Kern River Watershed Coalition Authority

Comprehensive Groundwater Quality Management Plan – Second Revision

Kern County, California • November 2017

Prepared for:

Kern River Watershed Coalition Authority

Prepared by:

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PROVOST & PRITCHARD
CONSULTING GROUP
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Revised Comprehensive Groundwater Quality Management Plan – Second Revision

Kern County, California
November 2017 ***(Second Revision)***
October 2016 *(First Revision)*
February 2015

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Abbreviations

AFY/ac ..... Acre-feet per year per acre

AGR ..... Agriculture

AEWSD ..... Arvin-Edison Water Storage District

AFY ..... Acre-feet per year

A/R ..... Applied versus removed

ASA-CCA ..... American Society of Agronomy Certified Crop Advisors

BGS ..... Below ground surface

CDFA ..... California Department of Food and Agriculture

CDPH ..... California Department of Public Health

CGQMP ..... Comprehensive Groundwater Quality Management Plan

CIMIS ..... California Irrigation Management Information System

Coalition ..... Kern River Watershed Coalition Authority

COC ..... Constituent of concern(s)

CVHM ..... Central Valley Hydrologic Model

CVRWQCB ..... Central Valley Regional Water Quality Control Board

CV-SALTS ..... Central Valley Salinity Alternatives for Long-Term Sustainability

DAC(s) ..... Disadvantaged community(ies)

Dairy General Order ..... Waste Discharge Requirements General Order for Existing Milk Cow Dairies (Order R5-2013-0122)

DBCP 1,2-dibromo-3-chloropropane

DPR ..... California Department of Pesticides Regulation

DWR ..... California Department of Water Resources

ET ..... Evapotranspiration

FT ..... Foot/feet

FREP ..... Fertilizer Research and Education Program

GAR ..... Groundwater Quality Assessment Report

GAMA ..... Groundwater Ambient Monitoring & Assessment Program

General Order ..... General Order R5-2013-0120

GQMP ..... Groundwater Quality Management Plan

GTM Program ..... Groundwater Quality Trend Monitoring Program

GTM Workplan ..... Groundwater Quality Trend Monitoring Workplan

GWPA(s) ..... Groundwater Protection Area(s)

HVA(s) ..... High Vulnerability Area(s)

ILRP ..... Irrigated Lands Regulatory Program

IND ..... Industrial

ITRC ..... Cal Poly Irrigation Training and Research Center

KCWA ..... Kern County Water Agency

KRWCA ..... Kern River Watershed Coalition Authority

Mg/L ..... Milligrams per liter

MCL ..... Maximum contaminant level

MRP ..... Monitoring and Reporting Program

MUN ..... Municipal

NHI ..... Nitrate Groundwater Pollution Hazard Index

N ..... Nitrogen

NO_3 ..... Nitrate

NRCS ..... Natural Resources Conservation Service

RWQCB ..... Central Valley Regional Water Quality Control Board

SSJVWQC ..... Southern San Joaquin Valley Water Quality Coalition

SWRCB-AEP ..... State Water Resources Control Board Agricultural Expert Panel

SWRCB-DDW ..... State Water Resources Control Board Division of Drinking Water

TLHR ..... Tulare Lake Hydrologic Region

Tulare Lake Basin Plan ..... Water Quality Control Plan for the Tulare Lake Basin

UCCE ..... University of California Cooperative Extension

USDA ..... United States Department of Agriculture

USGS ..... United States Geological Survey

WDR(s) ..... Waste Discharge Requirement(s)

WRMWSD ..... Wheeler Ridge-Maricopa Water Storage District

Section One

Introduction

1 Introduction

This Comprehensive Groundwater Quality Management Plan (**CGQMP**) has been prepared on behalf of the Kern River Watershed Coalition Authority (**KRWCA** or **Coalition**) in response to Waste Discharge Requirements (**WDR**) General Order R5-2013-0120 (**General Order**). Groundwater Quality Management Plans (**GQMPs**) are required in areas:

- Where there is a confirmed exceedance of water quality objectives in groundwater and irrigated agriculture may cause or contribute to the exceedance;
- Defined as high vulnerability areas (HVAs) by the Groundwater Assessment Report (GAR) process;
- As required by the Basin Plan for a constituent or constituents discharged by irrigated agriculture; or
- When an Executive Officer determines trends of degradation contributed to by irrigated agriculture will threaten applicable beneficial uses.

In accordance with the outline in Attachment A and the specifications in Attachment B, Monitoring and Reporting Program (**MRP**), to the General Order, this CGQMP shall;

- Investigate potential irrigated agricultural sources of waste discharge to groundwater;
- Review physical setting information for the plan area such as geologic factors and existing water quality data;
- Develop a strategy with schedules and milestones to implement practices to ensure discharge from irrigated lands are meeting Groundwater Receiving Water Limitation;
- Develop a monitoring strategy to provide feedback on GQMP progress;
- Develop methods to evaluate data collected under the GQMP; and,
- Provide reports to the Central Valley Water Board on progress.

Rather than submitting separate management plans for noted exceedances, the KRWCA has elected to submit a single comprehensive plan to the Central Valley Regional Water Quality Control Board **(CVRWQCB**).

1.1 Background

The KRWCA boundary generally coincides with the Kern River Watershed boundary (**Figure 1**) and encompasses 3.5 million acres of land (gross acres), of which approximately 622,200 acres were irrigated (irrigated acres), as defined from 2013 Kern County Agricultural Commissioner data. As of the July 31, 2016 Participant List, 524,804 grower reported irrigated acres were registered to KRWCA members. Of the gross acres, approximately 97,600 acres are classified as urban, commercial, or industrial areas. The largest population center within the KRWCA is the City of Bakersfield.

The KRWCA area is separated into the primary boundary, which includes the valley floor, and a secondary boundary that contains very little irrigated acreage. The primary boundary includes approximately 1,023,600 gross acres of land that are within the boundary of the Kern County

groundwater subbasin. This includes approximately 619,200 irrigated acres on the San Joaquin Valley floor, as defined in 2013 data. The Upper Kern River Watershed is located almost exclusively within the KRWCA secondary boundary and encompasses approximately 1.5 million acres in the southeastern portion of the San Joaquin Valley.

1.2 Constituents of Concern

Constituents of concern (COCs) were identified using data collected for the development of the GAR. Nitrates, pesticides and salinity are referred to collectively as constituents of concern and abbreviated as COCs throughout the CGQMP. The MCL for Nitrate is 45 mg/L (as nitrate) and pesticides with designated MCLs were included in data analysis described in **Section 3**. **Section 4.1** describes characteristics of these COCs in detail.

1.3 Geographic Boundaries of Comprehensive Groundwater Quality Management Plan

Areas to be covered by the KRWCA CGQMP include all HVAs assigned by the CVRWQCB on 30 March 2015. These HVAs also include irrigated acreage identified in the KRWCA GAR on a field by field basis to be high vulnerability to nitrate and or pesticide impacts. The KRWCA GAR defined HVAs as areas which:

- Fall within groundwater protection areas (**GWPA**) for pesticide leaching by California Department of Pesticide Regulation (**DPR**); or,
- Are identified by the Nitrate Groundwater Pollution Hazard Index (**NHI**) to have a high nitrate leaching risk from the land surface; or,
- Have groundwater quality exceedances for nitrates and/or pesticides above the MCL.

The HVAs identified by the KRWCA and the CVRWQCB are presented on **Figure 2**.

1.4 Comprehensive Groundwater Management Plan Implementation

The CGQMP is designed to address defined COCs throughout KRWCA HVAs. Activities to implement the CGQMP include identifying relevant management practices, communicating them through grower outreach and education, and monitoring existing and future rates of adoption of protective practices. These activities are supported by the South San Joaquin Valley Management Practices Evaluation Program (**SSJV MPEP**), as described in the MPEP Workplan. **Table 1** outlines the sections of the CGQMP and the SSJV MPEP Workplan which jointly address CGQMP requirements. The Groundwater Quality Trend Monitoring (**GTM**) Program will also provide data to support implementation of the MPEP and CGQMP.

Section Two

Physical Setting & Information for CGQMP Area

2 Physical Setting & Information for CGQMP Area

2.1 Land and Hydrology Characteristics

Potential sources and transport mechanisms of COCs to groundwater are dependent on factors such as climate, land use, soils, geologic and hydrologic characteristics within the KRWCA. These factors are described in the following sections to define the physical setting in which irrigated agriculture takes place in the KRWCA.

2.1.1 Climate

The climate of the KRWCA is considered semi-arid to desert. Potential evapotranspiration (**ET**), the amount of water evaporated and transpired from healthy grass in a normal year, is 57.9 inches in the southern San Joaquin Valley (Jones, 1999). Potential ET from May to August varies little, less than 5 percent, from year to year (Sanden, 2014a). Effective precipitation, the portion of precipitation that can be beneficially used by crops, averages 3.4 inches in a normal year (Kern County Water Agency, 2005). As such, local surface water supplies are limited and irrigated agriculture in the region relies on groundwater supplies and imported surface water supplies from the north.

2.1.2 Land Use

Information on land use within the KRWCA was developed from the Kern County Agriculture Commissioner, U.S. Department of Agriculture (USDA), and the California Department of Water Resources (DWR). Kern County has the second largest crop-based economic value of agricultural counties in the state and nation, producing over 250 crops; including 30 types of fruit and nuts, over 40 varieties of vegetables, over 20 field crops, lumber, nursery stock, livestock, poultry and dairy products (USDA, 2014). Reviewing land use data within the KRWCA primary boundary illustrates the change in crops and irrigation systems that have occurred in recent history. See **Figure 3** for a review of the KRWCA historical (1990) cropping distribution, referencing the DWR crop database, and **Figure 4** for 2013 cropping distributions as documented by the Kern County Agriculture Commissioner.

Overall, the proportion of permanent crops grown in Kern County has increased significantly in the past 20 years and in the nearly all cases, these plantings are developed with highly efficient drip and/or micro-spray irrigation systems. Widespread conversion from gravity irrigation systems to pressurized systems has been accompanied by an increasing use of fertigation, where liquid fertilizer is delivered to the crop in irrigation water. Pressurized systems allow for precise fertilizer delivery, although fertigation is used in some surface irrigation systems as well. Irrigation water and delivery infrastructure are currently the most expensive components of agricultural production in Kern County. Growers are also generally motivated to employ efficient nutrient management because fertilizer additions represent another large expense.

The predominant KRWCA crop in 1990, from the DWR crop database (DWR, 2014), was cotton. Cotton accounted for about 236,000 irrigated acres (aerial extent), over one third of all irrigated acres. Cotton, field crops (small grains, hay and forage), alfalfa, and truck crops (vegetables, melons and berries) made

up almost 80 percent of the cropped irrigated acreage; however, almond, grape, and citrus were also significant individual crops at this time. **Table 2** lists the various KRWCA crops in 1990 and respective percent of total irrigated acreage.

For 2013, the Kern County Agriculture Commissioner spatial crop database provides land use data in commodity acres, which may include multiple counting of double and triple cropped irrigated acres (County of Kern Agriculture and Measurement Standards, 2014). **Table 3 l**ists the commodity acreage and percentage of total cropped area in 2013. In 2013, 466,347 irrigated acres were single-cropped while 152,894 irrigated acres were multi-cropped. Cotton acreage fell to approximately 38,000 acres in 2013 (less than 20 percent of 1990 acreage). In contrast, almond and pistachio acreage increased from 62,000 to 162,000 acres and 3,000 to 44,000 acres, respectively. Corn also increased from 6,000 acres to 40,000 acres, replacing some alfalfa acreage, and much of the range and pasture acreage.

2.1.3 Soils

Soils on the Kern County valley floor have two general origins that are approximately delineated by the trough of the valley. The eastern alluvial fans were deposited primarily through runoff and sediment transport from the Sierra Nevada, Tehachapi, and Transverse Mountain ranges. These soils are of igneous and metamorphic origin; typically, well drained, lower in salinity, and of ideal quality for agriculture. The western alluvial fans originated from Coastal Range sedimentary rock formed on the sea bottom. This region tends to have more areas with poorly drained soils of relatively marginal quality. Many of the soils on the west side of the valley required some reclamation before crops could be grown profitably.

The primary area of the KRWCA can be divided into five main areas relative to soil texture and typical cropping: the Clay Rim, Foothills, Kern Fan, Northern Areas, and Wheeler Ridge/Arvin Edison regions (**Figure 5**). Soil pH is generally higher in the southern and northwestern areas of the primary KRWCA area. These areas roughly correspond to alluvium from the San Emigdio Mountains and fringes of alluvial fans. High salinity is typical of historic lakebed, swamp and overflow, and alluvial fan margin soils; the combination of high pH and high salinity is found in many of those areas.

The Clay Rim region accounts for approximately 154,000 gross acres in the KRWCA's primary boundary, and consists of heavy (fine-textured) soils extending from the mid-northwestern boundary of the focus area southerly to the southern tip. It includes the historic Buena Vista Lake Bed and historic Kern Lake Bed, derived from lacustrine deposits, and historic swamp and overflow lands at the margins of alluvial fans and historic lake beds.

The Foothills region represents about 63,000 gross acres, and consists of medium-textured soils extending along the eastern edge of the focus area.

The Kern Fan region, approximately 225,000 gross acres, includes soil derived from river deposition. Because of their alluvial origins, soil texture varies with the distance from the mouth of the historic drainage coming from the foothills, but can generally be characterized as coarse-textured.

The Northern Areas region, 330,000 gross acres, is generally comprised of soils that are less easily characterized and divergent in texture.

The Wheeler Ridge/Arvin-Edison region encompasses 198,000 gross acres and generally has coarse-textured soils. The region boundary generally follows the Arvin-Edison Water Storage District (**AEWSD**) and Wheeler Ridge-Maricopa Water Storage District (**WRMWSD**) borders, with some exceptions. A

portion of northeastern AEWSD has been included in the Foothills region, as it is more consistent with that area in terms of cropping and soils. Similarly, because of differences in soil texture and crop type in the northern part of WRMWSD, the northern portion is included in the Clay Rim region

Historic lake beds, swamps, and overflow lands consist of slightly acidic lacustrine and alluvial fan margin soils that are formed when fine particles settle out from lake and swamp water. The Kern and Buena Vista historic lake beds are comprised of clay soils with little variation. In particular, the Buena Vista lakebed, though it has silty clay soils at the surface, is underlain by a very thick horizon of clay soil with very low permeability. Surface soils typically have a relatively high saturation percentage (60 percent to 80 percent), meaning that they hold relatively large amounts of water compared to coarser-textured soils with large pores that drain water more readily.

Generalizations may be made regarding the preferred KRWCA regions and soils for cultivating different crops. In the KRWCA primary boundary most citrus is grown along the eastern side, or Foothills region, where soils are medium-textured. The Foothills regional topography also creates microclimates with fewer incidences of freezing temperatures, conducive to citrus cultivation. Mountain and foothill areas in the northeastern part of the KRWCA boundary are used as rangeland for cattle or sheep and are primarily non-irrigated. Crops such as dryland wheat may be grown in this area. Grapes are typically grown on coarse or medium-textured soils found in the northeastern portion of the KRWCA primary area and in the southern area corresponding to the Kern Fan. In contrast, the heavy (fine-textured) soils of the Clay Rim region are dominated by cotton, wheat, corn and tomatoes. In general, permanent crops have expanded onto various soils that were previously not used to grow trees and vines. Corn and silage has also expanded on various soil types in response to livestock feed demand, primarily in proximity to dairy developments. See Section 2 in the KRWCA GAR for additional analysis.

2.1.4 Geology

The primary KRWCA area is located mostly within the southern portion of the San Joaquin Valley, a long structural trough filled to a depth of up to 10,000 feet of marine and continental sediments. The continental sediments represent a variety of depositional environments including fluvial, deltaic, lacustrine, and alluvial fan sequences which form an alluvial wedge that thickens to the west across the valley. The secondary KRWCA area extends over a large area of varying geologic and hydrogeologic environments, including upland areas of igneous and metamorphic rock and small valleys filled with continental sediments. The primary portion of the KRWCA area is located almost entirely in the areas of recent alluvium on the floor of the San Joaquin Valley. The entire KRWCA area is in the Tulare Lake Hydrologic Region (**TLHR**) (DWR 2003).

2.1.4.1 Regional Stratigraphy

Surficial regional geology is shown on **Figure 6** (USGS 2014) and key elements of the geologic and hydrogeologic setting are summarized below.

A geologic map of recent deposits (Page 1986) is presented on **Figure 7** with detail of the Neogene and Holocene (late Tertiary and younger) basin sediments that comprise the majority of the valley floor portion of the KRWCA area. These basin sediments are rimmed by Tertiary and pre-Tertiary bedrock to the east, south, and west. The Kern River bisects the area and it is underlain by recent channel deposits. The morphology of the recent alluvial fan is indicated by the trajectory of the canal systems south of the river. The terminus of the ancestral river occurred at inland lakes including the historical Kern Lake and

Buena Vista Lake beds, shown on the map. During long periods of large flows, the river drained north to the Tulare Lake Bed. These paleo-drainages are associated with the deposition of fine-grained sediments, shown on the map as flood-basin deposits and older lacustrine deposits. There are small areas east of the San Joaquin Valley near Stallion Springs and Tehachapi that are also included in the KRWCA primary area.

The mapped geology in the secondary portion of the KRWCA area indicates a wide range of materials and depositional environments. Nearly 80 percent of this area is mapped as igneous and metamorphic materials that likely have no primary porosity. The remaining 20 percent of the secondary area is equally distributed between older lithified sedimentary material and recent alluvial, glacial, or landslide deposits.

Geologic cross sections for the Maricopa-Edison area are attached as **Appendix A** (P.R. Wood and R.H. Dale, 1964). Publicly available geologic cross sections that extend across portions of the Coalition's area will be included in future work plans and reports to present data in a graphical format.

2.1.5 Hydrogeology

The groundwater hydrology of the KRWCA area is considered notable within the TLHR due to the groundwater basin configuration, hydrologic stresses, and depth to first-encountered groundwater. As noted in the expert report submitted to the CVRWQCB, these unique aspects represent spatial disconnects throughout the KRWCA area which must be accounted for in the GTM Program required by the General Order (Gailey 2013). There is very little information regarding groundwater conditions in the secondary portion of the KRWCA. This is especially true of groundwater level information as there are few groundwater level measurements available and no assessment of regional groundwater patterns has been completed.

The United State Geological Survey (**USGS**) Central Valley Hydrologic Model (**CVHM**) estimates the vertical and horizontal aquifer parameters of the entire Central Valley, and was used to represent relative aquifer parameter distribution in the Kern County subbasin. The Corcoran Clay is a regionally extensive low permeability unit located in much of the San Joaquin Valley (Croft 1972). However, in Kern County the Corcoran Clay is not considered to be as low permeability or to function as a continuous aquitard or barrier to vertical flow as it does in the other portions of the Central Valley, most notably to the north. The Corcoran Clay is also present at deeper depths than in other areas of the Central Valley (Schmidt and Associates 2006 and Schmidt and Crewdson, personal communication, October 2012).

2.1.5.1 Groundwater Basins and Subbasins

The primary portion of the KRWCA area includes parts of four DWR designated basins:

- The Kern County Portion of the San Joaquin Groundwater Basin (Kern County Subbasin, No. 5-22.14);
- The Cummings Valley Groundwater Basin (No. 5-27);
- The Tehachapi Valley West Groundwater Basin (No. 5-28); and,
- The Brite Valley Groundwater Basin (No. 5-80).

The locations of these groundwater basins are shown on **Figure 8**.

The majority of the primary portion of the KRWCA area is within the Kern County Subbasin, which is the southern-most portion of the San Joaquin Valley Groundwater Basin, as defined by DWR. The Kern County Subbasin is included in the CVHM. The USGS generally used the DWR delineations of groundwater basins in the Central Valley in the development of the active area of the CVHM.

2.1.5.2 General Groundwater Chemistry

The primary portion of the KRWCA area includes the majority of the Kern County Subbasin of the San Joaquin Groundwater Basin, which is an inland groundwater basin with no significant outflow. In the Tulare Lake Basin and areas immediately adjacent to it, there is a tendency for salts to accumulate, due to almost no percolation (frequently upward groundwater gradients) and evapoconcentration. Localized areas of elevated salinity can develop upgradient where inadequate leaching, flushing, and outflow occur due to local drainage impairments such as poorly drained soil or limited surface drainage toward the historic Tulare Lake.

Shallow zones in the eastern subbasin are primarily characterized as containing calcium bicarbonates and increasing in sodium concentrations with depth. This trend shifts from east to west, with west side water primarily containing sodium sulfate to calcium-sodium sulfate. Shallow groundwater in the western region is characterized by high TDS, sodium chloride, and sulfate which is problematic for agricultural uses. Arsenic levels in groundwater are often associated with lakebed deposits (DWR 2003).

Although general groundwater chemistry is variable, a representative regional assessment was conducted by the USGS (2008). The USGS analyzed spatially distributed and statistically unbiased results from the Groundwater Ambient Monitoring & Assessment (**GAMA)** for the Kern County Sub-basin. A summary of their findings is provided in **Table 4**. As required by the General Order (Appendix MRP-1 3.b.ii, Piper Diagrams are provided in this CGQMP to visually represent groundwater and surface water chemistry within the KRWCA area (**Appendix B**). Piper diagrams illustrate water quality by plotting a matrix transformation of the graph of the major cations and anions; the resulting diagram allows comparison of ionic composition differences in water quality (P.R. Wood and R.H. Dale, 1964).

As required by the General Order, the GAR will be revised in the next five-year cycle, scheduled for February 2020. Revisions to the GAR will include a detailed description of readily available public groundwater data (range of EC, concentrations of major anions and cations, nutrients, TDS, pH, dissolved oxygen and hardness).

2.1.5.3 Water Bearing Zones

The majority of the primary portion of the KRWCA area overlies the Kern County Subbasin. The assessment of subsurface sediments focused on this aquifer. The majority of the water bearing material in the Kern County Subbasin is relatively young (Pliocene to Holocene) continentally derived unconsolidated alluvium, with marine derived unconsolidated alluvium of similar age present in the western and southern portions of the Subbasin (Wood and Davis 1959; Davis et al., 1959; Hilton et al., 1963; Wood and Dale, 1964; Dale et al. 1966; Croft, 1972; Page, 1973; Bartow and McDougall, 1984; Page, 1986; Williamson et al., 1989; Bertoldi et al., 1991 and DWR, 2006a). An assessment of water bearing zones with respect to well construction information will be conducted within the KRWCAs forthcoming GTM Program.

As outlined by the DWR, the Kern Subbasin water bearing zones are generally comprised of sediments deposited during the Tertiary and Quaternary age. These formations include:

- **Olcese Formation:** Primarily sand, ranging from 100 - 450 feet (**ft**) thick, supplies drinking water in the northeastern portion of Kern County where the formation occurs as a confined aquifer;
- **Santa Margarita Formation:** Coarse sand, ranging from 200 - 600 ft thick, supplies drinking water in the northeastern portion of Kern County where the formation occurs as a confined aquifer;
- **Tulare Formation:** Comprised of clays, sands, and gravels, up to 2,200 ft thick, derived from the Coastal Range, moderately to highly permeable and yielding moderate to large water quantities, includes the Corcoran Clay Member;
- **Kern River Formation:** Includes poorly sorted lenticular clay, silt, sand, and gravel derived from the Sierra Nevada, ranging from 500 – 2,000 ft thick, moderately to highly permeable and yielding moderate to large water quantities, includes the Corcoran Clay Member;
- **Older Alluvium/Stream and Terrace Deposits:** Loosely consolidated lenticular deposits of clay, silt, sand, and gravel, 250 ft thick, yielding large water quantities; and,
- **Younger Alluvium/Flood Basin Deposits:** Stratified and discontinuous clay, silt, sand, and gravel beds, up to 150 ft thick, permeability varies with fine grained percentage, as with deposits underlying historic Buena Vista and Kern Lakes (DWR 2003).

Shallow groundwater areas identified and mapped by the Kern County Water Agency (**KCWA**) roughly correlate to areas of low permeability soils in and around the Buena Vista and Kern Lake beds in the southern portion of the Subbasin, and within the western portion of the Semitropic Water Storage District. The KCWA has been tracking the presence of these shallow groundwater areas since 1976, and the extent of the area has generally increased over that period (KCWA, 2011). While the shallow groundwater areas are contoured separately from the unconfined aquifer, there is no indication that shallow groundwater is actually a completely separate and distinct water body.

Irrigation wells have been documented to be drilled to depths exceeding 2000 ft (Herb Simmons, Provost & Pritchard, personal communication, 15 December 2014). Municipal public supply wells in the Kern County Subbasin often range from 500-1000 ft, as reviewed by the USGS (ref 2006), but can reach up to 2000 ft. Domestic wells may be completed to total depths of 100 ft to 1000 ft, varying dramatically throughout the KRWCA along with depth to groundwater. These depth ranges are reasonably in line with the outlined water bearing formations. Well depth data will be further refined throughout the GTM Program.

2.1.5.4 Discharge & Recharge Zones

Groundwater recharge is the sum of the hydrogeologic processes by which water percolates into a groundwater aquifer, a function of available water and permeable ground surfaces. Permeability of ground surfaces vary with the varying soils and surficial geology as described in previous sections. Unsaturated hydraulic conductivity values represent the best available information regarding relative permeability of the unsaturated zone throughout the Kern County Subbasin portion of the KRWCA primary area. The regional distribution of hydraulic conductivity values for the unsaturated zone is discussed in **Section 2.1.5.6**.

Natural recharge, a function of precipitation, ET, and soil moisture holding capacity, is limited in the primary area. In the secondary area natural recharge is dominant but difficult to estimate because of

variable precipitation/runoff, limited extent of unconsolidated material, and predominance of fractured bedrock groundwater.

Agricultural return flow is the water that runs off crop land and/or percolates past the root zone in excess of the crop needs, or root zone water holding capacity. Agricultural return flow is primarily a function of irrigation efficiency, effective precipitation, and management. Municipal return flow results from precipitation and water applied to the ground surface in municipal settings that exceeds evaporation, consumptive use, and root zone water holding capacity, or percolation from stormwater detention basins. Treated wastewater is regulated by the CVRWQCB under specific individual WDRs and waste discharge permits. Recharge from septic systems is significant in the KRWCA, but is not measured or estimated. Recharge from wastewater generated by food processing, confined animal facilities, and other industries may also be significant, but are generally regulated under WDRs.

Enhanced recharge and banking is performed in the KRWCA area by multiple water agencies through mechanisms such as recharge ponds, canal seepage as water is conveyed, and seepage from reservoirs. In-lieu recharge activities that displace groundwater use by providing surface water, in-lieu of pumping groundwater, are also a significant recharge management practice in the region. Canal seepage is generally high-quality water, and managed recharge is considered to have an overall positive benefit to groundwater quality in the KRWCA area. There are a number of enhanced groundwater recharge projects in the KRWCA area. Additional analysis and mapping of these projects is presented in Section 8 of the KRWCA GAR.

Recharge areas are a "primary" net benefit to groundwater quantity, and high source water quality may provide a "secondary" net benefit by diluting the concentrations of groundwater constituents. Major groundwater recharge sources in the KRWCA area generally have lower concentrations of nitrate and salinity than the receiving groundwater aquifer. However, minor recharge sources may have higher concentrations of nitrates and salinity, and could negatively impact groundwater quality.

2.1.5.5 Water Sources and Water Chemistry

The water bearing zones which supply domestic, irrigation, and municipal users vary throughout the KRWCA region. Typically, domestic wells will utilize shallower groundwater aquifers due to the cost of drilling deeper wells, but there is no comprehensive record for domestic well depth ranges. Due to their shallower depths, domestic wells typically are more greatly affected by groundwater quality issues associated with surface level activities, specifically nitrates and 1,2-dibromo-3-chloropropane (**DBCP**).

As noted, municipal supply and agricultural wells have been estimated by the DWR to be drilled to depths exceeding 2,000 ft. Currently, agricultural irrigation wells are being drilled through all usable water bearing zones. The usability of the water tends to decrease with depth as the TDS increases, especially with the presence of connate water, but there is no consistent depth or trend associated with this phenomenon. Municipal wells are drilled and screened based on site specific factors, including the presence of nitrate and DBCP in the shallow water bearing zones, or the presence of arsenic and radionuclides at variable depths. Arsenic is present in many San Joaquin Valley formations, but is only present in groundwater under specific geochemical conditions that are often associated with lakebed areas. Sediments throughout the KRWCA may contain radionuclides, but it is highly variable and must be defined on an individual site. Due to this variability, municipal wells are not necessarily shallower than agricultural wells (Herb Simmons, Provost & Pritchard, personal communication, 15 December 2014).

It is estimated that groundwater accounts for approximately 39 percent of total water supply in the region; however, during dry years it can increase to as much as 60 percent. Applied irrigation water in the KRWCA is a mix of both available ground water and imported surface water. Groundwater quality is dependent on regional conditions and water bearing zones.

As discussed previously, general groundwater quality for the Kern County sub-basin can be found in **Table 4** (USGS 2006). General groundwater quality of applied irrigation water throughout the KRWCA may be more specifically defined throughout the GTM Program. Friant-Kern Canal (**FKC)** surface water monitoring was reviewed to determine a representative water quality of surface water used for irrigation throughout the KRWCA. Surface water samples taken for regional baseline monitoring at the Calloway Avenue Station on the Friant-Kern Canal from 1996 to 2006 were summarized in **Table 5** (USBR 2014). These results provide an analysis of the general chemistry of surface water in reaches of the FKC which is applied as irrigation water.

2.1.5.6 Aquifer Characteristics

As noted above, KCWA prepares two annual depth to groundwater maps. There is one annual spring map showing depth to groundwater in the unconfined aquifer throughout the Kern County Subbasin (**Figure 9**), and another showing depth to water in shallow groundwater areas (**Figure 10**) where water is present at less than 20 feet below ground surface.

Based on annual spring groundwater elevation contours prepared by KCWA for 2000 through 2013 (KCWA 2014), the highest groundwater elevations in the period were in the spring of 2007 (wet period) and the lowest occurred in the spring of 2013 (dry period). The spring 2007 groundwater elevation contours are shown on **Figure 11**. The 2007 wet period unconfined aquifer depth to groundwater ranges from less than 50 ft below ground surface (**bgs**) to over 700 ft bgs. The deepest groundwater depths occur in the southern portion of the KRWCA primary area. The 2013 dry period depth to water contours are similar but show that groundwater is generally 30 to 80 ft lower. Groundwater elevations in 2007 were highest near the Kern River and the associated groundwater banking operations. The lowest groundwater elevations during this period are in the northwest portion of the Subbasin. Selected illustrative hydrographs showing a range of local groundwater elevation trends throughout the KRWCA primary area are shown in **Figure 12**.

A groundwater elevation surface to represent changes from drought conditions was found by subtracting the spring 2012 surface from the spring 2013 surface, and on average groundwater elevations within the KRWCA primary area decreased over 34 ft. The highest magnitude reductions in groundwater elevations during this period occurred along the eastern edge of the Subbasin. Between 2005 and 2006, a wet period, groundwater elevation changes ranged between increases of over 120 ft to decreases of nearly 140 ft, with an average increase of over 13 ft. The dominant groundwater elevation trends in the area are the large variations near the Kern River on the Kern Fan produced by the high volumes of managed recharge and recovery associated with groundwater banking projects. These effects dissipate away from the Kern Fan, where groundwater elevation patterns are more muted and show seasonal effects, short term responses to wet and dry periods, and long-term groundwater declines.

Given the significant variations in groundwater elevations that occur throughout the Kern Subbasin in response to variations in hydrologic conditions, no single groundwater elevation surface should be taken to be representative of groundwater flow directions. Therefore, a combined groundwater elevation

surface was generated to represent trends in groundwater elevation and flow directions throughout the Subbasin, found on **Figure 13**. These flow directions show that average groundwater flow north of the Kern River is generally towards the north and center of the Subbasin, focused on low average elevations in the north.

The thickness of the unsaturated zone varies over time and space in the Kern County Subbasin. The combined depth to groundwater and depth to shallow groundwater contour data show the variation in depth to groundwater over time and space, which is the same as unsaturated zone thickness. These changes in unsaturated zone thickness occur in response to temporal and geographic variation in recharge and groundwater use.

The KRWCA assessed variations in unsaturated zone thickness by comparing groundwater elevation contour maps from multiple years to one another. This analysis involved the conversion of contour datasets into surfaces representing groundwater elevation using geographic information system (**GIS**) tools. The depth to groundwater and depth to shallow groundwater contour data prepared by KCWA was used to define the thickness of the unsaturated zone based on the results of the comparison of groundwater elevations described above. Since the spring 2007 depth to water data corresponds to the highest groundwater elevations in the period of study, it also corresponds to the shallowest depth to groundwater and thinnest unsaturated zone. This condition was chosen to characterize the unsaturated zone for the hydrogeologic evaluation because it is conservative with regard to travel time from ground surface to first encountered groundwater.

The hydraulic conductivity parameters from the CVHM groundwater model were extracted for the unsaturated zone throughout the primary KRWCA area. The combined depth to groundwater surface described above was interpolated to the CVHM grid to identify the depth of the unsaturated zone. The distribution of these hydraulic conductivity values is shown on **Figure 14** and **Figure 15**. These unsaturated hydraulic conductivity values represent the best available information regarding relative permeability of the unsaturated zone throughout the Kern County Subbasin portion of the KRWCA primary area.

As part of the SSJV MPEP, a valley-wide Ksat analysis was performed in the Workplan, Section 3.5.1.2.

2.1.6 Beneficial Uses

The CVRWQCB Water Quality Control Plan for the Tulare Lake Basin (**Tulare Lake Basin Plan**) designates groundwater aquifer beneficial uses to be protected, water quality objectives to protect those beneficial uses, and a program of implementation needed for achieving or sustaining these objectives. **Table 6** outlines the beneficial uses for the Kern County Basin hydrologic units and all associated satellite basins.

A Basin Plan amendment for regions throughout the Tulare Lake Basin is currently being pursued by the Central Valley Salinity Alternatives for Long-Term Sustainability (**CV-SALTS**), which may result in a de-designation of some groundwater areas from specific beneficial uses.

Section Three

Groundwater Assessment Report

3 Groundwater Assessment Report

Although the KRWCA currently employs the HVA assigned by the CVRWQCB as of 30 March 2015, the GAR provided the baseline analysis to define HVAs. As noted in **Section 1.2**, the KRWCA GAR defined HVAs as areas which:

- Fall within groundwater protection areas (**GWPA**) for pesticide leaching by California Department of Pesticide Regulation (**DPR**);
- Are identified by the Nitrate Groundwater Pollution Hazard Index (**NHI**) to have a high nitrate leaching risk from the land surface; or,
- Have groundwater quality exceedances for nitrates and/or pesticides.

The GAR was submitted on February 4, 2015 and included analyses of data conducted throughout 2014. The KRWCA identified HVAs are presented on **Figure 16**, and include analysis of additional dairy acreage now included in the Coalition. Ultimately, incorporating analysis changes recommended by the RWQCB the KRWCA identified 276,593 irrigated acres within the primary boundary as high vulnerability based on water quality exceedances, the NHI analysis, and DPR GWPAs. As defined in the GAR, these irrigated acreage values reflect cropped field information processed from 2013 Kern County Agriculture Commissioner data. See **Table 7** for the high vulnerability area by designation type.

The updated CVVRWQB identified HVAs are presented on **Figure 2.** The CVRWQCB defined an additional 130,791 irrigated acres as high vulnerability, bringing the total irrigated acres of high vulnerability area to 407,384 irrigated acres.

The total irrigated acreage by crop type in the identified HVA is presented in **Table 8**. The top 80 percent of identified KRWCA HVA, by irrigated acreage, includes almonds, grapes, truck crops, citrus, field crops, alfalfa, and pistachios.

3.1 Data Sources

The data employed to analyze the groundwater quality exceedances for the purpose of the GAR was collected and compiled into a comprehensive groundwater quality database. The sources of groundwater quality data available for this study are:

- State Water Resources Control Board Division of Drinking Water [**SWRCB-DDW**, formerly California Department of Public Health (**CDPH**), through the GAMA program];
- CDPH Archived Data;
- DWR;
- Cleanup Sites (EDF) (through the GAMA program);
- KCWA;
- DPR CDPH (through the GAMA program);
- USGS (through the GAMA program);

- CVRWQCB Waste Discharge Requirements General Order for Existing Milk Cow Dairies (Order R5-2013-0122) Monitoring Data.

The resulting database includes over 145,000 records for the three constituents of focus (nitrate, total dissolved solids, and pesticides) from over 6,700 locations. These groundwater quality data represent available results from 1909 through 2014. Well construction information was not generally available for the wells for which groundwater quality data was available. As a result, the analyses presented in the CGQMP and GAR did not include any evaluation of depth or aquifer material associated with groundwater quality results. As noted, it is assumed for the sake of this evaluation that all groundwater quality results represent first encountered groundwater. Analyses will be refined to include well construction data throughout with the development of the GTM Program.

3.2 Data Analysis

Data from multiple sources was collected and compiled into a comprehensive groundwater quality database for the KRWCA area to fulfill the requirements of the GAR. The resulting database included over 145,000 records for the three constituents of focus from over 6,700 locations. This water quality data included available groundwater quality analysis results from 1909 through 2014. Some of the available groundwater quality data were associated with wells for which location information was not available; these data were not included in the analyses presented below. The MCL of 45 mg/l nitrate as nitrate has been used to identify nitrate impacted groundwater in the KRWCA area.

Development of the KRWCA GAR included analysis of trends in nitrate concentrations based on publicly available data for all nitrate sample results reported at the detection limit or higher. Unfortunately, currently available data sets were inadequate to define trends. Although many wells may either have documented historic or current readings there was insufficient continuous data over an adequate time period to define temporal trends. Long term trend analysis of nitrate concentrations in groundwater will be developed with data gathered under the GTM program and will inform future HVA designations.

Pesticide impacted groundwater in the KRWCA area was identified by exceedance of respective MCLs for those detected constituents with established MCL values. The relevant MCLs for evaluating exceedances were identified from the California State Water Resources Control Board (**SWRCB**) Water Quality Goals database (SWRCB 2014a), an online searchable database that provides State and national established primary MCLs, secondary MCLs, State public health goals (**PHGs**), and State notification levels (**NLs**), among other water quality numeric standards for numerous constituents. The State or national MCL was used to determine thresholds for each detected pesticide constituent. Some constituents do not have established State or national MCLs. A summary of the pesticides that were detected in the available data along with the respective thresholds is included in **Table 9**.

As noted the analyses presented in this section do not include any evaluation of depth or aquifer material associated with water quality results. For this analysis, it was assumed that all groundwater quality results represent first encountered groundwater. GTM Workplan will include the collection of well construction data to provide additional information on the vertical distribution of constituents over time and first encountered groundwater.

3.3 High Vulnerability Designations

3.3.1 Water Quality Exceedances

Groundwater quality analysts used USGS CVHM grid cells (one square mile) to identify impacted groundwater quality. This approach is considered conservative, accounting for spatial imprecision when identifying groundwater well locations and correlating spatial groundwater quality results. Approximately 132,232 irrigated acres are identified as being within fields intersecting CVHM grids impacted by nitrate and/or pesticides, presented on **Figure 17**. The irrigated acreage impacted by nitrates, pesticides, or both nitrate and pesticide exceedances is shown comparatively in **Figure 18**. Of the 132,232 irrigated acres impacted by groundwater quality exceedances, 92 percent of this area was impacted by nitrate exceedances only, 3 percent was impacted by pesticide exceedances only, and 5 percent was impacted by both nitrate and pesticide exceedances.

3.3.1.1 Nitrate Exceedance Mapping

The spatial distribution of maximum concentrations of nitrate (**NO_3^-**) in groundwater wells from 1920 to 2014 is split into three groupings (0-45, 45-90, and greater than 90 mg/L NO_3^-) (**Figure 19**). Recent maximum nitrate concentrations in groundwater between 2000 and 2014 (**Figure 20**) illustrate less data availability but indicate that recent spatial trends remain similar. A geostatistical analysis of the historical and current nitrate groundwater quality data was used to further illustrate areas where groundwater quality may already be impacted. The maximum concentration was calculated for all wells. Within a grid cell of one square mile, the maximum well concentration was taken to represent the maximum nitrate concentration in that area. The area discretization for this analysis was the grid cell for the USGS CVHM; the resulting nitrate distribution is shown on **Figure 21**.

3.3.1.2 Salinity Exceedance Mapping

The distribution of maximum concentrations of TDS in groundwater wells from 1909 to 2014 is shown on **Figure 22**. Wells with high TDS concentrations are generally found clustered to the west of the primary boundary area. This is consistent with the KCWA Water Supply Reports (KCWA, 2012), which illustrate historical salinity concentrations in the western Central Valley portion of Kern County. In the western edge of the basin, the alluvial fan may thin and wells located here may be screened in bedrock formations rather than alluvium. As with nitrate, there are higher TDS concentrations in the eastern and southern portions of the primary boundary, as well.

The maximum and grid approach to represent existing groundwater quality impacted areas described for nitrate was also used for TDS. The maximum TDS results for the CVHM grid cells are shown on **Figure 23**. Grid cells with no color applied indicate areas where no TDS data are available.

3.3.1.3 Pesticide Exceedance Mapping

The water quality threshold for each individual detected constituent was compiled from various sources as discussed above and shown in **Table 10**. If the sampled concentration was greater than the respective MCL, the location was mapped as an exceedance. Pesticides or pesticide-related products have been detected in more than 1,000 of the over 5,000 wells with pesticide sampling results in the KRWCA area.

The pesticide impacted area is shown on **Figure 24**. This area was developed using the CVHM grid methodology used to develop the nitrate and salinity impacted areas. The pesticide impacted area on **Figure 24** includes any grid cell that has an exceedance of MCLs for a specific pesticide. Grid cells where sampling has occurred without any detectable pesticides and those where detectable concentrations have been reported are also shown on **Figure 24**. The detections and exceedances are located in different parts of the primary portion of the KRWCA area and do not appear to have a spatial trend. Pesticide concentrations appear to have a higher frequency in the center of the primary study area, but the frequency of monitoring is also greatest in this location. There are no detections in the southern portion of the study area, but there is also little to no sampling in this area.

3.3.2 Nitrate Groundwater Pollution Hazard Index (NHI)

The NHI, an overlay and index assessment method, focuses on the main contributors to nitrate leaching potential related to agricultural land use at the ground surface: soil type, crop type, and irrigation type. Each type of soil, crop, and irrigation method is assigned a hazard value based on its respective potential to leach nitrogen. The hazard values for each parameter (soil, crop and irrigation method) are multiplied to determine the overall nitrate leaching hazard of the given agricultural management system (field).

Fields with NHI scores over 20 are considered to have a relatively high nitrate leaching risk, although the scores from 1 to 80 have no linear or quantitative significance; i.e., a score of 60 does not indicate twice as much leaching potential as a score of 30. Rather, the threshold of 20 is used to distinguish between a combination of factors that results in a relatively low leaching potential from one that results in a relatively high leaching potential. The NHI results for the area under evaluation indicate that 83 percent of irrigated lands within the KRWCA fall into the lower nitrogen leaching risk category (**Figure 25**). This is largely because of the transition to highly efficient and/or uniform irrigation systems used on deep-rooted crops, or irrigation systems with typically lower efficiency and/or uniformity used on fine-textured soils.

3.4 High Vulnerability Area Prioritization

To facilitate and focus groundwater quality monitoring and agricultural system management efforts, all identified KRWCA HVAs were prioritized. Priority values were calculated throughout the identified HVA to define a three-tier system of high (Tier I), medium (Tier II), and low (Tier III) priorities. The KRWCA HVA prioritization framework considers the proximity of high vulnerability lands to public and disadvantaged community (**DAC**) groundwater supply wells, a multiplicative overlay and index evaluation of relative hydrogeologic (intrinsic) sensitivity, and the NHI. In addition to designating tiers based on the calculated priority value, the categorization was updated to include all HVAs upgradient of a DAC as Tier 1 lands.

A full description of the prioritization framework can be found in the KRWCA GAR Section 11. The final acreage in each Tier is presented in **Table 17**, ranging from 22,031 irrigated acres classified as Tier 1 to 283,293 acres classified as Tier III. **Figure 26** provides a flowchart of the various prioritization parameters, the scenarios for each parameter, and the points applied to each respective scenario.

3.4.1 Relative Hydrogeologic Sensitivity

The hydrogeologic sensitivity incorporated unsaturated zone thickness, horizontal hydraulic conductivity, and vertical hydraulic conductivity in a multiplicative overlay and index method. This index method produced a representation of the combined relative hydrogeologic sensitivity in the KRWCA area. For each CVHM grid cell, the respective relative unsaturated thickness sensitivity value, relative horizontal hydraulic conductivity sensitivity value, and relative vertical hydraulic conductivity sensitivity value (as identified by the methods described above) were multiplied together to produce a combined relative hydrogeologic sensitivity score or index. The combined relative hydrogeologic sensitivity index coverage for the KRWCA area is shown on **Figure 27**. These sensitivity values only indicate relative vulnerability, and no determination of absolute sensitivity has been made or implied for these data.

3.4.2 Upgradient of Public Groundwater Supply Wells

To identify HVAs upgradient of public groundwater supply wells, a well capture zone analysis was utilized. A total of 472 public groundwater supply wells were identified in an analysis of SWRCB-DDW data obtained from GAMA. Public groundwater supply wells within disadvantaged communities (**DACs**) were also incorporated in the KRWCA HVA prioritization framework. DACs are defined as places or communities whose median household income (**MHI**) is 80 percent or less of the statewide MHI. DAC wells are included on **Figure 28** in yellow along with non-DAC public water system groundwater supply wells. A total of 126 public groundwater supply wells associated with DACs were identified.

Capture zones for all of the public groundwater supply wells discussed above were estimated using the uniform flow equations (Todd and Mays 2005). The uniform flow equations are a means of approximating the area of an aquifer that contributes flow to a well operating in sloping groundwater surface. In these conditions the contribution of flow to a well is not equal from all directions, but extends upgradient, with a stagnation point in the downgradient direction

As discussed, HVAs upgradient of a DAC supply well capture zone were automatically categorized as a Tier 1 priority.

3.4.3 Nitrogen Groundwater Pollution Hazard Index (NHI) Risk Categorization

The NHI field analysis detailed in the HVA designation was included in the KRWCA HVA prioritization framework. The NHI focuses on the main contributors to potential nitrate leaching at the land-use level on the surface (soil, crop, and irrigation type) and therefore it is important to include in the prioritization of the HVA. The NHI was developed to be used as an assessment of relative leaching potential as well as an evaluation tool to help improve agricultural management practices to become more protective of groundwater. Incorporation of the NHI in the KRWCA prioritization framework allows for resources to be focused on areas where practices have a relatively higher potential to leach nitrate in the area. Additional background information on the NHI can be found throughout the KRWCA GAR sections 10.

3.4.4 Prioritization Results

As noted, **Figure 26** provides a flowchart of the various prioritization parameters, the scenarios for each parameter, and the points applied to each respective scenario. For each identified HVA field, the respective upgradient of public water supply well scenario, relative hydrogeologic sensitivity scenario,

and NHI scenario was determined. Scenario points were added together to arrive at an HVA field prioritization score (an additive overlay and index approach), as illustrated by mapping on **Figure 29** and the prioritization scenario table shown in **Table 12**. The identified irrigated acreage within each prioritization parameter scenario by crop type is presented in **Table 13**.

Table 14, **Table 15**, and **Table 16** present the KRWCA prioritization tiers by both crop and irrigation types, with irrigated acreages for each scenario, for Tiers I, II, and III, respectively.

There are 581 irrigated acres designated as HVA in the secondary area designated as Tier II lands.

3.4.4.1 NHI Prioritization Results

The KRWCA NHI results indicate that certain crop systems consistently fell into the higher nitrate leaching risk category. The following key cropping scenarios are examples of the agricultural systems that may be considered higher risk in the finalized NHI categorization (in order of acreage):

- Silage corn on sprinkler or surface irrigation on medium to coarse-textured soils;
- Field crops (wheat) with surface irrigation on medium or light-textured soils;
- Potato on sprinkler or surface irrigation; and,
- Truck crops and vegetables.

Crops that have relatively low nitrate leaching risk due to low NHI scores include:

- Alfalfa;
- Perennials with high efficiency irrigation;
- Pasture; and,
- Processing tomatoes.

Permanent crops such as almonds are predominantly irrigated with drip irrigation, which results in a lower nitrate leaching risk rating for those crops. Alfalfa is a high-water user and has significant acreage in the KRWCA, but because alfalfa is a legume and fixes its own nitrogen from the atmosphere, it is not a priority in nitrate leaching risk management. Processing tomatoes are largely drip-irrigated in the KRWCA, yielding a low NHI score.

Section Four

Constituents of Concern

4 Constituents of Concern & CGQMP Setting

4.1 Constituents of Concern

As presented, COCs were identified using data collected for the development of the GAR. This section describes COCs within the KRWCA, potential sources of and fates of identified COCs in groundwater.

4.1.1 Nitrates

Other than nitrogen fertilizers, there are several natural sources of soil nitrogen. Soil nitrogen is essential to plants and soil organisms that cannot capture nitrogen directly from the atmosphere. Free-living and symbiotic soil microbiota fix atmospheric nitrogen into plant and microbial biomass, which becomes soil organic matter when it dies and decomposes. Ammonium (an inorganic form of nitrogen) is produced when that organic matter is mineralized (converted to basic inorganic components), or deposited from the atmosphere. This is the main natural source of non-gaseous, inorganic soil nitrogen.

Nitrate is a naturally occurring form of nitrogen that is formed from nitrification (a microbially-mediated process common in soils) of ammonium. Nitrate and ammonium are taken up by microbes and plants to form amino acids. Geologic sources of nitrate also exist in some locales. DWR (1970) noted that weathering granite, shales rich in organic matter, underground peat deposits, oilfield brines, and connate waters are considered potential natural sources of nitrate, and mapped the presence of nitrate in Kern from 1950 to 1969. Nitrates can also be found in groundwater from application of nitrogen fertilizers to irrigated agricultural and landscaped areas, as well as contributions from percolation from feedlots or dairies, wastewater and food processing waste percolation, and leachate from septic system drainfields (Harter T., et al. 2012). To address nitrate contamination of groundwater the KRWCA proposes a dynamic process that is described in greater detail in **Section 5**.

4.1.2 Pesticides

Agricultural pesticides are chemicals used to control organisms which can be harmful to crops, including bacteria, fungi, weeds, insects and vertebrates, as well as other vectors of disease. Pesticides are generally synthetic and do not occur naturally in the environment. In addition to agricultural applications, pesticides are used in residential lawn and garden areas, as well as golf courses and roadside or railway weed control. Pesticides contain active and inert ingredients that may be considered environmental pollutants depending on their solubility, bioavailability, and the direct and indirect impacts to organisms. Several of the chemicals assumed to be pesticides for the purposes of this analysis (e.g., naphthalene) have other non-agricultural uses and may originate from activities other than agriculture. Chemicals categorized as pesticides can be found in a variety of non-agricultural products.

Concentrations in most water bodies are low, generally ranging from 10^{-5} to 10^{-3} mg/L (Chapman and Kimstach, 1992 and Montgomery, 1993). There are at least 146 individual chemical compounds that may indicate the presence of pesticides in a water quality sample.

Pesticide impacted groundwater in the KRWCA area was identified by an exceedance of the respective MCL for detected constituents. Pesticides found to have at least one sample in exceedance are provided in **Table 10**. The respective uses of pesticides found in exceedances for multiple samples are described

in the following **Section 4.2.1**. The majority of detected exceedances can be considered legacy issues caused by pesticides which are no longer permitted for use.

To address pesticides present in groundwater, the KRWCA proposes to use the approach further described in **Section 5.3,** which includes grower outreach and education to emphasize proper irrigation wellhead protection and closure of abandoned wells, and greater awareness and understanding of DPR requirements. Prevention of potential impacts from pesticides is already being addressed by the DPR's Groundwater Protection Program and associated resources on pesticide use requirements to meet water quality objectives.

4.1.3 Salinity

Salinity in groundwater can originate from natural sources, sewage, runoff and deep percolation from urban and agricultural areas, industrial wastewater, and oilfield-produced water. Complex hydrogeologic processes often dissolve, transport, dilute, concentrate, and/or precipitate salts. Variations in surface water availability affect available recharge water volumes throughout the KRWCA. Recharge with high quality surface water is related to a subsequent dilution of salts in the in affected groundwater basins. The sources of applied irrigation water and the leaching fraction applied determine the steady-state salinity of percolating water. Salinity is commonly measured as Electrical conductivity (**EC**) in micro mhos per centimeter (µmhos/cm; often dS/m in soils literature, which is 1000 µmhos/cm) or Total Dissolved Solids (**TDS**) in mg/L during routine water quality sampling. Both sample analyses represent numerous individual constituents that together make up total salinity. EC is the measure of dissolved minerals in an aqueous solution and is directly related to the ability of the solution to conduct electrical current, whereas TDS is generally inorganic and organic suspended solids under 2 microns.

High TDS in the western and southern edges of the primary KRWCA study area may represent naturally occurring high salinity in groundwater. Elevated salinity may result from local geologic conditions associated with marine origin materials which form aquifers and overlying soils through which water moves. However, there is insufficient water quality data and historic and current hydrogeologic process information to define the specific source of TDS found in these areas. As a result, no attempt to distinguish between naturally occurring and anthropogenic sources of TDS was included in this study.

CV-SALTS is an initiative to identify salinity management strategies that will achieve a salt balance and keep agriculture economically viable. The KRWCA has contributed to the Central Valley Salinity Coalition and the CV-SALTS process since 2013 and will remain actively involved in this important stakeholder process.

4.2 Identification of Constituent of Concern (COC) Source

4.2.1 Irrigated Agriculture

COC migration to groundwater generally occurs with deep percolating water as it travels through the unsaturated zone (deep percolation). As such, in irrigated agriculture, the application of water and the method of irrigation is a key factor influencing groundwater impacts. Some deep percolation is required to allow salts to be leached away from the root zone, which is necessary to sustain agricultural production. Irrigation efficiency, irrigation distribution uniformity, and effective nutrient management can help to minimize deep percolation of nitrates.

Improperly abandoned or improperly constructed wells may provide a direct conduit of surface level constituents to groundwater. Kern County maintains stringent well permitting and construction standards for new wells, and requires proper well abandonment and destruction to minimize risk of direct transport of COCs.

4.2.1.1 Sources of Nitrogen

Nitrate migrates to groundwater when water containing nitrate travels beyond the root zone and through the unsaturated zone. In irrigated agriculture, the application of water and the method of irrigation are key factors influencing percolation of nitrate to groundwater. Although a leaching fraction of applied irrigation water is necessary to leach salts from the root zone, irrigation efficiency, distribution uniformity nutrient management and proper timing of leaching can help to minimize nitrate impacts to groundwater.

4.2.1.2 Sources of Pesticides

Pesticides found to be in exceedance of water quality objectives in the KRWCA can be attributed to a variety of uses in multiple cropping systems, particularly historical uses. The following sections define the primary and secondary uses in cropping systems, permitted years, and significant chemical features of pesticides found to be in exceedance for multiple samples in the KRWCA.

4.2.1.2.1 1,2 Dibromoethane (EDB)

EDB was used as a fumigant for a variety of crops and as a quarantine fumigant for citrus and tropical fruits and vegetables until it was suspended for use for agriculture in 1983 (EPA: Ethylene Dibromide, 2016). EDB was also an additive in leaded gasoline and was removed from gasoline formulas following the banning of leaded gasoline. Therefore, any detections of EDB are considered a legacy issue.

The majority of EDB degradation occurs in the topsoil; however, it is stable in aqueous conditions, aiding its ability to leach easily into groundwater. The reducing conditions in groundwater slow microbial degradation. As a result, EDB can persist in groundwater longer than in aerobic or semi-aerobic environments.

4.2.1.2.2 1,2-Dibromo-3-cloropropane (DBCP)

DBCP is a fumigant pesticide that was commonly used to kill nematodes in soil prior to planting. DBCP was used on over 40 crops in the United States. In 1977 DBCP was no longer permitted for use in irrigated agriculture within California, and is considered to be a legacy issue.

Based on DBCPs high sorption capacity, it was expected to adsorb to soil or be broken down via chemical or biological degradation pathways before leaching into the groundwater table. However, DBCP contamination has been found in the KRWCA area groundwater, and throughout the San Joaquin Valley. Presence in groundwater may be attributed to improperly abandoned wells or inadequate wellhead protection that provided an opportunity for DBCP to transport directly to the groundwater. Once in groundwater, DBCP becomes highly mobile and lingers with a half-life of 20 years (EPA: DBCP, 2016.

4.2.1.2.3 Atrazine

Atrazine is an extensively used herbicide used to control broadleaf and grassy weeds primarily in corn, sorghum and sugarcane fields. On a smaller scale, atrazine is used on residential lawns and golf courses.

However, this residential practice is more prominent in the Southeast United States (EPA: Atrazine, 2016).

Atrazine typically sorbs within the first 12 inches of soil and degradation results in an inactive compound. Depending on temperature, pH and available moisture, the halflife of atrazine varies between three to six months. Despite this, atrazine has been detected within the KRWCA boundary. This may be attributed to improperly abandoned wells or inadequate wellhead protection, which may have provided an opportunity for atrazine to transport directly to the groundwater.

4.2.1.2.4 Carbon Tetrachloride (CTCL)

Carbon tetrachloride, or CTCL, was used as a pesticide fumigant for grain storage, milling distribution and processing phases. It is no longer registered as a pesticide in California and its use as a fumigant was banned in 1986 (EPA: Carbon Tetrachloride, 2016). CTCL detections are considered to be a legacy issue. Although most of CTCL in the environment evaporates due to its high vapor pressure, if it leaches into groundwater it can persist for long periods of time. CTCL's halogenated structure slows degradation, further contributing to a long residence time.

4.2.1.2.5 Chlordane

Chlordane was a pesticide used on a variety of crops, including corn and citrus. It was also used on residential properties to prevent pest damage to home lawns and gardens. The EPA banned all uses of chlordane in 1988 (EPA: Chlordane, 2016). Chlordane detections in groundwater are considered to be a legacy issue.

With a heavily halogenated structure, chlordane is not easily degraded. Chlordane also has a low vapor pressure, preventing volatilization. Therefore, it can persist in the soil and groundwater resulting in a lengthy residence time of approximately 37 to 3,500 days. The distribution coefficient between chlordane and geologic material is recorded as a Soil Organic Carbon-Water Partitioning Coefficient (K_{oc}) of 20,000 to 76,000. Chlordane easily binds in the presence of dissolved organic carbon to increase solubility (ASTDR, 2016).

4.2.1.3 Salinity

The application of water to support agriculture leads to the uptake of water and an increase in concentration of solutes in the rootzone. It is critical to apply sufficient water to leach salts from the rootzone to maintain soil and agronomic viability; therefore, discharges of potentially elevated salinity can only be partially mitigated. Generally, improper drainage can result in elevated levels of EC leaching into groundwater. However, the extent of elevated salinity throughout the KRWCA may also be attributed to the natural geologic and hydrogeologic characteristics described previously.

Irrigation methods on many permanent crops have been converted to drip or micro irrigation systems, and application rates are now more closely matched to a crop's water usage, reducing the amount of water that can potentially be lost to runoff or below the root zone as deep percolation. However, this improvement in irrigation efficiency may cause soil salinity concentrations to increase as less water is applied to leach these salts below the root zone.

4.2.2 Alternative Sources

COCs can also be found in groundwater as a result of percolation from feedlots or dairies, food processing facility discharges, or from municipal or industrial wastewater. Approximately 39,200 irrigated acres of the KRWCA area falls under the regulatory coverage of the CVRWQCB Waste Discharge Requirements General Order for Existing Milk Cow Dairies (Order R5-2013-0122) (**Dairy General Order**). Historical dairy facilities were identified by reviewing the Kern County Planning Department Dairy List (County of Kern, 2005) and cross checking the facilities to 1995 aerial photography (**Figure 30**). Current dairy facilities were identified by a spatial dataset based on 2012 Dairy General Order program monitoring of all reported dairy facilities and associated crop acreages provided by the CVRWQCB (CVRWQCB, 2012). The 2012 spatial dataset was crosschecked with 2012 aerial photography.

It is unknown how many acres within the KRWCA boundary are under the regulatory jurisdiction of other WDR's or conditional waivers of WDR's (i.e. effluent wastewater, food processing, recycled water, etc).

4.2.3 Source Identification Study

The KRWCA will not be pursuing a source identification study for any areas of COC exceedance within the primary region. Previous efforts to define the relative contribution of various nitrate producing activities to groundwater impacts have yielded inconclusive results, especially in defining or explaining legacy impacts. As such, the cost and effort required to thoroughly conduct an identification study is considered to have little benefit.

4.3 Management Practices Baseline

In the KRWCA GAR, the NHI and its extensive background research (Letey et al., 1979; Plant Nutrient Management Technical Advisory Committee, 1994; and Wu et al, 2005) provided a baseline evaluation of agricultural system management decisions which can minimize the potential for nitrate leaching. The NHI focuses on the main contributors to nitrate leaching potential that interact in land-use decisions at the surface: soil type, crop type, and irrigation type. The NHI includes fertigation practices and deep ripping within the hazard values assigned to soil, crop, and irrigation types. NHI ranking provided a clear and direct tool to define relative nitrate leaching throughout the KRWCA area. Analysis of the interaction of these factors provides a foundation for the recommendation of reasonable management practices to reduce COC leaching risk. Currently implemented practices are a baseline to evaluate the relative influence of future management practices to reduce risk of COC impacts.

4.3.1 Existing Practices

Spatial irrigation data, analyzed in the KRWCA GAR, is presented on **Figure 31**. Overall, permanent crops (e.g. almonds, pistachios, grapes, etc.) are increasing significantly in the region and in nearly all cases the plantings are developed with highly efficient drip and/or micro spray irrigation systems. This trend is most prevalent in Kern County, though similar trends are found in other San Joaquin Valley counties. For example, by 2012, 91 percent of almonds were irrigated with drip or micro-sprinkler irrigation systems in Kern County, compared to 82 percent and 83 percent of almonds in Tulare and Fresno counties, respectively. Similar trends exist in citrus and grapes. For example, in 2012, 91 percent of grapes were

irrigated with drip or micro-sprinkler systems in Kern County, compared to 63 percent in Fresno County and 77 percent in Tulare County (Kimmelshue and Tillman, 2013). This is likely due to the scarcity and expense of water, as well as the shift to permanent crops in Kern County. Pressurized irrigation systems are also increasing on annual crops such as tomatoes. This change reduces water requirements and increases yield by improving irrigation efficiency, reducing plant water stress, and delivering nutrients more efficiently through fertigation.

Fertigation is common in drip, micro-sprinkler, and impact head sprinkler irrigation systems. For example, most vegetables on drip and sprinkler systems are fertigated (Nunez, personal communication, 2014). It is also used in surface irrigation systems, such as on the Buena Vista Lake Bed where some, but not all, fertilizer may be injected into the irrigation water. In this case, the fertilizer source is close to the field so that fertilizer travel time in the irrigation water is reduced.

Farm Evaluation Surveys and Nitrogen Management Plans (**NMP**) are required to be completed by all members in the High Vulnerability Areas as identified by the GAR. Farm Evaluations were required by the General Order to be submitted to the third-party coalition in spring 2016 by large farms (those greater than 60 acres) and growers in HVAs. The Farm Evaluation catalogues field specific crop and irrigation practices, including the implementation of protective practices relevant to irrigation efficiency, nitrogen application efficiency, and sediment and erosion control. The NMP Summary Reports were required to be submitted in spring of 2017 for growers of large farms in HVAs.

These submissions will provide the first Coalition specific data to begin tracking existing grower practices and subsequent changes over time. Analysis and summaries of these reports will be provided in submissions as required by the General Order.

Section Five

Management Plan Strategy

5 Management Plan Strategy

Fulfillment of CGQMP requirements outlined in the General Order relies on the implementation of multiple co-dependent elements of the ILRP. These elements include the GAR, required member reports such as the Farm Evaluation Survey, NMP Summary Reports, the MPEP, and the GTM program. The implementation timelines for these elements vary, but as the results of each become available the CGQMP will incorporate the results as required by the General Order. The following section highlights the significance and application of each of these elements in the ongoing management plan strategy.

5.1 Approach and Prioritization

Within the KRWCA's Primary Boundary (**Figure 1**), known exceedances of the groundwater quality objective for nitrate are well documented in the GAR. Nitrate exceedances were demonstrated to be the most prevalent groundwater impact within the KRWCA, as noted in **Figure 18.** The additional COCs described in **Section 4.1**, pesticides and salinity, will be addressed concurrently with Nitrate throughout the management plan area. To facilitate and focus groundwater quality monitoring and agricultural system management efforts, the KRWCA has prioritized all identified HVAs within the KRWCA. This prioritization will also be used in implementation of the CGQMP.

5.1.1 CGQMP Strategy and MPEP Implementation

The implementation of the CGQMP is linked with the MPEP throughout the General Order. The General Order requires CGQMPs to address HVAs as identified in the GAR through the implementation of protective practices. The MPEP identifies, promotes implementation of, and monitors implementation and benefits of protective practices. As specified in the General Order, the purpose of the MPEP is to determine the effects, if any, of irrigated agricultural practices on first encountered groundwater under varied conditions (e.g., soil type, depth to groundwater, irrigation practice, crop type, nutrient management practices). Some MPEP Workplan elements and their relevance to the CGQMP are described in the following sections.

The KRWCA has joined with six other coalitions to form the Southern San Joaquin Valley **(SSJV)** MPEP Committee, and collaborates actively with a technical team (SSJV MPEP Team) to develop and implement a MPEP Workplan. This process and the MPEP Workplan (Workplan) that was submitted to the CVRWQCB on 21 November 2016, with updates submitted 28 September 2017, further advanced the understanding of what the MPEP entails and the timeline to comply with the requirements of the General Order. Section 1 of **Appendix C** discusses how the MPEP will interface with individual coalitions to fulfill GQMPs addressing HVAs. Surface-level management decisions that influence nitrate leaching must be informed by a clear understanding of the relationship of these decisions to nitrate transport, the constraints in a range of agricultural management systems, and the factors that influence grower management choices.

The CGQMP strategy and MPEP implementation is outlined in **Appendix C,** "Identification, Extension, and Implementation of Management Practices to Minimize Nitrate Leaching from Crop Root Zones to Satisfy Groundwater Quality Management Plan Requirements." The SSJV MPEP was developed to be an efficient and collective effort to identify and increase implementation of protective practices to address requirements that pertain to both the MPEP and CGQMP. **Table 1** outlines the sections of the CGQMP

and the SSJV MPEP Workplan which jointly address CGQMP requirements. **Figure 32** and **Figure 33** provide the SSJV MPEP Workplan master schedule.

Management plan implementation will rely on education and outreach to address irrigation and nutrient management practices which have already been demonstrated to be protective or practices that the MPEP evaluation demonstrates as protective. Outreach will also incorporate surface level metrics, such as nitrogen applied and removed values (**A/R Ratios**), to provide direct grower feedback mechanisms on currently and potentially implemented practices. See **Section 6** for further description of monitoring methods.

Additional research must define Nitrogen removal coefficients for different crops to allow the reporting of A/R ratios, a critical grower feedback metric. The Nitrogen Management Plan Technical Advisory Workgroup (**NMP TAWG**) convened in 2015 to coordinate applicable research to support the reporting of nitrogen A/R ratios. The Central Valley Water Quality Coalitions submitted a literature review on nitrogen removal values from Dr. Daniel Geisseler to the CVRWQCB on January 13, 2017 (Geisseler, 2016) and is currently awaiting feedback.

5.1.2 Prioritization of HVAs and Crop Types within HVAs

5.1.2.1 KRWCA's HVA Prioritization

To facilitate and focus groundwater quality monitoring and agricultural system management efforts, all identified KRWCA HVAs were prioritized in the GAR. Priority values were calculated throughout the identified HVA to define a three-tier system of high (Tier I), medium (Tier II), and low (Tier III) priorities. The prioritization framework was presented in **Section 3.4** of this CGQMP, and Section 11 of the KRWCA GAR. HVA analysis and subsequent prioritization referenced crops and irrigation systems defined on fields in 2013 Kern County Agriculture Commissioner data.

The prioritization analysis, as described above, categorized HVA fields in tiers based on hydrogeologic sensitivity, potential impacts to groundwater supply wells, and the NHI. **Table 17** presents the KRWCA prioritization tiers by crop type and the respective irrigated acreages. The top three crops classified in Tier I, by acreage, are almonds, truck crops, and field crops.

Table 18 presents the KRWCA prioritization tiers by irrigation system type and the respective irrigated acreages. Within the Tier I prioritization category, four major irrigation types were identified (in order of acreage):

- Surface
- Drip
- Sprinkler/surface
- Sprinkler

Table 14, **Table 15,** and **Table 16** present the KRWCA prioritization tiers by both crop and irrigation types, with irrigated acreages for each scenario, for Tiers I, II, and III, respectively.

It is important to note that the entire agricultural management system needs to be considered when analyzing the prioritization results, and that irrigation system type has a significant impact on the resulting prioritization tier. This correlation between irrigation system type and resulting prioritization tier is common for most of the crops identified in the KRWCA HVA. Surface irrigation methods are more

prevalent in Tier I and Tier II (a limited amount of pressurized irrigation methods are also included in Tier II), while pressurized irrigation methods are more prevalent in Tier III.

5.1.2.2 SSJV MPEP Crop Type Prioritization

In addition to prioritization of HVAs within the KRWCA boundaries, the SSJV MPEP Team developed a prioritization scheme for the SSJV to guide MPEP implementation. This is described in Section 3.7 of the SSJV MPEP Workplan.

"The following criteria are proposed as the basis for selection of in-depth sampling and field studies:

- *Crops that represent the largest land area and economic value.*
- *Crops and cropping systems with the largest N surplus and/or largest depth of leaching water applied.*
- *Crops and cropping systems preferentially grown on coarse soils (e.g. sweet potatoes).*
- *Crops and cropping systems in areas with shallow depth to groundwater (i.e., hydrogeologic sensitivity).*
- *Regions of the MPEP area classified as disadvantaged communities (i.e., proximity to public groundwater supply wells).*

Initial modeling results, along with assessments of soil, vadose zone, and groundwater properties, as well as crop area distribution, will provide a basis for prioritizing effort relative to these criteria. Magnitudes of crop production area and value of the major commodities (presented in Section 3.5.1.1) will inform decisions about crop selection for more detailed study and data collection."

5.2 Actions Taken to Fulfill the CGQMP

This CGQMP specifies the actions that will be taken to address groundwater impacts through the implementation and validation of protective practices, as necessary. This includes outreach and education, implementation of the SSJV MPEP Workplan to identify and validate protective practices, and ongoing monitoring to demonstrate progress in protecting receiving water. Monitoring will include tracking responses to required member reports, analysis of trends in proxy metrics (A/R ratio's), and long-term groundwater trend monitoring. Groundwater quality data from required monitoring will be analyzed alongside regional and site-specific Soil & Water Assessment Tool **(SWAT)** model estimates of potential groundwater impacts by the SSJV MPEP Team to support the objectives of the MPEP and the CGQMP.

5.3 Implementation Strategy

CGQMP implementation will be integrated with SSJV MPEP activities and other ILRP elements to address groundwater quality impacts. The KRWCA will leverage the ongoing efforts of the SSJV MPEP to compile background information for management practices, facilitate training programs, and produce outreach and educational materials appropriate to protective management practices.

5.3.1 Partner Agencies and Entities

Section 2.2 of the SSJV MPEP Workplan, "Institutional Approach", describes efforts to maximize existing resources and knowledge regarding nitrogen and irrigation management. This includes the SSJV MPEP, technical support by agronomists, horticulturalists, plant nutritionists, soil scientists (specialists in management, soil fertility, soil chemistry, soil physics, plant physiology, plant nutrition, agro-meteorology, and modeling), and hydrogeologists (specialists in groundwater systems, as well as their management and modeling). Additional support can be found with technical partners, including public sector expertise, industry and commodity groups, and partner programs. Additional discussion of the role of partners can be found in the MPEP Workplan, but specific resources include:

- California Department of Food and Agriculture (**CDFA**);
- Fertilizer Research and Education Program (**FREP**)
- Kern County Agricultural Commissioner
- NRCS
- Cal Poly Irrigation Training and Research Center (**ITRC**)
- UCCE
- Central Valley water quality coalitions

The missions of institutions and programs such as the UCCE, ITRC, and FREP make them ideal partner organizations to help accomplish the objectives of the CGQMP. Existing training programs and outreach materials developed by these partners will be employed to the greatest extent possible. This will allow KRWCA to benefit from the knowledge and expertise of existing programs, while contributing to expansion of the knowledge base through the SSJV MPEP.

Additional research objectives for specific cropping systems will likely be achieved in partnership with commodity groups that are dedicated to providing access to information on effective field level management practices to improve production and efficiency. Resources and consultation provided by American Society of Agronomy (**ASA**) Certified Crop Advisers (**CCAs**) will also be employed throughout regional implementation of nutrient management plans and evaluation of irrigation management.

5.3.2 Protective Management Practices

5.3.2.1 Priority Practices to Address COCs

The priority management practices that will be promoted for implementation by the members to control transport of COCs to groundwater include 1) wellhead protection and proper maintenance of wells and 2) proper destruction of abandoned wells, and 3) accounting for nitrogen in irrigation water. The KRWCA will continue to work with growers to direct them to county resources for appropriate well management and destructions in the case of abandonment. Additionally, the KRWCA will provide information on proper well management and destruction methods at outreach events. The content of the outreach will be developed based on member responses to Part B (Irrigation Well Information) of the Farm Evaluation Surveys. Accounting for Nitrogen in irrigation water is addressed under both the NMP and Part C (Nitrogen Management Practices to Limit Percolation of Nitrates) of the Farm Evaluation.

5.3.2.2 Agricultural Practices to Reduce Deep Percolation of COCs

There has been extensive research on agricultural management practices in California, particularly relative to irrigation and nutrient management, including publications such as Nitrogen Source Reduction to Protect Groundwater Quality (Dzurella et al., 2012). The SSJV MPEP also identifies protective practices which may limit deep percolation of COCs. Where there is uncertainty about management practice performance, or where additional knowledge is needed, the SSJV MPEP initiates investigations to close these knowledge gaps or develops needed tools.

As part of education and outreach the SSJV MPEP Team is working with CDFA, UCCE, and other partners to inventory known protective management practices. A selection of currently identified practices that may reduce deep percolation of nitrate and other constituents can be found in Table 3-3 beginning on page 3-28 of the MPEP workplan, referencing Dzurella et al., (2012) (reproduced as **Table 19**). Practice 29 (know N content of irrigation water and adjust fertilizer rates accordingly) is a priority practice that will be promoted for implementation. The SSJV MPEP will direct management practice evaluations where information is missing, and continue to develop and validate additional protective practices.

The outreach component of the workplan is designed to boost education and outreach for the identified protective management practices to applicable cropping systems. The KRWCA will continue to communicate additional findings relevant to protective practices as they become available through annual monitoring and coordination with SSJV MPEP.

The initial focus of the education and outreach will be those members that have been identified as outliers compared to other growers, based on information from their Nitrogen Summary Report; and those members that have not implemented the highest priority management practices or those that are likely to improve nitrogen use efficiency in their cropping system or avoid other impacts.

5.3.2.3 Additional Practices to Address COCs

COC pesticides subject to the DPR's Groundwater Protection Program are under the purview of the DPR's regulatory program and recommendations. The KRWCA will direct affected growers to DPR resources to meet requirements associated with pesticide use to meet water quality objectives, as applicable.

5.3.2.4 Technically and Economically Feasible Practices

Protective practices advocated by the KRWCA to growers must first be demonstrated to be technically and economically feasible for growers to implement. Technical and economic feasibility are significant factors to consider when evaluating barriers to the adoption of management practices. Barriers to adoption may be due to a lack of available educational tools or resources, but may also be due to a technical or economic burden of practice implementation.

The KRWCA will seek to mitigate barriers to adoption which are within the scope of the Coalition. Activities to address implementation barriers may include education and outreach to simplify complex practices, guidance on available site alternatives, and directing growers to available public funding and technical resources. Significant technical or economic barriers to implementation of protective practices are beyond the scope of the KRWCA to address directly. In these cases partner agencies and research institutions will be relied on.

The barriers to adoption for practices outlined in **Table 19** are a preliminary identification of the relative technical and economic feasibility of implementing the selected protective practices. Section 3.2 of **Appendix C** defines the methodology to address barriers to adoption.

Site specific and operational conditions will require different combinations of management practices to protect groundwater quality. The success of the CGQMP is dependent on member growers tailoring the implementation of practices to site conditions. The KRWCA will continue to support grower efforts to implement protective practices through outreach and support in conjunction with the SSJV MPEP.

5.3.2.5 Practice Effectiveness and Limitations

The agricultural practices summarized in **Table 19** have been demonstrated to improve overall cropping efficiency, and thus are considered protective against deep percolation of nitrate and other constituents. The relationship of management practice suite effects on underlying groundwater quality will be illumined by methods presented in the MPEP Workplan. Site specific and regional analysis of cropping systems within the MPEP, long term groundwater monitoring, and feedback metrics will help to validate effectiveness of protective practices.

5.3.3 Outreach Strategy

5.3.3.1 General KRWCA Outreach Approach

Since the establishment of the Coalition, the KRWCA has worked to support growers in meeting requirements of the ILRP. This includes the completion of required third-party reports and associated research such as Annual Monitoring Reports, the GAR, the development of the SSJV MPEP Workplan, and the GTM Workplan. The KRWCA also supports growers through extensive outreach and education in completing required member reports.

KRWCA conducted numerous member outreach meetings to discuss the findings of the GAR and the development of the HVAs. This outreach provided growers with a foundational understanding of the extent of groundwater impacts from COCs. Outreach focusing on ongoing groundwater quality and trends will continue to be conducted as additional data are collected and interpreted. The KRWCA also devoted significant effort in training growers and consultants in how to correctly complete Farm Evaluation Surveys and NMPs throughout 2015 and in early 2016. The KRWCA also organizes and facilitates NMP self-certification training for its members. Additional outreach on the required Sediment and Erosion Control Plans is also in progress in 2016 and will continue in 2017.

5.3.3.1 CGQMP & SSJV MPEP Outreach Approach

Ongoing education will provide feedback on analysis of member surveys including relevant performance metrics (such as A/R and Farm Evaluation Surveys), and the findings of the SSJV MPEP regarding protective practices. The KRWCA will coordinate with the SSJV MPEP to define outreach curricula reflecting protective management practices throughout the CGQMP area. See **Appendix C** for additional description of the CGQMP & MPEP outreach strategy.

As discussed in the SSJV MPEP Workplan Section 2.4, “Outreach Approach”, a multi-pronged effort will leverage current resources to reduce duplication of effort and to effectively support growers.

"The main themes of information that the SSJV MPEP will focus on include the following:

- Early outreach to rapidly expand implementation of known, protective practices.
- Program and process information, explaining regulatory obligations and how to meet them, schedules, meetings, and where to find information on protective practices.
- Referrals to technical advisors who can assist growers in fitting suites of protective practices to growers' specific settings and needs.
- New and highly relevant information on protective practices and environmental performance, as it is collected and generated.
- Information from growers regarding crop selection, location, and management, mainly obtained through coalitions.

Growers have historically obtained information to guide management decisions from a variety of sources, including the following:

- Information from public-sector experts housed within UCCE, USDA-NRCS, United States Department of Agriculture Agricultural Research Service, CDFA, CSU Fresno, California Polytechnic State University San Luis Obispo, out-of-state cooperative extension services, irrigation and drainage districts, and occasionally other public agencies (e.g., county departments, DWR, California Departments of Fish and Wildlife and Pesticide Regulation, County Agricultural Commissioners, State and Regional Water Boards, Bureau of Reclamation, and the United States Geological Survey (USGS) and Fish and Wildlife Service.
- Private-sector experts housed within commodities groups, Certified Crop Advisers (CCAs), Pest Control Advisers, private institutes (e.g., International Plant Nutrition Institute, Western Growers Association), input manufacturers and vendors, and production cooperatives.
- Social networks including other growers, friends, neighbors, and family members.
- Growers' experiential knowledge bases, which tend to be the most site-specific and best informed about field and management history.

The formats of information exchange among growers vary widely, and include the following:

- One-on-one, word of mouth, or written communication.
- Presentations at grower (often winter) meetings, technical workshops, and training sessions.
- Online tools and databases, including a Grower/Advisor Webpage, to promote and accelerate understanding and implementation of protective management practices.
- Targeted mailings to memberships of various groups.
- Online and printed newsletters, and online repositories of scientific literature, extension circulars, handbooks, soil surveys, and other references.
- GARs, trend monitoring programs, groundwater quality management plans, and annual reports produced by member coalitions.

- Surveys relating to growers' crop selections, practices, needs, and preferences (e.g., surveys conducted by coalitions to meet Farm Evaluation and Nitrogen Summary Report requirements of the General Order).

… The success of outreach will therefore depend on prioritizing practices that growers can use and that have potential to increase levels of groundwater quality protection, and on leveraging the broad range of existing outreach resources through collaboration and partnership."

5.3.3.2 Outreach Activities and Tools

CGQMP outreach activities will leverage ongoing outreach programs conducted by partner groups (UCCE, USDA/NRCS, CSU, CDFA, and commodity groups) and Central Valley Water Quality coalitions in coordination with the SSJV MPEP. This network of cooperating partners will assist in the development and delivery of CGQMP relevant curricula, resulting in the optimal use of resources. KRWCA outreach events will include presentations of applicable grower feedback, and early implementation curricula from the SSJV MPEP. Developed curricula and educational material will be hosted online by the SSJV MPEP to streamline outreach and promote grower access.

KRWCA growers currently participate in the many agricultural outreach programs conducted by CGQMP implementation partners, which provide growers with information on protective practices. The SSJV MPEP will help to coordinate partner meetings where information on protective practices will be provided. The KRWCA will seek to document growers' participation in these events. The SSJV MPEP maintains an online database of outreach and outreach-related activities. Events may be hosted by coalitions and/or cooperating partners. This allows the SSJV MPEP team and member coalitions to track grower participation in outreach activities. Additional description of these tools is provided in Section 3 of **Appendix C.**

A timetable for outreach events associated with the SSJV MPEP is provided in the Workplan master schedule (**Figure 32** and **Figure 33**). The SSJV MPEP Team will develop the outreach curricula pertaining to the initial inventory of management practices, which may include a combination of relevant meeting materials, videos, fliers, and online tools. Resources will be organized into a Grower/Advisor webpage to increase accessibility to coalition members and consultants.

Additional tools to support outreach are described in Sec 3.11 of the SSJV MPEP Workplan, and are summarized below:

- Helpful information for growers and their advisors to efficiently derive maximum benefit from required Nitrogen Management Planning processes.
- Tools to facilitate second-language growers to understand and comply with LTILRP requirements and derive maximum water quality and production advantages.
- Query-able management practice databases to assist growers in evaluating the potential cost and benefits (production, water quality, labor) benefits of various suites of management practices, applied at their specific management block locations and planting dates.

The KRWCA considers grower outreach and education to be a critical component of the ILRP. As required by the General Order, outreach products and activities will be summarized and reported to the CVRWQCB annually as part of the Groundwater Quality Management Report and Annual Monitoring Report.

5.3.4 Management Practices Implementation Schedule

Many of the practices listed in **Table 19** are currently implemented by growers to minimize fertilizer loss and maximize irrigation efficiency. The Farm Evaluation Surveys track the implementation of some nitrogen efficiency, irrigation efficiency, and sediment and erosion control practices. Seventeen of the practices described by Dzurella et al., (2012) are included in the Farm Evaluation Surveys. The initial Farm Evaluation Surveys were completed by members in the CGQMP area during Spring 2016. Analysis of the Farm Evaluation Surveys will provide a management practice baseline for KRWCA members throughout HVAs.

5.3.4.1 Timetable to Identify & Implement Management Practices

The current timetable for the implementation of the CGQMP is reliant upon the ongoing implementation of the SSJV MPEP. The initial identification of management practices shown to be protective of groundwater quality will be provided to growers during the initial outreach and education phase. Additional protective practices will be evaluated throughout the timeline of the MPEP Workplan. The SSJV MPEP Workplan master schedule provides a timetable for program milestones (**Figure 32** and **Figure 33**).

The proposed time schedule for compliance focuses on the immediate communication with members that report outlier data in nitrogen use along with the outreach specific to tiered prioritization areas. The outline below specifies the sequence of KRWCA activities and deliverables for management practices review and implementation of the CGQMP.

- Year 1 (first year after approval of CGQMP)
  - Analyze and summarize all collected Farm Evaluations to define baseline implementation of practices throughout the KRWCA. Identify those members that have not implemented priority management practices that include (1) wellhead protection and proper maintenance of un-used wells, (2) proper destruction of abandoned wells, and (3) accounting for the amount of nitrate in irrigation supply water from the Farm Evaluation and provide education and outreach to those members.
  - Evaluate reported Nitrogen Summary Report data for nitrogen applied versus crop yield, and A/R ratios for crops with available nitrogen removed coefficients and determine annual statistics. Provide direct feedback to members on performance relative to other growers and outreach to those members that have reported Nitrogen Summary Report data which is a statistical outlier as compared with other members.
  - Define baseline performance of protective practices currently implemented throughout the HVA and high priority areas using SSJV MPEP results. Specifically, SWAT modeling to evaluate effects of management practice application (See SSJV MPEP Workplan Schedule, **Figure 32** and **Figure 33**.
  - Coordinate with SSJV MPEP Team on research of known protective practices and develop additional outreach curriculums for MPEP focused member meetings.
  - Identify Tier I member areas, evaluate baseline practices and nitrogen use information, and target outreach and promote practice implementation by crop as appropriate, with a focus on priority practices and MPEP curriculums.

- Year 2
  - Analyze and summarize all collected Farm Evaluations to develop annual analysis and track trends in the implementation of practices over time throughout the HVAs. Define the implementation of priority management practices and determine increase in reported practices. Provide targeted outreach regarding well management and accounting for N in irrigation water as necessary.
  - Evaluate reported Nitrogen Summary Report data for nitrogen applied versus crop yield, and A/R ratios for crops with available nitrogen removed coefficients and determine annual and multi-year statistics. Provide direct feedback to members on performance relative to other growers and outreach to those members that have reported Nitrogen Summary Report data which is a statistical outlier as compared with other members.
  - Determine performance of implemented practices as defined by SSJV MPEP Team investigation of cropping scenarios with SWAT modeling to evaluate performance of management practice suites (see SSJV MPEP Workplan Schedule, **Figure 32** and **Figure 33**).
  - Evaluate progress in implementation of applicable practices in Tier I areas, curate ongoing outreach with respect to findings. Identify members in Tier II areas, evaluate baseline practices and nitrogen use information by crop, and target outreach and promote practice implementation as appropriate.
- Year 3
  - Continue tracking trends and progress in implementation of priority protective practices over time throughout the HVA and high priority areas. Provide targeted outreach regarding well management, accounting for N in irrigation water as well as practices defined as protective by the MPEP for respective cropping scenarios.
  - Continue analysis and tracking of A/Y trends, calculate nitrogen removal for crops with available nitrogen removal coefficients to develop A/R ratios and multi-year averages (as discussed in **Section 6.1.2.1**). Provide direct feedback to members on performance relative to other growers and outreach to those members that have reported Nitrogen Summary Report data which is a statistical outlier as compared with other members.
  - Coordinate outreach and education to growers incorporating SSJV MPEP Team resources and findings of site specific modeling results demonstrating impact of implemented practices.
  - Integrate multi-year grower reported data as SWAT modeling parameter inputs for the SSJV MPEP to analyze landscape-level trends and demonstrate progress. Assess landscape level modeling and relationship to changes in underlying groundwater quality as demonstrated by SSJV MPEP groundwater evaluation.
  - Continue to evaluate progress in implementation of applicable practices in Tier I and Tier II areas, curate ongoing outreach with respect to findings. Identify members in Tier III areas and evaluate baseline practices and nitrogen use information to target outreach and promote practice implementation.

The third year of CGQMP implementation can be considered the steady state of the CGQMP implementation. Member submittals, SSJV MPEP progress, and annual monitoring will continue to

inform CGQMP implementation and support grower outreach efforts throughout Tier I to Tier III areas. Progress in implementing protective practices, as necessary, will be demonstrated by the findings of the SSJV MPEP and feedback provided by growers on the efficacy of outreach, described in **Section 6**.

As described in **Section 4.3**, Management Practices Baseline, irrigation efficiencies in Kern County are overall some of the highest in the Central Valley (Kimmelshue and Tillman, 2013), and many growers currently utilize multiple protective practices. Therefore, for many KRWCA members, it may be demonstrated implementation of additional management practices may not be necessary to protect water quality and comply with the General Order.

5.3.5 Performance Goals

KRWCA will work with enrolled HVA growers defined under this CGQMP to obtain the required member submittals according to the timeline specified in the General Order. Successful completion of Farm Evaluation Surveys and NMP Summary Reports are foundational indicators of grower performance. KRWCA expects to receive close to 100% of required submissions annually, with ongoing action to support grower reporting.

KRWCA members will be provided feedback on their reported information with respect to trends over time and relative to other growers. The KRWCA will conduct specialized outreach to members that appear to be statistical outliers with respect to nitrogen reporting and/or practice implementation. To track the goals of the CGQMP, the KRWCA will analyze member submittals to define the implementation of priority practices and practices applicable to tiered areas. Additional practice priorities will be introduced by the SSJV MPEP analysis. The timeline for implementation of the MPEP identified practices will be subject to Executive Officer approval.

Performance goals for the implementation of protective practices to limit deep percolation of nitrate are based on the performance of currently adopted protective practices. For example, in Section 3.6.3 of the SSJV MPEP Workplan, "Benchmark Existing Level of BMP Adoption":

> *"Another important MPEP objective is to provide a quantitative framework to predict how adoption of BMPs can reduce nitrate losses to groundwater. Achieving this objective will require characterizing the current N balances and net N surpluses for the most vulnerable regions, crops, and cropping systems (Section 3.6.2), as well as benchmarking the current degree of adoption of BMPs across the MPEP area. These benchmarks provide a baseline against which increases in BMP adoption levels can be evaluated for their impact on reducing nitrate losses using models and targeted field studies."*

As mentioned previously, certain practices identified as protective are already included in the Farm Evaluation Surveys. Additional protective practice implementation above the established baseline will be defined through the timetable of practice identification above (**Section 5.3.4.1**), including review of member submittals, SSJV MPEP findings, and scheduled monitoring. The KRWCA will work with growers to receive feedback on implementation progress as additional protective management practices are identified by the SSJV MPEP and other independent studies.

Reported member data will also inform the SSJV MPEP demonstration of program performance. Management parameters will be included among model management parameters to assess landscape level performance changes over time, and MPEP modeling will estimate the influence on underlying

groundwater. Section 3.12 – Assessing Adoption, Data Exchange with Coalitions (pages 3-69) of the SSJV MPEP Workplan describes this process:

> *"As these data become available, trends in implementation of protective practices can be characterized in greater detail and with greater accuracy. These characterizations will be combined with performance data to illustrate progress in protecting groundwater quality from degradation by irrigated agriculture. Results will be provided to coalitions for inclusion in annual reports, and included in MPEP deliverables, as appropriate"*

From **Section 2.1.4** (Pages 2-4 and 2-5):

"The Committee will document and demonstrate progress in protecting groundwater from nitrate emanating from irrigated agriculture. …

Assessment of landscape-level impact of program. This includes the following:

- *Development of a verification monitoring framework for landscape-level nitrate loading as a function of management and other factors.*
- *Refinements to the framework, including refined model inputs characterizing management and driving the landscape-level assessment of pre-MPEP and a series of post-MPEP conditions. These will be based on the following:*
    - *Comparisons with results of verification monitoring.*
    - *Results of management practice field monitoring and evaluation.*
- *Comparison of landscape-level performance trends over time.*
- *Collaborative work with coalitions to assess the impact of changing performance on underlying groundwater."*

The performance of the CGQMP strategy will also be assessed with respect to the effectiveness of KRWCA and SSJV MPEP outreach efforts in impacting grower decisions related to protective management practices. Preliminary findings indicate that priority practices will be implemented throughout member areas as outreach and educational support increases.

Grower receptivity and comprehension of outreach topics will be assessed by surveying a representative population of participating growers about the benefit of outreach and recommendations of areas for improvement. Survey results will be used to adjust and/or supplement outreach curricula and to follow up with participants, as necessary. Performance will be evaluated by the proportion of members reporting improved understanding, and where necessary, increased implementation of protective management practices. Where possible, KRWCA outreach will also be assessed to determine if educational barriers to the implementation of appropriate management practices were adequately addressed.

As the baseline of implemented practices is established, KRWCA will utilize the information contained in the Farm Evaluation Survey submittals as the quantitative tracking measure for practice implementation. For example, each year, the Coalition will identify by tier which management practices are being utilized by members, with the initial focus on Tier I. During the first year of implementation of the CGQMP, the baseline for management practices will be established. Each subsequent year, the Coalition will focus on members in prioritized tiers who are not implementing the required management practices and conduct direct outreach. The goal of the Coalition is to achieve 90% implementation of

top three priority management practices, with the goal of increasing above the starting percentage per tier by 5% implementation each year until the 90% implementation is achieved. For example, if a tier has 70% implementation of management practices in year one, the goal would be to increase to 90% implementation over the subsequent years, utilizing outreach and education, with a minimum goal of an increase of the 70% by 5% each year to achieve the 90% goal within 4 years. Beyond priority management practices, the timeline and scale of implementation of MPEP identified practices will be defined by Executive Officer Approval.

Section Six

Monitoring Methods

6 Monitoring Methods

6.1 Measure Achievement of CGQMP Goals

The KRWCA's CGQMP aims to reduce impacts from COCs within the CGQMP area through the implementation of management practices that are protective of groundwater quality, as appropriate. Fulfillment of the CGQMP will be validated by the following reporting and monitoring.

6.1.1 Farm Evaluation Surveys

Farm Evaluation Surveys provide the KRWCA with information on grower practices that are protective of water quality. The KRWCA will summarize these practices in an annual CGQMP update. Farm Evaluation Surveys are to be submitted to the KRWCA according to the timelines specified in the General Order. Farm Evaluations also serve as education for growers, drawing attention to management practices that may not have been previously considered or evaluated. Management practice implementation will be tracked through Farm Evaluation Survey data from the first submission forward.

6.1.2 Nitrogen Management Plans

Nitrogen Management Plan Summary Reports are to be submitted to the KRWCA according to the timelines specified in the General Order. The KRWCA began an outreach and education program for growers in 2015 to provide information necessary to complete the NMP. The KRWCA also provided opportunities for grower self-certification of NMPs. The KRWCA will continue to provide education and outreach to growers regarding the requirements of the NMP and NMP Summary Report. At least one additional KRWCA-sponsored NMP Self-Certification opportunity will occur in 2017 or 2018, and KRWCA members can attend other self-certification classes held by other coalitions, if necessary.

The KRWCA considers the NMP Summary Report to be a critical component of the ILRP and the information provided will be summarized and submitted to the CVRWQCB annually as part of the Groundwater Quality Management Report and Annual Monitoring Report. Nitrogen Summary Reports provide nitrogen applied/crop yield information, from which nitrogen removed values will be calculated and shared back with growers. To evaluate the trends in nitrogen use reported in the NMP Summary Report, the KRWCA will report the ratio of applied nitrogen (A) to nitrogen removed (R), the A/R metric recommended by the SWRCB-AEP.

$$\frac{A}{R} = \frac{Nitrogen\ Applied}{(Nitrogen\ removed\ at\ harvest)+(Nitrogen\ sequestered\ in\ the\ permanent\ wood\ of\ perennial\ crops)}$$

Nitrogen summary data will help to guide outreach and education. Feedback about nitrogen use in the context of grower peers will allow growers to critically assess their own nitrogen use and make appropriate adjustments where needed. Additionally, NMP Summary Reports will aid the KRWCA in identifying nitrogen use trends.

6.1.2.1 Research and Development of A/R Ratio Data

The Central Valley Water Quality Coalitions (excluding the California Rice Commission) convened a Nitrogen Management Plan Technical Advisory Workgroup (NMP TAWG) in March 2015 to develop guidelines to identify knowledge gaps that exist in the understanding of nitrogen removal values that are required in the annual NMP template and NMP Summary Report. The NMP TAWG consists of experts from the University of California, state and federal agencies such as the NRCS, and private industry. A "Crop Nitrogen Knowledge Gap Study Plan and Guidance Documents" report was submitted to the CVRWQCB on December 18, 2015 and a follow-up memo was submitted in response to CVRWQCB comments on February 19, 2016.

As a result, the Central Valley Water Quality Coalitions submitted a request to the CVRWQCB on November 19, 2015 to report nitrogen applied and the ratio of nitrogen applied to yield (A/Y) in the annual NMP Summary Report template rather than A/R. This reporting option allows for more consistent and reliable data from growers because it only requires information that all growers already collect with no additional calculations based on uncertain nitrogen removal information.

$$\frac{A}{Y} = \frac{Nitrogen\ Applied}{Actual\ Yield}$$

The Central Valley Water Quality Coalitions have contracted with Dr. Daniel Geisseler, University of California Department of Land, Air, and Water Resources CE Nutrient Management Specialist, to develop yield-to-removal (Y-to-R) conversion calculations/coefficients for 99% of the crops grown in the Central Valley. This work should address most of the knowledge gaps that were identified by the NMP TAWG, as described in the "Work Plan for Crop Nitrogen Knowledge Gap Study Plan and Guidance Documents" that was submitted by the CV Coalitions to the CVRWQCB on July 29, 2016. As Y-to-R conversions become available, the coalition will calculate A/R ratios from grower reported A/Y ratios. In addition to reporting A/R to the CVRWQCB, they will be shared with growers as an outreach and education tool. The sequence of Dr. Geisseler's activities is as follows:

- Task 1: Development of Y-to-R conversions for the 17 crops in the CDFA FREP database.
- Task 2: Identification of crops not included in the CDFA database that are grown on major Central Valley acreage. Ultimately, this work will develop Y-to-R values for 99% of the crop acreage in the Central Valley (not including non-alfalfa hay and silage).
- Task 3: Development of Y-to-R conversions for the additional crops that are not currently in the CDFA FREP database.
- Task 4: Assessment of the quality of the data as well as a description of additional work that will be needed to develop usable Y-to-R conversions for 99% of the crops grown in the Central Valley.

6.2 Measure Effectiveness of CGQMP Practices

6.2.1 Monitoring Grower Trends

The cornerstone of the ILRP is reconciling and tracking information provided in Farm Evaluation Surveys and NMP Summary Reports. The Coalition will track this information over the long term and attempt to establish a relationship between implemented practices and reported nitrogen applications for similar site conditions. This information will be shared with growers and will be one method to monitor management practice trends of KRWCA growers. This information will also be analyzed as a component of the SSJV MPEP and GTM Program.

6.2.2 SSJV MPEP Analysis

Data gathered by the coalition will also be used in the SSJV MPEP to characterize the extent and locations of implemented practices. Data characterizing crops, soils, climate, and management practices will be used to assess performance and aggregated to the landscape level to determine the influence that irrigated agriculture has on groundwater quality, if any, in the SSJV. This assessment will occur along with priority investigations to define performance on specific sites. Iterative SWAT modeling using the available and appropriate data will be utilized to gauge the performance of implemented practices throughout the SSJV. Each iteration of SWAT model processing and output will be successively refined as new data and better information becomes available. This process is described in Section 3.10 of the SSJV MPEP Workplan, "Landscape-Level Performance Assessment."

"Because the interactions between water, soil, plants, nitrogen, and the atmosphere are very complex and highly variable over time and space, attempts to quantify nitrate fluxes require a modeling framework that simulates water and N balances across the soil-plant-water-atmosphere continuum. In addition, the modeling framework must also incorporate spatial factors to quantify nitrate fluxes at scales ranging from field to watershed. SWAT (Neitsch et al., 2009) is a modeling framework that integrates crop production and physical data, producing output for the entire landscape, but specific down to relatively small spatial units of analysis (field or sub-field). For these and other reasons, SWAT has been selected as the central analysis tool to evaluate the influence of management practices on N losses and crop production. The use of SWAT does not, however, preclude use of other tools and models for focused investigations and to check SWAT results, as appropriate.

The landscape-level performance assessment will be conducted in three primary steps (Figure 2-2):

1. *Initial SWAT models will be developed to characterize the potential ranges of N loading based upon readily available information.*
2. *SWAT models will be refined by comparison with the results of field studies and benchmark N balance and N surplus data.*
3. *Updated SWAT models will be used to evaluate the effects of actual and hypothetical levels of BMP implementation across the MPEP area."*

6.2.3 Groundwater Quality Trend Monitoring Program

Long term groundwater monitoring data collection will be standardized through the KRWCA's GTM Workplan, which was submitted prior to July 1, 2017. Data collected will define long term, regional groundwater quality trends. Groundwater quality trends will be evaluated over multiple years to account for the temporal lag in the effects of surface activities on groundwater quality, which could be decades in Kern County.

The KRWCA is working to develop a groundwater monitoring network which will be implemented in high and low vulnerability areas, employing existing shallow wells. Well construction information was not available for existing wells, which were used to develop the GAR. This complicates determination of representativeness of shallow groundwater. However, legislation allowing public access to additional well construction information upon request from DWR has been enacted since the original submittal of the GAR was completed. Well classification will be included with future updates to the GAR and the upcoming GTM Program. The General Order requires annual groundwater monitoring of conductivity, pH, dissolved oxygen, temperature, and nitrate as nitrogen. Initial samples and those collected every five years thereafter will also be analyzed for total dissolved solids and general minerals analysis.

The MPEP will also rely on data acquired through the GTM Program for regional analysis. Sec 3.9.1 "Goals and Objectives Pertaining to Groundwater" of the SSJV MPEP Workplan defines the specific overlap in the MPEP and the GTM objectives.

"The MPEP and GQTMP are very closely linked. Specifically, the MPEP supports the GQTMP by providing calculated constituent fluxes (e.g., volume and mass) through the vadose zone and into groundwater to assess ongoing impacts from agricultural operations, residual (vadose zone) impact, and legacy contamination issues. In turn, the monitoring data generated under the GQTMP supports the MPEP by providing feedback in the form of regional groundwater constituent concentrations to assess groundwater quality changes on a regional scale, and their response to changing management practices and other contributing factors.

Both programs include groundwater monitoring activities. The MPEP, as developed herein, will include monitoring of first-encountered groundwater at a few select sites, and will maximize use of existing wells to the greatest extent feasible (Section 3.8). It is expected that the emphasis of GQTMP monitoring will be on a mix of domestic, municipal, and agricultural water supply wells that do not target first-encountered groundwater."

6.3 Validate KRWCA Outreach Approach

Grower comprehension and the effectiveness of outreach will be assessed to refine subsequent outreach. The goal is to continually improve grower outreach to maximize the benefits to KRWCA growers and the increased implementation of protective management practices, as necessary. . This work is expected to include surveys of growers at outreach events and mailings to assess and refine outreach. Surveys may include questions regarding:

- Historical changes in management practices which growers recognized as producing a significant change in operation (e.g. cost reductions, increased yields, efficiency, etc).
- Management practices implemented recently (e.g. those practices implemented in the last 12 months).

- Plans to adjust management practices in the future (e.g. those practices planned to be implemented in the next 12 months).
- Barriers to implementing management practices (e.g. logistical, conflicting interests, production, financial, etc.).
- Information and educational items that were useful for the grower in making informed management decisions.

Section Seven

Data Evaluation & Reporting

7 Data Evaluation & Reporting

After the NMP Summary Report data is received and summarized, A/R ratios will be calculated and reported annually. They will also form a long-term data set for summary and interpretation. Results will be shared with growers through outreach events to educate members regarding their own practices in the context of their peers. This information will be included in the Management Plan Status Report for the review of the CVRWQCB.

Annually, the Management Plan Status Report will summarize the Farm Evaluation Surveys and NMP Summary Reports, as required by the General Order. The results will be summarized in box and whisker plots and grouped by similar crop and soil types within townships (or larger areas if a township contains too few fields to provide meaningful context). Spatial mapping at a township level will also be presented to assist in the analysis of implemented management practices. Grower data will be used as input parameters in the SSJV MPEP SWAT modeling to provide a landscape-level performance assessment of practices as they evolve over time. The GTM, as required by the General Order, will be implemented to determine current groundwater quality conditions relevant to irrigated agriculture, and to develop long-term groundwater quality data that can be used to evaluate the regional effects of irrigated agriculture in high and low vulnerability areas. The GTM Workplan was submitted to the CVRWQCB prior to July 1, 2017.

In each report, the KRWCA will analyze the data (e.g. summary statistics, SWAT modeling outputs, numerical modeling, index computation, graphical presentation, narrative, mapping, or some combination thereof) so that it can be interpreted and ultimately used as the basis for grower outreach.

Section Eight

Duties & Responsibilities

8 Duties & Responsibilities

Nicole Bell is the current KRWCA ILRP Program Manager and will be responsible for administering the Comprehensive Groundwater Quality Management Plan. The KRWCA Board of Directors may change project administration duties from time to time. The CGQMP Organizational Chart is included as **Figure 34.** The KRWCA will rely on a team of technical consultants to support ongoing implementation of the CGQMP. KRWCA contracted consultants manage surface water and groundwater monitoring programs, lead stakeholder involvement, analyze and process data, and support the overall implementation of the ILRP by growers.

As discussed, The KRWCA has joined with six other coalitions to form the SSJV MPEP Committee, and hired a technical team (SSJV MPEP Team) to support CGQMP and MPEP implementation. An initial evaluation of potential KRWCA partners includes organizations and programs that have missions which prioritize implementation of effective nutrient and irrigation management. Although these organizations are well suited to working in conjunction with the KRWCA and the SSJV MPEP Team and have been actively involved in aspects of the ILRP, there have been no formal agreements to collaborate in implementation efforts. However, planning of joint and coordinated work with these technical partners is ongoing.

Section Nine

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9 References

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Tables & Figures

Table 1. CGQMP & MPEP Table

Requirements of Appendix MRP-1 of the General Order		Sections that Address Requirements	
		KRWCA CGQMP	SSJV MPEP Workplan
I.A. Introduction and Background Section			
	The introduction portion of the management plan shall include a discussion of the COCs that are the subject of the plan and the water quality objective(s) or trigger(s) requiring preparation of the management plan. The introduction shall also include an identification (both narrative and in map form) of the boundaries (geographic and surface water/ groundwater basin[s] or portion of a basin) to be covered by the management plan including how the boundaries were delineated.	Section 1 Introduction, Section 1.3 Geographic Boundaries of Comprehensive Groundwater Quality Management Plan, Section 3.3 Constituents of Concern	N/A
I.B.1. Physical Setting and Information			
I.B.1.a	Land use maps which identify the crops being grown in the SQMP watershed or GQMP area. For groundwater, these maps may already be presented in the Groundwater Assessment Report (GAR) and may be referenced and/or updated as appropriate. Map(s) must be in electronic format using standard Arc-geographic information system (ArcGIS shapefiles).	Section 2.1.2 Land Use	Section 3.5.1.1, Cropping
I.B.1.b	Identification of the potential irrigated agricultural sources of the COC(s) for which the management plan is being developed. If the potential sources are not known, a study may be designed and implemented to determine the source(s) or to eliminate irrigated lands as a potential source.	Section 4.1 Identification of Constituent of Concern (COC) Sources and Fate in the Environment	Section 3.6, Source Quantification
I.B.1.c	A list of the designated beneficial uses as identified in the applicable Basin Plan.	Section 4.2 Beneficial Uses	N/A
I.B.1.d	A baseline inventory of identified existing management practices in use within the management plan area that could be affecting the concentrations of the COCs in surface water and/or groundwater (as applicable) and locations of the various practices.	Section 4.3 Management Practices Baseline	Section 3.6.3, Benchmark Existing Level of BMP Adoption
I.B.1.e	A summary, discussion, and compilation of available surface water and/or groundwater quality data (as applicable) for the parameters addressed by the management plan. Available data from existing water quality programs may be used…The GAR developed for the third-party's geographic area, and groundwater quality data compiled in that document, may serve as a reference for these data.	Section 3.1 Available Groundwater Data, Section 3.2 Previous Studies and Monitoring	Section 3.5.2.2, Groundwater Conditions
I.B.3. Groundwater – Additional Requirements			
I.B.3.a	Soil types and other relevant soils data as described by the appropriate Natural Resources Conservation Service (NRCS) soil survey or other applicable studies. The soil unit descriptions and a map of their areal extent within the study area must be included. The GAR developed for the third-party's geographic area, and the soils mapping contained in that document, may satisfy this requirement.	Section 2.1.3 Soils	3.5.1.2, Soil Characteristics
I.B.3.b	A description of the geology and hydrogeology for the area covered by the GQMP.	Section 2.1.4 Geology, Section 2.1.5 Hydrogology	Section 3.5.2 Characterizations of Sub-Root Zone Process Factors
I.C. Management Plan Strategy			
I.C.1	A description of the approach to be utilized by the management plan (e.g., multiple COC's addressed in a scheduled priority fashion, multiple areas covered by the plan with a single area chosen for initial study, or all areas addressed simultaneously [area wide]). Any prioritization included in the management plan must be consistent with the requirements in section XII of the Order, Time Schedule for Compliance.	Section 1.1 Approach and Prioritization	Section 3.1, Master Schedule; Section 3.7, Initial Prioritization of Investigations; and Section 3.13, Regulatory Deliverables
I.C.2	The plan must include actions to meet the following goals and objectives: • Compliance with the Order's receiving water limitations (section III of the Order). • Educate Members about the sources of the water quality exceedances in order to promote prevention, protection, and remediation efforts that can maintain and improve water quality.	Section 1.1 CGQMP Strategy and MPEP Implementation, Section 5.3.2 Protective Management Practices, Section 5.3.3 Outreach Strategy, Section 5.3.5 Performance Goals	Section 2.4, Outreach Approach and Section 3.11, Sharing Findings with Coalition Members (Outreach), Section 3.6.3, Benchmark Existing Levels of BMP Adoption; 3.8, Focused Field Studies; Section 3.9, A Multi-Pronged Approach to Assessing the Influence of Irrigated Lands on

Requirements of Appendix MRP-1 of the General Order		Sections that Address Requirements	
		KRWCA CGQMP	SSJV MPEP Workplan
	• Identify, validate, and implement management practices to reduce loading of COC's to surface water or groundwater, as applicable, thereby improving water quality.		Groundwater Quality; Section 3.10, Landscape-level Performance Assessment; Section 3.12, Assessing Adoption, Data Exchange with Coalitions, Section 3.9.4, Summary Rationale for a Multi-Pronged Approach
I.C.3	Identify the duties and responsibilities of the individuals or groups implementing the management plan. This section should include: • Identification of key individuals involved in major aspects of the project (e.g., project lead, data manager, sample collection lead, lead for stakeholder involvement, quality assurance manager). • Discussion of each individual's responsibilities • An organizational chart with identified lines of authority.	Section 5.3.1 Partner Agencies and Entities, Section 8 Identification of Project Administration, Section 8.2 Individual Responsibilities, Section 8.3 Organizational Chart	Section 2.2, Institutional Approach
I.C.4	Strategies to implement the management plan tasks.		Entire Management Practices Evaluation Workplan
I.C.4.a	Identify the entities or agencies that will be contacted to obtain data and assistance.	Section 5.3.1 Partner Agencies and Entities	Section 2.2, Institutional Approach
I.C.4.b	Identify management practices used to control sources of COCs from irrigated lands that are: • Technically feasible; • Economically feasible; • Proven to be effective at protecting water quality, and • Will comply with Sections III.A and B of the Order. Practices that growers will implement must be discussed, along with an estimate of their effectiveness or any known limitations on the effectiveness of the chosen practice(s).	Section 5.3.2 Protective Management Practices	Section 2.1.4, Demonstrating Progress; Section 3.8, Focused Field Studies; and Section 3.10, Landscape-level Performance Assessment
I.C.4.c	Identify outreach that will be used to disseminate information to participating growers. This discussion shall include: the strategy for informing growers of the water quality problems that need to be addressed, method for disseminating information on relevant management practices to be implemented, and a description of how the effectiveness of the outreach efforts will be evaluated. The third-party may conduct outreach efforts or work with the assistance of the County Agricultural Commissioner's, U.C. Cooperative Extension, Natural Resources Conservation Service, Resource Conservation District, California Department of Food and Agriculture, or other appropriate groups or agencies.	Section 5.3.3 Outreach Strategy, Section 5.3.5 Performance Goals, Section 6.3 Validate KRWCA Approach	Section 2.4, Outreach Approach and Section 3.11, Sharing Findings with Coalition Members (Outreach)
I.C.4.d	A specific schedule and milestones for the implementation of management practices and tasks outlined in the management plan. Items to be included in the schedule include: time estimated to identify new management practices as necessary to meet the Order's surface and groundwater receiving water limitations (section III of the Order); a timetable for implementation of identified management practices (e.g., at least 25% of growers identified must implement management practices by year 1; at least 50% by year 2).	Section 5.3.4 Management Practices Implementation Schedule, Section 5.3.5 Performance Goals	Section 3.1, Master Schedule
I.C.4.e	Establish measureable performance goals that are aligned with the elements of the management plan strategy. Performance goals include specific targets that identify the expected progress towards meeting a desired outcome.	Section 5.3.5 Performance Goals	Section 3.1, Master Schedule and Section 3.12, Assessing Adoption, Data Exchange with Coalitions
I.D. Monitoring Methods			
I.D.1	The monitoring system must be designed to measure effectiveness at achieving the goals and objectives of the SQMP or GQMP and capable of determining whether management practice changes made in response to the management plan are effective and can comply with the terms of the Order. Management practice-specific or commodity-specific field studies may be used to approximate the contribution of irrigated lands operations. Where the third-party determines that field studies are appropriate	Section 6.1 Measure Achievement of CGQMP Goals, Section 6.2 Measure Effectiveness of CGQMP Practices	Section 3.8, Field Studies and Section 3.10, Landscape-level Performance Assessment

Requirements of Appendix MRP-1 of the General Order		Sections that Address Requirements	
		KRWCA CGQMP	SSJV MPEP Workplan
	or the Executive Officer requires a technical report under CWC 13267 for a field study, the third-party must identify a reasonable number and variety of field study sites that are representative of the particular management practice being evaluated.		
I.D.3	The third-party's Management Practice Evaluation Program and Groundwater Quality Trend Monitoring shall be evaluated to determine whether additional monitoring is needed in conjunction with the proposed management strategy(ies) to evaluate the effectiveness of the strategy(ies). This may include commodity-based representative monitoring that is conducted to determine the effectiveness of management practices implemented under the GQMP. Refer to section IV of the MRP for groundwater monitoring requirements.	Section 1.1 CGQMP Strategy and MPEP Implementation, Section 6.3 Additional Monitoring Required, Section 6.3 Validate KRWCA Outreach Results	Section 3.7, Initial Prioritization of Events and Section 3.9, A Multi-Pronged Approach to Assessing the Influence of Irrigated Lands on Groundwater Quality
I.E. Data Evaluation			
I.E.1	Methods to be used to evaluate the data generated by SQMP/GQMP monitoring and to evaluate the effectiveness of the implemented management practices must be described. The discussion should include at a minimum, the following: • Methods to be utilized to perform data analysis (graphical, statistics, modeling, index computation, or some combination thereof). • Identify the information necessary to quantify program effectiveness going forward, including the tracking of management practice implementation. The approach for determining the effectiveness of the management practices implemented must be described. Acceptable approaches include field studies of management practices at representative sites and modeling or assessment to associate the degree of management practice implementation to changes in water quality. The process for tracking implementation of management practices must also be described. The process must include a description of how the information will be collected from growers, the type of information being collected, how the information will be verified, and how the information will be reported.	Section 5.3.5 Performance Goals, Section 7 Data Evaluation & Reporting	Section 3.7, Initial Prioritization of Events; Section 3.8, Focused Field Studies; Section 3.9, A Multi-Pronged Approach to Assessing the Influence of Irrigated Lands on Groundwater Quality; Section 3.10, Landscape-level Performance Assessment; Section 3.11, Sharing Findings with Coalition Members (Outreach); and Section 3.12, Assessing Adoption, Data Exchange with Coalitions
I.E.2	The plan must include actions to meet the following goals and objectives: • Compliance with the Order's receiving water limitations (section III of the Order). • Educate Members about the sources of the water quality exceedances in order to promote prevention, protection, and remediation efforts that can maintain and improve water quality. • Identify, validate, and implement management practices to reduce loading of COC's to surface water or groundwater, as applicable, thereby improving water quality.	Section 1.1 CGQMP Strategy and MPEP Implementation, Section 5.3.2 Protective Management Practices, Section 5.3.3 Outreach Strategy, Section 5.3.5 Performance Goals	Section 2.4, Outreach Approach and Section 3.11, Sharing Findings with Coalition Members (Outreach), Section 3.6.3, Benchmark Existing Levels of BMP Adoption; 3.8, Focused Field Studies; Section 3.9, A Multi-Pronged Approach to Assessing the Influence of Irrigated Lands on Groundwater Quality; Section 3.10, Landscape-level Performance Assessment; Section 3.12, Assessing Adoption, Data Exchange with Coalitions, Section 3.9.4, Summary Rationale for a Multi-Pronged Approach
I.E.3	Identify the duties and responsibilities of the individuals or groups implementing the management plan. This section should include: • Identification of key individuals involved in major aspects of the project (e.g., project lead, data manager, sample collection lead, lead for stakeholder involvement, quality assurance manager). • Discussion of each individual's responsibilities • An organizational chart with identified lines of authority.	Section 5.3.1 Partner Agencies and Entities, Section 8 Identification of Project Administration, Individual Responsibilities, Figure 34 Organizational Chart	Section 2.2, Institutional Approach
I.E.4	Strategies to implement the management plan tasks.		Entire Management Practices Evaluation Workplan
I.E.4.a	Identify the entities or agencies that will be contacted to obtain data and assistance.	Section 5.3.1 Partner Agencies and Entities	Section 2.2, Institutional Approach

Table 2. 1990 KRWCA Irrigated Acres and Percent of Total

Crop	1990 Irrigated Acres	% of Total
Alfalfa	96,302	14.09%
Almond	62,254	9.11%
Carrots	7,304	1.07%
Citrus	32,292	4.72%
Corn	6,125	0.90%
Cotton	236,853	34.66%
Field Crop	102,334	14.97%
Fruit Tree	11,604	1.70%
Grapes - Table and Wine	66,681	9.76%
Nut Tree	2,198	0.32%
Pistachios	3,111	0.46%
Range/Pasture	4,199	0.61%
Silage/Forage	2,520	0.37%
Truck Crop	49,675	7.27%
Total:	**683,451**	**100%**

Table 3. 2013 KRWCA Commodity Acres and Percent of Total

Crop	2013 Commodity Acres	% of Total
Alfalfa	76,220	9.45%
Almond	162,813	20.20%
Carrots	37,654	4.67%
Citrus	56,732	7.04%
Corn	39,496	4.90%
Cotton	38,033	4.72%
Field Crop	130,554	16.19%
Fruit Tree	15,140	1.88%
Grapes - Table and Wine	87,359	10.84%
Nut Tree	1,535	0.19%
Pistachios	43,565	5.40%
Range/Pasture	375	0.05%
Silage/Forage	667	0.08%
Truck Crop	116,010	14.39%
Total:	**806,153**	**100%**

Table 4. General Groundwater Chemistry (USGS 2006)

Analyte	Range	Average	Units
pH	7.7-9.7	8.26	Standard Units
DO	0.2-9	3.84	mg/L
Specific Conductivity	208-1740	667	µS/cm
Na	21-183	71	mg/L
Ca	4-141	54.6	mg/L
Mg	0.01-50.6	8.63	mg/L
Cl	6.88-339	52.8	mg/L
SO_4	12.1-779	151.1	mg/L
TDS	126-1400	447.5	mg/L
Hardness	10-560	171	mg/L as $CaCO_3$
Nitrite	0.27-.668	0.25	mg/L

Table 5. General Irrigation Surface Water Chemistry within KRWCA Area (USBR 2014)

Analyte	Range	Average	Units
Na	2-75.3	26.15	mg/L
Ca	2-58.3	21.25	mg/L
Mg	1.47-3.27	2.17	mg/L
Cl	1.3-100	20	mg/L
HCO_3	9.9-110	47.18	mg/L
SO_4	1.1-120	18.74	mg/L
TDS	10-450	113.73	mg/L
Hardness	7.6-44	15.23	mg/L

Table 6. Tulare Lake Basin Groundwater Beneficial Uses

Hydrologic Unit	DAU*	MUN	AGR	IND	PRO	REC-1	REC-1	WILD
Kern County Basin	245	●	●	●				
	254	●	●	●	●	●	●	●
	255	●	●	●				●
	256	●	●	●	●			
	257	●	●	●		●		
	258	●	●	●	●			
	259	●	●	●				
	260	●		●				
	261	●	●	●				
Satellite Basins								
Kern River Valley		●	●	●				
Walker Basin Creek Valley		●	●	●				
Cummings Valley		●	●	●		●	●	
Tehachapi Valley West		●	●	●		●	●	●
Castaic Lake Valley		●	●	●				
Brite Valley		●	●	●		●	●	●
Cuddy Canyon Valley		●		●			●	
Cuddy Ranch Area		●	●					
Cuddy Valley		●	●	●				
Mil Potrero Area		●		●			●	

*DAU=Detailed Analysis Unit

Table 7. KRWCA High Vulnerability Area by Identification Scenario

KRWCA HVA Identification Scenario	Irrigated Acres (ac)	Percent of HVA (%)
NHI Field Score > 20	66,622	24.09%
NHI Field Score > 20 & WQE	45,939	16.61%
NHI Field Score ≤ 20 & WQE	163,917	59.26%
DPR GWPA (Leaching)	115	0.04%
Total HVA:	**276,593**	**100.0%**

KRWCA: Kern River Watershed Coalition Authority
HVA: High Vulnerability Area
WQE: Water Quality Objective Exceedance
DPR: California Department of Pesticide Regulation
GWPA: Groundwater Protection Area

Table 8. KRWCA High Vulnerability Area by Crop Type

Crop	Acres (ac)	Percent of Total (%)	Cumulative Percent (%)
Almonds	115,009	28.2%	28.2%
Truck Crops	70,575	17.3%	45.6%
Grapes	40,709	10.0%	55.5%
Potatoes	30,605	7.5%	63.1%
Field Crops	29,214	7.2%	70.2%
Cotton	24,180	5.9%	76.2%
Corn	22,589	5.5%	81.7%
Citrus	21,563	5.3%	87.0%
Pistachios	19,332	4.7%	91.7%
Alfalfa	12,641	3.1%	94.9%
Fruit Tree	10,852	2.7%	97.5%
Tomatoes	7,638	1.9%	99.4%
Nut Tree	2,129	0.5%	99.9%
Pasture	351	0.1%	100.0%

Table 9. Pesticides Detected in KRWCA Area

Pesticides Detected in KRWCA Area	
1,2 Dibromoethane (Edb)	Dinoseb
1,2 Dichlorobenzene (1,2-Dcb)	Diuron
1,2 Dichloropropane (1,2 Dcp)	Endothall
1,2-Dibromo-3-Chloropropane (Dbcp)	Endrin
1,3 Dichloropropene	Eptc
2,4,5-Tp (Silvex)	Glyphosate (Round-Up)
2,4-Dichlorophenoxyacetic Acid (2,4 D)	Heptachlor
Acenaphthene	Heptachlor Epoxide
Acetone	Hexachlorobutadiene
Alachlor	Hexazinone
Aldicarb	Lindane (Gamma-Bhc)
Aldicarb Sulfone	Methiocarb
Atrazine (Aatrex)	Methoxychlor
Bentazon	Methyl Bromide (Bromomethane)
Bromacil	Metolachlor
Butachlor	Metribuzin
Carbofuran	Molinate
Carbon Disulfide	Naphthalene
Carbon Tetrachloride	Norflurazon
Chlordane	Oxamyl
Cyanazine	Paraquat
Deethylatrazine	Penoxalin
Diazinon	Picloram
Dicamba (Banvel)	Prometon
Dichlorprop	Prometryn
Dieldrin	Propachlor (2-Chloro-N-Isopropylacetanilide)
Dimethoate	Simazine
Dimethoate	Thiobencarb
Dimethyl Phthalate	Xylenes (Total)
Di-N-Butylphthalate	

Table 10. Maximum Contaminant Levels for Detected Pesticides

Pesticide	Maximum Contaminant Level (MCL, µg/L)	Total Number of Samples	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Date of First Sample	Date of Most Recent Sample	Number of Wells with Exceedances	Number of Samples Exceeding Threshold
1,2 Dibromoethane (EDB)	0.05	16,145	ND (<10)	0.63	7/28/1983	6/25/2014	34	171
1,2 Dichlorobenzene (1,2-DCB)	600	15,986	ND (<15)	7	1/4/1984	6/25/2014		
1,2 Dichloropropane (1,2 DCP)	5	15,890	ND (<10)	7	7/28/1983	6/25/2014	2	2
1,2-Dibromo-3-chloropropane (DBCP)	0.2	17,593	ND (<100)	74	10/19/1980	6/25/2014	156	1,443
1,3 Dichloropropene	0.5	14,174	ND (<1)	7	8/8/1984	6/25/2014	1	1
2,4,5-TP (Silvex)	50	1,454	ND (<10)	1	10/15/1984	7/10/2013		
2,4-Dichlorophen-oxyacetic acid (2,4 D)	70	3,598	ND (<100)	65	7/6/1984	6/1/2796		
Acenaphthene	N/A	268	ND (<10)	8	6/10/2792	4/1/2013		
Acetone	N/A	11	ND (<1)	42	9/3/1987	1/26/2011		
Alachlor	2.0	6,011	ND (<4)	5.9	1/7/1985	6/12/2014	1	1
Aldicarb	N/A	2,413	ND (<5)	88	11/27/1979	6/1/2796		
Aldicarb Sulfone	N/A	1,633	ND (<5)	97	3/1/1989	5/19/2014		
Atrazine	1.0	9,894	ND (<2.4)	8.5	5/3/1985	6/12/2014	4	9
Bentazon	18	3,941	ND (<20)	48	2/10/1989	6/3/2014	2	2
Bromacil	N/A	7,437	ND (<20)	23	8/30/1984	5/15/2014		
Butachlor	N/A	782	ND (<1)	1	2/22/1993	9/20/2012		
Carbofuran	18	3,226	ND (<50)	8	8/30/1984	5/19/2014		
Carbon Disulfide	160	642	ND (<1,000)	0.5	9/26/2001	2/6/2014		
Carbon Tetrachloride	0.5	6,938	ND (<12)	9.7	1/4/1984	12/30/1999	7	26
Chlordane	0.1	3,442	ND (<40)	35	7/10/1984	5/5/2014	4	4
Cyanazine	N/A	820	ND (<150)	0.023	5/3/1985	9/20/2012		
Deethylatrazine	N/A	639	ND (0)	0.52	3/2/1993	4/27/2011		
Diazinon	N/A	5,251	ND (<4)	2	8/30/1984	5/15/2014		
Dicamba	N/A	1,697	ND (<15)	0.08	2/14/1985	5/5/2014		
Dichlorprop	N/A	14	ND (<1)	0.5	6/30/1989	7/7/2004		
Dieldrin	N/A	660	ND (<2.5)	0.2	7/10/1984	9/20/2012		
Dimethoate	N/A	5,574	ND (<100)	2	8/30/1984	5/15/2014		
Dimethyly Phthalate	N/A	144	ND (<10)	0.8	7/10/1984	4/1/2013		
Di-N-Butylphthalate	N/A	187	ND (<10)	9.5	7/10/1984	7/19/1999		
Dinoseb	7	1,069	ND (<100)	0.18	8/30/1984	6/1/2796		
Diuron	N/A	3,709	ND (<50)	6.5	8/30/1984	9/20/2012		
Endothall	100	2,135	ND (<100)	64	8/30/1984	5/19/2014		
Endrin	2.0	1,430	ND (<10)	0.2	7/10/1984	7/10/2013		
EPTC	N/A	879	ND (<50)	170	8/30/1984	7/29/2011		
Glyphosate (Round-up)	700	1,710	ND (<25)	19	7/25/1986	9/16/2013		
Heptachlor	0.01	3,363	ND (<1.9)	0.005	7/10/1984	3/28/2014		
Heptachlor Epoxide	0.01	3,386	ND (<2.2)	0.021	7/10/1984	3/28/2014	2	2
Hexachlorobutadiene	N/A	5,008	ND (<10)	7	7/10/1984	12/29/1999		
Hexazinone	N/A	1,046	ND (<0.9)	0.24	9/29/1992	8/29/2012		
Lindane (Gamma-BHC)	0.2	3,826	ND (<5)	0.22	7/6/1984	3/28/2014	1	1
Methiocarb	N/A	145	ND (<10)	4	5/9/1989	12/14/2009		
Methoxychlor	30	4,140	ND (<100)	0.77	7/6/1984	3/28/2014		
Methyl Bromide (Bromomethane)	N/A	12,407	ND (<118)	7	1/17/1984	6/25/2014		

Pesticide	Maximum Contaminant Level (MCL, µg/L)	Total Number of Samples	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Date of First Sample	Date of Most Recent Sample	Number of Wells with Exceedances	Number of Samples Exceeding Threshold
Metolachlor	N/A	4,340	ND (<1)	1	7/10/1987	5/15/2014		
Metribuzin	N/A	4,641	ND (<2.4)	0.5	7/10/1987	5/15/2014		
Molinate	20	6,383	ND (<4)	2	9/9/1985	5/15/2014		
Naphthalene	N/A	17,743	ND (<1,000)	358	7/10/1984	6/25/2014		
Norflurazon	N/A	571	ND (<0.04)	2.48	3/29/1995	4/27/2011		
Oxamyl	50	2,430	ND (<50)	9	8/30/1984	5/19/2014		
Paraquat	N/A	237	ND (<100)	1.7	8/30/1984	12/14/2009		
Penoxalin	N/A	56	ND (<10)	0.5	8/31/1986	11/22/1999		
Picloram	500	980	ND (<1)	0.1	1/30/1991	7/10/2013		
Prometon	N/A	2,352	ND (<1.3)	1.12	3/18/1986	3/28/2014		
Prometryn	N/A	5,843	ND (<2.8)	2	5/3/1985	5/15/2014		
Propachlor (2-Chloro-N-isopropylacetanilide)	N/A	673	ND (<1)	1	2/22/1993	11/9/2012		
Simazine	4	10,252	ND (<10.1)	3.5	6/1/1982	6/12/2014		
Thiobencarb	70	6,088	ND (<4)	1	9/9/1985	5/15/2014		
Xylenes (total)	1,750	16,720	ND (<100)	38000	1/4/1984	6/25/2014		

Table 11. KRWCA High Vulnerability Area Prioritization Tier Acreage

Prioritization Tier	Irrigated Acres (ac)	Percent of Total (%)
Tier I	22,031	5.4%
Tier II	102,061	25.1%
Tier III	283,293	69.5%
Subtotal:	**407,385**	**100%**

Table 12. High Vulnerability Area Prioritization Scenarios and Resulting Tiers

Upgradient of Public Groundwater Supply Wells	Hydrogeologic Sensitivity	NHI	Points	Prioritization Tier
DAC	High	High	7	Tier I
Yes	High	High	6	Tier I
DAC	Medium	High	6	Tier I
Yes	Medium	High	5	Tier I
DAC	Low	High	5	Tier I
No	High	High	5	Tier I
Yes	Low	High	4	Tier II
DAC	High	Low	4	Tier I*
No	Medium	High	4	Tier II
Yes	High	Low	3	Tier II
DAC	Medium	Low	3	Tier I*
No	Low	High	3	Tier II
Yes	Medium	Low	2	Tier III
DAC	Low	Low	2	Tier I*
No	High	Low	2	Tier III
Yes	Low	Low	1	Tier III
No	Medium	Low	1	Tier III
No	Low	Low	0	Tier III

*All HVAs upgradient of a DAC are automatically prioritized as Tier 1

Table 13. KRWCA High Vulnerability Area Prioritization Parameters Acreage by Crop Type

Crop	Hydrogeologic Sensitivity (ac)			Upgradient of Public Groundwater Supply Wells (ac)			NHI (ac)	
	Low	Med	High	No	Yes		Low	High
					Non-DAC	DAC		
	0 pts	1 pt	2 pts	0 pts	1 pt	2 pts	0 pts	3 pts
Alfalfa	10,537	12,997	645	20,894	1,205	2,080	22,138	2,042
Almonds	61,506	52,130	1,373	107,100	3,754	4,155	94,351	20,658
Citrus	25,548	5,057	0	28,594	1,562	449	30,259	346
Corn	3,587	8,827	227	11,269	504	868	1,781	10,860
Cotton	3,332	15,864	135	18,224	758	350	10,348	8,984
Field Crops	10,412	18,473	330	26,215	1,568	1,431	14,398	14,816
Fruit Tree	6,173	4,657	22	10,172	261	419	8,780	2,073
Grapes	46,300	23,561	714	65,699	2,497	2,379	69,464	1,111
Nut Tree	1,003	1,086	40	2,021	47	61	393	1,735
Pasture	147	204	0	276	25	50	95	256
Pistachios	10,831	11,557	202	21,705	238	646	17,205	5,384
Potatoes	8,601	12,622	340	19,065	1,684	814	3,505	18,058
Tomatoes	3,684	3,954	0	6,884	389	365	4,981	2,657
Truck Crops	21,203	19,087	419	37,948	635	2,126	15,871	24,837

Table 14. KRWCA Prioritization Tier I Acreage by Crop and Irrigation System Type

Prioritization Tier	Crop	Irrigation System Type	Total Acres (ac)
Tier I	Almonds	Drip	3,021
		Surface	2,319
		Sprinkler	36
	Truck Crops	Sprinkler/Surface	1,108
		Sprinkler	930
		Surface	597
		Drip	216
	Field	Sprinkler/Surface	1,398
		Surface	852
		Drip	151
		Sprinkler	64
	Grapes	Drip	1,851
		Surface	384
		Sprinkler	144
	Alfalfa	Surface	1,647
		Sprinkler	421
		Sprinkler/Surface	185
		Drip	120
	Potatoes	Sprinkler	1,598
		Sprinkler/Surface	240
		Surface	167
		Drip	50
	Corn	Sprinkler/Surface	781
		Surface	550
	Cotton	Surface	865
		Sprinkler/Surface	65
		Drip	40
	Pistachios	Drip	646
		Surface	27
	Citrus	Drip	345
		Sprinkler	104
		Surface	53
	Tomatoes	Surface	217
		Drip	144
		Sprinkler/Surface	77
		Sprinkler	4
	Fruit Tree	Surface	215
		Drip	143
		Sprinkler	79
	Nut Tree	Surface	100
	Pasture	Surface	53
		Flood	13
		Sprinkler	9
		Drip	1
		Total Acres (ac):	**22,031**

Table 15. KRWCA Prioritization Tier II Acreage by Crop and Irrgation System Type

Prioritization Tier	Crop	Irrigation System Type	Total Acres (ac)
Tier II	Truck Crops	Sprinkler	11,736
		Surface	6,663
		Sprinkler/Surface	4,215
		Drip	21
		Drip/Sprinkler	14
	Almonds	Surface	17,612
		Sprinkler/Surface	264
		Drip	183
		Micro Sprinkler	165
		Micro	39
	Potatoes	Sprinkler	12,679
		Surface	2,248
		Sprinkler/Surface	1,160
		Flood	25
	Field Crops	Surface	9,723
		Sprinkler/Surface	2,660
		Sprinkler	465
	Corn	Surface	5,216
		Sprinkler/Surface	4,413
		Sprinkler	2
	Cotton	Surface	7,774
		Sprinkler/Surface	268
		Sprinkler	11
	Pistachios	Surface	5,357
	Tomatoes	Surface	1,396
		Sprinkler	664
		Sprinkler/Surface	298
	Fruit Tree	Surface	1,736
		Drip	75
		Drip/Sprinkler	38
	Alfalfa	Surface	1,265
		Sprinkler/Surface	445
	Nut Tree	Surface	1,615
		Sprinkler	20
	Grapes	Drip	1,006
		Surface	105
	Citrus	Surface	294
	Pasture	Surface	164
		Sprinkler/Surface	27
		Total Acres (ac):	**102,061**

Table 16. KRWCA Prioritization Tier III Acreage by Crop and Irrigation System Type III

Prioritization Tier	Crop	Irrigation System Type	Total Acres (ac)
Tier III	Almonds	Drip	88,221
		Sprinkler	2,540
		Surface	449
		Drip/Sprinkler	129
		Micro	31
	Grapes	Drip	52,489
		Surface	13,418
		Sprinkler	1,042
		Sprinkler/Surface	134
		Drip/Sprinkler	2
	Citrus	Drip	29,135
		Drip/Sprinkler	661
		Sprinkler	14
	Alfalfa	Surface	14,251
		Sprinkler	4,535
		Drip	1,038
		Sprinkler/Surface	273
	Pistachios	Drip	16,440
		Sprinkler	101
		Drip/Sprinkler	19
	Truck Crops	Sprinkler	8,266
		Drip	5,646
		Surface	874
		Sprinkler/Surface	297
		Drip/Sprinkler	126
	Field	Sprinkler	8,046
		Sprinkler/Surface	3,109
		Surface	1,825
		Drip	911
		MicroSprinkler	8
	Cotton	Sprinkler	6,565
		Sprinkler/Surface	3,528
		Drip	125
		Surface	91
	Fruit Tree	Drip	7,711
		Sprinkler	848
		Micro	6
	Tomatoes	Drip	3,071
		Sprinkler	1,738
		Sprinkler/Surface	29
	Potatoes	Sprinkler	2,747
		Drip	648
	Corn	Sprinkler	978
		Sprinkler/Surface	344
		Drip	242
		Surface	114
	Nut Tree	Drip	277
		Sprinkler	114
		Micro	3
	Pasture	Surface	77
		Sprinkler	8
		Total Acres (ac):	**283,293**

Table 17. KRWCA Prioritization Tier Acreage by Crop Type

Prioritization Tier	Crop	Total Acres (ac)
Tier I	Almonds	5,376
	Truck Crops	2,851
	Field Crops	2,466
	Grapes	2,379
	Alfalfa	2,373
	Potatoes	2,056
	Corn	1,331
	Cotton	970
	Pistachios	672
	Citrus	501
	Tomatoes	442
	Fruit Tree	438
	Nut Tree	100
	Pasture	75
Tier II	Truck Crops	22,649
	Almonds	18,263
	Potatoes	16,111
	Field	12,848
	Corn	9,632
	Cotton	8,054
	Pistachios	5,357
	Tomatoes	2,358
	Fruit Tree	1,850
	Alfalfa	1,710
	Nut Tree	1,635
	Grapes	1,111
	Citrus	294
	Pasture	190
Tier III	Almonds	91,370
	Grapes	67,085
	Citrus	29,810
	Alfalfa	20,096
	Pistachios	16,560
	Truck Crops	15,209
	Field	13,900
	Cotton	10,308
	Fruit Tree	8,565
	Tomatoes	4,838
	Potatoes	3,396
	Corn	1,678
	Nut Tree	393
	Pasture	85
	Total Acres (ac):	**407,385**

Table 18. KRWCA Prioritization Tier Acreage by Irrigation System Type

Prioritization Tier	Irrigation System Type	Total Acres (ac)
Tier I	Surface	8,047
	Drip	6,726
	Sprinkler/Surface	3,855
	Sprinkler	3,391
	Flood	13
Tier II	Surface	61,167
	Sprinkler	25,577
	Sprinkler/Surface	13,751
	Drip	1,284
	Micro Sprinkler	165
	Drip/Sprinkler	52
	Micro	39
	Flood	25
Tier III	Drip	205,953
	Surface	290
	Sprinkler	34,517
	Sprinkler/Surface	4,046
	Drip/Sprinkler	38,438
	Micro	40
	MicroSprinkler	8
	Total Acres (ac):	**407,385**

Table 19. Protective Practices Dzurella et al

	Management Practice	Barriers to Adoption
Irrigation and Drainage Design and Operation		
Irrigation System Evaluation and Monitoring		
1	Conduct irrigation system performance evaluation	Operational cost, land tenure, training
2	Install and use flow meters or other measuring devices to track water volume applied to each field at each irrigation	Capital cost, operational cost, training
3	Conduct pump performance tests	Operational cost, training
Irrigation Scheduling		
4	Use weather-based irrigation scheduling	Operational cost, logistics, training, technology
5	Use plant-based irrigation scheduling	Operational cost, logistics, training
6	Use soil moisture content to guide irrigation timing and amount	Operational cost, logistics, training
7	Avoid heavy pre-plant or fallow irrigations for annual crops	Risk to yield or quality, logistics, training
Surface Gravity System Design and Operation		
8	Convert to surge irrigation	Capital cost, operational cost, logistics, training
9	Use high flow rates initially, then cut back to finish off the irrigation	Operational cost, logistics, training
10	Reduce irrigation run distances and decrease set times	Risk to yield or quality, capital cost, operational cost, land tenure, training
11	Increase flow uniformity among furrows (e.g. by compacting furrows)	Operational cost
12	Grade fields as uniformly as possible	Operational cost, training
13	Where high uniformity and efficiency are not possible, convert to drip, center pivot, or linear move systems	Capital cost, operational cost, land tenure, training
Sprinkler System Design and Operation		
14	Monitor flow and pressure variation throughout the system	Operational cost
15	Repair leaks and malfunctioning sprinklers; follow manufacturer recommended replacement intervals	Capital cost, operational cost, training
16	Operate sprinklers during the least windy periods, when possible	Logistics
17	Use offset lateral moves	Operational cost, logistics, technology
18	Use flow-control nozzles when pressure variation is excessive	Capital cost, land tenure, training
Drip and Micro-Sprinkler System Design and Operation		
19	Use appropriate lateral hose lengths to improve uniformity	Training, capital cost
20	Check for clogging; prevent or correct clogging	Operational cost, capital cost, training
Other Irrigation Infrastructure Improvements		
21	Installation of sub-surface drains in poorly drained soils[1]	Capital cost, technology
22	Backflow prevention	Capital cost, training
Crop Management		
Change Crops to Use Those with Smaller N Requirements and Greater N Efficiency		
23	Cover crops to recover residual soil nitrate and immobilize it in soil organic matter	Risk to yield or quality of cash crop, capital cost, operational cost, logistics, training, technology, increased irrigation requirements for the cash crop
24	Include deep-rooted or N-scavenger crop species in annual crop rotations	Risk to yield or quality, capital cost, operational cost, logistics
25	Include perennial crop in rotation, e.g. alfalfa or perennial grasses	Capital cost, logistics, land tenure
Nitrogen Fertilizer Management		
Improve Rate, Timing and Placement of N Fertilizers		
26	Adjust N-fertilizer rates based on soil nitrate testing	Operational cost, training
27	Adjust timing of N fertilization based on plant tissue analysis	Risk to yield or quality, operational cost, training, lack of robust relationships between tissue test and amount of N fertilizer required
28	Apply N fertilizer in small multiple doses, rather than one or two large doses, to meet crop demand during the growing season without deficiency or excess	Operational cost, training

	Management Practice	Barriers to Adoption
29	Know N content of irrigation water and adjust fertilizer rates accordingly	Operational costs, logistics, training
30	Reduce total N-fertilizer rates by replacing low-uptake-efficiency N-fertilizer applications to soil with high-uptake-efficiency foliar-N applications	Operational costs, training, technology
31	Vary N-application rates within large fields according to site-specific needs based on heterogeneity in soil N supply and/or crop growth	Operational costs, capital costs, training, technology
32	Use delayed injection procedure when fertigating in surface gravity systems	Operational costs, logistics, training
34	Develop an N budget that includes crop N harvest removal, supply of N from soil and other inputs to guide decisions on N-fertilizer rates and timing	Operational costs, training, technology
35	Use controlled release fertilizers, nitrification inhibitors, and urease inhibitors	Risk to yield quantity or quality, capital cost, training, technology, benefits depend on soil types and N-fertilizer management practices
Improve Rate, Timing, and Placement of Animal Manure and Organic Amendment Applications		
36	Apply appropriate rates of manure and compost, taking N mineralization characteristics of these organic N sources into account	Risk to yield quantity or quality, operational cost, logistics, training, technology
37	Incorporate solid manure immediately to decrease ammonia volatilization loss	Operational costs, training
38	Use delayed injection to improve application uniformity when applying liquid manure in surface-gravity irrigation systems	Operational cost, logistics, training, technology
39	Use quick-test methods to monitor dairy lagoon water N content immediately before and during application, and adjust application rate accordingly	Operational costs, training, technology
40	Calibrate solid manure and compost spreaders	Operational cost, logistics, training
Promote Overall Healthier Soil		
41	Promote healthy soil to augment water and nutrient holding capacity and reduce nutrient loss[1]	Time and knowledge required to integrate organic amendments and other healthy soil promotion (e.g., reduced tillage) into cropping system.

[1]Presumably beneficial to N management primarily by promoting more uniform crop growth and N uptake across the field.

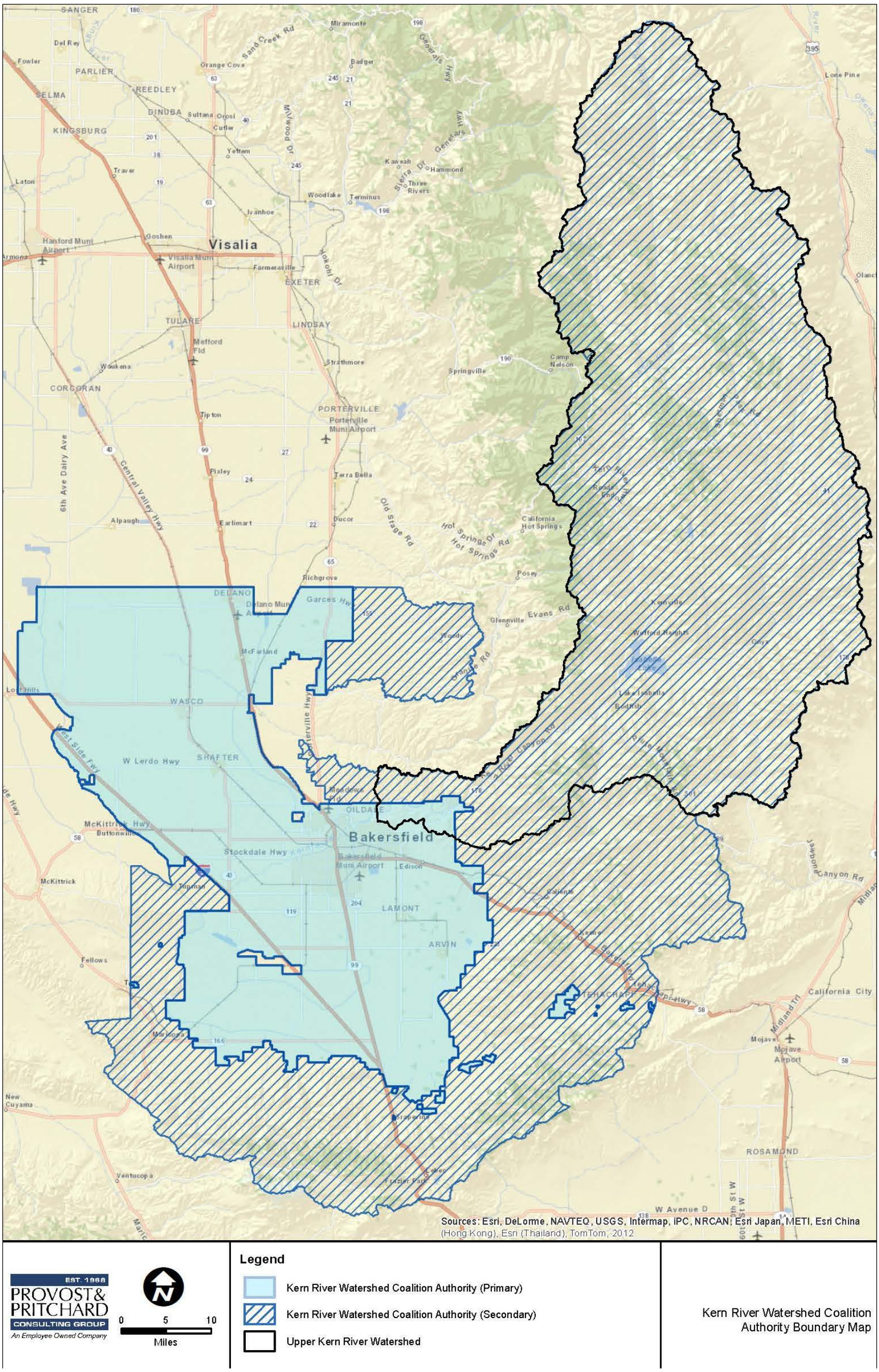


Figure 1. KRWCA Boundary Map

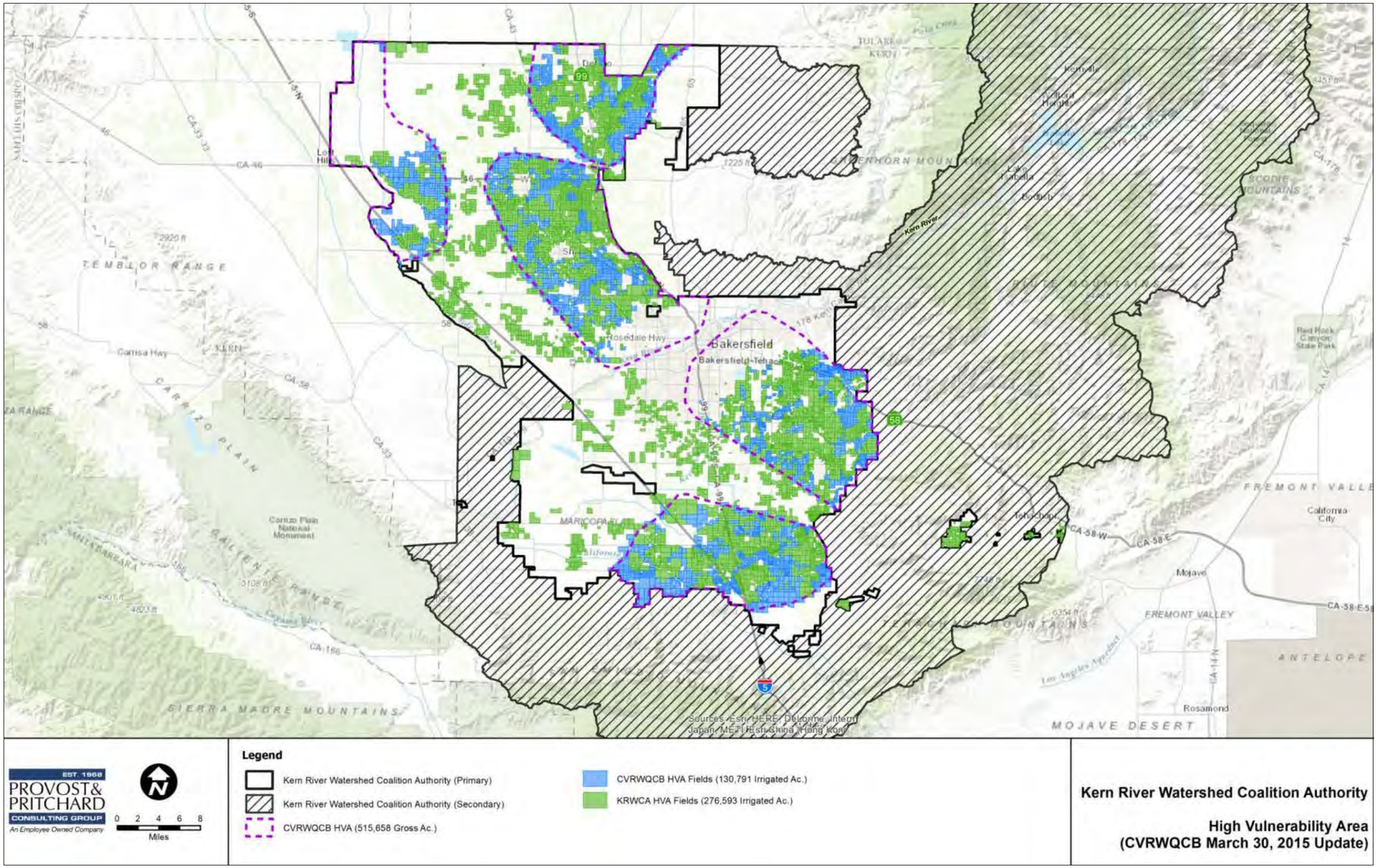


Figure 2. High Vulnerability Areas (CVRWQCB March 30, 2015 Update)

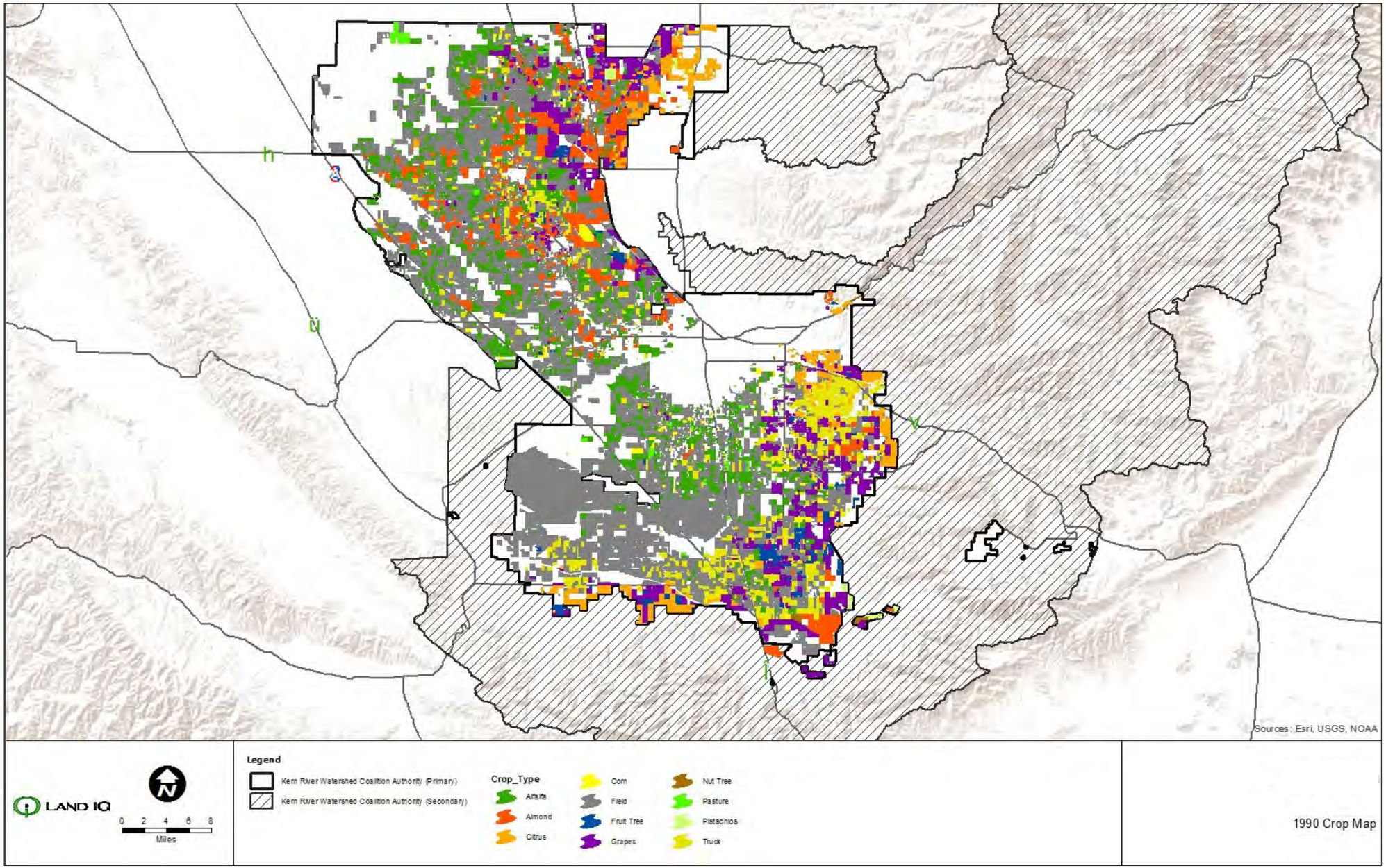


Figure 3. 1990 DWR KRWCA Crop Map

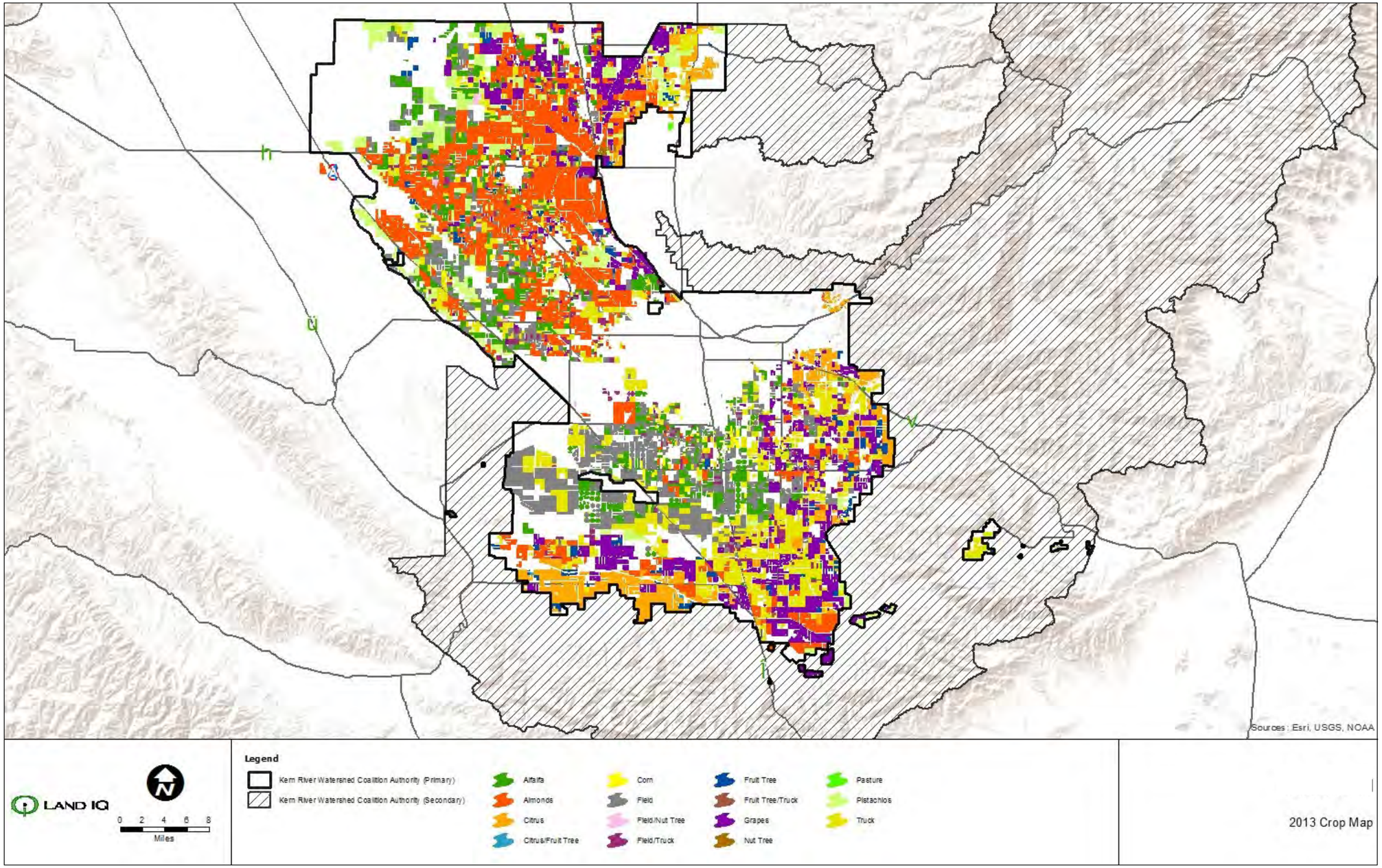


Figure 4. 2013 KRWCA Crop Map

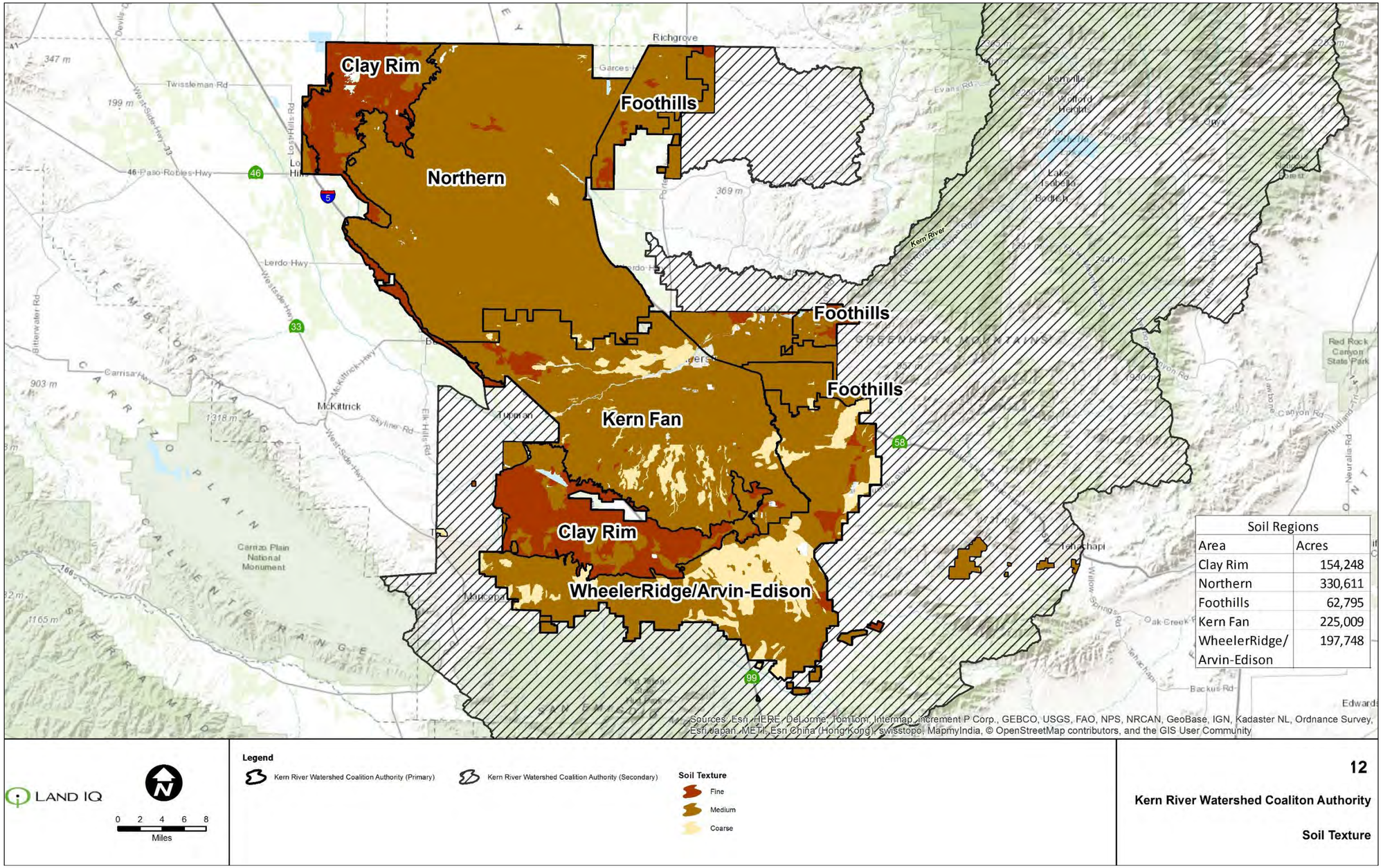


Figure 5. KRWCA Soil Texture Map

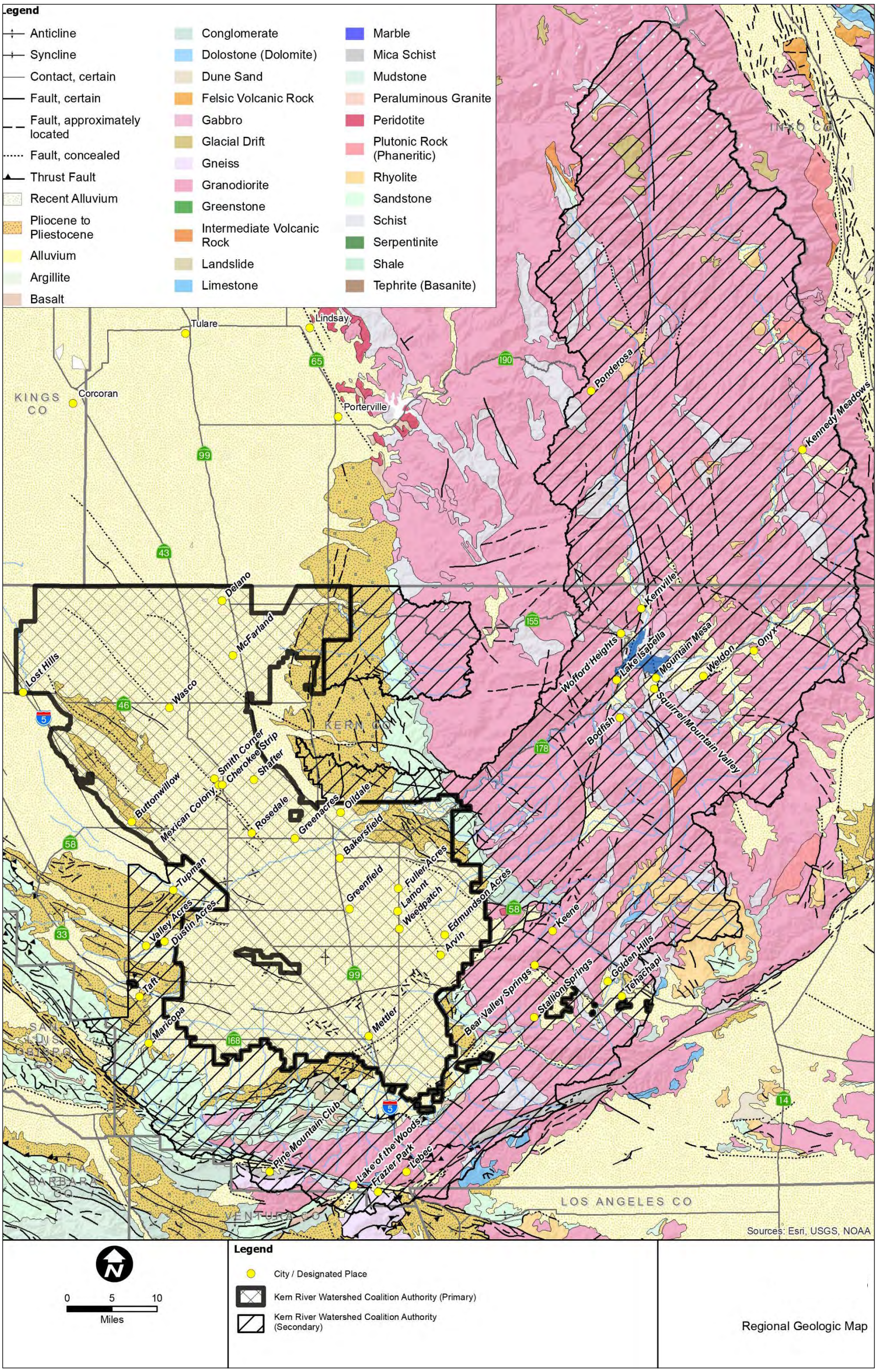


Figure 6. Regional Geologic Map (USGS 2014)

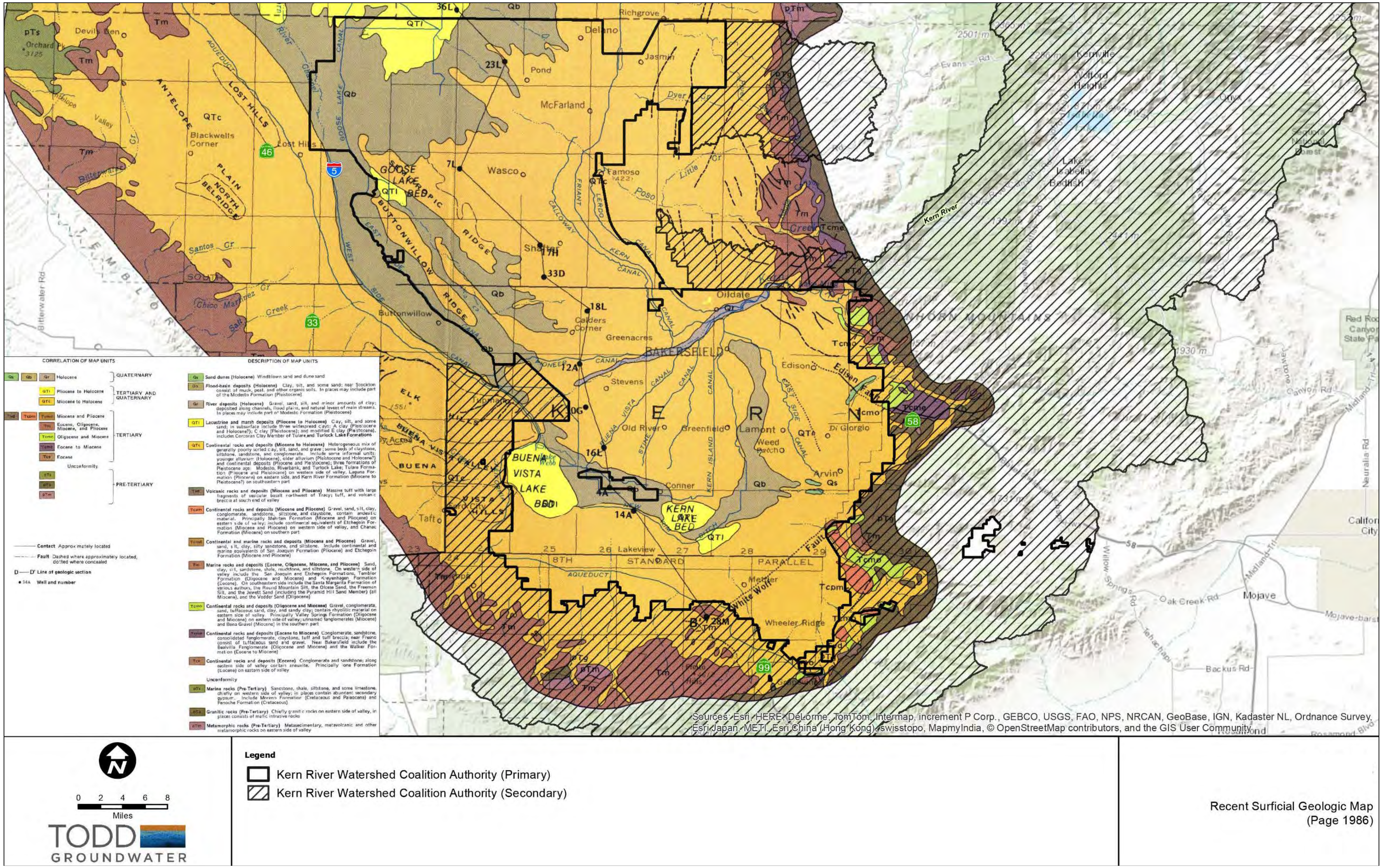


Figure 7. Geologic Map of Recent Deposits (Page 1986)

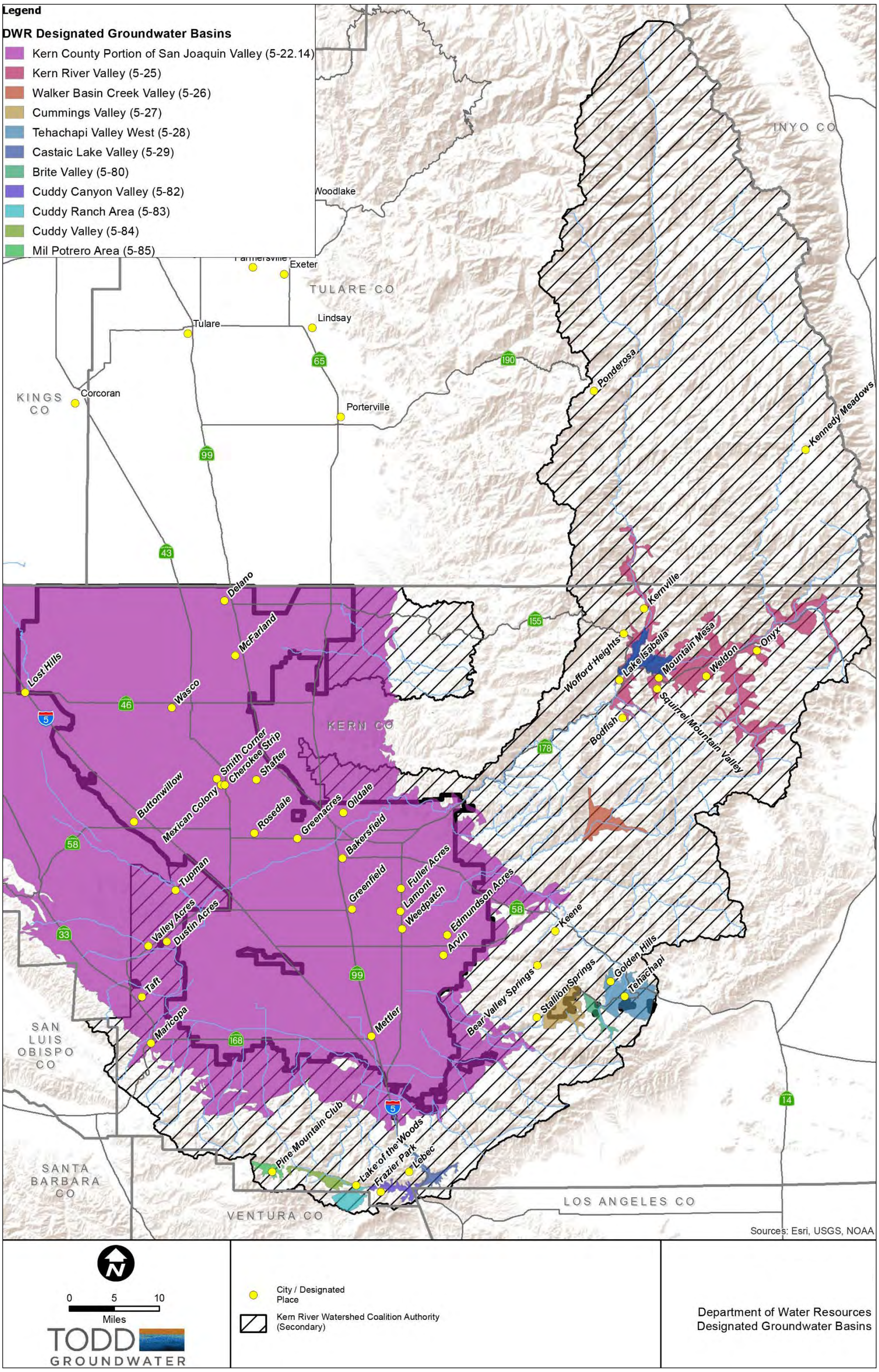


Figure 8. DWR Designated Groundwater Basins

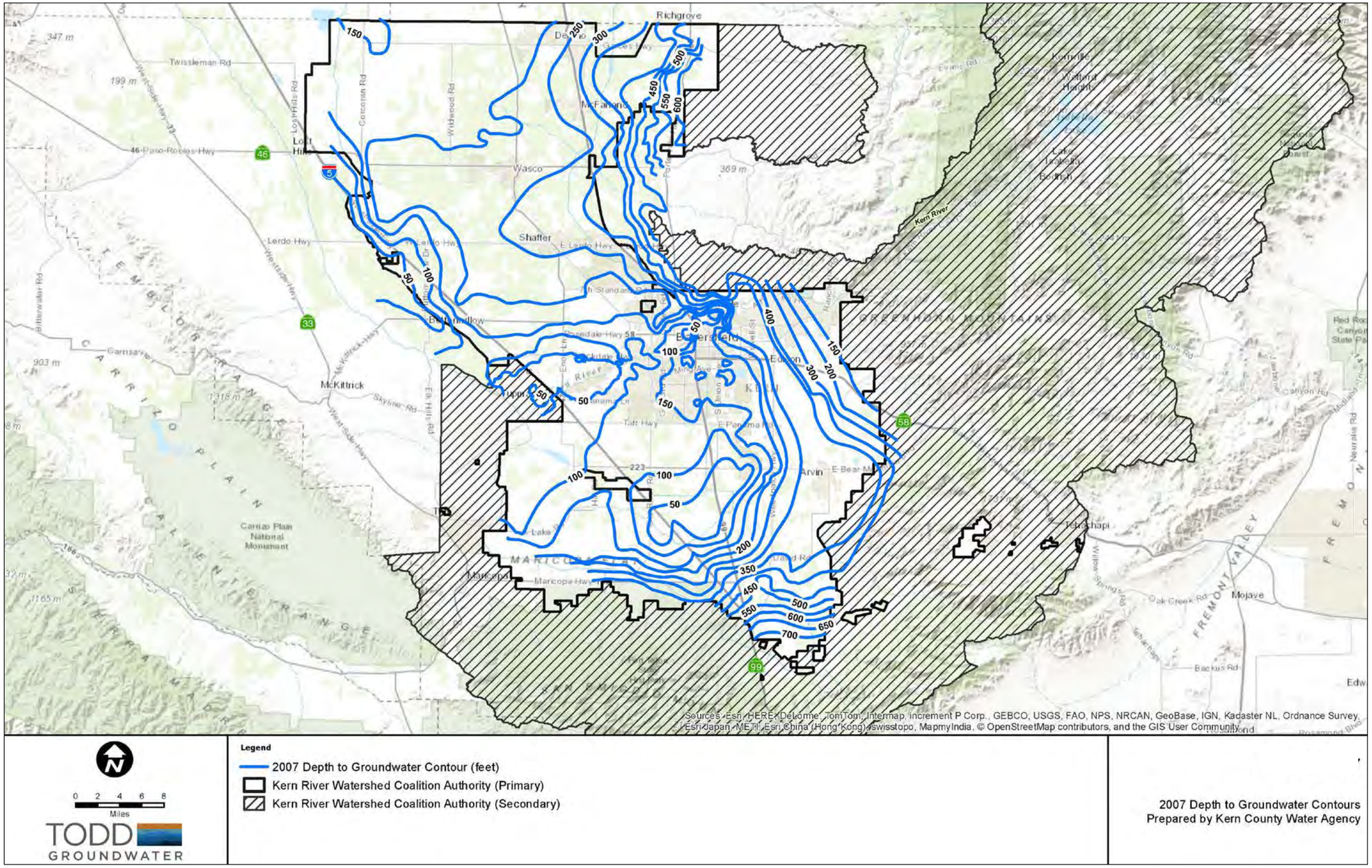


Figure 9. 2007 Depth to Groundwater Contours

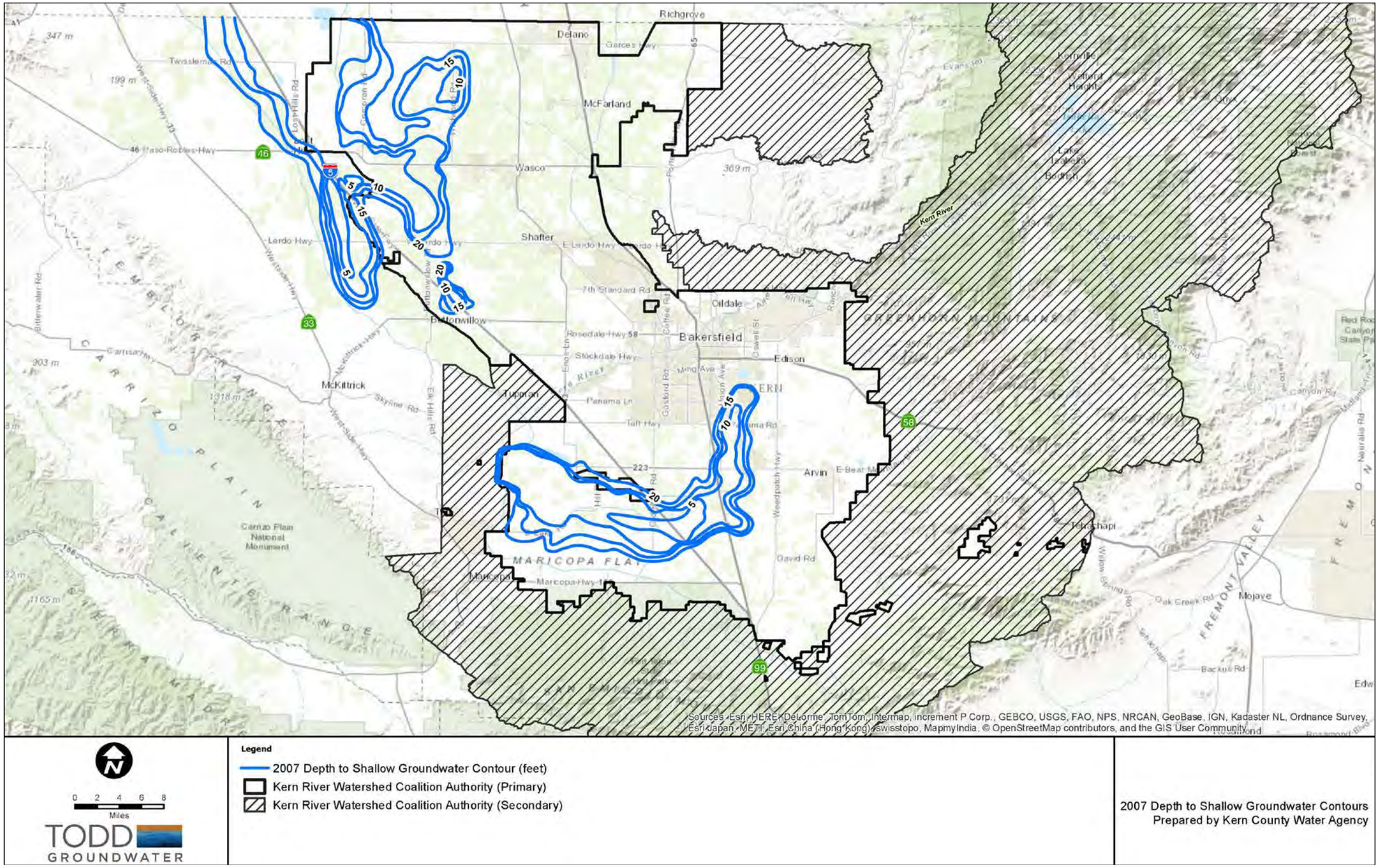


Figure 10. 2007 Depth to Shallow Groundwater Contours

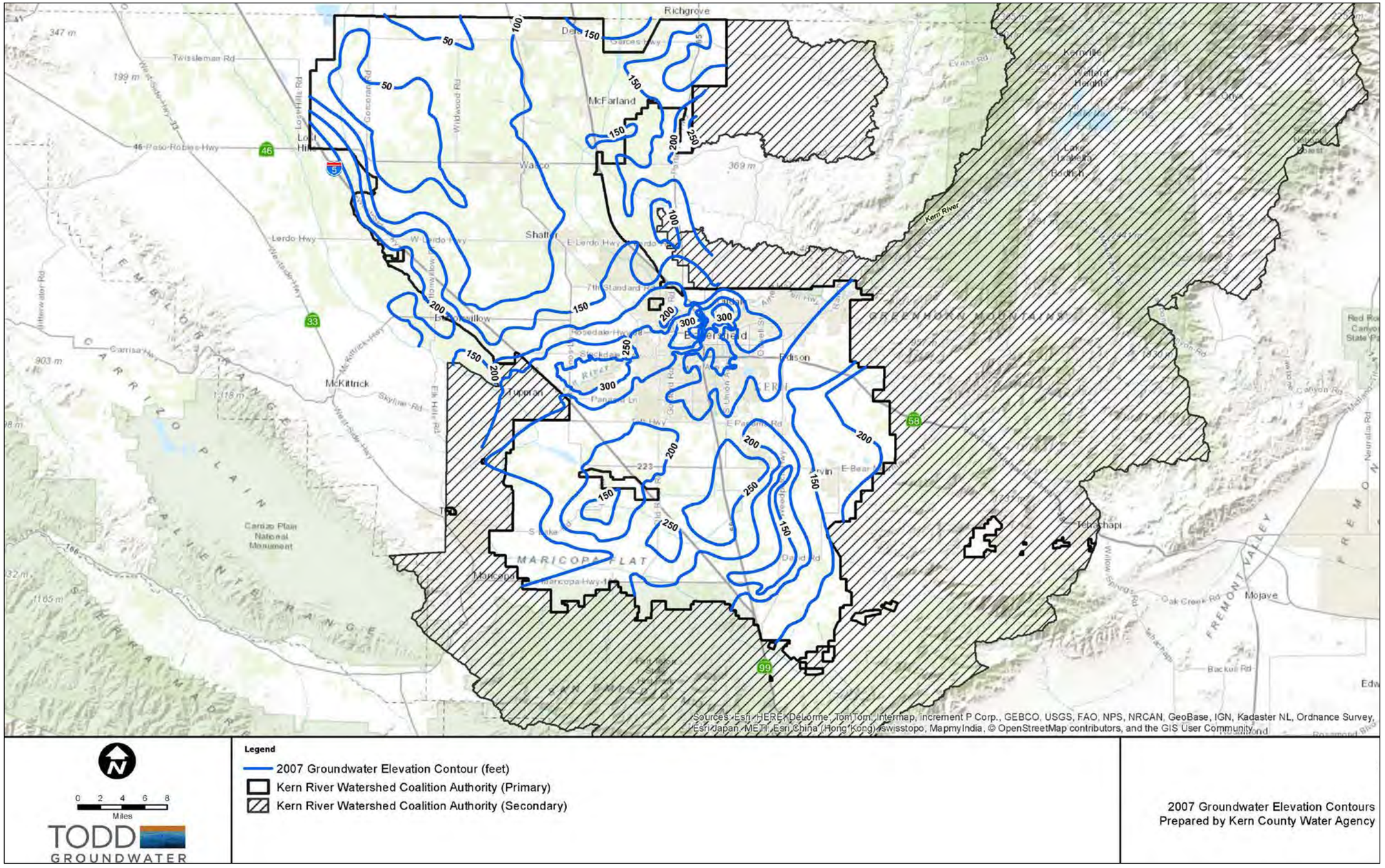


Figure 11. 2007 Groundwater Elevation Contours

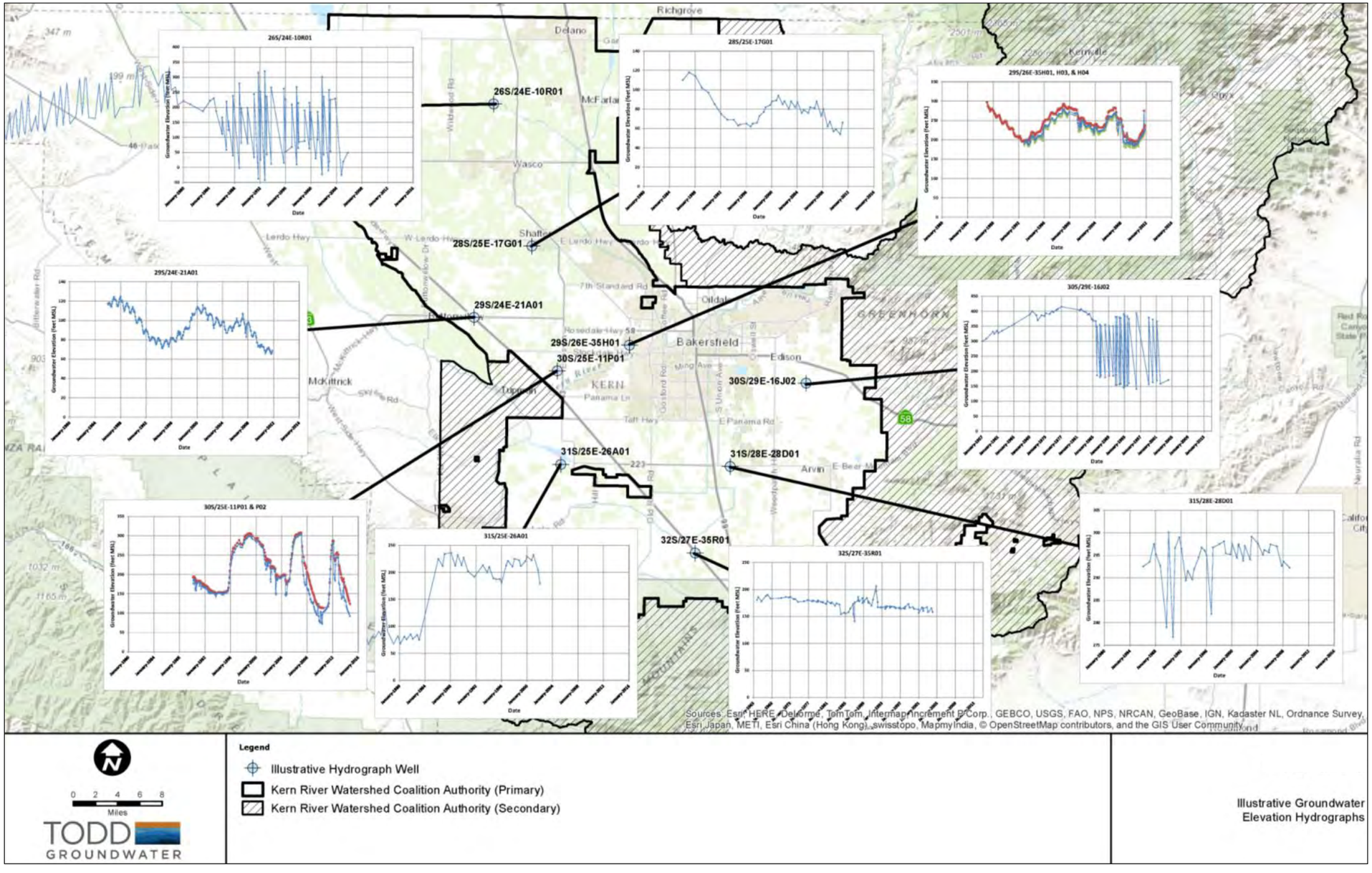


Figure 12. Illustrative Groundwater Elevation Hydrographs

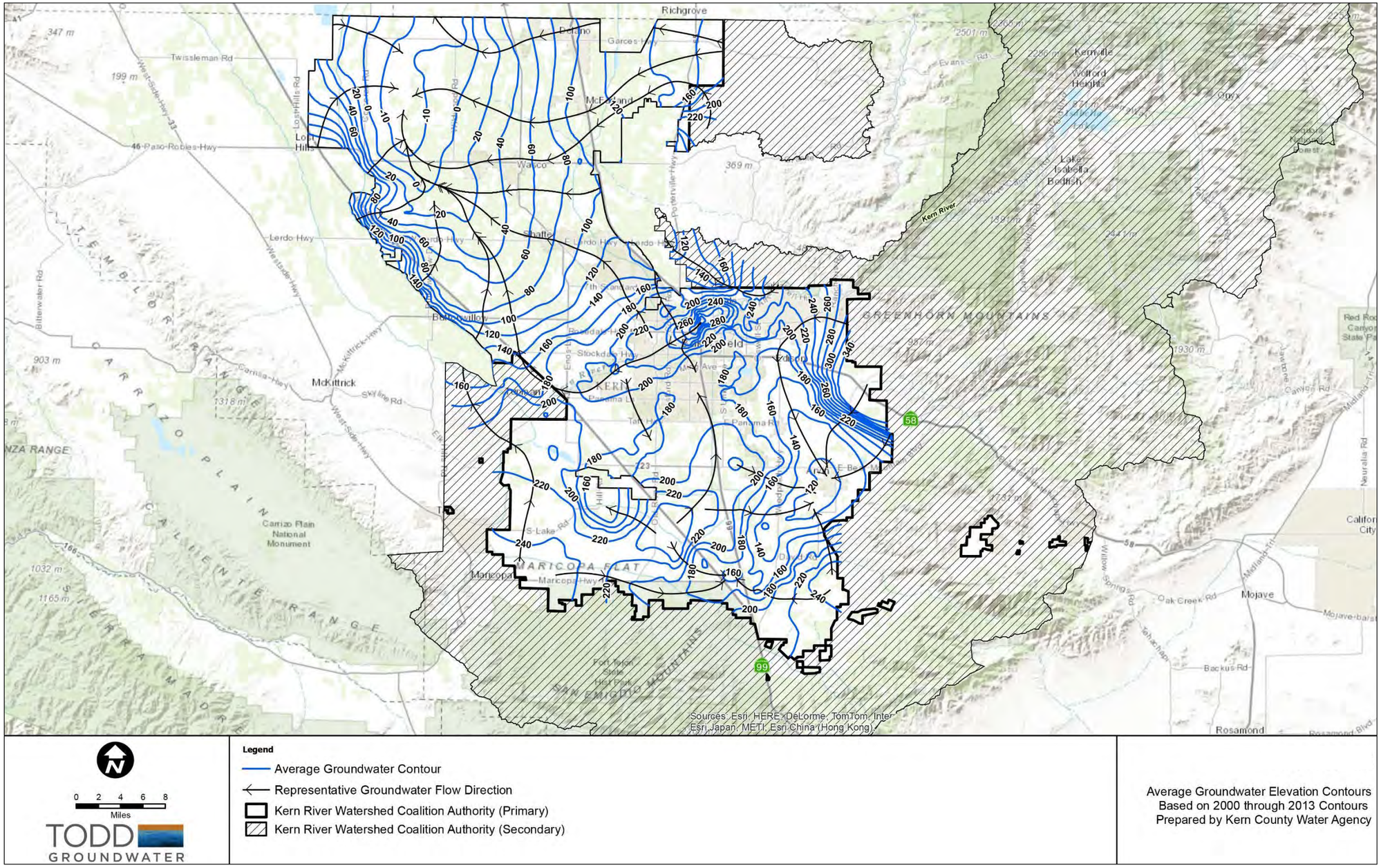


Figure 13. Average Groundwater Elevation Contours and Groundwater Flow Direction based on 2000 through 2013

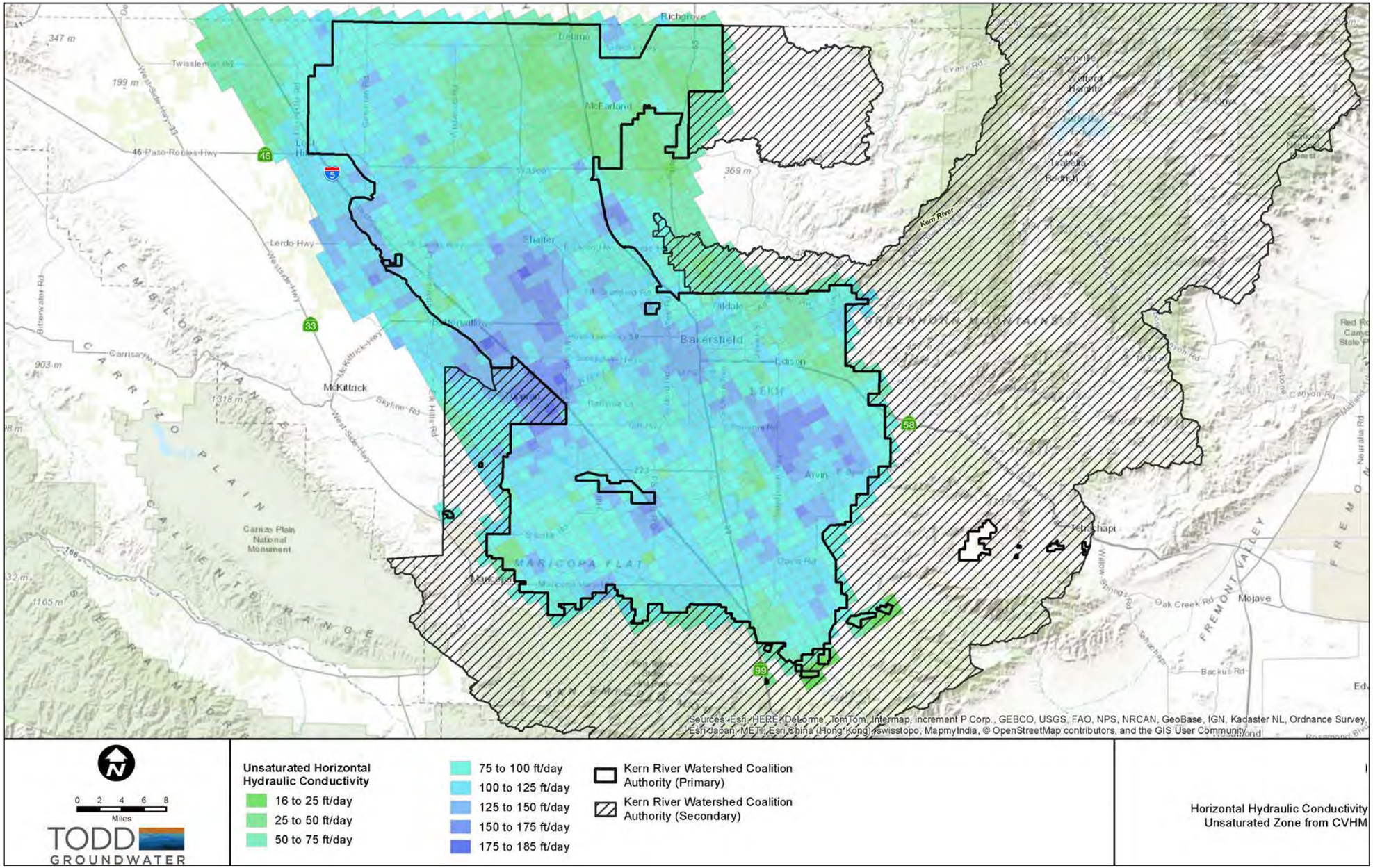


Figure 14. Horizontal Hydraulic Conductivity

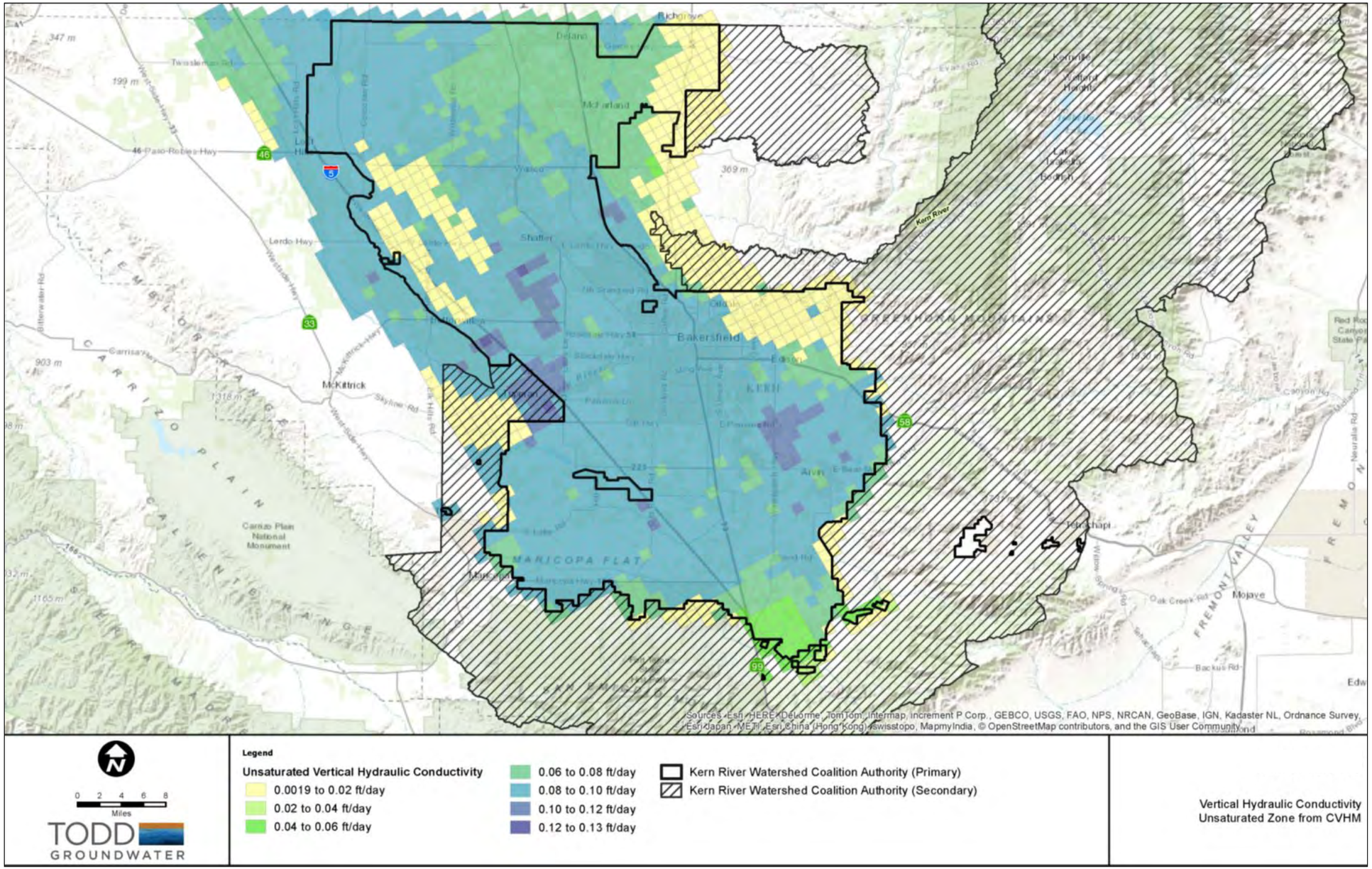


Figure 15. Vertical Hydraulic Conductivity

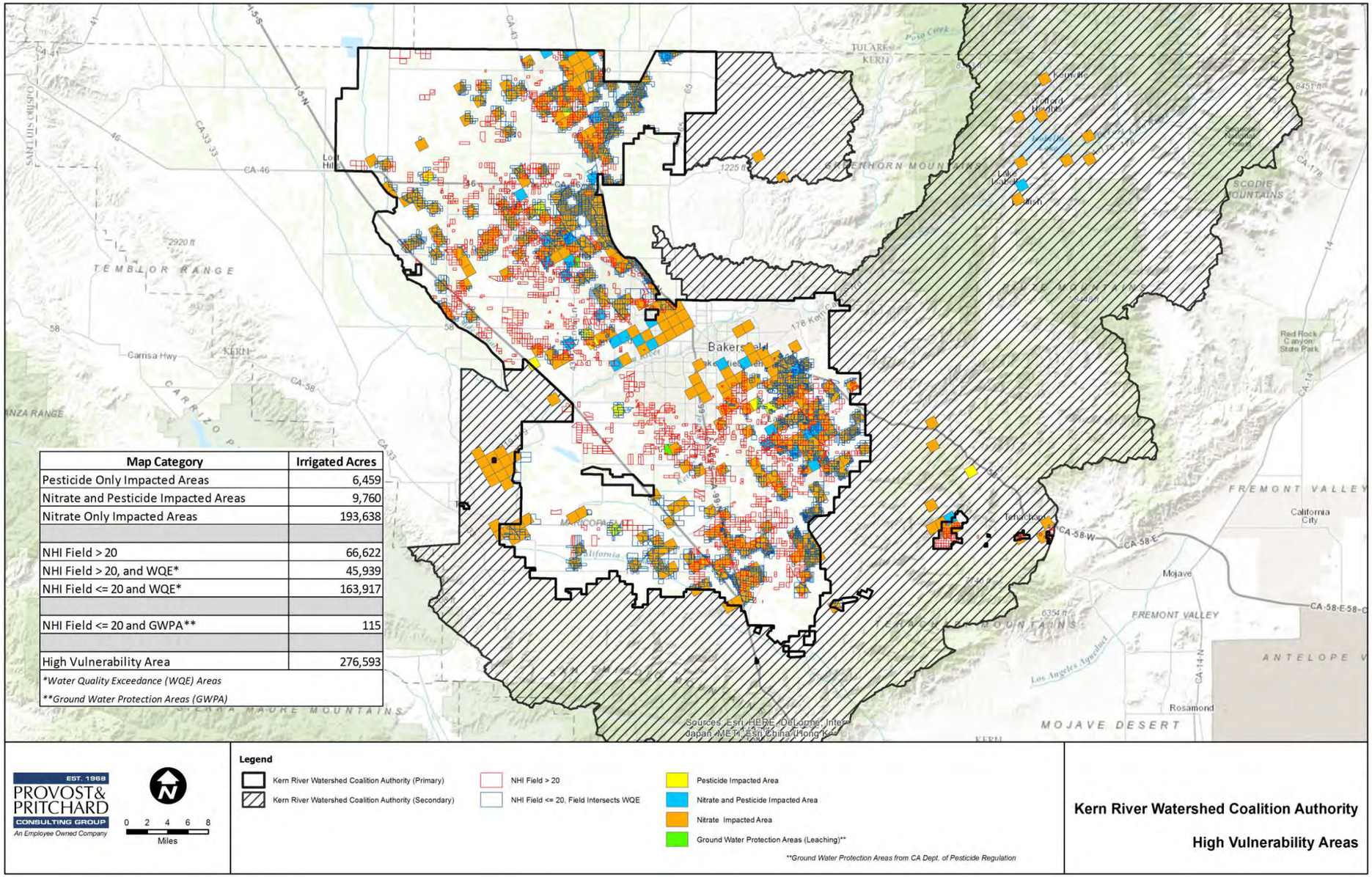


Figure 16. KRWCA GAR Identified HVA

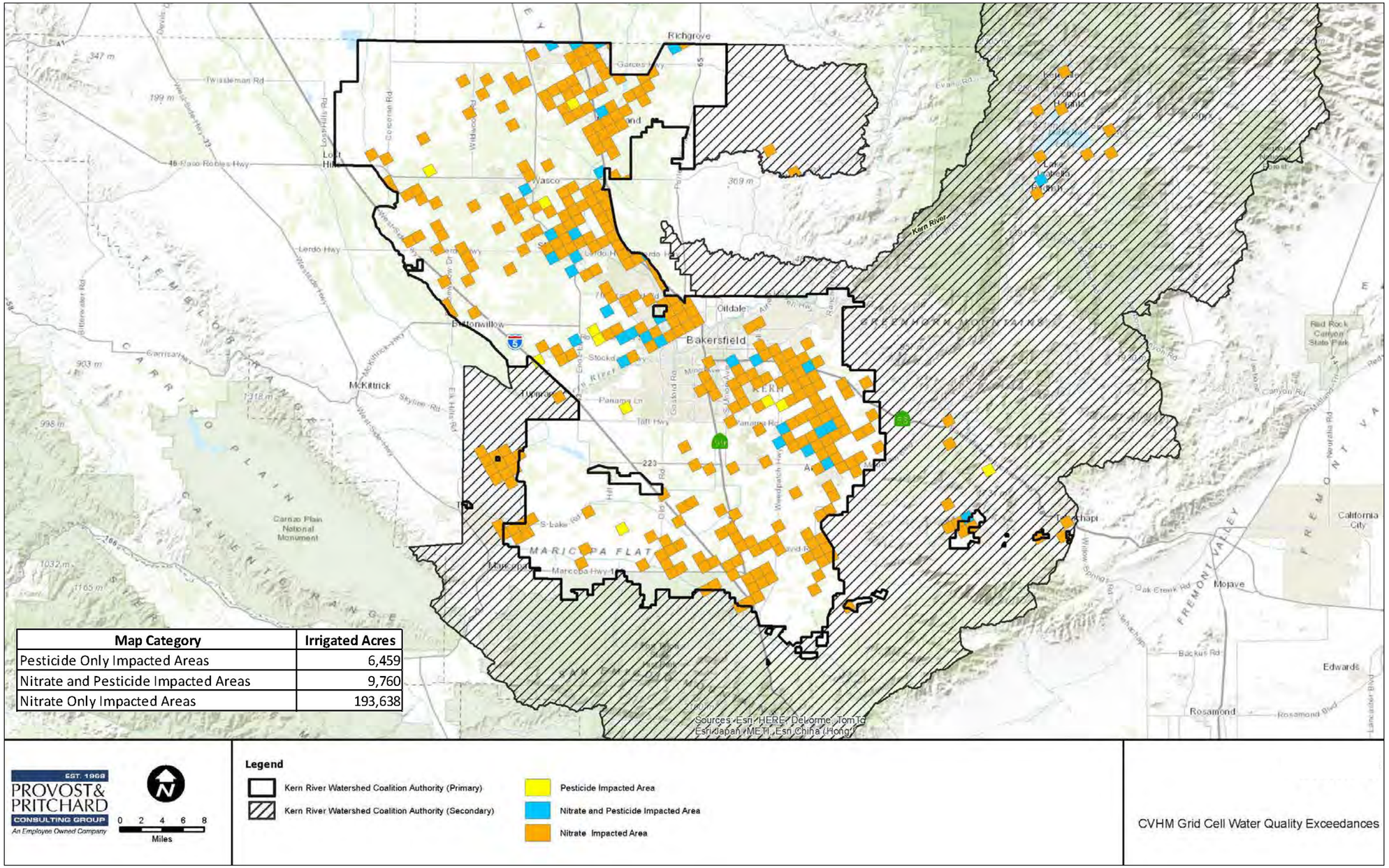


Figure 17. CVHM Grid Cell Water Quality Exceedances Map

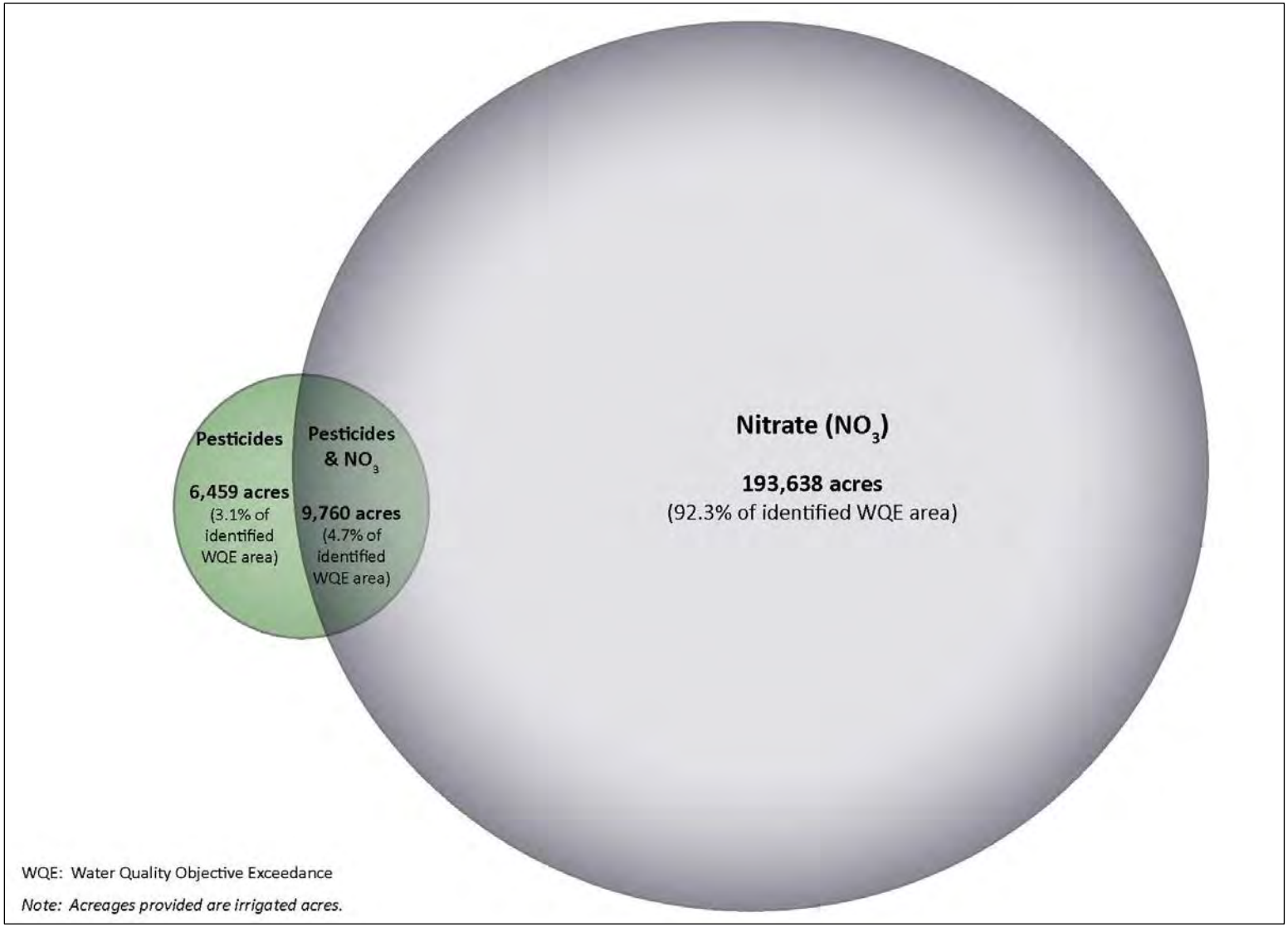


Figure 18. Nitrate vs. Pesticide analysis of Water Quality Exceedances

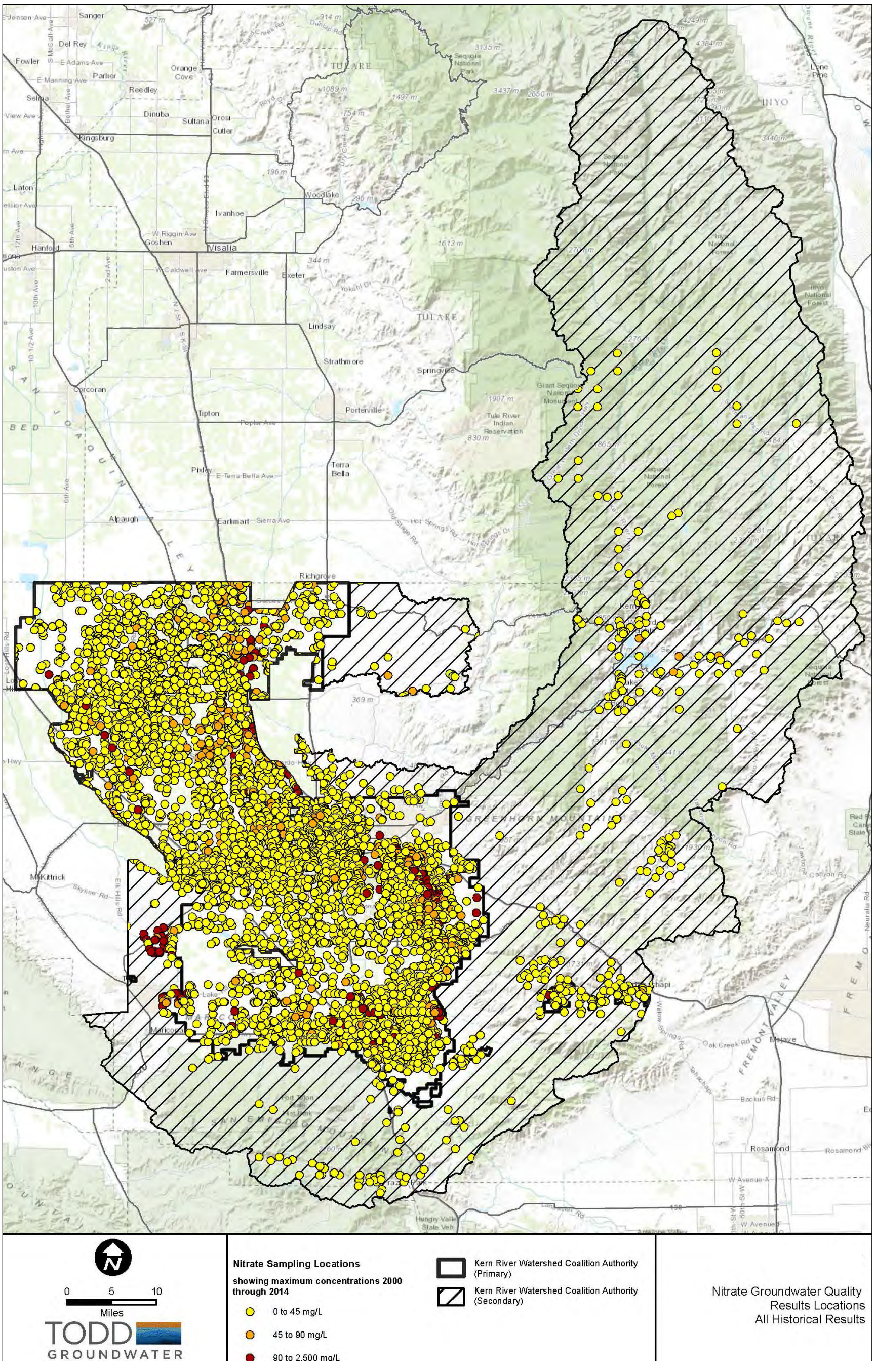


Figure 19. Nitrate Groundwater Quality Results, All Historical

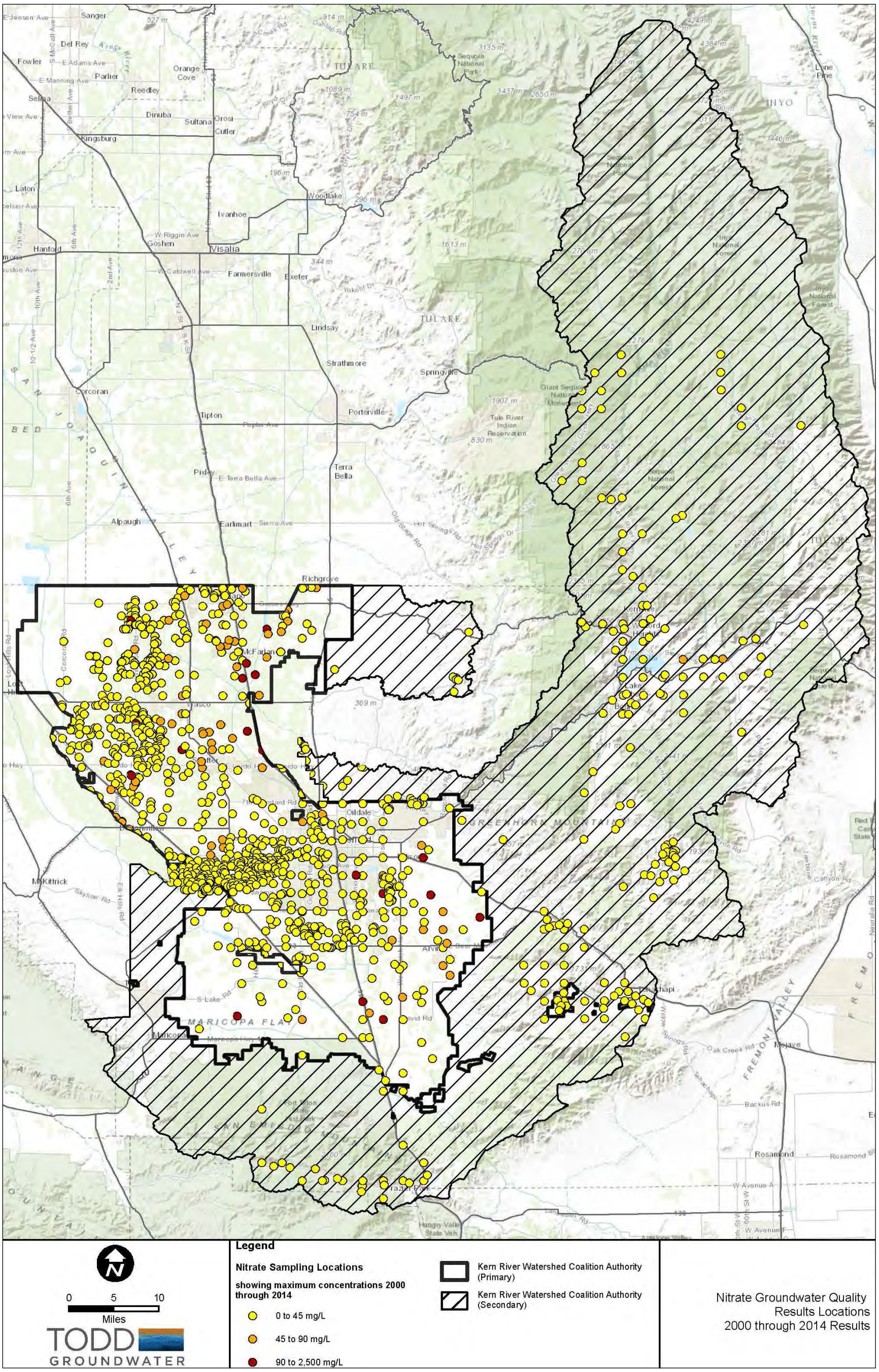


Figure 20. Nitrate Groundwater Quality Results, 2000-2014

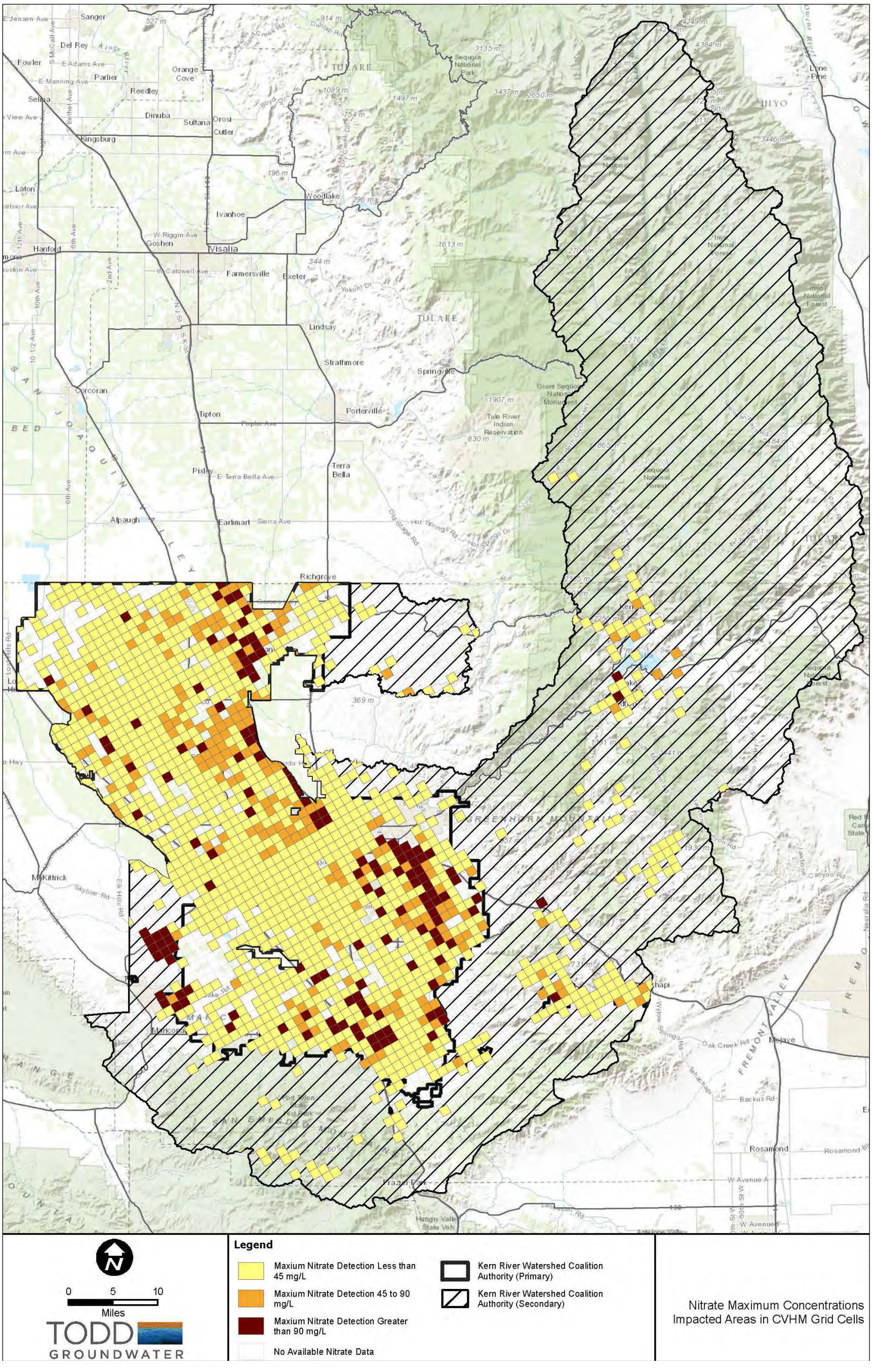


Figure 21. Nitrate Maximum Concentrations Impacted Areas

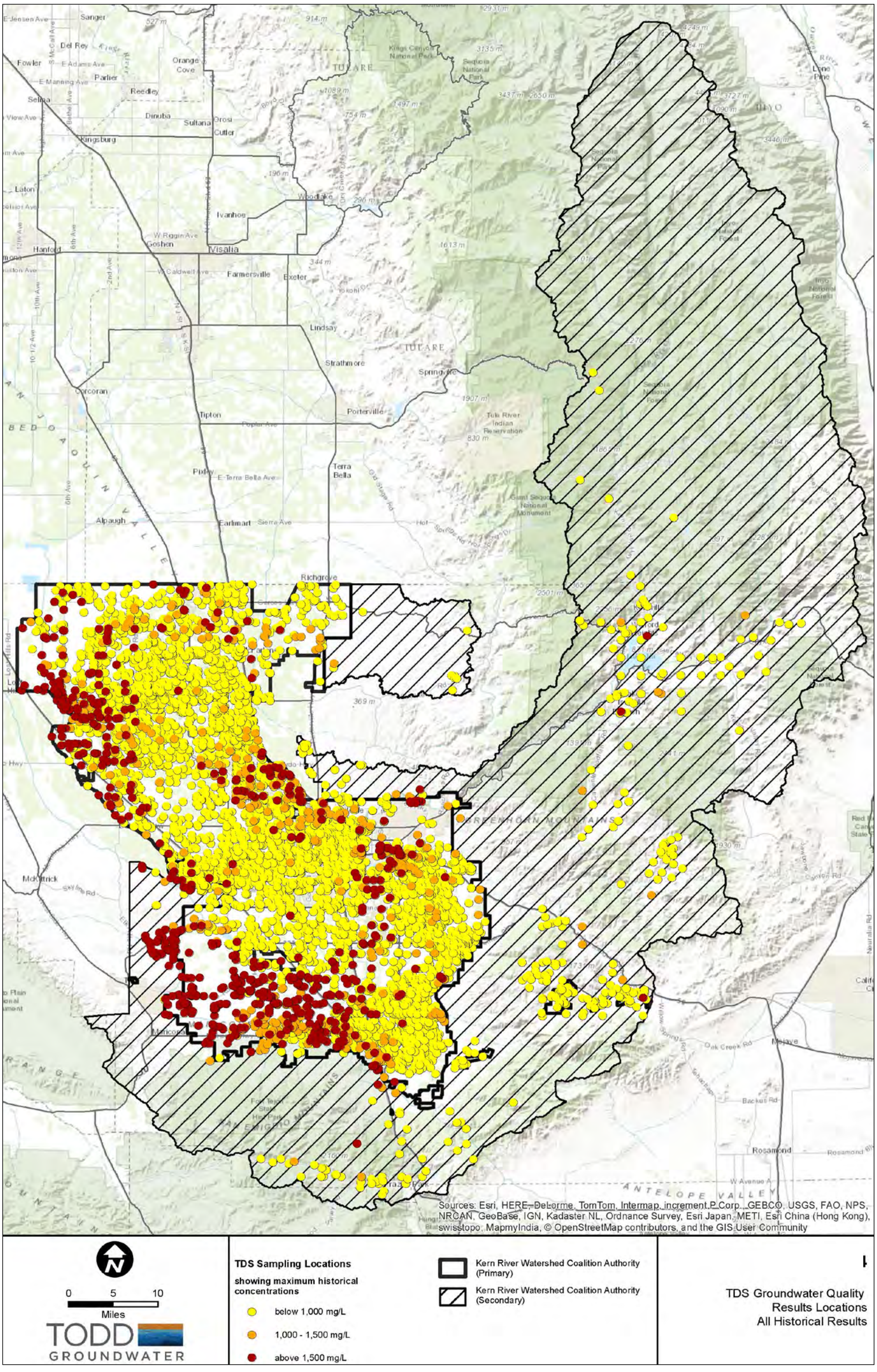


Figure 22. TDS Groundwater Quality Results, All Historical

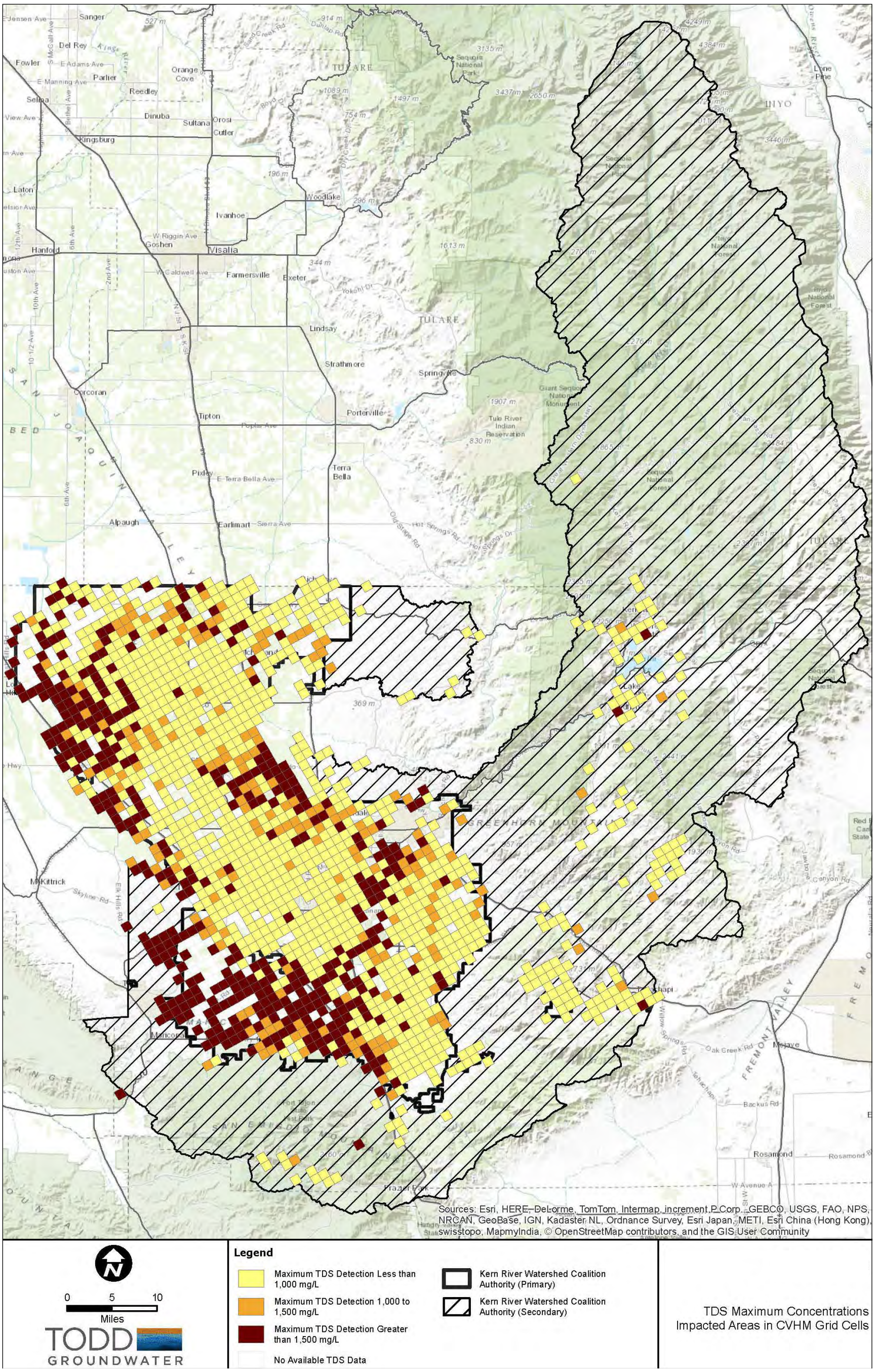


Figure 23. TDS Maximum Concentrations Impacted Areas

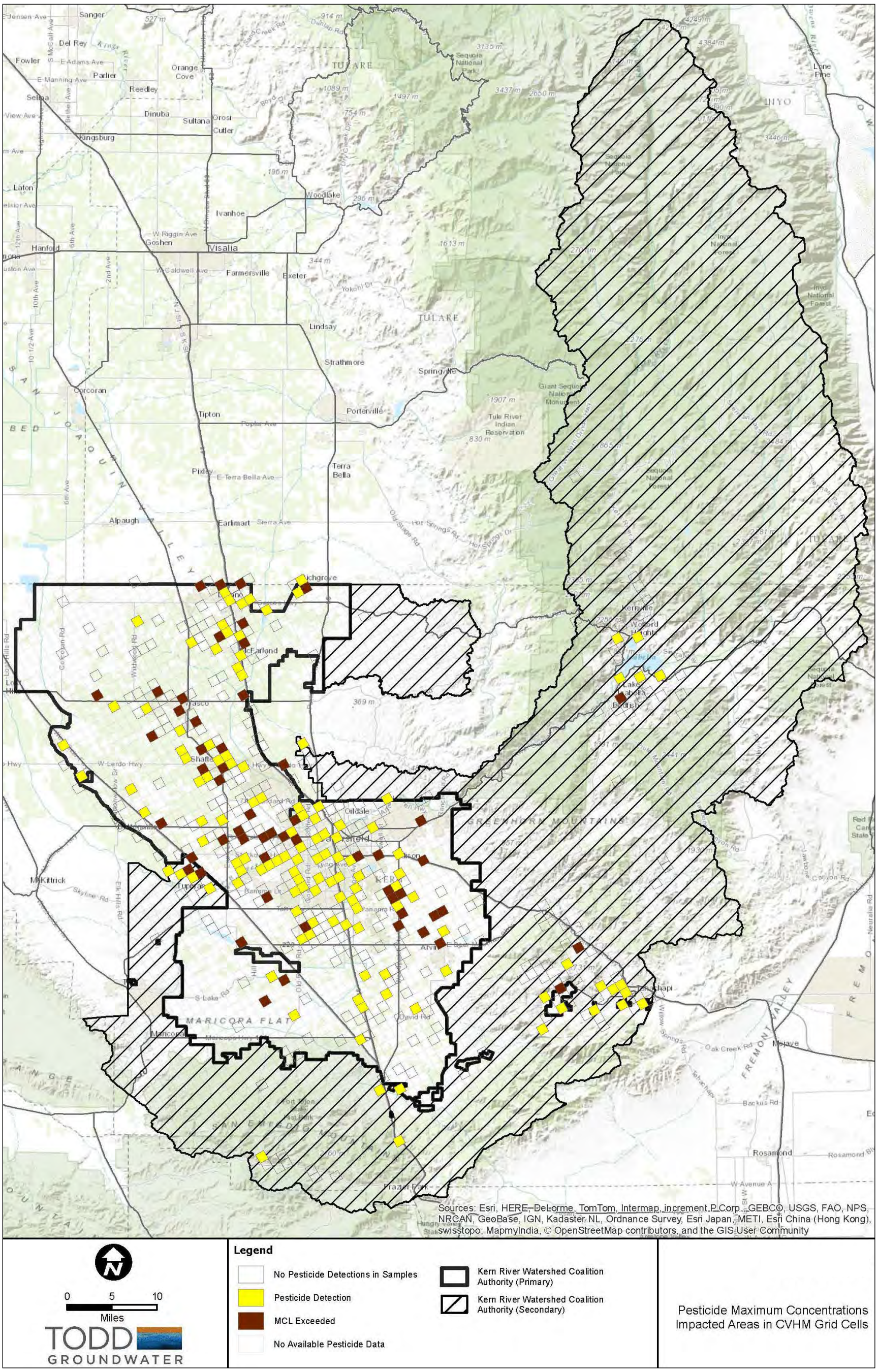


Figure 24. Pesticide Maximum Concentrations Impacted Area

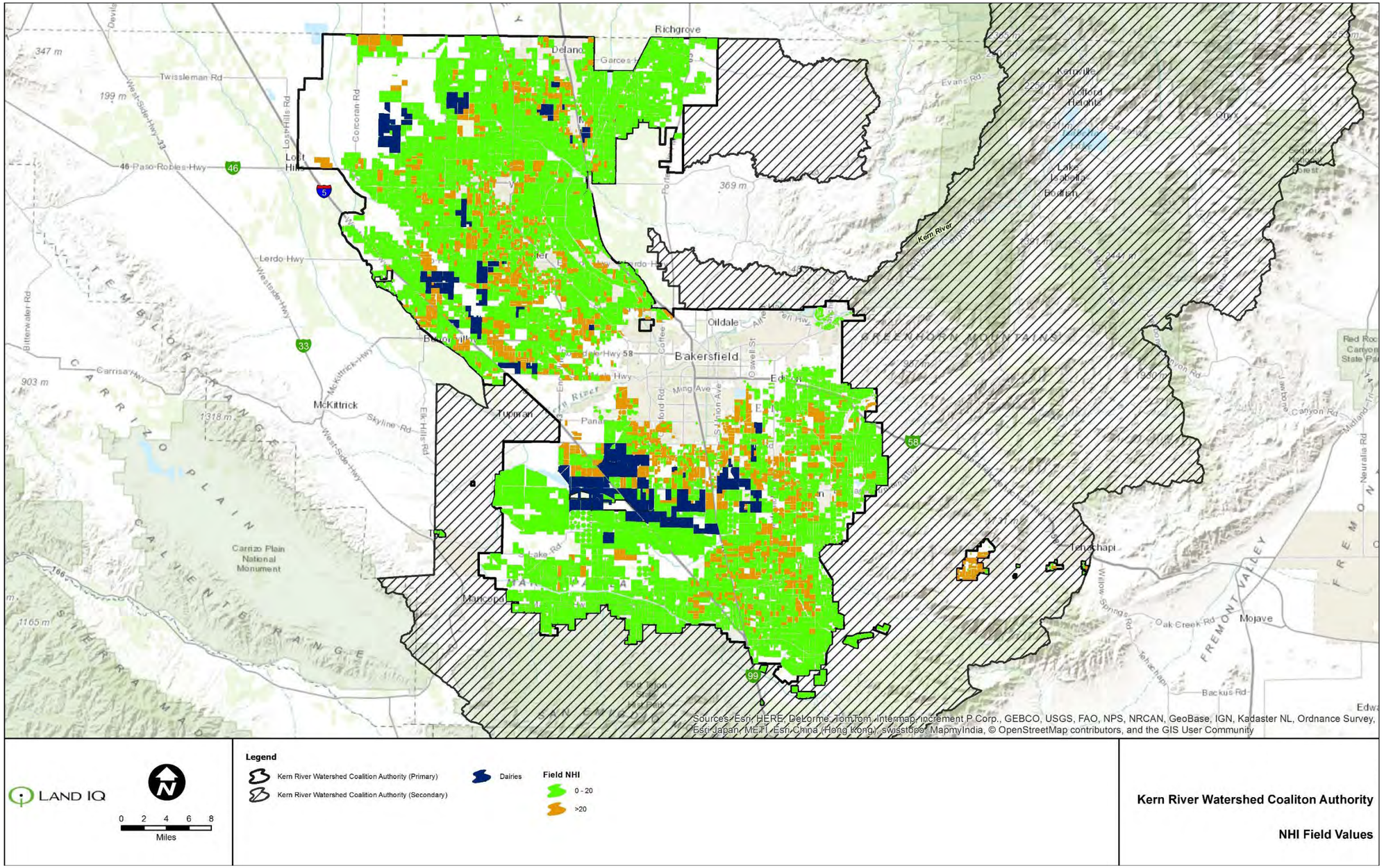


Figure 25. NHI Categorization Field Values

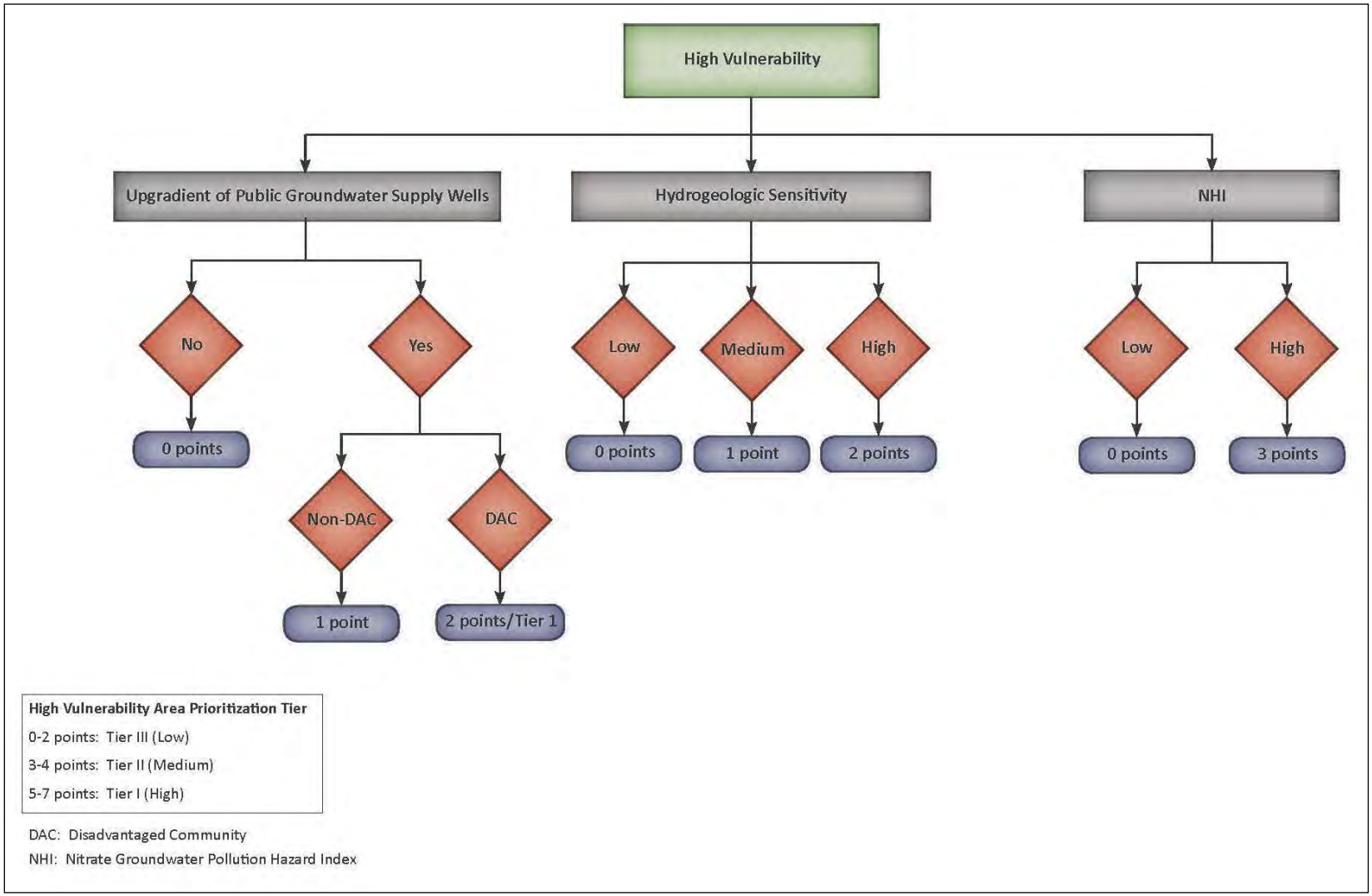


Figure 26. HVA Prioritization Flowchart

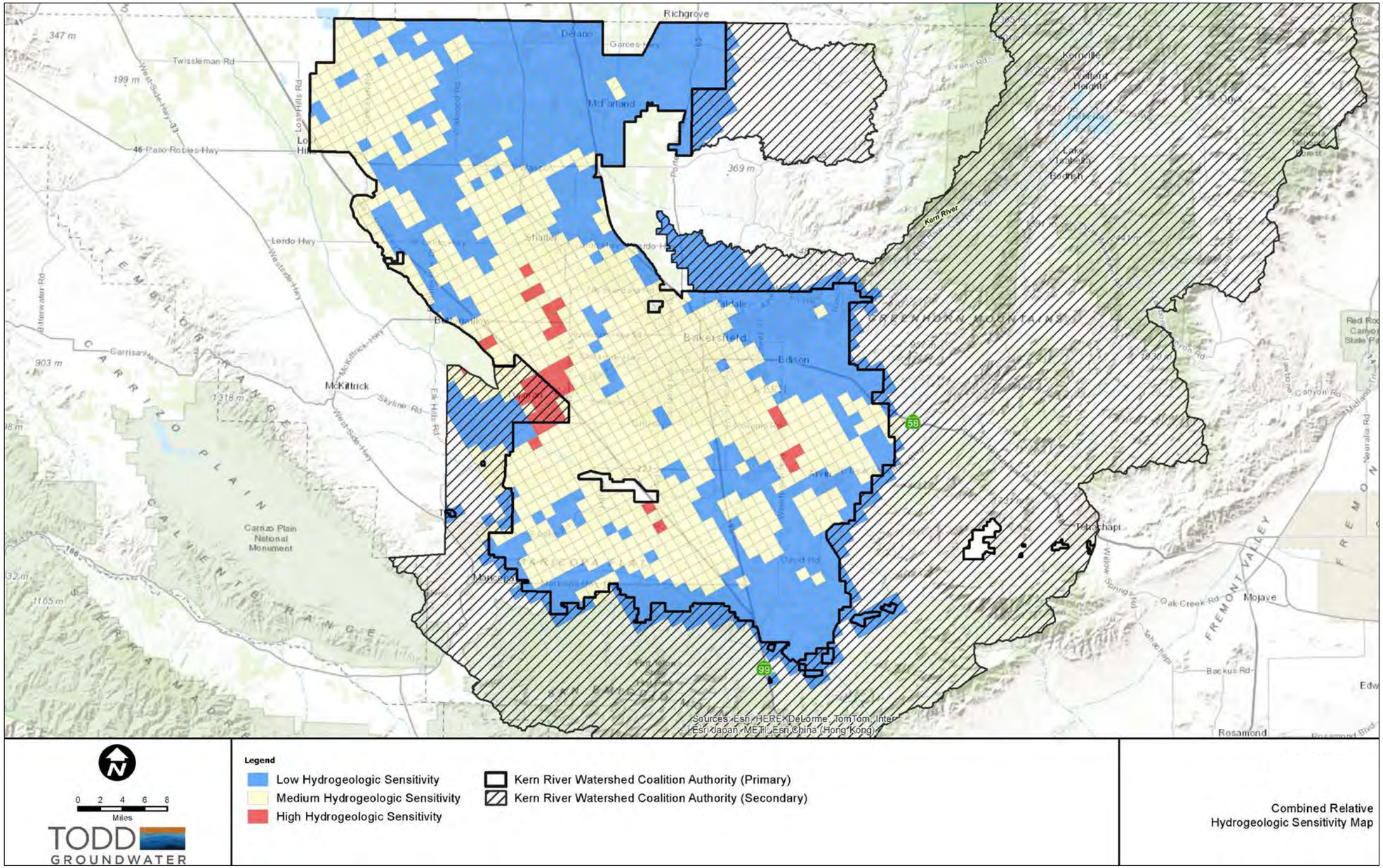


Figure 27. Combined Relative Hydrogeologic Sensitivity Map

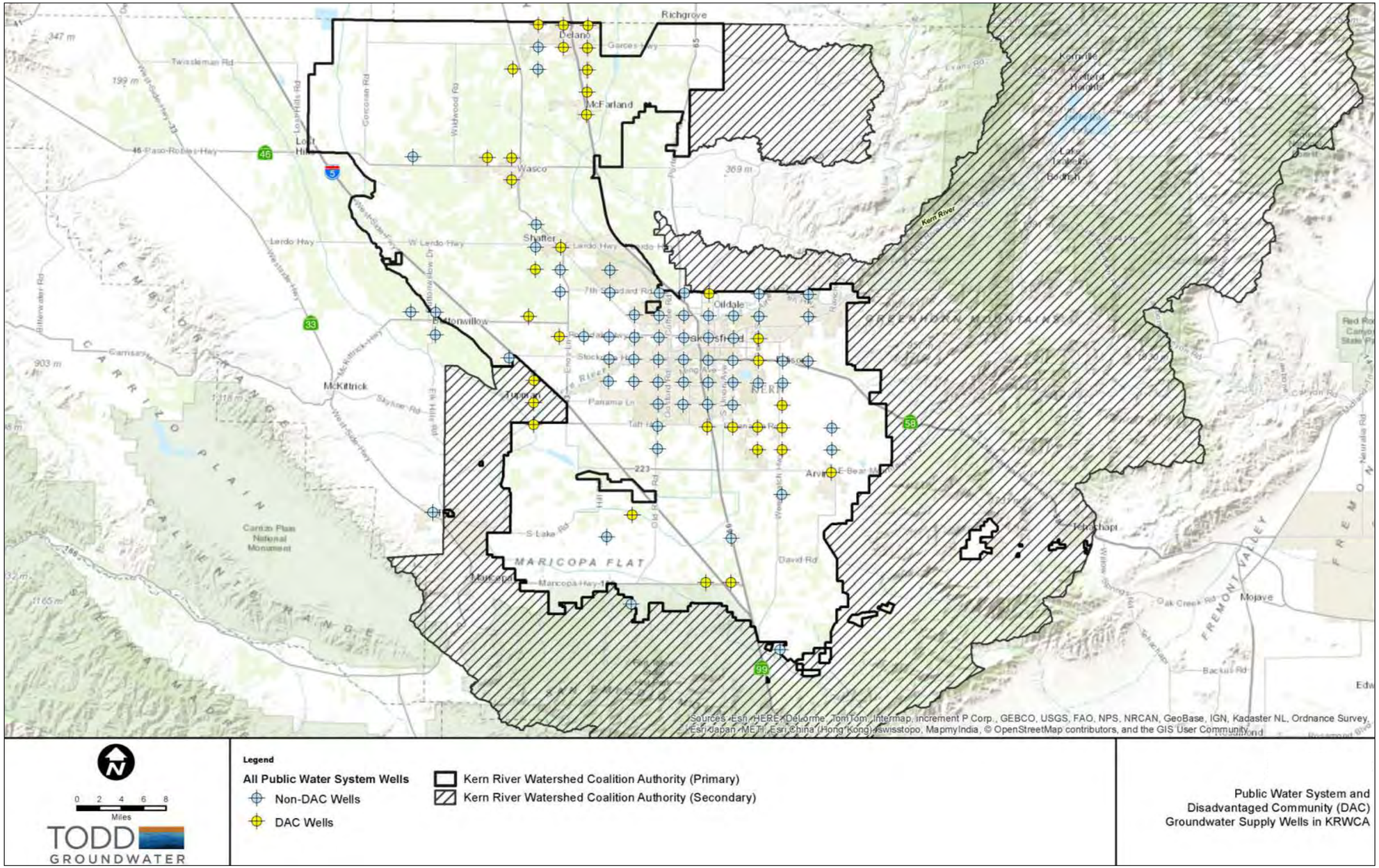


Figure 28. Public Water System and Disadvantaged Community (DAC) Groundwater Supply Wells in KRWCA

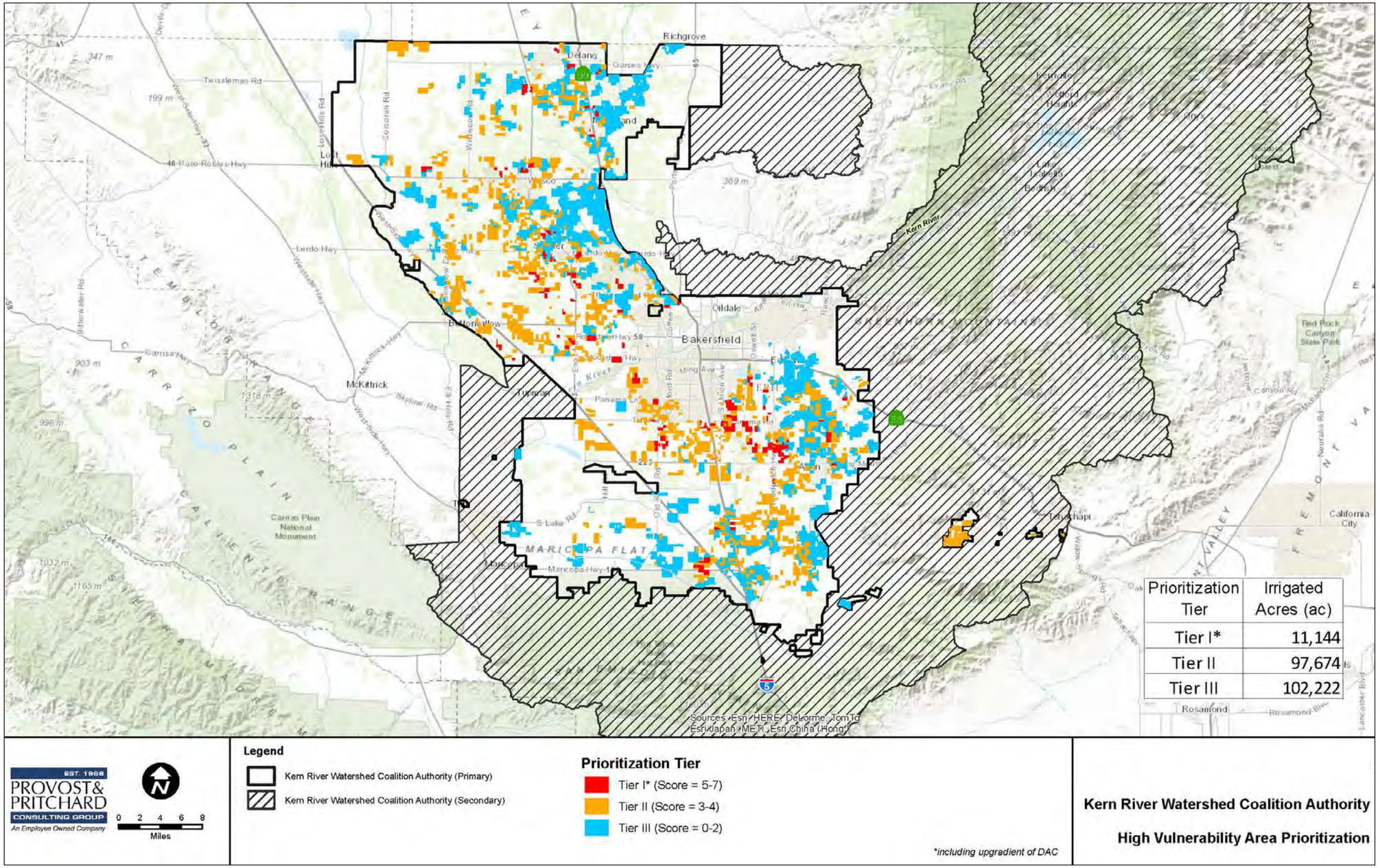


Figure 29. HVA Prioritization Map (Tier 1, 2 ,3)

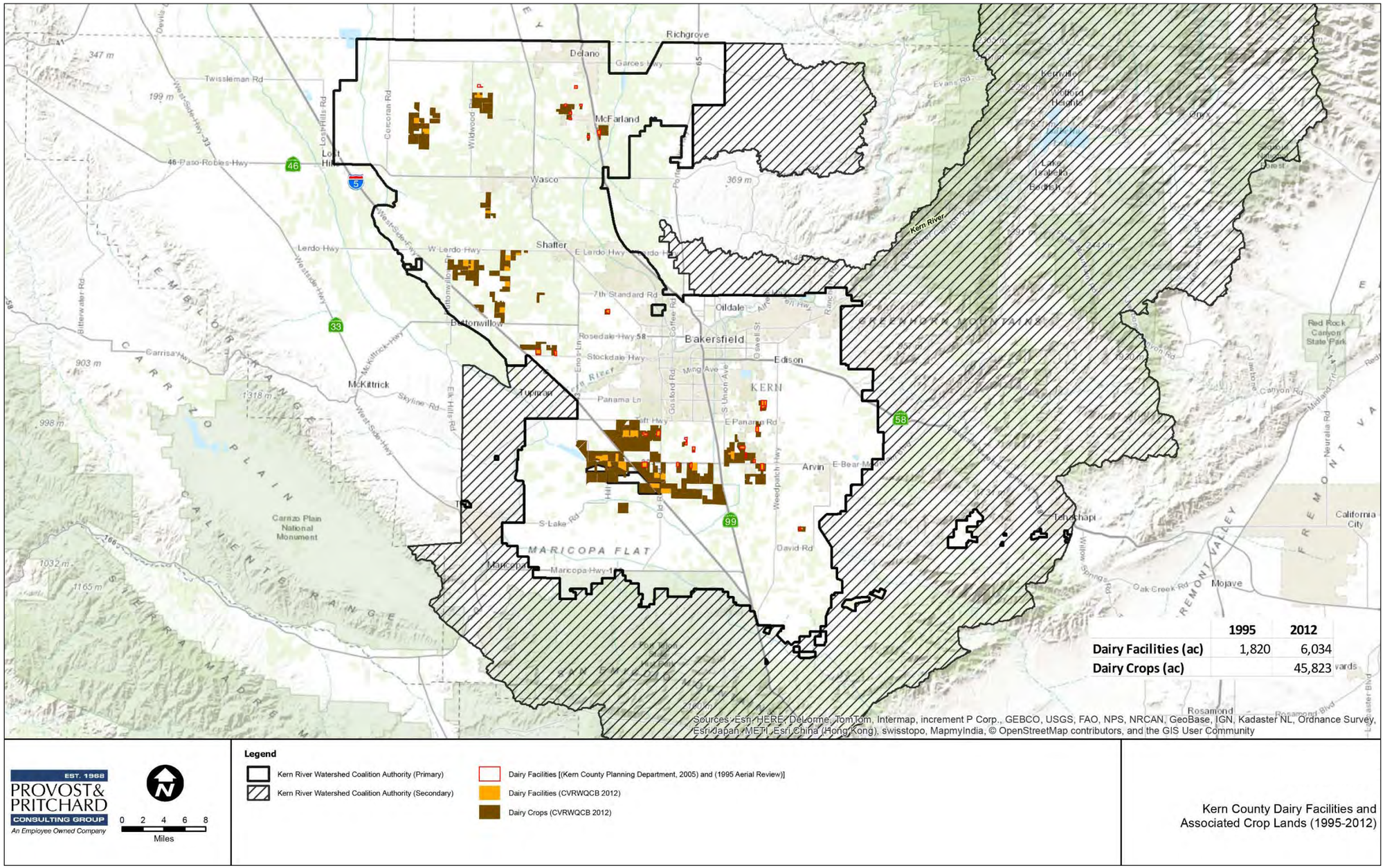
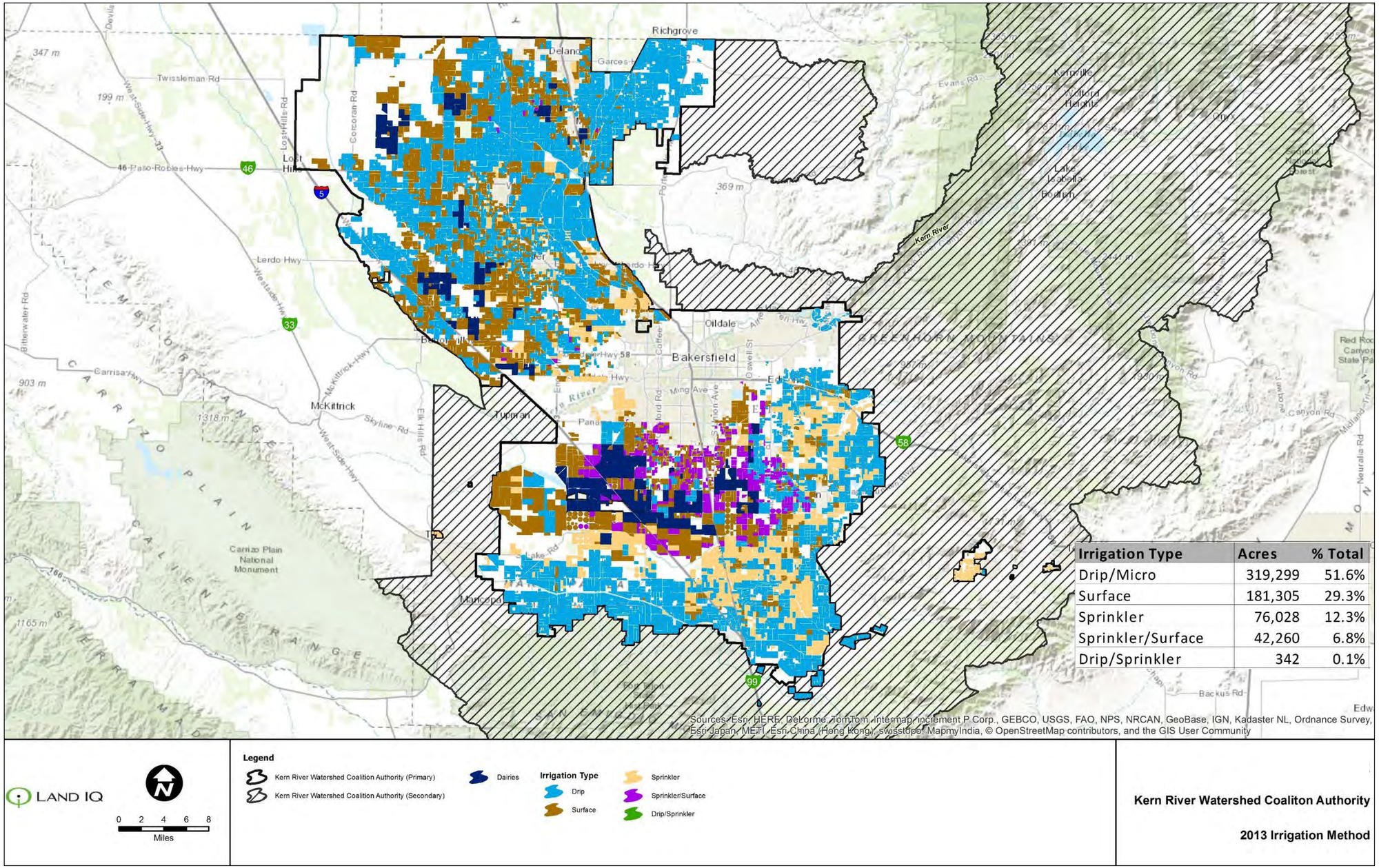
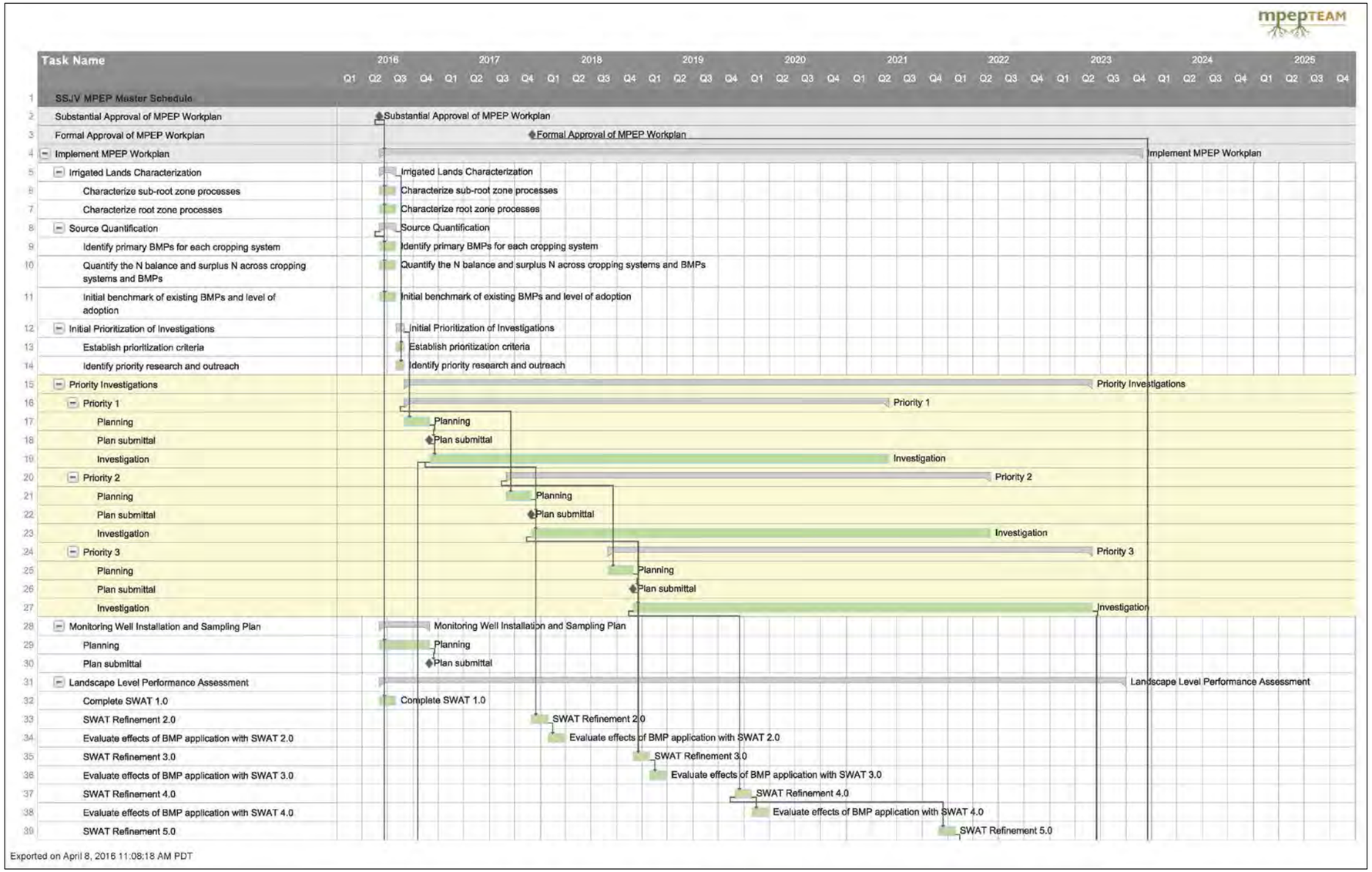


Figure 30. Kern County Dairy Facilities and Crop Lands (1995-2012)



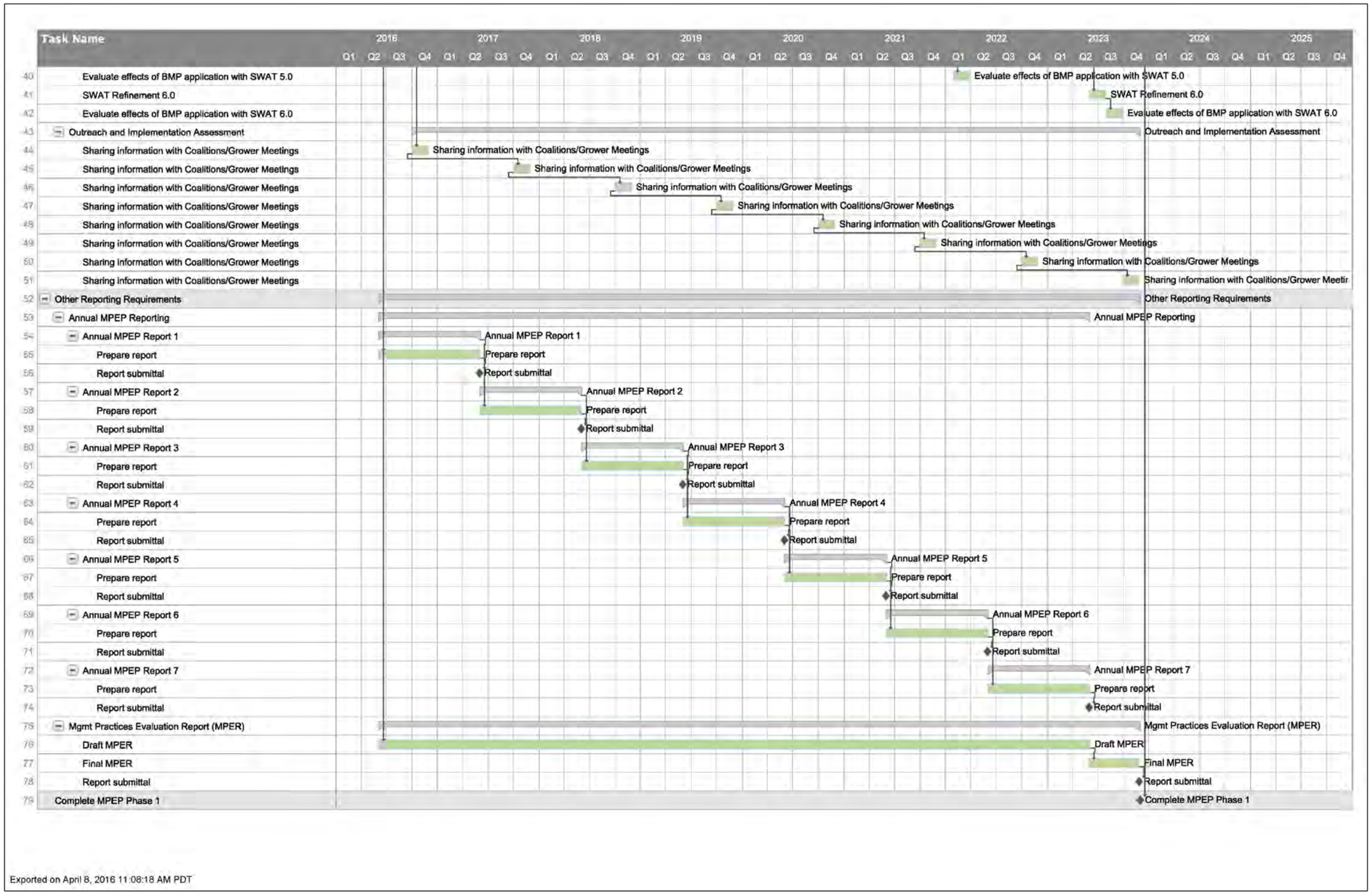
Irrigation Type	Acres	% Total
Drip/Micro	319,299	51.6%
Surface	181,305	29.3%
Sprinkler	76,028	12.3%
Sprinkler/Surface	42,260	6.8%
Drip/Sprinkler	342	0.1%

Figure 31. 2013 Irrigation Method



Source: MPEP Team for the SSJV MPEP Committee. September 2017. figure 3-1 Management Practices Evaluation Workplan, Southern San Joaquin Valley MPEP Committee

Figure 32. MPEP Master Schedule (Page 1)



Source: MPEP Team for the SSJV MPEP Committee. May 2016. Discussion Draft Management Practices Evaluation Workplan, Southern San Joaquin Valley MPEP Committee

Figure 33. MPEP Master Schedule (Page 2)

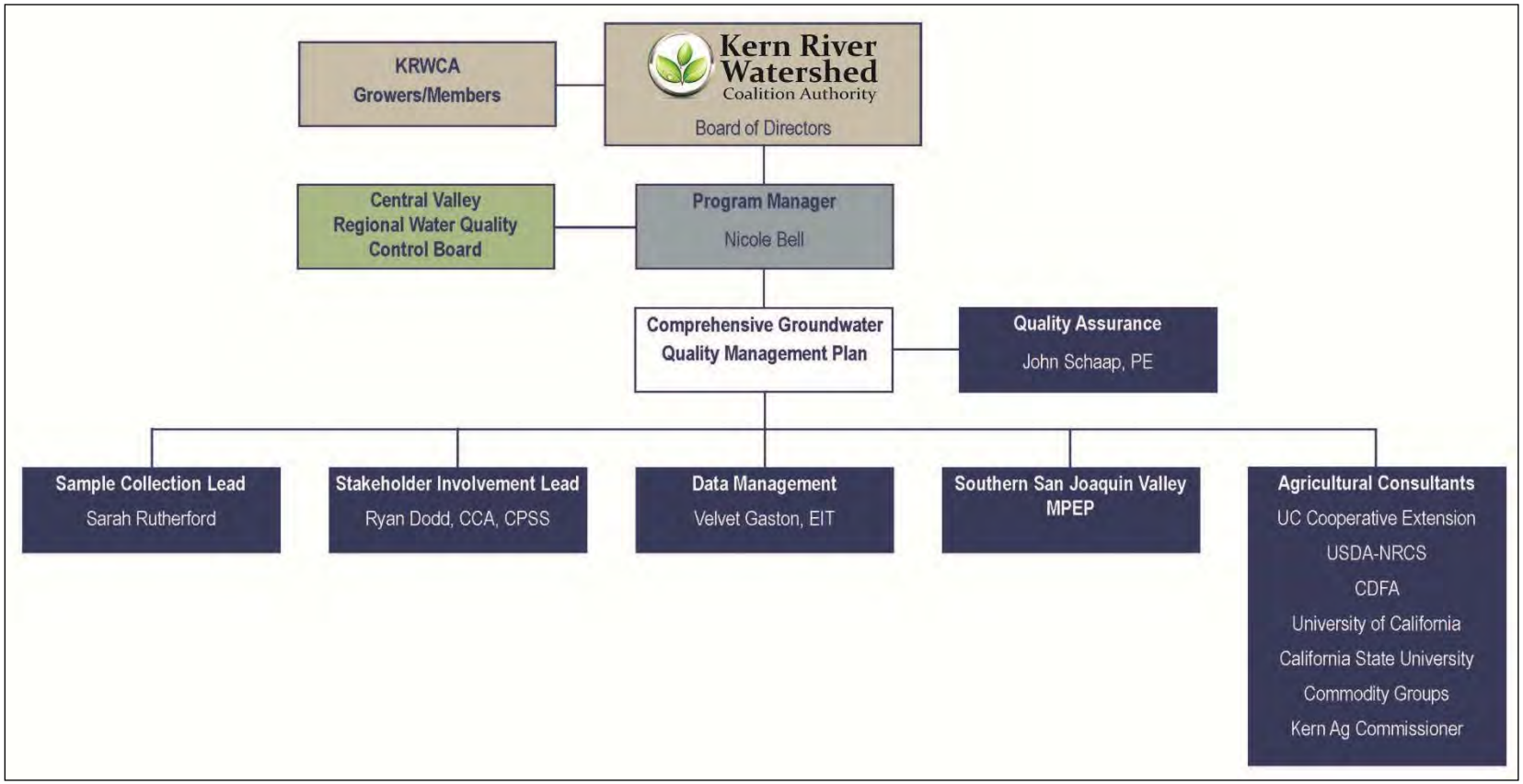


Figure 34. CGQMP Organizational Chart

Appendix A

Edison-Maricopa Area Geologic Cross Sections

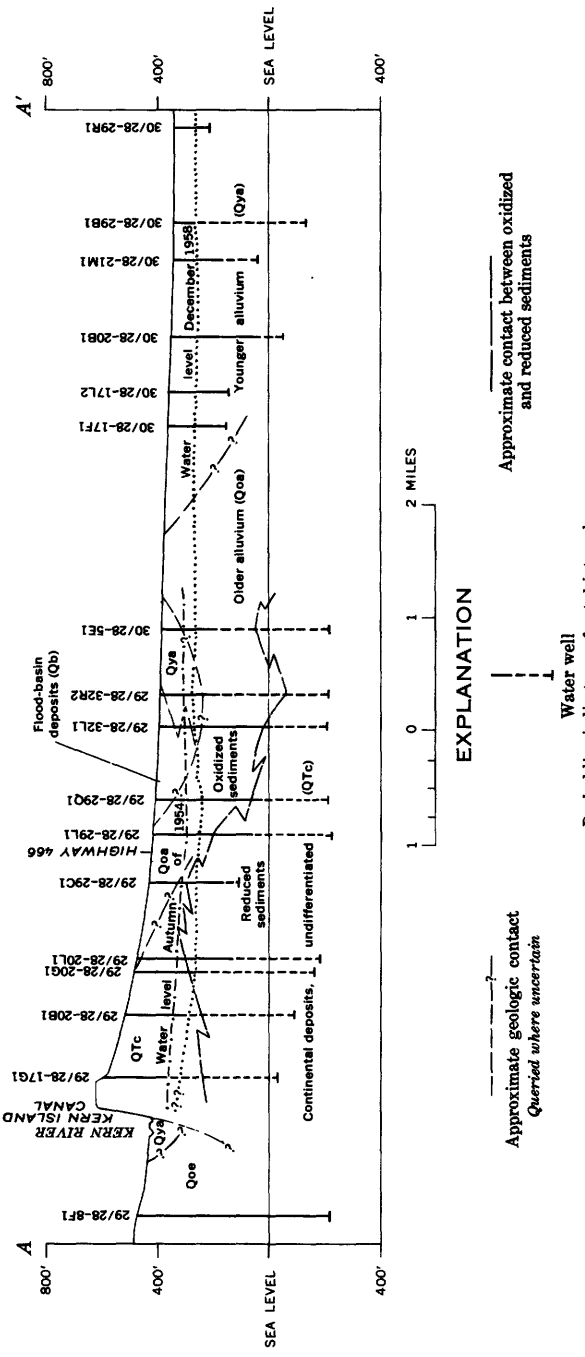


FIGURE 5.—Section along line A–A' showing general geology and water-level profiles for 1954 and 1958. See plate 3 for alinement of section, location of wells, and explanation of geologic symbols.

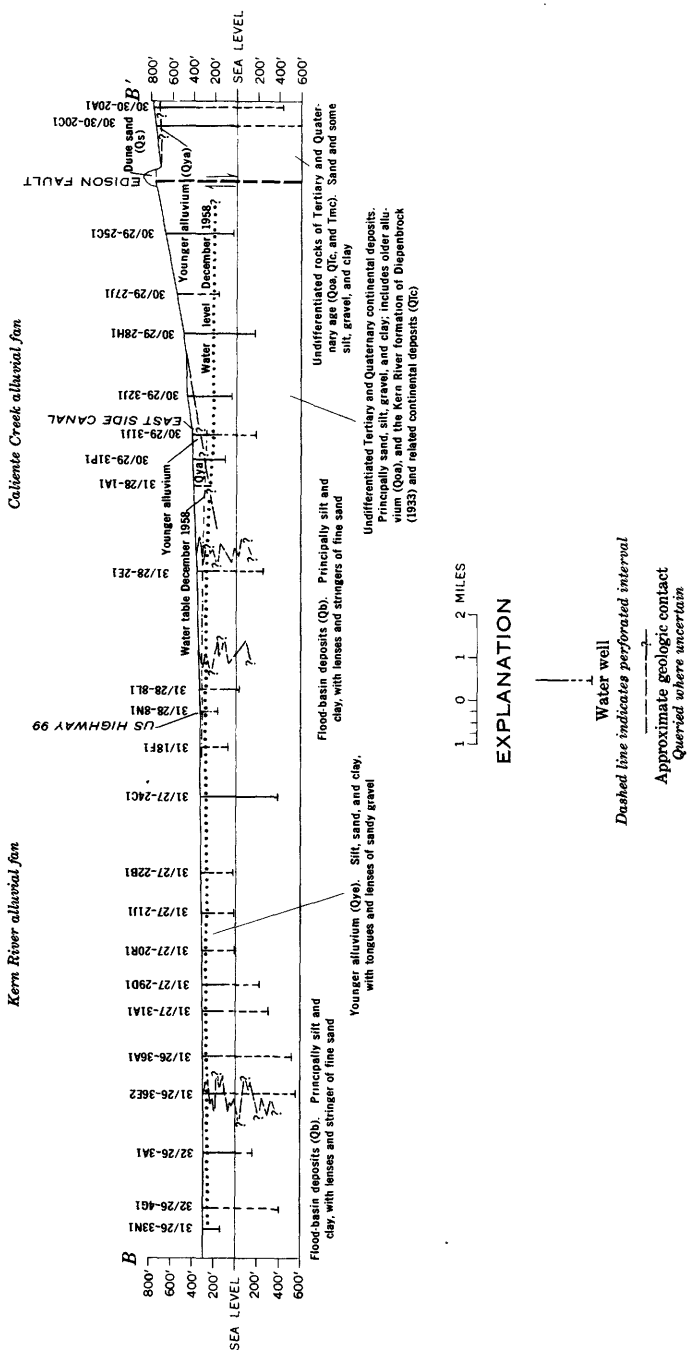
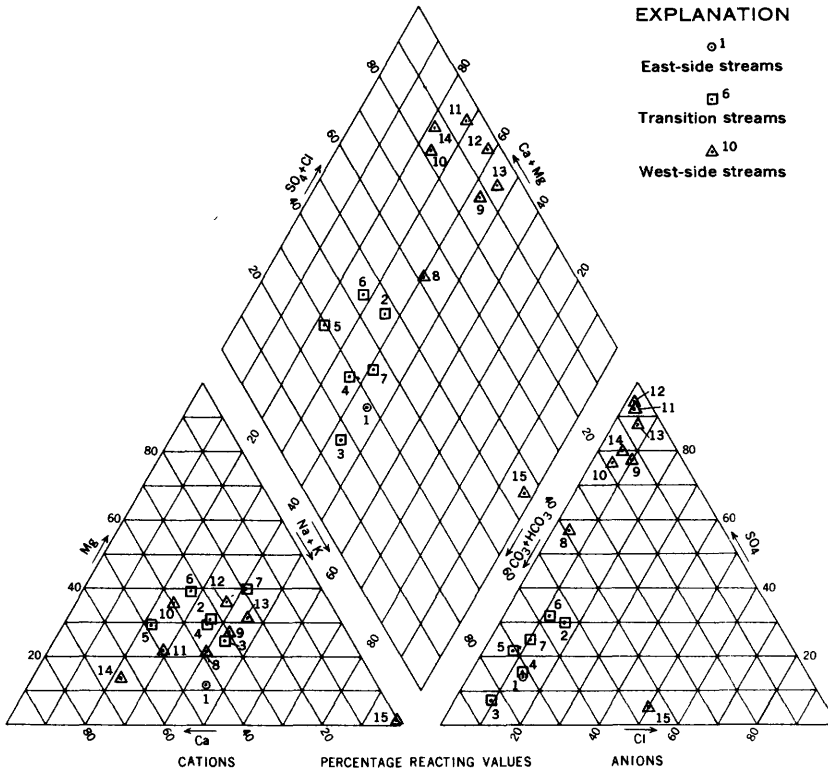


FIGURE 6.—Section along line *B–B'* showing general geology and water-level profiles for December 1958.

Appendix B

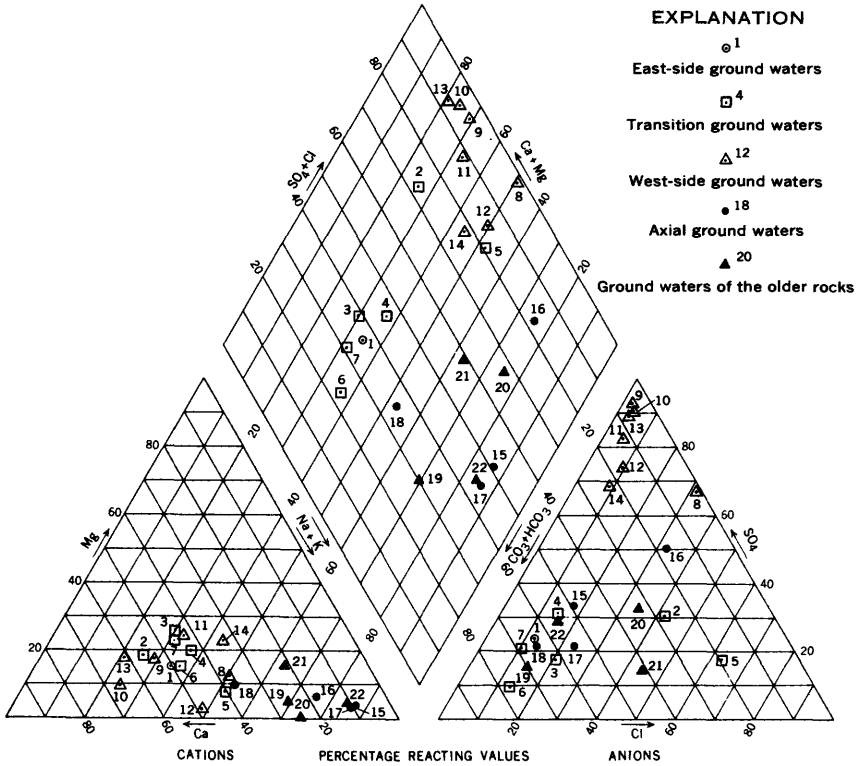
Surface Water and Groundwater Piper Diagrams



Type	Stream	Sampling point	Date	Sum (ppm)
	East-side stream			
1	Kern River	29/28-2M	Oct. 1950 to Sept. 1956	[1] 95
	Transition streams			
2	Caliente Creek	30/30-13K	3 -18-57	631
3	Unnamed Creek	31/30-23A	3 -17-57	359
4	Caparell Creek	11N/18W-9R	10-22-56	674
5	Tunis Creek	11N/18W-20R	6 - -46	297
6	Pastoria Creek	11N/19W-36	6 - -46	386
	West-side streams			
7	Grapevine Creek	10N/19W-32A	10- 6-56	576
8	Tecuya Creek	11N/19W-31M	10- 6-56	2,440
9	Pleito Creek	11N/21W-27C	3 -11-57	2,370
10	San Emigdio Creek	11N/22W-36	2 -19-47	1,400
11	Santiago Creek	11N/23W-12B	3 -16-57	3,280
12	Bitter Creek	11N/23W-9A	3 -16-57	5,480
13	Bitterwater Creek	11N/24W-29	9 -1915	8,790
14	Bitterwater Creek	11N/24W-2A	10- 5-56	2,960
15	Sandy Creek	32/23-14A	9 -15-54	7,630

[1] Average of 40 samples.

FIGURE 19.—Chemical character of stream waters in the Edison-Maricopa area, California.



Type	Well	Date	Sum (ppm)	Depth or perforated interval (ft)
	East-side ground waters			
1	31/27-9H1	8-12-58	269	106-346
	Transition ground waters			
2	30/28-12A1	5-20-52	748	202
3	30/29-28H1	7- 6-55	388	220-654
4	31/28-2D1	7-10-56	428	350-610
5	31/29-34A1	1-11-56	616	800
6	31-30-32C1	8-30-56	253	134-212 249-258
7	11N/19W-15Q1	7-12-56	324	1,000
	West-side ground waters			
8	31/24-26M1	9-28-55	5,120	390
9	32/25-20P1	6- 4-54	3,540	423-804
10	32/27-17N1	10-15-54	1,990	183-800
11	12N/22W-36R1	5- 3-56	1,080	1,266
12	11N/21W-11Q1	11-15-51	681	321-1,002
13	11N/21W-12G1	5- 2-56	1,550	352-1,201
14	11N/20W-10Q2	5- 2-56	1,000	400-1,000
	Axial-trough ground waters			
15	31/25-13B1	6- 1-53	248	150-551
16	31/25-16J1	9-26-56	985	360-1,140
17	31/26-36A1	11- 2-55	180	180-811
18	32/28-12F1	5-24-57	251	298-853
	Ground waters of the older rocks			
19	29/28-28E1	4- 6-51	158	248-348
20	29/29-36M2	9-25-57	491	450-650 1,020-2,125
21	31/30-17E1	5-29-56	320	310-737
22	11N/18W-27G1	7-12-56	269	500

FIGURE 20.—Chemical character of typical ground waters in the Edison-Maricopa area, California.

Appendix C

MPEP & GQMP Management Practices

TECHNICAL MEMORANDUM

IDENTIFICATION, EXTENSION, AND IMPLEMENTATION OF MANAGEMENT PRACTICES TO MINIMIZE NITRATE LEACHING FROM CROP ROOT ZONES TO SATISFY GROUNDWATER QUALITY MANAGEMENT PLAN REQUIREMENTS

PREPARED FOR: South San Joaquin Valley Management Practices Evaluation Plan Committee

PREPARED BY: MPEP Team

DATE: August 25, 2016

It is anticipated that versions of this document, when appended to a GQMP deliverable by a South San Joaquin Valley (SSJV) Management Practices Evaluation Program (MPEP) member coalition, will serve to inform the Central Valley Regional Water Quality Control Board (Central Valley Water Board) about the management practices component of the coalition's GQMP.

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LIST OF ABBREVIATIONS

CCA	Certified Crop Adviser
CDFA	California Department of Food and Agriculture
COC	constituent of concern
Committee	SSJV MPEP Committee

CSU	California State University
DWR	California Department of Water Resources
General Order	Waste Discharge Requirement General Order for the Growers within the Tulare Lake Basin Area that are members of a Third-Party Group, General Order No. R5-2013-0120, as modified by General Order No. R5-2013-0143.
GQMP	Groundwater Quality Management Plan
LTILRP	Long-term Irrigated Lands Regulatory Program
MPEP	Management Practices Evaluation Program
N	Nitrogen
NH_4	Ammonium
NMP	Nitrogen Management Plan
NO_3	Nitrate
NUE	nutrient use efficiency
SSJV	Southern San Joaquin Valley
SWAT	Soil and Water Assessment Tool
TDS	total dissolved solids
UCCE	University of California Cooperative Extension
USDA	United States Department of Agriculture
USDA-NRCS	United States Department of Agriculture Natural Resources Conservation Service
USGS	United States Geological Survey
Central Valley Water Board	Central Valley Regional Water Quality Control Board
WDR	Waste Discharge Requirement
Workplan	SSJV MPEP Workplan

1 BACKGROUND AND PURPOSE

The Kaweah Coalition's GQMP was submitted in February 2015, and comments received from the Central Valley Water Board at the end of June 2016. During this 16-month interval, a great deal transpired as the LTILRP developed. Among these developments, the Kaweah Coalition joined with six others to form the SSJV MPEP Committee (Committee), and hired the MPEP Team to develop a workplan. This process and the Discussion Draft Workplan (2016; Workplan) advanced everyone's understanding of what the MPEP would entail, and when it would begin to produce results. Kaweah can

now draw on this work to more clearly articulate how management practices will be identified, communicated to growers, implemented, and assessed, as requested in comments received from the Central Valley Water Board.

The Workplan deals explicitly with how that program will interface with individual coalitions, including their GQMPs. Section 2.1.3 (Exchanging Data with Coalitions and Informing Groundwater Quality Analyses) reads as follows:

As mentioned previously, individual LTILRP coalitions are engaged in complementary activities that can inform the MPEP and allow for more rapid, effective work. Examples of data and work products from the coalitions that are potentially relevant to the MPEP include the following:

- *Coalitions' data about the type and location of practices are fundamental to assessing the effects of irrigated agriculture on underlying groundwater. These data might arise from the following sources:*
    - *Farm Evaluations*
    - *Nitrogen Summary Reports*
    - *GARs*
    - *Trend Monitoring Reports*
- *Methodology and results (e.g., surface loading, loading to groundwater) from the MPEP can inform Groundwater Quality Management Plans (GQMPs) and other groundwater analyses undertaken by coalitions.*

Since the General Order provides for GQMPs to identify priority/urgent areas, and requires an MPEP to develop practices for such areas, it follows that the output of the MPEP should satisfy GQMP requirements related to management practices. The purpose of this memo is to fulfil this requirement for member coalition GQMPs related to nitrate.

The MPEP can satisfy management practice related requirements for any constituent of concern (COC), as evidenced by the following passage from Section 1 of the Workplan:

The current General Orders focus on controlling nitrate (NO_3) contamination of groundwater by irrigated agriculture, but the overall program also pertains to other constituents that could be construed as pollutants (e.g., sediment in runoff, salts). Nitrate movement through irrigated lands is therefore the main focus of this Workplan. If at some point other constituents need to be addressed by growers, the MPEP would likely serve the same functions for those constituents. At that time, addenda to this Workplan might be required to supplement and update the general approach with specific considerations relative to those constituents. However, the general approach described here, if successful, would otherwise remain intact.

Thus, for the Kaweah GQMP, where salinity and pesticides must be addressed, the MPEP will expand to incorporate practices that are protective relative to these COCs, in addition to practices deemed protective relative to nitrate.

The Workplan describes early outreach and assessment components:

- *…the initial inventory of management practices will result in a list of known, protective practices that will move immediately into this outreach process. It will be discussed with advisors and growers during 2016-17 meetings. Information on these practices will also be featured in an organized, accessible fashion on the Grower/Advisor Webpage, which water quality coalition membership will be encouraged to consult.* (p. 3-69)
- *…outreach products and activities will be documented and shared with the Central Valley Water Board in regular communications such as quarterly meetings and as part of required reporting.* (p. 3-69)
- …benchmarking the current degree of adoption of BMPs across the MPEP area. (p. 3-36)… Studies of management practice and production data from Farm Evaluations and Nitrogen Summary Reports, as supported and sanctioned by member coalitions, as well as similar data from packers who may gather such data from growers with whom they work. If these data are of sufficient quality, they could provide extremely powerful information about grower practices. (p. 3-38)
- *…a Grower/Advisor Webpage on its website, which includes an organized collection of many useful tools and references that already exist. This site will be updated as additional information becomes available from the Committee, member coalitions, partners (including the Central Valley Water Board), and other sources. This handy collection of resources for minimizing loss of applied nitrogen to groundwater will be available not only to member growers, but to growers and grower advisors anywhere. The Committee hopes that such a grower-oriented collection, focused on means to address this problem through sound management, will help growers actually apply these solutions in their practices on their fields, which must be done for actual benefits to be realized. Additional online tools, information, and applications will be developed to meet specific needs. For example:*
    - *Helpful information for growers and their advisors to efficiently derive maximum benefit from required Nitrogen Management Planning processes can be provided.*
    - *Tools to facilitate second-language growers to understand and comply with LTILRP requirements and derive maximum water quality and production advantages.*
    - *Query-able management practice databases to assist growers in evaluating the potential cost and benefits (production, water quality, labor) benefits of various suites of management practices, applied at their specific management block locations and planting dates. (p. 3-68)*

One purpose and feature of the SSJV MPEP is an efficient, collective effort to identify and increase implementation of protective practices, mainly by working with member coalitions to understand grower needs and to help them with resources to achieve this goal. As stated on page 2-6 of the Workplan:

- *Member coalitions are linked directly to the MPEP by their participation in the Committee. Growers are linked to the MPEP through their membership in their coalitions, meetings, communications, and data gathering. Growers will also participate in commodity, other winter, and special-purpose meetings where MPEP findings will be discussed during outreach sessions. Presenters primarily will*

be technical collaborators from public-sector research and extension, as well as private-sector production and grower experts.

Therefore, it is natural and appropriate that when information and outreach to promote implementation of protective practices is identified as part of a Groundwater Quality Management Plan developed by one of the member coalitions, work of this sort being done as part of the MPEP should be incorporated. It is understood that GQMPs signify high priority areas where a prompt response is required of the coalitions. At this time, as evidenced in excerpts from the Workplan, the corresponding elements of the MPEP are scheduled for the coming months and therefore constitute a timely component of the GQMP. For example, the soonest that growers can be convened to discuss practices for the next (2017) season is fall 2016/winter 2017, the very period targeted in the MPEP for early outreach.

The purpose of this document is to summarize the following:

- Protective management practices identified to for application as part of GQMPs
- Use of outreach to expand implementation of protective practices, including assessment of barriers to adoption and grower response to outreach
- Assessment of barriers to adoption, the impact of outreach, and the extent of practice implementation

2 MANAGEMENT PRACTICE OVERVIEW FROM WORKPLAN AND EXPANDED MANAGEMENT PRACTICE INVENTORY

Table 3-3, beginning on page 3-28 of the workplan contains a summary of the range of protective management practice types. That table is reproduced here for convenient reference, and will be used to frame more specific and expanded descriptions of practices that will be shared with growers.

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

Management Practice		Barriers to Adoption
Irrigation and Drainage Design and Operation		
Irrigation System Evaluation and Monitoring		
1	Conduct irrigation system performance evaluation	Operational cost, land tenure, training
2	Install and use flow meters or other measuring devices to track water volume applied to each field at each irrigation	Capital cost, operational cost, training
3	Conduct pump performance tests	Operational cost, training
Irrigation Scheduling		
4	Use weather-based irrigation scheduling	Operational cost, logistics, training, technology
5	Use plant-based irrigation scheduling	Operational cost, logistics, training

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

Management Practice		Barriers to Adoption
6	Use soil moisture content to guide irrigation timing and amount	Operational cost, logistics, training
7	Avoid heavy pre-plant or fallow irrigations for annual crops	Risk to yield or quality, logistics, training
Surface Gravity System Design and Operation		
8	Convert to surge irrigation	Capital cost, operational cost, logistics, training
9	Use high flow rates initially, then cut back to finish off the irrigation	Operational cost, logistics, training
10	Reduce irrigation run distances and decrease set times	Risk to yield or quality, capital cost, operational cost, land tenure, training
11	Increase flow uniformity among furrows (e.g. by compacting furrows)	Operational cost
12	Grade fields as uniformly as possible	Operational cost, training
13	Where high uniformity and efficiency are not possible, convert to drip, center pivot, or linear move systems	Capital cost, operational cost, land tenure, training
Sprinkler System Design and Operation		
14	Monitor flow and pressure variation throughout the system	Operational cost
15	Repair leaks and malfunctioning sprinklers; follow manufacturer recommended replacement intervals	Capital cost, operational cost, training
16	Operate sprinklers during the least windy periods, when possible	Logistics
17	Use offset lateral moves	Operational cost, logistics, technology
18	Use flow-control nozzles when pressure variation is excessive	Capital cost, land tenure, training
Drip and Micro-sprinkler System Design and Operation		
19	Use appropriate lateral hose lengths to improve uniformity	Training, capital cost
20	Check for clogging; prevent or correct clogging	Operational cost, capital cost, training
Other Irrigation Infrastructure Improvements		
21	Installation of sub-surface drains in poorly drained soils[1]	Capital cost, technology
22	Backflow prevention	Capital cost, training
Crop Management		

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

Management Practice		Barriers to Adoption
Change Crops to Use Those with Smaller N Requirements and Greater N Efficiency		
23	Cover crops to recover residual soil nitrate and immobilize it in soil organic matter	Risk to yield or quality of cash crop, capital cost, operational cost, logistics, training, technology, increased irrigation requirements for the cash crop
24	Include deep-rooted or N-scavenger crop species in annual crop rotations	Risk to yield or quality, capital cost, operational cost, logistics
25	Include perennial crop in rotation, e.g. alfalfa or perennial grasses	Capital cost, logistics, land tenure
Nitrogen Fertilizer Management		
Improve Rate, Timing and Placement of N Fertilizers		
26	Adjust N-fertilizer rates based on soil nitrate testing	Operational cost, training
27	Adjust timing of N fertilization based on plant tissue analysis	Risk to yield or quality, operational cost, training, lack of robust relationships between tissue test and amount of N fertilizer required
28	Apply N fertilizer in small multiple doses, rather than one or two large doses, to meet crop demand during the growing season without deficiency or excess	Operational cost, training
29	Know N content of irrigation water and adjust fertilizer rates accordingly	Operational costs, logistics, training
30	Reduce total N-fertilizer rates by replacing low-uptake-efficiency N-fertilizer applications to soil with high-uptake-efficiency foliar-N applications	Operational costs, training, technology
31	Vary N-application rates within large fields according to site-specific needs based on heterogeneity in soil N supply and/or crop growth	Operational costs, capital costs, training, technology
32	Use delayed injection procedure when fertigating in surface gravity systems	Operational costs, logistics, training
34	Develop an N budget that includes crop N harvest removal, supply of N from soil and other inputs to guide decisions on N-fertilizer rates and timing	Operational costs, training, technology

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

	Management Practice	Barriers to Adoption
35	Use controlled release fertilizers, nitrification inhibitors, and urease inhibitors	Risk to yield quantity or quality, capital cost, training, technology, benefits depend on soil types and N-fertilizer management practices
Improve Rate, Timing, and Placement of Animal Manure and Organic Amendment Applications		
36	Apply appropriate rates of manure and compost, taking N mineralization characteristics of these organic N sources into account	Risk to yield quantity or quality, operational cost, logistics, training, technology
37	Incorporate solid manure immediately to decrease ammonia volatilization loss	Operational costs, training
38	Use delayed injection to improve application uniformity when applying liquid manure in surface-gravity irrigation systems	Operational cost, logistics, training, technology
39	Use quick-test methods to monitor dairy lagoon water N content immediately before and during application, and adjust application rate accordingly	Operational costs, training, technology
40	Calibrate solid manure and compost spreaders	Operational cost, logistics, training

[1]Presumably beneficial to N management primarily by promoting more uniform crop growth and N uptake across the field.

This brief list of practices captures most of the categories of practices available to growers to retain mobile nutrients (like nitrogen) in their root zone so that the largest practicable proportion of it is used by the plant, and the least practicable amount percolates downward. Many practices are usable as they are stated (e.g., item 40, calibration of solid manure and compost spreaders could be implemented by any grower using these implements). Some require crop-specific information (e.g., item 27, adjusting timing of N fertilization based on plant tissue analysis requires that reference values for specific tissues be established, along with sampling and analysis protocols that produce consistent results). Not all practices apply to all crops. For example, tissue tests have not been found to be useful when assessing almond N status.

As part of early outreach, the SSJV MPEP is working with CDFA, UCCE, and other partners to inventory known protective management practices. This inventory is informed by the rather substantial knowledge base (literature, scientific and grower expertise) regarding practices that help growers to retain N for crop use and avoid excessive percolation losses. The inventory is being developed in database format so that it can be deployed in prioritizing and developing outreach curriculum, working with coalitions to assess implementation through Farm Evaluations, and to serve as an online resource to help growers explore and develop their management options. Practices tie into MPEP modeling/performance assessments too, since most can be quantitatively captured in model parameters and results. The inventory currently contains over 150 practices associated with various crops and crop classes, has identified 23 high-priority documents for review, posted 22 references in an online collection of grower resources (http://www.ssjwqc.org/_pdf/MPEP%20Tables.pdf), and identified

another 29 to be posted. The inventory is being further augmented and will be posted during the coming months.

GQMP

3 METHODOLOGY

This section describes methods used for outreach, and for the assessment of how well outreach is working so that it can be improved.

3.1 OUTREACH

Coalitions and partners (UCCE, USDA/NRCS, CSU, CDFA, commodity groups) all have ongoing outreach programs that are partly or wholly devoted to sharing protective management practices with growers with the goal of broader implementation. The MPEP/GQMP outreach program aims to harness and supplement these programs to ensure that ILRP commitments are met, and to document these activities. To this end, MPEP/GQMP outreach will entail the following:

- A database of outreach and outreach-related activities and products, including dates, format (live presentation, video, online tools, or hardcopy literature [mailings, fliers]), practices covered, and number of grower/members participating. To the extent practicable, this will include events that occurred before the inception of the database. This database will periodically be shared with the Water Board so that staff can assess outreach.

- Curricula developed in the form of meeting materials (agendas and presentations), video, fliers, and online tools and informational resources.

- A network of cooperating partners, including other water quality coalitions, CDFA, UCCE, private-sector experts (e.g., CCAs), CSU, NRCS, and commodity groups will be tapped to assist with development and delivery of curricula. The video and online options will help to extend these scarce resources to meet what is a growing need. CDFA staff are currently working with the MPEP Team to expand the practices inventory. One or more protective practices workshops are planned with UCCE in the September/October timeframe, specifically to finalize curricula for the early-outreach period. All of these groups have been involved in developing the Workplan.

- Growers already attend many meetings where protective practices to achieve good environmental performance are discussed. The Workplan specifies that, to make the best use of grower's and partner's time, curricula will be delivered at these meetings whenever practicable. The MPEP Team is identifying candidate meetings and working with organizers to include on their agendas protective practice sessions where the curricula can be delivered to growers. Many of the partners listed previously are responsible for convening these meetings and are the focus of these contacts.

3.2 ASSESSMENT

While outreach is crucial for reaching growers, follow up and assessment are essential to understanding how effective outreach is. Assessment results will guide refinement of outreach so that it can become increasingly effective at informing and affecting grower behavior, and in expanding implementation of protective practices that are suitable to each crop, soil, climate, and hydrographic setting. Assessment methods are discussed in this section.

The means and methods for assessing outreach consist of the following:

- A database of outreach activities (including sponsor, subject matter, locale, number of participants, and curricula) has been developed to capture past, ongoing, and future activities. All relevant activities will be included, whether sponsored by water quality coalitions or not. This is appropriate since the MPEP strategy is to multiply effort through collaboration with a wide range of partners.
- Barriers to adoption will be investigated by discussing individual practices with key resource persons, including growers and those who work closely with them (CCAs, Farm Advisors, and NRCS staff). Once a barrier is identified, means will be sought to lower this barrier. Some examples of barriers and actions that may be taken to alleviate them include the following:
    - When growers or farmworkers lack information or training, this can be supplemented through outreach.
    - When practices are exceedingly complex, simplified versions, or tools that enable growers to cope with complexity, can be developed.
    - When material resources are lacking, funding and volume pricing can be sought to offset costs.
    - When practices are ill adapted to certain types of operations or soil/topographic/management settings, more workable alternatives will be sought, and the “recommendation domain” (the conditions under which the practice is applicable and necessary) will be adjusted. Ideally, each practice should be associated with a defined recommendation domain. In some cases, questions of applicability and alternative practices will need to be fed back into field research performed by MPEP research partners.
- Grower receptivity and comprehension to outreach topics will be assessed by discussing practices with groups of growers participating in outreach events. Results will be employed to adjust and/or supplement outreach curricula, and to follow up with participants, so that practices as communicated are acceptable and understood by participants.
- Management practice implementation will be tracked through Farm Evaluation data. As mentioned previously, certain practices are already included in Farm Evaluations. As other priority practices are identified, these will be added so that the extent and pace of implementation can be tracked. This information will also inform landscape-level modeling that demonstrates program performance. Many management parameters, when known, can be included among model management parameters, so that model output will reflect performance changes over time that result from management shifts.

4 SCHEDULE

[This section to be developed separately by each coalition, depending on their individual order, GQMP, and program.]

5 REFERENCES

MPEP Team for the SSJV MPEP Committee. May 2016. Discussion Draft Management Practices Evaluation Workplan, Southern San Joaquin Valley MPEP Committee.

Kern River Watershed Coalition Authority

www.krwca.org