974). KDWD's SWP contract included a buildup schedule that reached the maximum amount in 1990, consisting of 25,500 AF of firm supply and 4,500 AF of unregulated surplus supply to be delivered during four winter months on an as-available basis (AECOM, 2004). In 1994, the surplus water was eliminated as part of the Monterey Agreement, revising the District's SWP maximum amount to 25,500 AFY. The SWP water supply is used to balance the area's groundwater overdraft and provide supplemental surface water deliveries to the various portions of the District.

In the absence of a readily-available means to convey SWP water into the District, KDWD executed exchange agreements with Buena Vista Water Storage District (BVWSD) to allow BVWSD access to KDWD's SWP allotment for an equal amount of BVWSD rights on the Kern River. This arrangement allowed KDWD to divert its SWP allotment from the Kern River using existing facilities while BVWSD accessed the SWP water directly from the California Aqueduct.

Since the early 1990s, the availability of SWP water has declined. Recent restrictions on the importation of SWP water by the courts have resulted in greater uncertainty for future supplies (AECOM, 2009). For the 14-year period of 1998 through 2011, the District's full allotment of SWP water was available during only one year. Given the uncertainties associated with ongoing court restrictions and other conditions, the District estimates that 50 percent of its SWP contract amount, on average, will be available.

3.2.4 Other Sources of Water

Although KDWD is not a long-term contractor for the Central Valley Project (CVP), it is eligible for excess non-storable CVP water (Section 215 flood water) during wet years (typically about two out of every ten years). If capacity is available, this surplus CVP water is delivered to KDWD via the Friant-Kern Canal (ESA, September 2012).

In addition, certain lands within the District also receive treated municipal effluent (recycled water) from the City of Bakersfield Wastewater Treatment Plants (WWTP) and Lamont Public Utility District (LPUD) WWTP (see WWTP and Lamont PUD locations on Figure 3). These lands, referred to as sewer farm lands, use recycled water for irrigation. In 2000, these lands covered approximately 6,000 acres and were estimated to use approximately 18,000 AFY of recycled water for irrigation (ESA, September 2012).

3.3 Operations and Facilities

The District owns, operates, and/or maintains physical infrastructure to support conjunctive management of surface water and groundwater. Facilities and operations are summarized below.

3.3.1 Canals and Surface Water Conveyance

KDWD operates gravity conveyance systems consisting of five main canals and laterals covering about 150 miles and associated with the five service areas. These canals are shown on Figure 4 and, from west to east, include the Buena Vista Canal, Stine Canal, Farmers Canal, Kern Island Canal (including the main canal and the Central Branch), and Eastside Canal. These canals connect to regional facilities via the Kern River Canal, the Carrier Canal, and the Arvin-Edison Intake Canal (all shared with other users), allowing diversion of Kern River water and other water sources into the District (KDWD, 2002). Canals are mostly unlined; small reaches through some urban areas consist of either concrete-lined canals or pipelines (Boyle, November 1975).

Seepage of surface water through the bottoms of the unlined canals (associated with the conveyance of surface water) represents a significant portion of groundwater recharge and is considered part of the District's water supply. KDWD recognizes this benefit to groundwater resources and has maintained the canals without installing concrete liners. The District measures and manages operational canal losses in certain areas for the benefit of specific groundwater users.

Annual canal losses in each of the KDWD service areas have been estimated for 1998 – 2011, a time period representing average hydrologic conditions for Kern River flows. These operational losses are based on data presented in the Kern River annual operations reports, although the estimates differ slightly (typically within 1 to about 10 percent) from those summarized specifically as canal loss[2]. Average canal losses are estimated at about 55,880 AFY as shown in Table 4.

Table 4
Operational Loss/Groundwater Recharge from Canals

Service Area	Average Canal Loss (1998 - 2011)		2011 Canal Loss % of Total Supply
	(AFY)	(%)	
Buena Vista	7,389	13%	41%
Stine	3,957	7%	37%
Farmers	8,278	15%	44%
Kern Island	33,411	60%	31%
Eastside	2,845	5%	24%
TOTAL	55,880	100%	

In general, the amount of canal loss is commensurate with the diversion rights associated with each service area. As shown in Table 4, Kern Island receives more than one-half (60%) of the total recharge because of the higher diversions amounts into that large service area. Loss along the Farmers Canal also contributes to recharge in the Stine service area where the canal crosses service area boundaries (Figure 4).

Overall, the average annual canal loss (groundwater recharge) of 55,880 AFY represents between 30 and 40 percent of the total surface water diverted on a district-wide basis. That percentage varies across the District as shown on the right side of Table 4, where 2011 canal loss is represented as a percentage of total water supply. As shown in the table, a higher loss rate is associated with deliveries in the western service areas (Buena Vista, Stine, and Farmers) compared to the central (Kern Island) and eastern (Eastside) service areas. Numerous factors affect these losses including antecedent soil moisture content, local subsurface conditions (e.g., soil/sediment permeability and storage), and duration and amounts of water in each canal. Actual seepage and percolation rates also vary significantly with time. Canal loss is less in the summer months when more water is running in the canals and channel bottoms are continuously wetted.

[2] *The annual summary of canal loss presented in the Kern River Operations report is a simple subtraction of delivered supplies from entitlement diversions and does not always account for all water coming into the District.*

3.3.2 Recharge Basins

KDWD owns and operates approximately 814 acres[3] of spreading basins throughout the District to allow for groundwater replenishment. These basins have been constructed since 2003 as part of a joint project with The Metropolitan Water District of Southern California (Metropolitan), described in Section 3.4 of this GWMP Update. Although these facilities were constructed to support the KDWD banking arrangement with Metropolitan, the District also operates these facilities for local groundwater replenishment and storage of excess surface water when available. Basins have been constructed or are under construction at seven locations in Kern Island, Buena Vista, Stine, Farmers, and Eastside service areas as shown in Figure 4 and summarized in Table 5.

Table 5
KDWD Recharge Basins for Groundwater Replenishment and Banking

Recharge Basins	Service Area	Size (acres)	Average Infiltration Rate (ft/day)[1]	Average Annual Recharge Capacity (AFY)
Destefani	Buena Vista	215	0.43	34,000
Pit	Stine	72	0.20	5,000
Dairy	Stine	40	0.45	6,500
Ramero	Farmers	169	0.45	28,000
Stonefield	Stine	80	0.45	13,000
Kern Island	Kern Island	160	0.45	26,000
Di Giorgio[2]	Eastside	78	0.30	8,500
TOTAL		**814**	**0.41**	**121,000**

[1] *Average infiltration rate based on estimates of average annual recharge capacity provided by KDWD*
[2] *Di Giorgio recharge basins under construction*

As shown in Table 5, infiltration rates average about 0.41 feet per day, but vary by basin and with time. The lower infiltration rate associated with the Pit spreading basin is likely the result of finer-grained soils in that area, as discussed in more detail in Section 4.

The total annual recharge capacity of 121,000 AFY is theoretical and assumes basins are full and recharge continuously at average infiltration rates. Nonetheless, this amount illustrates that large volumes of water can be recharged when water is available. Significant amounts of additional groundwater recharge can also be achieved through release of water into the unlined canals, especially during winter months when both recharge water and canal capacity are available. An examination of seepage losses during these time periods indicates that more than 4,000 AF/month could be recharged along the existing in-district conveyance systems (Todd Engineers, September 2011).

3.3.3 District Wells

As part of the banking project with Metropolitan, the District has constructed or purchased 18 wells to recover banked groundwater. About one-half of these wells were installed adjacent to two of the larger

[3] *Basins on 736 acres are in operation; basins on 78 acres are currently under construction.*

spreading basins in Kern Island and Buena Vista service areas. Additional wells have been drilled along the northern portion of the District. KDWD well locations are shown on Figure 4. Up to 32 wells may be incorporated into the banking program at project build-out (KDWD, 2002).

The total annual average capacity of the wells is estimated at 94,000 AFY. Wells have been tested or operated at rates ranging from about 1,800 gallons per minute (gpm) to about 4,500 gpm. KDWD can use these wells for recovery of banked water or to pump groundwater for in-District use.

3.3.4 Isabella Reservoir Storage Rights

KDWD also has access to storage space in Isabella Reservoir and can store Kern River water accruing to its water rights. Available storage is based on an agreement that sets individual month-by-month storage limits. In addition, KDWD can store SWP exchange water using BVWSD's storage space with a carryover limit of 6,000 AFY that must be used prior to March 15 of the following year (Boyle, 2000). End-of-month storage and carryover limits under normal operating conditions are shown in Table 6.

Table 6
Isabella Reservoir Storage Limits
Kern Delta Water District

Service Area	End-of-Month Storage (AF)	Carryover (AF)
Kern Island	18,000	2,500
Buena Vista	11,000	1,500
Stine	9,000	1,500
Farmers	6,000	1,500
TOTAL	44,000	7,000

Ref: Boyle, August 2000

3.4 Management Programs

KDWD's ongoing surface water and groundwater management programs are complementary and provide flexibility for the effective use of the various water sources available to the District. Key programs are described below.

3.4.1 Water Allocation Plan (WAP)

To provide operational flexibility and to prevent forfeiture of surface water rights, KDWD has implemented a Kern River Water Allocation Plan (WAP) (Todd Engineers, September 2011). The plan prioritizes management actions to allow full use of the District's entitlement of Kern River water to beneficially manage water sources and preserve groundwater resources. The Kern River WAP identified five primary objectives for management of Kern River water:

- Meet existing underserved irrigation demand within KDWD boundaries
- Maintain sustainable groundwater resources and a sustainable water balance

- Provide equitable distribution of water among the historical utility service areas
- Serve the growing demand for water and emerging needs of customers in KDWD
- Preserve KDWD's water rights assets.

The WAP prioritized management actions as listed in Table 7. Proposed actions include meeting demands in each service area (Priority 1), movement of water between service areas to meet all in-district irrigation demands (including non-utility lands that currently rely on SWP water and groundwater) (Priority 2), provision of water for meeting in-district municipal and industrial demands (Priority 3) and groundwater replenishment and storage for both in-district and out-of-district areas (Priorities 4, 5, and 6).

Table 7
KDWD Allocation of Kern River Water

Priority	Management Action	Average[1] (acre-feet/year)
1	Deliver Water for Irrigation within Service Areas According to Service Area Water Rights	168,895
2	Deliver Available Water for Irrigation within District	10,488
3	Meet In-District M&I Demands	6,281
4	Perform In-District Groundwater Recharge	15,281
5	Store Water in Pioneer Project	226
6	Other Uses (meeting addtl surface demands, ground-water recharge, transfers to out-of-district agencies)	772
Average Annual Adjusted Entitlement		**201,943**

1. Annual averages 1997-2007; amounts vary significantly on a monthly and annual basis.
From Todd, September 2011

With more effective use of available surface water, the WAP decreases groundwater demand for in-district supplies and also increases recharge water available for groundwater replenishment.

3.4.2 Banking Programs with Metropolitan and Valley Water Districts

A key KDWD groundwater management program is an in-district banking partnership with two out-of-district water agencies, The Metropolitan Water District of Southern California (Metropolitan) and San Bernardino Valley Municipal Water District (Valley). The banking agreement allows for the agencies to store up to 50,000 AFY beneath KDWD, with a maximum storage amount of 250,000 AF. KDWD has significant flexibility for delivery and recovery options and can choose to credit the banking account if the project water can be put to beneficial use within the District (replacing groundwater use as in-lieu recharge). Water delivered for banking is subject to operational losses of 11 percent as measured at the point of KDWD delivery. This water is left in the groundwater basin for the benefit of basin users and adds to the total groundwater in storage. Stored water (less loss) can be returned to Metropolitan and/or Valley via direct extraction or through water exchanges.

This banking program funded the construction of recharge basins and groundwater extraction wells that can be shared with in-district groundwater replenishment and recovery activities. Since the banking agreement was implemented in 2003, all of the project recharge basins and most of the project extraction wells have been purchased or constructed.

From 2003 through 2011, about 213,277 AF have been either recharged or credited (in-lieu) by KDWD for banking. Accounting for operational losses (11 percent by agreement), about 189,817 AF have been stored in the basin. Of that amount, 29,722 AF have been returned to the banking partner (in this case, Metropolitan), leaving 160,095 AF stored in the groundwater basin for subsequent recovery. Details of the banking program are summarized in the table below.

Table 8
Water Banking Program Summary 2003 - 2011
Kern Delta Water District

Service Area / Banking Partner	Recharge	In-Lieu	Total Deliveries	Operational Loss (11%)	Stored Water	Returned Water	Current Water in Storage
Buena Vista Service Area	44,672	16,516	61,188	6,731	54,457	8,527	45,930
Eastside Canal Service Area	0	16,022	16,022	1,762	14,260	2,233	12,027
Farmers Service Area	10,508	5,878	16,385	1,802	14,583	2,283	12,300
Kern Island Service Area	36,412	27,253	63,665	7,003	56,662	8,872	47,790
Stine Service Area	22,259	33,757	56,016	6,162	49,854	7,806	42,048
TOTALS:	**113,851**	**99,426**	**213,277**	**23,460**	**189,817**	**29,722**	**160,095**
Metropolitan Water District			183,277	20,160	163,117	29,722	133,395
Valley Municipal Water District			30,000	3,300	26,700	0	26,700

All values in AF

As shown on the table, most of the banked water has been recharged in the Buena Vista, Kern Island, and Stine service areas. Almost one-half of the deliveries involve a credit for in-lieu recharge. Again, operational losses represent an increase in the total groundwater in storage that is not returned to the banking partner. The available storage capacity in the subsurface is more than sufficient for these volumes of banked water. For example, assuming an average storage coefficient of 20 percent, the current stored water for banking (160,095 AF) represents an average water level rise of about six feet beneath the District. Even if the storage is less in certain areas of low permeability, the example illustrates the ability to store even larger volumes of water.

3.4.3 State Water Project (SWP) Water Allocation Plan

KDWD allocates its allotment of 25,500 AFY of SWP water among the service areas in accordance with a SWP Allocation Plan, developed in 1974 and amended in 1981 and 2009 (KDWD, 1974, 1981, and 2009). Based on underserved irrigation demand from surface water, declining groundwater levels, existing facilities, and other factors, a firm supply of SWP exchange water was allocated first to two zones of benefit:

1. Eastside Service Area (up to 0.5 AF/acre)

2. Non-utility areas (up to 0.3 AF/acre)

If additional water is available, equal amounts of SWP water are provided to other service areas as requested.

3.4.4 Out-of-District Banking

KDWD participates in several of the formal banking projects along the Kern River to optimize its use of water sources and provide overdraft protection of the groundwater system. From 1995 through 2006, KDWD banked approximately 63,660 AF of excess SWP water, CVP water, and high-flow Kern River water in Berrenda Mesa, Pioneer Project, COB 2800, and Kern Water Bank. Of that amount, approximately 23,670 AF was banked for subsequent recovery and approximately 39,990 AF was banked for overdraft protection.

3.5 GWMP Management Area

The planning and management area covered by this GWMP Update includes the approximate 129,000 acres within the District boundaries. A description of the physical conditions within the Management Area are summarized below, including topography, climate, surface water, soils, and land use.

3.5.1 Physical Setting

The management area is located in the southern San Joaquin Valley. This area of the valley floor is relatively flat to gently sloping and is surrounded by uplands including the Sierra Nevada to the east, the Coast Ranges to the west, and the San Emigdio/Tehachapi Mountains to the south (Figure 2). The Kern River, with headwaters in the Sierra Nevada, cuts across the valley floor to the west and provides surface water supply for the region. The river is located an average of about five miles north of KDWD (Figure 1).

Within KDWD, the ground surface elevation slopes at an average of about 10 feet per mile to the southwest. The highest ground surface elevations are in the northeast at approximately 420 feet above mean sea level (msl). The lower surface elevations of about 290 feet msl are in the south and southwest coincident with paleo-lakebeds that have been drained and placed into agricultural production. Most of the District has a ground surface elevation between 300 and 350 feet msl.

3.5.2 Hydrologic Setting

Long-term average annual rainfall in Bakersfield is approximately 6.03 inches per year (NOAA, 2011). Data from 1998-2011 are shown on Figure 5. Because most of the rain occurs outside of the primary irrigation season and varies significantly from year to year, precipitation is not a main source of agricultural supply. In addition, high intensity/short duration storms are typical of the region; such conditions are not conducive for efficient use of the water by crops. Nonetheless, a small portion of rainfall is available in most years to supplement other irrigation supplies. Todd Engineers conducted an assessment of daily crop consumptive use in KDWD service areas from 1998 to 2011 along with daily precipitation records to estimate the amount of rainfall that could contribute to irrigation demand. That analysis suggested that an average of approximately 20 percent of total rainfall could be used effectively by crops. This estimate is generally consistent with amounts used in a calibrated groundwater model developed for KDWD (Boyle, 2001).

Kern River flow is a better indicator of hydrologic conditions than rainfall because the river is the primary surface water supply for the region. Because Kern River headwaters are located in the Sierra Nevada more than 50 miles east of KDWD, precipitation patterns that control river flow are not always consistent with rainfall patterns on the valley floor. Kern River flows are typically represented by the *river index*, a calculated value that relates annual flow to the long-term average. Annual river indices for 1998 – 2011 are provided on the bottom of Figure 5. As shown, annual flows during this 14-year period exhibit high variability ranging from 35 percent (2007) to 232 percent (1998) of the long-term average. Dry conditions from 1999 through 2004 and 2007 through 2009 averaged about 60 percent. Indices from the relatively wet years of 1998, 2005, 2006, 2010 and 2011 were all above 100 percent of the long-term average.

There are no significant, un-managed surface water drainageways that cross the District. Due to the conveyance of surface water along canals and the predominance of agricultural lands, surface water is highly managed. As such, surface water-groundwater interaction occurs primarily through operational canal loss, seasonal irrigation return flows, and managed recharge associated with groundwater banking.

3.5.3 Soils

The depositional history of the Kern River has influenced the shallow subsurface sediments and soil profile beneath the District. Historically, the terminus of the Kern River has been at large inland lakes. The ancestral river flowed from east to west across the valley before turning north toward the large Tulare Lake Bed some 40 miles away. During flood stage in the main east-west channel, flows spilled to the south across KDWD and terminated into two smaller inland lakes, Kern and Buena Vista lakes, portions of which lie within the KDWD southern boundary. These two now-dry lakebeds historically received thick deposits of fine-grained sediments as flood flows diminished and dropped their bed load[4].

These depositional patterns have resulted in the thick sequences of coarse-grain sediments (sand) in northern and central KDWD and fine-grained deposits (silt and clay) in the paleo-lakebeds as indicated by the soil texture map shown on Figure 6. Here soil textures are color-coded and listed in the legend by decreasing grain size (texture). Loamy sands to fine sandy loams, shown by yellow and light orange, are the dominant soil textures in the north central portions of the District with an additional patch of loamy sand in the eastern-most area near Lamont (Figure 6). Loams to clay, shown in dark orange, green, brown, and dark red, are the primary soil textures along the southern boundary of KDWD. An additional north-south band of fine-grain textures also occurs in east-central KDWD (Figure 6).

The correlation of these textures to soil permeability is shown on Figure 7 by the mapping of saturated hydraulic conductivity (K) values (a parameter controlled by permeability). Areas of silt and clay contain

[4] *Since the regulation of river flows with the construction of Isabella Dam in the early 1950s, the lakebeds no longer receive regular surface water inflow and have been converted to agriculture.*

lower K values (red and orange) and sandy soils correlate to higher K values (yellow and blue) of 6 feet per day (ft/day) to more than 30 ft/day. This map allows for more discrete differentiation of permeability zones and provides an indication of areas of higher drainage (recharge). District recharge basins are also shown on the map and allow a comparison to infiltration rates and relative K values. As shown on Figure 7, most of the recharge basins occur in higher permeability zones with the exception of one small basin (Pit) in the southwest, which occurs in an area of lower permeability soils. This basin has a lower infiltration rate than other basins, likely as a result of lower permeability conditions in the shallow subsurface. Although these permeability values pertain to shallow soils (about 10 to 30 feet deep), the depositional pattern is also mirrored in the sub-soil sediments, suggesting that the K zones are good indicators of relative recharge areas across the District.

3.5.4 Land Use

The primary land use beneath KDWD is irrigated agriculture. Over the last few decades, urban areas have increased as the City of Bakersfield has expanded to the south into northern KDWD. In 1975, urban areas only covered about one percent of the District lands (about 949 acres). But by 2010, urbanization covered more than 13 percent of the area (16,880 acres) (AECOM, 2010). The 2012 aerial photograph on Figure 8 shows the areas of current urban and agricultural land use as well as the Bakersfield city limits and sphere of influence.

The increase in urbanized lands is not expected to result in a decrease in water demands on KDWD supplies. Through an agreement with the City of Bakersfield, KDWD may provide municipal and industrial (M&I) supply when lands formerly supplied by KDWD become urbanized. An analysis in the District's Kern River WAP indicated that KDWD may be required to supply an additional 6,281 AFY for M&I demand (see Table 7, Priority 3) (Todd Engineers, September 2011).

The total number of acres irrigated within KDWD has been estimated at about 99,000 acres. However, with double cropping and multiple crops grown throughout the year on the same parcel, the number of permitted agriculture acres is likely higher than historically reported. For example, KDWD estimated that irrigated lands represented the equivalent of about 130,000 acres for their 2011 crop survey. In addition, even with an increase in urbanized areas, the amount of irrigation water demand has increased over time. A variety of factors may have contributed to this condition including changes in cropping patterns and fewer acres fallowed.

Figure 9 shows the pattern of agriculture and primary crops grown in 2011 in KDWD. As indicated by the 2011 data, five crops – alfalfa, wheat/oats, corn, and cotton – cover more than about 70 percent of the irrigated areas. Alfalfa, wheat/oats, and corn are grown throughout the District. Cotton and tomatoes are the primary crops in the south, in particular on the Kern Dry Lake bed. Grapes (represented by *vines* on the map) are grown primarily in the east (Figure 9).

4 State of the Groundwater Basin

KDWD and the Management Area for this GWMP are located in the Kern County Subbasin, a portion of the larger San Joaquin Valley Groundwater Basin as designated by the California Department of Water Resources (DWR) (Figure 2) (DWR, 2006). The Kern County Subbasin (DWR Basin No. 5-22.14) is defined by the Kern County line on the north, the granitic bedrock of the Sierra Nevada and Tehachapi Mountains on the east and southeast, and the marine sediments of the Coast Ranges and San Emigdio Mountains on the west and southwest. The subbasin covers more than 3,000 square miles of the southern end of the valley. The Management Area (KDWD boundary) is shown on Figure 2 and covers about 200 square miles of the south central portion of the subbasin, approximately 7 percent of the total subbasin area.

Current groundwater conditions in the Management Area have been reviewed to identify any new issues of concern and provide a basis for updating the Basin Management Objectives (BMOs). The review includes a description of local aquifers, evaluation of groundwater occurrence and flow, documentation of groundwater quality, and a re-assessment of groundwater use. Groundwater issues of concern are summarized at the end of Section 4.

4.1 Aquifers and Hydrostratigraphy

The aquifers beneath the Management Area are comprised primarily of Tertiary- and Quaternary-age continental sediments extending to depths below 1,000 feet in the subsurface. The base of fresh water has been mapped to depths of more than 3,000 feet locally (Page, 1973). The deeper deposits are composed of older coalescing alluvial fans from the Coast Ranges in the west and the Sierra Nevada in the east and have been designated the Tulare Formation and Kern River Formation, respectively. The overlying younger sediments consist of alluvial fan, fluvial, and flood basin deposits.

A geologic map provided on Figure 10 shows the surficial geologic units in the region and the KDWD boundaries. As shown on the map, the north and central portions of KDWD are underlain by Tertiary to Quaternary-age valley fill deposits, composed locally of sands and gravels deposited on the Kern River alluvial fan. Flood basin and lacustrine deposits of the Kern and Buena Vista dry lake beds rim the southern boundary and correspond to the fine-grain textures noted previously (Figure 6).

The depths and thickness of the various units have not been differentiated previously beneath KDWD and have been considered one continuous aquifer system by other investigators (Boyle, 2001). Nonetheless, the changes in depositional patterns with depth are reflected in the subsurface geology, and several zones can be generally delineated with the incorporation of geophysical logs recorded in various District wells.

In general, log data indicate more permeable layers of sand and gravel inter-bedded with less permeable layers of silt and clay extending to depths of about 700 to 1,000 feet (the bottom of most water wells in the District[5]). An analysis of the upper 1,000 feet of the alluvial aquifers was conducted using about 50 geophysical logs recorded in wells within KDWD and immediately adjacent to District boundaries. Although textures and thickness of the aquifer units vary over the area, the geologic section can be delineated generally into three hydrostratigraphic packages, consistent with previous interpretations by the DWR beneath the Kern Water Bank northwest of KDWD. These packages are referred to herein as the Upper, Middle, and Lower zones of the alluvial aquifer.

Figure 11 shows five geophysical logs across the District arranged on cross section A-A' to illustrate the aquifer zone delineation. The middle log is from one of the District's recovery wells near the Kern Island recharge basin. The northwest-southeast location of the cross section across the District is shown on the inset map on Figure 11.

In general, the Upper Zone refers to the alluvial deposits from the ground surface to a depth between 200 and 300 feet. The Middle Zone extends from the base of the Upper Zone to between about 600 and 800 feet, and the Lower Zone is defined by the alluvial deposits below the Middle Zone. The 2010 water table is also presented on Figure 11 to illustrate the location of the water table in the Upper Zone. As shown on the figure, the Upper Zone is mostly unsaturated in the northwest and central areas. Saturation in the Upper Zone increases to the southeast.

The resistivity readings presented on the right side of each log were used to interpret general aquifer characteristics and textures, with higher resistivity readings indicating relatively higher-permeability units of sand and gravel[6]. Note that the resistivity scale shown at the bottom of each log is consistent for the three logs in the west (0 to 100 ohm meters), but changes for the two southeastern logs (e.g., 0 to 80 ohm meters and 0 to 50 ohm meters). These two wells contain relatively fine-grained, lower permeability sediments as indicated by the lower resistivity measurements. None of the geologic units in these two wells have resistivity readings above 50 ohm meters (typical of sands in this area). By comparison, numerous units have resistivity measurements above 50 ohm meters in the other wells (Figure 11).

Using the resistivity logs on Cross Section A-A', characteristics of the three zones of the alluvial aquifer can be estimated. The Upper Zone contains thick sands and gravels in the western and central portions of the District as indicated by the higher resistivity zones on the three western-most logs. Upper Zone resistivity readings were much lower in the southeast, indicating silts and clays. This is the area that corresponds to lower permeability soils discussed previously (Figure 7). As indicated by the label on the cross section, perched water has been identified close to the surface in nearby shallow wells.

The Middle Zone consists of a relatively thick section of inter-beds with more permeable intervals occurring in the central District wells. Although only a few wells have penetrated more than 100 to 150

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[5] According to well records, less than three percent of the water supply wells in KDWD are drilled below 900 feet. In general, wells have been drilled deeper over time with almost one-half of the deeper wells drilled after 1990.

[6] Resistivity readings are also influenced by changes in groundwater quality, degree of saturation, and other factors, but a check between driller log descriptions and resistivity logs in some wells indicate that the correlation of higher resistivity to zones of higher permeability is adequate for the purposes of this characterization.

feet of the Lower Zone, the unit appears to be composed of mostly sand in the west with lower permeability sediments in the southeast. These descriptions provide a general framework for groundwater conditions beneath the District, recognizing that alluvial deposits are heterogeneous and local conditions vary.

4.2 Groundwater Occurrence and Flow

Groundwater has been characterized as unconfined to semi-confined beneath KDWD. The Upper Aquifer contains a water table that fluctuates seasonally with local recharge and temporally in response to drought and wet hydrologic conditions. Groundwater pumping is likely the largest controlling factor on water levels with depth, although exact pumping depths are generally unavailable.

In general, groundwater flows from north to south across the District, influenced by recharge along the Kern River and subsurface inflow into the District from the north. Pumping centers also influence the direction of groundwater flow. Data and analyses used to further examine groundwater occurrence and flow in the Management Area are described below.

4.2.1 Water Levels

Water level data have been compiled from DWR, KCWA, and KDWD in support of this study. Hydrographs have been generated from more than 300 wells to view trends and fluctuations in water levels over time. Figure 12 presents 12 representative hydrographs prepared for wells with sufficiently long records to include the drought conditions of the early 1990s. This is a time when many areas experienced record declines in water levels. Horizontal and vertical scales are consistent on the graphs (except Hydrograph 8) to facilitate viewing.

Although there is some variability among the hydrographs on Figure 12, many water level records are consistent with the general observations listed below (e.g., Hydrographs 1, 2, 6, and lower graphs on 10 and 12):

- relatively low water levels in the early 1990s,
- rising water levels in the late 1990s (especially 1998),
- declining water levels through about 2004
- rising water levels from 2005 and 2006
- rising water levels in 2005/2006
- declining water levels 2007 through 2010 with minor recovery in late 2010 and 2011.

In general, these observations are consistent with years of above-average rainfall and higher flows on the Kern River including 1998, 2005/2006 and 2010/2011 (Figure 5). Most wells have fluctuated only about 40 to 80 feet over the entire time period. However, some wells indicate significant declines with minimal recovery (e.g., Hydrograph 7 on Figure 12). Notwithstanding the variation in patterns, most water levels are close to the early 1990s levels.

Several hydrographs show relatively consistent water levels over time with no significant trend and only minimal fluctuations (e.g., Hydrograph 8, 9, and shallow graphs in red on Hydrographs 10 and 12). These wells coincide with areas of low-permeability soils and subsurface sediments described previously

(Sections 3.5.3 and 4.1). These deposits are also characterized by low percolation rates. Water recharged at the surface (including infiltration of precipitation and agricultural return flows) drains slowly and builds up in the shallow subsurface. Shallow wells in these areas have documented consistently high water levels for decades. Nearby wells indicate large vertical gradients between these perched zones and the underlying water levels as measured in and near pumping wells (see water level differences between the red and blue graphs on Hydrographs 10 and 12).

The zone where perched water accumulates has been delineated by KCWA as shown on Figure 13. These zones are areas of high recharge and slow drainage that appear to be in equilibrium in the shallow subsurface. In the southern portion of KDWD, the perched zone overlies the low permeability clays associated with the paleo dry lakes. Perched water here likely represents return flows from irrigation. The north-trending arm of the perched layer corresponds with low permeability soils and basin deposits shown previously on Figures 7 and 10. Perched water here likely originates from both return flows and losses along the Central Branch canal. As noted previously, Kern Island has a larger supply of surface water than other service areas and is associated with the largest amount of recharge from canal loss.

4.2.2 Groundwater Flow

Groundwater elevation contour maps prepared by DWR and KCWA have been used to examine groundwater flow patterns in the Management Area. KCWA prepares annual contour maps from water levels measured prior to the summer irrigation season when numerous cones of depression complicate local groundwater flow. Two annual spring contour maps, 2010 and 1998, have been selected for illustration of groundwater flow patterns in the Management Area during relatively low (2010) and high (1998) water levels.

The water level contour map shown on Figure 14 presents water levels from Spring 2010 in feet msl. During this period, water levels were generally below 200 feet msl across most of the District and below 150 feet msl in the southwest and east. An isolated area above 200 feet msl occurs along Highway 99, south of the Kern Island recharge basin. Here, lower permeability soils hold recharge from canals and return flows, creating areas of higher water levels in a perched system and at the water table.

As shown by the contours and generalized flow arrows on Figure 14, groundwater flows from the Kern River to the south and southeast into KDWD. Beneath the District, groundwater generally flows southwest and southeast, influenced by local groundwater pumping. There is also a component of groundwater inflow into southern KDWD as indicated by the north-northeast flow arrow in the south-central portion of the District. In this area, low permeability soils are recharged by agricultural return flows; this recharge creates a hydraulic gradient to the north.

These groundwater flow patterns are altered somewhat when water levels are higher. Figure 15 presents a groundwater elevation contour map during Spring 1998 when water levels were typically about 50 feet higher than in 2010. During this time period, water levels are above 200 feet msl beneath most of the District. Recharge along the Kern River creates subsurface inflow from the north and northwest, a pattern similar to Spring 2010 conditions. But with higher water levels beneath central KDWD, hydraulic gradients create more complicated patterns of flow in western KDWD. Subsurface outflow appears to occur in the southwest, although most of the flow is likely captured by pumping wells either within or just south of the boundary (Figure 15). Subsurface outflow occurs to the east, similar to the flow pattern indicated on Figure 14.

4.3 Groundwater Quality

Groundwater quality beneath KDWD has been designated for both agricultural and municipal beneficial uses (among others). Groundwater constituents/parameters that may limit irrigation use include salinity (represented as chloride, electrical conductivity, or total dissolved solids - TDS), sodicity (represented as sodium or sodium adsorption ratio), boron, and others. Previous evaluations have described groundwater as suitable for irrigation with no significant constituents of concern. Municipal beneficial use is governed by drinking water quality standards.

Groundwater quality data collected from 1986 through 2006 were provided by KDWD in support of this study. The most comprehensive data set was collected in the early 1990s and contained inorganic analyses for general minerals from 20 wells across the District. Although these data are relatively old, they are capable of monitoring potential impacts from agriculture, which has been the predominant land use overlying the basin since the late 1800s. The 1990s data represent any potential cumulative impacts from decades of similar cropping patterns and practices. To supplement the older data, KDWD sampled four of the District's wells in July 2013. To evaluate groundwater quality, three selected constituents from the early 1990s and 2013 data – TDS, nitrate, and sodium – have been posted on District maps on Figures 16a and 16b, respectively. In addition, a smaller data set from a few wells sampled in 2005 and 2006 are included on Figure 16a for completeness. These two figures illustrate the geographical distribution of general inorganic water quality across the Management Area and provide some information on changes in quality from the 1990s to 2013. Data posted on the two maps (Figures 16a and 16b) are discussed in more detail below.

4.3.1 Total Dissolved Solids (TDS)

As shown by the TDS values on Figures 16a and 16b, groundwater is not highly mineralized in most areas as indicated by relatively low concentrations; most values meet the TDS secondary maximum contaminant level (MCL) of 500 mg/L for drinking water. TDS values range from 144 mg/L (north-central KDWD) to 1,623 mg/L (southwest KDWD in the paleo-lakebed of Buena Vista Dry Lake). The average TDS value posted on Figure 16a is 418 mg/L. In general, values average about 315 mg/L in northwestern KDWD, about 200 mg/L in north-central KDWD, and about 530 mg/L along the western boundary. Wells in southwestern KDWD have highly variable TDS values ranging up to 1,623 mg/L and are likely being influenced by the high salt content of the paleo-dry lake bed sediments. The 2013 data (Figure 16b) indicate TDS values from 160 mg/L to 200 mg/L in the four north-central District wells, values generally consistent with the older data.

The relatively low values of TDS in northern KDWD are likely influenced by the decades of surface water recharge through canal loss and irrigation return flows from relatively low-TDS surface water. Kern River water concentrations averaged approximately 110 mg/L in 1986 (when the most surface water quality data were available). The lowest TDS concentrations in groundwater were recorded in the northern Kern Island Service Area (144 mg/L to 199 mg/L) where most of the canal loss and surface water return flows occur. However, canal loss along the Eastside Canal does not appear to correlate to lower TDS values; concentrations in wells along that canal average about 530 mg/L (Figure 16a).

To further examine the potential changes in TDS values with depth, more recent TDS data from a shallow/deep well pair were reviewed (see data boxes on Figure 16a labeled Shallow and Deep in northwest KDWD). Although the actual construction data are not available for these wells, well information indicates that these monitoring points target shallow aquifers at about 200 to 300 feet deep and deeper aquifers below about 400 feet. Recent data from this well pair suggest that TDS in deeper aquifers (132 mg/L) is lower than in the shallow aquifers (280 mg/L). Additional data would be needed to confirm this relationship or determine if a similar relationship occurs in other areas.

4.3.2 Nitrate

Nitrate concentrations from the 1990s samples did not indicate any wells or areas of concern. The average nitrate concentration shown on Figure 16a is 8 mg/L. All concentrations were below the primary MCL of 45 mg/L. To examine the vertical nature of nitrate concentrations, more recent data from the shallow/deep well pair in northwest KDWD were reviewed (Figure 16a). Although only one sampling event is available, these data indicate that the shallow nitrate concentration (16 mg/L) is higher than nitrate in the deeper zone (0.7 mg/L). Nitrate concentrations measured in 2013 (Figure 16b) were generally consistent with the 1990s data and range from 7.9 mg/L to 13 mg/L. Again, all concentrations are within the drinking water standards.

4.3.3 Sodium and Boron

As shown on Figure 16a, sodium concentrations are elevated above the irrigation water quality standard of 69 mg/L in some areas. The average concentration of data on Figure 16a is 58 mg/L with a median of 47 mg/L. Higher sodium concentrations occur generally in the southeastern and southwestern portions of the District and may be associated with the low permeability silts and clays documented in this area. Sodium concentrations in the northern wells in 2013 (Figure 16b) are relatively low at 25 to 29 mg/L and are consistent with the older data in this area.

Although not posted on Figures 16a and 16b, boron concentrations were also reviewed for irrigation suitability. All boron concentrations were below 0.6 mg/L, an acceptable range for crops grown in KDWD. A typical irrigation standard for most crops is 7 mg/L.

Additional inorganic groundwater constituents were evaluated with time by comparing data from the 1990s, 2001 through 2006, and the 2013 samples with a focus on the northern wells where most of the data were available. In general, no significant water quality changes were identified.

Observations from data posted on Figures 16a and 16b and discussed in this section are constrained by the limited number of sampling events and the absence of data within the central and southern portions of KDWD. Most wells in the program contained only one or two samples from 1990 to 2013. Further, very few wells have been sampled since the 1990s; all of the 2006 and 2013 data were concentrated in a small area involving only a few wells. Local groundwater quality conditions likely vary and current conditions may be different than in the 1990s. Nonetheless, there are no areas or constituents of concern indicated by the available groundwater data.

4.4 Groundwater Use

Groundwater has been used in KDWD for more than 100 years to supplement surface water supplies. According to drillers' logs, more than 1,700 wells have been drilled within District boundaries (KCWA, 2011b). About 1,000 of these wells were drilled between the 1950s and the late 1970s prior to the availability of imported water supplies. Over the last 30 years, about 500 additional wells have been drilled. The number of active, inactive, or abandoned wells in the District is unknown.

Most wells in KDWD have been drilled to a total depth of about 400 to 600 feet and were screened primarily in the Upper and Middle aquifer zones. Since the 1990s, an increasing number of wells have been drilled to depths of about 800 to 1,000 feet with screens typically in the Middle and Lower aquifers. Even though the recent trend is toward deeper wells, only about seven percent of all wells extend below 800 feet.

Although most of the wells were drilled for agricultural irrigation, numerous wells in the northern portion of the District provide municipal supply, including wells operated by the City of Bakersfield, Cal Water, and Greenfield County Water District. Information on municipal demand within the District boundary is further documented in Section 4.4.2. Given the depth to groundwater, pumping beneath the District does not appear to significantly change surface water flows.

Previous analyses of agricultural water demand have been updated for this GWMP to provide a more detailed assessment of groundwater use. For this analysis, groundwater use is estimated by subtracting surface water deliveries (including local water and imported water) from total irrigation demand in KDWD over the last 14 years (1998 – 2011), a time period representing average hydrologic conditions. This analysis and results are described in more detail below.

4.4.1 Agricultural Irrigation

Total irrigation demand for the KDWD service areas has been developed from the crop permit database compiled by the Kern County Agricultural Commissioner's Office. This database contains the crop type and associated parcels in a spatial Geographical Informational System (GIS) format (for example, see the 2011 crop data presented on Figure 9). Although KDWD crop surveys were also reviewed for the analysis, the County database allowed for a more detailed and spatial compilation of crops over time including double cropping. In addition, more detailed crop categories are contained in the County data than in many of the District surveys.

One potential inaccuracy in the County data involves the assignment of multiple crops to an entire parcel when the crop may actually be planted on only a portion of the parcel (referred to as multiple plantings by the County). Although this process may over-estimate irrigated acreage in some areas, it was noted to occur most often on smaller parcels. Total estimated irrigated acreage is also slightly over-estimated in the analysis because it includes the entire service areas of the District, including acreage north of KDWD boundaries. However, groundwater use in this area is immediately adjacent to the District and is considered relevant to the total demand on groundwater in the vicinity.

4.4.1.1 Primary Crops in KDWD

Over the last 14 years, the total number of annual irrigated acres in the KDWD service areas has averaged about 118,000 acres. That amount has increased about 14 percent over the last six years from about 112,000 acres to more than 127,000 acres.

County maps indicate that approximately 42 different crops[7] were grown on this acreage. Of these, 12 crops (or groups of crops) represent 80 percent or more of the total irrigated acreage. These crops are listed on Table 9. As shown on the table, each of the 12 crop groups covers more than 1,000 acres in most years of the study period. In addition, the first four crops (alfalfa, cotton, wheat/oats, and corn) have been planted on at least 10,000 acres annually and represent an average of 72 percent of the total irrigated area. The 2011 distribution of these and other crops are also shown on Figure 9.

Table 9
Primary Crops Grown in Kern Delta Water District

CROP, ACRES	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Alfalfa	26,559	26,774	19,960	27,679	30,545	27,026	28,183	29,850	29,869	30,076	32,259	32,186	28,338	27,263
Cotton	23,160	28,403	33,383	30,468	21,607	23,818	26,006	24,954	18,837	17,631	11,746	11,968	11,640	15,253
Wheat / Oats	NA	19,838	14,312	16,197	20,142	22,246	18,475	16,511	19,516	20,308	26,320	25,652	26,589	25,554
Corn	16,187	12,643	10,968	14,087	18,082	16,521	15,494	16,690	16,095	14,063	15,227	17,114	16,745	20,035
Misc. Field	9,545	488	685	1,017	240	1,865	2,237	4,287	5,412	9,676	14,908	7,541	7,209	10,092
Carrots	1,895	6,553	5,515	5,169	5,185	4,568	3,608	4,479	4,659	5,231	4,665	3,905	3,866	3,455
Grapevines	5,761	5,626	4,673	5,651	5,245	4,868	4,622	4,595	4,569	5,059	5,052	5,074	5,069	5,408
Vegetables	339	676	738	395	628	649	756	1,654	1,269	1,455	1,226	1,780	2,366	3,697
Tomato	37	298	1,053	968	1,402	1,330	1,588	1,548	1,625	2,633	3,044	3,790	4,218	2,206
Potato	1,673	2,914	2,707	2,277	2,559	2,186	1,756	1,412	1,944	1,968	1,547	1,706	1,632	1,965
Onion (dry)	2,269	3,883	3,376	1,927	1,956	2,347	1,705	963	1,081	972	1,050	1,901	2,150	2,611
Almonds	743	703	3,315	782	793	771	834	1,028	1,323	1,645	1,948	2,041	2,225	3,782
TOTAL ACRES	**88,170**	**108,798**	**100,686**	**106,617**	**108,384**	**108,194**	**105,264**	**107,971**	**106,198**	**110,715**	**118,992**	**114,659**	**112,046**	**121,321**
% DISTRICT TOTAL	**81%**	**94%**	**90%**	**96%**	**95%**	**97%**	**97%**	**97%**	**86%**	**85%**	**88%**	**95%**	**97%**	**88%**

An examination of Table 9 indicates changes in cropping patterns over time. Acres for selected crops are plotted with time on Figure 17 to illustrate major crop trends. As shown on the figure, cotton and alfalfa represent the largest plantings in the District from 1998 through 2005 (more than 20,000 acres each). However, in 2006, cotton experienced a sharp decline in response to a drop in price and has not recovered to pre-2005 levels. During the decline in cotton acreage, increases in acreage occurred for alfalfa, wheat/oats, and miscellaneous field crops. Smaller increases were also noted for corn, almonds, tomatoes, and other vegetables. Many of these increases were associated with an overall increase in irrigation demand.

4.4.1.2 Total Irrigation Demand

Total irrigation demand for 1998 through 2011 has been estimated using daily crop coefficients from DWR and local climate data. The evapotranspiration (ET) demand of the crop was calculated by multiplying the reference monthly evapotranspiration rate (from the local Shafter CIMIS station) by the crop coefficient for each crop type (or group of crops). Daily crop coefficients and growing seasons for

[7] *The number of crops reflects some grouping of related crops with similar water demands.*

over 40 crops were derived from the DWR irrigation estimation tool *CPU M+*. Daily precipitation was compared to crop ET and applied to meet a portion of crop demand.

An irrigation efficiency of 80 percent was assumed for the analysis (20 percent return flows). This estimate was based on reported irrigation methods and associated efficiencies in numerous District crop reports (most recently in 2000). Reported efficiency values ranged from 76 percent to 92 percent across the District with the lower values covering most of the District and higher efficiencies in areas of low permeability soils in the south.

This analysis produced an estimated applied water rate required for each crop grown in the District. The applied water rate was multiplied by the crop acreage to produce an overall irrigation demand for each year. Applying this methodology to hydrologic data from 1998 through 2011 provided the irrigation demand values shown on Figure 18. As shown on the chart, irrigation demand has ranged from about 348,000 AFY (2003) to 436,000 AFY (2008). In general, demand has risen over the last five years (since 2006), with the four highest annual irrigation demand estimates occurring in 2007, 2008, 2009, and 2011.

4.4.1.3 Irrigation by Surface Water and Groundwater

The portion of the total irrigation demand that is met by surface water deliveries[8] is shown on Figure 18. The remaining demand is assumed to be met with groundwater. For the 14-year period shown on Figure 18, surface water averages about 141,000 AFY and groundwater pumping averages about 245,000 AFY. In general, the use of surface water has increased somewhat over time as the District has become more efficient in diverting and storing surface water when available. For example, the four largest annual surface water deliveries have occurred within the last seven years.

As shown on Figure 18, the portion of irrigation supplied by groundwater varies significantly from year to year based on the amount of surface water available. In years of relatively low surface water availability (e.g., low flows in the Kern River in 2007), pumping accounts for almost 75 percent of the irrigation demand. In relatively wet years (e.g., 2005 and 2006), surface water can supply up to about one-half of the demand, reducing the need for additional groundwater pumping. On an average basis, groundwater provides about two-thirds of the total irrigation water supply.

Most of the groundwater pumping occurs in areas where surface water rights are limited or unavailable. Figure 19 divides groundwater pumping the estimates in Figure 18 into the corresponding service areas. As shown, almost one-half of the KDWD groundwater pumping occurs in the Non-utility areas where the only surface water available is a portion of the limited supply of SWP allocated to the District on an annual basis. Groundwater pumping represents about 20 percent of the irrigation supply in the Stine Service Area. Although Stine has a Kern River water right, the amount is typically not sufficient to accommodate demands within the 20,000-acre service area (the second largest in KDWD). The Eastside Service Area is associated with the lowest amount of groundwater pumping due to its small size (Figure 4).

[8] *Surface water deliveries are less than actual diversions due to seepage and other losses.*

4.4.2 Municipal Water Supply

Urban areas that serve municipal and industrial (M&I) water supply have expanded into KDWD over time (mostly from the north) and currently cover about 16,880 acres within KDWD boundaries, or 13 percent of the area. Urban areas within or adjacent to KDWD include a portion of the City of Bakersfield, the City of Greenfield, the communities of Lamont and Weedpatch, and other unincorporated areas and communities such as the small community of Pumpkin Center. Service areas of the City overlap District areas while the KDWD boundary circumnavigates around some of the smaller communities (e.g., Greenfield and Lamont, see Figure 3). Some private domestic wells also pump within District boundaries but net consumption of this water is judged small compared to agricultural and municipal consumption; it has not been estimated for this GWMP update.

Groundwater provides most of the municipal supply, which is replenished locally from natural recharge, canal seepage, spreading basins, and recycled water. In addition, KDWD recharges water on behalf of small community water systems including Greenfield County Water District (CWD) to maintain groundwater levels and support municipal pumping. In this capacity, KDWD has served as an M&I wholesaler for groundwater replenishment (Todd Engineers, September 2011). Recent pumping and future estimates for the main municipal suppliers are summarized in the following sections.

4.4.2.1 City of Bakersfield

The City of Bakersfield is served by two municipal suppliers: Cal Water and the City of Bakersfield Water System (Figure 3). Water supply is a combination of groundwater, river water, and SWP water (from KCWA, ID-4). The use of treated imported SWP water has increased in recent years with the expansion of local water treatment plants.

Cal Water is the largest municipal water supplier in Bakersfield. Groundwater has historically supplied up to 80 percent of Cal Water's demands supplemented by surface and imported water. Its groundwater system includes about 115 active wells with a design capacity of 142,000 AFY. Total 2010 pumping was 44,000 AFY (Cal Water, 2011). Cal Water has four active wells within KDWD. Annual production from these wells has ranged from 23 AFY to 2,619 AFY and averaged 1,563 AFY from 1998 to 2011. Data are summarized on Table 10. Cal Water production within KDWD has decreased significantly since 2007 when two high production in-District wells were no longer being pumped. Future system-wide pumping is predicted to decrease below 35,000 AFY when additional proposed surface water projects are completed (Cal Water, 2011).

Table 10
Annual Municipal Pumping within District Boundaries (AFY)

YEAR	Cal Water	Bakersfield	Greenfield CWD	Lamont	TOTAL
1998	1,975	5,572	1,120	4,922	13,589
1999	2,139	6,228	1,114	5,966	15,447
2000	2,347	5,368	1,329	5,269	14,313
2001	2,365	6,093	1,360	5,278	15,096
2002	2,619	6,176	1,507	5,524	15,826
2003	2,479	5,088	1,653	5,763	14,983
2004	2,298	4,836	2,026	4,640	13,799
2005	2,415	4,345	2,169	5,226	14,155
2006	1,518	4,717	2,486	3,683	12,404
2007	34	5,144	2,574	4,450	12,202
2008	41	5,216	2,554	4,220	12,031
2009	23	6,100	2,445	3,235	11,802
2010	62	5,904	2,282	3,649	11,897
2011	not available	6,936	2,258	3,879	13,073
14-Year AVG	1,563	5,552	1,920	4,693	13,616
2020	system-wide pumping predicted to decrease	system-wide pumping predicted to decrease	2,651	4,555	NA

Greenfield 1998-2001 data from KCWA annual reports. 2003-2011 data from Greenfield.
2002 pumping estimated as halfway between 2001 and 2003.
COB and Cal Water pumping derived from monthly pumping records
Lamont 1998-2001 data from KCWA annual reports. 2002-2011 data from AECOM (2013).
2020 based on 1.8% annual increase from Kern COG (2010)

Bakersfield's City Water System service area covers about 35 percent of the western portion of the Bakersfield (about 38 square miles) and provides surface water and groundwater to a population of 118,600. Cal Water operates the City's water distribution system including 50 active groundwater wells within City boundaries, 12 of which are in KDWD. Between 1998 and 2011, system-wide pumping ranged between 24,361 AF (1998) and 45,517 AF (2008). Pumping in 2011 was 35,520 AF. Pumping from wells within District boundaries for the 1998 to 2011 period is summarized in Table 10. As shown in the table, City pumping has ranged from 4,345 AFY to 6,936 AFY and averaged 5,552 AFY.

Some of this pumped water is treated and reused for irrigation. Wastewater treatment occurs at the City's WWTP #2 in northern KDWD (Figure 3). A portion of the effluent is used for irrigation of non-human consumption crops within KDWD boundaries and irrigation return flows provide recharge to the groundwater system. Wastewater is stored in reservoirs on City-owned land just south of the WWTP. Biosolids from the City's WWTP #2 and #3 are also spread on this land. Between 2000 and 2010, effluent flow ranged from 15,300 AFY to 18,200 AFY.

4.4.2.2 <u>Greenfield County Water District</u>

Greenfield CWD supplies groundwater to a population of about 8,500 in Greenfield from five wells. Greenfield CWD's average annual pumping from 1998 to 2011 was 1,920 AFY. Annual pumping totals are shown on Table 10. Pumping increased from 1,114 AFY in 1998 to 2,574 AFY in 2007. Since 2007 it has remained within the 2,260 to 2,560 AFY range.

4.4.2.3 Lamont Public Utilities District

The Lamont Public Utilities District (PUD) is located on the eastern edge of KDWD and supplies water to the communities of Lamont, Weedpatch and other surrounding areas. It currently serves a population of about 13,900 through 4,200 service connections (AECOM, January 2013). It has three service areas and nine wells but four of the wells are inactive due to water quality problems (arsenic, perchlorate, and nitrate) and aging infrastructure (CDPH, June and October 2012). Lamont PUD is seeking affordable financing to either construct new wells or water treatment plants (Kennedy/Jenks, 2011). Between 1998 and 2011, pumping has ranged from 3,649 AFY (2010) to 5,966 AFY (1999) (Table 10).

Lamont PUD also has a wastewater treatment plant south of Lamont that has two aeration ponds, two lined facultative ponds, two lined storage ponds, and six older unlined storage ponds. Current flows average 1.4 mgd (1,570 AFY) (CRWQCB, June 2012). The plant has disposal capacity problems and effluent discharge quality violations. Currently, all effluent goes to Community Recycling and Resource Recovery, Inc. for composting manufacturing (on 190 acres of Lamont PUD land adjacent to and south of the WWTP) and to irrigate 130 acres of nearby non-human consumptive crops.

4.4.2.4 Future KDWD Municipal Groundwater Use

In an agreement with the City, KDWD may serve water to those urban lands that have received KDWD water deliveries in the past (prior to urbanization) including the 4,775 acres currently served by the City. This responsibility would be linked to the average amount of water that KDWD has delivered historically to a certain area (Todd Engineers, September 2011).

Based on this agreement, urbanized lands historically served by the District but currently served by the City represent a potential un-met demand for KDWD. The urbanized lands within the Greenfield CWD and Lamont PUD also represent an increasing demand for either KDWD wholesale water delivery or the KDWD sale of water for groundwater recharge (Todd Engineers, September 2011).

4.5 Groundwater Issues of Concern

The evaluation of current groundwater conditions highlights several groundwater issues to address in the GWMP Update, as discussed in more detail below.

4.5.1 Water Levels and Groundwater Storage

Although water levels have varied over time in response to wet and dry hydrologic conditions, current water levels appear to be at or near water levels in the early 1990s drought. This occurs at a time when approximately 160,000 AF is in groundwater storage associated with out-of-district banking (Table 8). Without this stored water, water levels would be even lower.

Current water levels do not appear to be sufficiently low to create district-wide issues with groundwater pumping and wells. Well screens and likely associated pump settings appear to be sufficiently deep to continue normal operation. However, if water levels continue to decline, well operation could be impacted. Further, the decline in water levels increases lift costs for pumpers.

4.5.2 Change in Groundwater Storage and Potential Overdraft Conditions

The evaluation of current groundwater conditions provide estimates for the primary components of inflows and outflows to the groundwater system as summarized on Table 11.

Table 11
Groundwater Budget Components

INFLOW	AFY
Irrigation Return Flows (Surface Water)	28,200
Irrigation Return Flows (Groundwater)	49,000
Irrigation Return Flows (Municipal Effluent)	3,600
SWP for Irrigation	12,750
Canal Loss	55,880
Banking Recharge (less loss)	101,327
Banking In lieu (reduces pumping below)	88,489
Banking Loss (credited to KDWD)	23,460
Urban Return Flows	1,000
Subtotal Inflows	**363,707**
OUTFLOW	
Irrigation Pumping	245,000
Municipal Pumping	13,616
Banking recovery	29,722
Subtotal Outflows	288,338
ESTIMATED CHANGE IN STORAGE	75,369

Note: Subsurface inflows and outflows are not included in the analysis.

This list is generally based on average conditions from 1998 through 2011, but also combines some estimates for future operation, such as the estimate of 12,750 AFY of SWP (estimated to be available at one-half of the District's full allotment of 25,500 AFY, on an average basis over time). Further, the groundwater budget analysis is incomplete. Two key components, subsurface inflow and outflow, are not included on Table 11. These amounts are complex and variable over space and time; accurate estimates cannot be made without a quantitative tool such as a groundwater model. Currently the District's groundwater model is not sufficient for this analysis.

In consideration of these limitations, the groundwater budget cannot be used to generate an accurate estimate of changes in groundwater storage or to determine if the entire Management Area should be characterized as in overdraft. Nonetheless, it highlights the importance of two key management activities – maximizing the District's use of Kern River water as described in the WAP and continuation of the banking program. As reflected in the groundwater budget components in Table 11, use of Kern River water produces significant irrigation return flow and recharge through canal loss. In addition, its use for irrigation directly offsets groundwater pumping. The groundwater banking program has generated the most significant components of inflow through direct recharge, in lieu pumping, and groundwater storage credit to KDWD. Without the banking program, the net change in groundwater storage in Table 11 would be negative.

To more accurately develop an ongoing groundwater budget for the Management Area, the District intends to update and/or modify existing numerical groundwater models to allow tracking of subsurface inflows and outflows, as well as provide more detailed assessments of groundwater storage over time. The District is currently participating in the development of a regional numerical model for the Kern Fan Monitoring Committee. A modified portion of that model may be employed for future groundwater assessments in the Management Area.

4.5.3 Protection of Primary Recharge Zones

The protection of groundwater recharge across the District is an important component for the continued use and sustainability of the groundwater resource. Recent legislation (AB 359) recognizes the importance of identifying primary groundwater recharge areas and requires that a GWMP include a map of the primary recharge zones in the Management Area.

For KDWD, the primary source of recharge includes banking in recharge basins, seepage through unlined canals, and return flows from surface water irrigation. Return flows from groundwater irrigation also represent a large recharge volume but do not result in a net increase in groundwater storage because more groundwater is removed through crop ET. As such, recharge from groundwater return flows is judged less important than for surface water return flows. In addition to the application areas of these recharge sources, the permeability of soils and subsurface sediments also influence recharge. Lower permeability zones restrict the rate and volume of recharge from return flows and canal loss. Although return flows provide some recharge in urban areas, the amounts are small compared to the irrigation return flows.

Using these observations, a map illustrating the primary areas of recharge in the GWMP Management Area is provided as Figure 20. As seen on the figure, the primary areas of recharge are highlighted in blue and represent the recharge basins and canals associated with significant amounts of groundwater recharge. More than 100,000 AF has been recharged in the recharge basins over time and average annual operational canal losses are estimated at more than 55,000 AFY. Even in areas where canals overlie lower permeability soils (light yellow), some losses (and associated recharge) occur. The light orange areas of the map identify where irrigation return flows are being recharged through the more permeable soils. The amount of recharge represented by this exact area is unknown, but an average of at least 30,000 AFY of irrigation return flows from surface water has been estimated on a District-wide basis. The darker orange areas on the map represent permeable soils that are associated with a 2011 land use other than irrigated agriculture (including temporary fallowing). Note that Figure 20 is based on 2011 cropping patterns and land use, both of which change from year to year. Although Figure 20 identifies the primary areas of recharge in the basin, specific locations and amounts of recharge will vary over time.

The light orange areas that are not covered by a Service Area (hatched areas) represent recharge from return flows that originate from groundwater. These areas are underlain by permeable soils conducive to high recharge rates, but in areas where surface water is generally unavailable for irrigation. Although recharge occurs in this area, it is the remainder of a net loss to groundwater. Urban areas (gray) and areas with low permeability soils (light yellow) are associated with less recharge than other defined areas on Figure 20.

These primary recharge areas represent current conditions and are subject to change. Over time, the distribution and amount of surface water deliveries, urban development, and other land use issues may change. Nonetheless, this map is a useful planning tool for developing future groundwater management strategies and zones of wellhead protection.

4.5.4 Groundwater Quality

Although the review of groundwater quality did not indicate specific areas or constituents of concern, data are sparse and may not represent current conditions. The lack of groundwater quality data represents a data gap that can be addressed in the GWMP process over time, focusing initially on key areas of recharge and pumping.

4.5.5 Subsidence

Declining water levels are associated with increased potential of inelastic land subsidence. Subsidence in the Management Area was first documented in 1953 following an assessment related to the 1952 Arvin-Tehachapi earthquake. A more detailed evaluation was conducted by the USGS in 1975 that documented land subsidence due to groundwater withdrawal (Lofgren, 1975). That evaluation indicated subsidence of about 0.5 feet up to about 9 feet just outside of the southern and eastern KDWD boundary from 1957 through 1970; the largest impact within KDWD (about five feet) had occurred along the southern boundary coincident with the paleo-Kern bed. During that time period, water levels had fallen up to 100 feet, especially in northern KDWD as a result of overdraft conditions in the 1960s.

Since that time, groundwater levels have fluctuated with wet and dry cycles, but have not fallen significantly below 1975 levels. A recent water level assessment associated with the KDWD Environmental Impact Report (EIR) for the Kern River WAP compiled data back to the 1950s. Although only a few wells had complete records since that time, data indicate that current water levels are within about 10 feet of 1975 levels over most of the Management Area. One possible exception is in southwestern KDWD where declines in pumping wells were more significant over time.

A key mitigation measure to slow or arrest land subsidence is to allow water levels to recover to pre-subsidence conditions. Maintaining water levels at 1975 levels or higher would mitigate any further risk of subsidence.

To provide ongoing monitoring of potential land subsidence in the District, data from a nearby monitoring station should be incorporated into the KDWD monitoring program. The National Geodetic Survey manages a network of continuously operating reference stations (CORS) that provide satellite data for government, academic, and private use. One CORS, BKR1, is located within about 1,500 feet of the southern KDWD boundary on Old River Road. Data could be accessed and downloaded from this station on a periodic basis to evaluate changes in benchmark elevations over time.

5 Basin Management Objectives

Based on the evaluation of groundwater conditions beneath the Management Area, the following Basin Management Objectives (BMOs) have been identified for this GWMP Update.

5.1 Mitigate Overdraft

Since 1990, water levels beneath the District have recovered and declined in response to wet and dry years without an overall rising or falling trend in most areas. Exceptions to this observation are declining water levels in areas where surface water is limited or unavailable including localized areas in the southwest and southeast KDWD.

This BMO identifies the 2011 water levels as a maintenance level for future groundwater conditions in the basin. By this designation, the BMO is considered quantitative. Actions to implement should water levels fall will depend on the timing and duration of the declines. Localized areas may continue to decline in the short term, but ongoing management strategies are expected to result in overall water level recovery for the basin in the future.

5.2 Preserve Groundwater Quality

Groundwater quality supports current beneficial uses within the District including agriculture, municipal supply and other uses. Degradation of groundwater quality is recognized as a potential threat to both agriculture and drinking water. By incorporating metrics such as drinking water quality standards and irrigation suitability standards, this BMO is considered quantitative. KDWD is committed to preserving the high quality groundwater in the Management Area; a fundamental aspect is monitoring. Improvements to the District's groundwater quality monitoring program are incorporated into this GWMP Update and are documented in Appendix C.

5.3 Manage Groundwater Storage

To ensure a sustainable groundwater supply, KDWD will manage groundwater in storage and storage capacity. Management will seek to maximize the amount of groundwater in storage while maintaining areas in which to recharge excess surface water when available. Groundwater in storage and storage capacity will be evaluated from data collected in the water level monitoring program. The groundwater banking program already contains accounting requirements for managing banked water in storage; this is an example of how the BMO is quantitative. Also embedded in this BMO is the recognition that areas of primary groundwater recharge must be identified and preserved. Section 4 provides quantitative analyses of the primary recharge components.

An additional component of this BMO is the ongoing evaluation of surface water-groundwater interaction. As described in Section 4, operational loss along canals and return flows from irrigation of surface water are the primary seasonal sources of recharge to the groundwater system. In all areas of the District, there is a sufficient vadose zone to receive the recharge. Even in areas of low permeability with relatively shallow water levels, the sediments drain sufficiently to allow for the seasonal infiltration. Monitoring wells around the recharge basins allow for the tracking of managed recharge in those areas.

To develop a more accurate estimate of groundwater storage changes and groundwater/surface water interaction, KDWD is considering an update and/or modification of a numerical groundwater model capable of analyzing and tracking groundwater conditions beneath the Management Area.

5.4 Avoid Further Inelastic Land Subsidence

As previously discussed, subsidence up to about nine feet has occurred near the southern KDWD boundary with lesser amounts occurring to the north within the District boundary. Subsidence of that magnitude occurred in response to water level declines of up to 100 feet beneath KDWD from the 1950s to the 1970s. Since that time, water levels have not fallen significantly below 1970s levels, indicating that any additional subsidence would have been minimal. If water level maintenance is achieved as stated above, further subsidence would be prevented. For this GWMP Update, 2011 water levels are designated as target levels for avoidance of inelastic land subsidence. Further, monitoring of land subsidence will be incorporated into the GWMP monitoring program through the download and review of geodetic data from the nearby CORS monitoring station. Data from the CORS station along with documentation of water level changes make this BMO quantitative.

5.5 Update District Monitoring Programs

The ongoing groundwater level and quality monitoring program will be reviewed and modified as necessary to document groundwater conditions on an annual basis and demonstrate the ability to achieve BMOs. Although the evaluation of groundwater quality did not indicate significant areas or constituents of concern, existing data are sparse and limited to certain areas within the District. Surface water quality monitoring is also key to ensure that recharge along canals and in recharge basins do not adversely impact groundwater quality. To date, surface water data indicate lower salinity and mineralization than local groundwater and has likely improved groundwater quality in areas of primary recharge (Figure 20).

One management strategy for evaluation is a more systematic District-wide groundwater quality monitoring plan to be implemented and updated over time. In addition, the monitoring program will be updated to allow ongoing assessments of groundwater storage and inelastic land subsidence. The KDWD monitoring program and protocols that incorporate plans for improved monitoring are provided in Appendix C.

5.6 Coordinate Groundwater Management Activities with Other Agencies

KDWD has already developed mutually-beneficial management programs with several neighboring water districts and local agencies. In addition, KDWD continues to cooperate with local, state, and federal regulatory agencies. Examples of these cooperative programs are described in this GWMP Update and include the following:

- CASGEM Monitoring Cooperative Group with BVWSD and RRBWSD
- Resolution with AEWSD to cooperatively pursue mutually beneficial groundwater management activities
- Joint project with AEWSD to construct infrastructure to allow water to be conveyed across district boundaries more efficiently
- Groundwater banking agreements with Metropolitan Water District of Southern California and San Bernardino Valley Municipal Water District (Valley)
- Agreements with the City of Bakersfield and Greenfield County Water District (and others) to enhance groundwater recharge for the benefit of municipal pumpers
- Provision of SWP water via KCWA through exchange agreements with BVWSD
- Participation in regional out-of-district banking projects including the Pioneer Project operated by KCWA
- Cooperating with KDWD customers and the Central Valley Water Board to develop steps for compliance with recent regulations on the management of agricultural water, including Best Management Practices (BMPs).

In support of this BMO, KDWD documents these efforts as part of the GWMP Update and intends to pursue additional opportunities for coordinated groundwater management.

6 DWR-Suggested Components and Groundwater Management Strategies

Numerous management strategies have been identified and considered for inclusion in this GWMP update. These strategies have been developed using the DWR checklist of management components from AB3030 as a framework (Water Code Section 10753.7). Application of each DWR component to the KDWD Management Area is discussed below. Strategies for groundwater basin management of each component are summarized in Table 12. When applicable, ongoing KDWD management activities are also included. There is significant overlap for many components and many strategies are applicable for more than one component. To minimize duplication in Table 12, applicable strategies may be listed with only the more relevant components.

6.1 Saline Water Control

For KDWD, this component relates to management of sources that contribute to the overall salinity or TDS of groundwater. A review of groundwater quality has identified local areas of mineralized groundwater in southwest and southeast KDWD. These areas correspond to low-permeability flood-basin sediments and are likely indicative of natural processes rather than human activities. Nonetheless, groundwater quality data are sparse and additional evaluation would be helpful to assess current and future conditions.

Key management strategies involve a more detailed identification of TDS values across the area and the continued use of lower TDS Kern River water for delivery and recharge. Specific action items for consideration are provided in Table 12.

6.2 Identification and Management of Wellhead Protection Areas and Recharge Areas

The municipal water purveyors within and adjacent to KDWD are responsible for delineating and managing wellhead protection areas around the water supply wells. KDWD can assist in this process through identification of municipal wellhead areas within KDWD and survey of activities in those areas. General areas of municipal wells have been identified in this GWMP Update through a discussion of water purveyors in Sections 2.2 and 4.4.2 and on Figure 3.

KDWD is familiar with the Kern County Well Ordinance (Chapter 14) that provides for the design, construction, repair, and reconstruction of agricultural and domestic wells (and other wells) to protect groundwater quality. Through this GWMP, KDWD encourages compliance with both County and State well construction standards for all wells in the District.

In addition, the primary areas of recharge have been discussed and identified on a map to assist the District with groundwater management and provide for compliance under AB 359. This map will be updated as conditions for groundwater recharge change across the District. These and other management strategies are listed in Table 12.

Table 12
DWR GWMP Components and Management Strategies

Management Component	Applicable BMO(s)	Potential KDWD Management Strategies
Saline Water Control	Preserve Groundwater Quality	• Identify areas of elevated TDS or highly mineralized water • Expand monitoring of groundwater quality • Maximize Kern River water for delivery and recharge (WAP) • Provide education on fertilizer management
Identification and Management of Wellhead Protection Areas and Recharge Areas	Preserve Groundwater Quality; Manage Groundwater Storage; Coordinate with Other Agencies	• Identify and update primary recharge areas (provided as Figure 20) • Identify areas of water supply wells • Encourage compliance with County/State well construction standards and surface seals • Provide education on managing agricultural runoff away from wells
Regulation of Migration of Contaminated Groundwater	Preserve Groundwater Quality; Coordinate with Other Agencies	• Identify areas and constituents of concern • Improve groundwater quality monitoring program • Coordinate with Regional Water Boards and other local agencies on water quality issues
Administration of Well Abandonment and Destruction Program	Preserve Groundwater Quality; Coordinate with Other Agencies	• Encourage compliance with Kern County Department of Health Services Well Ordinance • Obtain and review DWR Well Driller's Reports for well locations, construction, and destruction
Mitigate Overdraft	Mitigate Overdraft; Manage Groundwater Storage; Avoid Further Inelastic Land Subsidence	• Optimize local river water and imported water sources for use and recharge (WAP) • Monitor water levels and identify areas of declines • Monitor groundwater storage capacity • Develop and maintain an in-district groundwater budget using an updated groundwater model
Conduct Groundwater Replenishment and Facilitate Conjunctive Use Operations	Mitigate Overdraft; Manage Groundwater Storage; Coordinate with Other Agencies; Avoid Further Inelastic Land Subsidence	• Continue banking programs with outside partners • Estimate Kern River water recharge from irrigation • Continue to recharge excess surface water • Preserve unlined canals • Continue to document canal loss (including intentional recharge in canals)
Groundwater Monitoring of Levels and Storage	Update District Monitoring Programs	• Monitor water levels (for in-district evaluations and CASGEM) • Update estimates of groundwater in storage and storage capacity • Develop and adopt monitoring protocols (Appendix C of this document)
Management of Groundwater Extractions	Mitigate Overdraft; Manage Groundwater Storage; Avoid Further Inelastic Land Subsidence	• Maximize Kern River and imported water deliveries (WAP) • Develop more detailed estimates of groundwater extractions on a spatial and temporal basis • Manage District wells to minimize pumping impacts to others
Identification of Well Construction Polices	Preserve Groundwater Quality; Manage Groundwater Storage; Coordinate with Other Agencies	• Adopt well standards in the Kern County Well Ordinance • Identify in-district well issues, if any • Adopt DWR well construction standards
Construction and Operation of Groundwater Management Facilities	Mitigate Overdraft; Manage Groundwater Storage; Preserve Groundwater Quality; Coordinate with other Agencies	• Operate recharge basins and District wells for efficient recharge and recovery • Construct additional proposed recharge basins associated with the Banking Program • Manage Banking Program recharge to balance in lieu use and rechage in spreading basins • Optimize in-district recharge and deliveries • Preserve unlined canals • Manage surface water storage capacity in Isabella Reservoir • Use in-county banking facilities in accordance with the WAP
Monitoring and Management of Inelastic Land Surface Subsidence	Avoid Further Inelastic Land Subsidence; Update District Monitoring Programs	• Maintain water levels above historical low levels • Document subsidence to date • Periodically download and monitor the CORS geodetic data
Development of Relationships with Federal, State, and Local Regulatory Agencies	Coordinate with Other Agencies; Manage Groundwater Storage; Preserve Groundwater Quality; Update District Monitoring Programs;	• Continue to participate in the cooperative monitoring group for CASGEM compliance • Continue to work with the Central Valley Water Board on agricultural water management • Continue coordination with KCWA and BVWSD for imported water deliveries and exchange
Review Land Use Plans and Coordination with Land Use Planning Agencies	Coordinate with Other Agencies; Mitigate Overdraft; Manage Groundwater Storage; Preserve Groundwater Quality;	• Coordinate activities with Kern County Planning Commission • Address mutual Kern County goals such as the preservation of agricultural lands • Coordinate with Bakersfield on urban growth and build-out
Plan to Involve Local Agencies	Coordinate with Other Agencies; Mitigate Overdraft; Manage Groundwater Storage; Preserve Groundwater Quality	• Conduct public hearings on the GWMP process • Continue coordination with KCWA and BVWSD for imported water deliveries and exchange • Provide urban water to the City of Bakersfield per agreement • Continue coordinated groundwater management with AEWSD as per the Resolution 01-25 • Continue participation in the IRWMP process • Notify local agencies on GWMP activities

6.3 Regulation of Migration of Contaminated Groundwater

No areas of contaminated groundwater have been identified from the groundwater quality data reviewed for this GWMP Update. Additional monitoring is recommended and will provide more information on groundwater quality potential issues or areas of concern. Key management strategies include the improvement of the groundwater quality monitoring program and analysis of monitoring data. Many of the strategies listed under the wellhead protection component above are applicable to this component as well. Management strategies are listed in Table 12.

6.4 Administration of Well Abandonment and Destruction Program

The Kern County Ordinance Code Chapter 14 provides requirements for abandonment and destruction of agricultural, domestic, and other water supply wells. The District is aware of the ordinance and encourages compliance from local drillers and well owners for the protection of groundwater quality. State construction standards are also incorporated into the strategies. In addition, drillers' logs are available from KCWA on a confidential basis to review the location and construction of wells in the Management Area. Available drillers' logs through 2011 have been compiled for this GWMP Update as discussed in Section 4. These management strategies are summarized in Table 12.

6.5 Mitigate Overdraft

Most water level hydrographs do not indicate a long-term decline in water levels. In addition, an examination of inflows and outflows over average hydrologic conditions suggests a positive change in groundwater storage, primarily due to current banking operations. Using these two observations, the occurrence or level of overdraft, if present, is difficult to define for the Management Area. Further, components of subsurface inflow and outflow have not been evaluated; these are complex and transient and are best estimated with a calibrated groundwater model. KDWD plans to consider the incorporation of groundwater modeling into a more detailed assessment of overdraft for periodic updates to the GWMP.

Additional strategies to mitigate overdraft conditions are also incorporated into this GWMP Update. Many of these involve ongoing programs such as the in-district banking project and the Kern River WAP. These and other strategies are listed in Table 12.

6.6 Conduct Groundwater Replenishment and Facilitate Conjunctive Use Operations

This management component relates directly to the previous component and is addressed through similar management strategies. The initiation of the banking program with outside partners allowed the District to develop key infrastructure of conjunctive use facilities to optimize all water sources. With more than 800 acres of recharge basins and 150 miles of canals, KDWD is well-suited to continue and expand conjunctive use for replenishing and sustaining groundwater resources. These facilities offer a recharge capacity of 121,000 AFY and a recovery capacity of 94,000 AFY. In addition, KDWD participates in the Pioneer Project, an out-of-district banking project where it has approximately 24,000 AF in groundwater storage. Finally, KDWD uses available surface water storage in Isabella Reservoir, which can provide, on average, approximately 44,000 AF of additional capacity to the District's infrastructure. A portfolio of management activities involving conjunctive use operations is listed in Table 12.

6.7 Groundwater Monitoring of Levels and Storage

KDWD has monitored water levels for decades and has coordinated monitoring with other agencies including KCWA and DWR. Currently KDWD is participating in a cooperative group of monitoring entities to fulfill requirements of the California State Groundwater Elevation Monitoring (CASGEM) program. In addition, KDWD monitors additional wells to support ongoing evaluations of local groundwater conditions. Details of the District's current monitoring program, including monitoring protocols, are provided in Appendix C. A summary of management strategies is provided in Table 12.

6.8 Management of Groundwater Extractions

Estimates of groundwater extractions for planning purposes can guide groundwater management activities. Although these amounts are not available on a well-by-well basis, KDWD estimates from cropping patterns and in-district knowledge are judged sufficient in guiding most management activities. Pumping from District wells is monitored and managed through the groundwater banking program.

More detailed pumping estimates could be developed by comparing surface water deliveries to estimated irrigation demand on a spatial and temporal basis. Further, this knowledge could assist in developing more detailed plans of in-lieu recharge and the timing needs of surface water and groundwater. Finally, these estimates could support better management of water levels to minimize well interference among growers. Several management strategies focused on groundwater extractions are provided in Table 12.

6.9 Identification of Well Construction Policies

For this GWMP Update, KDWD adopts the well construction policies developed by the Kern County Well Ordinance and the DWR well construction standards. These local and state standards provide guidance for the proper installation and abandonment activities to protect groundwater quality. In addition, KDWD invites the PAC to provide information on any issues that well owners have identified that may affect groundwater management activities. These activities are listed in Table 12.

6.10 Construction and Operation of Groundwater Management Facilities

As envisioned by DWR, this component could involve numerous types of facilities operated for contamination cleanup, recharge, storage, conservation, water recycling, and/or groundwater extraction projects. Groundwater management facilities in KDWD have been discussed previously in Section 4 and summarized in Section 6.6. These facilities consist of recharge basins, recovery wells, and conveyance canals that facilitate the optimal use of water sources for the benefit of basin users and the groundwater resource. Applicable strategies for the groundwater management facilities are summarized in Table 12.

6.11 Monitoring and Management of Inelastic Land Surface Subsidence

A detailed evaluation of inelastic subsidence in the Management Area was published in 1975. Since that time, water levels have remained close to or above 1975 levels and further significant subsidence is not anticipated. However, a nearby CORS monitoring site with geodetic data exists within about 1,500 feet of the southern boundary of the Management Area where the greatest amount of subsidence in KDWD has been recorded. KDWD will consider incorporating data from this monitoring station as part of its ongoing land subsidence monitoring. These strategies are summarized in Table 12.

6.12 Development of Relationships with Federal, State, and Local Regulatory Agencies

KDWD has developed numerous cooperative relationships with regulatory agencies. The District is working with the Central Valley Water Board on behalf of local growers to meet requirements of the agricultural water management program. In addition, KDWD, BVWSD, and RRBWSD have formed a cooperative group to serve as the monitoring entity for compliance with the state's CASGEM program. As a participant in the SWP, KDWD also works with KCWA and BVWSD on requirements for allocation, exchange, and use of SWP water.

6.13 Review Land Use Plans and Coordination with Land Use Planning Agencies

As part of this GWMP Update, KDWD has reviewed planning documents by local land use agencies as described in Section 2. Numerous goals and objectives from those plans are relevant to and support KDWD groundwater management activities. Some of those mutual goals involve the preservation of agricultural lands and the provision of supplemental municipal water supply for the City of Bakersfield to support build-out (as per existing agreement). These land use coordination activities are summarized in Table 12.

6.14 Plan to Involve Local Agencies

KDWD already participates with other water districts and local agencies to manage the shared groundwater resource. Some of those activities include participation in the IRWMP planning process, cooperative CASGEM monitoring with BVWSD and RRBWSD, and a resolution with AEWSD to conduct mutually beneficial groundwater management activities. The resolution passed by the KDWD Board of Directors of the intent to develop a GWMP was broadcast to the public. Local agencies have also been made aware of the District's ongoing GWMP efforts. Specific activities to coordinate with local agencies are listed in Table 12.

7 GWMP Implementation and Schedule

KDWD has been conducting groundwater management activities since its inception and has been documenting those activities in GWMPs since 1996. As an update to these plans, this GWMP Update includes numerous programs that are already in place, more recent programs that have been implemented in the past few years, and additional activities planned for implementation in the future.

7.1 GWMP Strategies and Implementation Schedule

Table 13 lists the key ongoing programs and additional selected strategies that are incorporated into this GWMP Update. Most of the additional strategies involve more coordination with local agencies and improvements to the District's monitoring program. Also included on Table 13 is the status and implementation schedule for each program or strategy.

7.2 Monitoring and Reporting

Current monitoring programs, including recommended improvements, are documented in Appendix C. Monitoring protocols for the various media are also included. Results from GWMP monitoring will be incorporated into monitoring reports provided annually to the PAC as described below.

7.3 Annual Reporting and Five-Year GWMP Updates

KDWD intends to prepare a report on the progress of its GWMP on an annual basis. Annual reports will be provided to the PAC and will document ongoing programs and important changes that occurred in the prior year. Monitoring data can be attached as an appendix for PAC review. It is envisioned that future annual reports will consist of a concise document for the PAC's internal use and will not contain the detail provided herein. This GWMP Update has been expanded to include legislative requirements that had not been included in previous plans. In addition, an updated hydrogeologic assessment of the groundwater basin was conducted to provide a basis for ongoing strategies and monitoring protocols.

In addition to the annual reports, the GWMP and management programs will be re-evaluated in a more detailed assessment every five years to provide the level of analysis needed to modify groundwater management strategies.

Table 13
Selected Groundwater Management Strategies and Implementation Schedule

Selected GWMP Strategies	Description	Status and Schedule
Kern River Water Allocation Plan (WAP)	Recently-developed program to optimize the use of Kern River water throughout the District. Program will enhance groundwater recharge and reduce groundwater pumping. Surface water return flows, canal loss, and intentional recharge also contribute to improved groundwater quality. Project-level EIR was certified September 2012. No infrastructure modifications or other construction is needed.	Ongoing
In-District Banking Program with Outside Partners	Agreements with Metropolitan and Valley water districts to store water up to 50,000 AFY in the basin for future recovery. Program increases groundwater in storage, includes a credit of 11 percent to KDWD, and funds conjunctive use factilities including recharge basins and recovery wells.	Ongoing; improvements including additional recharge basins and recovery wells are scheduled for 2014.
In-District Conjunctive Use Program	Elements of this program are incorporated into the Kern River WAP, but the strategy is listed separately to highlight the ongoing use of District-owned recharge basins and recovery wells for groundwater management activities on an as-needed basis. KDWD has the ability to select recharge areas, use of recovered water, and timing of activities to best manage water levels and groundwater storage in the basin.	Ongoing
Out-of-District Banking Program	Agreement with Pioneer Project to store excess water in the banking project for groundwater replenishment and/or future recovery. Supports groundwater replenishment in an area upgradient of the District that contributes some subsurface inflow to the Management Area. Currently, KDWD has 24,000 AF in storage for subsequent recovery.	Ongoing
SWP Water Allocation Plan	SWP water is allocated on a higher priority basis to non-utility areas that have no access to Kern River water. Secondary priority SWP water is delivered to areas with only limited Kern River water rights. This SWP water reduces groundwater pumping. If allocation is not needed for irrigation, KDWD uses it to recharge groundwater in areas of high pumping to manage storage and levels.	Ongoing
Coordinate Well Construction Policies	KDWD will compile and maintain well construction standards in the District's office including the Kern County Well Ordinance and work with landowners to ensure compliance.	To be implemented in 2013 with the adoption of this GWMP Update.
Coordinate with Land Use Policies	KDWD will provide the GWMP Update to Kern County land use planners to ensure consistent policies are implemented.	To be implemented in 2013 with the adoption of this GWMP Update.
Water Level Monitoring Program	KDWD will continue to cooperate with BVWSD and RRBWSD to monitor and report water levels through the CASGEM program coordinated by DWR. In addition, KDWD may expand or modify its in-district water level monitoring to better manage water levels and respond to potential future groundwater management issues.	Ongoing
Monitor Groundwater Storage	KDWD compiles water level data to support estimates for groundwater in storage. KDWD intends to update and/or modify an existing groundwater model as a tool for periodic assessments of groundwater storage changes and tracking groundwater budgets over time.	Implementation by 2014.
Groundwater Quality Monitoring Program Improvements	KDWD will continue to monitor groundwater quality and make improvements to its monitoring program over time. In particular, representative wells will be added to allow for better spatial distribution of data. A selected group of constituents will be identified for monitoring on more-frequent and less-frequent schedules. A more complete water quality monitoring event will be conducted every five years.	Ongoing; improvements to be incorporated over the next two years and coordinated with the Agricultural Water Management Program
Land Subsidence Monitoring Program	KDWD will continue to track water levels across the Management Area with a focus on areas in the southern District that may be more suceptible to land subsidence. KDWD will periodically obtain and review data from nearby CORS geodetic station.	To be implemented in 2013 with the adoption of this GWMP Update.

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FIGURES

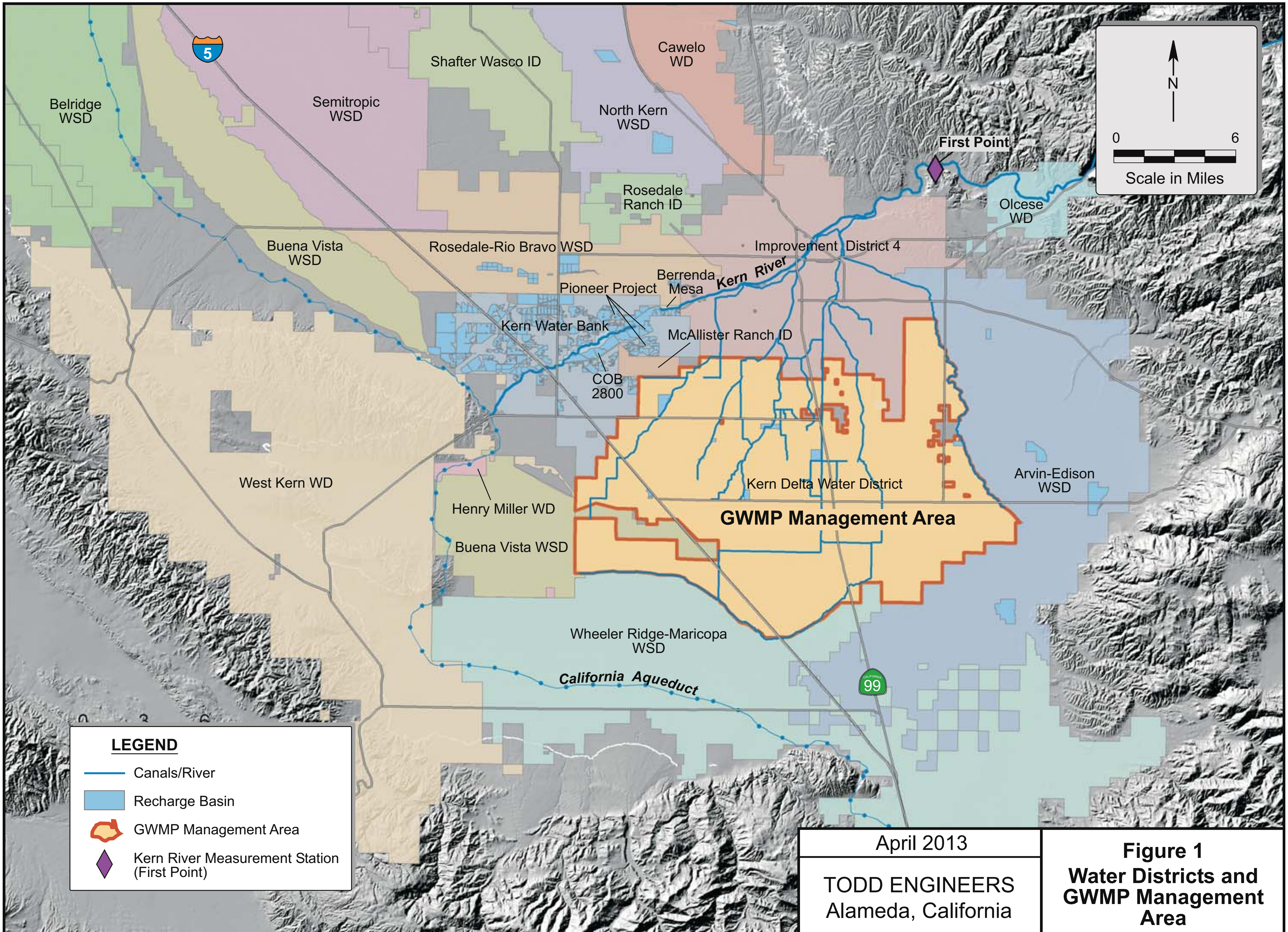

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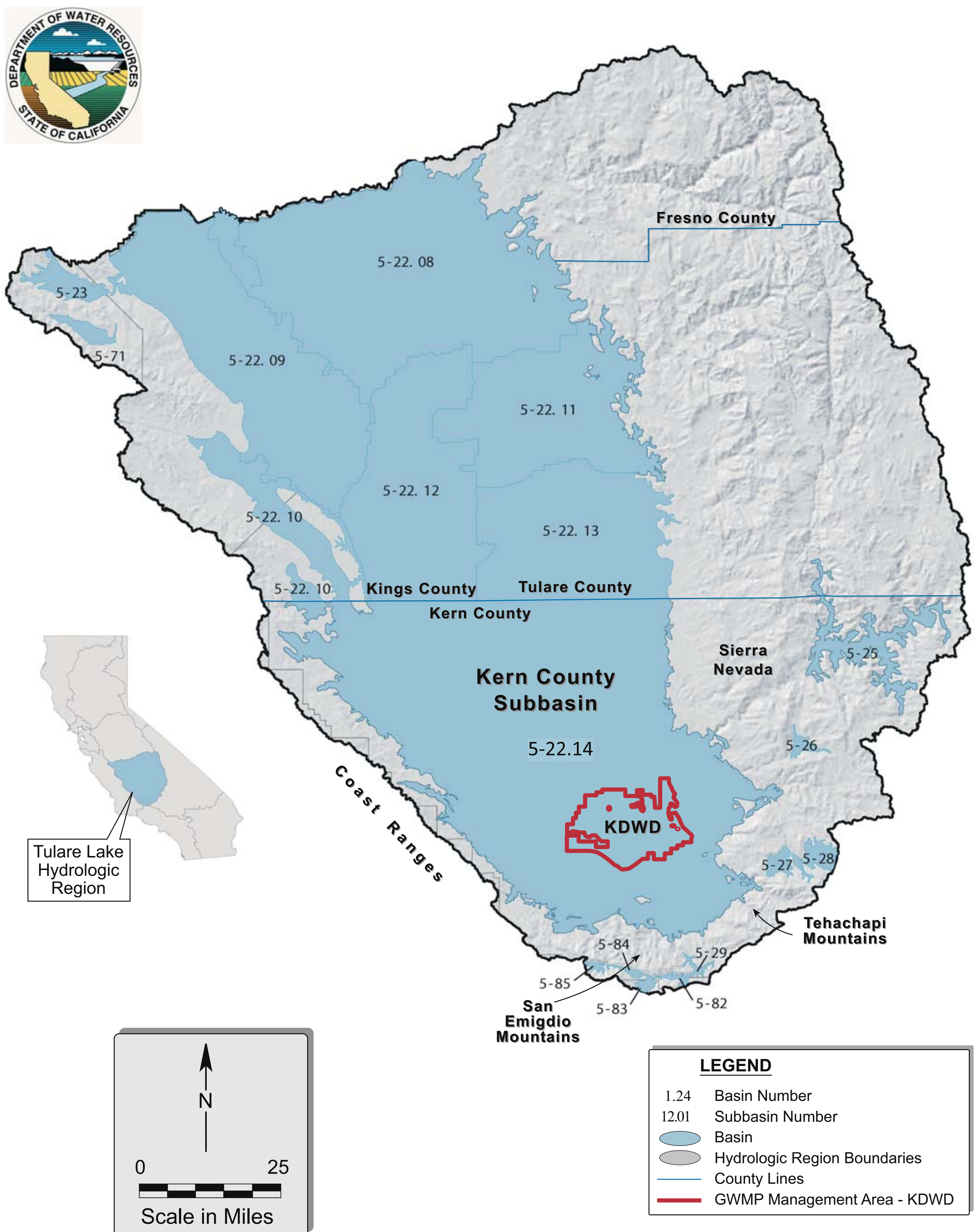
Figure 1
Water Districts and GWMP Management Area



Source: DWR, 2006.

April 2013	**Figure 2**
TODD ENGINEERS Alameda, California	**Groundwater Subbasins and Management Area**

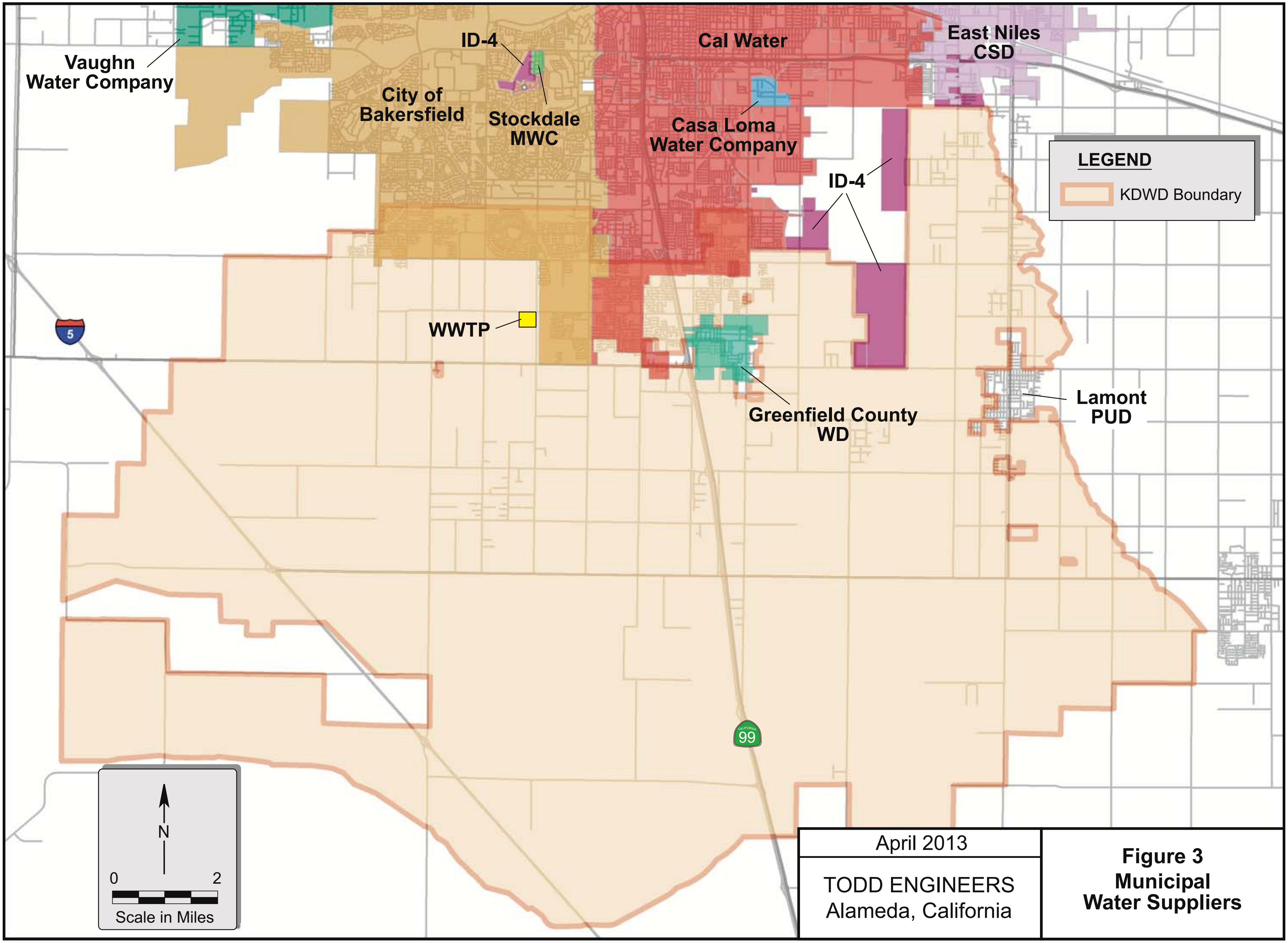


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Figure 3
Municipal
Water Suppliers

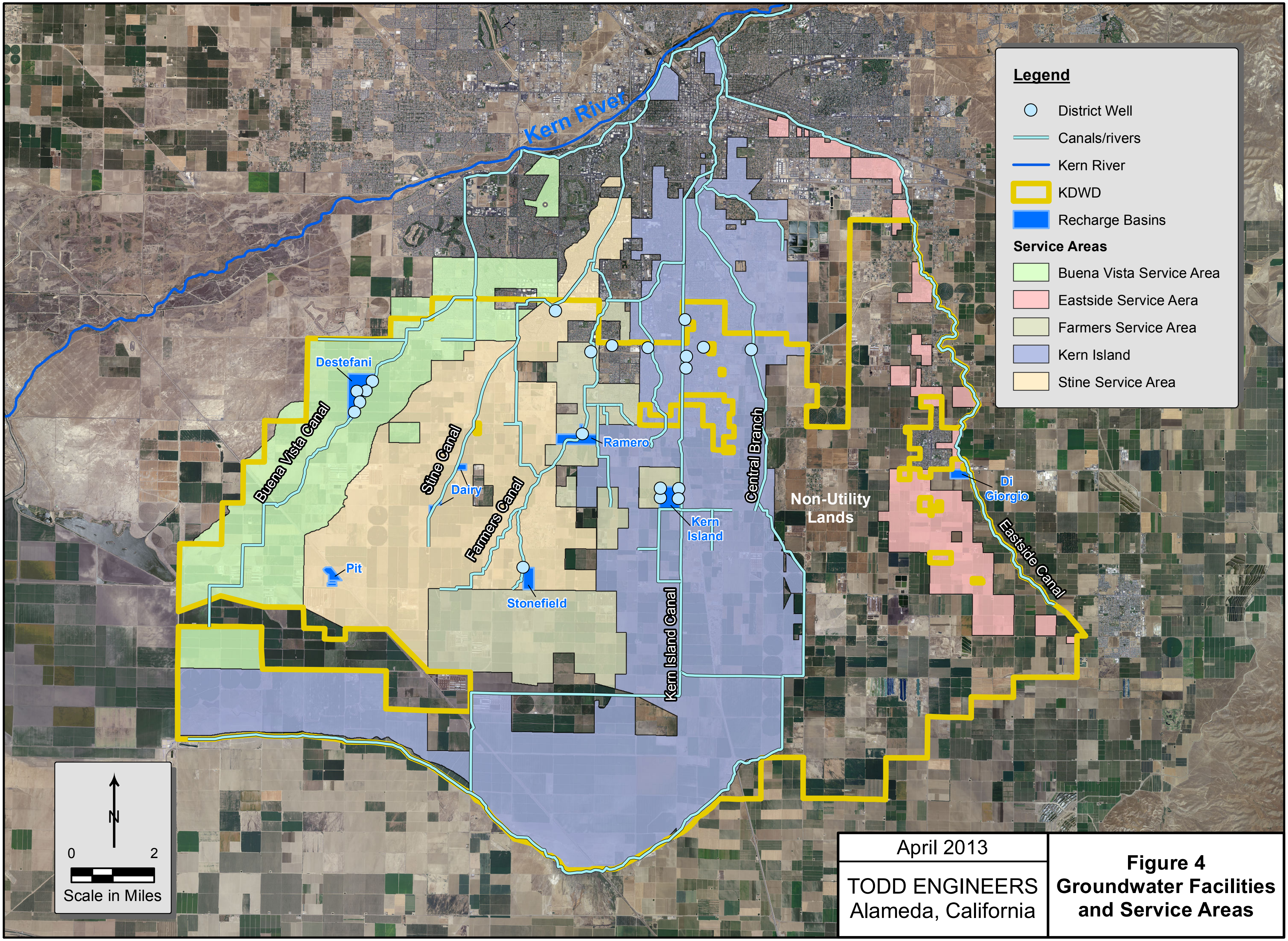

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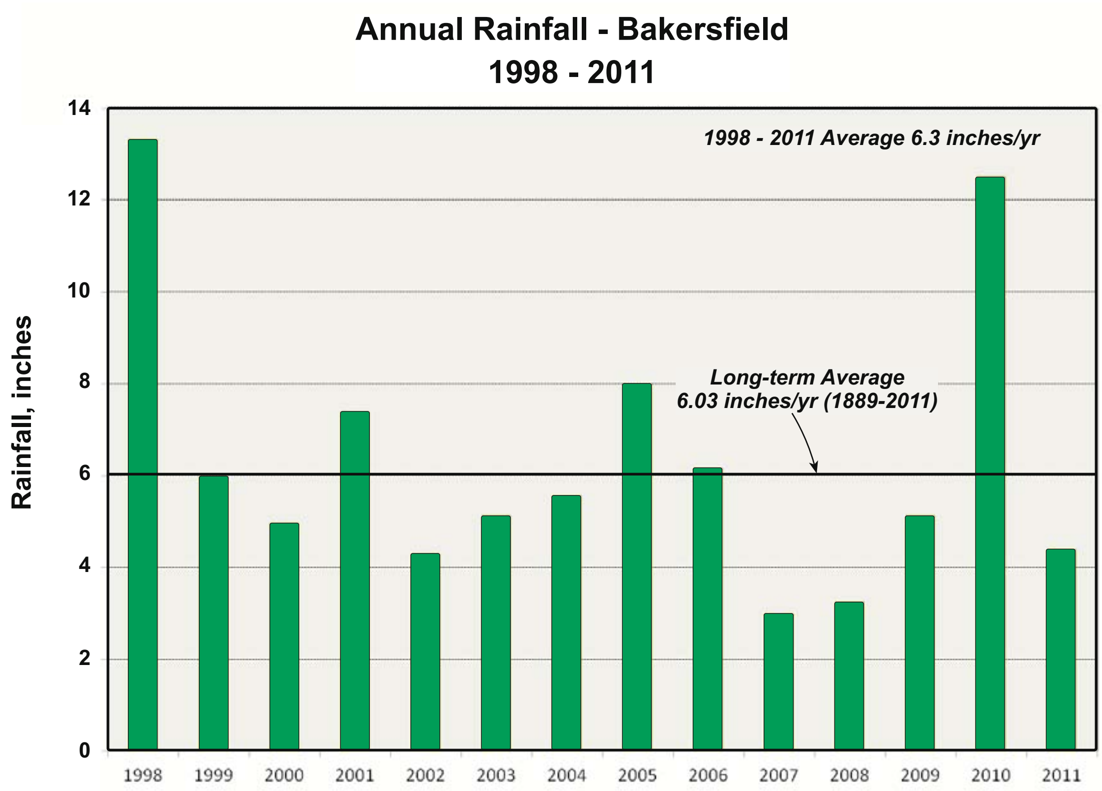
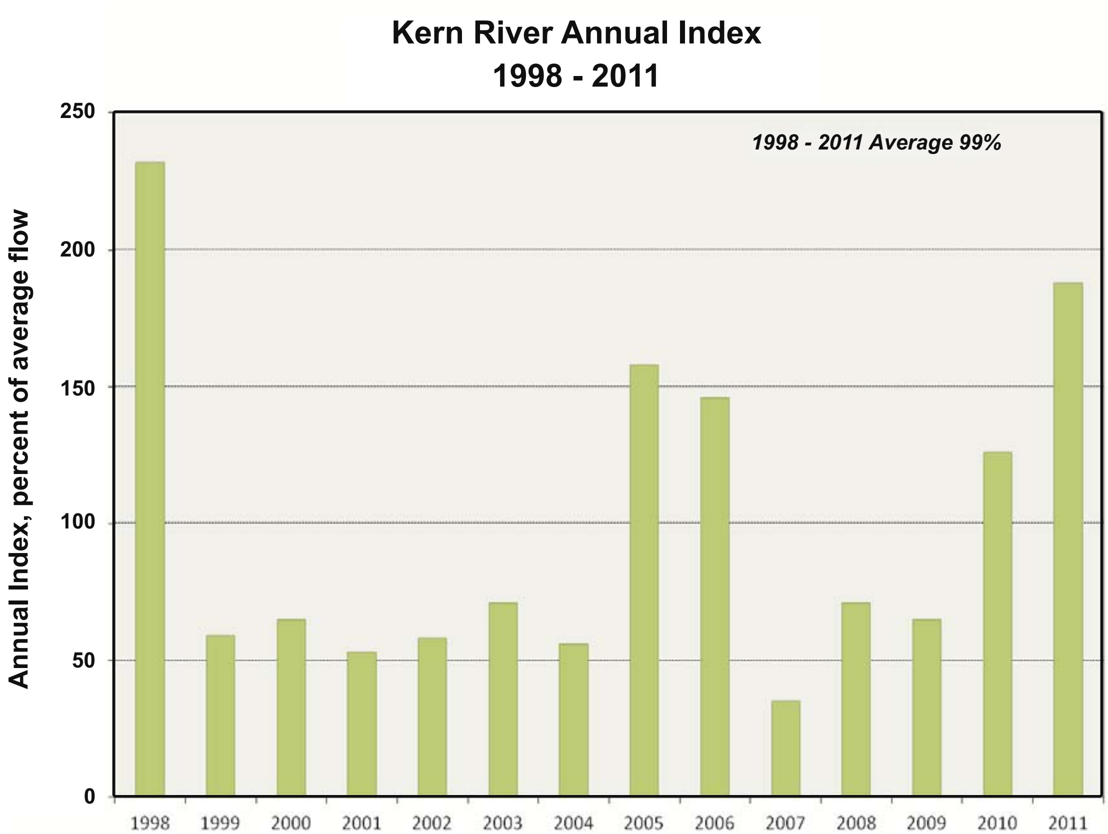
Figure 4
Groundwater Facilities and Service Areas





April 2013	**Figure 5**
TODD ENGINEERS Alameda, California	**Rainfall and Kern River Index**

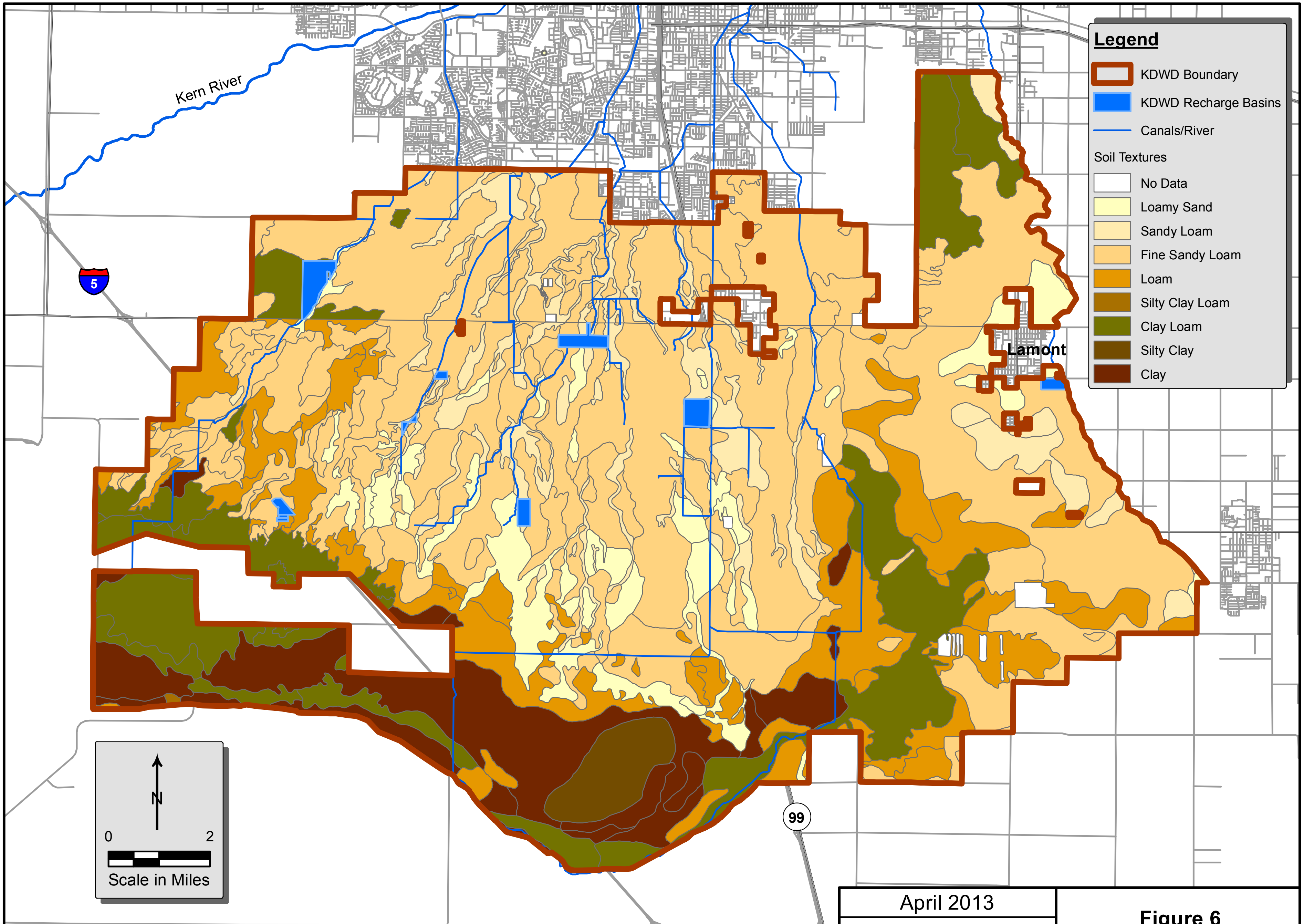


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Figure 6
Soil Texture Map

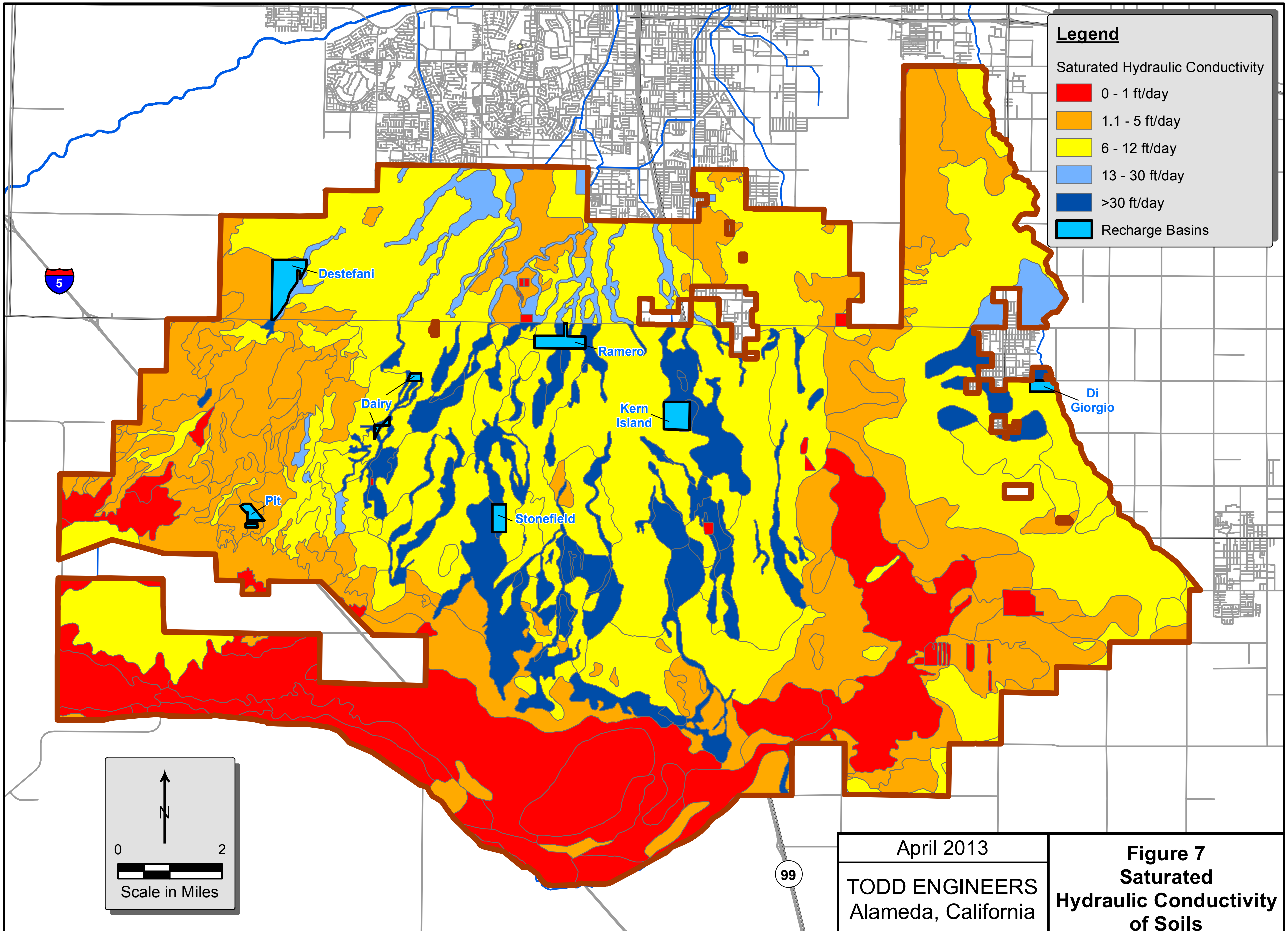

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Figure 7
Saturated Hydraulic Conductivity of Soils

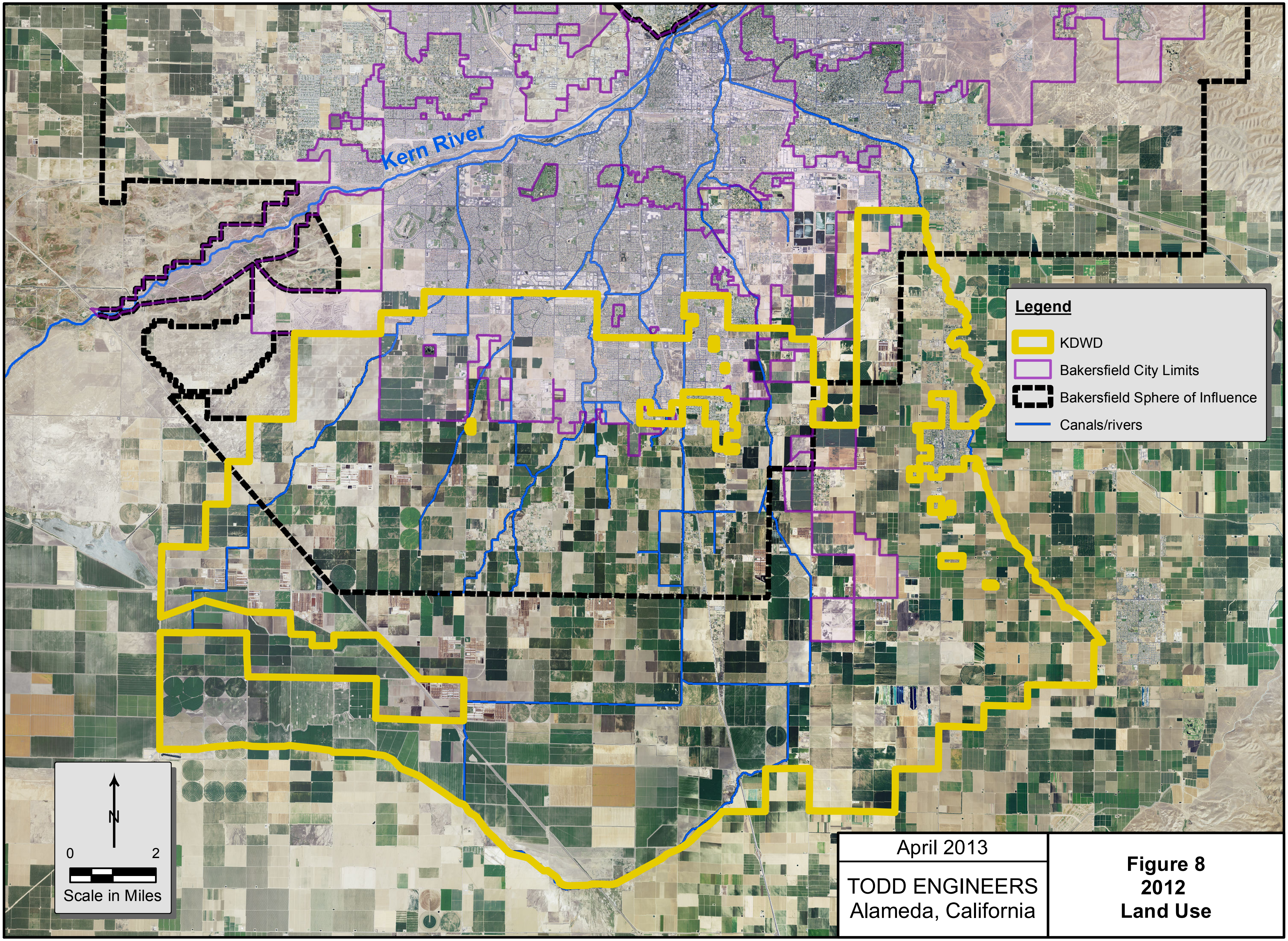

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Figure 8
2012
Land Use

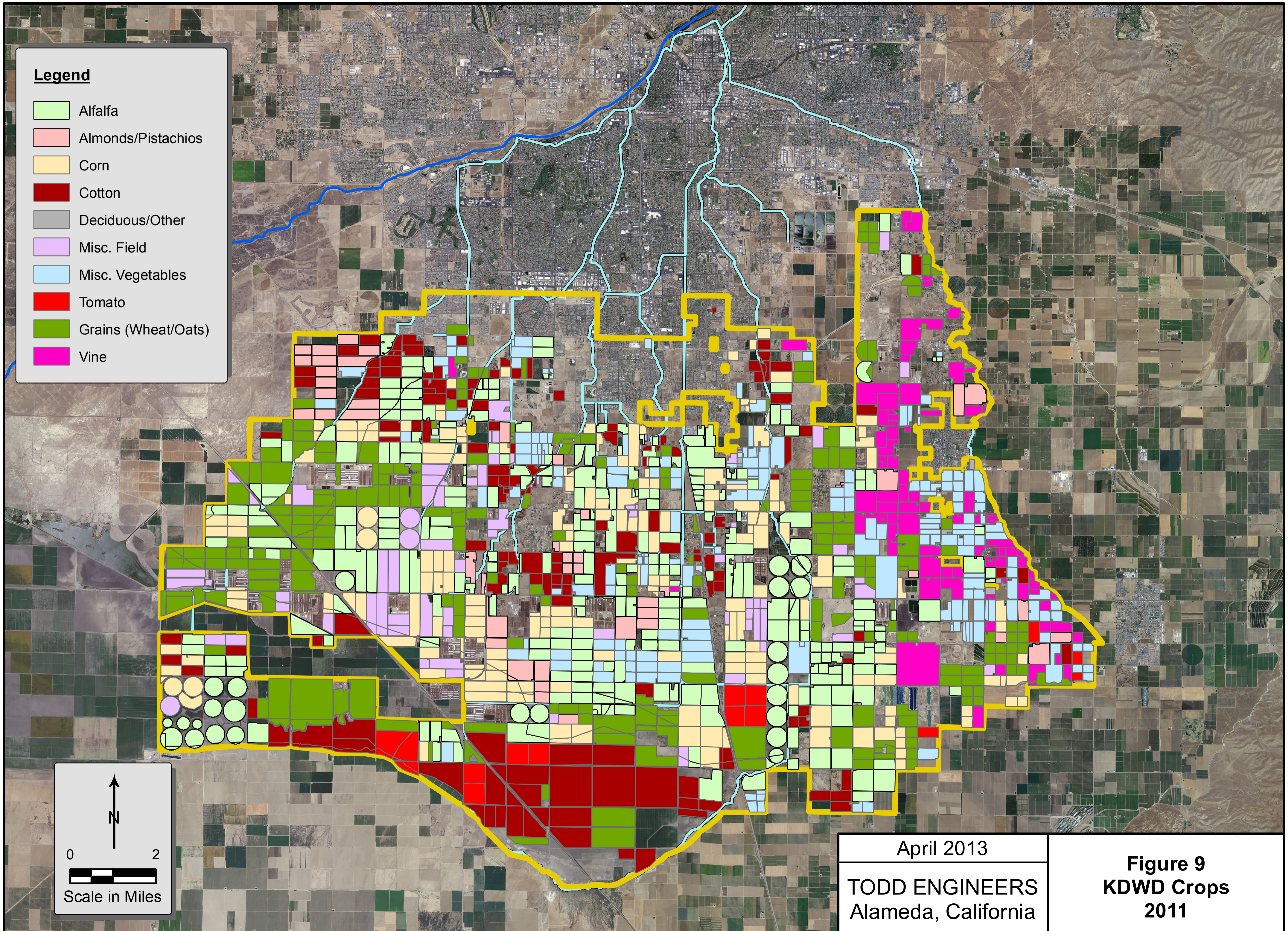

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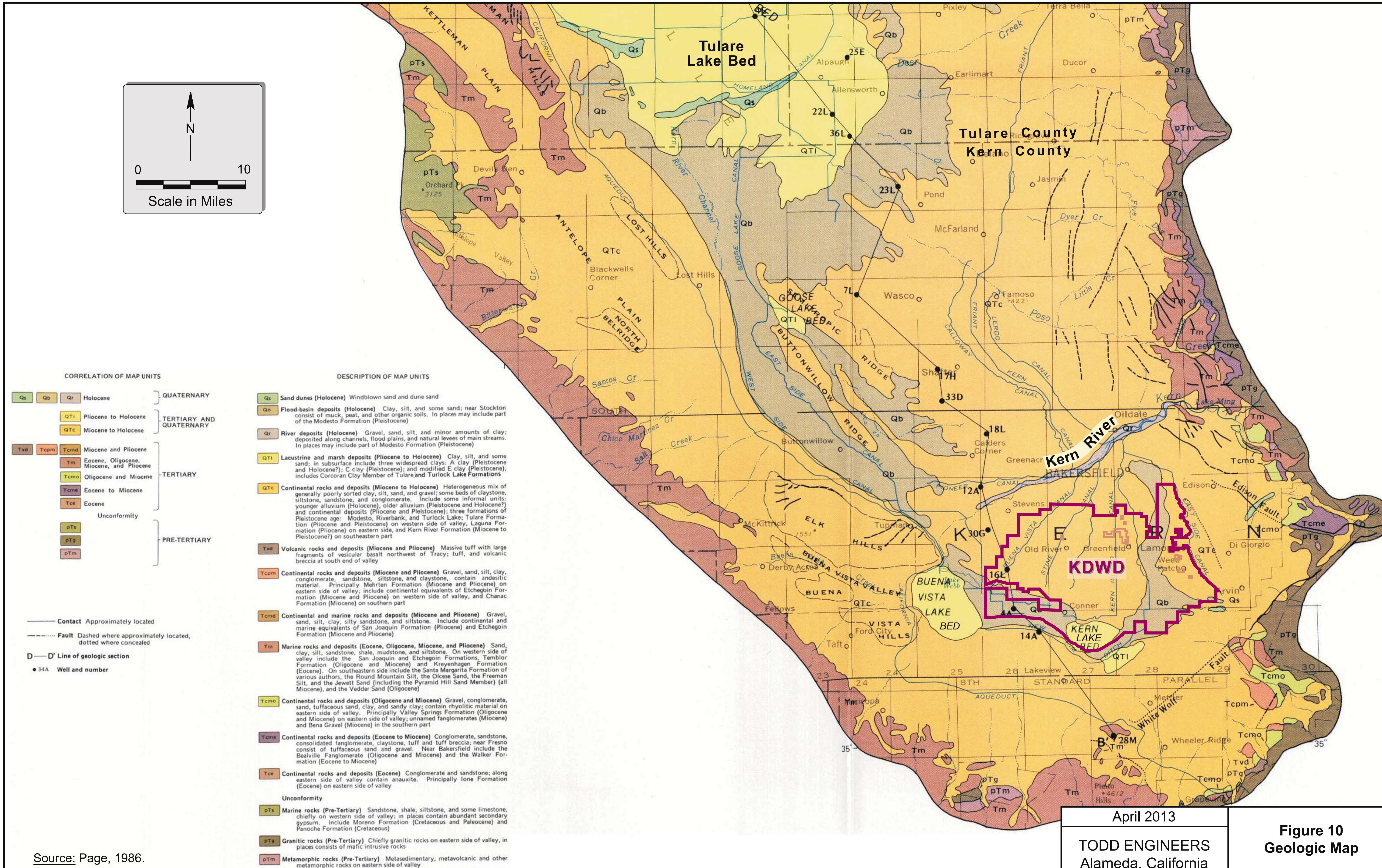
Figure 9
KDWD Crops
2011



Source: Page, 1986.

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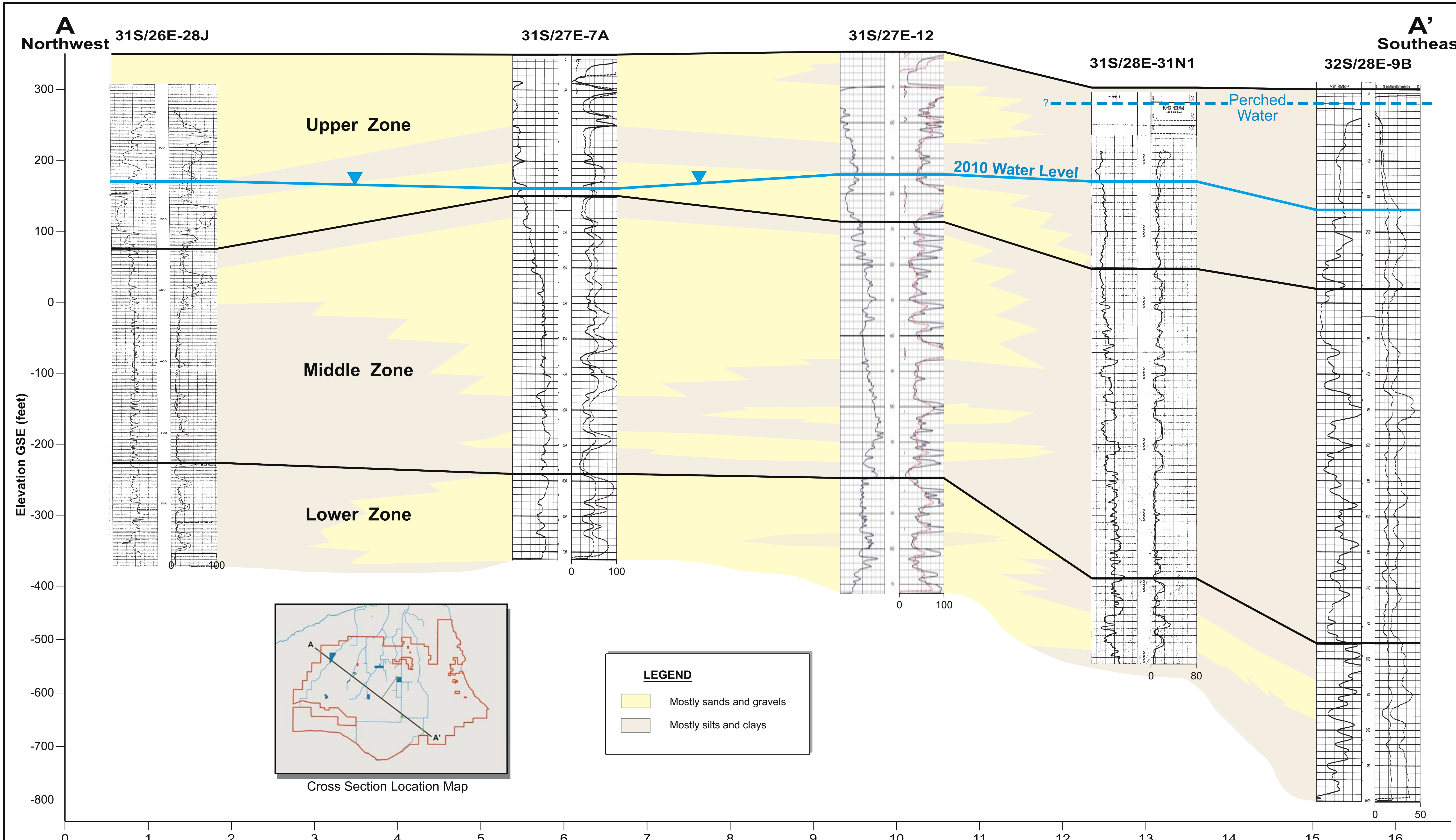
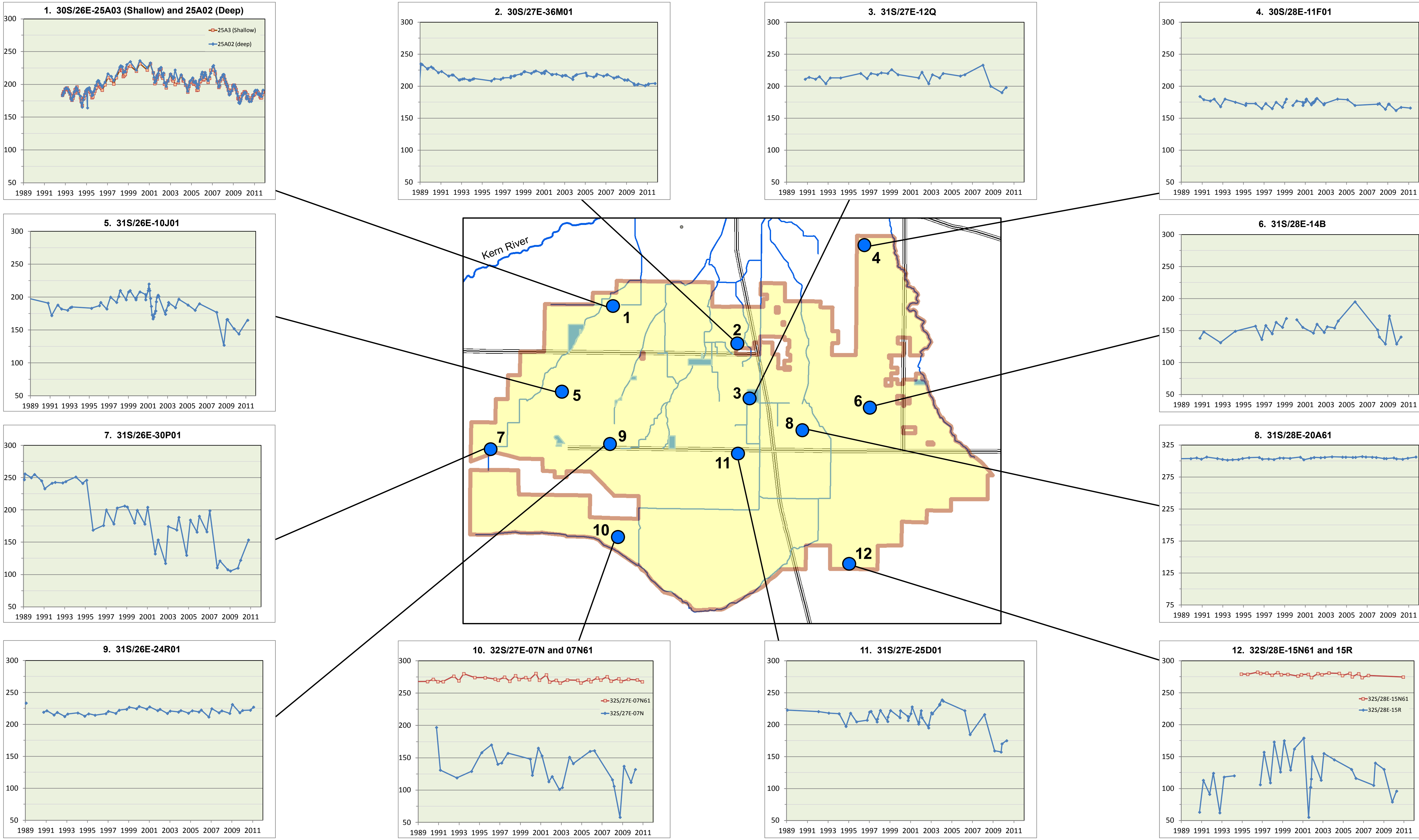
Figure 10
Geologic Map



April 2013	Figure 11 Cross Section A - A'
Todd Engineers Alameda, California	



Water level elevations in feet, MSL

April 2013	**Figure 12**
TODD ENGINEERS Alameda, California	**Selected KDWD Hydrographs 1989 - 2011**

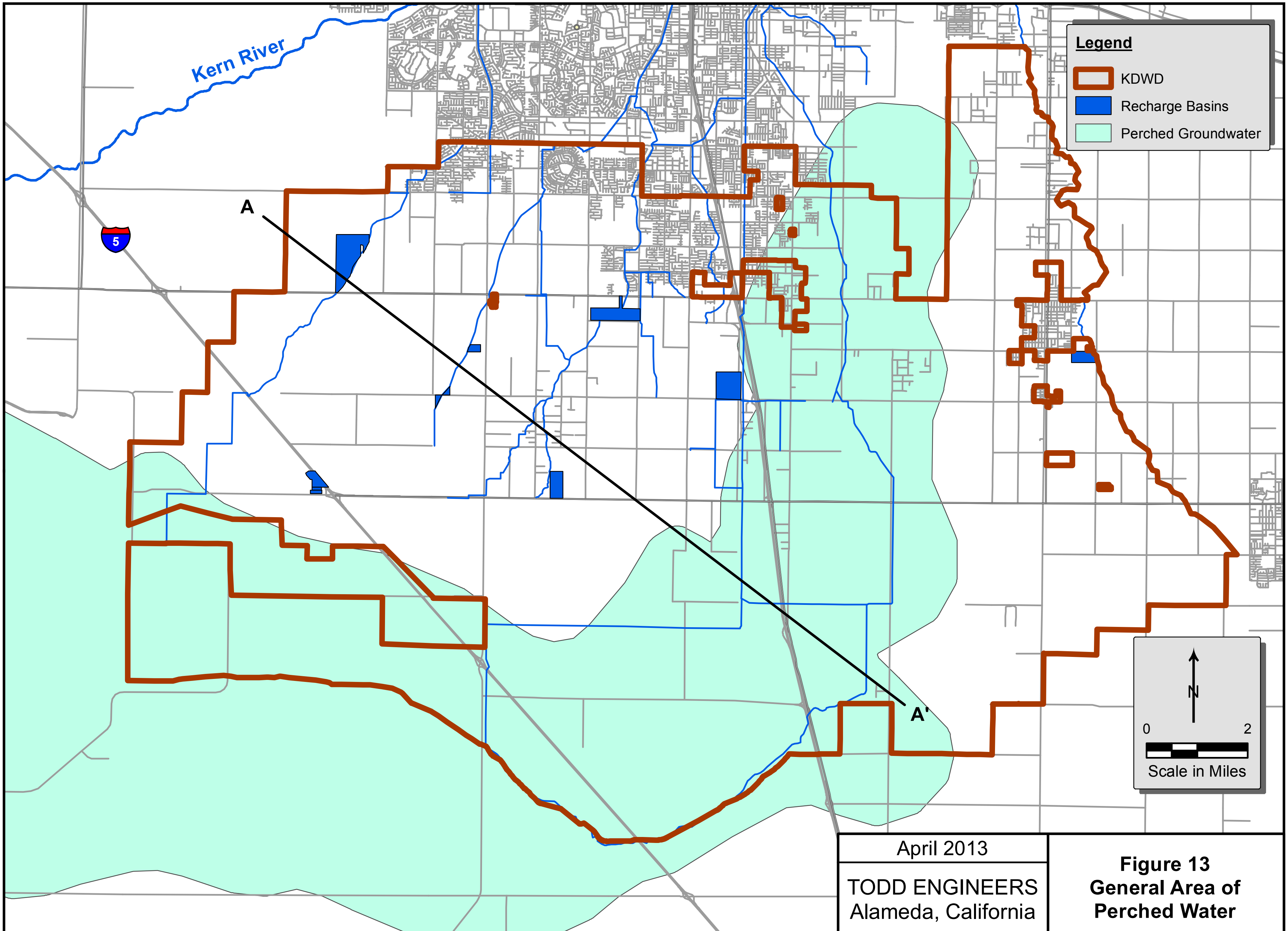


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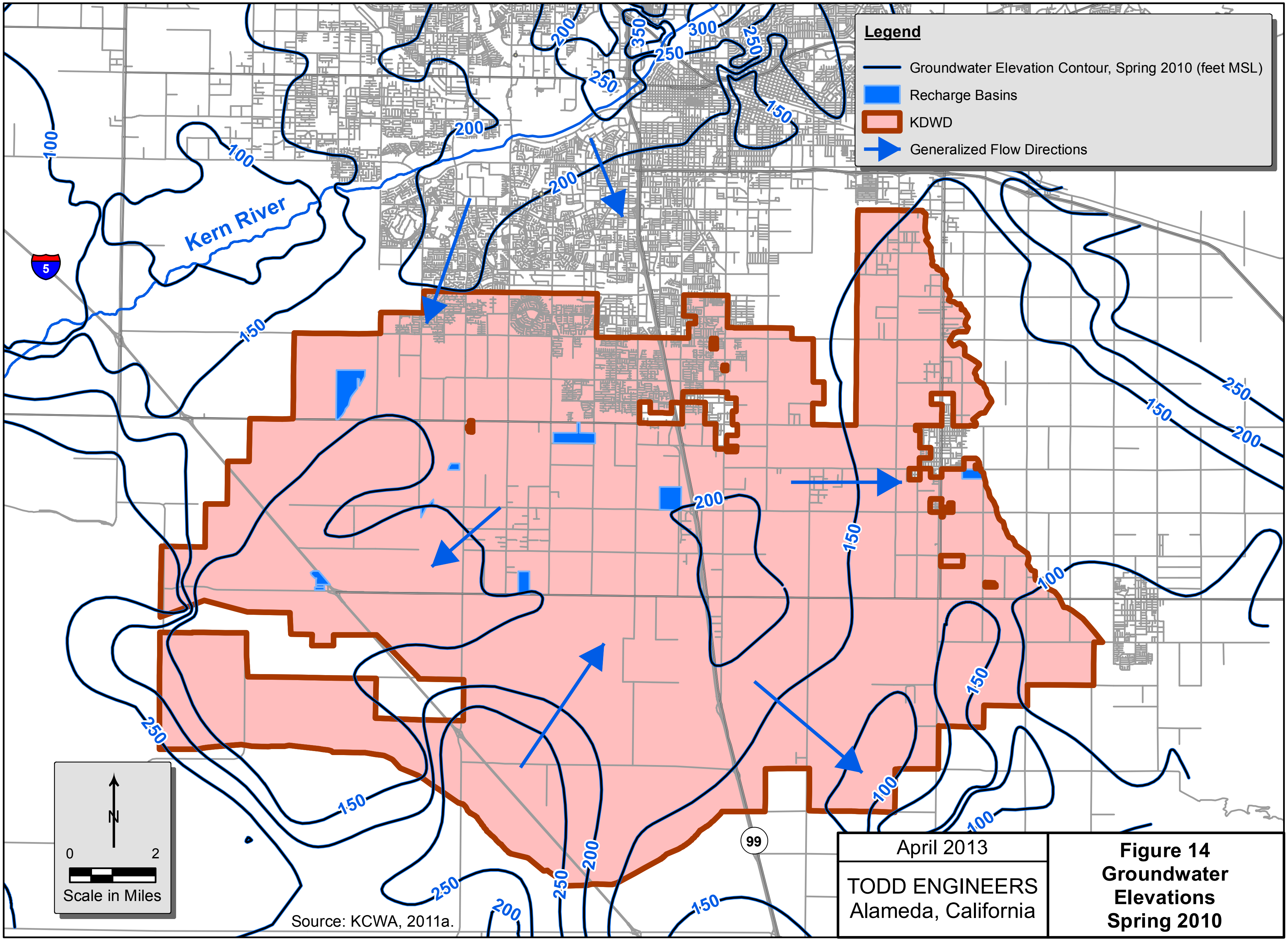
Figure 13
General Area of Perched Water



Legend
Groundwater Elevation Contour, Spring 2010 (feet MSL)
Recharge Basins
KDWD
Generalized Flow Directions
Kern River
5
99
100
150
200
250
300
350
N
0
2
Scale in Miles
Source: KCWA, 2011a.
April 2013
TODD ENGINEERS
Alameda, California
Figure 14
Groundwater Elevations Spring 2010

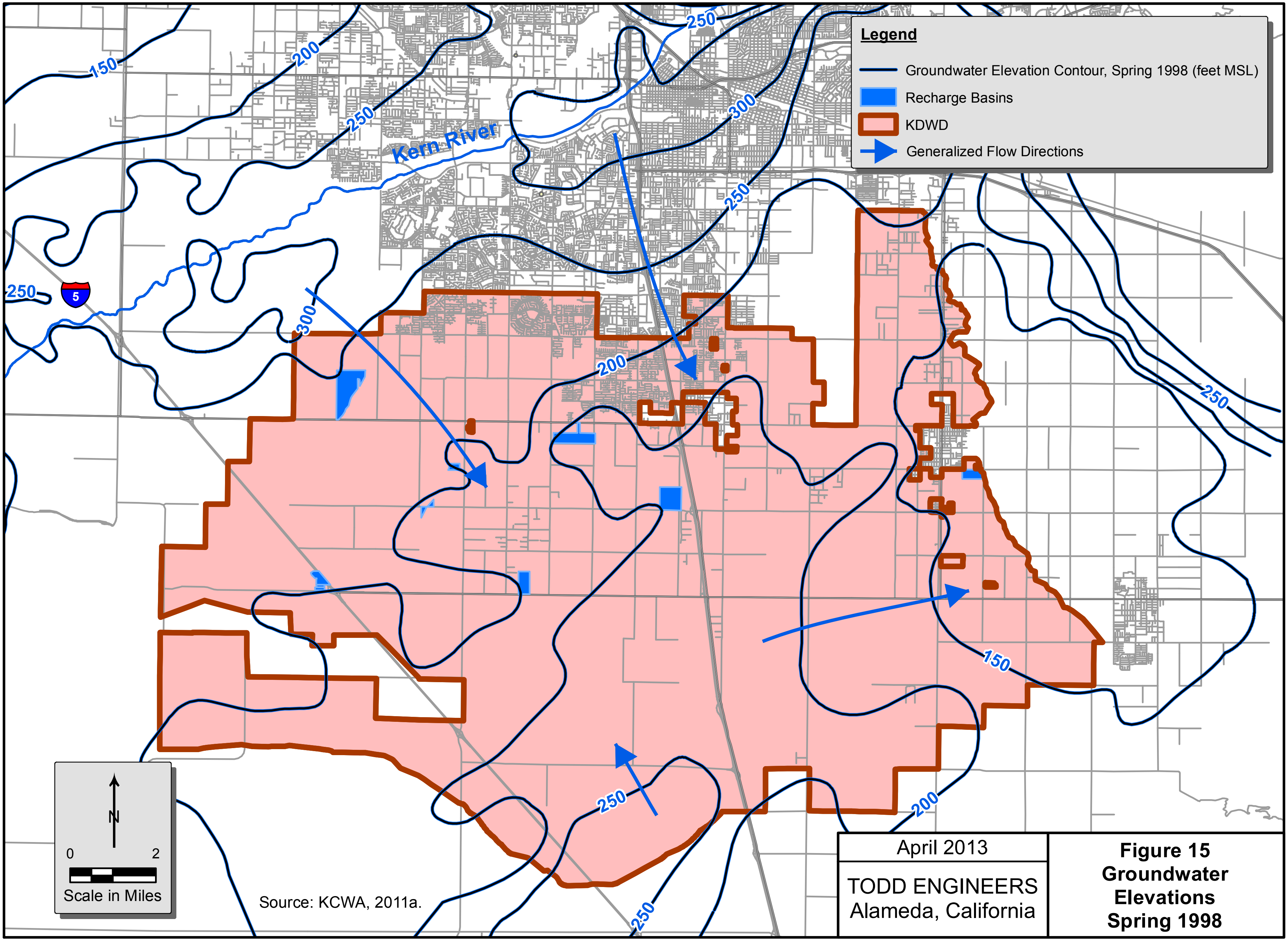
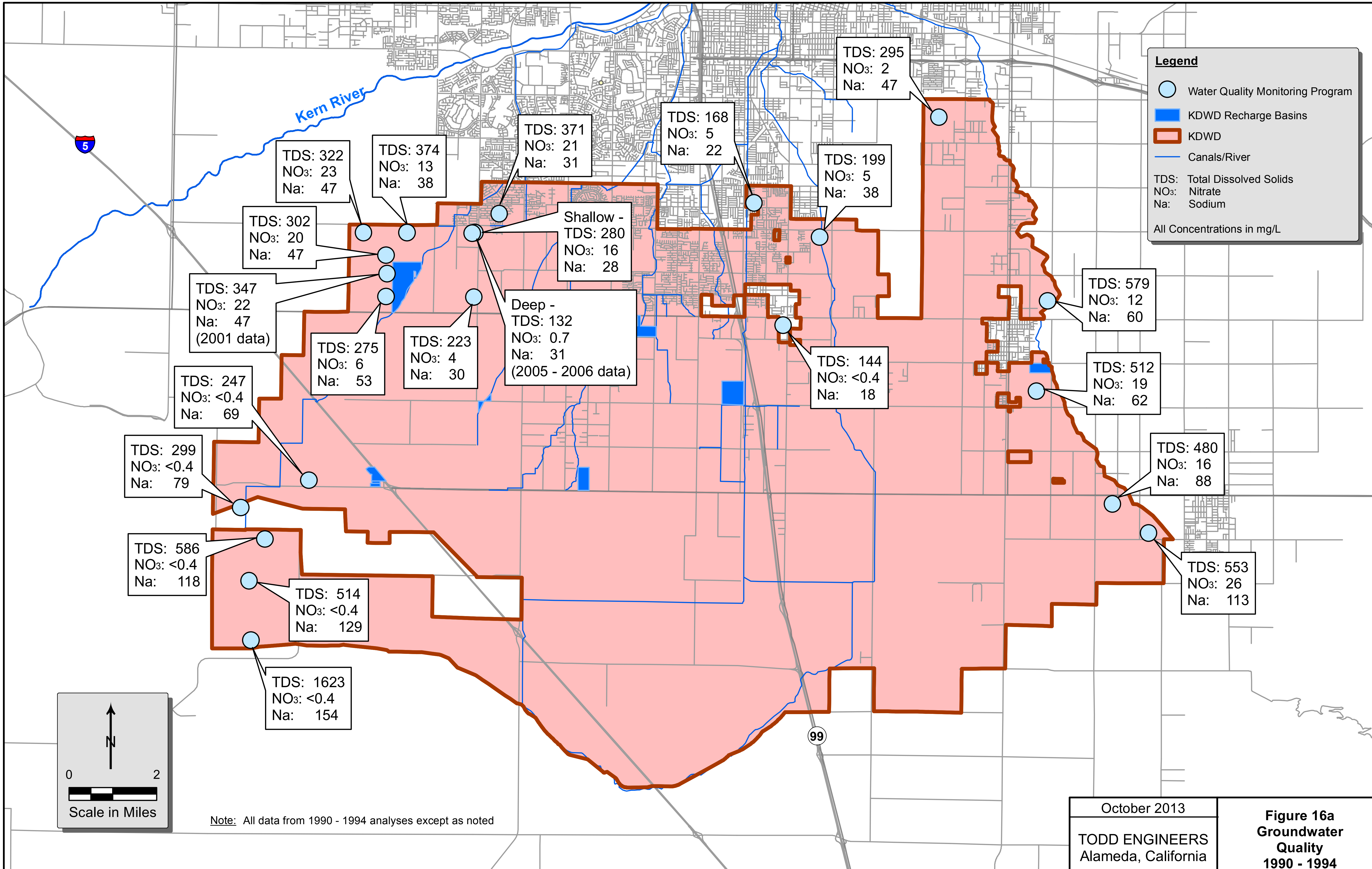


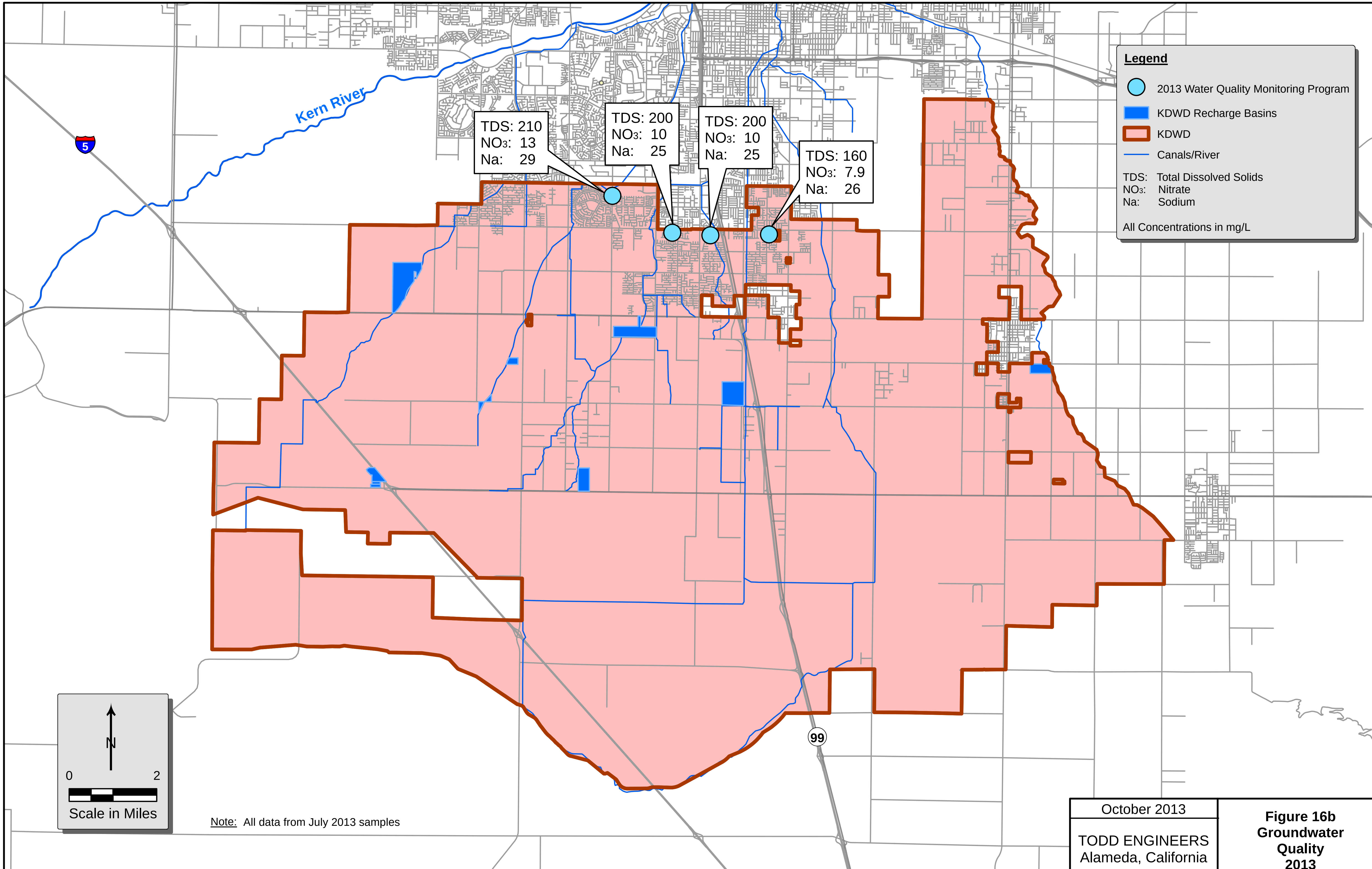
Figure 15
Groundwater Elevations
Spring 1998



October 2013

TODD ENGINEERS
Alameda, California

Figure 16a
Groundwater Quality
1990 - 1994

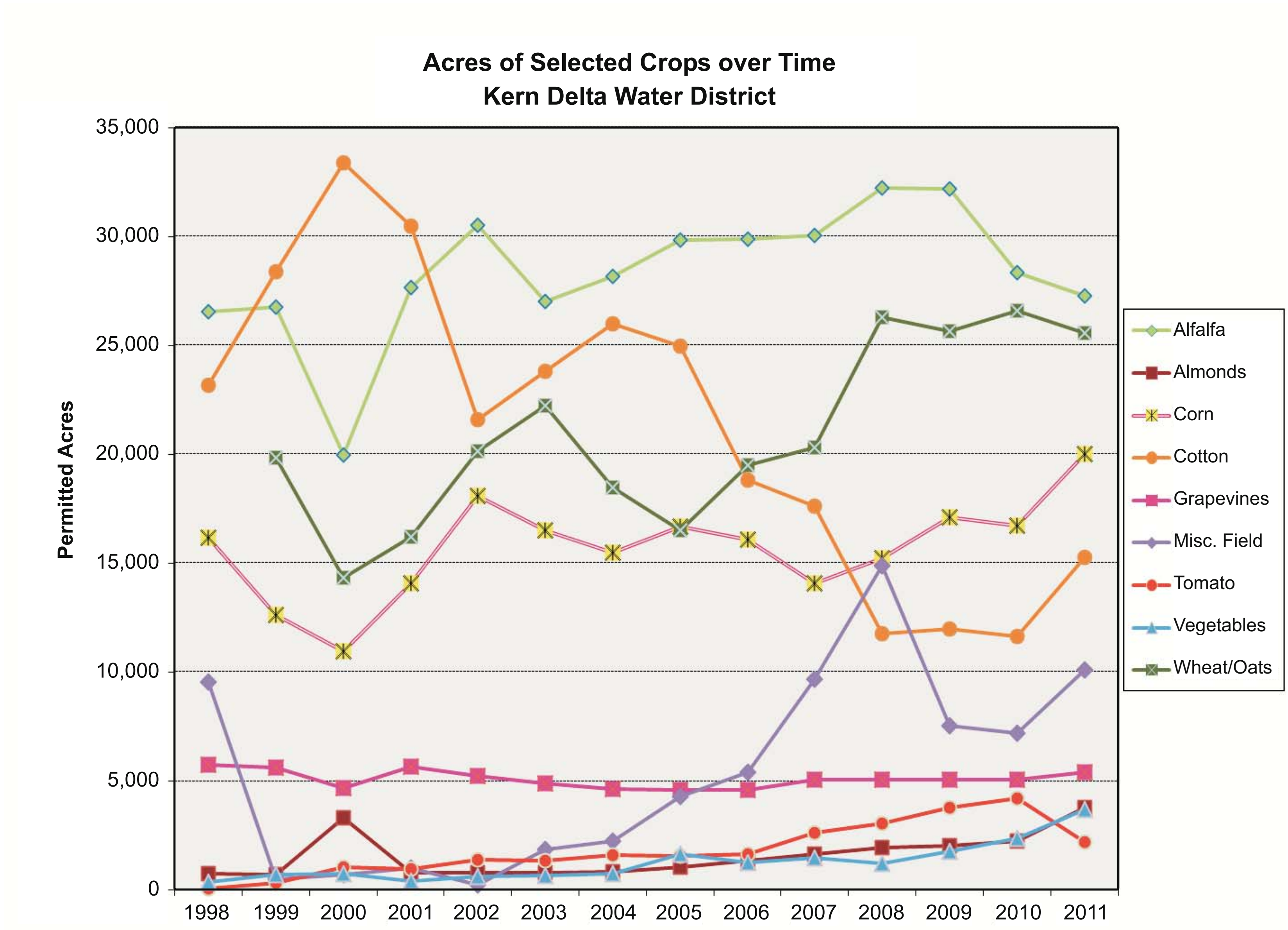


Note: All data from July 2013 samples

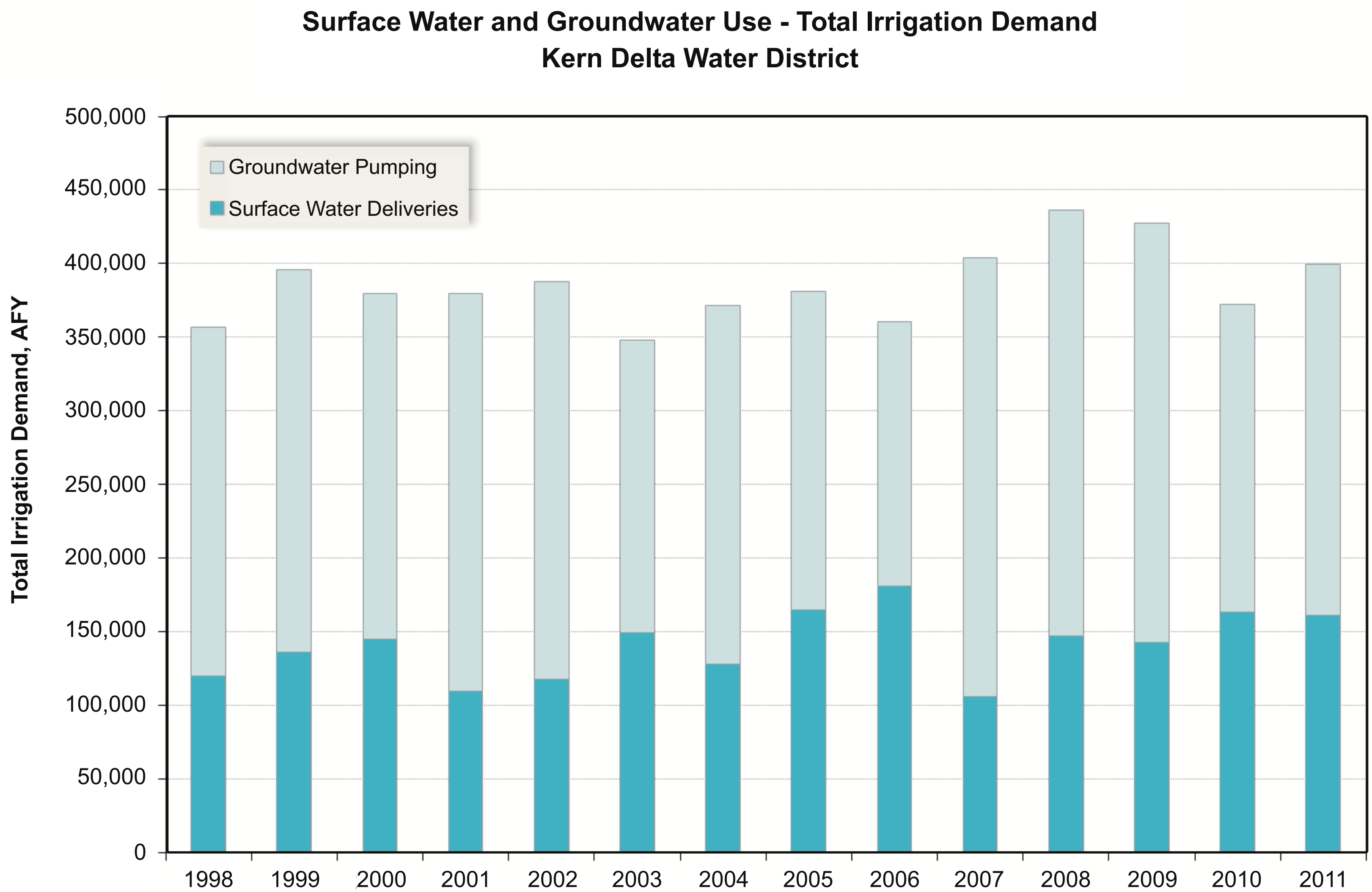
October 2013

TODD ENGINEERS
Alameda, California

Figure 16b
Groundwater Quality
2013

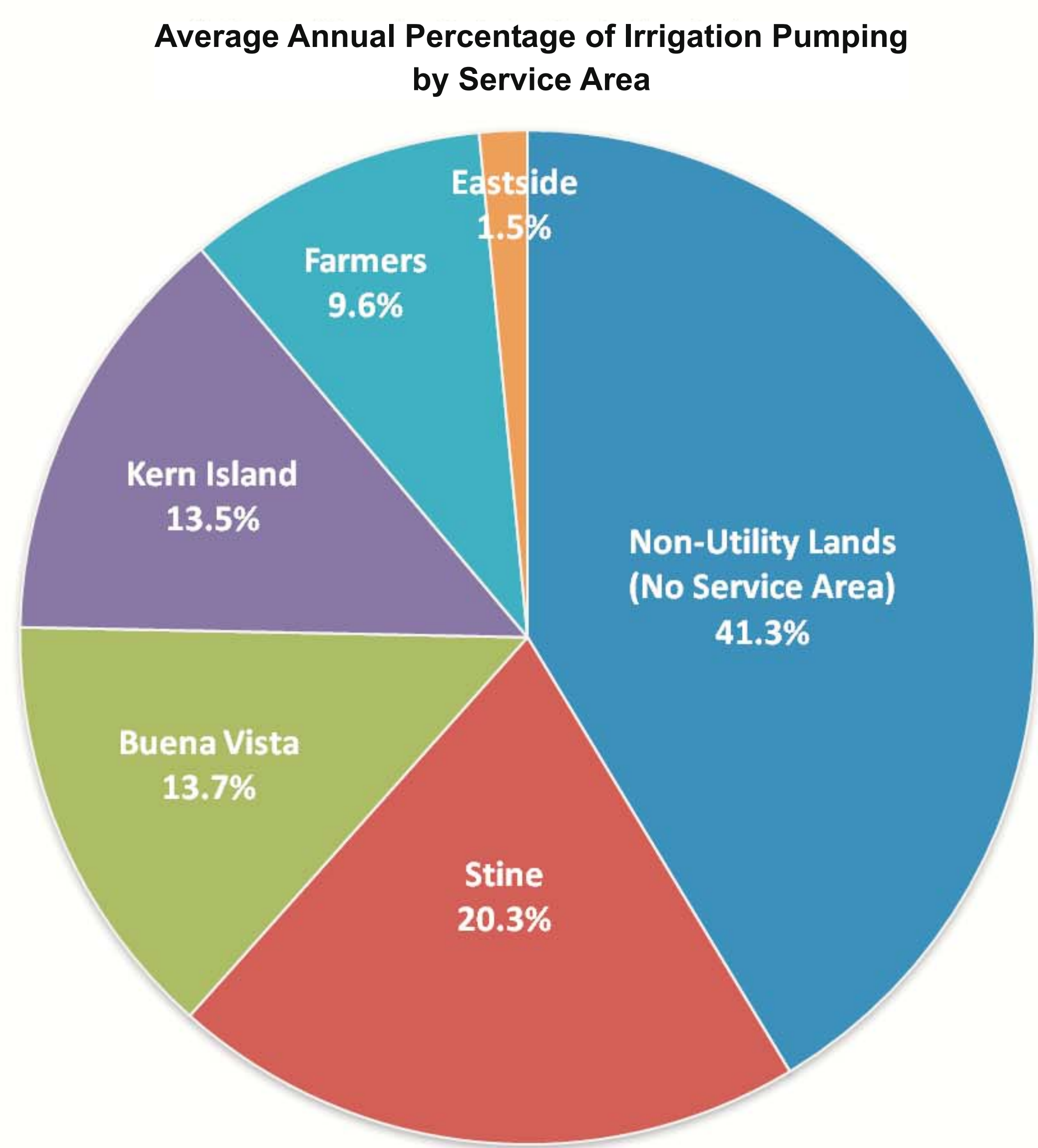


April 2013	**Figure 17 Changing Patterns of Selected Crops**
TODD ENGINEERS Alameda, California	

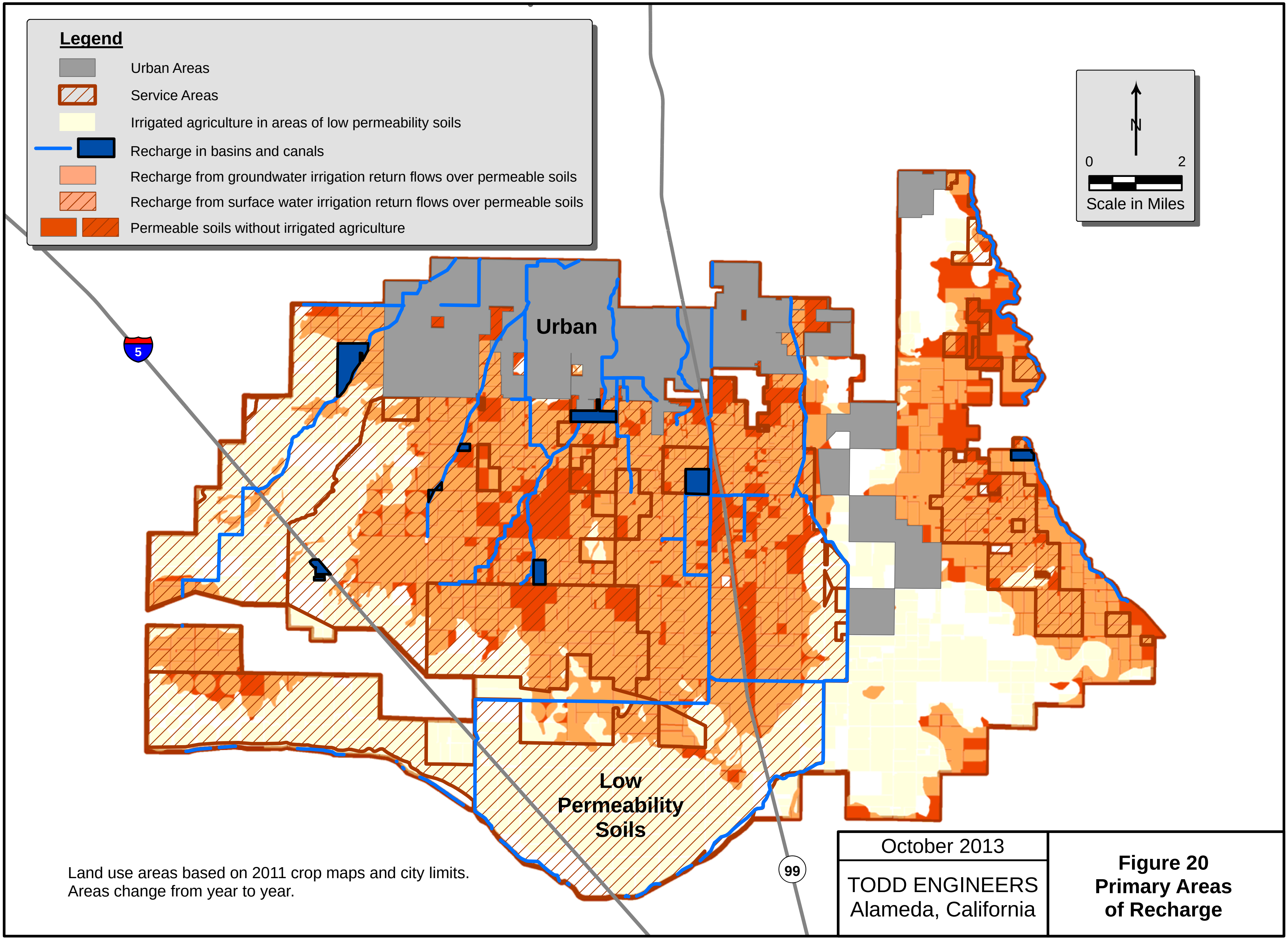


NOTES: Surface Water Deliveries include Kern River, SWP, and other water obtained through exchange agreements. Amounts shown are actual deliveries that do not include canal seepage and other losses. Total irrigation demand accounts for the effective precipitation available to offset irrigation, evaluated on a daily basis. An average irrigation efficiency of 80 percent is assumed.

April 2013	**Figure 18**
TODD ENGINEERS Alameda, California	**Surface Water and Groundwater Agricultural Use**



April 2013	**Figure 19**
TODD ENGINEERS Alameda, California	**Percentage of Irrigation Pumping in Each Service Area**



October 2013

TODD ENGINEERS
Alameda, California

Figure 20
Primary Areas of Recharge

Appendices
GWMP Update

Kern Delta Water District

FINAL

TODD ENGINEERS

APPENDIX A

Resolution No. 2012-05

Intention of the Kern Delta Water District to Update its Groundwater Management Plan

BEFORE THE BOARD OF DRIECTORS
OF THE
KERN DELTA WATER DISTRICT

IN THE MATTER OF: **RESOLUTION NO. 2012-05**

INTENTION OF THE KERN DELTA WATER DISTRICT
TO UPDATE ITS GROUNDWATER MANAGEMENT PLAN

WHEREAS, Part 2.75 (commencing with Section 10750) of Division 6 of the California Water Code, otherwise known as the Groundwater Management Act of 1992 (AB 3030), authorizes this District to adopt and implement a Groundwater Management Plan; and

WHEREAS, on October 15, 1996, the District adopted a Groundwater Management Plan pursuant to the Groundwater Management Act of 1992 in order to preserve local management and enhance existing groundwater management programs; and

WHEREAS, in 2002, Water Code 10750 et seq. was amended by SB 1938, providing recommendations and requirements for agencies that elected to develop a groundwater management plan; and

WHEREAS, in 2003, the District signed an agreement with Metropolitan Water District of Southern California for a water banking program that significantly increased its groundwater management infrastructure, and

WHEREAS, in 2010, the District amended its Groundwater Management Plan and Agricultural Water Management Plan, noting the District's intent to comply with Water Code amendments; and

WHEREAS, in 2011, the District submitted a groundwater level monitoring plan to the California Department of Water Resources (DWR) in compliance with the California Statewide Elevation Monitoring (CASGEM) Program (SB 6) and is participating in the CASGEM program as part of the Kern Fan Authority through an agreement with Buena Vista Water Storage District, Rosedale Rio Bravo Water Storage District, and Henry Miller Water District with BVWSD; and

WHEREAS, in 2011, amendments to the Water Code pertaining to groundwater management plans were made by AB 359, which requires, among other things, that recharge areas be mapped and included in a groundwater management plan; and

WHEREAS, the District has participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County, which contains groundwater management activities of local agencies in the region; and

WHEREAS, the District has recently prepared a Water Allocation Plan to optimize its use of Kern River water among District service areas that will involve the conjunctive management of surface water and groundwater; and

WHEREAS, the Board thinks that the adoption of a groundwater management plan will be in the best interests of the District's landowners and water users; and

WHEREAS, the Board would like to update its groundwater management plan to document and integrate various legislative requirements with ongoing and planned groundwater management activities; and

WHEREAS, notice of a public hearing to consider and adopt this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" was published pursuant to Water Code §10753.2; and

WHEREAS, a public hearing was held on June 19, 2012 to consider the adoption of this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" pursuant to Water Code §10753.2;

NOW, THEREFORE, BE IT RESOLVED, and ordered by the Board of Directors as follows:

1. This Board of Directors hereby declares its intention to prepare an updated Groundwater Management Plan that integrates ongoing and future groundwater management activities and recent legislative amendments to the Water Code.

2. The General Manager is authorized and directed to take such steps as are necessary to update the Groundwater Management Plan for Board consideration, and to publish a copy of this Resolution as required by law.

3. Upon completion of the updated Groundwater Management Plan, the Board of Directors will consider adopting and implementing the plan in accordance with the process required by law.

4. If adopted, the plan would be submitted in electronic form to DWR in compliance with the law and copies of the plan would be made available to the public.

5. The General Manager shall take such steps as are necessary to ensure active public participation in the groundwater management planning process. To support the process, the General Manager shall develop a plan for public involvement that includes a Public Outreach List of stakeholders and interested parties for provision of public review and comment periods, and public hearings pursuant to Water Code Section 10753 et seq.

6. Any member of the public or other interested party is invited to participate in the development of the plan and can do so by contacting the General Manager and being placed on the Public Outreach List.

All the foregoing being on motion of Director Cerro, seconded by Director Collins, and authorized by the following vote, namely:

AYES: Frick, Tillema, Antongiovanni, Cerro, Garone, Cosyns, Collins, Palla

NOES: None

ABSENT: Kaiser

ABSTENTIONS: None

I HEREBY CERTIFY that the foregoing Resolution is the Resolution of said District as duly passed and adopted by said Board of Directors at a legally convened meeting held June 19, 2012.

WITNESS my hand and the Seal of said Board of Directors this 19th day of June, 2012.

David Cosyns

David Cosyns, Secretary

[SEAL]

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P. O. BOX 440
BAKERSFIELD, CA 93302

KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD, CA 93307

Ad Number:	12816584	**PO #:**	**Groundwater**
Edition:	TBC	**Run Times**	**2**
Class Code	Legal Notices		
Start Date	6/5/2012	**Stop Date**	6/12/2012
Billing Lines	37	**Inches**	222.95
Total Cost	$ 135.46	**Account**	1KDE05
Billing Address	KERN DELTA WATER DIST 501 TAFT HWY BAKERSFIELD,CA 93307		

--

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 6/5/12
6/12/12

ALL IN YEAR 2012

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

Terri Brice

DATED AT BAKERSFIELD CALIFORNIA
6/12/12

Solicitor I.D.: 0

First Text
NOTICE OF PUBLIC HEARINGNotice is Hereby

Ad Number 12816584

NOTICE OF PUBLIC HEARING
Notice is Hereby Given that on the 19th day of June, 2012 at 1:30 PM in the Board Room located at 501 Taft Highway, Bakersfield, California 93307, the Kern Delta Water District (District) will conduct a public hearing on the proposal to adopt a Resolution of Intention to revise the District's Groundwater Management Plan. The purpose of the revisions is to update the District's Groundwater Management Plan to ensure conformance with recent legislative changes to relevant laws and integrate ongoing and future groundwater management activities. This notice is made pursuant to and in compliance with Water Code §10753.2.
If you have any questions relating to the issues addressed herein, please do not hesitate to contact the District and we will do our best to answer and address all issues you may have.
June 5, 12, 2012
(12816584)

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P. O. BOX 440
BAKERSFIELD, CA 93302

KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD, CA 93307

Ad Number: 13306899 **PO #:** Revised Res 2012-05
Edition: TBC **Run Times** 2
Class Code Legal Notices
Start Date 9/30/2013 **Stop Date** 10/7/2013
Billing Lines 97 **Inches** 8.10
Total Cost $ 1,045.08 **Account** 1KDE05
Billing Address KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD,CA 93307

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STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 10/7/13
9/30/13

ALL IN YEAR 2013

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

Tessi Brice

DATED AT BAKERSFIELD CALIFORNIA

10/7/13

Printed on 10/6/2013 at 11:23:19AM

Solicitor I.D.: 0

First Text
BEFORE THE BOARD OF DRIECTORSOF THEKERI

Ad Number 13306899

(over)

BEFORE THE BOARD OF DRIECTORS
OF THE
KERN DELTA WATER DISTRICT

IN THE MATTER OF: **RESOLUTION NO. 2012-05**

INTENTION OF THE KERN DELTA WATER DISTRICT
TO UPDATE ITS GROUNDWATER MANAGEMENT PLAN

WHEREAS, Part 2.75 (commencing with Section 10750) of Division 6 of the California Water Code, otherwise known as the Groundwater Management Act of 1992 (AB 3030), authorizes this District to adopt and implement a Groundwater Management Plan; and

WHEREAS, on October 15, 1996, the District adopted a Groundwater Management Plan pursuant to the Groundwater Management Act of 1992 in order to preserve local management and enhance existing groundwater management programs; and

WHEREAS, in 2002, Water Code 10750 et seq. was amended by SB 1938, providing recommendations and requirements for agencies that elected to develop a groundwater management plan; and

WHEREAS, in 2003, the District signed an agreement with Metropolitan Water District of Southern California for a water banking program that significantly increased its groundwater management infrastructure, and

WHEREAS, in 2010, the District amended its Groundwater Management Plan and Agricultural Water Management Plan, noting the District's intent to comply with Water Code amendments; and

WHEREAS, in 2011, the District submitted a groundwater level monitoring plan to the California Department of Water Resources (DWR) in compliance with the California Statewide Elevation Monitoring (CASGEM) Program (SB 6) and is participating in the CASGEM program as part of the Kern Fan Authority through an agreement with Buena Vista Water Storage District, Rosedale Rio Bravo Water Storage District, and Henry Miller Water District with BVWSD; and

WHEREAS, in 2011, amendments to the Water Code pertaining to groundwater management plans were made by AB 359, which requires, among other things, that recharge areas be mapped and included in a groundwater management plan; and

WHEREAS, the District has participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County, which contains groundwater management activities of local agencies in the region; and

WHEREAS, the District has recently prepared a Water Allocation Plan to optimize its use of Kern River water among District service areas that will involve the conjunctive management of surface water and groundwater; and

WHEREAS, the Board thinks that the adoption of a groundwater management plan will be in the best interests of the District's landowners and water users; and

WHEREAS, the Board would like to update its groundwater management plan to document and integrate various legislative requirements with ongoing and planned groundwater management activities; and

WHEREAS, notice of a public hearing to consider and adopt this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" was published pursuant to Water Code §10753.2; and

WHEREAS, a public hearing was held on June 19, 2012 to consider the adoption of this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" pursuant to Water Code §10753.2;

NOW, THEREFORE, BE IT RESOLVED, and ordered by the Board of Directors as follows:

1. This Board of Directors hereby declares its intention to prepare an updated Groundwater Management Plan that integrates ongoing and future groundwater management activities and recent legislative amendments to the Water Code.
2. The General Manager is authorized and directed to take such steps as are necessary to update the Groundwater Management Plan for Board consideration, and to publish a copy of this Resolution as required by law.
3. Upon completion of the updated Groundwater Management Plan, the Board of Directors will consider adopting and implementing the plan in accordance with the process required by law.
4. If adopted, the plan would be submitted in electronic form to DWR in compliance with the law and copies of the plan would be made available to the public.
5. The General Manager shall take such steps as are necessary to ensure active public participation in the groundwater management planning process. To support the process, the General Manager shall develop a plan for public involvement that includes a Public Outreach List of stakeholders and interested parties for provision of public review and comment periods, and public hearings pursuant to Water Code Section 10753 et seq.
6. Any member of the public or other interested party is invited to participate in the development of the plan and can do so by contacting the General Manager and being placed on the Public Outreach List.

All the foregoing being on motion of Director Cerro, seconded by Director Collins, and authorized by the following vote, namely:

AYES:	Frick, Tillema, Antongiovanni, Cerro, Garone, Cosyns, Collins, Palla
NOES	None
ABSENT:	Kaiser
ABSTENTIONS:	None

I HEREBY CERTIFY that the foregoing Resolution is the Resolution of said District as duly passed and adopted by said Board of Directors at a legally convened meeting held June 19, 2012.

WITNESS my hand and the Seal of said Board of Directors this 19th day of June, 2012.

/s/ David Cosyns
David Cosyns, Secretary

"Pursuant to this Resolution a Groundwater Management Plan has been prepared. That Plan was reviewed at a duly noticed public hearing held September 17, 2013 and will be considered for adoption by the board of directors of the Kern Delta Water District at the regular board meeting to be held October 15, 2013."

September 30, October 7, 2013 (13306899)

APPENDIX B

Resolution No. 2013-05

Adoption and Implementation of the Kern Delta Water District Groundwater Management Plan Update

BEFORE THE BOARD OF DRIECTORS
OF THE
KERN DELTA WATER DISTRICT

IN THE MATTER OF: **RESOLUTION NO. 2013-05**

ADOPTION AND IMPLEMENTAION OF THE KERN DELTA WATER DISTRICT GROUNDWATER MANAGEMENT PLAN UPDATE

WHEREAS, Part 2.75 (commencing with Section 10750) of Division 6 of the California Water Code, otherwise known as the Groundwater Management Act of 1992 (AB 3030), authorizes this District to adopt and implement a Groundwater Management Plan; and

WHEREAS, on October 15, 1996, pursuant to Resolution No. 96-03 the District adopted a Groundwater Management Plan pursuant to the Groundwater Management Act of 1992 for the purposes of implementing the plan and establishing a Groundwater Management Program within the District; and

WHEREAS, in 2002, the Groundwater Management Act was amended by SB 1938; and

WHEREAS, in 2003, the District signed an agreement with Metropolitan Water District of Southern California for a water banking program that significantly increased its groundwater management infrastructure, and

WHEREAS, in 2010, the District amended its Groundwater Management Plan and Agricultural Water Management Plan, noting the District's intent to comply with Water Code amendments; and

WHEREAS, in 2011, the District submitted a groundwater level monitoring plan to the California Department of Water Resources (DWR) pursuant to the California Statewide Elevation Monitoring (CASGEM) Program (SB 6) and is participating in the CASGEM program as part of the Kern River Fan Group through an agreement with Buena Vista Water Storage District, Rosedale Rio Bravo Water Storage District, and Henry Miller Water District with BVWSD; and

WHEREAS, in 2011, amendments to the Water Code pertaining to groundwater management plans were made by AB 359, which requires, among other things, that recharge areas be mapped and included in a groundwater management plan; and

WHEREAS, the District has participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County; and

WHEREAS, the District prepared a Water Allocation Plan to optimize its use of Kern River water among District service areas that involves the conjunctive management of surface water and groundwater; and

WHEREAS, on June 19, 2012 the Board of Directors held a public hearing in accordance with Water Code §10753.2 and thereafter adopted Resolution 2012-05 "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan"; and

WHEREAS, a draft Groundwater Management Plan Update has been prepared; and

WHEREAS, notice of a public hearing to consider the adoption of the Groundwater Management Plan Update" was published pursuant to Water Code §10753.2 and a public hearing was held on pursuant thereto on September 17, 2013;

NOW, THEREFORE, BE IT RESOLVED, and ordered by the Board of Directors as follows:

1. The foregoing are true and correct.

2. The Board of Directors hereby adopts the Groundwater Management Plan Update and the Monitoring Protocols contained therein dated October 11, 2013 in accordance with Part 2.75 of Division 6 of the California Water Code.

3. The Board of Directors hereby authorizes the General Manager to execute all documents, and take any other action necessary or advisable to carry out the purpose of this resolution.

All the foregoing being on the motion of Director ________, seconded by Director ________ and authorized by the following vote, namely:

AYES: Antongiovanni, Cerro, Collins, Cosyns, Frick, Garone, Kaiser, Tillema, Palla

NOES: None

ABSENT: None

ABSTAIN: None

I HEREBY CERTIFY that the foregoing resolution is the resolution of the Kern Delta Water District as duly passed and adopted by its Board of Directors at a legally convened meeting held on the _____ day of October, 2013.

WITNESS my hand and the official seal of said Board of Directors this 15th day of October, 2013.

____
President of the Board of Directors
KERN DELTA WATER DISTRICT

ATTEST:

____
Secretary of the Board of Directors
KERN DELTA WATER DISTRICT

PROOF OF PUBLICATION

RECEIVED
SEP 1 0 2013

The BAKERSFIELD CALIFORNIAN
P. O. BOX 440
BAKERSFIELD, CA 93302

KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD, CA 93307

Ad Number:	13269849	**PO #:**	**GWMP 2nd Hear**
Edition:	TBC	**Run Times**	**2**
Class Code	Public Notices		
Start Date	9/2/2013	**Stop Date**	9/9/2013
Billing Lines	39	**Inches**	3.26
Total Cost	$ 142.62	**Account**	1KDE05
Billing Address	KERN DELTA WATER DIST 501 TAFT HWY BAKERSFIELD,CA 93307		

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STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 9/9/13
9/2/13

ALL IN YEAR 2013

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

DATED AT BAKERSFIELD CALIFORNIA
9/9/13

Printed on 9/9/2013 at 8:48:46AM

Solicitor I.D.: 0

First Text
Notice of Kern Delta Water District to C

Ad Number 13269849

Notice of Kern Delta Water District to Consider Adoption of its Groundwater Management Plan Update:

On September 17, 2013, at 1:30 pm, Kern Delta Water District will hold a public hearing at its office at 501 Taft Highway in Bakersfield to consider adoption of its *Groundwater Management Plan Update*, prepared in compliance with California Water Code Sections 10750 to 10756. The plan summarizes the groundwater basin, updates Basin Management Objectives (BMOs), and evaluates groundwater management strategies. It describes management strategies selected for implementation including ongoing groundwater management and monitoring activities being conducted by the District. Copies of the draft plan may be obtained for the cost of reproduction at Kern Delta Water District, 501 Taft Highway, Bakersfield, CA 93307-6247.

September 2, 9, 2013
(13269849)

APPENDIX C

Monitoring Program and Protocols

C. Monitoring Program and Protocols

KDWD conducts numerous monitoring activities to support groundwater and surface water management programs. Monitoring objectives are described below followed by protocols of the current program and future monitoring refinements for the various media being monitored.

C.1 Monitoring Objectives and Programs

KDWD monitors surface water flows, groundwater levels and quality, groundwater storage, and subsidence to meet a variety of District objectives including:

- Fulfillment of California Ambient Groundwater Elevation Monitoring (CASGEM) Program
- Compliance with Kern River Surface Water Rights
- Execution of groundwater banking agreements with Metropolitan Water District of Southern California and San Bernardino Valley Municipal Water District
- Understanding and tracking of groundwater levels and quality for overall groundwater management
- Evaluation of adverse impacts from potential land subsidence

C.2 Surface Water Flows and Quality

As a First Point diverter and water rights holder on the Kern River, KDWD measures surface water diversions and deliveries.

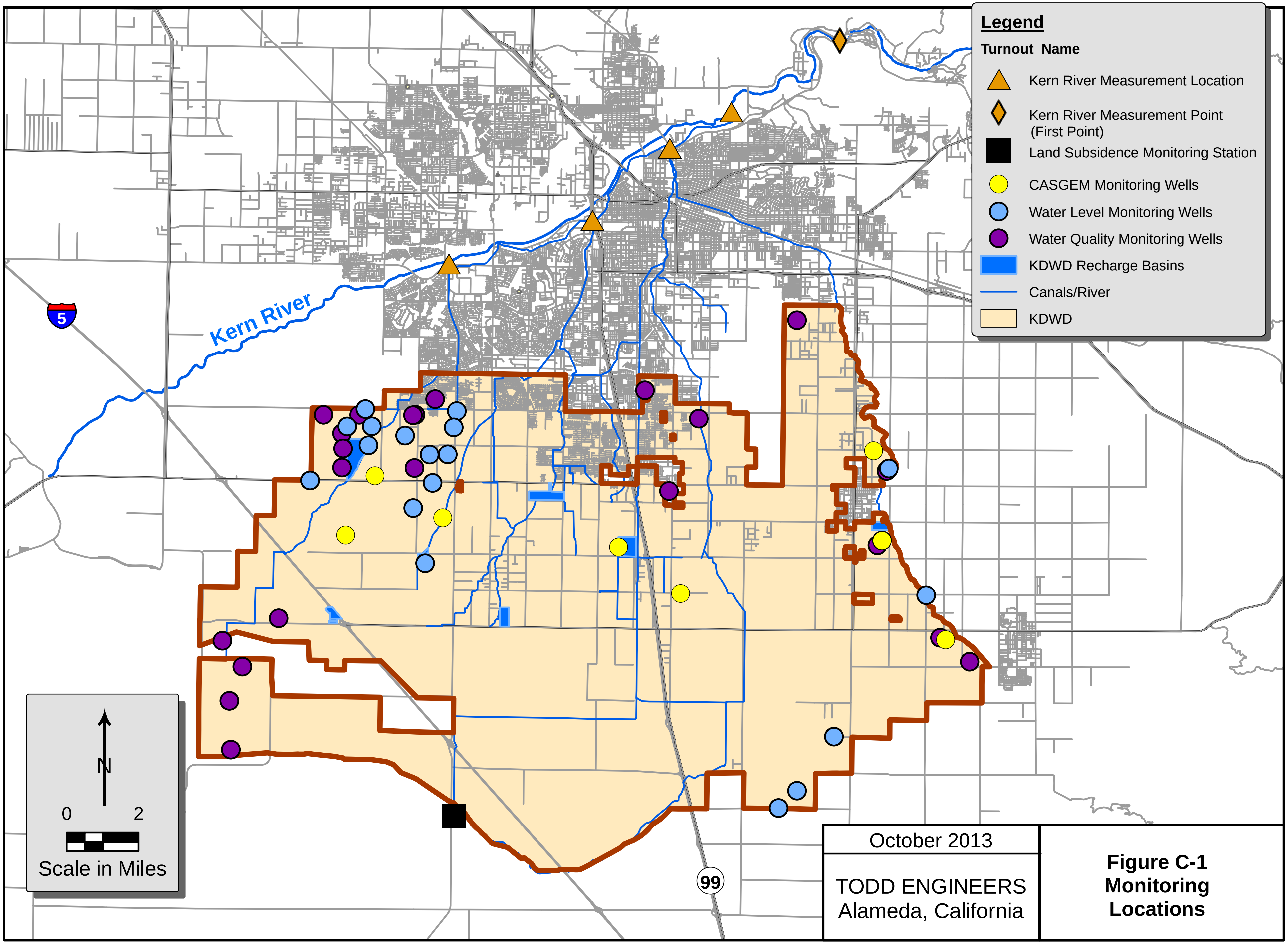
C.2.1 Methods

Kern River flows are measured at First Point and routed into regional canals for conveyance into the District. KDWD monitors Kern River diversions at four monitoring points as listed below and shown on Figure C-1:

- Rocky Point Weir as water is diverted into the Carrier Canal
- Kern Island – Eastside Weir at the Arvin Edison Intake Canal
- Stine-Farmers Weir at the Stine Headgate
- Buena Vista Canal Weir on the River Canal.

Deliveries from the KDWD main canals and laterals are also monitored, allowing estimates of groundwater recharge along the unlined canals. Data are summarized on a daily basis.

The City of Bakersfield and Improvement District No. 4 (ID-4) monitors surface water quality at various locations along the Carrier and River canals. As part of these monitoring protocols, KDWD will compile key relevant water quality data as available and incorporate them into its monitoring reports.



October 2013

TODD ENGINEERS
Alameda, California

Figure C-1
Monitoring Locations

C.2.3 Data Management

Surface water flow and diversion monitoring data are provided to the City of Bakersfield, where it is compiled into the annual hydrographic reports. These reports provide accounting of monthly diversions, deliveries, and loss along the canals among all First Point diverters. In addition, KDWD maintains records for internal accounting.

C.3 Water Levels

Since 1989, KDWD has conducted a groundwater level monitoring program involving approximately 100 to 150 wells. Typically, semi-annual measurements are made in Spring and Fall representing the annual high and low water levels, respectively. Almost all of the wells are active or inactive agricultural wells that have been made available for District monitoring. Although construction data are limited, most wells are screened in various aquifer zones and measurements represent average water levels beneath the District. Data are used to track changes in water levels and estimate trends and fluctuations. Over time, the number and location of wells has varied with changes in well availability and changes in program objectives.

In addition to the ongoing water level monitoring program, eight key wells have been selected for more systematic water level monitoring as part of the CASGEM program. Water level monitoring locations are shown on Figure C-1.

C.3.1 Methods

For active wells, measurements are made after the well pump has been turned off for at least 24 hours, when possible. In addition, data are compared to inactive wells to assess the reliability of the readings.

Reference point elevations are measured by field personnel with handheld global positioning system (GPS) devices. Water level measurements are made with an acoustic sounder. Field personnel follow the procedure recommended by the sounder manufacturer as reproduced below:

1. Place sensor inside well or in contact with the wellhead at the reference point.
2. Plug the sensor cable into the Speaker jack on the unit.
3. Turn selector knob to Auto and turn the power on.
4. Note the pulsing sound from the sensor and the 4 dashes on the unit display; within seconds, the distance to the water surface will appear on the display. It is normal for the unit to transmit 6 or 7 pulses before the reading is displayed.
5. Readings are saved electronically and noted manually on field forms.

C.3.2 Monitoring Points

The 2012 water level monitoring program consisted of 23 wells, including eight key wells that have been identified for the CASGEM program. The locations of the water level monitoring points are provided on Figure C-1 with the CASGEM wells highlighted. Construction data are not available for most wells in the larger District water level program. Available data for the CASGEM wells are provided on Table C-1.

Table C-1
CASGEM Monitoring Wells
Kern Delta Water District

Well Designation		Year Drilled	Location		Reference Elevation (ft, msl)	Total Depth (ft, bgs)	Screen Interval	
No.	State Well Number		Latitude	Longitude			Top (ft, bgs)	Bottom (ft, bgs)
1	30S/26E-35C01	2008	35.16.143	119.08.998	333	630	230	600
2	31S/26E-10J	1977	35.14.705	119.09.842	332	709	400	709
3	31S/27E-7B	1955	35.15.150	119.06.990	335	641	156	630
4	31S/27E-12Q	2008	35.14.486	119.01.805	327	720	200	697
5	31S/28E-20D	1961	35.13.379	118.59.968	317	200	100	200
6	30S/29E-31C	NA	35.16.878	118.54.325	417	NA	NA	NA
7	31S/29E-7K	1991	35.14.705	118.54.051	412	780	330	780
8	31S/29E-28C	1963	35.12.317	118.52.157	412	530	280	530

C.3.3 Frequency

Water levels are recorded in Spring and Fall to capture annual fluctuations from seasonal groundwater pumping. Typically, wells are measured in April and November, representing the annual high and low water levels, respectively. Some of these wells may be monitored more frequently (e.g., quarterly) to address specific groundwater management issues.

C.3.4 Data Management

All water level data are maintained in the District's hydrography division. Field measurements for the CASGEM wells are compiled, checked, recorded on the DWR Form 1213, and uploaded to the CASGEM website. Field measurements will be kept onsite for one year for reference.

C.4 Groundwater Quality

Groundwater quality issues identified previously within KDWD have focused on salts and nutrients. The City of Bakersfield, Cal Water and other purveyors monitor wells in and near KDWD for drinking water quality – no issues of concern have been identified (Stetson, 2007). Although significant amounts of high quality water are recharged in the District, the combination of increased groundwater pumping and high salinity sediments to the south represent a potential for deteriorating water quality. The primary discharge of groundwater beneath the District is to wells. As groundwater is reused for irrigation, salts and nutrients can become concentrated in the soils and groundwater over time. A review of groundwater quality data from the early 1990s and a few additional monitoring points from 2005-2006 indicate that problematic levels of salts and nutrients have not occurred. However, more recent monitoring is needed to confirm and track this issue.

C.4.1 Methods

Clean laboratory containers will be obtained for sample collection and transport to the laboratory. Chain-of-custody forms will be completed to track the sample from collection through analysis. California-certified laboratories will be used for the analysis.

To the extent practical, the well will be pumped (purged) prior to sample collection. Field personnel will note the time that the pump was turned on and the amount of water purged prior to sampling. Water samples will be collected at a sampling port if available to minimize volatilization or air entrainment.

C.4.2 Monitoring Points

The final groundwater quality monitoring program will be developed over time. As an initial program, the eight wells included in the CASGEM program will be considered for groundwater quality analysis. These wells were selected because well construction data are generally available and a long-term water level record will be developed to inform future interpretation of groundwater quality data. Because most of these wells are privately owned, permission to sample for water quality must be obtained. Additional wells owned by the District will also be considered for the program unless determined to be duplicative with other wells.

C.4.3 Frequency

Groundwater quality monitoring will be conducted annually each fall. Although the actual timing is yet to be determined, September or October will be considered after the irrigation season is complete and water in the vadose zone has had some time for percolation.

C.4.4 Analytes

Major anions and cations, along with general physical parameters, are the focus of the KDWD groundwater quality monitoring program. These analyses are relatively inexpensive and provide specific concentrations on salts (TDS) and nutrients (NO_3) as well as valuable data on overall groundwater chemistry. As a quality control measure, an anion-cation balance will be requested to ensure the analytical integrity of the sample.

Additional analytes may be incorporated from time to time to address specific issues as they arise. Drinking water quality data (Title 22) may be available from municipal wells within the District and can be incorporated as available.

C.4.5 Data Management

All laboratory data are filed in the District's hydrography division. Data are transferred into an electronic database as needed for comparison and analysis. Electronic software for storing and analyzing groundwater quality data includes Microsoft Excel or Access database formats. Well locations will be entered in the project GIS for spatial analysis of the data.

C.5 Groundwater Storage

KDWD examines changes in groundwater levels from their ongoing monitoring program. As water levels rise and decline annually, changes are noted and reported to the KDWD Board of Directors in an internal groundwater monitoring report. In addition, KCWA prepares annual water level contour maps that cover the Management Area. These maps are reviewed and compared to changes indicated in ongoing water level monitoring.

The District intends to update or modify an existing groundwater model to allow for a more rigorous evaluation of changes in groundwater storage. Water level contour maps will continue to be generated annually; these can be coupled to the groundwater model to provide a more quantitative approach to changes in groundwater budgets and storage.

C.5.1 Methods

In 2001, the District retained Boyle Engineering to construct a MODFLOW groundwater model across the Management Area. That model has not been updated and is not available for a quantitative assessment of groundwater storage. A more regional MODFLOW model is currently being developed by the Kern Fan Monitoring Committee, a project in which KDWD is participating. That model contains more updated information and covers most of KDWD. Model completion is currently scheduled for late 2013. The District may elect to modify and use one of the existing models to conduct ongoing assessments of groundwater storage in the Management Area. After review of the model water budgets over several decades, simplifying assumptions and a streamlined analytical method may be developed to quickly monitor changes in groundwater storage outside of the numerical model.

C.5.2 Data Management

The groundwater model will be based on a detailed database that incorporates groundwater recharge and discharge within and beyond the Management Area. Changes in water levels and the groundwater budgets will be the primary output from model simulations, including quantitative assessments of subsurface inflow and outflow.

C.6 Groundwater Extractions

The analysis of groundwater use provided in Section 4.4 provides an estimate of groundwater extractions for irrigation based on a systematic assessment of irrigation demand. This methodology is judged sufficient for ongoing groundwater management activities. In the future, a more detailed accounting of groundwater use would allow for better planning and a more quantitative assessment of groundwater conditions.

For future activities, KDWD staff will work with the PAC and District customers to develop more accurate methods of determining groundwater extractions. This will allow for better management of water levels and storage and help identify areas in which to focus future recharge and conjunctive use strategies.

C.7 Land Subsidence

Prior to this GWMP Update, monitoring of land subsidence has been conducted indirectly only through the use of water level monitoring data. To improve land subsidence monitoring, a more direct monitoring approach will be implemented. This approach will incorporate currently available geodetic data near KDWD into the monitoring program as described in more detail below.

An additional improvement will include the tabulation of vertical datum from key benchmarks throughout the District. As new infrastructure is added, survey elevations will be updated at these locations as an additional check on potential land subsidence.

C.7.1 Methods and Data Management

Two continuously operating reference stations (CORS) are monitored by the National Geodetic Survey. The stations provide global navigation satellite system data in support of three dimensional positioning for a variety of applications throughout the United States. CORS-enhanced post processed coordinates are within a few centimeters relative to the National Spatial Reference System both horizontally and vertically. Data can be downloaded for each station free of charge.

Two stations are maintained in Bakersfield and one station, Bakersfield 1 (BKR1), is located on Old River Road at the Kern Dry Lake Bed about 1,500 feet south of the KDWD boundary as shown on Figure C-1. The current latitude/longitude of the station is 350756.63N; -1190634.19E with a vertical datum of 56.745 meters (186.2 feet). The other station, BKR2, is located north of KDWD, and will serve as a reference point for changes at BKR1. Vertical and horizontal data from the CORS BKR1 and BKR2 will be downloaded and reviewed on an annual basis.

C.7.2 Data Management

Data from BKR1 and BKR2 will be tabulated over time including horizontal and vertical coordinates. Changes in vertical datum at BKR1 will be compared to BKR2 for potential changes beneath KDWD. Significant changes at BKR1 that do not occur at BKR2 will be identified for further evaluation.

APPENDIX D

Index to Recommended and Required Components of a Groundwater Management Plan

D. Index to Recommended and Required Components of a Groundwater Management Plan

To facilitate the review and use of this GWMP Update, an index of key GWMP components is provided on Table D-1. These GWMP components have been compiled from the Water Code and various lists by DWR and others. Most of these components are incorporated throughout the structure of the GWMP Update, and not all appearances are referenced. However, the table lists representative sections of the document and demonstrates inclusion of the recommended and required components in this GWMP Update.

Table D-1
Index to Required and Recommended Components of a Groundwater Management Plan

GWMP Component		Location in This GWMP Update*
A. CWC § 10753.7 *et seq.* Required Components (SB 1938)		
1	Develop Quantitative Basin Management Objectives	Section 5
2	Involve and Cooperate with Other Agencies	Sections 2.1, 2.2, 2.3, 2.4, 2.5, and 2.6. Sections 3.4.2, and 3.4.4. Section 4.4.2. Section 5.6. Sections 6.2, 6.4, 6.6, 6.9, 6.12, 6.13, 6.14. Section 7.1 and Table 13.
3	Prepare Map of DWR Bulletin 118 Groundwater Basin and Management Area. Show Map of Other Agencies	Figures 1, 2, and 3
4	Provide Map of Primary Recharge Areas	Figure 20, Section 6.5.3.
5	Develop and Adopt Monitoring Protocols for Groundwater Levels, Storage, Quality, and Inelastic Land Subsidence	Appendix C, Section 5.5, Sections 4.5.4 and 4.5.5, 6.7, and 6.11. Section 7 and Table 13
6	Document Public Involvement Plan	Section 1.3, Appendix A
7	Monitor and Describe Changes in Surface Water Flows/Quality affecting levels or caused by pumping	Sections 3.5.2 (last paragraph), 4.3 (4.3.1), 4.4 (3rd paragraph), 4.5.2., and 5.5, and Appendix C, especially Section C.2.
B. CWC § 10753.7 *et seq.* Voluntary Components (AB3030)		
1	Control Saline Intrusion	Table 12, Section 6.1.
2	Manage Wellhead Protection and Recharge Areas	Table 12, Section 6.2.
3	Prevent Migration of Groundwater Contamination	Table 12, Section 6.3.
4	Administer Well Abandonment and Destruction Program	Table 12, Section 6.4.
5	Mitigate Overdraft Conditions	Table 12, Section 6.5.
6	Manage Groundwater Extraction and Replenishment	Table 12, Section 6.6, and 6.8.
7	Monitor Groundwater Levels and Storage	Table 12, Section 6.7.
8	Facilitate Conjunctive Use Operations	Table 12, Section 6.6.
9	Identify Well Construction Policies	Table 12, Section 6.9.
10	Operate Contaminant Remediation, Recharge, Conservation, Recycling, or Extraction Projects	Table 12, Section 6.10.
11	Develop Relationships with Regulatory Agencies	Table 12, Section 6.12.
12	Coordinate with Land Use Planning Agencies	Table 12, Section 6.13.
C. DWR Suggested Components		
1	Assemble Project Advisory Committee	Section 1.3.
2	Describe GWMP Management Area	Section 1.2. Section 3, especially 3.5. Section 4 (all).
3	Link BMOs with Best Management Practices	Table 12, Chapter 6, Section 2.5, Section 5.6 (last bullet item)
4	Describe GWMP Monitoring Program	Appendix C. Sections 4.2, 4.4, 4.5 (especially 4.5.5). Section 5.5. Sections 6.3, 6.7, and 6.11, Section 7.2.
5	Describe Integrated Water Management Planning Efforts	Section 2.4. Sections 3.4, especially 3.4.2, and 3.4.4.
6	Provide GWMP Implementation Schedule	Section 7. Table 13.
7	Describe Ongoing Reporting of Management Activities	Section 7.3.

* Numerous aspects of each component are incorporated throughout this GWMP Update; specific references to all related text are too numerous to provide a comprehensive list. Rather, primary sections of the GWMP dedicated to each of the components are provided in this table.

Appendix F: Water Quality Information

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Source Water 2014

Constituent	Units	PHG*	MCL*	Source			
				Friant Kern	Groundwater	Aqueduct	Kern River
Primary Inorganic Chemicals							
Aluminum	mg/L	0.6	1	ND	ND	ND	0.528
Antimony	mg/L	0.02	0.006	ND	ND	ND	ND
Arsenic	mg/L	0.000004	0.010	ND	ND	0.006	0.006
Asbestos	MFL	7	7	ND	ND	ND	ND
Barium	mg/L	2	1	ND	ND	ND	ND
Beryllium	mg/L	0.001	0.004	ND	ND	ND	ND
Cadmium	mg/L	0.00004	0.005	ND	ND	ND	ND
Chromium, Total	mg/L	N/A	0.05	ND	ND	0.001	0.001
Chromium, Hexavalent	mg/L	0.00002	0.010	ND	ND	0.001	ND
Cyanide	mg/L	0.15	0.15	ND	ND	ND	ND
Fluoride	mg/L	1	2	0.14	0.14	0.16	0.28
Lead**	mg/L	0.0002	0.015	ND	ND	ND	ND
Mercury	mg/L	0.0012	0.002	ND	ND	ND	ND
Nickel	mg/L	0.012	0.1	ND	ND	ND	ND
Nitrate (as NO_3)	mg/L	45	45	4.82	4.88	3.49	ND
Nitrite (as Nitrogen, N)	mg/L	1	1	ND	ND	ND	ND
Nitrate + Nitrite (sum as Nitrogen, N)	mg/L	10	10	1.09	1.10	0.79	ND
Perchlorate	mg/L	0.006	0.006	ND	ND	ND	ND
Selenium	mg/L	0.03	0.05	ND	ND	ND	ND
Thallium	mg/L	0.0001	0.002	ND	ND	ND	ND
Secondary Standards							
Aluminum	mg/L	N/A	0.2	ND	ND	ND	0.528
Color	Units	N/A	15	< 2.5	< 2.5	< 2.5	30
Copper**	mg/L	0.3	1.3	ND	ND	ND	ND
Foaming Agents (MBAS)	mg/L	N/A	0.5	ND	ND	ND	ND
Iron	mg/L	N/A	0.3	ND	ND	ND	0.855
Manganese	mg/L	N/A	0.05	ND	ND	ND	0.035
Methyl tert-butyl ether	mg/L	N/A	0.005	ND	ND	ND	ND
Odor	Units	N/A	3	3	4	4	4
Silver	mg/L	N/A	0.1	ND	ND	ND	ND
Thiobencarb	mg/L	N/A	0.001	ND	ND	ND	ND
Turbidity	Units	N/A	5	0.38	0.32	0.55	7.72
Zinc	mg/L	N/A	5.0	ND	ND	ND	ND
Total Dissolved Solids	mg/L	N/A	1000	136	136	276	126
Specific Conductance	uS/cm	N/A	1600	243	244	507	248
Chloride	mg/L	N/A	500	21.3	21.0	75.0	9.68
Sulfate	mg/L	N/A	500	17.3	17.3	53.8	25.5
General Minerals							
Total Alkalinity (as $CaCO_3$)	mg/L	N/A	N/A	64	66	67	80
Bicarbonate	mg/L	N/A	N/A	78.1	80.5	73.2	97.6
Carbonate	mg/L	N/A	N/A	ND	ND	8.4	ND
Hydroxide	mg/L	N/A	N/A	ND	ND	ND	ND
Total Hardness (as $CaCO_3$)	mg/L	N/A	N/A	71.5	73.5	89.8	64.4
Calcium	mg/L	N/A	N/A	23.9	24.6	27.5	19.6
Magnesium	mg/L	N/A	N/A	2.88	2.94	5.13	3.76
Sodium	mg/L	N/A	N/A	18.9	18.9	60.4	23.7
Potassium	mg/L	N/A	N/A	1.39	1.43	1.74	2.46
pH	Units	N/A	N/A	8.90	8.64	9.00	7.91
Additional Analyses							
Ammonia	mg/L	N/A	N/A	0.05	0.06	0.07	0.06
Boron***	mg/L	N/A	1	ND	ND	0.17	0.25
Bromide	mg/L	N/A	N/A	0.10	0.07	0.28	0.03
Phosphate	mg/L	N/A	N/A	ND	ND	ND	ND
Silica	mg/L	N/A	N/A	19.3	18.7	12.4	6.88
Total Organic Carbon	mg/L	N/A	N/A	0.65	0.60	1.5	2.1
Radioactivity							
Gross Alpha	pCi/L	N/A	15	4.42	ND	ND	5.52
Gross Beta	mrem/yr	N/A	4	-	-	-	-
Radium 226 + Radium 228	pCi/L	N/A	5	-	-	-	-
Radium 226	pCi/L	0.05	N/A	-	-	-	ND
Radium 228	pCi/L	0.019	N/A	-	-	-	ND
Strontium-90	pCi/L	0.35	8	-	-	-	-
Tritium	pCi/L	400	20,000	-	-	-	-
Uranium	pCi/L	0.43	20	-	-	-	4.5

*Applicable to treated water only
**Values identified as MCLs are Action Levels under the lead and copper rule
***Values identified as MCLs are Notification Levels or Advisory Levels for constituents lacking MCLs

N/A = Not Applicable
ND = Not Detected
NTU = nephelometric turbidity units

Source Water 2014 - continued

Constituent	Units	PHG*	MCL*	Sample Date			
				Friant Kern	Groundwater	Aqueduct	Kern River
Regulated Volatile Organic Chemicals							
Benzene	mg/L	0.00015	0.001	ND	ND	ND	ND
Carbon Tetrachloride	mg/L	0.0001	0.0005	ND	ND	ND	ND
1,2-Dichlorobenzene	mg/L	0.6	0.6	ND	ND	ND	ND
1,4-Dichlorobenzene	mg/L	0.006	0.005	ND	ND	ND	ND
1,1-Dichloroethane	mg/L	0.003	0.005	ND	ND	ND	ND
1,2-Dichloroethane	mg/L	0.0004	0.0005	ND	ND	ND	ND
1,1-Dichloroethylene	mg/L	0.01	0.006	ND	ND	ND	ND
cis-1,2-Dichloroethylene	mg/L	0.1	0.006	ND	ND	ND	ND
trans-1,2-Dichloroethylene	mg/L	0.06	0.01	ND	ND	ND	ND
Dichloromethane	mg/L	0.004	0.005	ND	ND	ND	ND
1,2-Dichloropropane	mg/L	0.0005	0.005	ND	ND	ND	ND
1,3-Dichloropropene	mg/L	0.0002	0.0005	ND	ND	ND	ND
Ethylbenzene	mg/L	0.3	0.3	ND	ND	ND	ND
Methyl tert-butyl ether	mg/L	0.013	0.013	ND	ND	ND	ND
Monochlorobenzene	mg/L	0.07	0.07	ND	ND	ND	ND
Styrene	mg/L	0.0005	0.1	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	mg/L	0.0001	0.001	ND	ND	ND	ND
Tetrachloroethylene	mg/L	0.00006	0.005	ND	ND	ND	ND
Toluene	mg/L	0.15	0.15	ND	ND	ND	ND
1,2,4-Trichlorobenzene	mg/L	0.005	0.005	ND	ND	ND	ND
1,1,1-Trichloroethane	mg/L	1	0.2	ND	ND	ND	ND
1,1,2-Trichloroethane	mg/L	0.0003	0.005	ND	ND	ND	ND
Trichloroethylene	mg/L	0.0017	0.005	ND	ND	ND	ND
Trichlorofluoromethane	mg/L	1.3	0.15	ND	ND	ND	ND
1,1,2-Trichloro-1,2,2-Trifluoroethane	mg/L	4	1.2	ND	ND	ND	ND
Vinyl Chloride	mg/L	0.00005	0.0005	ND	ND	ND	ND
Xylenes (total)	mg/L	1.8	1.75	ND	ND	ND	ND
Regulated Non-Volatile Synthetic Organic Chemicals							
Alachlor	mg/L	0.004	0.002	ND	ND	ND	ND
Atrazine	mg/L	0.00015	0.001	ND	ND	ND	ND
Bentazon	mg/L	0.2	0.018	ND	ND	ND	ND
Benzo(a)pyrene	mg/L	0.000007	0.0002	ND	ND	ND	ND
Carbofuran	mg/L	0.0017	0.018	ND	ND	ND	ND
Chlordane	mg/L	0.00003	0.0001	ND	ND	ND	ND
Dalapon	mg/L	0.79	0.2	ND	ND	ND	ND
1,2-Dibromo-3-chloropropane	mg/L	0.0000017	0.0002	0.000012	0.000013	ND	ND
2,4-Dichlorophenoxyacetic acid (2,4-D)	mg/L	0.02	0.07	ND	ND	ND	ND
Di(2-ethylhexyl)adipate	mg/L	0.2	0.4	ND	ND	ND	ND
Di(2-ethylhexyl)phthalate	mg/L	0.012	0.004	ND	ND	ND	ND
Dinoseb	mg/L	0.014	0.007	ND	ND	ND	ND
Diquat	mg/L	0.015	0.02	ND	ND	ND	ND
Endrin	mg/L	0.0018	0.002	ND	ND	ND	ND
Endothall	mg/L	0.094	0.1	ND	ND	ND	ND
Ethylene Dibromide	mg/L	0.00001	0.00005	ND	ND	ND	ND
Glyphosate	mg/L	0.9	0.7	ND	ND	ND	ND
Heptachlor	mg/L	0.000008	0.00001	ND	ND	ND	ND
Heptachlor Epoxide	mg/L	0.000006	0.00001	ND	ND	ND	ND
Hexachlorobenzene	mg/L	0.00003	0.001	ND	ND	ND	ND
Hexachlorocyclopentadiene	mg/L	0.002	0.05	ND	ND	ND	ND
Lindane	mg/L	0.000032	0.0002	ND	ND	ND	ND
Methoxychlor	mg/L	0.00009	0.03	ND	ND	ND	ND
Molinate	mg/L	0.001	0.02	ND	ND	ND	ND
Oxamyl	mg/L	0.026	0.05	ND	ND	ND	ND
Pentachlorophenol	mg/L	0.0003	0.001	ND	ND	ND	ND
Picloram	mg/L	0.5	0.5	ND	ND	ND	ND
Polychlorinated Biphenyls	mg/L	0.00009	0.0005	ND	ND	ND	ND
Simazine	mg/L	0.004	0.004	ND	ND	ND	ND
2,4,5-TP (Silvex)	mg/L	0.003	0.05	ND	ND	ND	ND
2,3,7,8-TCDD (Dioxin)	mg/L	0.00000000005	0.00000003	waived	waived	waived	waived
Thiobencarb	mg/L	0.07	0.07	ND	ND	ND	ND
Toxaphene	mg/L	0.00003	0.003	ND	ND	ND	ND

*Applicable to treated water only
**Values identified as MCLs are Action Levels under the lead and copper rule
***Values identified as MCLs are Notification Levels or Advisory Levels for constituents lacking MCLs
MCL = Maximum Contaminant Level
MFL = million fibers per liter: MCL for fibers exceeding 10 micrometers in length

N/A = Not Applicable
ND = Not Detected
NTU = nephelometric turbidity units
pCi/L = picocuries per liter
PHG = Public Health Goal

Source Water 2014 - continued

Constituent	Units	PHG*	MCL*	Sample Date			
				Friant Kern	Groundwater	Aqueduct	Kern River
Unregulated Volatile Organic Chemicals							
tert-Amyl methyl ether	mg/L	N/A	N/A	ND	ND	ND	ND
Bromobenzene	mg/L	N/A	N/A	ND	ND	ND	ND
Bromochloromethane	mg/L	N/A	N/A	ND	ND	ND	ND
Bromomethane	mg/L	N/A	N/A	ND	ND	ND	ND
Tertiary butyl alcohol***	mg/L	N/A	0.012	-	-	-	-
n-Butylbenzene***	mg/L	N/A	0.26	ND	ND	ND	ND
sec-Butylbenzene***	mg/L	N/A	0.26	ND	ND	ND	ND
tert-Butylbenzene***	mg/L	N/A	0.26	ND	ND	ND	ND
Chloroethane	mg/L	N/A	N/A	ND	ND	ND	ND
Chloromethane	mg/L	N/A	N/A	ND	ND	ND	ND
2-Chlorotoluene***	mg/L	N/A	0.14	ND	ND	ND	ND
4-Chlorotoluene***	mg/L	N/A	0.14	ND	ND	ND	ND
Dibromomethane	mg/L	N/A	N/A	ND	ND	ND	ND
1,3-Dichlorobenzene***	mg/L	N/A	0.6	ND	ND	ND	ND
Dichlorodifluoromethane***	mg/L	N/A	1	ND	ND	ND	ND
1,3-Dichloropropane	mg/L	N/A	N/A	ND	ND	ND	ND
2,2-Dichloropropane	mg/L	N/A	N/A	ND	ND	ND	ND
1,1-Dichloropropene	mg/L	N/A	N/A	ND	ND	ND	ND
Diisopropyl ether	mg/L	N/A	N/A	ND	ND	ND	ND
Ethyl tert-butyl ether	mg/L	N/A	N/A	ND	ND	ND	ND
Hexachlorobutadiene	mg/L	N/A	N/A	ND	ND	ND	ND
Isopropylbenzene***	mg/L	N/A	0.77	ND	ND	ND	ND
p-Isopropyltoluene	mg/L	N/A	N/A	ND	ND	ND	ND
Naphthalene***	mg/L	N/A	0.017	ND	ND	ND	ND
Nitrobenzene	mg/L	N/A	N/A	ND	ND	ND	ND
Pentachloroethane	mg/L	N/A	N/A	ND	ND	ND	ND
n-Propylbenzene***	mg/L	N/A	0.26	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	mg/L	N/A	N/A	ND	ND	ND	ND
1,2,3-Trichlorobenzene	mg/L	N/A	N/A	ND	ND	ND	ND
1,3,5-Trichlorobenzene	mg/L	N/A	N/A	ND	ND	ND	ND
1,2,3-Trichloropropane***	mg/L	0.0000007	0.000005	0.000007	0.000009	ND	ND
1,2,3-Trimethylbenzene	mg/L	N/A	N/A	ND	ND	ND	ND
1,2,4-Trimethylbenzene***	mg/L	N/A	0.33	ND	ND	ND	ND
1,3,5-Trimethylbenzene***	mg/L	N/A	0.33	ND	ND	ND	ND
Methyl isobutyl ketone***	mg/L	N/A	0.12	ND	ND	ND	ND
Unregulated Non-Volatile Synthetic Organic Chemicals							
Aldicarb***	mg/L	N/A	0.007	ND	ND	ND	ND
Aldicarb Sulfone	mg/L	N/A	N/A	ND	ND	ND	ND
Aldicarb Sulfoxide	mg/L	N/A	N/A	ND	ND	ND	ND
Aldrin***	mg/L	N/A	0.000002	ND	ND	ND	ND
Bromacil	mg/L	N/A	N/A	ND	ND	ND	ND
Butachlor	mg/L	N/A	N/A	ND	ND	ND	ND
Carbaryl***	mg/L	N/A	0.7	ND	ND	ND	ND
Chlorothalonil	mg/L	N/A	N/A	ND	ND	ND	ND
Diazinon***	mg/L	N/A	0.0012	ND	ND	ND	ND
Dicamba	mg/L	N/A	N/A	ND	ND	ND	ND
Dieldrin***	mg/L	N/A	0.000002	ND	ND	ND	ND
Dimethoate***	mg/L	N/A	0.001	ND	ND	ND	ND
Diuron	mg/L	N/A	N/A	ND	ND	ND	ND
3-Hydroxycarbofuran	mg/L	N/A	N/A	ND	ND	ND	ND
Methomyl	mg/L	N/A	N/A	ND	ND	ND	ND
Metolachlor	mg/L	N/A	N/A	ND	ND	ND	ND
Metribuzin	mg/L	N/A	N/A	ND	ND	ND	ND
Propachlor***	mg/L	N/A	0.09	ND	ND	ND	ND
Trifluralin	mg/L	N/A	N/A	ND	ND	ND	ND
2,4,5-T	mg/L	N/A	N/A	ND	ND	ND	ND

*Applicable to treated water only
**Values identified as MCLs are Action Levels under the lead and copper rule
***Values identified as MCLs are Notification Levels or Advisory Levels for constituents lacking MCLs
MCL = Maximum Contaminant Level
MFL = million fibers per liter: MCL for fibers exceeding 10 micrometers in length
mg/L = milligrams per liter (parts per million)
mrem/yr = millirems per year

N/A = Not Applicable
ND = Not Detected
NTU = nephelometric turbidity units
pCi/L = picocuries per liter
PHG = Public Health Goal
uS/cm = microsiemens per centimeter

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Appendix G: Climate Change and Vulnerability Assessment Technical Memorandum

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8 September 2014

California Department of Water Resources
Division of Integrated Regional Water Management
Financial Assistance Branch – Attn: Ted Daum
Post Office Box 942836
Sacramento, CA 94236-0001

Subject: Climate Change and Vulnerability Assessment submission as an addendum to the Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan (Kern IRWMP)

Dear Mr. Daum:

Enclosed please find the Climate Change and Vulnerability Assessment submission as an addendum to the Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan (Kern IRWMP). It is being submitted as a result of the June 6, 2014 IRWM Plan Review Process recommendations prepared by DWR. Members of the Kern IRWMP Executive Committee discussed the results of the Plan Review Process with you during a conference call on July 7, 2014, when it was determined that the Climate Change Standard and Vulnerability Assessment should be addressed so that the Kern IRWMP would be in compliance with the IRWM Guidelines. This will also enable the Kern IRWMP to meet the requirements of the Proposal Solicitation Package for Emergency Drought Funding; an application was submitted by project proponents on July 21, 2014.

The Kern IRWMP participants met on August 25, 2014 to conduct the Vulnerability Assessment and review the draft Climate Change submission (agenda and meeting notes attached). Comments were received and incorporated.

Your contact person for matters regarding this submittal is:

Ms. Lauren Bauer
Kern County Water Agency
PO Box 58
Bakersfield, CA 93302-0058
661/634-1411
lbauer@kcwa.com

We appreciate your assistance in this matter. Please feel free to contact Ms. Bauer with any questions or comments.

Very truly yours,

KENNEDY/JENKS CONSULTANTS

Mary Lou Cotton
Practice Leader, Water Resources

Attachments

cc: Joe Yun, DWR

September 5, 2014

Technical Memorandum

To: Kern IRWMP Participants Group c/o Ms. Lauren Bauer, Water Resources Planner

From: Mary Lou Cotton

Subject: Vulnerability to Climate Change Technical Memorandum
K/J 1289035*01

Climate change refers to significant changes in temperature, precipitation, wind patterns and other weather that occur over several decades and beyond. Climatic changes observed in recent decades are occurring due to rising average global temperatures that are the result of elevated levels of gases released primarily by human activities, which trap heat in the atmosphere in a process known as the greenhouse effect. These so-called greenhouse gases (GHGs) include, among others, water vapor, carbon dioxide (CO_2) and methane (CH_4).

Climate change is impacting California water resources in many ways, including through rising sea levels, reduced snowpack, and more frequent and severe droughts. Impacts and vulnerabilities vary by region resulting in the need for tailored actions to ensure the viability of regional watersheds, including the Kern Region. These actions focus on reducing the intensity of climate change through mitigation measures and adapting to climate change effects.

This technical memorandum identifies the potential climate change vulnerabilities in the Kern Region as well as potential future actions to mitigate the vulnerabilities to climate change. The climate change vulnerability assessment presented in this section includes the checklist assessment in the Department of Water Resources (DWR's) *Climate Change Handbook for Regional Water Planning* and is consistent with climate change requirements in the Proposition 84 Integrated Regional Water Management Plan (IRWMP) Guidelines (June 2014).

1.1 Climate Change Projections Overview

A climate change assessment is performed using the output of computer models that project future conditions from inputs on GHG emissions. These models are not predictive, but provide projections of potential future climate scenarios that can be used for planning purposes.

Climate change has the potential to have significant impacts on the Kern IRWM Region. The U.S. Bureau of Reclamation (Reclamation), the State of California and others continue to study climate change and its potential impacts on water and other resources in the western states.

The primary climate variables projected by global climate models (GCMs) that are important for water resources planning in California are changes in air temperature, changes in precipitation patterns, and sea level rise. The State of California 2009 Climate Change Impacts Assessment (California Climate Change Center 2009) provides the scientific basis for developing statewide climate change impact projections. The 2009 assessment provided future climate projections to support water resources decision making in California. A set of six GCMs were run for two

GHG emissions scenarios, A2 and B1, selected from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES). The IPCC report provides a family of common scenarios that cover a range of plausible trends in GHG emissions over the 21st century as a result of economic, technological, and population change (IPCC 2007). Scenario A2 assumes higher GHG emissions and high growth in population and represents a more competitive world that lacks cooperation in development (similar to business as usual), while B1 is a lower GHG emission scenario that represents social consensus for sustainable development. Each GCM was used to simulate a historical period from 1950-1999 and a future projection period from 2000 to 2100. The 1950-1999 period serves as a baseline or "present condition" for the models so that future conditions can be projected. Table 1 lists the six GCM models and their sponsoring organization, the combination of which were used to evaluate climate change impacts in the Kern Region.

Table 1: Summary of Global Climate Models

GCM	Sponsoring Organization and Model Name
NCAR-PCM1[(a)]	National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM)
GFDL-CM21[(a)]	National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluids Dynamics Laboratory (GFDL) model, version 2.1
NCAR-CCSM3[(a)]	NCAR Community Climate System Model (CCSM)
MPI-ECHAM5	Max Plank Institute ECHAM5/MPI-OM Used by DWR for its climate change analysis for the 2011 Reliability Report, but the 2013 Draft Report Update uses Bay Delta Conservation Plan (BDCP) LLT CC5 input hydrology.
MIROC32	MIROC 3.2 medium-resolution model from the Center for Climate System Research of the University of Tokyo and collaborators
CNRM-CM3[(a)]	French Centre National de Recherches Météorologiques (CNRM) models
Four Model Average[(a)]	Cal-Adapt website. Average of the following four GCMs: NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3. Used in this analysis for Kern River Region

Note: (a) Model used by Cal-Adapt.

DWR used the MPI-ECHAM5 model with the A2 emissions scenario when preparing the 2011 *State Water Project Delivery Reliability Report*. MPI-ECHAM5 represents the median of the six GCMs listed in Table 1. However, the 2013 *Draft Delivery Reliability Report* (December 2013) uses the climate change input hydrology developed for the Bay Delta Conservation Plan (BDCP) for the Late Long Term planning horizon and the 5th climate change region (BDCP LLT CC5 input hydrology). This had the effect of lowering State Water Project (SWP) long-term future reliability, from 60% to 58%.

The California Energy Commission's Public Interest Energy Research Program (PIER) recently established the Cal-Adapt website (http://cal-adapt.org/), whose purpose is to explore California's climate change research. In part, the website provides output from four climate models (NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3) and two GHG emission scenarios (A2 and B1) downscaled to any location in California. The four GCMs are a subset of the six GCMs identified in Table 1. Because the BDCP LLT CC5 GCM is not included in Cal-Adapt, an average of the four GCMs (also provided by Cal-Adapt) with the A2 emission scenario was used in this analysis for the Kern Region.

1.2 Kern Region Climate Change Projections

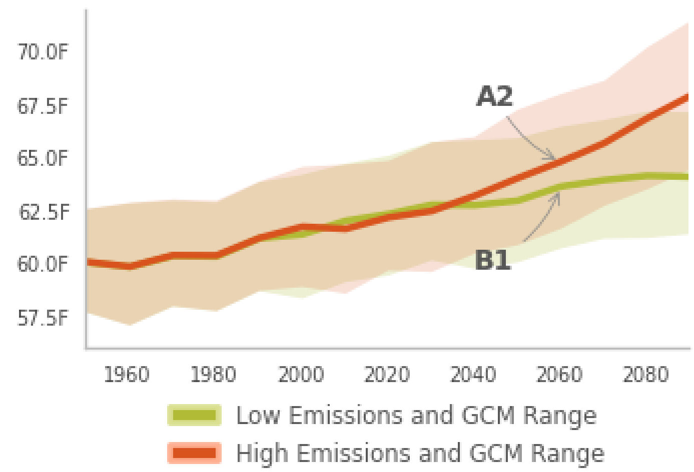
Climate change is expected to have various impacts on the Kern Region including: (1) changing hydrology, and the resultant impacts to conjunctive use operations, due to a shift from snow to rain precipitation, (2) higher wildfire risk due to warmer, drier conditions over the year, and associated impacts on water quality and flooding, (3) fluctuations in temperature resulting in longer and drier conditions over the year, and associated impacts on water quality and flooding, (4) longer and more severe multi-year droughts, (5) greater summer water demand from all categories of users and (6) impacts to habitats and species.

1.2.1 Temperature

Cal-adapt projects that locally, overall air temperatures are expected to rise from 1degree Fahrenheit (°F) to 2.3°F over the next few decades. The historical average annual temperature in the Kern region is 61.4°F; the A2 and B1 scenarios project increases of 3.5°F and 6.3°F by the end of the 21st century. Figure 1 shows the projected air temperature change for the four GCMs averaged from 2000 through 2100, compared with the historical baseline from 1950-2000. The projected temperature increases begin to diverge at mid-century so that, by the end of the century, the temperature increases projected in the higher emissions scenario A2 are almost twice as high as those projected in the lower emissions scenario B1.

Figure 1: Historical and Projected Annual Average

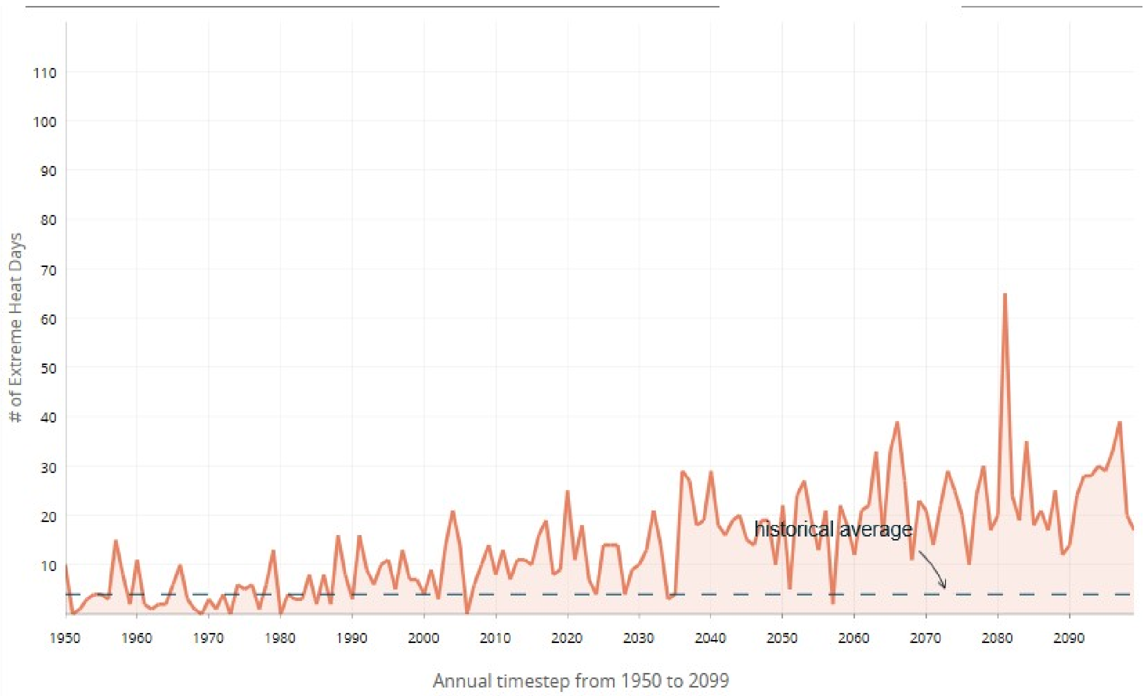
Air Temperature for Kern County



Source: Cal-adapt.org. Bakersfield Area

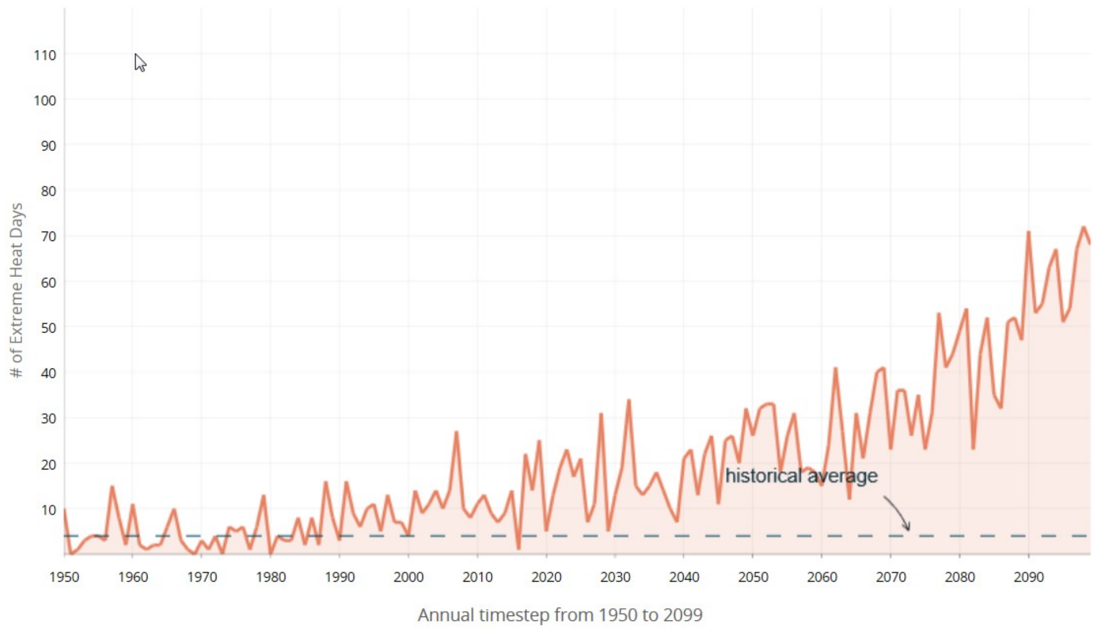
In addition to overall temperature increases, the region is projected to encounter higher incidences of extreme temperatures. Figure 2 and Figure 3 show the projected increases in extreme temperature days in Kern County for the B1 and A2 emission scenarios. This chart displays a count of the number of days that the selected area on the map is projected to exceed the area's calculated "extreme heat threshold" of 101 °F for each year 1950-2099. The historical annual average number of extreme heat days is four. Both scenarios project that number will increase to about 30 days by mid-century and either 40 or 70 days by the end of the century, depending on the emissions scenario. The increased temperatures will likely increase evaporation, leading to drier soils, increased crop evapotranspiration, and a longer growing season.

Figure 2: Number of Extreme Heat Days (Low Emission Scenario)



Source: Cal-adapt.org. Bakersfield Area

Figure 3: Number of Extreme Heat Days (High Emission Scenario)



Source: Cal-adapt.org. Bakersfield Area

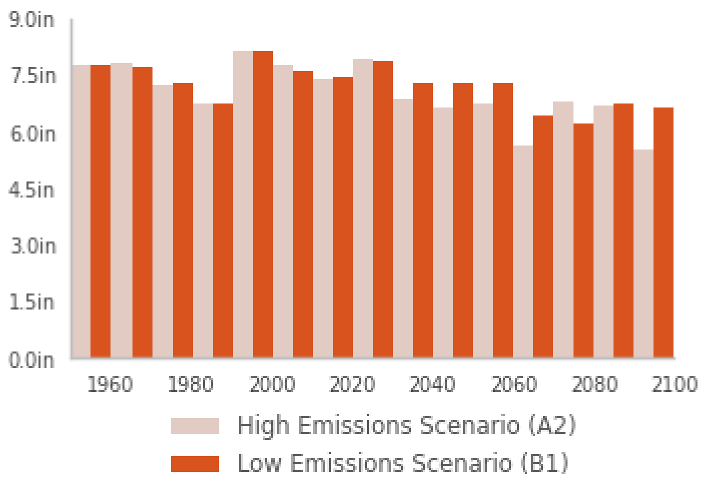
1.2.2 Precipitation

Precipitation in the Kern Region is essentially all in the form of rain, and significant shifts in the timing of precipitation are not expected to occur. On average the projections indicate little change in total annual precipitation in California. Furthermore, among several models, precipitation projections do not show a consistent trend during the next century. The Mediterranean seasonal precipitation pattern is expected to continue, with most precipitation falling during winter from North Pacific storms. One of the four climate models projects slightly wetter winters, and another projects slightly drier winters with a 10 to 20 percent decrease in total annual precipitation. However, even modest changes would have a significant impact because California ecosystems are conditioned to historical precipitation levels and water resources are nearly fully utilized.

Figure 4 shows the decadal precipitation projections from 1960 through 2100 for the Bakersfield area in Kern County. There appears to be continued variable precipitation over the next century, with an overall consistent decrease. Drier conditions may result in a reduction in effective precipitation for crop irrigation needs and higher wildfire risk in the Region.

Figure 4: Projected Annual Precipitation for the

Bakersfield Area in Kern County



Source: Cal-adapt.org. Bakersfield Area

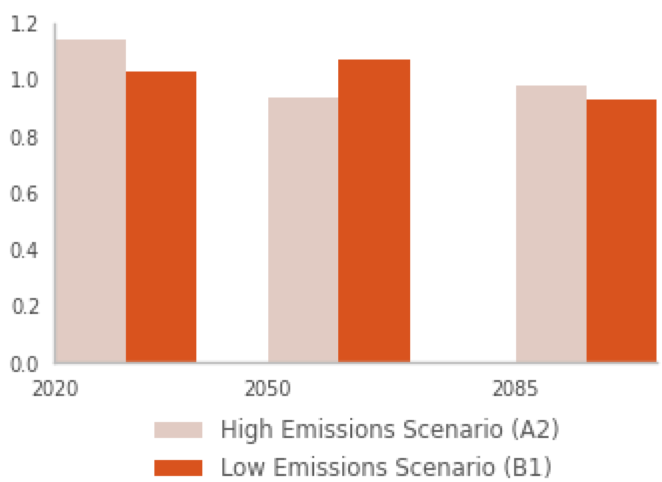
1.2.3 Wildfire

Fire is an important ecosystem disturbance. It promotes vegetation and wildlife diversity, releases nutrients into the soil, and eliminates heavy accumulation of underbrush that can fuel catastrophic fires. Statewide, the area projected to be burnt by wildfire toward the end of the century will increase substantially, especially in mountainous areas. As climate changes, it appears that summer dryness will begin earlier, last longer and become more intense. These changes may exacerbate fire occurrences, which have historically peaked in late summer and early fall. If temperatures rise into the medium warming range, the risk of large wildfires in California could increase by as much as 55 percent, which is almost twice the increase expected if temperatures stay in the lower warming range.

Because wildfire risk is determined by a combination of factors including precipitation, winds, temperature, landscape and vegetation conditions, future risks will not be uniform throughout the state. In years with wet winters, annual vegetation growth is plentiful. But accentuated dryness during summer would produce a hazardous fuel load that worsens the wildfire problem in some of Southern California wildlands. With expanding development into the urban/wildland interface, threats to human safety and property are even greater. The spread of invasive species that are more fire-prone, coupled with more frequent and prolonged periods of drought, all increase the risk of fires, and reduce the capacity of native species to recover. Wildfires are also bad news for the region in terms of air quality, human health, soil erosion and stress on watersheds.

Figure 5 shows projected increases in potential area burned in the Bakersfield area of Kern County. The y-axis represents the ratio of additional fire risk for an area compared to the expected burn area. These data are modeled solely on climate projections and do not take landscape and fuel sources into account. New wildfire risk projections are currently being produced that take more landscape information into account.

Figure 5: Projected Increase in Potential Area Burned in the Bakersfield Area of Kern County



Source: Cal-adapt.org. Bakersfield Area

Fire is an important process in maintaining a diverse ecosystem in the Region. It is unclear at this time whether projected increased wildfire risk will be beneficial or harmful to long term ecosystem health and habitat maintenance, but will likely negatively impact water quality with increased turbidity loading to water supplies.

1.3 Resources in the Kern Region Vulnerable to Climate Change

This section identifies the resources within the Kern Region, its related areas that are potentially affected, and their collective potential vulnerability to climate change. Table 2 provides a general overview of the water-related resources that are considered important in the Kern Region and potentially sensitive to future climate change. Resources that are likely to be vulnerable to climate change are considered for further analysis in the preceding subsections. Table 2 also highlights those resources in the Region that are unlikely to be affected by climate change and therefore they do not warrant further analysis and consideration at this time. The summary table provides the main categories applicable to water planning in the Kern Region with a general overview of the qualitative assessment of each category with respect to anticipated climate change impacts. Table 4 in Section 1.4 below provides the complete assessment of the regional vulnerability to the potential climate change impacts using the

'Vulnerability Assessment Checklist', found in the *Climate Change Handbook for Regional Water Planning* (DWR, 2011).

Table 2: Climate Change Vulnerability Assessment Overview

Watershed Characteristics	General Overview of Vulnerabilities
Water Demand	Urban and Agricultural Water Demand – Changes of hydrology in the Region as a result of climate change could lead to changes in water demand, both in quantities and patterns. Increased irrigation (outdoor landscape or agricultural) is anticipated to occur with temperature rise, increased evaporation losses with warmer temperature and longer growing season.
Water Supply	Imported Water – State Water Project (SWP) and Central Valley Project (CVP) water via the California Aqueduct and the Friant-Kern Canal are an important portion of the water resources available to the Region. Potential impacts on SWP and CVP water availability resulting from climate change directly affect the amount of imported water supply delivered to the Region, part of which will be delivered to recharge groundwater banking programs in the Kern Region. Groundwater – Changes in local hydrology could affect natural recharge to the local groundwater aquifers and the quantity of groundwater that could be pumped sustainably over the long-term. Decreased inflow from runoff, increased evaporative losses, warmer and shorter winter seasons can alter natural recharge of groundwater, as well as conjunctive use operations. Alternatively, if more precipitation occurs as rain, short-term high flows could result, and will require the Region to adapt to the faster runoff which will impact the timing of conjunctive uses. In addition, additional reductions in the imported water imposed by climate change would lead to more reliance on local groundwater, resulting in reductions in base flows, reduced groundwater outflows, increased depth to groundwater and increased land subsidence. .

Watershed Characteristics	General Overview of Vulnerabilities
Water Quality	Imported Water – Sea level rise could result in increases in chloride and bromide (a disinfection by product precursor), potentially requiring changes in drinking water treatment. Increased temperatures could result in an increase in algal blooms and taste and odor events. Regional Surface Water – Increased temperature could result in lower dissolved oxygen, increased algal blooms, and task and odor affect to the Kern River and its tributaries. Decrease in annual precipitation could result in higher concentrations of contaminants in these surface waters during droughts. Increased wildfire risk and flashier storms could increase turbidity loads for water treatment, irrigation filtration systems and spreading basins (sedimentation and loss of percolation rates). Return flows from groundwater banking programs have inherent water qualities. Increased use of banking projects is leading to replacement of higher quality snowmelt surface water (Kern River and Friant CVP), as these supplies are being diverted further upstream than historical diversions to effect transfers and exchanges, and replaced with groundwater supplies that are higher in salt constituents (TDS, nitrates, etc.).
Sea Level Rise	The Kern Region is not directly subject to sea level rise. However, potential effects of sea level rise would affect imported water supply conditions. As discussed above, the principal concern is the potential for sea water intrusion to increase Sacramento-San Joaquin Delta (Delta) salinity. While sea level rise is not a direct regional concern, pursuant to the California Ocean Protection Council Resolution adopted March 11, 2011, it should be considered in the project selection/prioritization process.
Flooding	Local surface flows could change as a result of more frequent and intense storm events, leading to more areas susceptible to flooding, and increasing risk of direct flood damage in the Kern Region.
Ecosystem and Habitat	Increased temperature and potential decreases in annual precipitation could put stress on sensitive ecosystems and alter habitats. Water-dependent recreation could also be affected by water quality impacts. In addition, the Kern Region may be subject to increased wildfire risk, which could alter habitat.
Hydropower	Hydropower production in the Kern Region is small, however power through the Western Area Power Administration operated by the BOR does provide power to the CVP. Because of the amount of hydropower used in comparison to the size of the Region is relatively small, climate change effects on hydropower are not considered to be significant.

Climate change processes are supported by extensive scientific research and are based on a vast number of peer-reviewed and published technical literature. Much of the available literature presents general information, but there is relatively little information that presents specific tools on how to assess impacts in the context of addressing climate change impacts on water resources. In addition, far less information is available on smaller geographic areas and the spatial resolution of the existing climate change models is still quite low. One additional challenge is that precipitation projections cannot be easily converted directly into surface runoff and groundwater recharge effects to connect with the local water resources planning activities.

The following sections present the vulnerability of each sector identified in Table 2 with respect to climate change projections given the existing tools and available data. This is an initial attempt using projections specific to the Kern Region for the vulnerability assessment in support of the IRWMP. The outcome of this initial assessment is intended to help understand the potential impacts, to integrate climate change into long-term planning, and to improve understanding of the uncertainties associated with climate change effects. Consistent with the water resources planning horizon in the Kern Region through 2050, the vulnerability analysis considers projections for mid-21st century (2050), consistent with DWR's modeling approach to climate change.

1.3.1 Water Demand

Increasing air temperatures due to climate change will result in increased evaporation leading to drier soils, increased plant evapotranspiration (ET), and a longer growing season. All of these factors generally increase water demand however there are not sufficient data available to estimate a total volume.

The Cal-Adapt A2 emissions scenario projects an average temperature increase for the Kern Region of about 3.3°F by the mid-century (2050) and increase of about 6.3°F by the end of century (Figure 1). Characterizing the impacts of temperature rise on water demand is a difficult task and discussed on a qualitative basis. While water use varies considerably depending on other factors such as regional economy, population, and land use, a qualitative assessment of water demand increase can be noted based on the projected temperature increase from the Cal-Adapt emission scenarios.

Kern County is characterized by its traditional industries, agriculture, oil and gas production, as well as increasing urbanization and population growth. Total water demand for the region is projected to increase only slightly. Water use to meet municipal water needs are projected to increase significantly due to population growth - about 48 percent from approximately 189,162 acre-feet per year (AFY) in 2005 to 281,284 projected for 2030 (Kern IRWMP 2011). However most of the use in the Kern Region is agricultural. Although historically the trend of agricultural water use has been decreasing, for purposes of this report future agricultural water demands are assumed to stay the same at 2,669,713 AFY (Kern IRWMP 2011), although there are some current reports that forecast a decrease in overall usage within the Region. Total 2005 urban and agricultural demand for the Kern Region is estimated at around 2,857,755 AFY and projected 2030 total demand is estimated to be 2,938,818 AFY, a change of just under 3 percent (Kern IRWMP 2011.

An important effect of changing weather conditions is likely to be on landscape and agricultural demand. Higher temperature generally increases ET rates; but some research studies also suggest higher CO2 levels and higher temperature increase rates of plant growth, and can shorten the time to plant maturity (Hanak and Lund, 2008). This would reduce the overall plant water uptake, partially compensating for potential reductions in agricultural water supply. Thus, the net effect on agricultural crops is still uncertain (Kiparsky and Gleick, 2005) and remains an important area of on-going research.

Qualitatively, the ET projections with climate change suggest water demand for agriculture in the Region is anticipated to increase during months where ET is high and decrease in months where ET is low. As a result of increased ET, urban water demand is anticipated to increase as well because of greater outdoor water use for landscape irrigation and agriculture.

Demand management is an important adaptation given decreased water supply as a result of climate change. Agriculture has a variety of water demand management options including fallowing fields of annual crops and changing the crop itself to one that may be less water intensive, yet economically viable. Additionally, in some cases, farmers may be able to switch their water source from surface water to groundwater. Demand management options for the urban landscape sector range from climate appropriate plants to improved irrigation methods. Water demand management strategies are discussed in Section 11.2 in the November 2011 Kern IRWM Plan.

1.3.2 Water Supply

For long-term water supply planning, coping with variability is a challenge. With potential additional changes imposed by climate change, there will be a heightened need to evaluate and respond to increased water supply variability.

Climate change is expected to affect Regional imported water supplies as follows:

- Total precipitation is expected to decrease in the Sierra Nevada sources, reducing runoff to surface supplies.
- Snow pack projected to decrease as precipitation shifts toward more rain and less snow.
- Timing of runoff is expected to shift to earlier in the year, affecting reservoir storage especially in the spring and summer months, as well as groundwater recharge activities.
- Sea level rise may impact Delta water deliveries.

Climate change is expected to affect Regional surface and groundwater supplies as follows:

- Total precipitation is not projected to change significantly, however the trend is decreasing.
- Variability in annual precipitation is expected to continue, with vulnerability to droughts. This is especially important for the highly variable Kern River system.
- More intense storms anticipated that may affect surface water runoff, surface storage and groundwater recharge.

Climate change is expected to affect Regional oil and gas activities requiring supplies as follows:

Oil and gas drilling in the county could be impacted by decreasing water availability, particularly in times of drought by limiting the amount of water available for cooling, fuel extraction, and power generation. The effects of climate change and water availability on the oil and gas sector include a combination of potential direct and indirect impacts. Water is required in many different stages of the oil and gas value chain, from exploration to processing to transport, and the volume of water used in these activities varies, with the largest volume used in the refining process. Among exploration and production processes, the largest volume of water is used as a supplemental source.

Because the Kern Region relies heavily on imported supplies, any reduction or change in the timing or availability of those supplies could have negative impacts on the Region. Reductions in imported water supplies would lead to increased reliance on local groundwater, recycled water or other sources of supplies if demand was not reduced. Changes in local hydrology could affect surface storage of water and natural recharge to the local groundwater and the quantity of groundwater that could be pumped in a sustainable manner. The following sections describe potential climate change impacts to the region's water supplies.

1.3.2.1 Imported Supplies

Imported water deliveries to the Kern Region are from the SWP and CVP via the California Aqueduct, and the Friant-Kern Canal. Increasing development and environmental demands on water availability and quality for agricultural, municipal and industrial (M&I), and groundwater banking purposes, coupled with curtailments of imported SWP and CVP deliveries due to prolonged drought and regulatory restrictions, have intensified the competition for available water supplies in the Kern Region. It is estimated that due to drought and decreases in imported water supply, about 45,000 acres of farmland in the Region will be idled and an additional 100,000 acres will be under-irrigated. Climate change impacts are likely to exacerbate these challenges.

In an effort to assess the impacts of these varying conditions on SWP supply reliability, DWR issues its "*State Water Project Delivery Reliability Report*". DWR's long-term SWP delivery reliability analyses incorporate assumptions that are intended to account, among other impacts, for potential supply shortfalls related to global climate change. The long-term average delivery of contractual SWP Table A supply is projected to be 62 percent under current conditions and 58 percent under future conditions over the 20-year projection (DWR 2013). Within that long-term average, SWP Table A deliveries can range from 12 percent (single dry year) to 97 percent (single wet year) of contractual amounts under current conditions, and from 11 percent (single dry year) to 98 percent (single wet year) under future conditions. Contractual amounts are projected to be 31 percent during multiple-dry year periods (assuming a 4-year dry period), and from 81 to 85 percent during multiple wet periods (assuming a 4-year wet period). Table 3 shows SWP supplies projected to be available to the Region in average/normal years and summarizes estimated SWP supply availability in a single dry year and over a multiple dry year period. While detailed analysis of CVP supply reliability has not been performed, it is likely that similar impacts from climate change will also apply to the CVP.

Table 3: Kern County Water Agency (KCWA) Wholesaler Supply Reliability (AF)

Wholesaler (Supply Source)	2015	2020	2025	2030
Average Water Year				
DWR (SWP)				
KCWA Table A Supply	579,263	579,263	579,263	579,263
% of Table A Amount(a)	58%	58%	58%	58%
Single Dry Year				
DWR (SWP)				
KCWA Table A Supply	109,860	109,860	109,860	109,860
% of Table A Amount(a)	11%	11%	11%	11%
Multiple Dry Year				
DWR (SWP)				
KCWA Table A Supply	309,606	309,606	309,606	309,606
% of Table A Amount(a)	31%	31%	31%	31%

Note: (a) Percentages of Table A amount from DWR's *2013 SWP Delivery Reliability Report* and assumes future conditions. Also assumes Table A contract amount of 998,730 AFY.

1.3.2.2 Groundwater

The San Joaquin Valley groundwater basin covers the majority of the managed groundwater resources in the Kern Region. Other groundwater basins in the Kern Region include the Kern River Valley groundwater basin to the east; Walker Basin Creek Valley groundwater basin to the southeast; Cummings Valley and Tehachapi Valley West on the eastern side of the Region, Brite Valley to the southwest; and Cuddy Canyon Valley, Cuddy Ranch Area, Cuddy Valley; and

Mil Potrero Area basins to the south. All of these groundwater basin boundaries are within the watershed boundary of the Kern Region (see Figure 2-7 in the November 2011 Kern IRWM Plan for basin locations).

One of the longest-standing issues in the Kern Region is groundwater overdraft. Groundwater provides approximately 39 percent of local water needs; however it is estimated to be as much as 60 percent in dry years. Further, certain portions of the groundwater basin underlying the Kern Region have experienced overdraft conditions.

The Kern Region is well-known for its long-established and successful conjunctive use and banking programs. These programs overlie the major portions of the groundwater basin and can access surface supplies from the Kern River, the SWP, the Friant-Kern Canal, and more. In times of high flows, these surface supplies are recharged and stored to help to lessen the effects of dry period conditions when the Region relies on the groundwater basin.

The groundwater in the Kern Region may also be subject to decreasing reliability related to the extent and duration of longer drought periods that may occur due to climate change. There are limited data available to quantify the sustainable groundwater supplies and therefore to assess the resiliency of these supplies after drought events. A better understanding of groundwater supplies will be important to continued resiliency against climate change, as water supply management becomes a more important issue in the Region.

While the basins have supply exceeding the future projected pumping levels, based on the basins' characteristics and their natural recharge processes, changes in local hydrology and natural recharge are anticipated to have a direct impact on available groundwater storage. Warmer winters would increase the amount of runoff available for groundwater recharge, but reductions in inflow from runoff and increased evaporative losses could reduce the amount of natural recharge. The extent to which climate change will change the natural recharge processes and the impact of that change are not exactly known and are difficult to quantify.

1.3.3 Water Quality

Improving water quality is a Kern Region Plan objective that may be impacted by climate change. Studies of potential climate change impacts on water quality exist, but few trends in relationships between hydroclimate (hydrology and weather variables) have been identified. Key climate vulnerabilities potentially important to the Kern Region include increasing temperature and changes in precipitation patterns. Increased wildfire risk is another potential factor that could affect water quality in the Kern Region. Outside the Kern Region, sea level rise in the Delta is expected to impact water quality of imported SWP water.

Surface waters in the Region are expected to be more directly vulnerable to water quality impacts of climate change, while water quality impacts to groundwater sources would be indirect, as conjunctive use and banking programs can increase the amount of salts in the underlying aquifer dependent on the source of the recharge water.

1.3.3.1 Imported Water Quality

SWP water currently meets or exceeds applicable standards (see Appendix D in the November 2011 Kern IRWM Plan for data). However, there is concern with some constituents that are approaching SWP acceptance criteria, particularly arsenic and selenium. SWP and CVP water is vulnerable to potential effects of climate change at the source in the Delta and in storage in Regional reservoirs. Sea-level rise will increase the intrusion of salinity into the Delta and its exported water. This will increase chloride and bromide (a disinfection byproduct [DBP] precursor that is also a component of sea water) concentrations in the SWP and CVP imported water. In addition, decreased freshwater flows into the Delta could increase the concentration of organic matter, which contribute to potentially higher DBP formation concentrations, in the SWP and CVP water. However, CVP water from the Friant system is of very high-quality as it originates from Sierra snowmelt and is similar in characteristics to Kern River supplies.

Extreme storm events, although rare, may cause quick response time thereof in canal flow rates, which may be more intense due to climate change and may present treatment challenges for source water and sedimentation issues in recharge basins because of increased turbidity. In the past, high turbidity events in reservoirs and conveyance facilities have required modification of the treatment processes (primarily additional chemical usage) for extended periods. In addition, an intense winter rainfall event after a wildfire in a watershed that burned the prior year can result in extremely high turbidities and fine organic matter in the water. The additional sludge production can overwhelm the treatment plants' solids handling equipment and require plants to be shut down or reduce their capacities for brief periods of time, or make capital investment to enlarge solids handling facilities. Similarly, turbidity events can negatively impact porosity in recharge basins, lessening their absorptive capacity. This combination of more intense rainfall events and increased wildfire risk is more likely under projected climate change conditions.

The warmer temperatures could also lead to increased taste and odor events triggered by algal blooms; which are characterized by water quality changes during the spring and summer such as increases in DO and DO saturation, pH and fluorescence. Water treatment plants can be designed to address taste and odor events through pre-ozonation but use of higher ozone dosages to control taste and odor events must also consider the need to control bromate formation (from the oxidation of bromide), which could increase due to greater bromide levels in the imported SWP and CVP water affected by climate change. Local canals would have to deal with the algae and effects thereof with higher treatment cost (i.e. copper sulfate).

1.3.3.2 Regional Surface Water Quality

The primary regional surface water in the Kern Region is the Kern River. Local minor streams, many of which are ephemeral, provide additional local surface water. A very small percentage of minor stream runoff is collected and used as irrigation for agriculture; the majority of these irregularly-occurring flows serve to recharge local groundwater basins. However, the Kern River serves as a major source of supply to groundwater banking programs in the Region.

The Kern River and its tributaries, while generally considered a high quality supply, are vulnerable to potential water quality impacts due to climate change as a result of increased temperature, more frequent heavy rainfall events, increased wildfire risk, and longer periods of low natural stream flow from decreased annual precipitation. Increased water temperature generally reduces DO and can promote algal blooms if nutrients are available in the source. The storm events can transport sediments and other pollutants along the river, while long periods of low flow can increase concentrations of pollutants from wastewater plant and non-point discharges. Increased wildfires may contribute to the turbidity events. Key water quality constituents of concern are nitrogen and chloride, in addition to reduced DO and increased algae growth, turbidity and sedimentation. Taken together these can impact drinking water supplies as well as supplies utilized for groundwater recharge.

Imported water stored in Isabella Reservoir will also be vulnerable to climate change when considering reduced runoff volumes which could affect turbidity and increasing water temperatures, dissolved oxygen (DO) levels, and pH.

1.3.3.3 Groundwater Quality

Groundwater quality throughout the region is typically suitable for most urban and agricultural uses with only localized impairments including high TDS (salts), sodium chloride, sulfate, nitrate, organic compounds, boron and arsenic. High TDS, arsenic, boron, and nitrates are the primary groundwater quality issues. Various constituents can impact agricultural uses and M&I uses in different ways.

Any water quality impacts to groundwater sources due to climate change are expected to be indirect, primarily due to decreased recharge from lower precipitation, increased periodic recharge from earlier/faster snowmelt runoff and increased use of groundwater to make up loss of imported or local surface water supplies. Decreased recharge and increased groundwater pumping may allow concentrations of groundwater contaminants such as perchlorate and volatile organic compounds to increase, which may trigger additional treatment requirements and increase groundwater treatment costs. Increased use of lower quality groundwater may also have some concerns associated with soil properties over a long period.

1.3.4 Flooding

Flooding is one of the most costly and destructive natural disaster; thus, a change in flood risk is a potential significant effect of climate change that could have great implications for the Kern Region. Local minor streams are the second-largest source of local surface water to the Region after the Kern River. Streams with measurable runoff are grouped into four separate watershed areas: Poso, Caliente, El Paso, and San Emigdio. Under certain hydrologic conditions, some of these streams carry very large flows that can be quite damaging. Examples include flooding in the Kelso Creek area, and in the area around the cities of Arvin and Lamont. Regional efforts to address flooding and to better manage such flow events have been initiated among various parties in the Region, including the County of Kern, KCWA and the affected areas.

The FEMA Flood Insurance Rate Map for the Kern Region designates multiple areas as “High Risk,” areas with a 1 percent or greater risk of flooding in any year and a 26 percent chance of flooding over the life of a 30-year mortgage. The area at greatest flood risk is the area surrounding the communities of Lamont, Weedpatch, and the city of Arvin. The area is also prone to wildfires, which impact water quality when rain washes fire debris into waterways. Other large flood area includes the Buena Vista lakebed as well as areas in the historic Tulare lakebed and nearby drainage areas. Areas along the Kern River and other local streams like Tejon, El Paso and Grapevine in the southern region are also considered to have a high flood risk. These areas are depicted in Figure 2-8 in the November 2011 Kern IRWM Plan.

Regional efforts to address flooding and to better manage such flow events have been initiated among various parties in the Kern Region, including the County of Kern, KCWA and the affected areas. For more information on flood management see Section 10.2 in the November 2011 Kern IRWM Plan.

While the Cal-Adapt climate change model projects precipitation decrease of 10 percent by 2050 on the long-term basis, research data suggest that there is a risk of increased flooding in California (Kiparsky and Gleick 2005). Flooding depends not only on average precipitation but on the timing and intensity of precipitation. Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms would occur. This could present larger areas susceptible to flooding and increase the risk of direct flood damage in the Region.

1.3.5 Ecological Health and Habitat

Ecosystem health and habitat protection are important to the Kern Region. Increased temperature, changes in precipitation patterns, and increased wildfire risk projected for potential climate change scenarios are potential stressors to ecosystems and habitat in the Region.

Environmental resources of the Kern Region include the Kern River, Sequoia National Forest, several wildlife refuges, and the unique flora and fauna of the Tejon Pass area and Transverse Ranges. The riparian forest along the South Fork Kern River in the vicinity of Onyx and Weldon is one of the highest quality and most extensive stands of that vegetation type in California. This section of the river has the largest populations of Southwestern willow flycatchers and yellow-billed cuckoos in California. Much of this forest is conserved in the USFS South Fork Wildlife Area, Audubon California’s Kern River Preserve, and California Department of Fish and Game’s (CDFG’s) Canebrake Ecological Reserve. For more detail on the Kern Region's ecological resources, see Section 2.4 in the November 2011 Kern IRWM Plan. All of these species and habitats have acclimated to the historical climate and water resources and may or may not to adapt to potential changes due to future climate change.

Increased air temperature will increase water temperature in rivers, tributary streams, ponds, and lakes, with resulting decreases in DO. This combination may stress fish and biota that depend on higher DO levels and colder water which may impact their sustainability. The increased annual average air temperatures may also alter plant habitat by changing the length and timing of the growing season and/or allowing non-native species to outcompete native species and disrupt ecosystems that depend on the present habitats. Thus, measures to control non-native species may be needed to maintain habitats. Water available for plant habitat could be impacted by potential decreases in annual precipitation and increases in ET due to projected increases in temperature. Decreased precipitation could also directly affect formation of vernal ponds.

Ackerly *et al.* (2012) summarizes existing research on the relationship between climate and biodiversity and how changes in climate historically have and will in the future impact habitat. In terrestrial systems, the impacts of rising temperature and changing precipitation patterns have the largest effect and that in estuarine and intertidal areas, sea-level rise results in the most important direct impact. These habitats may be affected directly by habitat loss through erosion, or indirectly via human responses such as coastal armoring (e.g., construction of sea walls) and other infrastructural changes.

1.4 Regional Vulnerability Assessment

Table 4 provides an assessment of the regional vulnerability to the potential climate change impacts using the 'Vulnerability Assessment Checklist', found in the 'Climate Change Handbook for Regional Water Planning' (DWR, 2011). This checklist provides a further evaluation of the effects on regional water demands and supplies, as well as water quality, flooding events, environmental and ecosystems, and hydropower systems within the Kern Region.

In addition to the assessment of vulnerabilities provided in Table 4, the Kern Region prioritized the identified vulnerabilities during a Stakeholder meeting in August 2014. The results are displayed in the Climate Change Vulnerabilities Prioritization Table provided in Appendix A. Meeting minutes from the August Stakeholder meetings are also included with Appendix A, documenting the planning efforts of the Region.

Table 4: Vulnerability Assessment Checklist

Resource Checklist Item	Kern Regional Condition
Water Demand	
Are there major industries that require cooling/process water in your planning region?	Kern County is characterized by its traditional industries, agriculture, oil and gas production, as well as increasing urbanization and population growth. Oil and gas drilling in the county could be impacted by decreasing water availability, particularly in times of drought by limiting the amount of water available for cooling, fuel extraction, and power generation. Additionally, process water is required in packing plants and other locations for processing crops harvested from the field, further contributing to the significance of the use.
Does water use vary by more than 50% seasonally in parts of your region?	Yes. A significant amount of water in the Kern Region is used for agricultural purposes, the demand for which fluctuates greatly in the summer compared to the winter.
Are crops grown in your region climate-sensitive? Would shifts in daily heat patterns, such as how long heat lingers before night-time cooling, be prohibitive for some crops?	Yes. The Kern Region is the second largest agricultural county in the state in economic value, and produces over 250 different crops, including over 30 types of fruits and nuts, over 40 types of vegetables, over 20 field crops, lumber, nursery stock, livestock, poultry and dairy products. Many of these are climate-sensitive and could be prohibitively affected by shifts in daily heat patterns.
Do groundwater supplies in your region lack resiliency after drought events?	With only six (6) inches per year of average rainfall, groundwater is necessary to maintain a sufficient water supply in the semi-desert climate of the Region. It is estimated that on average groundwater accounts for 39 percent of total water supply to the Region; however, it is estimated to be as much as 60 percent during dry years. Long-established and successful conjunctive use and banking programs. These programs overlie the major portions of the groundwater basin and can access surface supplies from the Kern River, the SWP, the Friant-Kern Canal, and more. In times of high flows, these surface supplies are recharged and stored to help to lessen the effects of dry period conditions when the Region relies on the groundwater basin.

Resource Checklist Item	**Kern Regional Condition**
Are water use curtailment measures effective in your region?	Stakeholders of this IRWMP have identified water use efficiency as an important component of water supply planning. One of the stated objectives of this IRWMP is to "Pursue and implement cost effective water use efficiency programs." In addition to direct water use efficiency, stakeholders have expressed a desire to improve system operation, reduce system water loss, and decrease energy use related to water infrastructure. Another objective of this IRWMP is to "Replace aging infrastructure to reduce system water losses, improve operational efficiencies, and reduce service interruptions." Lastly, implementation of agricultural land fallowing programs within the Region also help to curtail water use.
Are some instream flow requirements in your region either currently insufficient to support aquatic life, or occasionally unmet?	No. However, since 1994, the two large projects that import water into the Kern Region, the CVP and the SWP, have been incrementally impacted by environmental and regulatory requirements that have served to diminish the ability of the projects to reliably deliver water supplies. A large proportion of recent imported water cutbacks has stemmed from fishery issues in the Sacramento-San Joaquin Delta, where the pumping plants for the CVP and SWP are located, as well as San Joaquin River Settlement or Public Law 111-111 where water previously supplied to the CVP Friant Division for M&I and agricultural irrigation is being diverted into the San Joaquin River for in-stream flows.
Water Supply	
Does a portion of the water supply in your region come from snowmelt?	Yes. The Kern River is fed by annual snowmelt from the Southern Sierra Nevada, including Mount Whitney. The SWP, CVP and Friant system are also fed by Sierra snowmelt.

Resource Checklist Item	Kern Regional Condition
Does part of your region rely on water diverted from the Delta, imported from the Colorado River, or imported from other climate-sensitive systems outside your region?	Yes. The Kern Region receives SWP and CVP water delivered through the Delta, which is affected by climate change. Friant CVP also has a Delta connection with the San Joaquin River Restoration Program as well as San Joaquin River Exchange Contractor rights.
Does part of your region rely on coastal aquifers? Has salt intrusion been a problem in the past?	The Kern Region does not rely on coastal aquifers. While salt intrusion from coastal aquifers is not applicable, salt management is still an issue in the region with regard to increasing salinity in groundwater. Salt in imported water supplies such as the SWP and CVP is the major source of salt which circulates throughout the groundwater in Kern County.
Would your region have difficulty in storing carryover supply surpluses from year to year?	There is limited carryover available for SWP and CVP water in San Luis Reservoir. Carryover of Friant CVP water in Millerton Lake/Friant Dam has limited capacity. Carryover of Kern River water in Isabella Reservoir is limited by the Reservoir's flood control purpose and US Army Corps of Engineers Regulations. However, there are opportunities to expand the Region's groundwater storage capabilities.
Has your region faced a drought in the past during which it failed to meet local water demands?	No. Water demands have been met through the use of groundwater which, during drought, can result in significant declines in groundwater levels. To the extent that surface water supplies are reduced in the future (as a result of climate change and/or regulatory constraints), recharge will be reduced, which will affect the availability of groundwater for meeting local water demands.

Resource Checklist Item	**Kern Regional Condition**
Does your region have invasive species management issues at your facilities, along conveyance structures, or in habitat areas?	Yes. Aquatic pests, including invasive plants have been fought on the Kern River for decades. Prevention and control of invasive species is an ongoing battle by many resource agencies such as the Kern River Preserve Audubon Society, and the Kern River Ranger District. Canal operators treat aquatic weeds, mainly with use of copper sulfate.
Water Quality	
Are increased wildfires a threat in your region? If so, does your region include reservoirs with fire-susceptible vegetation nearby which could pose a water quality concern from increased erosion?	Yes. Parts of the Kern Region are prone to wildfires, which impact water quality when rain washes fire debris into waterways. In July 2008, the Piute Fire burned a significant area in the region. It was soon followed by a summer thunderstorm, which washed fire debris into the South Fork and ultimately down the Kern River. Many water purveyors were forced to switch from Kern River water to alternate sources to avoid contamination of settling ponds and costly treatment of the water.
Does part of your region rely on surface water bodies with current or recurrent water quality issues related to eutrophication, such as low dissolved oxygen or algal blooms? Are there other water quality constituents potentially exacerbated by climate change?	Yes. The Kern River, the primary native surface supply in Region, is generally considered a high quality supply. However, Isabella Lake which serves as the source for the lower Kern River is listed on the 303(D) list for dissolved oxygen and pH. Climate change could exacerbate these water quality conditions from increased temperatures. Banking return flows result in replacement of higher quality snowmelt water with groundwater.
Are seasonal low flows decreasing for some waterbodies in your region? If so, are the reduced low flows limiting the waterbodies' assimilative capacity?	Possibly. Annual Kern River flows and flows in local ephemeral streams could be decreasing through time.

Resource Checklist Item	Kern Regional Condition
Are there beneficial uses designated for some water bodies in your region that cannot always be met due to water quality issues?	No. Water is intended for many beneficial uses including agricultural water supplies, groundwater recharge, water replenishment, recreation, wildlife habitat, rare and endangered species, and wetland ecosystems. Most of these are met within the Kern Region; however there are two TMDLs for Lake Isabella with regard to DO and pH.
Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation?	No.
Sea Level Rise	
Has coastal erosion already been observed in your region?	No. The Kern Region is located in the Southern San Joaquin Valley, and concerns regarding coastal regions are not applicable.
Are there coastal structures, such as levees or breakwaters, in your region?	No.
Is there significant coastal infrastructure, such as residences, recreation, water and wastewater treatment, tourism, and transportation) at less than six feet above mean sea level in your region?	No.
Are there climate-sensitive low-lying coastal habitats in your region?	No.
Are there areas in your region that currently flood during extreme high tides or storm surges?	No.
Is there land subsidence in the coastal areas of your region?	No.
Do tidal gauges along the coastal parts of your region show an increase over the past several decades?	No.
Flooding	
Does critical infrastructure in your region lie within the 200-year floodplain?	Yes. The FEMA Flood Insurance Rate Map for the Kern Region designates multiple areas as “High Risk”, areas with a 1 percent or

Resource Checklist Item	Kern Regional Condition
	greater risk of flooding in any year and a 26 percent chance of flooding over the life of a 30-year mortgage. Figure 2-8 (in the November 2011 Kern IRWM Plan) shows the areas that are within the 100- and 500-year floodplain. Flooding can result in the inundation of structures, causing water damage to structural elements and contents, as well as impact damage to structures, roads, bridges, culverts, and other features from high velocity flows and from debris carried by floodwaters.
Does part of your region lie within the Sacramento-San Joaquin Drainage District?	No.
Does aging critical flood protection infrastructure exist in your region?	Yes. In general, many Kern County communities are older and the physical components of their water systems are aging and outdated. Aging infrastructure is a particular issue for rural communities and DACs.
Have flood control facilities (such as impoundment structures) been insufficient in the past?	Yes. The primary flood control facility in the Region is Isabella Dam on the Kern River. The dam protects the urban Bakersfield area and about 350,000 acres of agricultural land and oilfields. Kern River had an unregulated flow until 1954 when the Isabella Dam and Reservoir were constructed by the Army Corps of Engineers. Unfortunately, due to seepage and earthquake concerns, the flood control capacity of the reservoir has recently been limited. Other areas near Lamont in the southern portion of the Region also have infrastructure that could be impacted.
Are wildfires a concern in parts of your region?	Yes. Parts of the Kern Region are prone to wildfires, which impact water quality when rain washes fire debris into waterways.
Ecosystem and Habitat Vulnerability	
Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues?	Coastal aquatic habitats are not applicable to the Region. However,

Resource Checklist Item	**Kern Regional Condition**
	aquatic pests, including invasive plants have been fought on the Kern River for decades. Prevention and control of invasive species is an ongoing battle by many resource agencies such as the Kern River Preserve Audubon Society, and the Kern River Ranger District.
Does your region include estuarine habitats which rely on seasonal freshwater flow patterns?	No.
Do climate-sensitive fauna or flora populations live in your region?	Environmental resources of the Region include the Kern River, Sequoia National Forest, several wildlife refuges, and the unique flora and fauna of the Tehachapi Mountains, Tejon Pass area and Transverse Ranges. The riparian forest along the South Fork Kern River in the vicinity of Onyx and Weldon is one of the highest quality and most extensive stands of that vegetation type in California. This section of the river has the largest populations of Southwestern willow flycatchers and yellow-billed cuckoos in California. All of these resources could be potentially affected by climate change.
Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region?	Yes. There are threatened and endangered species in the Kern Region including the bald eagle, burrowing owl, California condor, California red-legged frog, least bell's vireo, and the San Joaquin kit fox to name a few. Whether or not changes in species distribution have occurred is unknown.

Resource Checklist Item	Kern Regional Condition
Does the region rely on aquatic or water-dependent habitats for recreation or other economic activities?	Yes. Water-dependent recreation includes a wide variety of outdoor activities that can be divided into two (2) categories. The first category includes fishing, boating, swimming, and rafting, which occur on lakes, reservoirs, and rivers. The second category includes recreation that is enhanced by water features but does not require actual use of the water, such as wildlife viewing, picnicking, camping, and hiking.
Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life?	No.
Do estuaries, coastal dunes, wetlands, marshes, or exposed beaches exist in your region? If so, are coastal storms possible/frequent in your region?	There are several wildlife refuges within the Kern Region including the Kern National Wildlife Refuge that manages some wetlands. Coastal storms are not possible in the Region, due to its location in the southern San Joaquin Valley.
Does your region include one or more of the habitats described in the Endangered Species Coalition's Top 10 habitats vulnerable to climate change	Yes, the Kern Region's eastern boundary is the southern Sierra Nevada, which is listed on the Top 10 habitats list.
*Are there areas of fragmented estuarine, aquatic, or wetland wildlife habitat within your region? Are there movement corridors for species to naturally migrate? Are there infrastructure projects planned that might preclude species movement**?***	Yes. There are many wildlife habitats in the Kern Region. Most notably is the Kern National Wildlife Refuge which provides habitat for wintering and migrating waterfowl, shorebirds, and marsh birds and also provides habitat for upland and riparian bird species. However, there are no infrastructure projects planned in the Region that are known to preclude species movement.

Resource Checklist Item	Kern Regional Condition
Hydropower	
Is hydropower a source of electricity in your region?	Yes. Within the Kern Region is the Rio Bravo Hydro Project Hydro Power Plant which has a design capacity of 14 mega watts (MWe). However, most of the energy provided in the Kern Region comes from its 37 high-efficiency cogeneration facilities that produce two sources of energy in the form of steam and electricity.
Are energy needs in your region expected to increase in the future? If so, are there future plans for hydropower generation facilities or conditions for hydropower generation in your region?	Yes. Energy needs in the Region will increase in the future as a result of several factors, which include changes in land use from agricultural uses to urban uses, increasing population and increases in groundwater pumping. However, the Kern Region has a variety of efforts planned to reduce energy use, and to develop local energy supply sources. These efforts include utilization of renewable resources, such as wastewater treatment plant digester gas recovery, hydropower, and solar power.

1.4.1 Vulnerability Prioritization

This section discusses a list of prioritized vulnerabilities based on stakeholder input on the importance of these sectors to the Kern Region. The watershed vulnerability assessment identifies the water resource characteristics for each sector most vulnerable to potential climate change projections. The Region can use the assessment results to prioritize the sectors with vulnerabilities and develop adaptive strategies to respond to potential climate change impacts. The sector vulnerability prioritization is defined as follows (1 being the sector most prioritized [high risk] and 4 being the sector least prioritized [low risk] with respect to climate change vulnerability):

1. Water Supply; Water Quality
2. Water Demand; Flooding
3. Ecosystem and Habitat
4. Sea Level Rise and Hydropower

The vulnerability assessment and prioritization was conducted based on the *Climate Change Vulnerability Checklist* provided as Table 4, data currently available and inputs from the stakeholders involved in the preparation of this study for the Kern Region. This assessment can be improved in the future with further data gathering and analyzing of the prioritized vulnerabilities.

1.5 Climate Change Adaptations

The Kern IRWMP (Plan) identifies strategies to address adapting and mitigating the general effects of climate change. The objectives for the Kern Region address adapting and mitigating the general effects of climate change, including changes in the amount, intensity, timing, quality, and variability of runoff and recharge. These “no regrets” adaptations recognize the current water management context for the region. In addition, mitigation strategies addressed by the objectives for the Kern IRWMP include energy efficiency improvements, emissions reductions, and carbon sequestration through vegetation growth. The Climate Change Handbook (DWR, 2011) was used to help develop these adaptation and mitigation strategies, which are listed in Table 10-2 in the November 2011 Kern IRWM Plan.

For this technical memorandum, potential adaptation strategies have been grouped by water resource and priorities developed in the climate change vulnerability analysis. This approach will allow the Kern Region to incorporate climate change adaptation and GHG mitigation measures in projects developed and evaluated as part of the IRWMP process. While the focus of this discussion is adaptation, some of the adaptation strategies will overlap with and enhance GHG mitigation measures.

1.5.1 Vulnerability Priority 1 (Highest) Sectors: Water Supply and Water Quality

Water supply and water quality were identified as the highest priority sectors that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

1.5.1.1 Water Supply

Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century. The overall impact will include reductions in Kern River, SWP and CVP imported water and greater reliance on groundwater supplies with the potential to affect long-term planning.

Suggested Regional adaptation strategies to address potential reductions in water supply include the following:

- Expand water storage and conjunctive management of surface and groundwater resources.
- Encourage local projects to increase regional self-reliance.
- Enhance use of recycled water for appropriate uses as a drought-proof water supply.
- Enhance practices of water exchanges and water banking outside the Region to supplement water supply.
- Encourage local agencies to develop and implement AB 3030 Groundwater Management Plans as a fundamental component of the IRWM plan.
- Develop plans for local agencies in the Kern Region to monitor the elevation of their groundwater basins.
- Encourage cities and the county agencies in the Kern Region to adopt local ordinances that protect the natural functioning of groundwater recharge areas.

1.5.1.2 Water Quality

Climate change projections suggest increased temperature and continued highly variable annual precipitation with slightly drier climate by mid-century that could degrade water quality.

Suggested Regional adaptation strategies to address potential water quality impacts include the following:

- Consider water quality improvements associated with water transfers and water banking on Regional water supply.

- Encourage projects (ex. conjunctive use) that improve water quality of contaminated groundwater sources.
- Increase implementation of low impact development (LID) techniques to improve stormwater management.
- Comply with NPDES permits to ensure water quality protection.

1.5.2 Vulnerability Priority 2 (Second Highest) Sectors: Water Demand and Flooding

Water demand and flooding were identified as the second highest priority sectors that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

1.5.2.1 Water Demand

Climate change projections suggest increases in average annual air temperature by mid-century and increased evaporative losses are expected to increase both urban and agricultural water demand. Suggested Regional adaptation strategies to address potential increases in water demand include the following:

- Aggressively increase cost effective water use efficiency.
- Encourage agricultural users to adopt efficient water management practices.
- Encourage landscape water users to adopt efficient water management practices, including xeriscaping.

1.5.2.2 Flooding

Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms will occur. Suggested Regional adaptation strategies to address potential increases in flood risk include:

- Improve emergency preparedness and response capacity in anticipation of potential increases in extreme events.
- Practice and promote integrated flood management among water and flood management agencies.
- Flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands.
- Avoid significant new development in areas that cannot be adequately protected from flooding.

- Encourage land use policies including LID that maintain or restore historical hydrological characteristics.

- Development of a Kern Region Flood Protection Plan.

1.5.3 Vulnerability Level 3 (Third Highest) Sector: Ecosystem and Habitat

Ecosystem Health and Habitat was identified as the third highest priority sector category that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below. Climate change projections of increasing annual average temperature suggest potential environmental stressors that may affect the sustainability of existing ecosystems and habitat. Suggested Regional adaptation strategies to address potential Ecosystem Health and Habitat impacts include the following:

- Promote water resources management strategies that restore and enhance ecosystem services.

- Provide or enhance connected “migration corridors” for animals and plants to promote increased biodiversity and allow the plants and animals to move to more suitable habitats to avoid serious impacts and support increased biodiversity.

- Consider projects that provide seasonal aquatic habitat in streams and support corridors of native riparian forests that create shaded riverine and terrestrial habitat.

1.5.4 Vulnerability Priority 4 (Lowest) Sectors: Sea Level Rise and Hydropower

Sea level rise and hydropower were identified as the lowest priority sectors for the Kern Region.

1.5.4.1 Sea Level Rise

Climate change projections suggest sea level rise off most of the California Coast of over half a meter by mid-century and by about one meter by the end of the century. Suggested Regional adaptation strategies to address potential reductions in water supply include the following:

- Support DWR/USBR strategies that minimize the impact of sea level rise on salinity intrusion into the Delta and impact water quality deliveries in the SWP and CVP.

- Support DWR/USBR strategies for protecting levees in the Delta from the potential effects of projected sea level rise.

1.5.4.2 Hydropower

Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century, affecting hydropower generation. Strategies to address potential reductions in hydropower include the following:

- Support alternative economically viable energy projects within the region including solar energy and wind energy.

1.6 Data Gaps and Next Steps

1.6.1 Data Improvement

The climate change assessment conducted in this Plan update is qualitative in some areas due to limited data, high level of uncertainty, and, in some cases, because impacts to a given sector are not expected to be severe. The intent of future data gathering is to address gaps in the current vulnerability assessment, to improve the understanding of climate change impacts and vulnerabilities, and to enable a more quantitative analyses. Recommended future data gathering efforts will include data that facilitate more quantitative analysis of the vulnerability, as described in the following sections. Data gathering efforts will be considered in the context of the current and proposed projects and funding available.

This section describes potential areas of future data gathering efforts for the priority sectors identified earlier. The recommendations focus on the top four priority sectors; namely, water supply, water quality, water demand, and flooding. The lower priority sectors include ecosystem health and habitat and fire, which require a lesser degree of data collection. Climate change vulnerability of ecosystem health and habitat is difficult to quantify, and reliance on generalized studies will likely satisfy the Region's needs. Thus, the Kern Region should prioritize data gathering efforts for the sectors most vulnerable to climate change impacts.

1.6.1.1 Climate Change Models and Scenarios

Cal-Adapt modeling results for the Kern Region were used for projections of temperature, ET, precipitation, and runoff for the Region. The California Energy Commission maintains the Cal-Adapt site and will update the modeling tools as new climate change modeling results, based on more refined data, become available from the ICCC. Thus, to the extent feasible, the available climate change tools and projections for the Region will be reviewed periodically and the vulnerability assessment updated in future versions of the Plan.

1.6.1.2 Updates on Climate Change Research

Research on the climate change impacts on water resources is ongoing and continues to evolve with further analysis and more refined methodologies. During the preparation of this Plan update, key literature resources on climate change have been reviewed. New scientific findings will be reviewed periodically and incorporated into the climate change vulnerability assessment, especially the findings pertinent to the sectors most vulnerable to the climate change in the Region.

1.6.1.3 Vulnerability Assessment Update

As noted above, a goal of further data collection is to enable a more quantitative analysis of the high priority watershed sectors that are more vulnerable to climate change in future Plan updates. Water supply and water quality were identified as the highest priority sectors and water demand and flooding were identified as the second highest priority sectors that could potentially be impacted by climate change.

1.6.1.4 Water Demand

Cal-Adapt projections suggest water demand in the Region is likely to increase as a result of higher temperature with the greatest temperature increase anticipated during dry months compared to wet months. Historical records of annual water demand data currently available are not specific enough to quantify the effects from increasing temperature. As discussed earlier in the vulnerability assessment, the most important effect of changing weather conditions is likely to be on agricultural demand, but the overall effects on agricultural water demand is uncertain.

Suggestions for future data gathering efforts to quantify the climate change effects on municipal and agricultural water demand include the following:

- Collect and analyze historical monthly records of water demand data for the Region to quantify the weather effects on water use and seasonal variations in response to changes in historical temperature.
- Collect and analyze historical monthly records of water demand data for each purveyor in the Region to demonstrate purveyor-specific patterns in response to changes in climate.
- Based on the water demand and temperature data, develop a regression analysis correlating water demand to temperature on a monthly or seasonal basis for the Region and each purveyor. The historical response can be used to infer future response with the projected changes in temperature with climate change.
- Characterize the variations in indoor and outdoor water use, both for the Region and each purveyor. Future data gathering should focus on the seasonal and monthly patterns both in indoor and outdoor usage to evaluate the effects of weather conditions on each use category.
- Collect and analyze historical agricultural water demand to quantity the weather effects on water use and seasonal variations in response to changes in historical temperature.
- Identify the major industries in the Region that require cooling and/or process water. As water temperature increases, cooling water needs may also increase.

1.6.1.5 Water Supply

Future assessment of water supply climate change vulnerability will incorporate the most up-to-date data available from DWR and the most current groundwater supply availability. Suggestions for future data gathering efforts to quantify the climate change effects on water supply include the following:

- Update DWR SWP Delivery Reliability Report projections - DWR provides an updated analysis and report every two years.
- Review or request other reports (e.g., USBR, Army Corp of Engineers, etc).
- Update available groundwater supply projections – Groundwater production in a given year varies depending on hydrologic conditions. Changes in local hydrology and natural recharge are anticipated to have a direct impact on available groundwater storage and may affect current safe operating ranges. Updates on the groundwater safe operating ranges will be needed when further assessments of water supply vulnerability to climate change are performed for future Plan updates.
- Evaluate the effects of reduction in precipitation from climate change on the groundwater operational ranges and quantify the potential reduction in groundwater supply due to reduction in precipitation from climate change.

1.6.1.6 Water Quality

Collection of historical water quality data within the Region would greatly improve the understanding of Regional water quality and how it may be impacted by climate change. For imported SWP water, the vulnerability analysis relied on DWR projections of water quality impacts in the Delta due to sea level rise and increases in salinity. Future analyses will incorporate updated DWR or other agency studies on the potential impacts of climate change on SWP quality.

Suggestions for future data gathering efforts to quantify the climate change effects on water quality include:

- Monitor future and collect historical water quality data within the Region during storm events.
- Develop a long-term water quality record for the Kern River that would assist in improving the understanding of Regional water quality.
- Collect long-term weather records associated with air temperature, precipitation, and ET to assess potential correlations with seasonal water quality.
- Develop, to the extent possible, a long term surface/ground/aerial deposition model that can be continuously updated and refined with newly available data. Model should be ready accessible to stakeholders and in a user-friendly format to allow better understanding of trends over time.

1.6.1.7 Flooding

A quantitative assessment of the potential impacts of climate change on flooding cannot be performed as climate projections are not sensitive enough to project short-term extreme events such as flooding. Rather, the 100-year and 500-year floodplains were used to define flooding risk zones that should be considered in location of water infrastructure.

Suggestions for future data gathering efforts to address the potential climate change effects on flooding include the following:

- Perform an inventory of runoff monitoring stations in the Region to see if a more robust runoff record can be developed. Those data may allow an analysis of historical storm events correlated with precipitation events as well as annual precipitation to provide a better understanding of conditions that may lead to more extreme flooding conditions.

As recommended by DWR's Climate Change Handbook for Regional Water Planning, future work should focus on gathering the 200-year floodplain maps for the Region after DWR develops them under the authorization of Senate Bill 5 (SB 5) enacted in 2007. Currently, the 100-year and 500-year floodplain maps are available from FEMA. Additional information on the DWR's Best Available Maps (BAM) program can be found at the following website: http://gis.bam.water.ca.gov/bam/.

- Coordinate with the Region stakeholders for advanced flood preparation and quick response and document the protocol(s).
- Perform an inventory of critical infrastructure located in floodplains, especially those that were impacted during the historical flood events in 1969 and 1983.
- Update the projections of runoff with climate change as updates from Cal-Adapt become available.
- Work with local flood plain managers and/or equivalent to determine areas of concern as information from FEMA evolves.

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Appendix A

Climate Change Vulnerabilities Prioritization

August 2014 Kern Region Stakeholder Meeting Minutes

Climate Change Vulnerabilities Prioritzation

Kern IRWMP Objectives	Climate Change Vulnerabilities	Prioritization (High, Medium, Low)
Increase Water Supply		
Through cooperation and collaboration with other regions restore water supplies to levels that will mitigate for water lost from the region and eliminate overdraft	Water Supply	H
Pursue and implement cost effective water use efficiency programs	Water Demand	M
Increase water storage capacity in the region by increasing recharge acreage and expanding groundwater banking programs before all prime recharge land has been developed	Water Supply, Sea Level Rise	H
Integrate management of water banking facilities to maximize conjunctive use over the planning horizon	Water Supply	H
Increase/augment water supplies to meet region demands (e.g., M&I, agricultural, environmental) by 2050.	Water Supply, Sea Level Rise	H
Improve Operational Efficiency		
Increase transfers and exchanges flexibility over the planning horizon	Water Supply	H
Create tools to re-regulate water supplies within the region, including storage, storm flows, and operational flows over the planning horizon	Water Supply	H
Increase distribution efficiencies and reduce energy usage over the planning horizon	Water Demand	M
Increase the use of alternate energy sources (e.g., solar)	Hydropower	M
Replace aging infrastructure to reduce system water losses, improve operational efficiencies, and reduce service interruptions	Water Supply, Flooding	M
Increase the use of recycled water for direct reuse within the Kern Region	Water Supply, Water Demand, Water Quality	M
Optimize local management of water resources to improve water supply reliability over the planning horizon	Water Supply	H
Increase pool of qualified candidates to operate water and wastewater systems	Water Quality	L
Improve Water Quality		
Monitor and/or manage headwaters/areas of origin, natural streams, and recharge areas to prevent or mitigate contamination	Ecosystem and Habitat, Water Quality	M
Identify and preserve prime recharge areas in the Kern fan area and other areas	Water Supply, Water Quality	H
Improve water quality for DACs and the watershed over the planning horizon	Water Supply, Water Quality	H
Continue to provide drinking water that meets or exceeds water quality standards; and support efforts to attain appropriate standards throughout the planning horizon	Water Supply, Water Quality	H
Maximize the use of lesser quality water for appropriate uses (landscaping, certain ag crops, “aesthetic” projects) throughout the planning horizon	Water Supply, Water Quality	M
Coordinate and enhance aquatic pest control efforts from this point forward	Ecosystem and Habitat, Water Quality, Water Supply	M
Promote Land Use Planning and Resource Stewardship		
Promote stewardship of the Kern River by applying appropriate measures in various reaches of the river from this point forward	Ecosystem and Habitat	M
Encourage the removal of non-native invasive plant species that affect water quality, reliability, and operations	Ecosystem and Habitat, Water Supply, Water Quality	M
Identify and promote the regeneration and restoration of native riparian habitat	Ecosystem and Habitat	M
Coordinate agricultural and urban water suppliers to more effectively address land use planning issues from this point forward	Habitat, Water Demand, Water Supply	M
Improve the linkage between land use planning and water supply in the region throughout the planning horizon	Ecosystem and Habitat, Water Supply	H
Increase educational opportunities to improve public awareness of water supply, conservation, and water quality issues throughout the planning horizon	Ecosystem and Habitat, Water Supply, Water Demand, Water Quality	H
Improve and coordinate integrated land use planning to support stewardship of environmental resources, such as the Kern River and Kern Fan, and integrate with habitat conservation plans and other ongoing planning efforts from this point forward	Ecosystem and Habitat, Water Supply	M
Preserve and improve ecosystem/watershed health throughout the planning horizon	Ecosystem and Habitat	M
Improve Regional Flood Management		
Improve regional flood management by addressing preparedness, response, and post flood actions throughout the planning horizon	Flooding	M
Reduce the effects of poor quality runoff throughout the planning horizon	Flooding. Water Quality	M
Identify and promote innovative flood management projects to protect vulnerable areas	Flooding	H
Plan new developments to minimize flood impacts from this point forward	Ecosystem and Habitat, Flooding	M

Tulare Lake Basin Portion of Kern County
Integrated Regional Water Management Plan

August 25, 2014 - 1:00 pm – 3:00 pm
Kern County Water Agency
Stuart T. Pyle Water Resources Center
3200 Rio Mirada Drive, Bakersfield, CA 93308

Meeting Objectives:

- Recommendations from DWR Plan Review Process:
- Climate Change Vulnerability Assessment Prioritization

PARTICIPANTS MEETING AGENDA

1:00	**I**	**Welcome and Introductions – Executive Committee Chair** Meeting purpose and agenda *A quorum of the EC was present as follows: Bill Taube, Chair, Regina Houchin, Jon Curry, Greg Fenton, and Lauren Bauer.*
1:05	**II**	**General Information Items** A. Revised/Updated Participant Funding Agreement – Lauren Bauer *Lauren described the process for obtaining indications from all signatories that they would be willing to execute the "First Amendment to the Agreement with KCWA for IRWM Plan Management Services." An email request for comments on the form of the agreement is currently being conducted; comments are due by COB September 1, 2014. After the Amendment is finalized, an email poll of signatories regarding their wiliness to execute will be conducted.*
1:20	**III**	**Funding Opportunities - KJ/P&P Team** A. Water Energy Draft PSP - $19M B. Update on Emergency Drought Funding Application *Mary Lou Cotton of Kennedy/Jenks Consultants gave a brief update on these items and referred to a handout of DWR's compiled list of applicants for the Emergency Drought Funding.*
1:30	**IV**	**IRWM Plan Status – KJ** ***A.*** Kern IRWM Plan DWR Plan Review Recommendations: Climate Change Vulnerability Assessment Prioritization – KJ and EC Members *Mary Lou described the draft Climate Change Technical Memo and Vulnerability Assessment table that were sent to the participants on August 20. She then described the Vulnerability Assessment and prioritization process, and led the group through a discussion of the vulnerabilities that could potentially impact the Tulare Lake Basin Portion of Kern County Region. The group collectively discussed and agreed upon the prioritization of the vulnerabilities, and directed Mary Lou to include it as part of the Climate Change package to be submitted to DWR by September 9, 2014.*
2:00	**V.**	**Public Comment** *Representatives from the Community Water Center reported that the Tulare Lake Basin Disadvantaged Community Study is ready and will be presented to the Tulare County Board of Supervisors on September 9. A draft of the report (prepared by Provost & Pritchard) is available on the Tulare County website. The report contains recommendations regarding DACs for various IRWM Regions.*
		Close

Appendix H: SBx7-7 Compliance for Agricultural Irrigation Districts

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IRRIGATION TRAINING & RESEARCH CENTER

SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts

SBx7 Compliance

Aug 26, 2012

IRRIGATION TRAINING & RESEARCH CENTER

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Irrigation Training & Research Center
Updated October 2012

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GROUPED DELIVERIES

Senate Bill x7-7 (SBx7-7) requires documented volumetric accounting to individual turnouts for water deliveries. Section 597.3 of the bill lists two very different requirements for devices (***bold, underlined, italics*** have been added for emphasis):

- Section 597.3(a) discusses measurement devices that must be used at points where there is a reasonable degree of flow rate control.
- Section 597.3(b) states that "An agricultural water supplier may measure water delivered at a location upstream of the delivery points or farm-gates of multiple customers using one of the measurement options described in §597.3(a) if the downstream individual customer's delivery points meet ***either*** of the following conditions:

  A. The agricultural water supplier does not have legal access to the delivery points of individual customers or group of customers to install, measure, maintain, operate, and monitor a measurement device.

  Or,

  B. An engineer determines that due to small differentials in water level ***or*** large fluctuations in flow rate or velocity that occur during the delivery ***season*** at a single farm-gate, accuracy standards of the measurement options in §597.3(a) cannot be met by installing a measurement device or devices (manufactured or on site built or in-house built devices) with or without additional components (such as gauging rod, water level control structure at the farm-gate, etc.).

This last section (B) in essence defines the most downstream point of measurement to be located at the "hand-off point".

The "hand-off point" can be defined as the location, moving downstream in the branching hydraulic network, below which the irrigation district no longer has good control over the flow rates that go to individual farm-gates.

For example, one might consider using a ditch or pipeline with a rotation delivery schedule, with one "head" or delivery at a time. That single "head" or flow rate is rotated among users, one at a time. There is no control over flow rates at individual turnouts (along that ditch or pipeline); the flow rate is controlled at the head of the ditch or pipeline.

This is also true of ditches or pipelines with a rotation delivery schedule, with two or three "heads" or deliveries. These systems typically have little or no precise flow control downstream of the heading. In some districts, the delivery points are not even to a field; the distribution pipelines have alfalfa valves for each border strip that is irrigated. When there is an internal splitting of two "heads", it is done without the benefit of the structures that provide good water level or pressure control.

While it may be possible in many cases to install flow measurement devices within these pipelines or canals, the measurement would be of uncontrolled flows unless the pipelines or canals were substantially modified. In other words, "additional components" besides the flow measurement devices would be required.

Rice systems are a special category, as good water management of rice irrigation is premised on maintaining a target water level in the fields, rather than on delivering a specific volume to a specific field.

That said, with traditional rice laterals, or with traditional rotation laterals, it is entirely reasonable to require farmers with new pressurized systems on such ditches/pipelines to install magnetic meters or propeller meters on their systems. Such flow measurement installations are rather typical and do not represent technical or fiscal challenges for implementation.

Conclusions

1. The wording of SBx7 appears to clearly indicate that the proper, most downstream flow measurement location would be at the head of any "community ditches". "Community ditches" (sometimes called "improvement districts") are defined as privately owned distribution systems that receive water from the irrigation district. The distribution, partitioning, and scheduling of water deliveries within the "community ditch" is not done by irrigation district personnel.
2. Irrigation district ditches and pipelines that are operated on a rotation schedule need an accurate flow measurement device at the head of the ditch or pipeline, but not at individual delivery points within/along the ditch or pipeline that receives water on a rotation schedule. This pertains to ditches and pipelines that are owned either by improvement districts or by irrigation districts.
3. Individual delivery points with pressurized irrigation systems that receive water from an irrigation district ditch or pipeline that is primarily a "rotation" system must be individually metered.

Note: The phrase "irrigation district" encompasses a wide range of district types including reclamation districts (e.g., RD108), water districts (e.g., Coachella WD), irrigation districts (e.g., Modesto ID), and Water Storage Districts (e.g., Buena Vista WSD).

FLOW RATE VS. VOLUMETRIC ACCURACY

SBx7 requires the verification of the accuracy of annual volumes provided at delivery points.

- For devices **with** totalizers, it can be assumed that:

  Flow rate accuracy = Volumetric accuracy

- For devices such as meter gates and orifice plates that do **not** have totalizers, the flow rate accuracy may only be part of the total desired 12% volumetric accuracy. The annual volumetric accuracy of any such single turnout depends upon errors due to:
  - IFR – Instantaneous flow rate error
  - CWLF – Canal water level fluctuations, or pipeline pressure fluctuations over time. The impact of these fluctuations are mostly self-canceling over the course of an irrigation season. This is discussed later in this report.
  - CBP – Changes in "backpressure". Backpressure is the pressure on the downstream side of the flow measurement device.
  - ARD – Accuracy of the recording of durations. For example, if an actual delivery lasts for a total of 25 hours but it is recorded and billed as a 24-hour delivery, this would be an error of one hour, or 4.2%

These inaccuracies must be mathematically combined to determine the total volumetric accuracy.

$$Volumetric\ accuracy = 100\ \times \left[1 - \sqrt{(IFR)^2 + (CWLF)^2 + (CBP)^2 + (ARD)^2}\right]$$

For example, assume the following errors expressed as decimals rather than as percentages. These are plus/minus errors ("within 5%" means "within +/- 5%"):

IFR is within 5% (IFR =.05) CBP = .03
CWLF = .02 ARD = .04

Then,

$$Volumetric\ accuracy\ (VA) = 100\ \times \left[1 - \sqrt{(.05)^2 + (.02)^2 + (.03)^2 + (.04)^2}\right]$$

$$VA\ =\ 92.7 = 93\%$$

The errors are independent of each other. Therefore, the total error does ***not*** equal the sum of the errors (14%), which would incorrectly indicate an 86% accuracy.

The maximum acceptable flow rate measurement error (expressed as a decimal) equals:

$$\text{Max. acceptable device flow rate error} = \sqrt{(1 - \frac{VA}{100})^2\ -\ ARD^2 - CBP^2 - CWLF^2}$$

For example, if the required volumetric accuracy (VA) = 88% (88) (i.e., within 12%) and:
ARD = .04 CBP = .03 CWLF = .02

Then, the maximum acceptable device flow rate accuracy error = 0.107 = 10.7%

That is, this specific device, when tested at a specific representative flow rate, must be within 89.3% accuracy.

IMPACT OF CANAL WATER LEVEL CHANGES ON ANNUAL VOLUMETRIC ACCURACY

Background

The volume delivered through flow measurement devices without totalizers is computed as:

$$\text{Volume} = (\text{Flow Rate}) \times \text{Time}$$

The flow rate is typically checked once per day, and a new flow rate is either noted on the records, or the flow rate control device is re-adjusted to provide the target flow rate.

During any 24-hour period, the canal water levels will fluctuate, resulting in a delivery of more or less flow rate than was originally set.

The question addressed in this section is: Over the course of an irrigation season with ten, twenty, or thirty 24-hour irrigation events, do these minute-to-minute fluctuations cancel out? If they do, this will remove the "CWLF" (discussed in the previous section) from consideration.

To examine this, ITRC obtained water level data from multiple locations throughout San Luis Canal Company, over a time period from June 8 to July 11, 2012. Canal levels were recorded automatically on an hourly basis. The total change in water level across the turnout [(water surface in the canal) - (water surface in the downstream ditch)] was also recorded at the start of each datalogging session. The irrigation district has typical flashboard check structures to maintain water levels in the majority of its locations.

A series of 22 sites were analyzed for 48-72 hours. It is believed that these sites are representative of the range of conditions throughout the district. No special management of the check structures was involved; the canal operators were unaware that the levels were being recorded.

Error Analysis

Water Level Error Model

In order to assess the error of volumetric flow rate measurement in the canal system, first the fluctuations in water level must be computed. A model was constructed to measure the percent error of the water level over a 24-hour period from a given starting point in the sample set.

The raw data was normalized so that canal fluctuations would be represented as a percentage of the head difference. In this way, all the data points could be accumulated to create a contiguous set of hourly fluctuations for the model data set. The resulting model contains a total of 5500 hourly data points.

Sample Set

A sample set was generated from the model. The sample set contained three different blocks. Each block had 30 different seasons with varying numbers of irrigations events per season. Block 1 had 30 seasons of ten 24-hour irrigations, Block 2 had 30 seasons of twenty 24-hour irrigations, and block 3 had 30 seasons of thirty 24-hour irrigations.

The starting points for the irrigation events in each season were selected by a random number generator. The error was recorded for each hour from the starting point for a total 24 hours. Thus, each irrigation event consisted of 24 data points, resulting in a total of 21,600 data points sampled for all of the seasons in all 3 blocks.

Results

If the present water level for a moment during an irrigation event in the model is equal to the starting water level for that event, then the percent error at that moment is zero. The percent error at each recorded time during an irrigation is calculated by the following equation:

$$\%\ Error\ at\ a\ moment = \frac{Present\ Water\ Level - Initial\ Water\ Level}{Initial\ Change\ in\ Head} \times 100$$

Where "Initial Water Level" is the water level when the 24-hour irrigation began.

The characteristics of the population of "errors" in water level are shown in the figure below.

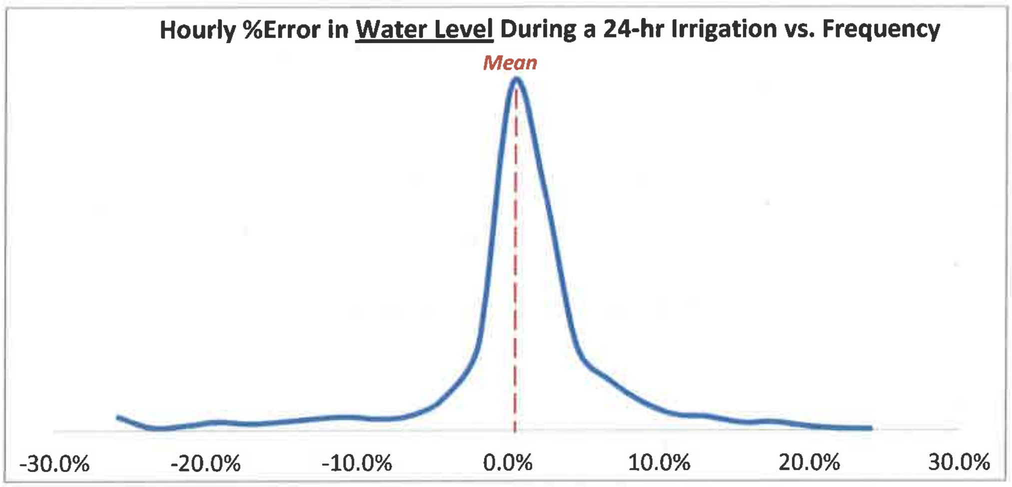


Figure 1. Sample distribution for hourly % error in water level vs. frequency

The variation in relative water levels over time is interesting, but of more interest is the impact on turnout flow rates. There are two possible situations, described below:

1. The flow measurement device is operated under "free flow". That is, the water jets out from it, and the flow rate through the orifice device is not affected by changing downstream water levels. The variation in flow rate over time can be computed, based solely on the upstream water level change. In this case, the sensitivity of the turnout flows to canal water levels is computed as:

$$Free\ Flow\ Error = (1 + Level\ Error)^{0.5} - 1$$

2. The flow measurement device operates under a "submerged" condition. In this case, what happens is that if the canal water level changes, the flow through the measurement device increases. But that also results in a rise in the downstream water level. This provides a "pressure compensating" effect. The total head change is less than the change in the canal water level. ITRC has examined a number of possible downstream channel conditions, and uses the following equation to estimate the effect of a change in canal water level:

$$Submerged\ Flow\ Error = (1 + Level\ Error)^{0.38} - 1$$

For each block (group of 30 randomly selected seasonal irrigation cycles), the mean and standard deviation of the error were computed. **Figure 2** shows the results of the analysis. The mean error is plotted for each block along with the standard deviations. The red bars are 1 standard deviation above the mean, and the green bars are 1 standard deviation below the mean.

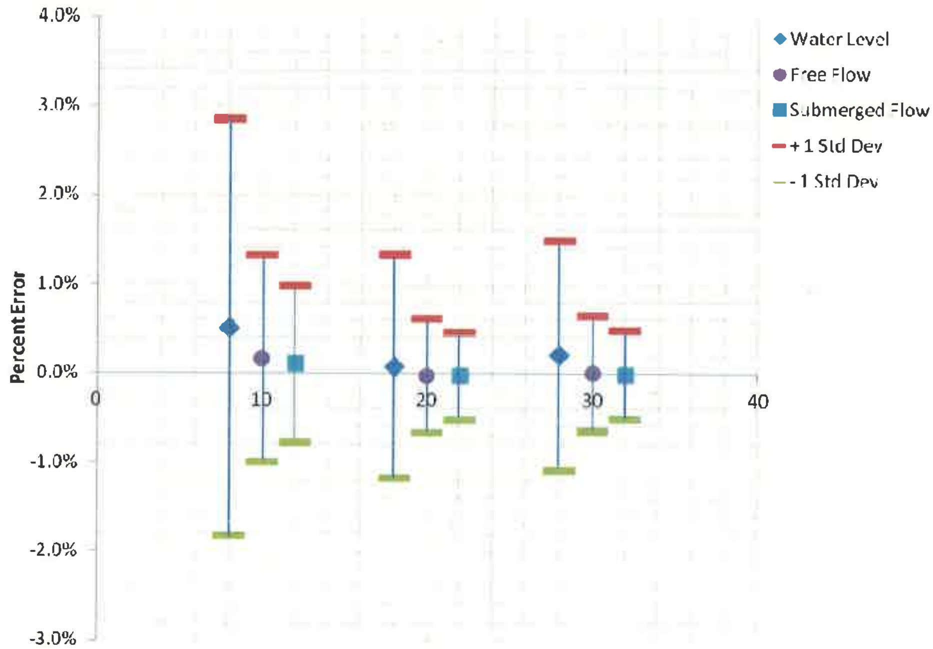


Figure 2. Means and standard deviations for each block

Conclusion

For the condition of 10 irrigations per season, the seasonal flow rate error due to fluctuating canal water levels averages less than 0.2%, regardless of whether the turnout is free flow or submerged flow. The average seasonal error for 20-30 irrigations per season is almost 0.0%.

Because most irrigation districts deliver more than 10 irrigations per season, it appears that a reasonable estimate of the annual volumetric error due to a fluctuating canal water level is about +/- 0.5%, when one considers one standard deviation from the mean.

While this data originated in a single district, ITRC believes that the conditions are representative of "typical" canal districts, based on experiences in about 150 irrigation districts in the western U.S. The exception would be the few irrigation districts that have a very extensive distribution of long-crested weirs or ITRC flap gates throughout the canals. An extreme example would be Modesto ID, in which case almost every check structure is a long-crested weir. In that case, the seasonal impact of fluctuating canal water levels is likely 0.0%, for all practical purposes.

SELECTION OF A REPRESENTATIVE SAMPLE FOR VERIFICATION OF ACCURACY

California Legislature SBx7 requires flow measurement devices to be within a required level of accuracy. For existing flow measurement devices, the acceptable error for volumetric flow measurement is ±12% as stated in §597.3(a)(1). Initial certification of existing devices requires a random and statistically representative sample set <u>or</u> an accepted statistical methodology as described in §597.4(a)(1) and §597.4(b)(1). This document defines a statistical methodology that can be used to provide good information that meets both the intent of SBx7 and the needs of the irrigation districts.

Background

Representative Sample

Irrigation districts have turnouts with flow measurement devices that supply water to areas with correspondingly varying annual delivered volumes. The selection process defined below is intended to define how to select a representative sample set of flow measurement devices for verification of volumetric measurement quality in the district as whole.

In an irrigation district with a wide range of acreages downstream of flow measurement devices, a simple random selection of measurement devices would statistically over-emphasize the importance of small delivery points. The sampling may only represent a very small percentage of all the water delivered in the district. The volume delivered through a turnout is related to the size of the area irrigated. Therefore, it is better to weigh the importance of each measurement device according to the area it services, rather than weighing all turnouts equally. Thus, the sample of flow measurement devices to be tested will be constructed using a ***probability-proportional-to-size (PPS)*** sampling method so that the likelihood of inspection for a given flow measurement device will be proportional to the acreage served by that device.

Considerations for Availability

Ideally, all the devices would be randomly selected by the PPS sampling process mentioned above, and then the selected devices would be evaluated for accuracy. However, only some percentage of the turnouts will be operating at a given time. Therefore, if a turnout is selected in a purely random manner, the customer served by that turnout may not be ready to irrigate, prohibiting evaluation of the flow measurement device at that turnout. It is also clear that even if farmers are scheduled to receive water from a turnout on a specific date/time, they do not always irrigate on that schedule; this makes advance and careful scheduling of field evaluations problematic.

A solution to this is to use ***opportunity sampling*** in combination with ***sampling quotas***. An opportunity sample is composed of samples taken as they are available or convenient. Since device availability will be an issue, devices should be inspected when they are available.

Point #1: To ensure that the data set is representative of the district's overall volumetric flow measurement, a minimum of 10% of the district's service area (or volume) should be represented by the combined service acreage for the turnouts in the sample set.

Point #2: To meet the SBx7 requirements, the minimum sample size of 5 and maximum of 100 for a particular device type should be evaluated.

Point #3: Two scenarios for sampling are described in this document:
- Advance Probability-Proportional-To-Size (PPS) Sampling
- Opportunity Sampling with a consideration of PPS

Scenario 1: Acreage-Based Sampling Using Probability-Proportional-to-Size (PPS)

Scenario 1 is the ideal situation, where at any given time all turnouts will be available for inspection.

Background

Representative Sample Selection

Flow measurement devices in a district will be assigned a number ***range*** based on the acreage (or known annual volume) that the devices serve (e.g., a turnout servicing 10 acres may be assigned 10 numbers such as 61-70). This numbering will have a logical sequencing that is appropriate for the given district. A random number generator will then be used to select a device from the developed sequence. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensurc that the random sample will be statistically representative of the overall accuracy of flow measurement within the district.

Random Selection Process

A random number generator will be used to select a device to be tested. If the number produced by the random number generator is within the range assigned to a device, then that device will be tested. Once a device has been tested, its range will no longer be considered in the selection process, and numbers randomly generated in its range will be ignored. This procedure will be improved from the example given in §597.4(b)(1), in that devices providing at least 10% of the district volume or acreage (rather 10% of the devices) will be tested, with a minimum of 5 devices, and not to exceed 100 individual devices of a certain type.

Device Types

It is important to take note of device types for this legislation. If 25% of existing devices (as estimated from the properly selected sample) of a particular type are not in compliance with ±12% accuracy requirements, the district must develop a plan to test another sample of measurement devices of this type as stated in §597.4(b)(2). This document interprets the intent of the legislation as applying to 25% of water delivered, rather than 25% of existing devices. For illustration, in the extreme case of a district with the following:

- 100 garden plots of 0.25 acres each, each with a measurement device (25 acres total)
- 50 larger fields of 80 acres each, each with a measurement device (4000 acres total)

Certainly, careful irrigation water management would not focus on the large number of very small plots that represent less than 1% of the total acreage. This document therefore assumes that the proper interpretation is to focus on reasonable measurement of at least 25% of sample water volume, rather than 25% of the sample devices.

Step 1: Assign Sequence Range Numbers to Each Turnout

Table 1 describes a sample scenario and shows a sequence range of number assignments for each turnout. The district in the sample scenario has one lateral with 10 turnouts serving a varying array of acreage.

Table 1. Example of assigning sequence range numbers

Turnout #	Acreage Served	Sequence Range From	Sequence Range To
1	10	**1**	**10**
2	10	**11**	**20**
3	15	**21**	**35**
4	15	**36**	**50**
5	2	**51**	**52**
6	2	**53**	**54**
7	5	**55**	**59**
8	5	**60**	**64**
9	50	**65**	**114**
10	50	**115**	**164**
Total	**164**		

Note that the final sequence number should be equal to the total acreage

Each turnout is assigned sequence range numbers based on their acreage. Turnout 1 is assigned the sequence range from 1 to 10 because it has 10 acres, and Turnout 2 is similarly assigned 11 to 20. Turnout 3 is assigned a longer sequence range, from 21 to 35, because it has 15 acres. Turnouts are continued to be assigned sequence range numbers in this fashion. As a result of this sequence range numbering, each turnout will represent a portion of the total 164 acres.

Step 2: Use a Random Number Generator to Select Turnouts

Use a random number generator to choose a number between 1 and the total acreage of the district. A random number generator can be a software program or simply pulling numbers out of a hat. In the example above the random number generator would pick a number between 1 and 164. If the number produced by the random number generator is between the sequence range numbers assigned to a device, then that device will be tested.

> Repeat this process until devices representing 10% of the acreage served (or volume delivered) have been selected with a minimum of 5 and a maximum of 100 per device type.

Continuing with the example data set above, assume that the first numbers selected by the random number generator were: 17, 24, 157, 156, 53, 42, 41, 36, 2, 12, and 52.

Eliminate duplicate turnouts, starting from the first random number.

With this random selection of numbers, the following turnouts are selected:

- 2 (selected by number 17; 12 is a duplicate)
- 3 (selected by number 24)
- 10 (selected by number 157; 156 is a duplicate)
- 6 (selected by number 53)
- 4 (selected by number 41; 41 and 36 are duplicates)

This provides the minimum number of 5 turnouts. Now, the acreage must be checked to verify that the selection represents more than 10% of the acreage (or volume).

Table 2. Example of randomly selected sample set

Green rows indicate the selected devices for the sample set

Turnout #	Acreage Served Acres	% of Total	Sequence Range From	To
1	10	6%	1	10
2	10	6%	11	20
3	15	9%	21	35
4	15	9%	36	50
5	2	1%	51	52
6	2	1%	53	54
7	5	3%	55	59
8	5	3%	60	64
9	50	30%	65	114
10	50	30%	115	164
Total	164	100%		

The five turnout samples represent 55% of the total acreage.

Therefore, this sample set meets the criteria of:

- greater than or equal to 10% of the acreage, and
- a minimum of 5 turnouts of a particular type - assuming all are the same device.

Note: If there is more than one device, this process would be repeated ***by device***. The final criteria to be met are:

- Including all device sample sets, at least 10% of the district acreage (or volume) must be accounted for.
- A minimum of 5 turnouts of a particular device, for each device.
- No more than 100 of any particular device.

Step 3: Evaluate Selected Turnouts and Record Data

Once the turnouts have been selected, evaluate each flow measurement device for accuracy. Record gate type, total acreage serviced by the device, and measured accuracy. This data will need to be retained for ten years or two Agricultural Water Management Plan Cycles as per 597.4(c).

To continue the example, **Table 3** shows how data should be recorded for the example district. For simplicity, it is assumed that all devices are meter gates.

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

Turnout #	Device Type	Acreage Served	Flow Accuracy Error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
	Total acreage sampled:	***92***	

Step 4: Determination of Compliance

SBx7 requires an annual volumetric accuracy of within 12% on existing devices. Table 3 addresses flow rate accuracy, not volumetric accuracy.

If 25% or more of the sampled area for a particular device type exceeds the 12% annual volumetric allowable error, then a second round of testing must be conducted. This second round of testing should be conducted in the same manner as the first, but only for the device type(s) that did not meet the required accuracy standard.

Compliance of this particular example. Table 3 is repeated below for illustration.

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

Turnout #	Device Type	Acreage Served	Flow Accuracy error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
	Total acreage sampled:	***92***	

Assuming that the minimum required flow rate accuracy is 10.7% (using the example), then only one turnout measurement device does not meet the requirement. No re-testing is needed, because:

1. Ninety-two acres were tested out of the total 164 acres. This is much greater than the 10% sample size required.
2. Five devices were sampled, which meets the minimum because all devices are of the same basic design.
3. The one device with greater than 10.7% error only represents 10 acres, which is 11% of the acreage sampled. This is below the allowable 25%.

Scenario 2: Limited Availability of Turnouts and Opportunity Sampling

Turnouts may not be available for inspection due to fluctuations in irrigation scheduling. Therefore, opportunity sample can be used to select devices to be evaluated. As opposed to the PPS random sample set, this sample will be based on availability and service size rather than a weighted random sampling.

Background

Representative Sample Selection

To ensure the sample is representative of the district as a whole, evaluators need to ensure that the area serviced by the devices evaluated is at least 10% of the district's entire area. Furthermore, when given a choice between devices of equal convenience, devices servicing a larger acreage should be given priority for inspection. Additionally, a minimum of 5 devices must be inspected. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensure that the opportunity sample will be statistically representative of the overall accuracy of flow measurement within the district.

Selection Process

Devices will be selected as they are available to be tested. Priority for evaluation will be given to devices that service greater acreage. Once a device has been tested, it will no longer be considered in the selection process. A minimum of 5 devices will be tested, and all evaluated devices (summation of all types) will service a combined 10% of the district's total area (or delivered volume), not to exceed 100 individual devices of a certain type.

Step 1: Choose a Currently Available Turnout

Select a turnout that is available for testing based on the size of the turnout, giving priority to turnouts that serve greater acreage. Do not test the same device more than once. **Table 4** shows an example of the selection process for two days. On the first day Turnout 10 serves the largest acreage out of the available turnouts. On day two, Turnout 5 is chosen because it serves the largest area and has not yet been tested. The district in this example has one canal lateral with 10 turnouts, and the turnouts have limited availability for testing.

Table 4. Device selection on two separate days

Green rows indicate the selected turnout. Grey rows indicate a turnout that has been tested.

Day 1

Turnout #	Currently Available	Acreage Served
1	yes	10
2	yes	10
3	no	9
4	yes	7
5	no	30
6	no	1
7	yes	1
8	yes	2
9	no	50
10	yes	50

Day 2

Turnout #	Currently Available	Acreage Served
1	no	10
2	yes	10
3	no	9
4	yes	7
5	yes	30
6	no	1
7	yes	1
8	yes	2
9	no	50
10	yes	50

Continue testing devices until the following criteria have been met:

- *At least 10% of the total district acreage is serviced by the devices tested*
- *At least 5 devices have been tested*
- *Test no more than 100 devices of a particular type*

Steps 2-4 : Follow the Previous Scenario Instructions

FLOW MEASUREMENT DEVICES

Background

This section is intended to provide useful information on several common flow measurement devices that might be considered for traditional, non-pressurized turnouts. Often, the problems with some of the devices (meter gates, orifice plates, and propeller meters) are largely associated with improper measurement, or improper installation or maintenance. If properly designed and maintained, all three of these measurement devices will generally fall well within required SBx7 requirements.

Meter Gates

Meter gates are one of the most common devices used in California irrigation districts to both measure and control flow rates. There is no doubt that many of these devices provide accurate results. However, as with all devices, certain rules must be followed. Typical physical inaccuracies associated with meter gates include:

1. *Incorrect "zero" measurement of gate opening*, as determined by the vertical movement of the threaded shaft.
   a. There are four primary reasons operators might measure the opening from an incorrect "zero" mark on the threaded shaft:
      i. The zero point is affected by "slop" in the connection between the shaft and the gate plate.
      ii. Wedges are used to force the plate against the gate frame during gate closure. These wedges are often adjusted in the field, so there is no standard stopping distance (vertically) for the plate.
      iii. When the plate begins to move, it may overlap the opening (by 0.5 - 2"). Although water may begin to leak as the plate moves out of the wedge constraint, the true zero is the opening at which the bottom of the plate is exactly at the bottom of the frame opening.
      iv. The "zero" point should always be determined while the gate is being raised.
   b. Once the zero point is known, a notch should be scribed into the shaft to note the location of the zero mark. Then the gate opening should always be measured as the gate is being opened, rather than being closed.

2. *Incorrect downstream water level measurement.*
   a. The stilling well must be placed over a full pipe, at a specific distance downstream of the meter gate.
   b. Many existing stilling wells were actually designed to be air vents, and have such a small diameter that there is constant surging. A large diameter stilling well, fed by a relatively small access hole at its bottom (about 1/6th the diameter of the stilling well), is needed to "still" the water surface so it can be measured downstream of the gate. The problem with a small access hole is that it can plug up easily. A good combination is a 2" access hole (connecting the stilling well to the top of the pipe) and a 12" stilling well.
   c. The pipe must be full at all flow rates. This may require the placement of a small obstruction downstream, in the pipe, similar to what is done with well pump discharges to keep propeller meters full. Various entities, including ITRC, have successfully designed side contractions in pipes to create "Replogle flumes" that have very little loss, and that pass bottom loads of silt. Something similar could be used downstream of the meter gates.

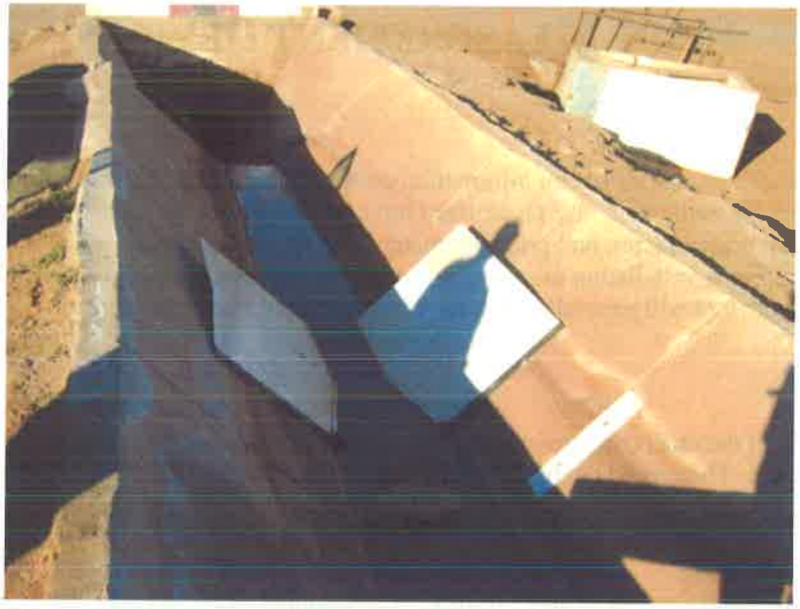


Figure 3. Side contractions rather than a traditional "Replogle Flume". Designed by USBR, Yuma. The rocks are not part of the design.

Another technique used in some districts to maintain a submerged condition on a gate is to install "bumps" in the bottom of a canal or ditch downstream of the turnout. These should be permanent "bumps" which, at low flows, will keep the water level high. The rule for building these "bumps" is:

> Build up the restriction from the bottom of the ditch/canal so that at high flow rates, the upstream water surface (relative to the bump) is only raised by about 0.1' or less. In other words, its presence will hardly be noticeable.

If farmers move downstream in their canal, setting siphons at a different place, this "bump" will keep the backpressure on the meter gate almost constant, and minimize the flow rate change that would normally occur.

3. *Incorrect gate opening geometry.* Since the plate has a larger outside diameter than the inside diameter of the pipe, the ratio of the open area between the two openings must be taken into account. Almost everyone uses tables that were developed decades ago. ITRC is not certain if the gate dimensions have changed since then, or if different manufacturers use different gate dimensions. ITRC is planning to verify this in the future.

4. *Non-standard entrance and exit conditions.* The flow rate is associated with a measured opening and head loss. The head loss will be different (at the same flow rate) with different entrance conditions. Various manuals, such as the USBR Flow Measurement Manual, provide recommended dimensions.

Orifice Plates

The following is an explanation of the characteristics of a submerged (on both sides) rectangular orifice plate.

According to the U.S. Bureau of Reclamation *Water Measurement Manual*, conditions for achieving accurate flow measurement of ± 2% for a fully contracted submerged rectangular orifice are:

- The upstream edges of the orifice should be straight, sharp, and smooth.
- The upstream face and the sides of the orifice opening need to be vertical.
- The top and bottom edges of the orifice opening need to be level.
- Any fasteners present on the upstream side of the orifice plate and the bulkhead must be countersunk.
- The face of the orifice plate must be clean of grease and oil.
- The thickness of the orifice plate perimeter should be between 0.03 and 0.08 inches. Thicker plates would need to have the downstream side edge chamfered at an angle of at least 45 degrees.
- Flow edges of the plate require machining or filing perpendicular to the upstream face to remove burrs or scratches and should not be smoothed off with abrasives.
- For submerged flow, the differential in head should be at least 0.2 feet.
- Using the dimensions depicted in **Figure 4** below, P > 2Y, Z > 2Y, and M > 2Y

The equation for determining the flow through a submerged orifice plate is:

$$Q = C_d A\sqrt{2g\Delta h}$$

Where:

Q = Flow Rate, CFS
C_d = Coefficient of Discharge, 0.61
A = Area of the orifice, ft^2
A = W x Y
W = Orifice opening width, ft
Y = Orifice opening height, ft
g = Acceleration due to gravity, 32.2 ft/s^2
Δh = Change in head, ft

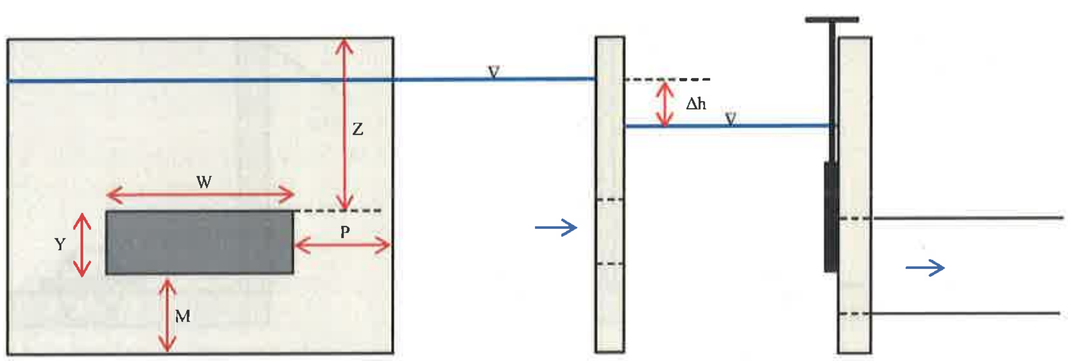


Figure 4. Flow through a submerged orifice plate

For a sharp-edged rectangular orifice where full contraction occurs from every side of the orifice, the coefficient of discharge is 0.61.

It is recommended that "Y" be smaller than "W", so that a good depth "Z" can be maintained. This helps keep the orifice entrance submerged all the time regardless of upstream water level fluctuations, and also provides for the proper entrance conditions.

It is assumed that the flow control gate will be located downstream of the orifice plate. The particular dimensions of that gate would rarely influence the performance of an orifice plate.

Typical problems include:

1. Inaccurate measurement of the difference in head.
   Solution:
   a. Careful relative calibration of pressure transducers, if used. They do not need to read a correct "elevation", but at zero flow rate must read the same "elevation".
   b. Install a horizontal reference steel plate on a bulkhead wall, so operators use the same reference elevation for both measurements if they manually measure the head difference.
2. The distances P, Z, or M are not greater than 2 times the smallest opening dimension (usually "Y"). In reality, it is rare that this "2 times" criteria is met in irrigation districts, except with very small flows.
   Solution:
   a. If only one side is suppressed (typically the bottom entrance, which might have no convergence), adjust the discharge coefficient, C_d as follows:

W/Y	1	2	4
Cd	0.63	0.64	0.65

   b. We do not know exactly how much to adjust the C_d if the distances P, Z, or M are less than two times the smallest opening dimension. Therefore, it is recommended that the orifice be installed in a plate that is wide enough and tall enough to approximately meet those required distances – even if the plate must be extended beyond the inlet to the turnout. See the figure below.

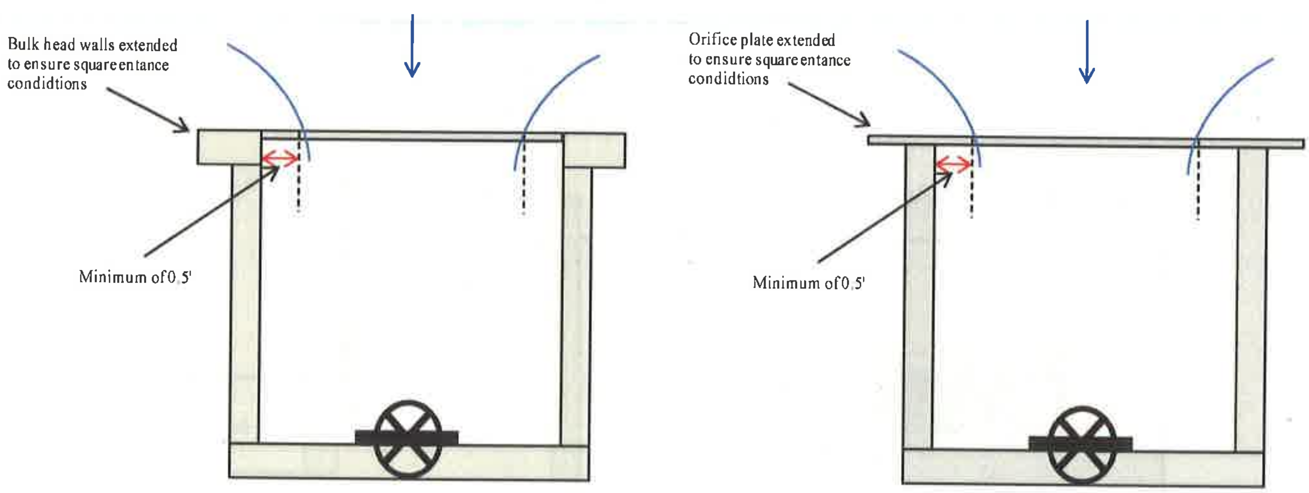


Figure 5. Installation of orifice

3. A single orifice size has a limited flow rate range. This is illustrated in the tables below. At too low a flow rate, the measured head difference is very small, often resulting in major errors in head difference. At too high a flow rate, the measured head difference is excessive, and may well exceed the available head. For this reason, *it is common to have a moveable plate that can be adjusted up and down,* varying the "Y" dimension.

   The addition of the moveable plate (often a rectangular sluice gate) creates the commonly known "CHO" or "constant head orifice". The device certainly does not create a "constant head", but it does provide an adjustable orifice. It provides the flexibility needed for a turnout to supply different flows at different times, with reasonably accurate head measurements. The opening should be adjusted so that the minimum head difference is greater than 0.2'. A 1' head loss across the orifice plate is more than what is attainable in many California irrigation district turnouts.

Table 5. Orifice size values

	Width of Orifice Opening, ft							
	1.0							
	Height of Orifice Opening, ft							
	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Flow Rate, CFS	Change in Head, ft							
5.0								1.0
4.5							1.0	0.8
4.0						1.0	0.8	0.7
3.5					1.0	0.8	0.6	0.5
3.0				1.0	0.8	0.6	0.5	0.4
2.5			1.0	0.7	0.5	0.4	0.3	0.3
2.0		1.0	0.7	0.5	0.3	0.3	0.2	0.2
1.5	1.0	0.6	0.4	0.3	0.2	0.1	0.1	
1.0	0.5	0.3	0.2	0.1				

	Width of Orifice Opening, ft						
	1.5						
	Height of Orifice Opening, ft						
	0.5	0.6	0.8	1.0	1.2	1.4	1.5
Flow Rate, CFS	Change in Head, ft						
11.0						1.1	1.0
10.0						0.9	0.8
9.0					1.0	0.8	0.7
8.0				1.2	0.8	0.6	0.5
7.0				0.9	0.6	0.5	0.4
6.0			1.0	0.7	0.5	0.3	0.3
5.0			0.7	0.5	0.3	0.2	0.2
4.5		1.0	0.6	0.4	0.3	0.2	0.2
4.0	1.2	0.8	0.5	0.3	0.2	0.2	0.1
3.5	0.9	0.6	0.4	0.2	0.2	0.1	0.1
3.0	0.7	0.5	0.3	0.2	0.1		
2.5	0.5	0.3	0.2	0.1			
2.0	0.3	0.2	0.1				
1.5	0.2	0.1					

Table 5 (continued). Orifice size values

	Width of Orifice Opening, ft								
	2.0								
	Height of Orifice Opening, ft								
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Flow Rate, CFS	Change in Head, ft								
20.0									1.0
19.0								1.2	0.9
16.0							1.0	0.8	0.7
13.0						0.9	0.7	0.5	0.4
10.0				1.0	0.7	0.5	0.4	0.3	0.3
9.0				0.8	0.6	0.4	0.3	0.3	0.2
8.0			1.0	0.7	0.5	0.3	0.3	0.2	0.2
7.0			0.8	0.5	0.4	0.3	0.2	0.2	0.1
6.0		1.0	0.6	0.4	0.3	0.2	0.1	0.1	
5.0	1.0	0.7	0.4	0.3	0.2	0.1	0.1		
4.5	0.8	0.6	0.3	0.2	0.1	0.1			
4.0	0.7	0.5	0.3	0.2	0.1				
3.5	0.5	0.4	0.2	0.1					
3.0	0.4	0.3	0.1						
2.5	0.3	0.2	0.1						
2.0	0.2	0.1							

	Width of Orifice Opening, ft											
	2.5											
	Height of Orifice Opening, ft											
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.5
Flow Rate, CFS	Change in Head, ft											
30.0											1.0	1.0
25.0									1.0	0.9	0.7	0.7
20.0							1.0	0.8	0.7	0.6	0.5	0.4
15.0					1.0	0.8	0.6	0.5	0.4	0.3	0.3	0.2
10.0			1.0	0.7	0.5	0.3	0.3	0.2	0.2	0.1	0.1	0.1
9.0			0.8	0.5	0.4	0.3	0.2	0.2	0.1	0.1		
8.0		1.2	0.7	0.4	0.3	0.2	0.2	0.1	0.1			
7.0		0.9	0.5	0.3	0.2	0.2	0.1	0.1				
6.0	1.0	0.7	0.4	0.2	0.2	0.1						
5.0	0.7	0.5	0.3	0.2	0.1							
4.5	0.5	0.4	0.2	0.1								
4.0	0.4	0.3	0.2	0.1								
3.5	0.3	0.2	0.1									
3.0	0.2	0.2										

	Width of Orifice Opening, ft													
	3.0													
	Height of Orifice Opening, ft													
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
Flow Rate, CFS	Change in Head, ft													
45.0													1.2	1.0
40.0												1.1	0.9	0.8
35.0										1.2	1.0	0.8	0.7	0.6
30.0									1.0	0.9	0.7	0.6	0.5	0.5
25.0							1.1	0.9	0.7	0.6	0.5	0.4	0.4	0.3
20.0						0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2
15.0				1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1
10.0			0.7	0.5	0.3	0.2	0.2	0.1	0.1					
5.0	0.5	0.3	0.2	0.1										

If steel theft is a concern, a marine plywood frame could be used to support a steel orifice opening frame. Fasteners used to connect the steel orifice to the plywood frame would need to be countersunk to minimize debris getting caught on them.

Trash Shedding Propeller Meters

For several decades there has been interest in "trash shedding propeller meters". ITRC examined the "cloggability" of an early design about 20 years ago. Boat propellers are sold with "weed shedding" features, which include specially designed propellers as well as fixed vanes upstream of the propeller that are intended to pass the weeds below or to the side of the boat propeller. McCrometer sells a saddle meter with the trash shedding options.

Mc® Propeller

MODEL M0300SW

CONFIGURATION SHEET
REVERSE BOLT-ON SADDLE
SURFACE WATER FLOWMETER

DESCRIPTION

The M0300SW is a bolt-on reverse-helix* propeller meter designed to shed debris often associated with surface water applications. The M0300SW is designed with the meter body turned 180 degrees from normal, a propeller installed nose-first on the bearing shaft, and a reverse flow style bearing assembly. This configuration allows the ell to curve with the flow, allowing grass or other debris to shed off with ease. The assembly design also reduces the ability of sand and silt to accumulate in the bearing.

The M0300SW features a fabricated stainless steel saddle with McCrometer's unique drive and register design. The stainless steel saddle eliminates the fatigue-related breakage common to cast iron and aluminum saddles and provides unsurpassed corrosion protection. Fabricated stainless steel construction offers the additional advantage of being flexible enough to conform to out-of-true pipe. The Model M0300SW is manufactured to comply with applicable provisions of American Water Works Association Standard No. C704-02 for propeller-type flowmeters. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

The impellers are manufactured of high-impact plastic, capable of retaining their shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of any standard McCrometer register, and since no change gears are used, the M0300SW can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The shielded bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

The instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective vinyl liner. The register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

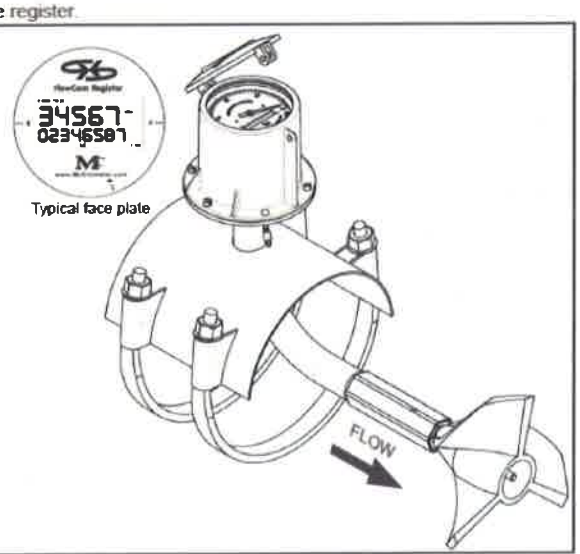
INSTALLATION

Standard installation is horizontal mount. If the meter is to be mounted in the vertical position, please advise the factory. A straight run of full pipe the length of eight pipe diameters upstream and five diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least three pipe diameters upstream and two diameters downstream of the meter.

* 4" meters use a forward helix propeller with a reverse register.

Typical face plate

The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available.



Typical face plate

APPLICATIONS

- **Surface Water**
- **Water Containing Trash**
- **Sand Producing Wells**
- **Irrigation District Turnouts**

McCrometer will also mount a reverse-facing propeller on a standard open flow meter, which can be mounted on stands above low pressure pipelines.

Propeller

CONFIGURATION SHEET

MODEL M1700 **OPEN FLOWMETER**

DESCRIPTION

Model M1700 Open Flowmeters are designed to measure the flow in canal outlets, discharge and inlet pipes, irrigation turnouts and other similar installations. The M1700 series meets or exceeds the American Water Works Association Standard C704-02. Constructed of stainless steel, the meter incorporates bronze mounting brackets that permit simple installation and removal. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

Impellers are manufactured of high-impact plastic, designed to retain both shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of standard McCrometer registers, and since no change gears are necessary, the M1700 can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The sealed bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

An instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective, self-lubricating vinyl liner. The die-cast aluminum register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

INSTALLATION

The M1700 must be mounted on a headwall, standpipe or other suitable structure so that the propeller is located in the center of the discharge or inlet pipe. A straight run of full pipe the length of ten pipe diameters upstream and two diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least five pipe diameters upstream of the meter. Please specify the inside diameter of the pipe when ordering.

The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available.
Typical face plates.

APPLICATIONS

The McCrometer propeller meter is the most widely used flowmeter for municipal water and wastewater applications as well as agricultural and turf irrigation measurements.
Typical applications include:

- Water and wastewater management
- Canal laterals
- Gravity turnouts from underground pipelines
- Sprinkler irrigation systems
- Golf course and park water management

A commercially available package that includes a reverse propeller meter and trash-shedding fixed vane, plus flow straighteners, is available from RSA.

Rubicon Transit Time Flow Meter

The Rubicon Sonaray flow meter is an interesting addition for larger turnouts with a canal supply, in that it also has a totalizer. The Rubicon literature cites a flow test in California, but it is unclear if the magmeter used for flow rate verification was recently calibrated. ITRC has found that new magmeters with guaranteed accuracies can be off by several percentage points. The device appears to be new, without substantial field testing in the USA.

Figure 6. Rubicon Sonaray flow meter

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