EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company

130 N. Garden Street
Visalia, CA 93291-6362
Tel: (559) 636-1166
Fax: (559) 636-1177
www.ppeng.com

May 14, 2014

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814
Sent via email to: commentletters@waterboards.ca.gov

Re: Agricultural Expert Panel Comments

Dear Members of the Agricultural Expert Panel:

I am a California registered agricultural and civil engineer with extensive experience with water quality issues, including assisting numerous dairymen with the Dairy General Order. I also support the Kern River Watershed Coalition Authority (**KRWCA**) that currently administers the Irrigated Lands Regulatory Program (**ILRP**) in the Kern Subwatershed.

Our coalition has done significant work over the past 2-3 years and prepared detailed reports, provided in comment letters during the promulgation of the Waste Discharge Requirements General Order for Growers within the Tulare Lake Basin Area that are Members of a Third-Party Group (**Order R5-2013-0120**). We trust that our prior efforts are helpful to you as you engage in your important work. We are providing some of our prior reports, references, and input with this letter, along with a brief summary of pertinent conclusions, with our thoughts about how they relate to your charge and questions.

Robert M. Gailey, P.G., C.HG. of the Source Group, Inc. noted (**Exhibit A**) that the KRWCA area is characterized by deep groundwater that was on average 265 ft below ground surface (bgs), according to DWR Spring 2010 data. He noted that this significant depth to groundwater, coupled with limited deep percolation (due to the efficiency of irrigation in this area) result in travel times to groundwater ranging from decades to centuries. The long travel times, along with groundwater banking and stresses on the groundwater table, legacy nitrate in transport, mixing from different sources, and other factors contribute to a significant temporal and spatial disconnect and associated variability between surface activities and observed water quality at depth. Because of this unique and complicated variability, we believe that the focus of the ILRP should be on surface activities. Management practices should be the leading approach; particularly practices recognizing and contributing to enhanced irrigation efficiencies and optimization of various methods of efficient nutrient management. Thus, we believe that your consideration of "Application of Management Practices" is very important and appropriate.

This same temporal and spatial disconnect between the surface activities and groundwater contributes to "noise" that complicates groundwater monitoring and interferes in making meaningful conclusions. As a result, significant doubt is introduced regarding the reliability of results, and it is likely that unavoidable costly, inappropriate, and false conclusions may be possible if this variability is not recognized and considered. The "Verification Measures" questions posed to the Expert Panel should be considered in the context of the KRWCA's unique hydrogeologic circumstances.

The most significant monitoring provision, and an area of considerable expense to achieve compliance in our General Order, is the Management Practice Evaluation Program (**MPEP**). We have been encouraged that you have discussed the MPEP in your meetings thus far, and strongly believe that this falls within your scope and charge. It should likely be addressed under the "Management Practices" and "Verification Measures Questions."

According to our Order, the overall goal of the MPEP is to determine the effects, if any, irrigated agricultural practices have on first encountered groundwater under different conditions that could affect the discharge of waste from irrigated lands to groundwater (e.g., soil type, depth to groundwater, irrigation practice, crop type, nutrient management practices, etc.). We share the same concern mentioned by Mr. Angermann on May 7 that as irrigated ag gets more efficient, the constituent concentrations in deep percolation increases. While the overall loading to first encountered groundwater is lower, the concentration data from first encountered groundwater monitoring wells depend on the extent of mixing that takes place.

Coalitions must address conditions relevant to high vulnerability areas, therefore the accurate and refined determination of high vulnerability areas is imperative in determining the scope of the MPEP. The Order also requires the coalitions to develop an estimate of the effect of Members' discharges of constituents of concern on groundwater quality in high vulnerability areas. A mass balance and conceptual model of the transport, storage, and degradation/chemical transformation mechanisms for the constituents of concern, or equivalent method approved by the Executive Officer, or as a result of the recommendations by the expert panels by CDFA and the State Water Board, must be provided. This is a significant part of the Order that was written to be receptive of, and directed by the Expert Panel's input.

Ultimately the coalition is obligated to provide a report no later than 6 years after implementation of each phase of the MPEP. The coalition shall submit a Management Practices Evaluation Report (**MPER**) identifying management practices that are protective of groundwater quality for the range of conditions found at farms covered by that phase of the study. The identification of management practices for the range of conditions must be of sufficient specificity to allow Members of the third-party and staff of the Central Valley Water Board to identify which practices at monitored farms are appropriate for farms with the same or similar range of site conditions, and generally where such farms may be located within the coalition area.

The MPEP will be a significant effort. We have tried to estimate the cost of the MPEP, but it depends primarily on the number of combinations of management practices, site conditions, crop types, and the resulting monitoring wells that will be required to analyze these combinations. RWQCB staff theorized in August 2012 that the MPEP could cost anywhere between one to five times as much as the Dairy Representative Monitoring Program (**RMP**). The Dairy RMP program spends approximately $1.5 million per year, so according to that estimate, the MPEP could cost $1.5 to 7 million per year, or $9 to $42 million over six years. We were never fully able to reconcile our cost estimates with the RWQCB, but their latest estimate prepared in advance of the September 2013 hearing estimated 6,664 monitoring wells would need to be installed in the Tulare Lake Basin. Staff estimated that there would be 1.8 million acres classified as high vulnerability in the Tulare Lake Basin (out of approximately 2.9 million total acres). Thus, staff assumed a monitoring well density of about 270 acres per monitoring well.

Please refer to our ILRP compliance cost estimate in (**Exhibit B**), particularly the section on the MPEP. We estimated the range of cost possibilities based on the number of combinations of crops, site conditions, and management practices. There are 250+ crops in the Central Valley. To what level can we aggregate these crops for analysis? How many site conditions should be analyzed? If we can't reasonably monitor in places like Kern because of deep groundwater, then we must work with other coalitions to derive the necessary conclusions; however, at this point it is unclear if we can work with other coalitions that may have significantly different approaches on their Groundwater Assessment Reports (**GARs**) as the GARs directly inform the MPEP process. In working together, we'll have to agree that other places are representative of our coalition area and that we'll abide by conclusions obtained there. Will they indeed be representative? How many management practices should be included in the studies to cover pesticide, irrigation, and nutrient practices? The number of combinations and the cost of the program can increase very rapidly with a small increase in any of these parameters. If we could justify 25 crop groups,16 management practices, and 9 site conditions, that would result in 3,600 monitoring sites and 10,800 monitoring wells (at 3 wells per monitoring site), with no replication. We have estimated that a study of this magnitude could cost approximately $150 million per year. This would be about 114 times the magnitude of the Dairy RMP program. With any replication to help factor out the inherent variability, the cost and effort goes up by the replication factor. On the other hand, the more that we aggregate crops, management practices, and site conditions into groups to reduce the total combinations, the more risk that we take of extrapolating bad conclusions to wider areas.

Our comments and technical work have sought to identify ways to achieve more efficient regulation. One important way to do this is to focus where effort is needed, and not devote resources where there is little to gain. To this end, the Nitrate Hazard Index (**NHI**) and its application to Kern is an extremely important tool that has been validated, accepted, used, and is cost-effective. Examples of these benefits have already been developed specific for the Kern Subwatershed (**Exhibit C**). A separate comment letter will be provided by Nicole Bell with more information on the NHI and the plentiful work that has gone into specifically evaluating this for the KRWCA area. This work is particularly pertinent to your consideration of "Vulnerability and Risk Assessment" questions.

We have expressed concerns associated with the improper use of the nitrogen mass balance. Nicole Bell will also be presenting a comprehensive document as an attachment to her letter that addresses the challenges of the N mass balance approach. We believe that the nitrogen mass balance has its place in planning nitrogen applications at a farmer level, but we must recognize the significant and severe limitations it possesses. It can't be assumed that all nitrogen unaccounted for transitions to groundwater. In fact, in many cases the exact opposite is true and has been proven many times in the literature. This is usually coupled with low rainfall areas, with deep rooted perennial crops with efficient N and water use. We submit that the nitrogen cycle can't be simplified to N applied minus N removed equals N leached, or some simplified permutation of that. This is simply not the case in the biogeochemical process that is the N-cycle.

We urge you to consider our technical reports and input as you consider the "Reporting" questions. We'd like to thank the Agricultural Expert Panel for their work on this important topic. Please let us know if we can assist you in your efforts by providing any additional information or testimony.

Respectfully,

John Schaap
RAE 563
RCE 61754

Enclosures:
Exhibit A: Comments on Hydrogeologic Points of Concern for the KRWCA Area (Gailey)
Exhibit B: Estimated Cost of Compliance Technical Report – Kern Coalition
Exhibit C: Assessment of Potential for Nitrate Migration in Kern Sub-Basin (Kimmelshue)

cc: Nicole Bell, KRWCA Manager

Exhibit A

Comments on Hydrogeologic Points of Concern for the KRWCA Area

COMMENTS ON HYDROGEOLOGIC POINTS OF CONCERN FOR THE KERN RIVER WATERSHED COALITION AUTHORITY AREA

Regarding Monitoring and Reporting Program Tentative Order R5-2013-XXXX Waste Discharge Requirements General Order for Growers within the Tulare Lake Basin Area that are Members of Third-Party Group

01-KRW-001

Prepared For:

Ernest A. Conant of Young Wooldridge, LLP

Counsel for Kern River Watershed Coalition Authority

Prepared By:

SGI environmental THE SOURCE GROUP, INC.
3478 Buskirk Avenue, Suite 100
Pleasant Hill, CA 94523

April 10, 2013

Robert M. Gailey, P.G., C.HG.
Principal Hydrogeologist

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

My name is Robert M. Gailey. I am licensed as a Professional Geologist and Certified Hydrogeologist in the state of California. Having practiced in the field of hydrogeology since 1985, my technical background includes both contaminant and water supply hydrogeology applied to urban, industrial and rural settings. I have technical degrees in Geology/Biology (Bachelor of Science) and Applied Hydrogeology (Master of Science), as well as a Master of Business Administration. My curriculum vitae is attached as Appendix A.

I have been retained on behalf of the Kern River Watershed Coalition Authority (KRWCA) to review and comment on the Monitoring and Reporting Program portion of *Tentative Order R5-2013-XXXX, Waste Discharge Requirements General Order for Growers within the Tulare Lake Basin Area that are Members of a Third-Party Group* dated March 2013. My area of focus is how hydrogeologic characteristics specific to the KRWCA area relate to the groundwater monitoring requirements, specifically the management practice evaluation and trend monitoring requirements for nitrate, stated in the tentative order.

The following information is a brief presentation of my review to date. My evaluation of the salient issues is ongoing and I may present additional comments in the future.

2.0 SUMMARY OF COMMENTS

From a hydrogeologic perspective, the KRWCA area is notably different from other parts of the Tulare Lake Hydrologic Region (TLHR) and also the East San Joaquin Watershed (ESJW) with respect to groundwater basin configuration, hydrologic stresses and depth to first-encountered groundwater. These hydrogeologic differences have the potential to greatly complicate groundwater monitoring as described in the tentative order. Among the issues that require additional consideration before the order is finalized are:

1. Time lags between agricultural activities at ground surface and changes in groundwater quality as a result of a thick unsaturated zone,
2. Nitrate residing in the unsaturated zone that acts as an ongoing source to groundwater years after nitrogen is applied at ground surface,
3. Processes acting on return flows during transit through the unsaturated zone,
4. Horizontal migration within the saturated zone and the resulting difficulty in attributing observed nitrate to specific source areas, and
5. The potential costs of an insufficiently planned groundwater quality monitoring program and the need for further study, or a pilot program as an interim regulatory step before any full-scale monitoring occurs.

The above-referenced points call into question the scientific basis, efficacy and cost effectiveness of groundwater monitoring as currently required in the tentative order and should be addressed in finalizing the tentative order.

3.0 PHYSICAL BACKGROUND

Figure 1 indicates the boundary of the KRWCA area. This area, a subsection of the South San Joaquin Valley Water Quality Coalition (SSJVWQC) and TLHR areas, contains a significant portion of Kern County and small portions of Tulare and Kings Counties, and is based upon water district boundaries. The primary groundwater subbasin in the KRWCA area as defined by the California Department of Water Resources (DWR) is the Kern County Subbasin (DWR Subbasin 5-22.14); however, small portions of the Tulare Lake and Tule subbasins (DWR Subbasins 5-22.12 and 5-22.13) are also included in the northern portion of the area. While Attachment A of the tentative order (Information Sheet) provides a brief summary of the geology, hydrogeology and groundwater quality for the TLHR area as a whole, the following sections present pertinent information on these topics specific to the KRWCA area.

3.1 Geology

The KRWCA area geology consists of sedimentary deposits located in the southernmost portion of the San Joaquin Valley that have been derived from the surrounding mountain ranges. The shallower deposits are continental in origin with a range of types that generally include alluvial fan, lacustrine and river (Page, 1986 and Gronberg et al, 1998). These deposits are as much as 15,000 feet thick resulting from structural deepening of the basin (Lofgren, 1975 and Page, 1986). The combination of deposits throughout the KRWCA area is a heterogeneous assemblage of alluvial fan deposits, both coarse- and fine-grained, interfingered with valley stream (coarser) and lake (finer) deposits (i.e., Wood and Dale, 1964; Dale et al, 1966; Croft, 1972) formed by processes that responded to changes in glacial activity in the Sierra Nevada as described by Weissmann et al (2002).

3.2 Groundwater Hydrology

The KRWCA area is part of a closed groundwater basin (Croft, 1972 and Bertoldi et al, 1991). Natural patterns and rates of groundwater flow, recharge and discharge have been significantly changed as a result of groundwater pumping, surface water importation, crop irrigation and artificial recharge (Bertoldi et al, 1991, Gronberg et al, 1998 and DWR, 2006)[1]. Groundwater pumping performed by, among others, agricultural, municipal and water banking operations extracts in excess of 2 million acre feet of groundwater per year (KCWA, 2008) from locations spread throughout the KRWCA area (Boyle et al, 2012). Recharge operations performed by many water storage districts and other entities (DWR, 2006; KCWA, 2008) introduce water to the subsurface through natural channels, irrigation canals, spreading basins. From 1971 through 2008, recharge operations introduced in excess of 27 million acre feet of water to the subsurface. In addition, some amount of groundwater recharge occurs as a result of irrigation return flows. Locally,

[1] See Figure 2 from Shelton et al (1998) for a graphical depiction of the extensive area within the KRWCA area that is involved in groundwater banking operations.

groundwater generally flows toward locations of groundwater pumping and away from locations of groundwater recharge.

First-encountered groundwater is relatively deep in the KRWCA area. Figures 2a and b display depth to water contours for first-encountered groundwater during the spring of 2010 as determined by the DWR and Kern County Water Agency (KCWA), respectively[2]. The depth to water ranges from as little as approximately 50 feet to as much as approximately 700 feet. Water in much of the area is between 150 and 300 feet deep. Figure 3 displays depth to water contours for first-encountered groundwater during the spring of 1988 as determined by the DWR. Comparison of Figures 2a and 3 indicates that first encountered groundwater is currently deeper than it was approximately two decades ago.

3.3 Groundwater Quality and Potential Sources of Nitrate

Nitrate in first-encountered groundwater is the primary focus of the tentative order. Boyle et al (2012) summarized information on nitrate concentrations in groundwater for the TLHR including the KRWCA area. Burton et al (2012) also investigated the occurrence of nitrate in groundwater in these areas. Several other studies have also investigated nitrate in groundwater in the San Joaquin Valley[3]; however, these studies focused on locations north of the KRWCA area (in other parts of the TLHR and in the ESJW) where, as discussed in later sections of this report, first-encountered groundwater is shallower and water quality impacts appear to be more pronounced.

Potential anthropogenic sources of nitrate to groundwater in the KRWCA area include: confined animal feeding operations, crop agriculture (past and current), dairies, municipal and industrial wastewater and sludge disposal, and septic systems[4]. Figure 4 indicates the current locations of various potential anthropogenic sources of nitrate throughout the KRWCA area, and Figure 5 (adapted from Harter et al, 2012) indicates the relative magnitudes of various sources at present[5]. While crop agriculture is a significant potential source, manure from dairies and other operations is also a significant potential source. Moreover, consideration of current potential sources is not sufficient to fully assess the potential sources of the observed nitrate in groundwater. Because the KRWCA is part of a closed groundwater basin, impacts accumulate over time (KCWA, 2008). Accordingly, Figure 6 builds upon Figure 5 by adding past potential sources starting in 1945 using

---

[2] The contours presented are for the geographically extensive first-encountered groundwater and do not include the limited areas of shallow groundwater outlined on Figure 2a.

[3] These studies include Botros et al (2012), Botros et al (2009), Burow et al (1998), Burton and Belits (2008), Domagalski et al (2008), Dubrovsky et al (1998), Dubrovsky et al (2010), Fischer and Healey (2008), Green et al (2008a), Green et al (2008b), Harter et al (2005), Landon et al (2010), Lindsey and Ruperet (2012), Onsoy et al (2005), Puckett et al (2008), Schmidt et al (2011), Singleton et al (2011) and Tesoriero (2007).

[4] Burton et al (2012) used available data sets from the KRWCA area to document statistical correlations between nitrate concentrations in groundwater and 1) dissolved oxygen content and 2) proximity to only certain types of crop agriculture (orchards and vineyards) and septic systems.

[5] The results of Harter et al (2012) are presented for discussion purposes. That work has not been reviewed in detail.

the information plotted on figures 7 through 10[6]. When accumulation over time is considered[7], past potential sources related to crop agriculture and manure are revealed as the most significant potential sources with approximately 79 percent of the total potential source contribution. Clearly, understanding the distribution of nitrate in groundwater in the KRWCA area must include consideration of historic activities. While the Central Valley Regional Water Quality Control Board has stated the order will not address the legacy issue in terms of regulating groundwater impacts from past land use practices, these impacts will affect groundwater quality monitoring conducted under the order.

3.4 Differences between KRWCA Area and Areas to the North

The KRWCA area differs from areas located farther north in the San Joaquin Valley: 1) the rest of the SSJVWQC/TLHR area and 2) the East San Joaquin Water Quality Coalition (ESJWQC)/ESJW area. The three points discussed below will be considered in the following sections of this report.

First, the depth to groundwater in the KRWCA area is significantly greater than in the areas located to the north. Table 1 compares the depths to first-encountered groundwater for the groundwater subbasins in the areas being discussed. Groundwater in the KRWCA area is by far the deepest based upon both the averages and maximum data. Boyle et al. (2012) graphically depict this condition (see Figure 2 of the cited document). As a result, it takes longer for agricultural return flows, where they exist, to reach first-encountered water in the KRWCA area.

Second, nitrate impact to first-encountered groundwater is less pronounced in the KRWCA area than it is to the north. Boyle et al. (2012) provide a graphical comparison of the areas (see Figures 41 through 44 of the cited document). Burton et al. (2012) provide statistics that support this conclusion. The aggregate conditions in the KRWCA area (i.e. hydrogeologic conditions and agricultural management practices) appear to be more protective of groundwater quality than is the case for areas located to the north.

Finally, there are significant hydrologic stresses imposed upon the groundwater system in the KRWCA area. With rainfall being approximately one-half to one-third of that for the above-referenced areas located to the north (Williamson et al, 1989; Gronberg et al., 1998), a substantial amount of groundwater pumping occurs in order to meet the water demand. Given the demand on the groundwater resource and decline in water levels over time mentioned in Section 3.2, a substantial amount of groundwater recharge has been performed to maintain the resource. These

---

[6] Estimation of past potential nitrate sources (crop, manure and other) for Figure 6 involved scaling the values presented by Harter et al (2012). The scaling value for each category was calculated as the ratio of past (1945 to 2002) to current (2003 to 2007) for an indicator variable that was summed over the two time intervals. For the Crop category, the indicator variable was the product of acres in production (Figure 7) with synthetic nitrogen applied (Figure 8). For the Manure category, the indicator variable was the manure nitrogen applied (Figure 9). For the Other category, the indicator variable was the Kern County population (Figure 10).

[7] It is assumed that all nitrogen is converted to nitrate and there are no losses over time.

pumping and recharge operations have created the potential to induce lateral flow of groundwater and migration of dissolved constituents over significant distances.

Table 1

Summary of Depth to First-Encountered Groundwater within the ESJW and TLHR Areas

DWR Groundwater Subbasin or Group	Minimum	Average	Maximum
East San Joaquin Watershed (ESJWQC)	1	88	277
Kings Subbasin	0	87	254
Kaweah Subbasin	6	102	214
Tulare Lake Subbasin	1	77	309
Tule Subbasin	2	159	440
Kern County Subbasin (KRWCA)	100	265	634

Notes:
1) Results are in feet and rounded to the nearest foot.
2) Analysis performed on DWR monitoring data for spring 2010.
3) Averages were calculated on data declustered at the township-range level.
4) East San Joaquin Watershed water level data from the following DWR groundwater subbasins were used: Chowchilla, Madera, Merced, Modesto and Turlock
5) Consistent with Figures 2a, 2b and 3, the KRWCA entries do not address the limited areas of shallow groundwater outlined in Figure 2a.

4.0 SCIENTIFIC CHALLENGES FOR MONITORING GROUNDWATER QUALITY IN THE KRWCA AREA

The premise for groundwater quality monitoring in the tentative order is that collecting information will allow the effectiveness of irrigation and fertilizer management practices to be evaluated and improved where necessary in order to protect the quality of first-encountered groundwater. However, there are several aspects the hydrogeology in the KRWCA area that will complicate interpretation of the collected monitoring data. As observed in a United States Geological Survey (USGS) study conducted in both the TLHR and the ESJW areas by Burow et al. (2008), "Protection of groundwater for present and future use requires monitoring and understanding of the mechanisms controlling long-term quality of groundwater." The following sections identify some of the more important mechanisms that influence groundwater quality and discuss the implications for the Management Practice Evaluation and Groundwater Trend Monitoring programs required by the tentative order.

4.1 A Thick Unsaturated Zone Creates Time Lags Between Activities at Ground Surface and Changes in Groundwater Quality at Depth

As indicated on figures 2a and b, the depth to first-encountered groundwater in the KRWCA area varies greatly. Table 1, presented previously, summarizes the range in depth to water across the area and compares this condition to other areas within the TLHR and ESJW areas. Most of the studies conducted in the San Joaquin Valley and cited in the tentative order as a basis for regulating irrigated agriculture have been conducted in areas other than the KRWCA area, in areas where groundwater is much shallower. As indicated on Figure 11, the depth to first-encountered groundwater in the vast majority of the KRWCA area is much greater than that in the types of studies referenced in the tentative order[8]. The significant distance between ground surface and first encountered groundwater over much of the KRWCA area (hundreds of feet) increases transit times for return flows migrating down through the unsaturated zone to saturated groundwater. This condition creates a time lag between 1) irrigation and nitrogen management activities at ground surface and 2) changes in the quality of first-encountered groundwater[9].

Appendix B presents the results of nitrate travel time calculations for bulk flow through the unsaturated zone under the range of conditions that occur in the KRWCA area. Both agronomic factors (return flow and nitrogen lost below root zone) and hydrogeologic factors (unsaturated zone stratigraphy and depth to first encountered groundwater) were considered. The results indicate that nitrate may reach first-encountered groundwater in as little as 10 to 15 years in some areas, but requires many decades to several centuries for the migration path to be completed in other

[8] See references in Footnote #3.

[9] This condition may exist in other parts of the TLHR and in some parts of the ESJW as well. However, the greater depths to groundwater in the KRWCA area make the condition more significant to the interpretation of groundwater quality in the KRWCA area.

areas where first encountered groundwater is deeper. It is acknowledged that a variety of processes may lead to a range of travel times with migration occurring faster or slower than the estimates presented here[10]. However, it appears that the processes are very site-specific and those which might lead to faster migration are not likely to occur consistently over significant unsaturated zone thicknesses and across changes in lithology (i.e., interlayered sands and clays). This view is consistent with research conducted on relatively thick unsaturated zones[11]. Furthermore, these calculations are consistent with the observation that water quality is less impacted in the KRWCA area than in the northern portion of the TLHR and the ESJW where groundwater is generally shallower (see Section 3.4).

The implication of the presence of a thick unsaturated zone across much of the KRWCA area is that a significant portion of the nitrate from past fertilization practices currently remains in-transit in the unsaturated zone. As a result, current changes in groundwater quality are associated with return flows resulting from past farm practices as opposed to current practices. A trend monitoring program conducted under such conditions cannot meet the monitoring goals of the tentative order because there is a temporal disconnect between actions at ground surface and reactions in groundwater located at depth. Changing current irrigation and fertilization practices cannot affect what has occurred in the past.

4.2 Nitrate in the Unsaturated Zone Acts as an Ongoing Source to Groundwater

In situations where transit times from ground surface to first-encountered groundwater are significant (many years or more), the unsaturated zone effectively acts as a reservoir for nitrate to be released to groundwater at a later time. This condition complicates trend monitoring and makes effective regulation of current farm practices very difficult.

While some researchers have interpreted data for shallow groundwater sites to indicate that nitrate migrates through the unsaturated zone quickly and leaves little residual, this does not appear to be the case in much of the KRWCA area partly because first-encountered groundwater is deep and the unsaturated zone has a significant storage capacity. Figure 12 demonstrates that the unsaturated zone can, in fact, act as a long-term reservoir for nitrate. The monitored site was farmed until approximately the year 2000 and then converted into a spreading ground for groundwater recharge. The nitrate concentration in groundwater when the land was used for farming was slightly below the drinking water Maximum Contaminant Level of 45 milligrams per liter (mg/l). After groundwater recharge operations began, the concentration rose to a high of

[10] For faster migration, these processes may include anion exclusion, fingering, funneling and flow along high hydraulic conductivity pathways. For slower migration, these processes may include physical interaction with soil, diffusion into slow velocity or immobile zones and denitrification under some conditions (Kung, 1990a and 1990b; Green and Bekins, 2010).

[11] McMahon et al. (2006) evaluated the transit times for chemicals through thick unsaturated zones in the High Plains region of the United States. For irrigated croplands with unsaturated zone thicknesses ranging from approximately 55 to 160 feet, they found that travel times to groundwater varied between approximately 50 and 370 years.

slightly more than 80 mg/l, and the elevated concentrations persisted for more than a decade as the newly established recharge operation continued. A reasonable interpretation of this information is that 1) the downward migration rate through the unsaturated zone increased as a result of the recharge operation, 2) groundwater concentrations increased as a result of the large amount of nitrate from past farming migrating downward at an increased rate and 3) the increased nitrate concentrations persisted because the reservoir of nitrate in the unsaturated zone was large[12]. Most recently, the nitrate concentrations in groundwater have begun to decrease. This development may be the result of the nitrate reservoir in the unsaturated zone being depleted over time by the flushing associated with the recharge operation.

Figure 13 presents data from an area not used as a spreading ground. Here, there is clearly a positive correlation between water level and nitrate concentration. Although the monitoring data early in the period of record are sparse, a reasonable interpretation of this information is that the unsaturated zone acts as a reservoir for nitrate which is released to groundwater during periods of high water levels when saturated groundwater conditions rise up into previously unsaturated sediments. As a result, in order for groundwater quality trend monitoring to be effective, the legacy issue discussed above must be considered and incorporated into the approach before the tentative order is finalized.

4.3 Processes Acting on Return Flows During Transit Through the Unsaturated Zone Can Affect Trends Observed in First-Encountered Groundwater

As noted above, several processes can lead to a range of travel times through the unsaturated zone beneath a single parcel. When thick unsaturated zones and long travel times to groundwater are also involved, there is the potential to mix older and younger return flows at the point where faster and slower migration paths terminate (first-encountered groundwater). To the extent that these flows are significantly different in age, they may have originated during times of different nitrogen management practices. Mixing of such flows could blur differences in water quality trends associated with past and current management practices that might otherwise be apparent.

The processes involved in creating the different flows may include 1) for faster migration, anion exclusion, fingering, funneling and flow along high hydraulic conductivity pathways and 2) for slower migration, physical interaction with soil, diffusion into slow velocity or immobile zones (Green et al., 2005) and denitrification under some conditions[13] (Dubrovsky et al., 2010; Landon et al., 2010; Schmidt et al. 2011). However, a USGS study conducted in the SSJVWQC area (Burow et al., 2008) noted that "few wells have been sampled over time spans long enough to assess the

[12] This example should not be interpreted as an indication that all recharge operations flush nitrate into the saturated zone. Land use history is a very important factor that must be considered. The purpose of this discussion is to provide evidence that past farming practices, as opposed to current farming practices, have added large amounts of nitrate to the unsaturated zone.

[13] For instance, above clay strata where the moisture content may increase and contact with air in the pore space may decrease. The decrease in dissolved oxygen and long travel times could create conditions conducive to nitrate loss by denitrification.

relation between regional management practices and potential long-term degradation of water quality in the eastern San Joaquin Valley aquifer system." So, it isn't clear what unresolved scientific questions may be encountered as the monitoring data are collected. Successful water quality trend analysis requires a favorable signal to noise ratio, and concentration data effectively contain noise when they are affected by processes that are not understood. Therefore, travel through a thick unsaturated zone is expected to increase the noise and complicate interpretation of actual trends unless the processes acting on the return flows are understood. The complexities that may be encountered during monitoring should be considered before the large-scale monitoring program in the tentative order is finalized. One approach for acquiring the necessary experience with monitoring deep groundwater would be to conduct a pilot monitoring program in a small portion of the KRWCA area.

4.4 Horizontal Flows in Subbasin Can Complicate the Attribution of Observed Nitrate to Specific Source Areas

As noted in Section 3 above, the KRWCA area is located within a closed groundwater basin that experiences relatively large artificial hydrologic stresses in the forms of water supply well pumping and recharge operations. In addition, many potential sources of nitrate are located close together (Figure 4). Under these conditions, nitrate from different sources likely mixes. In fact, a study of domestic well water quality in the SSJVWQC area (Singleton et al., 2011) found that many wells contained mixtures of nitrate from many sources (manure, fertilizer and septic/community wastewater). This finding is consistent with a USGS study conducted in the SSJVWQC area (Burow et al., 2008) that noted "Predicting the long-term fate of nitrate and pesticides in ground water in this region is difficult owing to intensive ground water pumping, mixed sources of recharge water, and complex flow paths through heterogeneous alluvial fan sediments." This situation can make the Management Practice Evaluation Program quite difficult to implement as existing water quality impacts may not be attributable to the monitored, or even specific, locations.

In addition, horizontal migration can induce changes in concentrations over time and complicate Trend Monitoring. Figure 14 provides an example. Two fairly similar periods of high water are contained in the plotted record; however, the concentration responses during those periods are quite different. The history of extraction and recharge in this part of the subbasin is indicated along the top of the figure.` While changes in the locations of extraction and recharge are not indicated, it is clear that there are differences in timing, duration and the cumulative magnitude of the hydrologic stresses. A reasonable interpretation of this information is that nitrate in the saturated zone migrates horizontally under the influence pumping and recharge.

In another USGS study that included locations in the San Joaquin Valley, Rupert (2008) noted the complexities associated with evaluating trends in groundwater quality data. Two of the points made were that 1) it is difficult to evaluate trends unless the recharge age is known so that correlation with changes in land use can be made and 2) changes in oxidation-reduction conditions can significantly affect trends. These are just some of the complexities that should be considered and evaluated before the large-scale monitoring program in the tentative order is finalized.

4.5 The Potential Costs of Insufficiently Planned Groundwater Quality Monitoring are Significant

Evaluations of potential costs associated with the monitoring programs required in the tentative order have been made on behalf of the State and continue to be revised. While a final assessment of the costs has not yet been prepared, it is clear that the program will be costly. Moreover, costs in the KRWCA area are likely to be higher than the average for the SSJVWQC area because the depth to first-encountered groundwater is greater than in other parts of the SSJVWQC area. Given the costs, details of the monitoring program should be carefully planned to increase the likelihood of successful implementation. Consideration of the issues raised above should be incorporated into that planning. The primary implication of these issues is that the monitoring program goals (evaluating the effectiveness of irrigation and fertilizer management practices and improving them where necessary in order to protect the quality of first-encountered groundwater) may not be achievable through the monitoring programs required in the tentative order. That possibility stems from problems with data interpretation that may be encountered, for the reasons stated above, when trying to attribute water quality conditions to farming activities at specific locations and times.

Potentially more costly than implementation of a flawed monitoring program would be regulatory required changes in farm management practices based upon incorrect conclusions from an insufficiently planned monitoring program (i.e., possibly contained in Groundwater Quality Management Plans). Acting on false positives would not achieve the goals of the monitoring program and would create additional costs (both direct costs associated with compliance activities and opportunity costs associated with any decreases in yield) for farmers. Further study or, possibly, a pilot program as an interim regulatory step should be considered before creating a comprehensive set of monitoring regulations given the, as yet, rudimentary understanding of how nitrate moves through subsurface in the KRWCA area.

5.0 COMMENTS ON SPECIFIC ASPECTS OF THE ORDER

The following sections highlight some of the more obvious shortcomings of the tentative order if it were applied to the KRWCA area. These comments are not intended to be presented as a comprehensive evaluation of the tentative order.

5.1 General Order

The details set forth in Section VIII (Required Reports and Notifications – Third Party) D (Groundwater Quality Assessment Report and Evaluation/Monitoring Workplans) involve 1) evaluation of groundwater quality vulnerability to impacts from irrigated agriculture (Management Practice Evaluation) and 2) observation of current and future groundwater quality trends attributable to irrigated agriculture (Trend Monitoring). It is important to note that complications associated with identifying sources, or potential sources, of groundwater contamination - both in space (i.e., impacts that migrate away from source locations) and time (i.e., the legacy issue) as noted in Section 4 of this report - will likely be encountered during the performance of the required work. Furthermore, it is likely that more questions than answers will be encountered in many instances. Some recognition of and allowance for these potential technical complications should be included in the tentative order. For example, the development of a Groundwater Quality Management Plan (Section VIII.H.2) should not be required of a current irrigated agricultural operation if there is evidence that an exceedance may have resulted from past (legacy) activities.

5.2 Attachment B – Monitoring and Reporting Program

The reasoning upon which the groundwater portion of this section of the tentative order is based follows from previous sections where there appears to be an implicit assumption that groundwater quality responds to activities occurring at ground surface over a relatively short time period[14]. As an example, Section IV (Groundwater Quality Monitoring and Management Practice Assessment, and Evaluation Requirements) requires that "The third party must collect sufficient data to describe irrigated agricultural impacts on groundwater quality and to determine whether existing or newly implemented management practices comply with the groundwater receiving water limitations of the Order." This task may require decades or more for areas where first-encountered groundwater is located deep beneath the ground surface and transit times are long. (See Section 4.1 of this report for supporting discussion.) Therefore, allowance for potentially long monitoring periods must be reflected in compliance schedules.

As stated above in these comments, there are several complex processes occurring in the KRWCA area that must be interpreted before attempting to link current changes in the quality of first encountered groundwater with current irrigation and fertilizer management practices. As a result, difficulties associated with identifying sources of groundwater contamination – both in space

[14] For the purposes of developing the tentative order, a very simple conceptual model of cause and effect has been applied to a situation where the aggregate effect of active transport processes could be significantly more complicated.

and time – will likely be encountered during the performance of the required work in many instances. Some recognition of and allowance for these potential technical complications should be noted.

Large-scale implementation of the monitoring concept is not appropriate for much of the KRWCA area without further consideration of the issues presented in these comments. Rather, a phased approach should be implemented with initial work being performed on a limited group of areas where technical interpretation of the water quality data is anticipated to be the least complicated. Areas of shallowest first-encountered groundwater may be appropriate candidates for the initial phase of work.

5.3 Appendix MRP-1, Management Plan Requirements, Surface Water and Groundwater

The details presented in Section I (Management Plan Development and Required Components) D (Monitoring Methods) 3 (Groundwater – Additional Requirements) involve evaluation of groundwater quality trend monitoring data in order to draw conclusions regarding additional monitoring requirements. As discussed above, there may be difficulties interpreting the data as a result of unique technical challenges that exist for the KRWCA area. Some recognition of and allowance for these potential technical complications should be noted.

Section I (Management Plan Development and Required Components) G (Source Identification Study Requirements) allows for the identification of sources other than irrigated agriculture that are responsible for groundwater quality impacts. The text should state that past irrigated agriculture is a potential source that is distinct from current irrigated agriculture. It is appropriate to include past irrigated agriculture as a distinct potential source because regulation of current agricultural practices will have no effect on impacts resulting from past practices.

5.4 Appendix MRP-2, Monitoring Well Installation and Sampling Plan and Monitoring Well Installation Completion Report

The reasoning upon which this section of the tentative order is based follows from previous sections where there appears to be an implicit assumption that groundwater quality responds to activities occurring at ground surface over a relatively short time period. As an example, Section II (Monitoring Well Installation and Sampling Plan), A (Stipulations), 4 states that "Groundwater monitoring shall…be of sufficient frequency to allow for evaluation of any seasonal variations." This assumption is flawed. Please refer to the discussion of complexities associated with the KRWCA area presented above.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon the information and analysis presented in the preceding sections of this report, it is clear that hydrogeologic characteristics specific to much of the KRWCA area will greatly complicate and impede implementation of the groundwater monitoring requirements stated in the tentative order. Moreover, the information presented in this report calls into question the scientific basis, efficacy and cost effectiveness of groundwater monitoring as currently required in the tentative order. These points should be addressed in finalizing the tentative order.

It should be noted, however, that there are some relatively small areas within the KRWCA area where the hydrogeology may not impede implementation of monitoring requirements as presented in the tentative order. In areas of shallow first-encountered groundwater (identified approximately with red dashed lines on figures 2a and 3), the depth to groundwater ranges between approximately 0 and 20 feet deep. Given the shallow depth to groundwater in these areas, any water quality responses to current irrigation practices may occur with little delay and trend monitoring may reflect the effects of current irrigation activities. However, impacts to groundwater quality in these areas may have accumulated over time, and current water quality conditions may reflect a combination of effects from past and current irrigation practices. Therefore, it is important that the language in the Tentative Order regarding source identification be modified to categorize past irrigation practices as sources separate from current irrigation operations (see second paragraph of Section 5.3 above).

7.0 REFERENCES

Bertoldi, G.L.., R.H. Johnson and K.D. Evenson. 1991. Ground Water in the Central Valley, California – A Summary Report. U.S. Geological Survey Professional Paper 1401-A. 44 p.

Botros, F.E., T. Harter, Y.S. Onsoy, A. Tuli and J.W. Hopmans. 2009. Spatial Variability of Hydraulic Properties and Sediment Characteristics in a Deep Alluvial Unsaturated Zone. Vadose Zone Journal, 8, 276-289.

Botros, F.E., Y.S. Onsoy, T.R. Ginn and T. Harter. 2012. Richards Equation-Based-Modeling to Estimate Flow and Nitrate Transport in a Deep Alluvial Vadose Zone. Vadose Zone Journal, 11(4), doi: 10.2136/vzj2011.0145.

Boyle, D., A. King, G. Kourakos, K. Lockhart, M. Mayzelle, G.E. Fogg and T. Harter. 2012. Groundwater Nitrate Occurrence, Technical Report 4 in: Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater, Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Science, University of California, Davis. July 2012. 277 p.

Burow, K.R., J.L. Shelton and N.M. Dubrovsky. 1998. Occurrence of Nitrate and Pesticides in Ground Water beneath Three Agricultural Land-Use Settings in the Eastern San Joaquin Valley, California, 1993-1995. U.S. Geological Survey Water-Resources Investigation Report 97-4284. 51 p.

Burow, K.R., J.L. Shelton and N.M. Dubrovsky. 2008. Regional Nitrate and Pesticide Trends in Ground Water in the Eastern San Joaquin Valley, California. Journal of Environmental Quality, 37, S249-S263.

Burton, C.A., J.L. Shelton and K. Belitz. 2008. Ground Water Quality Data in the Southeast San Joaquin Valley, 2005-2006 – Results from the California GAMA Program. U.S. Geological Survey Data Series 351, 103 p.

Burton, C.A., J.L. Shelton and K. Belitz. 2012. Status and Understanding of Groundwater Quality in the Two Southern San Joaquin Valley Study Units, 2005-2006 – California GAMA Priority Basin Project. U.S. Geological Survey Scientific Investigations Report 2011-5218, 150 p.

Croft, M.G. 1972. Subsurface Geology of the Late Tertiary and Quaternary Water-Bearing Deposits of the Southern Part of the San Joaquin Valley, California. U.S. Geological Survey Water-Supply Paper 1999-H. 29 p.

Dale, R.H., J.J. French and G.V. Gordon. 1966. Ground-Water Geology and Hydrology of the Kern River Alluvial-Fan Area, California. U.S. Geological Survey Open-File Report 66-0620. 92 p.

Domagalski, J.L., S.P. Phillips, E.R. Bayless, C. Zamora, C. Kendall, R.A. Wildman Jr. and J.G. Hering. 2008. Influences of the Unsaturated, Saturated, and Riparian Zones on the Transport of Nitrate near the Merced River, California, USA. Hydrogeology Journal, 16, 675-690.

Dubrovsky, N.M., C.R. Kratzer, L.R. Brown, J.M. Gronberg and K.R. Burow. 1998. Water Quality in the San Joaquin – Tulare Basins, California, 1992-1995. U.S. Geological Survey Circular 1159. 38p.

Dubrovsky, N.M., K.R. Burow, G.M. Clark, J.M. Gronberg, P.A. Hamilton, K.J. Hitt, D.K. Mueller, M.D. Munn, B.T. Nolan, L.J. Puckett, M.G. Rupert, T.M. Short, N.E. Spahr, L.A. Sprague and W.G. Wilber. 2010. The Quality of Our Nation's Waters – Nutrients in the Nation's Streams and Groundwater, 1992-2004. U.S. Geological Survey Circular 1350. 174p.

DWR. 2006. California's Groundwater (section on San Joaquin Valley Groundwater Basin, Kern County Subbasin). California Department of Water Resources Bulletin 118, updated January 20, 2006. (http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/5-22.14.pdf, last accessed 1/10/13).

Fisher, L.H. and R.W. Healey. 2008. Water Movement within the Unsaturated Zone in Four Agricultural Areas of the United States. Journal of Environmental Quality, 37, 1051-1063.

Green, C.T., D.A. Stonestrom, B.A. Bekins, K.C. Akstin and M.S. Schultz. 2005. Percolation and Transport in a Sandy Soil under a Natural Hydraulic Gradient. Water Resources Research, 41, W10414, doi:10.1029/2005WR004061.

Green, C.T., L.J. Puckett, J.K. Bohlke, B.A. Bekins, S.P. Phillips, L.J. Kauffman, J.M. Denver and H.M. Johnson. 2008a. Limited Occurrence of Denitrification in Four Shallow aquifers in Agricultural Areas of the Unites States. Journal of Environmental Quality, 37, 994-1009.

Green, C.T., L.H. Fisher and B.A. Bekins. 2008b. Nitrogen Fluxes through Unsaturated Zones in Five Agricultural Settings across the United States. Journal of Environmental Quality, 37, 1073-1085.

Green, C.T. and B.A. Bekins. 2010. Sustainability of Natural Attenuation on Nitrate in Agricultural Aquifers. U.S. Geological Survey Fact Sheet 2010-3077. 4 p.

Gronberg, J.M., N.M. Dubrovsky, C.R. Kratzer, J.L. Domagalski, L.R. Brown and K.R. Burow. 1998. Environmental Setting of the San Joaquin – Tulare Basins, California. U.S. Geological Survey Water-Resources Investigations Report 97-4205. 45 p.

Harter, T., Y.S. Onsoy, K. Heeren, M. Denton, G. Weissmann, J.W. Hopmans and W.R. Horwath. 2005. Deep Vadose Zone Hydrology Demonstrates Fate of Nitrate in Eastern San Joaquin Valley. California Agriculture, 59(2), 124-132.

Harter, T., J.R. Lund, J. Darby, G.E. Fogg, R. Howitt, K.K. Jessoe, G.S. Pettygrove, J.F. Quinn and J.H. Viers (Investigators). 2012. Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater, Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Science, University of California, Davis. January 2012. 78 p.

KCWA. 2008. Water Supply Report: 2008. Kern County Water Agency. 79 p.

Kung, K-J.S. 1990a. Preferential Flow in a Sandy Vadose Zone:1. Field Observation. Geoderma, 46, 51-58.

Kung, K-J.S. 1990b. Preferential Flow in a Sandy Vadose Zone: 2. Mechanism and Implication. Geoderma, 46, 59-71.

Landon, M.K., K. Belitz, B.C. Jurgens, J.T. Kulongoski and T.D. Johnson. 2010. Status and Understanding of Groundwater Quality in the Central-Eastside San Joaquin Basin, 2006: California GAMA Priority Basin Project. U.S. Geological Survey Scientific Investigations Report 2009-5266. 97 p.

Lindsey, B.D. and M.G. Rupert. 2012. Methods for Evaluating Temporal Groundwater Quality Data and Results of Decadal-Scale Changes in Chloride, Dissolved Solids and Nitrate Concentrations in Groundwater in the United States, 1988-2010. U.S. Geological Survey Scientific Investigations Report 2012-5049. 46 p.

Lofgren, B.E. 1975. Land Subsidence Due to Ground-Water Withdrawal, Arvin-Maricopa Area, California. U.S. Geological Survey Professional Paper 437-D. 55 p.

McMahon, P.B., K.F. Dennehy, B.W. Bruce, J.K. Bohlke, R.L. Michel, J.J. Gurdak and D.B. Hurlbut. 2006. Storage and Transit Time of Chemicals in Thick Unsaturated Zones under Rangeland and Irrigated Cropland, High Plains, United States. Water Resources Research, 42, W03413, doi:10.1029/2005WR004417.

Onsoy, Y.S., T. Harter, T.R. Ginn and W.R. Horwath. 2005. Spatial Variability and Transport of Nitrate in a Deep Alluvial Vadose Zone. Vadose Zone Journal, 4, 41-54.

Page, R.W. 1986. Geology of the Fresh Ground-Water Basin of the Central Valley, California, with Texture Maps and Sections. U.S. Geological Survey Professional Paper 1401-C. 54 p.

Puckett, L.J., C. Zamora, H. Essaid, J.T. Wilson, H.M. Johnson, M.J. Brayton and J.R. Vogel. 2008. Transport and Fate of Nitrate at the Ground-Water/Surface-Water Interface. Journal of Environmental Quality, 37, 1034-1050.

Rupert, M.G. 2008. Decadal-Scale Changes of Nitrate in Ground Water of the United States, 1988-2004. Journal of Environmental Quality, 37, S240-S248

Schmidt, C.M., A.T. Fisher, A. Racz, C.G. Wheat, M. Los Huertos and B. Lockwood. 2011. Rapid Nutrient Load Reduction During Infiltration of Managed Aquifer Recharge in an Agricultural Groundwater Basin: Pajaro Valley, California. Hydrological Processes, wileyonlinelibrary.com, doi: 10.1002/hyp.8320.

Shelton, J.L., I. Pimentel, M.S. Fram and K. Belitz. 2008. Ground-Water Quality Data in the Kern County Subbasin Study Unit, 2006 – Results from the California GAMA Program. U.S. Geological Survey Data Series 337. 75 p.

Singleton, M.J., S.K. Roberts, J.E. Moran and B.K. Esser. 2001. California GAMA Domestic Wells: Nitrate and Water Isotopic Data for Tulare County. Final Report for GAMA Special Studies Task 7.2, Specialized Analyses for GAMA Domestic Wells, LLNL-TR-450497. Lawrence Livermore National Laboratory. January 2001.

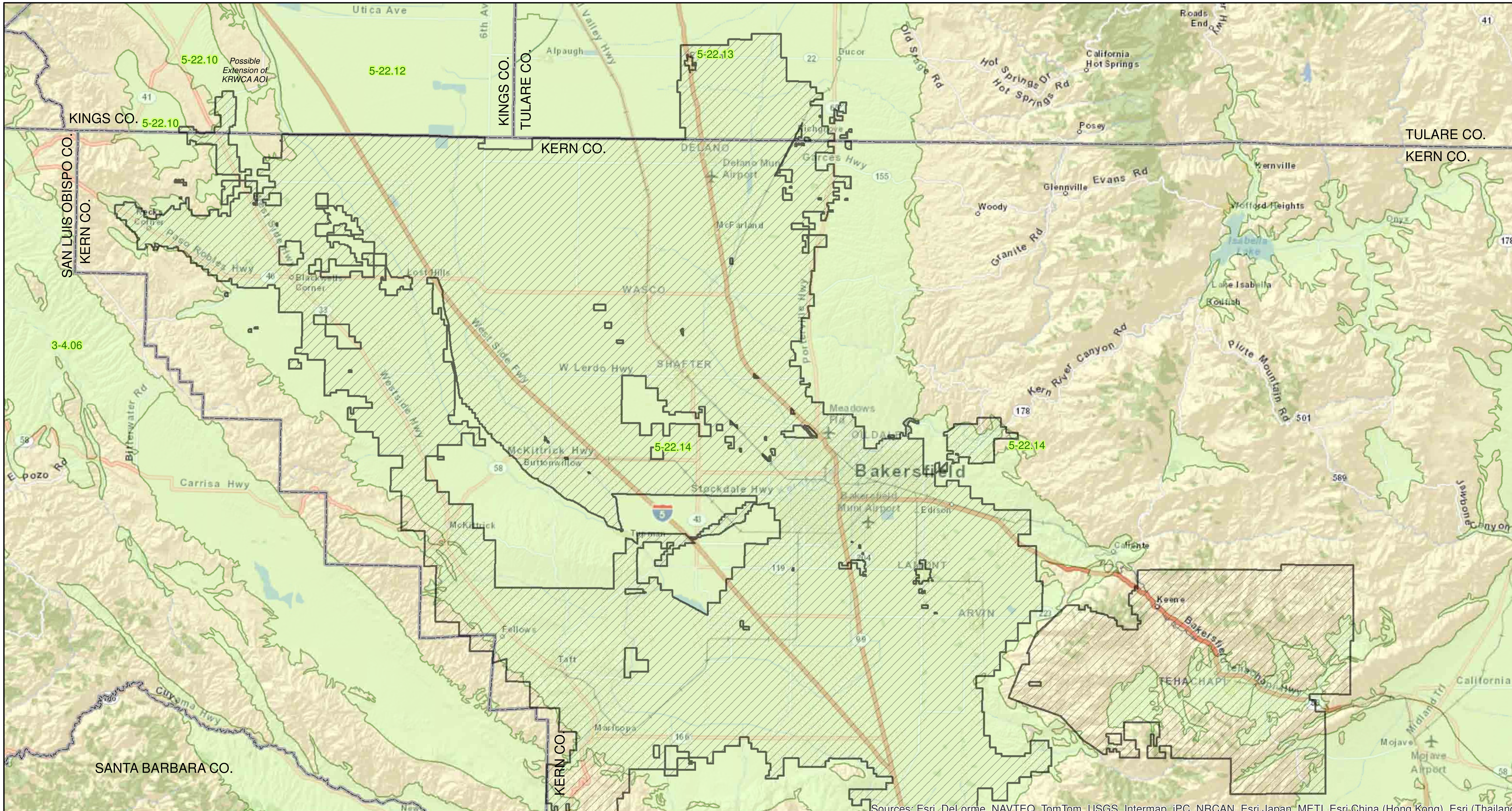
Tesoriero, A.J., D.A. Saad, K.R. Burow, E.A. Frick, L.J. Puckett and J.E. Barbash. 2007. Linking Ground-Water Age and Chemistry Data Along Flow Paths: Implications for Trends and Transformations of Nitrate and Pesticides. Journal of Contaminant Hydrology, 94, 139-155.

Weissmann, G.S., J.F. Mount and G.E. Fogg. 2002. Glacially Driven Cycles in Accumulation Space and Sequence Stratigraphy of a Stream-Dominated Alluvial Fan, San Joaquin Valley, California, U.S.A. Journal of Sedimentary Research, 72(2), 240-251.

Williamson, A.K., D.E. Prudic and L.A. Swain. 1989. Ground-Water Flow in the Central Valley, California. U.S. Geological Survey Professional Paper 1401-D. 127 p.

Wood, P.R. and R.H. Dale. 1966. Geology and Ground-Water Features of the Edison-Maricopa Area Kern County, California. U.S. Geological Survey Water-Supply Paper 1656. 108 p.

FIGURES



0 5 10 Miles

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company
130 N. Garden Street
Visalia, CA 93291
(559) 636-1166

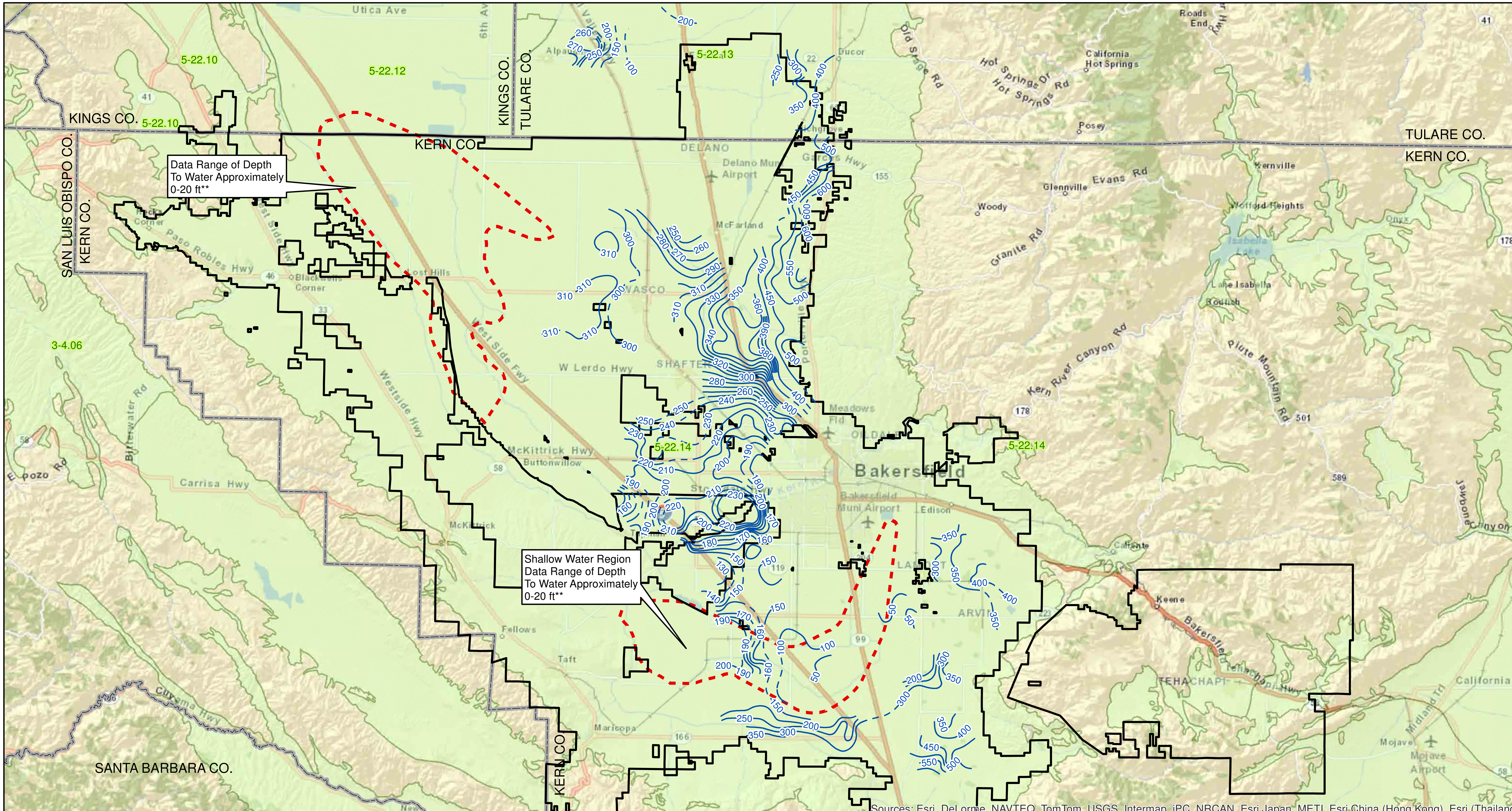
DWR Groundwater Basin/Subbasin (ID Label)
County
KRWCA Boundary

Kern County Irrigated Lands Program
Kern Sub-Watershed

KRWCA Area

FIGURE 1

4/5/2013: V:\Clients\Kern River Watershed Coalition Authority-3484\348412V1-ILRP 2012\GIS\Map\DataProcessingForRobGailey\ReportFigs\figure1.mxd



0 5 10 Miles

PROVOST & PRITCHARD CONSULTING GROUP
EST. 1968
An Employee Owned Company
130 N. Garden Street
Visalia, CA 93291
(559) 636-1166

- DWR Groundwater Basin/Subbasin (ID Label)
- County
- KRWCA Boundary
- Shallow Water Region - Approximate**

Depth To Water - Unconfined Aquifer***

- High Degree of Confidence
- Inferred

Data References:

**Areas digitized from CA DWR "Present and Potential Drainage Problem Areas" survey map, 2010
http://www.water.ca.gov/pubs/drainage/2010_shallow_groundwater_map__san_joaquin_valley/sgw10.pdf

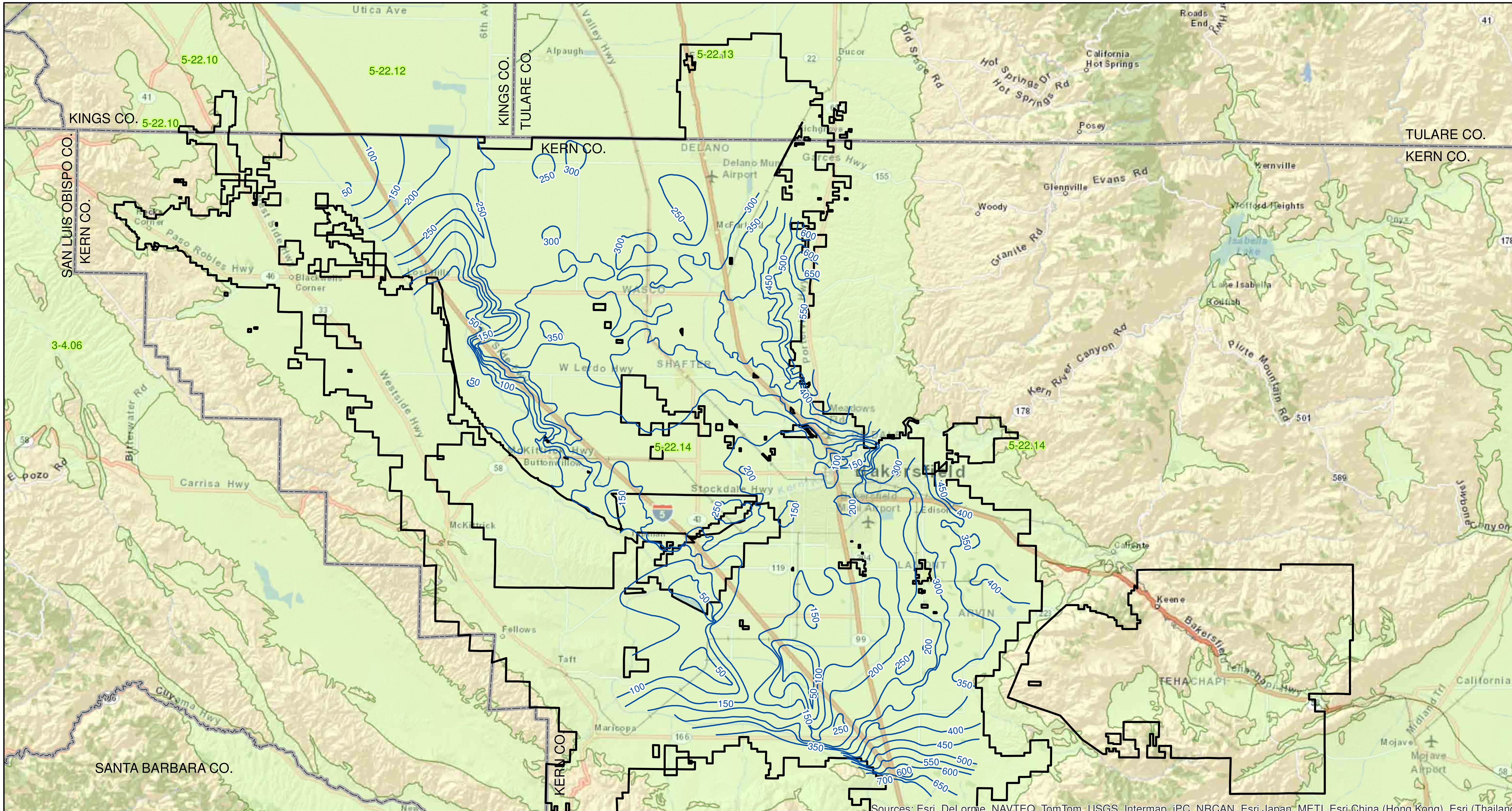
***Isopleth lines from CA DWR "Lines of Equal Depth to Water in Wells, Unconfined Aquifer, San Joaquin Valley, Spring 2010"
http://www.water.ca.gov/groundwater/data_and_monitoring/south_central_region/images/groundwater/sjv2010spr_unc_depth.pdf

Kern County Irrigated Lands Program
Kern Sub-Watershed

Spring 2010
Depth To Water In Wells
DWR Representation

FIGURE 2A

4/5/2013: V:\Clients\Kern River Watershed Coalition Authority-3484\348412V1-ILRP 2012\GIS\Map\DataProcessingForRobGailey\ReportFigs\figure2.mxd



0 5 10 Miles

PROVOST& PRITCHARD CONSULTING GROUP — An Employee Owned Company — EST. 1968

130 N. Garden Street
Visalia, CA 93291
(559) 636-1166

- DWR Groundwater Basin/Subbasin (ID Label)
- County
- KRWCA Boundary
- Depth to Water - KCWA Spring 2010, 50 ft interval**

Data References:

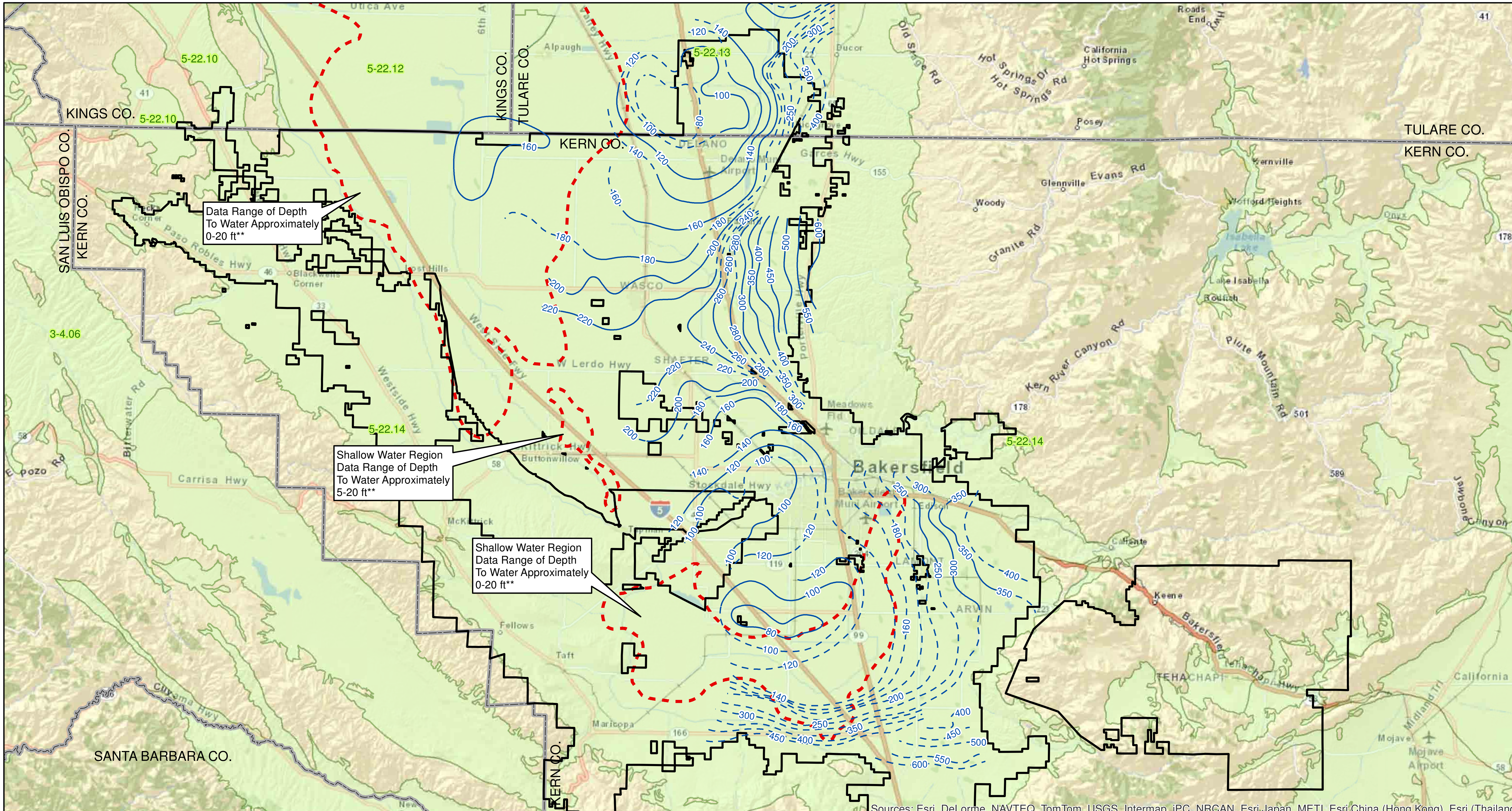
**Isopleth lines digitized from Kern County Water Agency, published map of Depth to Groundwater, Unconfined Aquifer, Spring 2010. Published 07/2010.

Kern County Irrigated Lands Program
Kern Sub-Watershed

Spring 2010
Depth To Water In Wells
KCWA Representation

FIGURE 2B

4/5/2013: V:\Clients\Kern River Watershed Coalition Authority-3484\348412V1-ILRP 2012\GIS\Map\DataProcessingForRobGailey\ReportFigs\figure2b.mxd



0 5 10 Miles

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company
130 N. Garden Street
Visalia, CA 93291
(559) 636-1166

DWR Groundwater Basin/Subbasin (ID Label)

County

KRWCA Boundary

Shallow Water Region - Approximate**

Depth To Water - Unconfined Aquifer***

High Degree of Confidence

Inferred

Data References:

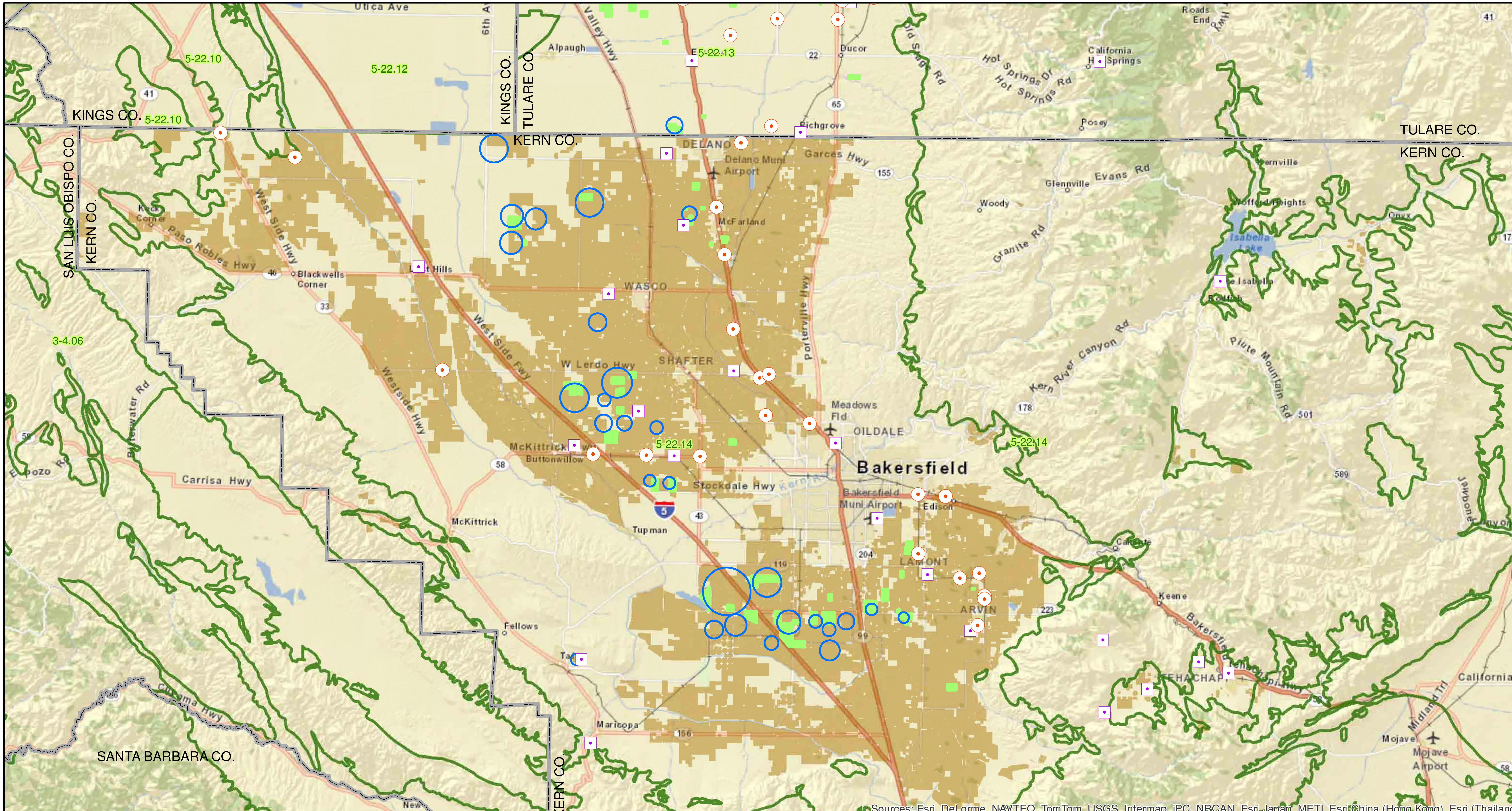
**Areas digitized from CA DWR "Present and Potential Drainage Problem Areas" survey map, Figure 4, data from 1986. Map dated April 1987. Report dated April 1988.
http://www.water.ca.gov/pubs/drainage/1986_drainage_monitoring_report__san_joaquin_valley/86dmr.pdf

***Isopleth lines from CA DWR "Lines of Equal Depth to Water in Wells, Unconfined Aquifer, San Joaquin Valley, Spring 1988"
http://www.water.ca.gov/groundwater/data_and_monitoring/south_central_region/images/groundwater/sjv1988spr_unc_depth.pdf

Kern County Irrigated Lands Program
Kern Sub-Watershed

Later 1980's
Depth To Water In Wells
DWR Representation

FIGURE 3



0 5 10 Miles

PROVOST& PRITCHARD CONSULTING GROUP

EST. 1968

An Employee Owned Company

130 N. Garden Street
Visalia, CA 93291
(559) 636-1166

- Food Processor (Approx. Location)*
- Waste Water Facility (Approx. Location)**
- Effluent, Biosolids, and On-Dairy Manure N for Cropland Application***
- Dairy Facility****
- Irrigated Lands - Kern County Crop Survey 2011
- DWR Groundwater Basin/Subbasin (ID Label)
- County

Data References:

* Approximate locations. UC Davis Report for the SWRCB SBX2 1 Report to the Legislature, Addressing Nitrate in California's Drinking Water. Technical Report 2. Hater et al. July 2012. Appendix Fig. 1.

**Approximate locations. UC Davis Report for the SWRCB SBX2 1 Report to the Legislature, Addressing Nitrate in California's Drinking Water. Technical Report 2. Hater et al. July 2012. Appendix Fig. 2.

***Generalized areas of modeled Nitrate applied to croplands, kg N/ha/yr >500 . UC Davis Report for the SWRCB SBX2 1 Report to the Legislature, Addressing Nitrate in California's Drinking Water. Technical Report 2. Hater et al. July 2012. Fig. 11.

****SWRCB draft dairy facilities parcels.

Kern County Irrigated Lands Program
Kern Sub-Watershed

Potential Nitrate Sources

FIGURE 4

4/5/2013: V:\Clients\Kern River Watershed Coalition Authority-3484\348412V1-ILRP 2012\GIS\Map\DataProcessingForRobGailey\ReportFigs\figure4.mxd

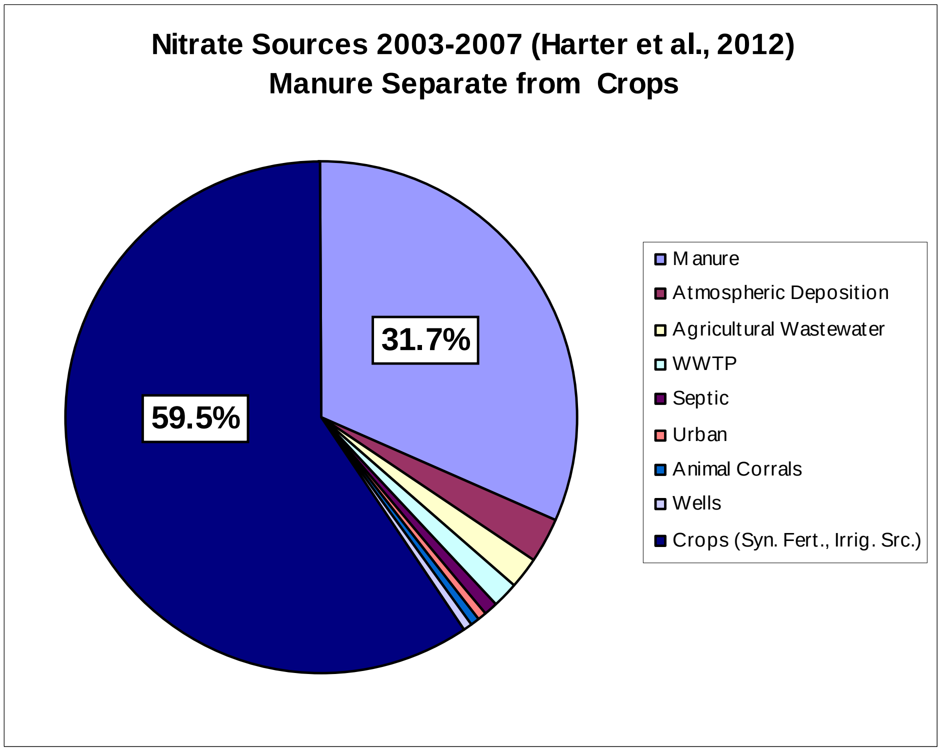


Figure 5: Current Nitrate Sources 2003 – 2007

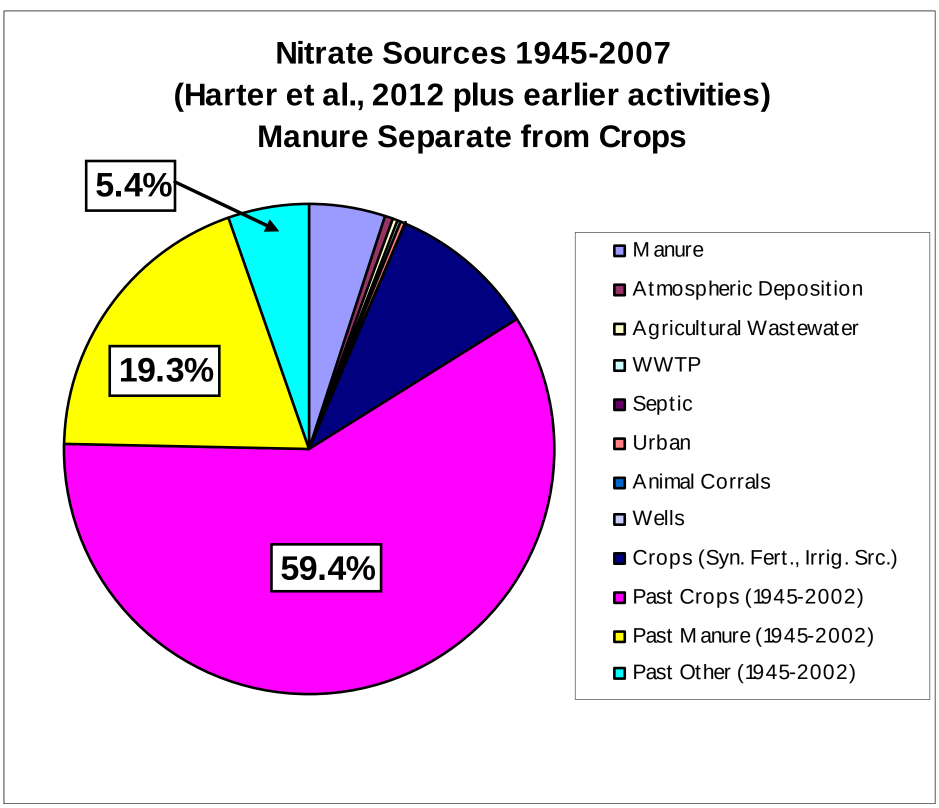


Figure 6: Current and Past Nitrate Sources 1945 – 2007

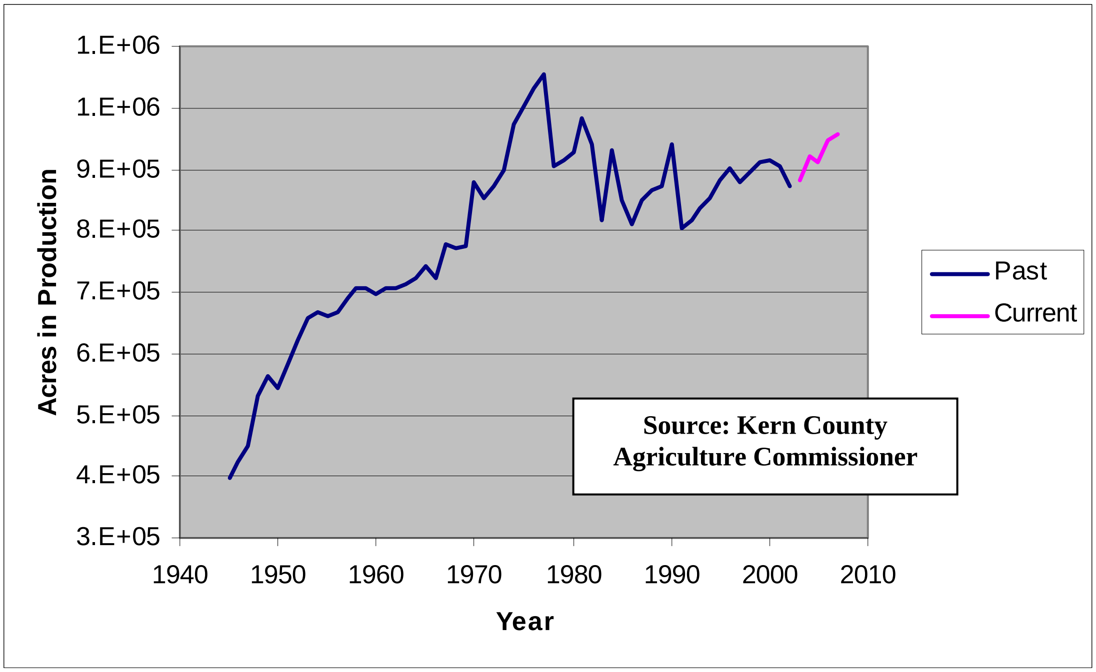


Figure 7: Historical Record of Kern County Acres in Crop Production

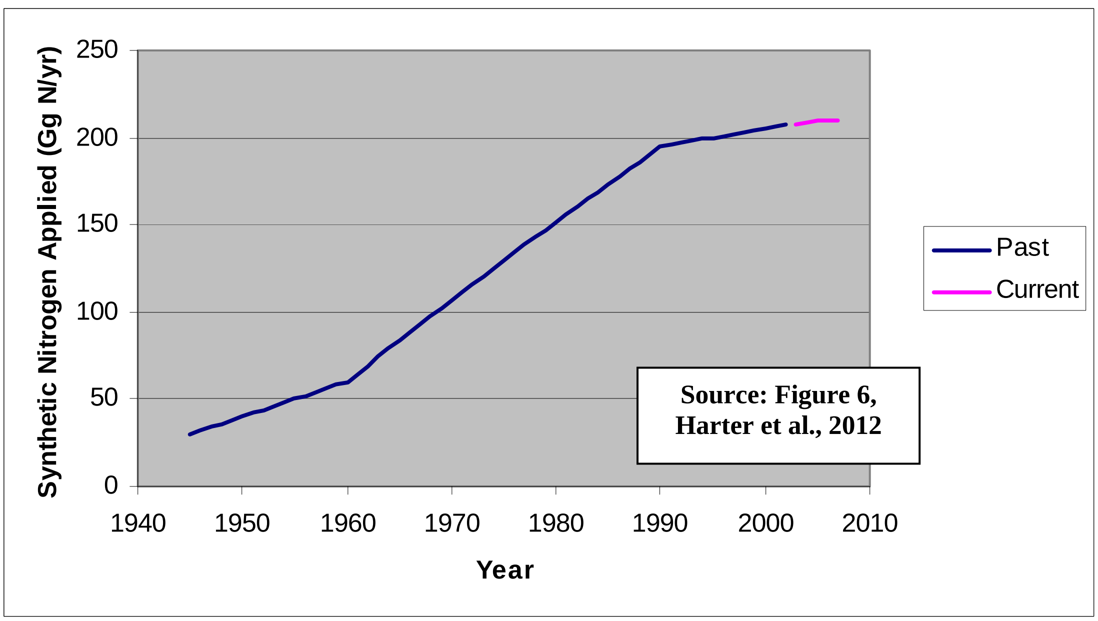


Figure 8: Historical Record of Fertilizer Nitrogen Applied to Crops in the United States

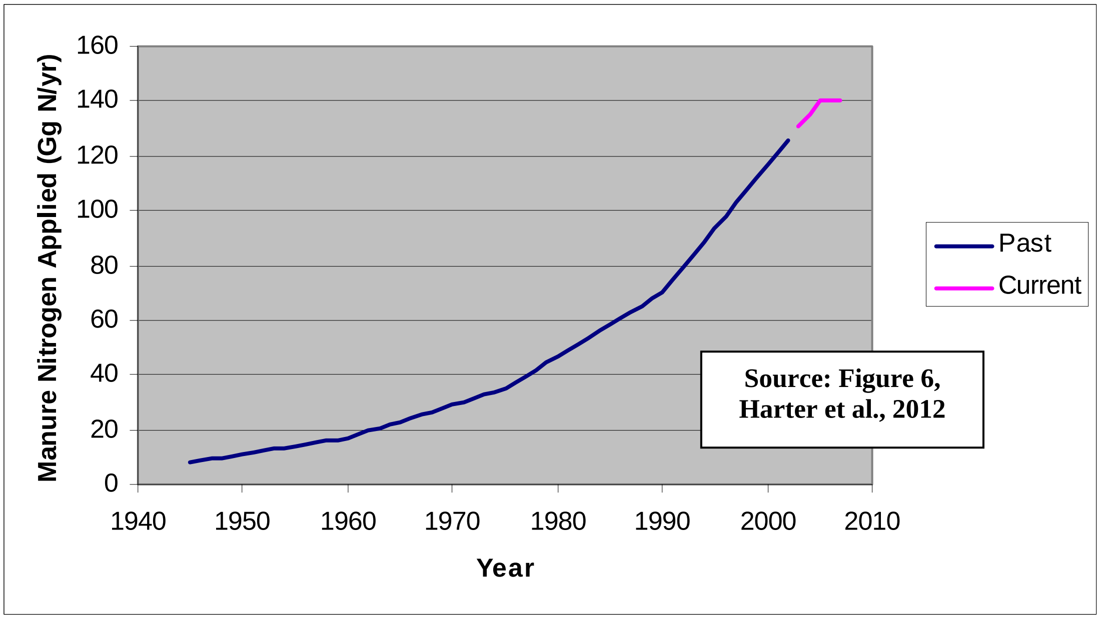


Figure 9: Historical Record of Manure Nitrogen Applied to Crops in the United States

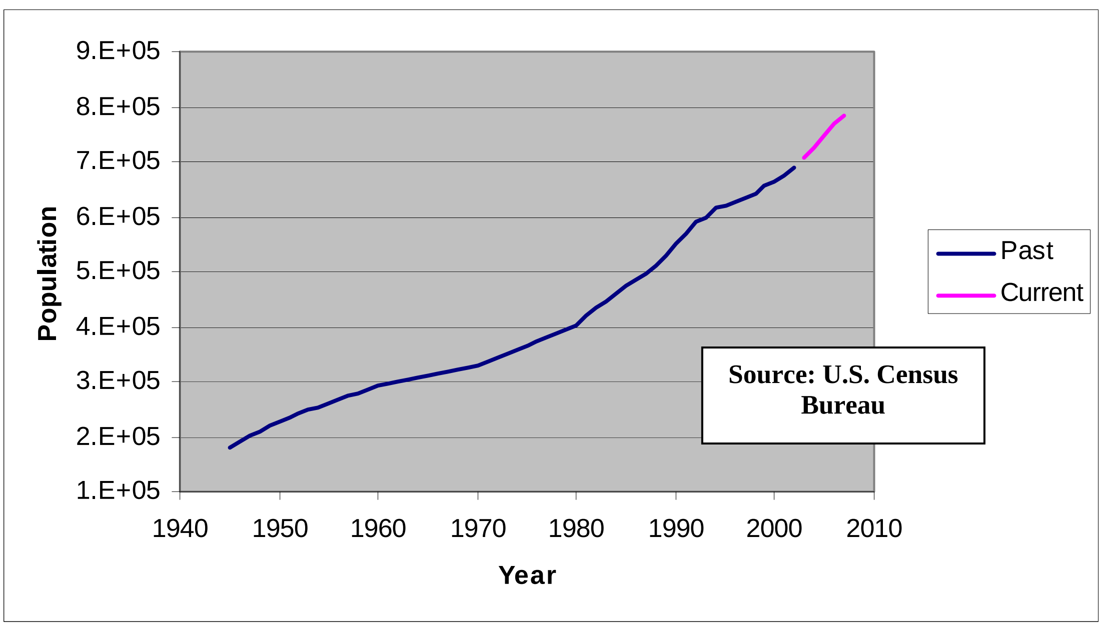
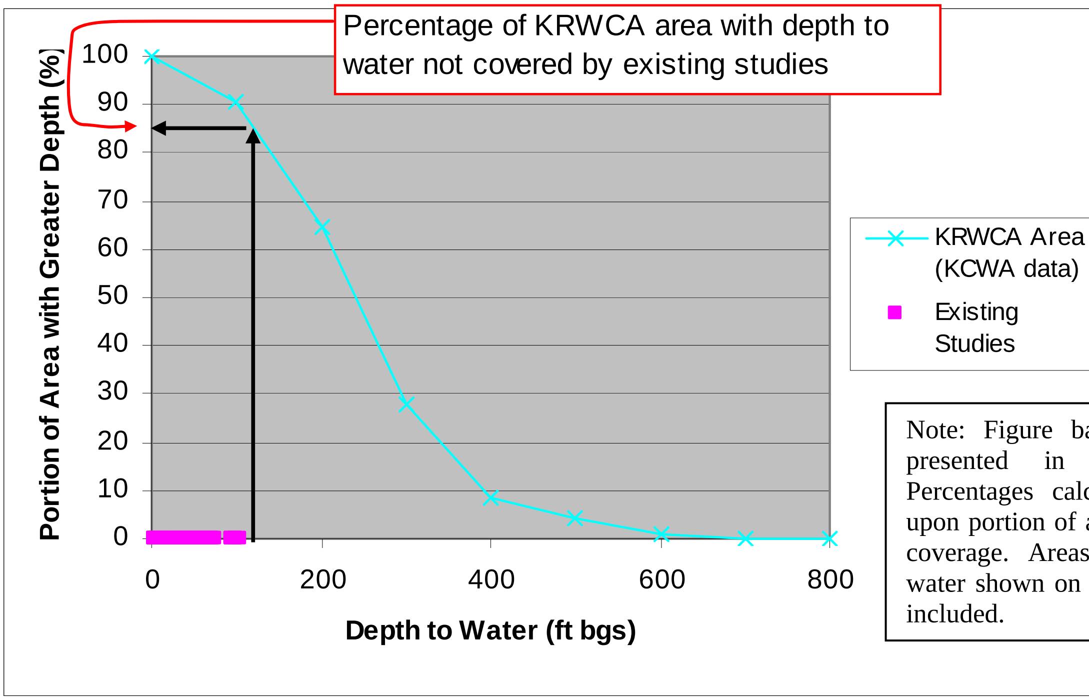


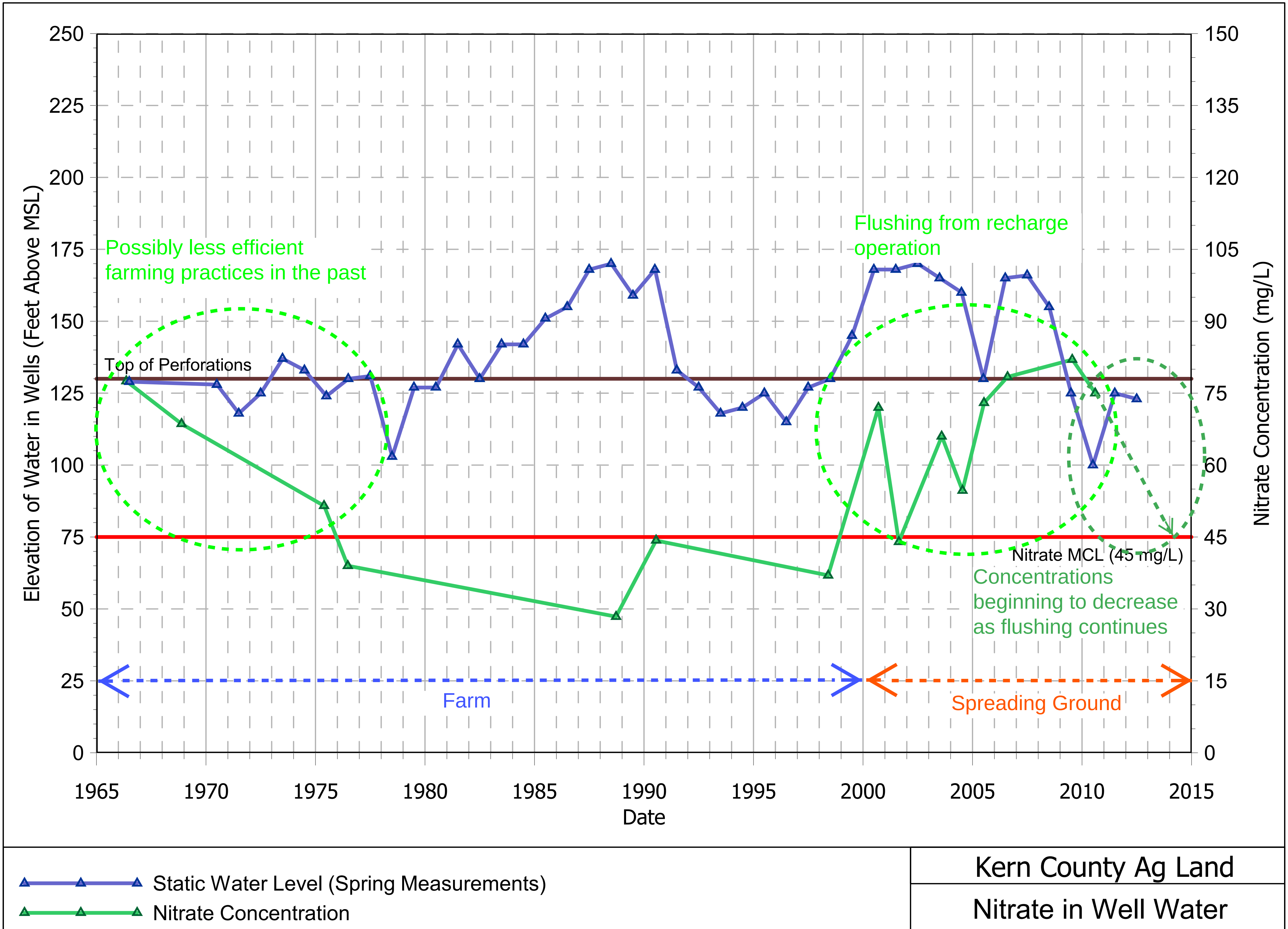
Figure 10: Historical Record of Kern County Population



Note: Figure based on data presented in Figure 2b. Percentages calculated based upon portion of area with data coverage. Areas of "perched" water shown on Figure 2a not included.

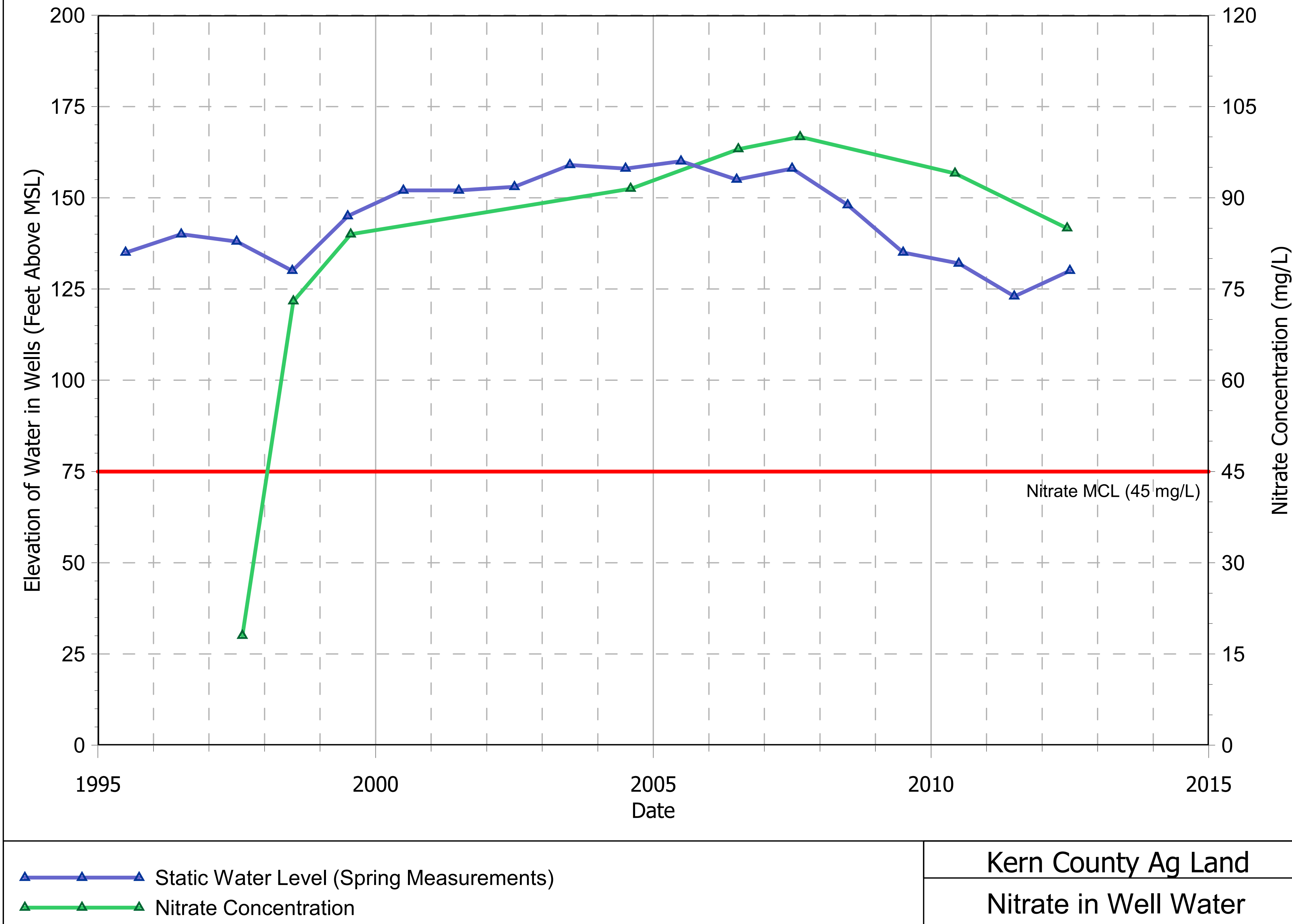
Figure 11: Portion of KRWCA Area with First-Encountered Saturated Zone Water Deeper than a Specified Value

Figure 12



Kern County Ag Land
Nitrate in Well Water
Unidentified Irrigation Well **1**

Figure 13

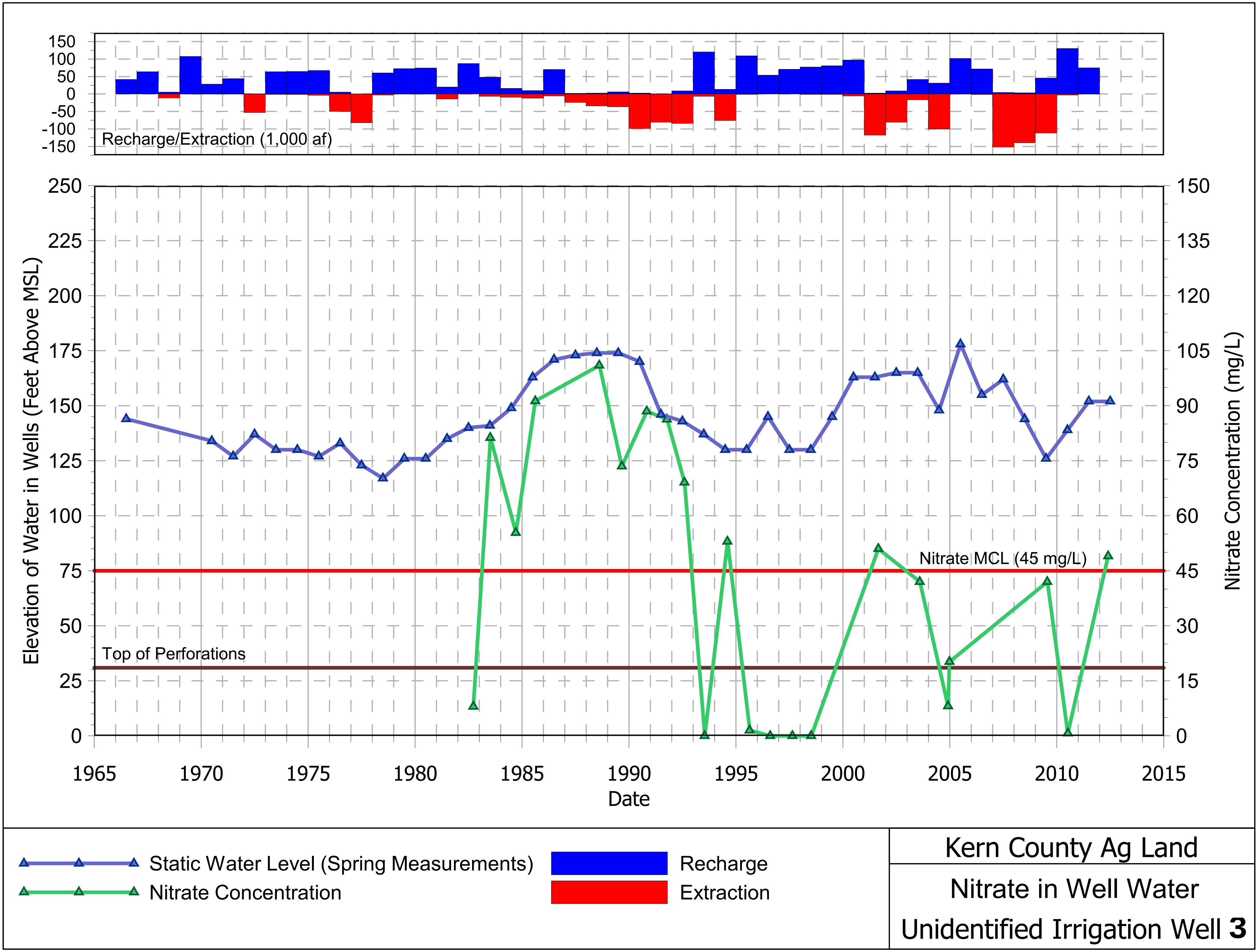


Kern County Ag Land

Nitrate in Well Water

Unidentified Irrigation Well 2

Figure 14



Recharge/Extraction (1,000 af)
150
100
50
0
-50
-100
-150
Elevation of Water in Wells (Feet Above MSL)
250
225
200
175
150
125
100
75
50
25
0
Nitrate Concentration (mg/L)
150
135
120
105
90
75
60
45
30
15
0
Nitrate MCL (45 mg/L)
Top of Perforations
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Date
Static Water Level (Spring Measurements)
Nitrate Concentration
Recharge
Extraction
Kern County Ag Land
Nitrate in Well Water
Unidentified Irrigation Well 3

APPENDIX A

CURRICULUM VITAE FOR ROBERT M. GAILEY

Robert M. Gailey, P.G., C.HG.

Principal Hydrogeologist

Summary

Mr. Gailey has 28 years of experience on a wide range of projects in the field of hydrogeology. In the process of conducting projects throughout much of the United States, he has conducted site investigations ranging from preliminary site assessments to remedial investigations, negotiated with regulatory agencies for closure of contaminated sites as well as operation of municipal supply wells, provided critical review of technical documents, prepared written and verbal arguments for litigation and cost allocation, evaluated strategies for capture of groundwater solute plumes, designed and implemented remedial actions, assessed the effectiveness of ongoing groundwater remediation programs, mapped aquifers and assessed conditions for water supply development, performed water supply well siting evaluations, assessed water supply well conditions and performance, evaluated potential effects of well-field operations on water rights for adjacent parcels, and evaluated potential impacts on groundwater supplies related to groundwater contamination and proposed land development. This work has been conducted in accordance with local and state requirements, and federal requirements (CERCLA, RCRA, and SDWA) as administered by both state and federal agencies. Many of the hydrogeologic evaluations have been performed at scales that range up to basin-wide analysis.

For remediation and wastewater projects, Mr. Gailey has worked on both active and inactive industrial and commercial facilities where both organic constituents (petroleum, semi-volatile organic compounds [SVOCs], and volatile organic compounds [VOCs]) and inorganic constituents (heavy metals, nitrate, perchlorate, total dissolved solids [TDS], and tritium) have been present. The types of industries involved include agriculture (dairy and crop), airline, banking, barrel processing, chemical, defense, dry cleaning, electronics, food processing, flare manufacturing, insurance, machining, mining, petroleum (retail, storage, and refining), real estate, steel, trucking, waste disposal, and wood treatment. In addition, he has performed review and analysis for law firms and government agencies (Army Corps of Engineers [ACE], Department of Energy [DOE], Environmental Protection Agency [EPA], and Washington Department of Ecology). This work has involved hydrogeologic evaluation, modeling, statistical and other data analysis, and database management. The purposes of this work have included characterizing site conditions, predicting exposure point concentrations, developing remedial designs, evaluating ongoing remedial effectiveness, and performing comparative data analyses to meet various project needs.

For water supply projects, Mr. Gailey has worked on both municipal and rural facilities. The industries served include private and municipal water supply, agriculture, food processing, hospital, hotel, and mining. This work has involved hydrogeologic evaluation, well siting and performance evaluation (step discharge, pumping and wire-to-water tests), flow and concentration profiling (under pumping and static conditions using both spinner logs and the U.S. Geological Survey [USGS] dye tracer approach) water quality impact assessment (arsenic, bacteria, nitrate, pesticides, TDS, uranium and VOCs), feasibility testing for well modification, modeling, database management, economic and optimization analysis, and preparing construction and equipment specifications. The purposes of this work have been included developing and rehabilitating municipal and other water supplies, enhancing well field operations, and managing groundwater resources.

Project Experience

- Provides technical analysis related to hydrogeologic aspects of projects. Issues for analysis include hydraulic analysis for water supply and construction projects, water supply assessment, the distribution and migration of constituents of concern in groundwater, benefits of naturally occurring biodegradation, remediation system performance, and environmental impact assessment under the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA).
- Provides testimony, technical counsel, and support for regulatory negotiations and litigation involving 1) groundwater/soil cleanup and cost allocation related to serial and adjacent tenancy of commercial, industrial, and retail parcels and 2) conflicts over water resources. Has prepared expert reports and material for interrogatories and declarations, participated in the meet-and-confer process and settlement discussion, developed case strategy under the client-attorney confidentiality umbrella, briefed expert witnesses on technical aspects of cases, and provided deposition testimony.

Water Supply Assessment and Service

- Serving as Technical Lead evaluating the source of PCE in a municipal water supply well located in the Central Valley of California. Vertical flow and concentration profiling (USGS dye tracer approach) under ambient (non-pumping) conditions has been performed and profiling under dynamic (pumping) conditions is planned. The goal of the project is to modify the well and improve water quality at the wellhead.

Project Experience – *Water Supply Assessment and Service (cont.)*

- Serving as Technical Lead for ongoing supply well water quality evaluations at various locations throughout California. At issue is whether pumping operations and the well screens can be modified to reduce constituent concentrations (i.e., arsenic, manganese, nitrate, TDS, uranium and VOCs) to below drinking water standards. Vertical flow and concentration profile data are often collected from the wells using miniaturized tools so that the pumps do not have to be removed (USGS dye tracer approach). Data collection plans are developed to, among other things, account for uncertainty in pump intake depths, maximize information value and minimize the impact of any data collection uncertainties. For projects where evaluation results indicate that modifications may improve water quality, feasibility testing is performed and, as appropriate, recommendations for final modification of operations and facilities are provided. Management, or support as appropriate, of fieldwork is provided throughout the projects.
- Serving as Technical Lead performing analysis and construction tasks related to rehabilitating and modifying a water supply well for a disadvantaged community located in the Central Valley of California. The goal of the project is to reduce nitrate concentrations at the wellhead. Project work includes preparing technical specifications as well as conducting construction inspection, vertical flow and concentration profiling (USGS dye tracer approach), feasibility testing data analysis.
- Providing technical support to a public utility district regarding data collection and analysis for establishing baseline hydrologic conditions in a small groundwater basin located on the Central Coast of California. The work is being performed to support interest in developing the water resource. Project work has included installing water level and barometric transducers, training district staff regarding transducer maintenance and data retrieval, and data analysis related to evaluating safe yield for the basin
- Serving as Technical Lead to provide technical specifications and construction inspection support for the rehabilitation of four municipal water supply wells located in the Central Valley of California. The work is being performed subsequent to an initial evaluation of ten wells (specific capacity testing, progressive-volume water quality sampling, and video inspection without removing the vertical turbine pumps). The wells have not been rehabilitated within the past 40 to 60 years, and the removal of significant amounts of calcium carbonate scaling is necessary to increase the specific capacities of the wells. Space and wastewater discharge limitations are particular challenges being addressed to successfully complete the project. Particular attention has been given to balancing the benefits of improving hydraulic performance of the wells against the potential costs of damaging the aged wells. Thus far, spinner log and specific capacity testing conducted before and after the rehabilitation work have quantified performance increases in specific capacity of as much as 30 percent.
- Serving as Technical Lead to provide technical specifications and construction inspection support for the rehabilitation of four municipal water supply wells and pumps located in the Central Valley of California. The wells have not been rehabilitated within the past 20 years, and the removal of calcium carbonate and iron oxide scaling as well as bacterial mass is necessary to increase the specific capacities of the wells. Because the municipality relies heavily on the groundwater portion of its water supply, the project is being phased so that the construction activity does not impede the municipality's ability to meet demand. Thus far, spinner log, specific capacity and wire to water testing conducted before and after the rehabilitation work have quantified performance increases in specific capacity of 16 percent and plant efficiency of 32 percent.

Project Experience – *Water Supply Assessment and Service (cont.)*

- Serving as Technical Lead for evaluating potential hydraulic manipulation evaluation of a municipal water supply well located in the Central Valley of California. The focus of the work is to reduce nitrate concentration at the wellhead by changing how the well draws from strata that contain varying concentrations of nitrate. Vertical flow and concentration profiling data from the well (USGS dye tracer approach) were considered in order to identify a design strategy that would allow the well to be brought back on-line without the use of expensive wellhead treatment. The design strategy entailed well screen modification. Field testing of the design concept entailed step-discharge testing, sequential discharge sampling and packer testing in order to evaluate the potential improvement to water quality and decrease in production capacity associated with the chosen well screen modification design. The testing results proved that well modification will be sufficient to address the water quality issue and no treatment system will be required. Current project activities involve finalizing the well modification.
- Provided technical consultation related to bringing a new municipal water supply well online in the Central Valley of California. At issue were bacterial concentrations (total coliform and heterotrophic place counts). Extended purging, chlorination and cycle testing resulted in approval from the Department of Public Health for bringing the well online.
- Served as Technical Lead to perform an analysis for a county water management agency in northeastern California that determined the applicability of alternative monitoring approaches for compliance with the California Statewide Groundwater Elevation Monitoring (CASGEM) program. Six basins were evaluated and a report consistent with California Water Code requirements was prepared within five weeks to meet a client deadline. The report, first in the state to be accepted by the California Department of Water Resources (DWR), was finalized with only minor revisions after review by the DWR.
- Provided technical review of a draft Environmental Impact Statement prepared in accordance with NEPA for a proposed shale gas hydraulic fracturing project to be performed in a western state. At issue were a variety of concerns related to impacts upon water quantity and quality.
- Served as Technical Lead for an expedited review of well and pumping system conditions for four municipal supply wells located in the Central Valley of California. Issues of interest were 1) reduced production rates over time and 2) potential improvements in water quality through well modification in order to avoid the use of treatment systems. Miniaturized equipment was used to video log the wells in order to perform an initial assessment of well and pumping system condition. The pumps in all four wells were further evaluated by performing wire-to-water testing. Three of the wells were further evaluated by performing flow and concentration profiling (USGS dye tracer approach). The constituents of potential concern were arsenic, uranium, manganese and TDS. The findings were that 1) reduced production rates had resulted from both pump wear and well screen fouling and 2) well modification likely would not significantly improve water quality. The field work and reporting was completed in just under four weeks to meet this client's schedule requirements.
- Provided consultation related to increasing the water supply for a medical facility in northern California. The initial task was to review water development efforts in a limited-access area that had been unsuccessful and to recommend additional efforts in the same area. After reviewing the available information and performing field reconnaissance of the subject area, an alternative course of action was identified. The alternative approach to water development was based upon making a connection, previously missed by others, between pieces of information related to the groundwater availability and pumping system capacity. Once limited pumping capacity was identified as the primary issue, additional work in the remote access area was avoided and a significant water supply was readily developed.
- Served as Technical Lead for evaluating potential hydraulic manipulation of a municipal water supply well located in southern California east of Los Angeles. The focus of the work was to reduce arsenic concentrations at the wellhead by changing how the well draws from strata that contain varying concentrations of arsenic. Vertical flow and concentration profiling data (USGS dye tracer approach) from the well were considered along with other water supply system information in order to identify a design strategy that would allow the well to be brought back on-line without the use of expensive wellhead treatment. The design strategy included a combination of well screen modification and blending of the well discharge with that from two other wells. Field testing of the design concept entailed step-discharge testing, sequential discharge sampling and packer testing in order to evaluate the potential improvement to water quality and decrease in production capacity associated with the chosen well screen modification design. In this case, it was established that the site hydrogeology did not support successful well modification.

Project Experience – *Water Supply Assessment and Service (cont.)*

- Served as Technical Lead for evaluating the potential to hydraulically manipulate a municipal water supply well located in the Central Valley of California. The constituent of concern was arsenic. Vertical flow and concentration profiling data (USGS dye tracer approach) were collected. No additional work related to well modification was performed since it was determined that the distribution of arsenic concentrations in strata located along the well screen was not conducive to well modification.
- Served as Technical Lead for a groundwater supply management analysis for a city in the Central Valley of California. The purpose of the project was to evaluate current production operations and suggest operational guidelines and facility modifications to both maintain required production and protect water quality from a variety of constituents (nitrate, uranium and VOCs).
- Served as Technical Lead for developing an irrigation supply well for an athletic park in a coastal area of northern California. Issues considered included well siting, design and yield, and potential water quality impacts from a nearby municipal wastewater treatment facility. An opinion on the potential affects on the groundwater system with respect to production potential and water quality was also prepared for use in a CEQA analysis.
- Served as Technical Lead for a water supply well source area contamination assessment in the Central Valley of California. The sources and migration pathways related to nitrate and other potential contaminants were evaluated through 1) property and well records review, 2) focused well sampling and 3) isotopic analysis to evaluate the age of water pumped from different screened intervals (USGS dye tracer approach) in the municipal well and fingerprint the source of contamination. The purposes of the assessment were to provide information for 1) designing a wellhead treatment system, 2) addressing groundwater cleanup needs and 3) negotiating with the responsible party (RP) and the Central Valley Regional Water Quality Control Board (RWQCB).
- Served as Technical Lead for a hydrogeologic evaluation of water supply development potential in a basin located near the Central Coast of California. Factors considered included geologic formation and structure of water-bearing strata, groundwater flow patterns, existing well yields, water quality distribution patterns and trends, and hydrogeologic conditions specific to the parcel considered for development. Because the basin was not in a state of overdraft, recommendations were made for site-specific investigation of the parcel.
- Served as Technical Lead for a water quality impact analysis in support of regulatory negotiations regarding plans for increased groundwater pumping by a growing community in the Central Valley of California. At issue was whether additional deep pumping would degrade water quality by causing shallow nitrate contamination to migrate downward in significant quantities. The available data were reviewed and historic conditions under which downward migration of nitrate had occurred were identified. This information suggested that the increased pumping would not cause water quality degradation. Technical negotiations with the State Water Board were conducted and a limited amount of additional hydrogeologic data was collected. The collected data corroborated the original findings and the plans for increased pumping were approved.
- Provided technical review for a hydrogeologic impact assessment of dewatering related to expansion of gravel mining operations in the Central Valley of California. The review entailed comparing the results of two different groundwater modeling studies, explaining differences in results of the two studies, and evaluating these differences within the context of potential impacts to the local groundwater system.
- Served as Senior Hydrogeologist for the preparation of a State loan application/workplan to conduct a feasibility study for supplementing a municipal groundwater-based drinking water supply in the Central Valley of California. The workplan included tasks related to modeling groundwater recharge and wellfield operations, and groundwater management planning under the Groundwater Management Act.
- Served as Senior Hydrogeologist and Project Manager on a water well rehabilitation and maintenance project for a water purveyor in northern California. The initial focus of the project was to develop and implement a course of action to rehabilitate under-performing wells. The second focus of the project was to develop and implement a long-term plan for preserving efficiency and extending the lives of satisfactorily-performing wells by considering the economic life expectancy of each well and specifying data collection requirements for tracking performance. This information was managed using database and economic analysis software.

Project Experience – *Water Supply Assessment and Service (cont.)*

- Served as Senior Hydrogeologist Project Manager for the rehabilitation of a municipal water supply well in northern California. Services included developing specifications for both chemical/mechanical rehabilitation of the well screen and installation of a new pumping system that was compatible with an existing variable-frequency drive.
- Served as Project Manager and Senior Hydrogeologist for a new well and reservoir siting study conducted for a municipality in northern California. The goal of the project was to identify viable sites for the new facilities from the list of surplus city-owned lands. Issues considered included aquifer characteristics, proximity to groundwater contamination, proximity to existing facilities, potential for well interference, site suitability for aboveground facilities, aesthetics, and other criteria.
- Served as Project Manager on the design of pumping and transmission facilities for two new municipal water supply wells on the Central Coast of California. Services included developing equipment and construction specifications, and providing construction and system startup inspection. Timely completion of the project allowed the client to apply for project cost reimbursement from Federal funds.
- Provided consultation regarding the rehabilitation needs of a municipal water supply well located in the Central Valley of California. Services provided included consulting with the client on issues that arose during field implementation of the rehabilitation measures.
- Served as Senior Hydrogeologist for an electronics manufacturing facility siting assessment in western Mexico. Issues related to the quality and reliability of the water supply for the proposed site were considered as part of the assessment.
- Served as Senior Hydrogeologist for assessing conditions for developing a groundwater supply for a fruit processing facility located in the northern Central Valley of California. The local groundwater quality was poor, and a well was designed to maintain efficiency and integrity under anticipated use scenarios. Requirements for the well installation and related water treatment system construction were specified in accordance with the California Department of Health Services Office of Drinking Water.
- Developed and installed groundwater and surface water level measurement instruments for a watershed monitoring project in southwestern Mexico. The work was part of a larger malaria control research project.
- Evaluated potential impacts on groundwater supplies related to a proposed land development project on the Central Coast of California. Available hydrogeologic data were reviewed within the context of plans for groundwater withdrawal related to the development. Potential reductions in water availability were identified, and recommendations were made to further assess the degree of impact.
- Performed data collection and interpretation for groundwater resource evaluations in eastern South Dakota. Glacially derived aquifers were delineated and characterized in support of agricultural water supply development.

Wastewater

- Serving as Technical Lead related to renegotiation of WDRs for a cheese plant in southern California east of San Diego. The project is driven by changes in the wastewater stream. Tasks performed include 1) characterization of the wastewater quantity and quality, 2) preparation of a Report of Waste Discharge and a Nutrient/Salt Management Plan, and 3) contribution of various types of information and insights to support infrastructure modifications at the facility. Negotiation with the Colorado River Basin RWQCB on the WDR modification is in-process.
- Serving as Technical Expert reviewing and commenting on draft language for a General Order and WDRs regarding the Irrigated Lands Regulatory Program that has been prepared by the Central Valley RWQCB.
- Served as Project Manager for an environmental site assessment conducted on a 150-acre mixed-use/agricultural parcel located in the Central Valley of California. The purpose of the assessment was to facilitate acquisition of the parcel for expansion of wastewater land application operations at a food processing facility. Accordingly, the list of details for the assessment was expanded to address the intended use of the parcel.

Project Experience – *Wastewater (cont.)*

- Served as Technical Lead for planning and analysis related to technical and regulatory aspects of performing surface and groundwater drainage in a coastal area of northern California. Issues considered include potential rates of drainage, surface water quality, septic discharges and permissible ocean discharges.
- Served as Technical Lead related to renegotiation of WDRs for a dairy in southern California east of San Diego. The project was driven by changes in both the wastewater stream and the lands to which the water would be discharged. Tasks performed include 1) completion of a water use audit that resulted in a 40% reduction in wastewater production, 2) preparation of a Nutrient Management Plan and an Engineered Wastewater Management Plan that were accepted by the RWQCB in initial form, 3) contribution of various types of information and insights that supported infrastructure modifications at the facility, and 4) expedited negotiation with the RWQCB on the WDR modification.

Groundwater Modeling and Optimization Analysis

- Served as Technical Lead for a prospective performance evaluation of a new wastewater storage pond liner technology proposed at a dairy in the Central Valley of California. Information on site conditions and planned pond design were used to construct a groundwater flow and transport model. A range of estimated seepage rates through the liner were simulated with the model in order to evaluate potential impacts to shallow groundwater quality. The evaluation was used to finalize construction requirements and permitting details for the new wastewater pond.
- Served as Technical Lead for a probabilistic cost analysis regarding the remediation of a commercial property in the Central Valley of California that was impacted by chlorinated volatile organic compounds. Site conditions were somewhat uncertainty because only preliminary characterization of soil, soil gas and groundwater had been performed. The set of tasks required to perform the cleanup were identified and cost ranges were estimated based upon the existing uncertainties. A Monte Carlo analysis was performed to evaluate the range in total project cost and the probabilities of occurrence for costs within the range. The results provided a cost-benefit basis for the potential purchaser of the property to make decisions regarding site management.
- Served as Technical Lead for sea water intrusion and groundwater/surface water interaction modeling studies. The work considered past and potential future effects of groundwater extraction for irrigation upon flow and water quality in a river and estuary on the Central Coast of California. Technical aspects of this work were assessing buried channel geometry and hydraulic properties from the wide range of available data, and evaluating the simultaneous effects of groundwater pumping and spring tide occurrence. Detailed transient models that included several river reaches and hourly tidal variations were created based upon previously available information and data collected for this project. The work was used to support negotiations with the California Department of Fish and Game and, ultimately, hearings at the State Water Resources Control Board.
- Served as Technical Lead for flow and transport modeling conducted to evaluate the source of nitrate contamination to a municipal water supply well located in the Central Valley of California. The model was calibrated using the results of 1) a 30-day pumping test and 2) flow and concentration profiling performed on the impacted municipal supply well. Important aspects of the modeling were 1) simulating the contaminant plume response to different historical pumping periods and 2) including the effects of a nearby improperly constructed water supply well that acted as a vertical conduit.
- Served as Technical Lead for hydrogeologic analysis and development of software for the prediction of groundwater quality impacts resulting from operations at a northern California facility. The software used historic and projected facility operations to predict sourcing and migration of tritium in groundwater. A flow and transport code was developed to simulate advection, dispersion, decay and other processes particular to the site that are not included in standard modeling packages (in-place constituent mass creation and rate-limited mass transfer at multiple spatial scales). Once calibrated, the model was used to evaluate the impacts of various future operations scenarios within the context of making facilities management and regulatory negotiation decisions.

Project Experience – *Groundwater Modeling and Optimization Analysis (cont.)*

- Served as Technical Advisor for modeling performed in support of a feasibility study regarding groundwater cleanup in the Central Valley of California. Flow and transport modeling were performed to evaluate contaminant plume movement under different remedial pumping scenarios. Of particular importance in this work were the effects of many water supply wells located near the plume and flows between vertically adjacent water-bearing zones.
- Served as Technical Lead for a study that developed conjunctive use strategies and wellfield operational rules related to meeting future municipal water supply requirements of a growing community in the Central Valley of California. The project entailed developing a groundwater flow model that included 1) the operations of wellfields run by two adjacent communities and 2) groundwater-surface water interactions. Once calibrated, the model was linked to optimization tools in order to cost effectively evaluate a range of operational scenarios. At issue was how to meet projected higher demands without mobilizing contaminants (naturally occurring total dissolved solids and two plumes containing VOCs and pesticides) that would result in increased future treatment costs. Results of the study included wellfield operations guidelines, suggested maximum extraction schedules, and proposed coordination of wellfield operations by the two adjacent communities. The model was extended in time and recalibrated four years later. Future plans are to use the model as part of water supply planning for city expansion.
- Served as Technical Lead on a groundwater management study performed to support remedial design for a landfill site in Arizona. Remedial designs necessary to accommodate Groundwater flows resulting from present and future water supply management practices were evaluated with a groundwater model developed for the project. The goal of the work was to develop designs that were both economically viable and able to contain the leachate plume as water supply pumping and basin recharge practices changed.
- Served as Senior Hydrogeologist for a feasibility study and remedial action at an industrial site in the Central Valley of California. The project was reviewed by the California Department of Toxic Substances Control (DTSC) and entailed hydrogeologic analysis and groundwater modeling to mitigate impacts to a water supply wellfield by VOCs. Evaluating and implementing wellhead treatment as the remedial approach entailed accounting for both seasonal variations in wellfield pumping demand and economic constraints on performance of the project. Use of automated/optimization techniques for assessment of design options streamlined the modeling process and reduced project expenditures. The work also included developing a cost-effective monitoring program for the remedial action.
- Served as Senior Hydrogeologist for a remedial action at a decommissioned research facility located in northern California. The project was reviewed by the EPA, DTSC, and the Central Valley RWQCB. It included hydrogeologic analysis and modeling to mitigate impacts to groundwater and nearby irrigation supply wells by VOCs, and litigation support. This work supported preparation of an Engineering Evaluation/Cost Analysis and an Interim Remedial Action, and favorable settlement of the litigation matter. The work also included an assessment of rehabilitation needs for injection wells used in the remedial action.
- Served as Technical Lead for an assessment of potential VOC, SVOC and metals concentrations in groundwater at an industrial facility located in northern California. The project, reviewed by the EPA, DTSC, and National Oceanic and Atmospheric Administration, entailed modeling groundwater transport of constituents of potential concern and mixing of the constituents with surface waters. The concentration predictions were used to support performance of ecological and human health risk assessments.
- Served as Technical Lead on a groundwater supply management study for a mining operation located in the western United States. The focus of the project was exploring options for both meeting water production requirements and capturing impacted water while accounting for restrictions related to water rights and well/transmission line capacity limits. Use of automated/optimization techniques for assessing options streamlined the process and allowed a more detailed study to be conducted with a limited budget.
- Served as Technical Lead for an evaluation of groundwater drainage rates and volumes resulting from a planned tunnel construction project in the Sierra Nevada of California. A spreadsheet model was constructed to simulate transient drainage from fractured host rock surrounding the planned tunnel construction. Best- and worst-case estimates of the drainage rates and volumes were prepared to support plans for removal of suspended solids from the water prior to discharge.

Project Experience – *Groundwater Modeling and Optimization Analysis (cont.)*

- Provided consultation regarding the feasibility of modeling groundwater flow and solute transport in an alluvial valley located in the western United States. Flow in the valley has been increasingly influenced by water supply pumping. Key elements for conducting the assessment were development of a complete conceptual model of how groundwater flow patterns have changed over time, and identifying a viable approach for model calibration.
- Served as Senior Hydrogeologist to develop a remedial approach for an industrial site in Nevada impacted by chlorinated VOCs. Groundwater modeling was used as a planning tool for phased implementation of a pumping system to address remediation requirements for the 7,000-foot-long plume. The plume was present throughout the saturated alluvium in a small valley, and viable remedial pumping designs are highly sensitive to available drawdowns and potential dewatering. Use of automated/optimization techniques for model calibration and design development streamlined the modeling process and reduced project expenditures.
- Supported development of technical strategy and provided senior review for groundwater modeling performed for remedial investigation/feasibility study and litigation tasks related to a site in Oregon impacted by chlorinated VOCs. Hydrogeologic analysis involved accounting for the effects of nearby water supply well pumping on VOC transport in the vicinity of the site. Automated/optimization techniques were developed and demonstrated to streamline the modeling process.
- Evaluated an optimization model for cost-effective disposal of dredging wastes for potential application to San Francisco Bay. The evaluation was performed for the ACE. Methods were developed for applying the model to problems that included constraints imposed by environmental regulations. A result of the evaluation was the determination that increased permitting fees might not change disposal patterns within the Bay.
- Analyzed transient hydraulic head data collected during soil boring to estimate the hydraulic conductivity and potential solute migration rates for a petroleum site in Oregon. The analysis entailed developing a mathematical model for assessing slug test data in a three-dimensional flow field. Performance of the analysis reduced project costs by providing migration rate information without installation of monitoring wells.
- Conducted a modeling study for the DOE to determine the effect of spatially variable solute adsorption on groundwater solute concentration predictions. This included use of statistical techniques to increase the reliability of the transport predictions. These techniques have recently been used on other projects to defend conclusions that are based upon model predictions.
- Developed pump-and-treat designs for capturing organic and heavy metal compounds at an impacted groundwater site in Canada. The design involved development of a site-specific model of groundwater flow and solute transport for prediction of exposure point concentrations and application of optimization techniques for developing designs. The designs involved minimum capital and recurring remediation costs. Reliability of concentration predictions upon which the designs were based was demonstrated through application of statistical techniques.

Modeling, statistical analysis, and database management tasks performed by Mr. Gailey on many of the above-referenced projects have entailed use of software including Groundwater Vistas, MODFLOW, MODPATH, MT3D, SEAWAT, RT3D, MOC, Bioscreen, Bioplume II/III, SUTRA, PEST, LINDO, STARPAC, GEOEAS, NPSOL, AQMAN, Visual MODFLOW, GMS, ModelCad and GIS/Key.

Groundwater Remediation

- Provided technical support on subsurface characterization, modeling and reporting for a solvent contamination site in southern California. Much of the work focused on addressing technical challenges posed by the hydrogeologic setting (structurally deformed, fractured sedimentary rock). The project included significant scientific contributions in the areas of field characterization and groundwater flow modeling.

Project Experience – *Groundwater Remediation (cont.)*

- Served as Principal Hydrogeologist for ongoing remedial action at an industrial site located in northern California. The project entailed conducting remedial activities (groundwater and soil vapor extraction) and monitoring progress toward cleanup for a multiparty, subregional plume of chlorinated VOCs. Reporting and interaction with the San Francisco Bay RWQCB involved completing semi-annual Self Monitoring Reports. Recent activity also included conducting a Five-Year Remedial Effectiveness Evaluation. Documenting and emphasizing the effects of impediments to pump-and-treat and naturally occurring biodegradation were important aspects of this project with respect to limiting future remedial requirements.
- Served as Principal Hydrogeologist for ongoing remedial action at an industrial site located in northern California. The project entailed conducting remedial activity (groundwater extraction) and monitoring progress toward cleanup for a plume of chlorinated VOCs. Reporting and interaction with the North Coast RWQCB involved completing semi-annual Self Monitoring Reports. Other project work also included reassessment of the hydrogeology and the approach to groundwater extraction with the goal of increasing project efficiency.
- Served as Principal Hydrogeologist for evaluating the results of shutting down a groundwater extraction system at an industrial site located in northern California. The San Francisco RWQCB approved remedial system shutdown on a temporary basis because (1) on-going pump-and-treat efforts had resulted in only limited progress toward attaining remedial goals and (2) there was evidence that naturally occurring biodegradation may have prevented plume migration. The project entailed evaluating the groundwater data (elevations as well as VOC and inorganic water chemistry) for pre- and post-shutdown periods. A convincing case for VOC degradation was made based on spatial data trends. A case for plume stabilization was also been made based on temporal data trends. Accounting for the effects of concentration rebound after pumping and plume migration from the source area was an important consideration for future site monitoring in order to assess whether the plume front was stable.
- Served as Principal Hydrogeologist for proposing monitored remedial system shutdown at an industrial site in northern California. The proposal to the North Coast RWQCB included a workplan for collecting the necessary groundwater data to demonstrate the effects of naturally occurring biodegradation of VOCs in groundwater.
- Served as Principal Hydrogeologist for ongoing remedial action at an industrial site located in northern California. The project entailed enhancing remedial activities (groundwater and soil vapor extraction) for a plume of chlorinated VOCs. Reporting and interaction with the DTSC involved conducting expedited conceptual and engineering design for expansion of a remedial system. Plans were also been developed for collecting data to document the potential effects of naturally occurring biodegradation in order to limit future remedial requirements. This work was conducted within the context of negotiating a Prospective Purchaser Agreement for an adjacent parcel that was impacted by the plume.
- Served as Principal Hydrogeologist for ongoing remedial action at an industrial site located in northern California. The project entailed conducting remedial activity (groundwater extraction) and monitoring progress toward cleanup for a specific site within a multiparty, subregional plume of chlorinated VOCs. Reporting and interaction with the EPA involved semi-annual Self Monitoring Reports. Recent activity also included reevaluating measures for maintaining a site-specific capture zone given that remedial activities were also occurring on adjacent sites.
- Served as Lead Hydrogeologist for remedial action design related to petroleum-impacted groundwater near residential water supply wells in central California. The constituents of concern included MTBE, and the Central Valley RWQCB conducted a detailed review of the Remedial Action Plan. The potential effects of residential well pumping were factored into the remedial pumping design so that containment of the constituents of concern was achieved and the water supplies were protected.
- Served as Senior Hydrogeologist for a fate and transport analysis related to petroleum-impacted groundwater near residential water supply wells in Alaska. The effects of naturally occurring biodegradation were incorporated into the analysis and supported the conclusion that risk to the water supplies was low.
- Served as Senior Hydrogeologist for a remedial investigation and action at an industrial facility in central California. The project was reviewed by the Central Valley RWQCB. It included hydrogeologic analysis, historical review, and negotiation to define remedial action requirements and allocate responsibility among responsible parties.

Project Experience – *Groundwater Remediation (cont.)*

- Served as Project Manager and Senior Hydrogeologist for a subsurface investigation of an air cargo facility at the San Francisco International Airport. The project was reviewed by the RWQCB and parties involved in cost allocation for cleanup of petroleum-impacted groundwater and soil. Evaluation of subsurface impacts and recommendation of future actions was conducted within the context of maintaining current business activities at the site and deferring any intrusive remedial activities until an appropriate time in the future.
- Served as Senior Hydrogeologist for a landfill closure in Mexico City, Mexico. Tasks performed included acquiring data on potential leachate production rates and recommending design parameters for a leachate collection system. Collection of the leachate was required to facilitate the next step of the closure, extraction of accumulated landfill gas.
- Served as Senior Hydrogeologist for a five-year review and remedial effectiveness evaluation of a groundwater cleanup operation in northern California. The project entailed evaluation of remedial performance data for six groundwater extraction systems installed in alluvial sediments and was reviewed by the San Francisco RWQCB. Key points considered during the evaluation were hydraulic containment of the chlorinated VOC groundwater plume, cumulative removal of groundwater and VOCs, VOC removal efficiency, offsite sources of VOCs, and the potential for attaining cleanup goals set by the RWQCB. Presentation of the project findings positioned the client well for negotiation on further remedial actions.
- Provided technical/economic analysis and technical review for remedial investigations/ feasibility studies involving three industrial sites owned by a single client in southern California. The work was performed under the review of the DTSC. Project findings were used to develop estimates of cleanup cost and facilitate completion of real estate transactions for the benzene-impacted properties. Detailed evidence of naturally occurring biodegradation was developed and used to limit the extent of cleanup measures that were considered.
- Served as Senior Hydrogeologist for a remedial investigation conducted at a commercial site in northern California. The investigation was performed under review of the San Francisco Bay RWQCB. Communication with the RWQCB on technical aspects of the investigation prior to commencing work positioned the client well for negotiations on further investigative requirements. The option for cost recovery was developed by maintaining consistency with the National Contingency Plan during the remedial investigation and interim remedial action, and by presenting arguments for the presence of off-site sources of chlorinated VOCs. Potential off-site source areas were identified, and arguments for requiring subsurface investigation by neighboring parties were supported through an analysis of site hydrogeology and migration potential. The arguments were presented and defended to the RWQCB. The ultimate goal of this effort is to identify other parties also responsible for the cleanup so that costs may be shared.
- Served as Project Manager and Senior Hydrogeologist for a soil and groundwater remedial investigation/feasibility study and an ecological river assessment conducted at a decommissioned wood treatment facility in Michigan. Creosote was present at the facility as a dense nonaqueous phase liquid. Negotiations with state regulatory agencies were key to successfully limiting the scopes of the investigations. Early data review allowed expeditious performance of the site characterization and development of a risk assessment strategy that both met regulatory requirements and was protective of client cleanup liability. The quality of the site characterization work contributed to the cooperative relationship between the client and regulatory agency, which reduced the potential for natural resource damage claims by the state.
- Performed remedial investigations and developed site closure arguments for petroleum sites in California, Florida, Massachusetts, and Rhode Island. The work in California was performed under the review of the Kern County Department of Environmental Health. Site closure arguments were accepted in all four states.
- Performed an emergency investigation, and designed, installed, and maintained a petroleum recovery system in response to a high-volume spill of diesel fuel into the subsurface at a commercial site in Massachusetts. Implementation of interim petroleum recovery measures minimized petroleum migration away from the source area. During the first year of recovery system operation, 25,000 gallons of fuel were recovered. System enhancements were then made to maintain recovery rates. Project costs were defrayed by reuse of the recovered fuel.

Project Experience – *Groundwater Remediation (cont.)*

- Designed, installed and maintained numerous petroleum and groundwater recovery systems in several states. This work also included evaluation of overall remedial effectiveness and the benefits of using groundwater infiltration systems to enhance petroleum recovery. Work in California was performed under review of the Central Valley RWQCB.
- Performed site assessments for real estate transactions involving retail petroleum, commercial, and industrial sites throughout California and Massachusetts. The assessment findings were used to facilitate completion of the transactions.

Litigation Support

- Recent cases in which Mr. Gailey has been declared as an expert:
  - RF Land Inc. v. City of Ripon (California) 2010
  - Raymond Coldani v. Jack Hamm and Patricia Hamm (Federal 2009)
  - NCH Corporation v. Hartford Accident and Indemnity Company, et al. (New Jersey) Deposition testimony in 2007
  - Union Bank of California v. Rheem Corp. (California), 2006
  - Pinal Creek Group v. Newmont Mining Corp., et al. (Federal – Arizona) Deposition testimony in 2003 and 2006
- Serving as a Technical Consultant regarding responsibility for VOC contamination of a municipal water supply well. The case is being heard in the California courts.
- Served as an expert witness regarding financial responsibility for nitrate contamination of a municipal supply well from an industrial facility in northern California. Contributions included planning both data collection from the impacted well and inspection of the industrial facility, as well as presenting findings during mediation. The case, filed in the California state court system, ultimately settled.

Project Experience – *Litigation Support (cont.)*

- Served as an expert witness regarding responsibility for nitrate contamination of groundwater in the vicinity of a dairy in northern California. Work on the case, filed under the Clean Water Act in the California state court system, involved field investigation and analysis, mediation support and presentations, and preparing a technical declaration in support of a motion for recovery of attorney/expert fees and costs. The case was ultimately rescinded.
- Served as an expert witness regarding cost recovery and future apportionment among RPs for cleanup of a large acid mine drainage site in Arizona. The case involved several RPs active over almost a century and located throughout a mining complex, had been filed under CERCLA, and was heard in the federal court system. Expert analysis included a comprehensive consideration of the site hydrogeology and historic mining activities, and flow calculations (water budgets and mass balance assessments on surface water and groundwater flows, and three-dimensional groundwater flow modeling) to assess the relative contributions to the acid plume by various RPs. Video taped deposition testimony was given twice.
- Served as an expert witness regarding insurance coverage claims related to cleanup of a Superfund site. The case was filed under CERCLA and heard in the New Jersey state court system. Analysis and opinion development focused on hydrogeologic and regulatory factors that would influence the ultimate cost of the cleanup. Methods for incorporating uncertainty into the cost estimates was also addressed. Deposition testimony was given. Issues related to the above-referenced opinions were subsequently dropped from the case.
- Served as an expert witness regarding cost recovery for a former electronics manufacturing facility. The case was filed under CERCLA and heard in the California state court system. Analysis and opinion development focused on hydrogeologic factors that controlled both the duration of release to groundwater and the extent of subsequent off-site migration. The case settled before any testimony was given.

Project Experience – *Litigation Support (cont.)*

- Served as a consultant regarding a CERCLA claim for damages related to a release of contamination into a San Francisco Bay Area aquifer that serves a large population of individual well owners (residential and agricultural). The case, filed by a class of plaintiffs, involves releases from a single industrial parcel where multiple RPs operated over time and was heard in the federal court system. Consultation has included document review, quantitative analysis related to the extent of contamination and potential cleanup timeframe, mediation brief preparation, development of computer animation visual aids for mediation discussions, and presentation at mediation.
- Provided consultation for mediation of cleanup cost allocation for petroleum-impacted groundwater and soil at the San Francisco International Airport. The project involved research and strategy development focused on supporting negotiations with some twenty responsible parties.
- Provided consultation for legal defense against a claim concerning financial responsibility for contamination of residential and agricultural water supplies and soil. The case involved two adjacent parcels in northern California, was filed under CERCLA, and heard in the federal court system. Data analysis and discussions with attorneys focused on the plausibility of claims made by the plaintiff with respect to source area locations, site hydrogeology and migration potential of the constituents, and differences in signature assemblages of constituents present at each of the two sites. The case settled before any testimony was given.
- Provided consultation for legal defense against a claim concerning financial responsibility for petroleum and heavy metals present in soil and groundwater. The case involved two adjacent industrial parcels in northern California, was filed under CERCLA and heard in the federal court system. Data analysis and development of arguments focused on the plausibility of claims made by the plaintiff with respect to source area locations, site hydrogeology and migration potential of the constituents, and differences in signature assemblages of constituents present at each of the two sites. The arguments prepared supported successful opposition to motions made by the plaintiff for widespread inspection of the defendant's property, settlement discussions, and the defendant's motion for summary judgment. Prior to a settlement being reached, Mr. Gailey participated in settlement discussions and preparing the expert witness for trial.
- Provided consultation for legal defense against a claim concerning financial responsibility for petroleum contamination at two adjacent retail/industrial parcels in northern California. Data analysis and development of arguments focused upon the adequacy of previously implemented remedial actions for which the plaintiff sought compensation. The technical merits of written arguments developed for the defense resulted in the plaintiff's claim being rescinded prior to the case being heard in court.
- Served as an expert witness for a defendant regarding a cost recovery claim concerning petroleum and chlorinated VOCs present in soil and groundwater. The case was filed under CERCLA and heard in the federal court system. It involved a single property in northern California, an initial owner-operator (the plaintiff), and a subsequent series of occupants (the codefendants). Data analysis and development of written arguments focused on both changes in the chemical composition of materials used for automotive fueling and repair between the 1940s and the 1980s, and the appropriate allocation of cost for site cleanup among the involved parties. Estimation of total cost for the cleanup was also performed. 1,2-Dichloroethane (DCA) was identified as a signature compound for releases to the environment that occurred before the codefendants occupied the site. Data collected by the plaintiff demonstrated that DCA was present across the property and supported arguments that the plaintiff was also responsible for the cleanup. The case settled before any testimony was given.
- Provided consultation in support of a class action suit against the state of California concerning a levee failure. Three-dimensional transient groundwater flow and soil mechanical processes were modeled to show that departure from guidelines for levee maintenance could have caused the failure. Mr. Gailey defended the modeling work in deposition. This work supported testimony of the expert witness.

Insurance Analysis Support

- Conducted a comprehensive assessment and estimation of future remediation costs in support of insurance premium pricing for a cost cap policy on two sites. Annual costs over the life of the policy were developed for three possible scenarios (high, medium, and low costs) based on detailed review and consideration of project characteristics. These characteristics included technical (engineering and science), regulatory and logistical issues. The results were presented and discussed during negotiations between the insurance company and insurance brokers over premium price.

Project Experience – *Insurance Analysis Support (cont.)*

- Conducted several assessments of remediation projects in support of insurance claims analyses. The overall approach and effectiveness of remedial actions were evaluated. In addition, costs incurred were identified and categorized with respect to policy coverage and exclusion categories. General projections of future costs and timelines were also prepared.

Education

MBA, University of California, Berkeley, 2003.
MS, Applied Hydrogeology, Stanford University , 1991.
BS, Geology/Biology, Brown University, 1985.

Professional Certifications and Registrations

Professional Geologist, California No. 5338
Certified Hydrogeologist, California No. 259
40-Hour OSHA HAZWOPER Safety Training
8-Hour OSHA HAZWOPER Refresher/Respirator Fit Test
8-Hour OSHA Site Supervisor Certification
First Aid/CPR Training

Continued Education

Isotope Methods for Groundwater Investigation, Groundwater Resources Association of California, 2007
Endangered Species Acts: Meeting the Challenges, Association of California Water Agencies, 1999
Groundwater Use and Management, University of California at Berkeley Extension, 1998
Drinking Water Regulation, University of California at Berkeley Extension, 1998
Water Supply and Fish in the Sacramento-San Joaquin Delta, University of California at Berkeley Extension, 1997
Managing Groundwater into the 21st Century, Association of California Water Agencies, 1997
Watershed Management and Source Water Protection: The First Barrier, American Water Works Association, 1997
Aquifer Storage and Recovery, American Water Works Association, 1997
Graduate Study in Environmental Engineering, Stanford University, 1990
Surveying, Wentworth Institute of Technology, 1986

Professional Memberships and Activities

Association of Ground Water Scientists and Engineers
Groundwater Resources Association of California
Technical reviewer for various journals

Publications

Gailey, R.M. 2000. Application of Mixed-Integer Linear Programming Techniques for Water Supply Wellfield Management and Plume Containment at a California EPA Site. Proceedings of the International Symposium On Integrated Water Resources Management, International Association of Hydrological Sciences.

Gailey, R.M. 1999. Application of Mixed-Integer Linear Programming Techniques for Water Supply Wellfield Management and Plume Containment at a California EPA site. Proceedings of the 26th Annual Conference on Water Resources Planning and Management, American Society of Civil Engineers. (Published on compact disc.)

Gailey, R.M. and M. Eisen. 1997. An Optimization-based Evaluation for Groundwater Plume Containment and Water Supply Management at a California EPA Site. p. 138. In: proceedings of XXVIIth IAHR Congress, Water for a Changing Global Community, Theme C: Groundwater An Endangered Resource.

Brogan, S.D. and R.M. Gailey. 1995. A method for estimating field-scale mass transfer rate parameters and assessing aquifer clean-up times. Ground Water 33 (6) 997-1009.

Gailey, R.M. and S.M. Gorelick. 1993. Optimal, reliable plume capture schemes: application to The Gloucester Landfill groundwater contamination problem. Ground Water 31 (1) 107-114.

Gailey, R.M., A.S. Crowe, and S.M. Gorelick. 1991. Coupled process parameter estimation and prediction uncertainty using hydraulic head and concentration data. Advances in Water Resources 14 (5) 301-314.

Publications (cont.)

Gailey, R.M. and D.E. Jones. 1987. The use of sediment permeability variations in the performance of petroleum recovery from glacial sediments. p. 515. In: Proc. of the Focus on Eastern Regional Groundwater Issues, National Water Well Association.

Presentations

A Case for Alternative Groundwater Monitoring under CASGEM in Northeastern California. Session Speaker, Groundwater Resources Association of California, 21st Annual Meeting and Conference, California Groundwater: Data, Planning and Opportunities, October 4 and 5, 2012, Rohnert Park, California.

Water Supply Well Rehabilitation Methods: Alternatives and Successes. Invited Speaker, Groundwater Resources Association of California Managing Wells in California and Protecting Groundwater Resources Symposium, August 22 and 29, 2012, Sacramento, California.

Factors Affecting Nitrate Concentrations in Water Supply Wells. 28th Biennial Groundwater Conference and 20th Annual Meeting of the Groundwater Resources Association of California, California's Water's Future Goes Underground, October 5-6, 2011, Sacramento, California.

Identifying the Sources of Nitrate to a Deep Municipal Water Supply Well Using Stable Isotopes of Nitrate, Groundwater Age Dating and Depth-Specific Sampling. Copresenter with Brad Esser, Groundwater Resources Association of California Environmental Forensics Symposium, April 12, 2011, Irvine, California.

Reducing Arsenic Concentrations from a Municipal Supply Well through Well Screen Modification. Invited Speaker, Arsenic Symposium: Treatment Alternatives and Case Studies, December 8-10, 2009, Bakersfield, Barstow and Ontario, California.

Simulating Flow and Transport Uncertainty Associated with Water Supply Well Modification Based upon Well Profiling and Pumping Test Data. Coauthor with Grace Su, 2010 National Groundwater Association Groundwater Summit, April 12-14, 2010, Denver, Colorado.

Reducing Arsenic Concentrations from a Municipal Supply Well through Well Screen Modification. Invited Speaker, Arsenic Symposium: Treatment Alternatives and Case Studies, December 8-10, 2009, Bakersfield, Barstow and Ontario, California.

Considering the Consumption of Energy and Other Resources during Pumping at the Well and Wellfield Scales. Invited Speaker, 27th Biennial Groundwater Conference and 18th Annual Meeting of the Groundwater Resources Association of California, Water Crisis and Uncertainty: Shaping Groundwater's Future, October 6-7, 2009, Sacramento, California.

Planning Combined Municipal Use of Groundwater and Surface Water: Technical and General Results from a Case Study. Session Speaker, Groundwater Protection Council Annual Forum 2009, Water/Energy Sustainability Symposium – Water and Energy Policy in the 21st Century, September 13-16, 2009, Salt Lake City, Utah.

Optimal Conjunctive Use of Surface Water and Groundwater Resources: A Tale of Two Cities. Session Speaker and Symposium Co-Chair, Applications of Optimization Techniques to Groundwater, a Groundwater Resources Association of California Symposium, October 16, 2008, Sacramento, California.

Details of Optimization and Applications to Groundwater Projects. Course Instructor and Co-Chair, a Groundwater Resources Association of California Short Course, October 15, 2008, Sacramento, California.

Application of a Simulation-Optimization Approach for Water Supply Wellfield Management and Plume Containment. Session Speaker, Groundwater Resources Association of California, 13th Annual Meeting and Conference, Managing Aquifers for Sustainability – Protection, Restoration, Replenishment, and Water Reuse, September 23-24, 2004, Rohnert Park, California.

Application of Mixed-Integer Linear Programming Techniques for Water Supply Wellfield Management and Plume Containment at a California EPA site. Session Speaker, International Association of Hydrological Sciences, International Symposium On Integrated Water Resources Management, April 9-12, 2000, Davis, California.

Application of Mixed-Integer Linear Programming Techniques for Water Supply Well Fixed Management and Plume Containment at a California EPA site. Session Moderator and Speaker, American Society of Civil Engineers Water Resources Planning and Management Division Annual Conference, June 6-9, 1999, Tempe, Arizona.

Presentations (cont.)

Wellfield Optimization: A Case Study. Session speaker, American Water Works Association, California-Nevada Section, Fall Conference, October 6-9, 1998, Reno, Nevada.

A Linear Programming Application for Water Resource Management at a Mining Operation. Session speaker, 25th Annual Conference on Water Resources Planning and Management, American Society of Civil Engineers, June 7-10, 1998, Chicago, Illinois.

Water Disposal Concerns with a Well Rehabilitation Project. Invited Speaker, American Water Works Association, California-Nevada Section, Water Well Monitoring and Rehabilitation Seminar, May 20-21, 1998, Stockton, California.

Quantifying Rate-Limited Mass Transfer Effects in the Field: Challenges Faced by Environmental Science Practitioners. Session speaker, American Geophysical Union Fall Meeting, December 8-12, 1997, San Francisco, California.

An optimization-based evaluation for groundwater plume containment and water supply management at a California EPA site. Session speaker, American Water Resources Association Annual Conference and Symposium on Conjunctive Use of Water Resources: Aquifer Storage and Recovery, October 19-23, 1997, Long Beach, California.

An optimization-based evaluation for groundwater plume containment and water supply management at a California EPA site. Session speaker, XXVII in IAHR Congress, Water For A Changing Global Community, August 10-15, 1997, San Francisco, California.

A method for estimating field-scale mass transfer rate parameters and predicting aquifer clean-up times. Session speaker, 1994 Groundwater Modeling Conference, August 10-12, 1994, Fort Collins, Colorado.

Design of optimal, reliable groundwater capture schemes. Session speaker, solving Ground Water Problems with Models, February 11-13, 1992, Dallas, Texas.

Design of optimal, reliable groundwater capture schemes. Lecturer, National Research and Development Conference on the Control of Hazardous Materials, February 4-6, 1992, San Francisco, California.

Design of optimal, reliable plume capture schemes: application to the Gloucester Landfill. Invited speaker, American Geophysical Union Fall Meeting, December 9-13, 1991, San Francisco, California.

The use of sediment permeability variations in the performance of petroleum recovery from glacial sediments. Session speaker, Focus on Eastern Regional Groundwater Issues, July 14-16, 1987, Burlington, Vermont.

Presentations on aspects of quantitative hydrogeology at the U.S. Geological Survey, Lawrence Berkeley National Laboratory, California Department of Water Resources, and universities (California State University at Sacramento, Harvard, Stanford, and the University of Illinois).

APPENDIX B

CALCULATIONS ON UNSATURATED ZONE TRANSIT TIME AND WATER QUALITY IMPACTS TO FIRST-ENCOUNTERED GROUNDWATER

APPENDIX B

CALCULATIONS ON UNSATURATED ZONE TRANSIT TIME AND WATER QUALITY IMPACTS TO FIRST ENCOUNTERED GROUNDWATER

Unsaturated zone transit time calculations were performed for representative locations within the KRWCA area. This work was accomplished in collaboration with a soil and agricultural scientist hired by the KRWCA (Joel Kimmelshue). From a larger evaluation conducted by Mr. Kimmelshue, entitled Kern River Watershed Coalition Authority Agricultural Return Flow and Nitrogen Transport Estimates and Comparisons, three locations were selected for evaluation (Figure B1). The salient details of each location are presented below.

- Location 1
  - Crop: citrus
  - Irrigation method: drip/micro
  - Soil: medium-grained
  - Return flow: 2.3 inches per year
  - Nitrogen lost below root zone: 15 pounds per acre per year
  - Unsaturated zone stratigraphy: loam in shallow subsurface transitioning to clay at depth
  - Depth to first-encountered groundwater: 500 feet
- Location 2
  - Crop: almonds
  - Irrigation method: drip/micro (90%) & flood (10%)
  - Soil: coarse-grained
  - Return flow: 5.0 inches per year
  - Nitrogen lost below root zone: 15 pounds per acre per year
  - Unsaturated zone stratigraphy: interlayered sand and clay
  - Depth to first-encountered groundwater: 330 feet
- Location 3
  - Crop: cotton/wheat
  - Irrigation method: furrow/border
  - Soil: coarse-grained
  - Return flow: 16.4 inches per year
  - Nitrogen lost below root zone: 55 pounds per acre per year
  - Unsaturated zone stratigraphy: interlayered sand and clay
  - Depth to first-encountered groundwater: 150 feet

Unsaturated flow and nitrogen transport was simulated using the Hydrus 1D software. Estimates of monthly return flows and annual nitrogen losses below the root zone were obtained from Mr. Kimmelshue and used to specify upper boundary conditions for the flow and transport simulations (variable flux for flow and constant concentration for transport). Depth to first encountered groundwater was obtained from Department of Water Resources data (Figure 2a) and used to develop lower boundary conditions for the flow and transport simulations (constant head for flow and zero gradient for transport). Stratigraphy was included for each of the three locations based upon information from well completion reports obtained from KRWCA members, and physical properties were assigned based upon database values provided through the Hydrus 1D software. Initial conditions for flow were developed by running the flow model once before the flow and transport simulation was performed[15]. It was assumed that 1) all nitrogen occurred as nitrate, 2) no attenuation occurred by denitrification, diffusion or other processes and 3) no acceleration or deceleration occurred by anion exclusion, physical interaction with the sediments or other processes. This approach appears to be similar to that taken as part of the UC Davis nitrate study (Boyle et al., 2012); however, the two approaches differ in one important aspect. The present work included stratigraphic variability based upon field information instead of assuming a homogeneous soil column. This information adds a site-specific element to the results.

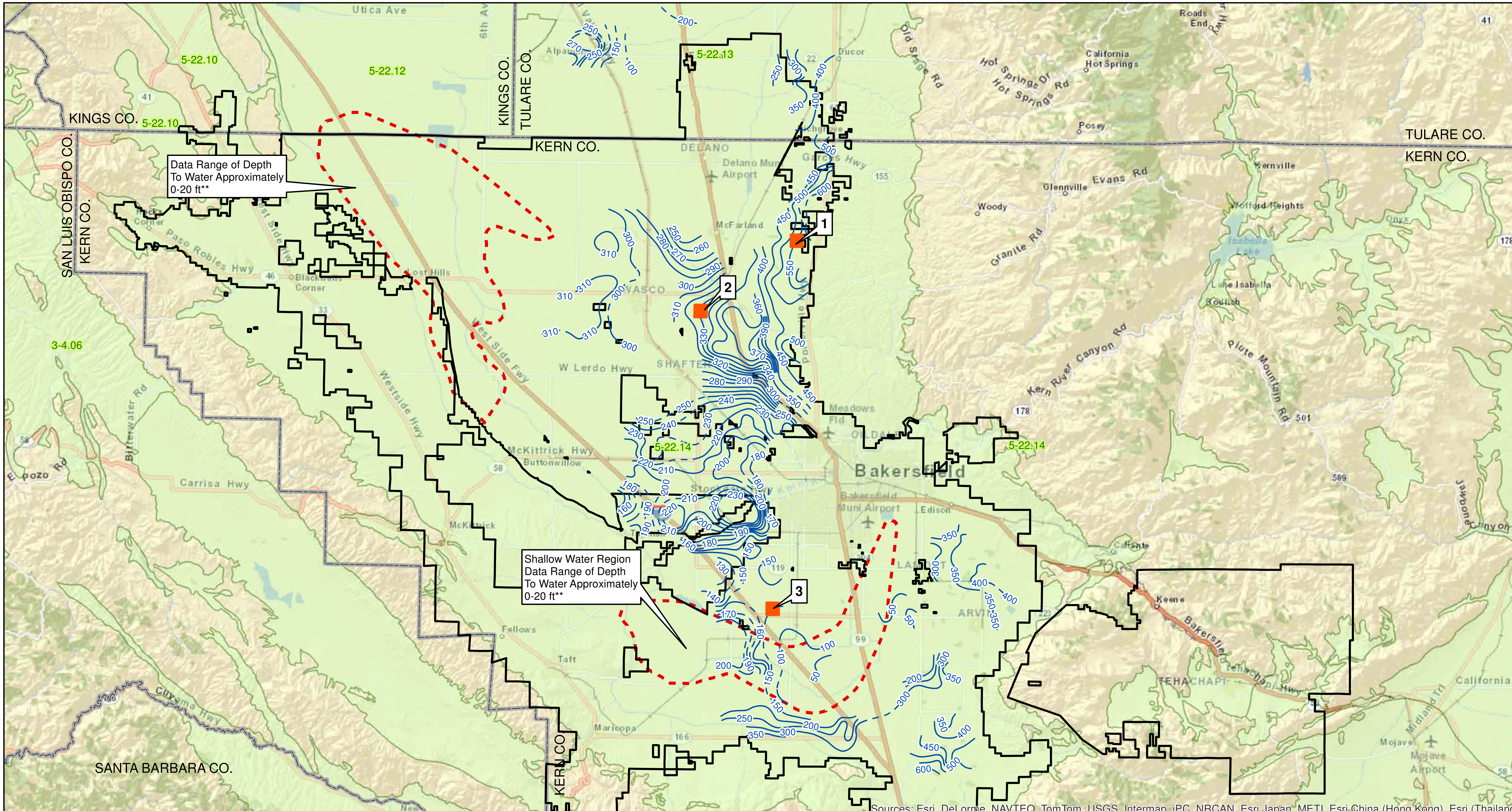
Transit times were calculated for transport from the bottom of the root zone to the bottom of the unsaturated zone. First arrival was considered as the simulated elapsed time when the nitrate concentration reached 1 mg/l at the bottom of the unsaturated zone[16]. Arrival of the 9 mg/l nitrate concentration, considered to be background (Boyle et al., 2012), was also considered. The results indicated a range in transport times[17]. For Location 1 where the depth to groundwater was greatest (Figure B1), arrival times were the greatest ranging from approximately 600 to 700 years (Figure B2). For Location 2 where the depth to groundwater was intermediate (Figure B1), arrival times were intermediate ranging from approximately 45 to 55 years (Figure B3). For Location 3 where the depth to groundwater was least (Figure B1), arrival times were the least ranging from approximately 10 to 15 years (Figure B4).

---

[15] The durations of the initial flow simulations were long enough to include the elapsed times for the transport simulations.

[16] Transport as nitrogen was simulated and the predicted nitrogen concentrations were then converted to nitrate concentrations.

[17] Transport mass balance errors were less than 0.5 percent.



0 5 10 Miles

Locations of Bulk Unsaturated Flow Estimates

DWR Groundwater Basin/Subbasin (ID Label)

County

KRWCA Boundary

Shallow Water Region - Approximate**

Depth To Water - Unconfined Aquifer***

High Degree of Confidence

Inferred

Data References:

**Areas digitized from CA DWR "Present and Potential Drainage Problem Areas" survey map, 2010
http://www.water.ca.gov/pubs/drainage/2010_shallow_groundwater_map__san_joaquin_valley/sgw10.pdf

***Isopleth lines from CA DWR "Lines of Equal Depth to Water in Wells, Unconfined Aquifer, San Joaquin Valley, Spring 2010"
http://www.water.ca.gov/groundwater/data_and_monitoring/south_central_region/images/groundwater/sjv2010spr_unc_depth.pdf

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company
130 N. Garden Street
Visalia, CA 93291
(559) 636-1166

Kern County Irrigated Lands Program
Kern Sub-Watershed

Locations For Unsaturated Flow Estimation

FIGURE B1

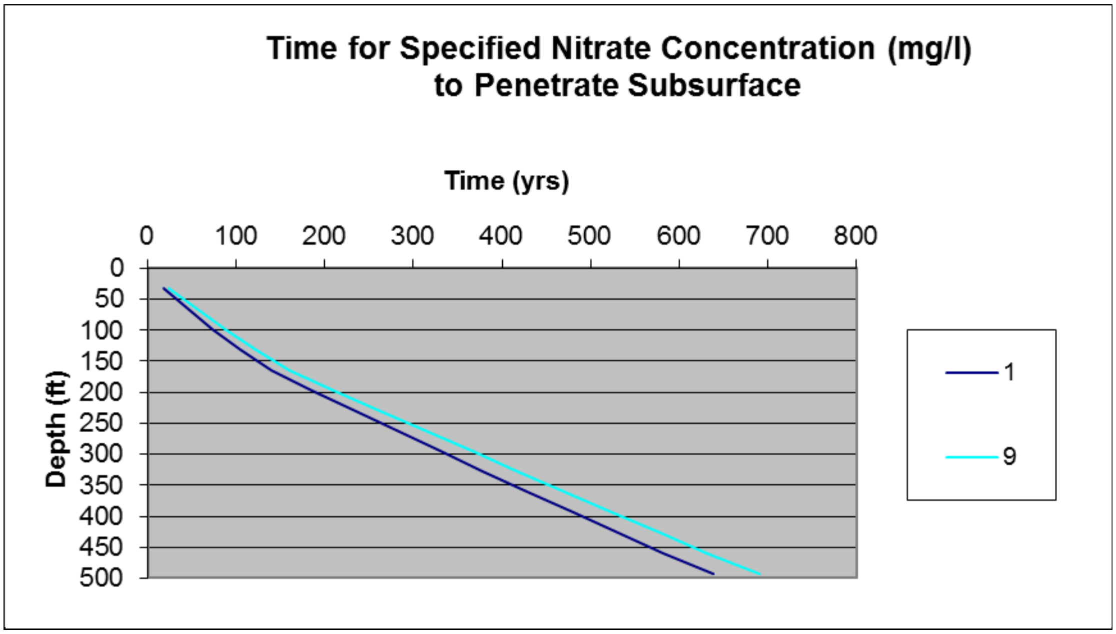


Figure B2: Nitrate Arrival Times for Location 1

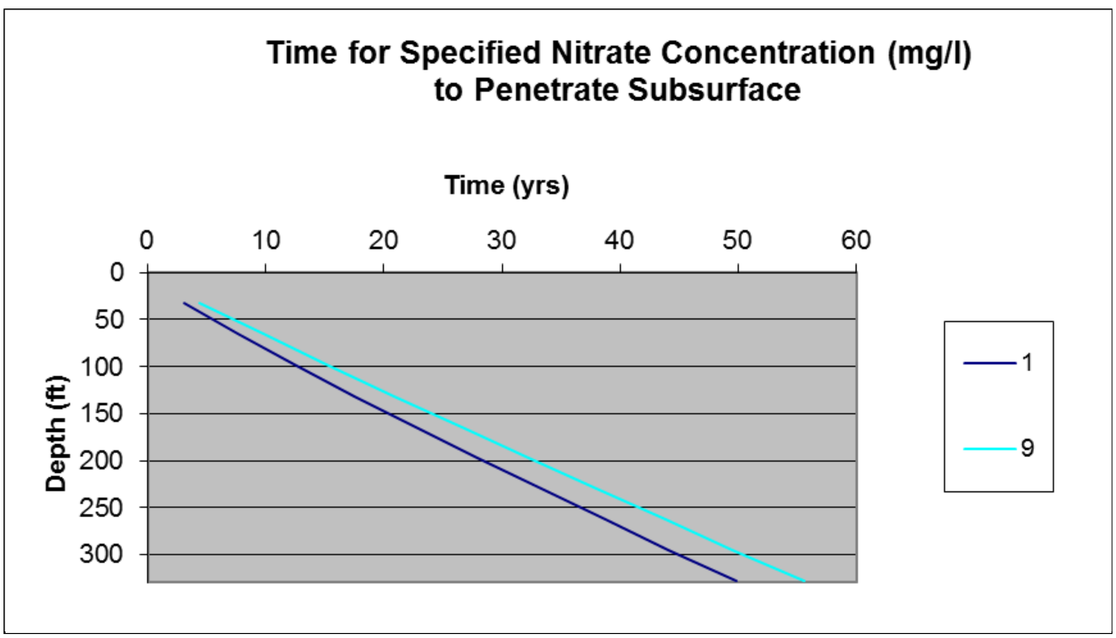


Figure B3: Nitrate Arrival Times for Location 2

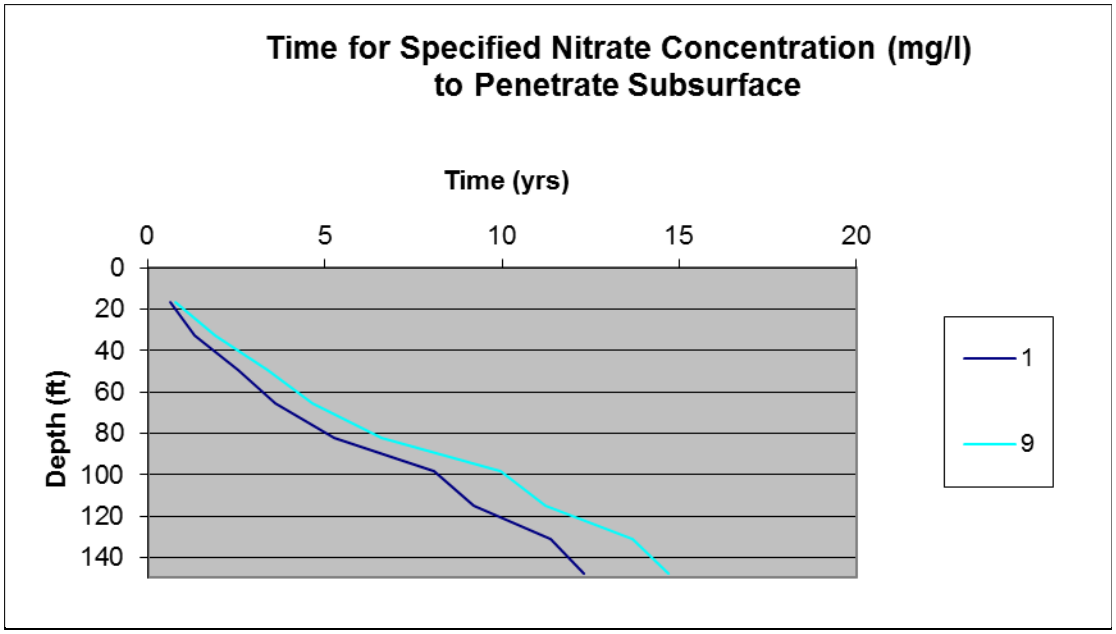


Figure B4: Nitrate Arrival Times for Location 3

Exhibit B

Estimated Cost of Compliance Technical Report
Kern Coalition

TENTATIVE WASTE DISCHARGE REQUIREMENTS GENERAL ORDER FOR GROWERS WITHIN THE TULARE LAKE BASIN AREA THAT ARE MEMBERS OF A THIRD-PARTY GROUP

4/15/2013
REVISED 5/12/2014

ESTIMATED COST OF COMPLIANCE TECHNICAL REPORT – KERN COALITION

Prepared For:

Kern River Watershed Coalition Authority
PO Box 151
Bakersfield, CA 93302

Prepared By:
Provost & Pritchard Consulting Group
130 N. Garden Street
Visalia, CA 93291

Principal Authors - Provost & Pritchard Consulting Group

The principal authors of this Report have hands on experience with farming and irrigation practices in the Southern San Joaquin Valley. They were also the principal engineers to help develop the implementation cost estimates for the Dairy General Order working with agronomists, the dairy industry organizations, and the Rancho Cordova Water Board Staff.

Donald Ikemiya, P.E. – Mr. Ikemiya is a Vice President at Provost & Pritchard with 28 years of engineering experience. He is a California registered Civil Engineer and Agricultural Engineer. He formerly was the Area Engineer for the USDA Natural Resources Conservation Service covering most of the southern Central Valley. He grew up on a farm and currently manages the financial aspects of the now leased family farm, located within the Tulare Lake Basin Area.

E. John Schaap, M.S., P.E. - Mr. Schaap is a Vice President at Provost & Pritchard with 17 years of engineering experience. He is a California registered Civil Engineer and Agricultural Engineer. He formerly managed his own engineering firm and worked for a major Central Valley agricultural producer. He grew up on a dairy in Texas, New Mexico, and Kern County, California.

The cost estimate presented in this Report was developed with significant detail by designating direct hourly costs and expenses to each of the required tasks in the March 2013 Tulare Lake Basin Area Tentative General Order.

An initial version of the cost spreadsheets and per acre costs were presented to the Water Board staff in Fresno on January 29, 2013.

ESTIMATED COST OF COMPLIANCE

TECHNICAL REPORT

KERN RIVER WATERSHED COALITION AUTHORITY

Table of Contents

Tables

Attachments

1

OBJECTIVES, APPROACH & ASSUMPTIONS

A. OBJECTIVES

The objectives of this Estimated Cost of Compliance Technical Report (Report/Study) include the following:

1. Provide a detailed assessment of the Kern River Watershed Coalition Authority's (KRWCA) Third Party and Member costs to comply with the March 2013 Tentative Waste Discharge Requirements General Order for Growers within the Tulare Lake Basin Area (Order).
2. Provide a comparative analysis of the $1.90 per acre incremental cost estimate above the current surface water only program, provided under Finding No. 39 in the Order, to the costs determined in this Study. We are unaware of what detailed assumptions the Water Board staff used or specifically how the $1.90/acre was determined, and are unaware if these assumptions were made public.
3. This Report is to provide concise explanations, coupled with detailed technical background.

B. APPROACH

1. The Kern Coalition is a sub-watershed of the Tulare Lake Basin area. This Report assesses the cost impacts of the Order within the Kern Coalition area and its Members. The Kern Coalition irrigated area is approximately 1,040,000 acres in size with an estimate of 902 Members ultimately joining the Kern Coalition.
2. The primary approach is to designate specific hours, an hourly rate, consultant expenses, and administrative expenses, on a requirement-by-requirement basis as written in the Order. The Report is written to correlate with the Order's Sections.
3. The surface water quality requirements are currently being addressed by the Kern Coalition and therefore the Third-Party and Member costs to comply with the surface water quality sections of the Order were not included in this Report.
4. The costs associated with implementing management practices that might be indirectly triggered or required, were largely not included in the Report costs. Only direct compliance practices (i.e. nitrogen management plans) were estimated. Although these costs will be significant for some individual members, a large majority of Kern Coalition Members have already implemented pressurized irrigation systems, tailwater recovery systems, and other practices that have improved irrigation water distribution uniformity.

C. ASSUMPTIONS

1. It is acknowledged that many of the specific requirements referenced and assumptions made in this Report are based on the information available at the time the Report was written. Future refinements of the costs are expected.
2. The Tentative Order's requirements are not well defined in numerous areas, thus assumptions were made in order to assign costs.
3. Numerical assumptions used in this Report are listed in Table 1 – 1 Kern Coalition Cost Analysis Assumptions.
4. Each Table in this report utilized data summarized from the corresponding detailed spreadsheet in the Appendix.

Table 1 – 1. Kern Coalition Cost Analysis Assumptions

Description	Tulare Lake Basin Area Tentative Order	Kern Coalition	Units
Total Irrigated Lands Area	2,890,000[1/]	1,040,000	Acres
Acres to be Under the Order	850,000[1/ 4/]	1,040,000	Acres
Growers with Irrigated Lands	10,700[1/]	902[3/]	Growers
Potential Members	7,200[1/]	902[3/]	Members
Current Members	--	350	Members
Members Needing to Enroll	--	552	Members
Small Farming Operation (<60 acres) Members	6,206[1/]	182[3/]	Small Farm Members
Small Farming Operation (<60 acres) Acres	133,000[1/]	4500[3/]	Small Farm Acres
Member Hourly Rate	$120[2/]	$120	Per Hour
Coalition Staff Hourly Rate	--	$120	Per Hour
Consultant Staff Hourly Rate	$120[2/]	--	Per Hour
Member Water Board Fee	$0.56	$0.56	Per Acre

1/ March 2013 Tentative Order - Findings No. 12

2/ July 2010 Draft Economic Analysis Technical Memorandum ICF International – Page 2-22

3/ Kern County Agricultural Commissioner Data

4/ This appears to be an error. The acres should match irrigated acres of 2,890,000.

2

WASTE DISCHARGE REQUIREMENTS THIRD-PARTY GROUP COSTS (SECTIONS IV.C & VIII)

A. SECTION IV.C PROVISIONS & REQUIREMENTS – THIRD PARTY

The costs associated with the Third-Party requirements to comply with the WDRs Section IV.C are described in this section. **Table 2 – 1 "Third Party Section IV.C Costs"** summarizes the estimated Kern Coalition costs.

Table 2 – 1 Third-Party Section IV.C Costs

Report Heading	WDR Section	Description	Third-Party One Time Costs			Third-Party Annual Costs		
			Total Hours	Expenses	One Time Upfront Costs[1/]	Total Hours	Expenses	Annual Costs
1.	IV.C.1	Organizational Documentation	72	$7,000	$15640	--	--	--
2.	IV.C.2	Prepare Annual Summaries	--	--	--	144	$4,000	$21,280
3.	IV.C.3	Response to Notice of Violation (NOV)	--	--	--	108	$22,600	$35,560
4.	IV.C.4	Develop, implement, track and evaluate effectiveness of GQMP	200	$100,000	$124,000	100	$40,000	$52,000
5.	IV.C.5	Submittals	--	--	--	100	$5,000	$17,000
6.	IV.C.6	Quality Assurance/Quality Control	--	--	--	100	$1,000	$13,000
7.	IV.C.7	Receipt of Notice of Applicability (NOA)	260	$7,000	$38,200	--	--	--
8.	IV.C.8	Conduct Education and Outreach activities			--	500	$24,000	$84,000
9.	IV.C.9	Annual Membership Participation Report			--	500	$11,000	$71,000
10.	IV.C.10	Ensure Requirements are Met			--	80	$2,000	$11,600
11.	IV.C.11	Fees			--	210	$10,000	$35,200
Third-Party Subtotal			**532**	**$114,000**	**$177,840**	**1,842**	**$119,600**	**$340,640**

1/ One time costs can occur anytime within the first five years of implementation.

1. Organizational Documentation (IV.C.1)

One time upfront costs for:

- Hiring staff to manage the operations.
- Identify responsible persons for program fulfillment.
- Setting up an organizational system and office.
- Update website for Third-Party functionality, create database for contact emails, addresses, transmittals of hardcopies and recordkeeping for Members.
- Annual costs are built into the other ongoing tasks.

2. Prepare Annual Summaries (IV.C.2)

Annual costs for:

- Utilizing accounting staff.
- Fee notices, collection of fees, and receipts.
- Prepare annual summaries of expenditures and revenue.
- Summaries mailed or made readily available to Members.
- First year fee notices and collections are higher in year one, but were annualized over 5 years.

3. Response to Notice of Violation (IV.C.3)

Annual costs for responses to a Notice of Violation (NOV):

- Assume one NOV per year, with approximately 20 Members impacted.
- Notify affected Members within 30 days of receiving NOV.
- Provide confirmation to Water Board of each notification.
- Prepare an annual summary of NOVs for submission to the RWQCB.
- Retain and manage consultants to help respond to and resolve NOV items.
- The cost for a consultant is allocated to expenses.

4. Develop & Implement Plans to Track & Evaluate (IV.C.4)

One time upfront costs for:

- The Third-Party is to develop and implement plans to track and evaluate the effectiveness of water quality management practices, pursuant to the Groundwater Quality Management Plan (GQMP).
- Requirements are identified in WDRs IV.C.4, VIII.I and portions of MRP-1.

Annual costs for:

- Annual updates to the GQMP due in May of each year,.

5. Submittals (IV.C.5)

Annual costs:
Most submittal requirement costs are embedded in the costs for each report. However, additional administrative costs are required to track, schedule, meet the deadlines, and file on an annual basis.

6. Quality Assurance Quality Control (QAQC) (IV.C.6)

Annual costs:
Annual costs are required to provide a fresh look at water quality monitoring and assessments in conformance with QA/QC.

7. Receipt of Notice of Applicability (NOA) (IV.C.7)

Upfront costs:
- Up-front costs to inform Members and future Members (within 30 days) of approval of the NOA, and to provide Members information on the Order's requirements.
- Request and track return receipt of a notice of confirmation form to be completed by each Member.

8. Conduct Education and Outreach Activities (IV.C.8)

Annual costs:
a) Educate Members of program requirements:
  - Water quality problems.
  - Exceedances of water quality objectives.
  - Degradation of water quality.

b) Maintain attendance lists for outreach events.
c) Provide Members with information on:
  - Water quality practices.
  - Environmental impacts of water quality practices.

d) Provide annual summary of education and outreach activities to Board, including:
  - Copies of educational and management practice information provided.
  - Report the total number of Members attended.
  - Describe the process used to provide information to non-attendees.

9. Annual Membership Participation Report (IV.C.9)

Annual costs:
a) Work with RWQCB to ensure all Members are addressing exceedances or degradation.
b) As part of the Membership List submittal, identify growers who have failed to:
  - Implement improved water quality management practices as specified (GQMP).
  - Respond to an information request associated with the GQMP or this Order.
  - Participate in Third-Party studies where the Third-Party is the lead.
  - Provide confirmation in an outreach event.
  - Submit required fees to the Third-Party.

10. Requirements by Subsidiary Groups (IV.C.10)

Annual costs:
- Ensure activities performed by subsidiary groups meet requirements.
- Assume 5 days of work per subsidiary group and up to 16 groups.

11. Fees (IV.C.11)

Annual costs:

- Collect RWQCB fees from Members and submit to Board.
- Collect fees from Members for reimbursement of Third-Party activities.
- Maintain records and/or reports for 5 years.

B. SECTION VIII REQUIRED REPORTS AND NOTICES – THIRD PARTY

The costs associated with the Third-Party requirements to comply with the WDRs Section VIII are described below. **Table 2 – 2 "Third-Party Section VIII Costs"** summarizes the Kern Coalition costs.

Table 2 – 2 Third-Party Section VIII Costs

Report Heading	WDR Section	Description	Third-Party One Time Costs			Third-Party Annual Costs		
			Total Hours	Expenses	One Time Upfront Costs	Total Hours	Expenses	Annual Costs
1.	VIII.A	Third-Party Application	40	$2,000	$6,800	--	--	--
2.	VIII.B	Membership (Participant) List	720	$3,100	$89,500	90	$600	$11,400
3.	VIII.C	Templates	0	$0	$0	55	$700	$7,300
4.	VIII.D	Groundwater Quality Assessment Report and Evaluation/Monitoring Workplans	Included in Attachment B MRP					
5.	VIII.F	Sediment Discharge and Erosion Assessment Report	200	$70,000	$94,000	--	--	--
6.	VIII.H	Monitoring Report (Attachment B – V.C)	--	--	--	800	$5,000	$101,000
7.	VIII.I	Comprehensive Groundwater Quality Management Plans (GQMP)	Included in MRP-1					
8.	VIII.J	Technical Reports-Where monitoring in not effective, provide technical reports	--	--	--	350	$2,000	$44,000
9.	VIII.K	Notice of Termination	--	--	--	--	--	--
10.	VIII.L	Total Maximum Daily Load (TMDL) Requirements	300	$5,000	$41,000	--	--	--
		Third-Party Subtotal	**1,260**	**$80,100**	**$231,300**	**1,280**	**$8,300**	**$163,700**

1. Third-Party Application (VIII.A)

Upfront costs:

- Submit request to Board within 30 days of Order effective date.

- Follow up actions.
- Formation costs in IV.C.1

2. Membership (Participant) List (VIII.B)

Upfront costs of and annual costs :

a) Submit list of Members to Board:
  - Within 180 days of reviewing NOA.
  - Annually by July 31 of each year.

b) List shall contain, at minimum:
  - All parcel numbers covered under the membership.
  - County of each parcel.
  - Section, Township, and Range associated with each parcel.
  - Number of irrigated acres for each parcel
  - Member names, mailing addresses, and contact name and phone number (can use Third-Party) with annual updates.
  - Name of farm operator for each parcel if different from the Member.
  - Identification of the crops grown and acreage of each crop.
  - Identification of each parcel that is a part of the Small Farming Operation, if applicable.

3. Templates (VIII.C)

The Kern Coalition costs were estimated with the assumption that the Eastern San Joaquin Coalition templates (yet to be approved) would be utilized. Costs for development of the templates have already been incurred, as part of the group option, and are not included in this estimate.

Upfront costs submitted to the RWQCB and annual costs of $7,000:

a) Farm Evaluation Template:
  - Group Option to Water Board within 90 days of NOA.
  - Identification of on-farm management practices implemented to achieve the Order's farm management performance standards.
  - Specifically track which management practices recommended in management plans have been implemented on the farm.
  - Identification if movement of soil occurs during storm events and/or during irrigation drainage events (sediment and erosion risk areas) and a description of where this occurs.
  - Identification if water leaves the property and is conveyed downstream and a description of where this occurs.
  - Location of in-service wells and abandoned wells.
  - Identification if well-head and backflow protection practices have been implemented.

b) Nitrogen Management Plan Template:
- Costs for member compliance with the templates are captured in section C, Member Requirements below.
- Nitrogen Management Plan Summary Report.

c) Sediment and Erosion Control Plan Template:

4. Groundwater Quality Assessment Report and Evaluation/Monitoring Workplans (VIII.D)

Costs for this section are included in the MRP Attachment B of the Order and Section 3 of this Report.

5. Sediment Discharge and Erosion Assessment Report (VIII.F)

Upfront costs:
- Submit one year after receiving NOA (Attachment B, VI).
- Notify impacted Members to prepare plan.

6. Monitoring Report (VIII.H)

Annual costs:
- MRP Attachment B, V.C.
- Submit monitoring reports to State Board GeoTracker database by 1 May annually.

7. Comprehensive Groundwater Quality Management Plan (GQMP) (VIII.I)

- The costs for this item are estimated under Section 4 of the report, Management Plan Requirements.

8. Technical Reports (VIII.J)

Annual costs:
- Where monitoring is not effective, provide technical reports.
- One report per year.

9. Notice of Termination (VIII.K)

- Negligible costs are estimated to be associated with this item.

10. Total Maximum Daily Load (TMDL) Requirements (VIII.L)

Upfront costs:
- Implement approved TMDLs in the Basin Plan, as applicable.

C. SECTION VII REQUIRED REPORTS & NOTICES – MEMBER

The costs associated with Member requirements to comply with the WDRs Section VII are described in this section. **Table 2 – 3 "Member Section VII Costs"** summarizes the Kern Coalition Costs.

Table 2 – 3 Member Section VII Costs

Report Heading	WDR Section	Descriptions	Member One Time Costs			Member Annual Costs		
			Total Hours	Expenses	One Time Upfront Costs	Total Hours	Expenses	Annual Costs
1.	VII.A	Notice of Confirmation (NOC) / Notice of Intent (NOI) / Membership Application	3,548	$123,900	$549,660			$0
2.	VII.B	Farm Evaluation	5,548	$22,933	$688,633	920	$0	$110,354
3.	VII.C	Sediment and Erosion Control Plan	63	$110,000	$117,500	50	$0	$6,000
4.	VII.D	Nitrogen Management Plan (NMP)				90,920	$2,637,246	$13,547,646
5.	VII.E	Mitigation Monitoring – Certain Members required to implement mitigation measures in Attachment C	400	$300,000	$348,000	40	$10,000	$14,800
6.	VII.F	Notice of Termination				50	$200	$6,200
7.	XI	Annual Fees Paid by Member					$582,500	$582,500
Member Subtotal			**9,559**	**$556,833**	**$1,703,793**	**91,980**	**$3,329,946**	**$14,267,500**

1. Notice of Confirmation (NOC) / NOTICE OF INTENT (NOI) / MEMBERSHIP APPLICATION (VII.A)

a) Member enrolled under Order R5-2006-00XX Southern San Joaquin Water Quality Coalition; 350 estimated Kern Members.
   - Within 150 days of NOA by Executive Officer.
   - Third-Party will provide NOC form from Member within 30 days of receiving NOA.

b) All other Growers:
- Growers not in Coalition, estimated 500 Members need to join.
- Complete Third-Party membership application.
- One-time fee of $200.
- Provide certification, written notice was provided of enrollment to non-Member parties.
- Third-Party will confirm membership.

c) 151 days after the Executive Officer's issuance of NOA to the Third-Party, Growers no yet members must:
- Estimate 52 Growers will miss the deadline.
- Complete NOI application to the Board.
- NOI processing fee.
- Membership application to Third-Party.
- Alternatively, a Grower may submit to the Board a RWD or NOI as an individual discharger. These costs not accounted in the cost estimate.

2. Farm Evaluation (VII.B) Upfront

The costs for the Farm Evaluation were estimated based on the template provided to the RWQCB on April 11, 2013 by the East San Joaquin Water Quality Coalition, under the group option. If the template or other Farm Evaluation guidelines are ultimately revised, our cost estimate will need corresponding adjustment.

a) Approximately $19,400 in third party up-front cost were estimated for five grower outreach events to explain and provide clarification in filling out the forms.
- Member time was included in the estimate for attending the outreach meetings.
- A small amount of member time was allotted for gathering parcel information, doing research on management practices in preparation for the meeting.
- Filling out part B for combinations of management practices by crop per farm.
- Drawing a map of the farm for onsite inspection purposes.

b) Assumptions for small vs large farms in low vs. high vulnerability are detailed in **Table 2 - 4 Farm Size and Vulnerabiity Areas** below.
- Slightly more time and expense was estimated for filling out the farm evaluation for large farms than for small. (3 combinations of crops/management practices to detail in part B vs. 1 for small farms).
- The time to fill out the farm evaluation on a recurring basis (annually in high vulnerability and every 5 years in low vulnerability) was estimated to be significantly less, once growers were familiar with it.

The following summarizes the major results of the Farm Evaluation cost estimate:

c) Members in Low Vulnerability Areas:
- Small Farming Operations cost to fill out the form of $595 per member.

- Farming Operations greater than 60 acres: $775 per member.
- Costs to fill out evaluations every five years were annualized. Costs to fill out the form on a recurring basis was estimated at $162 per member.

d) Members in High Vulnerability Areas:
- Costs for large growers were used for all growers in high vulnerability.
- For more details, refer to the **WDR Member Requirements Attachment.**

3. Sediment and Erosion Control Plan (VII.C)

The costs for the Sediment and Erosion Control Plan were estimated based on the template provided to the RWQCB on April 11, 2013 by the East San Joaquin Water Quality Coalition, under the group option. If the template or other guidelines are ultimately revised, our cost estimate will need corresponding adjustment.

a) Fifty (50) farms were assumed to be subject to the requirement for a Sediment and Erosion Control Plan in the Kern sub-watershed.
- Since the details of a self certification program are unknown at this point, and since a significant (and valuable) investment of time on the part of the grower would also be required for self certification, certification by a professional engineer was assumed.
- We assumed a flat cost of approximately $2200 to certify a plan based on the template.
- The plan assumes a small amount of grower time to work with the certifying party.
- The total cost estimated for each plan was $2,338.
- The estimated costs to implement management practices that would possibly be specified by the plans were not included.

4. Nitrogen Management Plan (NMP) (VII.D)

The costs for the nitrogen management plan were estimated based on the NMP template provided to the RWQCB on April 11, 2013 by the East San Joaquin Water Quality Coalition, under the group option.

a) Given the definition of high vulnerability stated in the Tentative Order, it is assumed that the entire Westside and all areas with poor quality perched water and underlying high nitrates will be high vulnerability.

b) It was assumed that only about 30% of the farms would be in the low vulnerability area, with corresponding lower regulatory requirements.

c) According to Kern Ag Commissioner data, there are approximately 902 farms in Kern, and approximately 182 of those farms have less than 60 acres.

d) **Table 2 - 4 Farm Size and Vulnerability Assumptions** summarizes the distribution of farm sizes assumed for the nutrient management cost analysis.

Table 2 – 4 Farm Size and Vulnerability Assumptions

	Small	Farms > 60 ac	Total
Low vulnerability	60	216	**276**
High vulnerability	122	504	**626**
TOTAL	**182**	**720**	**902**

e) There are approximately 1,040,000 irrigated acres in the Kern sub-watershed. Small farms comprise approximately 4500 acres, which averages out to approximately 25 acres per farm. Our analysis assumed that the remaining farms averaged 1,438 acres per farm, so that the sum total of acres would match the sub-watershed total.

f) Since the details of a self certification program are unknown at this point, and since a significant (and valuable) investment of time on the part of the grower would also be required for self certification, certification by a Certified Crop Advisor (**CCA**) was assumed. From our experience with the dairy order, we assumed a minimum flat cost of $1,200 plus $100 per field. Field size was assumed to be 25 acres on small farms and 80 acres on large farms. An irrigation well was assumed to exist on every small farm. On large farms, every well was assumed to serve 240 acres. Thus, large farms were assumed to have 6 wells.

g) Lab analysis cost assumptions are summarized in **Table 2 – 5 Lab Analysis Cost and Frequency Assumptions**.

Table 2 – 5 Lab Analysis Cost and Frequency Assumptions

Analysis	Cost per sample	Sample frequency
Soil	$20	One per field per year
Irrigation water	$60	One per well per year
Manure/compost	$33	One per field per year

h) Approximately six hours of time was assumed to be required per field, per year, for nutrient and yield recordkeeping. Other small amounts of grower time per field were assumed to be necessary for the following:

- Review of yield history and preparation for nutrient planning at the beginning of the season;
- Mid season review of yield potential and adjustments in nutrient planning;

- Ratio calculation;
- Reporting (in high vulnerability only).

i) Some expense is estimated for accomplishing grower outreach meetings in various parts of the sub-watershed, to help orient growers to the new requirements and to provide helpful information and guidance. This shows up as an up-front third party cost.

The following summarizes the major aspects of the results of the NMP cost analysis:

j) High Vulnerability Groundwater Area costs to prepare, certify, and implement an NMP:
   - Small Farming Operations: $2,433 total cost per farm, or about $97.30 per acre.
   - Farming Operations > 60 ac: $19,314 total cost per farm, or about $13.40 per acre.

k) Low Vulnerability Groundwater Area costs to prepare and implement an NMP:
   - Small Farming Operations: $1,823 total cost per farm, or about $72.90 per acre.
   - Farming Operations > 60 ac: $15,774 total cost per farm, or about $11 per acre.

5. CEQA Mitigation Monitoring (Attachment C) (VII.E)

a) Submit mitigation monitoring by an estimated 10 members per year for upfront and annual costs.
   - Implementation of CEQA mitigation measures (cultural resources, veg & wildlife, fisheries, ag resources, GHG emissions
   - Measures implemented
   - Potential environmental impact measures addressed
   - Location of measures (parcel number, county)
   - Steps taken to monitor success of measure

6. Notice of Termination (VII.F)

Estimate 5 terminations per year, mostly due to change in ownership or consolidation of farms.

7. Annual Fees Paid by Member (XI)

Tier 1 Water Board Fees at $100 per group plus $0.56 per acre.

3

MONITORING AND REPORTING PROGRAM ATTACHMENT B OF GENERAL ORDER

A. MONITORING AND REPORTING PROGRAM, SECTION IV

The costs associated with the Third-Party requirements to comply with the Monitoring and Reporting Program (MRP) in Attachment B, Section IV are described in this section. **Table 3** – **1 "Attachment B – MRP Section IV Low Estimate"** summarizes the Kern Coalition estimated costs.

Table 3 – 1 Attachment B – MRP Section IV Low Estimate

Report Heading	MRP Section	Description	Third Party-Upfront			Third Party-Annual		
			Total Hours	Expenses	One Time Upfront Costs	Total Hours	Expenses	Annual Costs
1.	IV.A	Groundwater Quality Assessment Report (GAR)	450	$250,500	$304,500			
2.	IV.B	Management Practice Evaluation Program (MPEP)	253	$141,028	$171,429			
3.	IV.C	Groundwater Quality Trend Monitoring IV.C	120	$5,000	$19,400	2,300	$12,000	$288,000
4.	IV.D	Management Practices Evaluation Workplan IV.D	253	$141,028	$171,429			
5.	IV.E	Trend Monitoring Workplan-following MRP IV.E	1,900	$16,000	$244,000			
		Section IV Subtotal	**2,977**	**$553,556**	**$910,758**	**2,300**	**$12,000**	**$288,000**

Table 3 – 2 Attachment B – MRP Section IV High Estimate

Report Heading	MRP Section	Description	Third Party-Upfront			Third Party-Annual		
			Total Hours	Expenses	One Time Upfront Costs	Total Hours	Expenses	Annual Costs
1.	IV.A	Groundwater Quality Assessment Report (GAR)	450	$250,500	$304,500			
2.	IV.B	Management Practice Evaluation Program (MPEP)	1,250	$1,350,000	$1,500,000			
3.	IV.C	Groundwater Quality Trend Monitoring IV.C	120	$5,000	$19,400	2,300	$12,000	$288,000
4.	IV.D	Management Practices Evaluation Workplan IV.D	1,250	$1,350,000	$1,500,000			
5.	IV.E	Trend Monitoring Workplan-following MRP IV.E	1,900	$16,000	$244,000			
		Section IV Subtotal	**4,970**	**$2,971,500**	**$3,567,900**	**2,300**	**$12,000**	**$288,000**

1. Groundwater Quality Assessment Report (GAR) (IV.A)

The proposed GAR outline must be submitted within 3 months after receiving the notice of applicability (**NOA**). The completed GAR must be submitted within 1 year after receiving the NOA. The following data and analysis are required:

a) GAR Components from existing federal/state/county/local databases and documents:
- Detailed land use information.
- Depth to groundwater map.
- Groundwater recharge information.
- Soil survey information.
- Shallow groundwater constituent concentrations (potential COCs).
- Existing groundwater data collection and analysis efforts.
- Discuss geological and hydrogeologic information.

b) GAR data review and analysis:
- Determine high vulnerability areas based on potential impacts from irrigated agricultural activities.
- Determine merit of incorporating existing data collection efforts to achieve objectives.
- Prepare ranking of high vulnerability area for prioritization of workplan activities.
- Utilize GIS mapping applications, graphics, tables to convey data, analysis, and results.

c) Groundwater vulnerability designations:

- Designate high/low vulnerability areas.
- Modify designations every 5 years after GAR approval.

d) Prioritization of high vulnerability groundwater areas:

- Identify exceedances of water quality objectives.
- Proximity of high vulnerability area to areas contributing to recharge to urban and rural communities.
- Identify existing irrigated agriculture field or operational practices.
- Consider largest commodity types comprising up to at least 80% of irrigated agricultural acreage.
- Consider legacy or ambient conditions of groundwater.
- Identify groundwater basins currently or proposed to be under review by CV-SALTS.
- Identify constituents of concern (e.g. relative toxicity, mobility).

Based on other prior detailed estimates of GAR cost that we have performed, we estimate the GAR cost for the sub-watershed to be approximately $304,500. This estimate is in reasonable agreement with the reported initial contracted price of the East San Joaquin GAR.

2. Management Practice Evaluation Program (MPEP) (IV.B)

The goal of the MPEP is to determine effects, if any, that irrigated agricultural practices have on groundwater quality. The following are requirements of the MPEP that are detailed in the Monitoring and Reporting Program of the Tentative Order.

a) Objectives of MPEP:

- Identify existing site and/or commodity specific practices protective of groundwater quality.
- Determine if newly implemented management practices are improving or may improve groundwater quality.
- Develop an estimate of the effected Members' discharges of COCs using a mass balance model.
- Utilize results of evaluated management practices to determine if management practices need to be improved.

b) Implementation on a watershed or regional commodity basis with other Third-Party groups. Prepare and submit a master schedule of the rank or priority for investigation of high-vulnerability areas.

c) Reports of the MPEP – reports shall evaluate the data and make a determination whether groundwater is being impacted by activities at farms.

d) Management Practices Evaluation Report (MPER):

- No later than 6 years after implementation of each phase.
- Identify management practices that are protective of groundwater quality.
- Identify management practices that are appropriate for site conditions on farms.

- Include maps showing types of management practices that should be implemented in certain areas.
- MPEP to include adequate technical justification for identifying protective management practices.
- Propose and implement new/alternative management practices if existing are not protective.
- GQMPs are to be updated to be consistent with the findings of the MPER.

The costs of the MPEP are variable at this point. There are two major options as noted above: perform the MPEP as a group, or just within the Kern area. Costs estimates can be refined once a decision is made on approach and once an MPEP workplan has been approved by the RWQCB. The following is our best estimate of the total cost of all activities associated with the MPEP options. Please refer to the following related areas of this report and the cost estimate spreadsheet:

- Management Practices Evaluation Workplan (item 4 below), and;
- Monitoring Well Installation, Sampling Plan, And Completion Report (section 5 of this report. This estimates major monitoring well costs for a Kern only approach.)

e) The Kern only option for executing the MPEP will be extremely expensive in Kern due to the significant depth to groundwater. Results will also be slow to reach monitoring wells, which may require monitoring over a longer period before conclusions can be made, probably incurring more cost. Nevertheless, growers in Kern may not choose to rely on conclusions that are derived in areas with much shallower groundwater. There is an argument for Kern doing its own MPEP, as Rob Gailey noted that 85% of the Kern area has groundwater deeper than what has been covered by existing studies. Areas with shallower groundwater may not have geology that is as protective, and may not benefit from natural attenuation or denitrification that Kern may benefit from due to its deeper groundwater.

f) Clay Rodgers noted at the 8/21/12 Tulare workshop that the Representative Monitoring Program (now MPEP), will be expensive. The name has changed, and there will potentially be less reliance on first encountered groundwater monitoring and more reliance on vadose zone monitoring (potentially using lysimeters) and modeling; however, staff has expressed that monitoring well data will be necessary to validate conclusions. Mr. Rodgers approached the question of cost using the Dairy Representative Monitoring Program (RMP) as an example. Mr. Rodgers indicated that the Dairy RMP had spent $2 million in two years and that it had a revenue stream of approximately $1.25 million dollars per year to support it.

g) As Mr. Rodgers noted, Central Valley irrigated agriculture, is much larger in scope than the dairy industry consisting of 33,000 farms on 7.5 million acres, with in excess of 250 crops. Mr. Rodgers emphasized that the management practices would likely be a bigger driver in determining the amount of work necessary for evaluating irrigated ag than the number of crops. Mr. Rodgers noted that there are fewer dairies with a smaller number of crops, but they have production areas in addition to cropland. Mr. Rodgers theorized that in the best case would be that the MPEP would be the same size as the dairy RMP, or a little larger. He theorized that the worst case the MPEP would be five times larger. This would result in a cost range of $1.5 to $7 million per year, or $0.20 to $1/acre a year. Using a cooperative approach, he estimated that costs would be on the low end. He noted that the disadvantages of representative monitoring include that after having agreed to representative monitoring, if results indicate that a grower needs to improve their management practices, they will be obligated to follow through and cannot at the end refuse to make prescribed improvements. Thus, growers must carefully consider their commitment to a monitoring program that proposes to monitor elsewhere, and make sure that all necessary variables are taken into account, to provide accurate results. This will be an important item for Kern's consideration, as it will be very expensive to monitor in Kern.

h) Looking at the draft Farm Evaluation template submitted on 4/11/13, the management practices can be characterized in the following way:
- Pesticide practices: 15 practices noted.
- Irrigation practices: 9 noted, which could fall into two broad categories of pressurized vs. surface irrigation systems.
- Nitrogen management practices: 11 noted. These could be further classified as application methods vs. management tools.
    - At the simplest level, the application methods could be contrasted as fertigation vs. alternative delivery methods (foliar, split applications, variable rate/GPS).
    - Management tools can be classified as technical (lab testing) vs. simple advising (published guidelines, etc.)
    - Thus under management, there seems to be a minimum of 4 combinations to evaluate.

i) If we consider only irrigation and nutrient practices and combinations therein, we could have a minimum of 2 irrigation x 4 nitrogen practices = 8 combinations of practices. It would easily be conceivable to have up to 16 combinations or more that should be incorporated, if we were to add pesticide practices as a variable, or further resolution on irrigation or nitrogen practices.

j) Mr. Rodgers noted that there are in excess of 250 crops grown in the Central Valley. At the simplest level these can probably be aggregated into three groups: field crops, vegetable crops, and fruit & nut crops. Knowing that there are many unique aspects about various crops, this may not be appropriate. It's very possible that there could be 25 or more crop groups that should be analyzed.

k) Regarding site conditions, at the simplest level, there should probably be three variables: coarse or sandy soils, medium texture soils, and fine (clayey) soils. Looking at the soil triangle, there could easily be 9 or more variables for site condition. Depth to water and other variables could also be introduced here, adding more variables.

l) Thus, looking at the possible combinations for a MPEP effort, we could have the following:
- Minimum: 3 crops groups x 8 management practices x 3 site conditions = 72 monitoring sites.
- Middle scenario: 14 crops groups x 12 management practices x 6 site conditions = 1008 monitoring sites.
- Possible maximum: 25 crops groups x 16 management practices x 9 site conditions = 3600 monitoring sites.

m) If a Kern-only MPEP were to be undertaken, it would have less diversity than the whole Central Valley. It may be possible to aggregate Kern into 6 crop groups x 8 management practices x 3 site conditions. There has been a relatively uniform adoption of advanced practices in Kern, which may lend to analyzing something closer to the minimum number of management practice factors. Regarding site conditions, 3 factors may be appropriate, as noted in Dr. Kimmelshue's work, and characterization of the sub-watershed into 3 major texture categories.

n) Given the above possibilities for combinations that may need to be analyzed, and using cost assumptions such as those noted in Section 5 regarding MWISP costs, we estimated the potential up-front and annual costs that may be incurred for MPEP programs at the various intensity levels. Assumptions used in the model included the following:
- Higher MPEP workplan costs for aggregation into fewer crop groups.

- Higher MPEP analysis and reporting work necessary to derive conclusion when crops were aggregated into fewer, larger groups.
- 3 wells per monitoring site (as opposed to the 5 or 6 that were used in the Dairy RMP). This is in recognition of the changes made with the name change from RMP to MPEP, with the intent to reduce the number of wells and rely on alternative methods instead. While alternatives to groundwater monitoring can have considerable cost, we did not account for their cost in this analysis.
- $4000 monitoring well cost for group option work, assuming that wells will be constructed in places with shallower groundwater.
- Kern share calculated by taking 1/7th of up-front and annual group option costs.

o) Once a model was built, other scenarios were devised that would roughly match the dairy RMP cost and something that was close to Mr. Rodgers anticipated worst case scenario of 5 times the dairy RMP cost.

Calculations for a Kern-only MPEP were undertaken with similar assumptions, but using a $17,000 well cost instead, to account for the deeper groundwater.

The data for all of these scenarios is summarized in **Table 3 - 3**. In addition, the percent of growers monitored is noted. As a reference, the dairy RMP proposes to ultimately monitor 65 out of 1250 dairies, a rate of approximately 5%

.

Table 3 – 3 MPER Cost Grid

Description	Crop groups	Management Practices	Site Conditions	Sites	% of growers monitored	Wells per site	Workplan cost per crop group	Analysis cost per crop group	Well drilling cost, ea	One time costs	Annual costs, $	Annual costs, $/ac	Annual, % of dairy RMP cost	Comments
Kern Only	6	8	3	144	16%	3	$250,000	$250,000	$17,000	$11,864,64	$5,932,800	$5.70	456%	There will doubtless be some duplication of effort with a Kern only MPEP. Is there a possibility for a hybrid option? Group option for certain crops, Kern only for other crops?
Group option														
Description	**Crop groups**	**Management Practices**	**Site Conditions**	**Sites**	**% of growers monitored**	**Wells per site**	**Workplan cost per crop group**	**Analysis cost per crop group**	**Well drilling cost, ea**	**Kern share of one-time costs**	**Kern share of annual costs, $**	**Annual costs, $/ac**	**Group annual cost, % of dairy RMP cost**	**Comments**
Match dairy RMP cost	3	4	3	36	0.1%	3	$300,000	$300,000	$4,000	$373,166	$211,886	$0.21	114%	Doubtful that we could cover the whole valley on this few combinations.
Minimum combinations	3	8	3	72	0.2%	3	$300,000	$300,000	$4,000	$489,189	$423,771	$0.42	228%	Risk being regulated on data that doesn't fit. This may not be enough combinations.
5x Dairy RMP	4	8	5	160	0.5%	3	$300,000	$300,000	$4,000	$858,514	$941,714	$0.94	507%	This was Clay Rodgers' worst case scenario. This may not be enough combinations to avoid bad conclusions.
Middle scenario for combinations	14	12	6	1008	3.1%	3	$150,000	$150,000	$4,000	$3,848,64(	$5,932,800	$5.93	3195%	Cost goes up exponentially with increase in combinations. Dairy RMP monitored 65 dairies out of 1250 represented = 5%. This is closest scenario to the same ratio.
Possible max combinations	25	16	9	3600	10.9%	3	$100,000	$100,000	$4,000	$12,316,57	$21,188,571	$21.19	11409%	This is still a modest number of crop groups and management practices considering the Valley's diversity. Costs are astronomical.

<u>MPEP Conclusions:</u>

Based on inspection of table 3.3, we think that the MPEP cost will exceed close to the worst case scenario noted by Mr. Rodgers, approximately five times the cost of the dairy RMP. This is just above the minimum scenario, with 4 crop groups, 8 management practices, and 5 site conditions, resulting in 160 monitoring sites. While all of the coalitions want to minimize the cost of the MPEP and other compliance obligations, irrigated agriculture cannot afford to be regulated based on bad data. If derived conclusions are wrong, it will be much more costly to change management practices wrongly. Given the fact that the executive officer has all of the power in approving the MPEP workplan, and given how adding factors can increase the work and cost almost exponentially, it will be very important to secure some sort of maximum expenditure for the MPEP, perhaps at the worst case scenario level of five times the dairy RMP (or about $1/acre/year), noted by the Assistant Executive Officer. Since irrigated agriculture can't afford to be regulated by bad data, additional time may be necessary to accomplish the MPEP, if the cost of work to be done on an annual basis needs to be limited.

As noted by the Kern-only MPEP scenario, if the Kern sub-watershed decides that it will not be able to abide by conclusions derived in shallower groundwater areas, the costs could be much higher. In addition, monitoring would have to be undertaken for a much longer period of time in order to get results. Monitoring for the Kern-only option, if undertaken at the intensity estimated, could cost close to $6/acre/year. Until other assurances can be made, this contingency could also cover the possibility of the number of combinations to be analyzed in the group option getting closer to the level of the middle scenario (14 crop groups x 12 management practices x 6 site conditions = 1008 monitoring sites.) If undertaken on behalf of the whole Central Valley, this represents monitoring on approximately 3.1% of the grower farms, a ratio that is closest to the ratio exhibited in the dairy RMP. Our cost estimate summary thus reflects a range of costs, due to the uncertainty surrounding the cost of the MPEP.

3. Groundwater Quality Trend Monitoring (IV.C)

a) Objectives:
- Determine baseline groundwater quality relevant to irrigated agriculture.
- Develop long-term groundwater quality info that can be used to evaluate regional effects of irrigated agriculture.

b) Implementation:
- Develop a groundwater monitoring network over high & low vulnerability areas.
- Employ existing shallow wells but not necessarily wells in the upper zone of the first encountered groundwater.
- Submit proposed Trend Groundwater Monitoring Workplan (MRP IV.E)

c) Reporting:
- Maps, tabulation of data, time of concentration charts, submitted electronically to GeoTracker.

- Evaluate data for trends as proposed in MRP IV.E.

4. Management Practices Evaluation Workplan (IV.D)

a) Submit workplan within 2 years after GAR approval.
b) Workplan approach:
   - Groundwater monitoring – must be first encountered groundwater.
   - Modeling of groundwater data.
   - Vadose zone sampling.
   - Other scientifically sound and technically justifiable methods for meeting objectives of the MPEP.
c) Groundwater quality monitoring – constituent selection (when groundwater monitoring is proposed):
   - Constituents to be assessed.
   - Frequency of data collection for each constituent.
d) Workplan implementation and analysis – explain how data at evaluated farms will be used to assess groundwater impacts on farms not evaluated.
e) Master work plan prioritization:
   - If high vulnerability areas are ranked in GAR, prepare a workplan timeline, priority, for areas and/or commodity.
   - Submittal dates for addendums proposing the details of each area's investigation.
f) Installation of monitoring wells:
   - Upon approval of a workplan, prepare and submit a Monitoring Well Installation & Sampling Plan (MWISP) as described in MRP-2.

5. Trend Monitoring Workplan – MRP IV.C (IV.E)

a) Submit workplan within 1 year after GAR approval.
b) Workplan approach:
   - Discussion of rationale for number of proposed monitoring wells and locations.
   - Consider variety of agricultural commodities produced.
   - Consider conditions discussed/identified in GAR related to vulnerability prioritization.
   - Areas identified as recharge to urban and rural communities
c) Well details for wells included in Trend Monitoring:
   - GPS coordinates, physical address of property, and CA State well number.
   - Well depth, top and bottom perforation depths.
   - Copy of the well drillers log, if available.
   - Depth to standing water (static), if available.
   - Well seal information (type of material, length of seal).
d) Proposed sampling schedule:
   - Annual sampling.
e) Workplan implementation and analysis:
   - Proposed method(s) to be used to evaluate tends in the groundwater monitoring data over time.

B. MONITORING AND REPORTING PROGRAM, SECTION V

The costs associated with the Third-Party requirements to comply with the Monitoring and Reporting Program (**MRP**) in Attachment B – Section V are described in this section. **Table 3 – 2 "Attachment B – MRP Section V"** summarizes the Kern Coalition costs.

Table 3 – 2 Attachment B – MRP Section V

Report Heading	MRP Section	Description	Third Party-Upfront			Third Party-Annual		
			Total Hours	Expenses	One Time Upfront Costs	Total Hours	Expenses	Annual Costs
1.	V.A	Quarterly Submittal of Monitoring Results	$0					
2.	V.B	Annual Groundwater Monitoring Results-Annually by May 1	$0			44	$16,000	$21,280
3.	V.C	Monitoring Reports-Annually by May 1			$0	410	$80,000	$129,000
4.	V.D	Surface Water Exceedance Reports	$0					
5.	VII	Water Quality Triggers for Development of Management Plans	$0					
6.	VIII	Quality Assurance Project Plan (QAPP)	$5000					
		Section V Subtotal				**454**	**$96,000**	**$155,480**

1. Quarterly Submittals of Surface Water Monitoring Results (V.A)

This program is actively being implemented. Therefore, no future costs are estimated here.

2. Annual Groundwater Monitoring Report (GWMR) (V.B)

This program is actively being implemented. Therefore, no future costs are estimated here.

3. Monitoring Reports (V.C)

The costs shown in the table above estimate the costs of prepare and submission of annual monitoring reports.

4. Surface Water Exceedance Reports (V.D)

This program is actively being implemented. Therefore, no future costs are estimated here.

5. Water Quality Triggers for Development of Management Plans (VIII)

This program is actively being implemented. Therefore, no future costs are estimated here.

6. Quality Assurance Project Plan (QAPP) (XI)

The QAPP will be modified from the present version. Approximately $5000 in extra effort is anticipated to incorporate groundwater item.

4

MANAGEMENT PLAN REQUIREMENTS MRP-1 OF GENERAL ORDER

The costs associated with the Third-Party requirements to comply with the Groundwater Management Plan in MRP-1 are described in this section. **Table 4 – 1 "MRP-1 –Groundwater MRP"** summarizes the Kern Coalition costs.

Table 4 – 1 MRP-1 –Groundwater Management Plan Requirements

			Third Party				Member	
			Up-front		Annual		Annual	
Report Heading	MRP-1 Section	Descriptions	Hours	Cost	Hours	Cost	Hours	Cost
1	A	Introduction and Background Section	24	$2,880				
2	B	Physical Setting and Information	492	$59,040				
3	C	Management Plan Strategy	210	$25,200				
4	D	Monitoring Method	76	$9,120				
5	E	Data Evaluation	72	$8,640				
6	F	Records and Reporting-Management Plan Progress Report			285	$34,200		
7	G	Source Identification Study Requirements	96	$11,520				
8		Implementation Estimate	250	$30,000	2000	$240,000	1800	$216,000
		MRP-1 Subtotal	1220	$146,400	2285	$274,200	1800	$216,000

There are many uncertainties regarding a groundwater management plan, including what constituents will need to be included, and the areal extent of the impacts. It is assumed that the major item to deal with will be nitrates, and that a Comprehensive Groundwater Management Plan will be issued with the GAR.

1. Introduction and Background Section (MRP-1.A)

Much of this work will be drawn from the GAR.

- Discussion of COCs, water quality objective(s), or trigger(s).
- Identification (narrative & map format) of boundaries to be covered by the management plan.
- Discussion how boundaries were delineated.

2. Physical Setting and Information (MRP-1.B)

a) Land use maps – partially satisfied in GAR:
   - Crop information by square-mile section (TRS) level.
   - Maps in electronic format using ArcGIS format.

b) Identification of potential irrigated agricultural sources of COCs:
   - If potential sources unknown, conduct source identification study (triggers MRP-1.G).
   - Or develop management plan for COCs (Triggers MRP-1.C).

c) List of designated beneficial uses for impacted water.

d) Baseline inventory of existing management practices with location to TRS level. Much of this will be drawn from the Farm Evaluations.

e) Available surface and/or groundwater quality data – partially satisfied in GAR:
   - Summary, discussion, and compilation of available data.
   - For COCs in the management plan.
   - Acceptable sources of quality data include, but not limited to SWAMP, GAMMA, USGS, DPH, DPR, DWR, local groundwater management plans, and GAR prepared by the Third-Party.

2.1 Groundwater – Additional Requirements (MRP-1.B)

a) Soil types and soil data as described by NRCS soil survey.

b) Description of geology and hydrogeology for the area:

c) Regional and area specific geology:
   - Groundwater basin and sub-basin in the area.
   - General water chemistry known.
   - Concentrations of major anions, cations, nutrients, TDS, pH, DO and hardness.
   - Provide Piper (tri-linear), Stiff, and/or Durov diagrams for the area.

d) Hydrogeology information:
   - Known water bearing zones.
   - Areas of shallow and/or perched groundwater.
   - Areas of discharge and recharge to basin.

e) Identify water bearing zones utilized for domestic, irrigation, and municipal water.

f) Aquifer characteristics know from existing information:
   - Depth to groundwater.
   - Groundwater flow and direction.

- Hydraulic gradient and conductivity.

g) Identification of irrigation water sources and general water chemistry.

3. Management Plan Strategy (MRP-1.C)

a) Description of approach and prioritization.
b) Goals and objectives:
- Compliance with water quality objectives.
- Education and outreach.
- Identify, validate, and implement management practices.

c) Identify duties and responsibilities of individuals/groups:
- Identification of key individuals.
- Discussion of each individual's responsibilities.
- Organizational chart with identified lines of authority.

d) Strategies to implement Management Plan tasks:
- Identify entities/agencies contacted to obtain data and assistance.
- Identify management practices used to control COC.
- Identify outreach to participants. Outreach is anticipated to deal with NMP training and accounting for N in well water. Meetings, website, and district correspondence is anticipated to be employed.
- Schedule and milestones for implementation of management practices and tasks.
- Establish measurable performance goals. Ratios will be monitored and progress will be tracked.

4. Monitoring Methods (MRP-1.D)

a) General requirements:
- Designed to measure effectiveness at achieving goals and objectives.
- Capable of determining management practices made in response to plan are effective.

b) Groundwater – additional requirements:
- May include commodity-based representative monitoring. We anticipate that we will rely on and tier off of MPEP efforts.
- Conducted to determine effectiveness of management practices implemented.

5. Data Evaluation (MRP-1.E)

a) Methods utilized to perform data analysis.
b) Identify information necessary to quantify program effectiveness.
- Tracking of management practice implementation.
- Describe approach used to determine effectiveness of management practices.
- Describe process for tracking implementation of management practices.
- Description of how information is collected from growers.

- Type of information collected.
- How information will be verified and reported.

6. Records and Reporting – Management Plan Progress Report (MRP-1.F)

a) This report is annual once management plan is implemented.
b) Executive summary, location map(s), and front pages.
c) Table with exceedances from the management plan.
d) Status update on preparation of the new management plan.
e) Summary and assessment of data collected during reporting period.
f) Summary of grower outreach conducted.
g) Summary of implementation of management practices.
h) Results of evaluation of management practices.
i) Evaluation of progress in meeting performance goals and schedules.
j) Recommendations for changes.

7. Source Identification Study Requirements (MRP-1.G)

a) This is a triggered report; not always required/included.
b) Evaluation of types of practices, commodities, and locations that may be a source. For nitrate, the NHI could be useful for this.
c) Continued monitoring at site/area and increased monitoring, if appropriate. For nitrate, we will monitor ratios, primarily.
d) Assessment of potential pathways through which discharge can occur.
e) Schedule of conducting study
f) Field studies:
    - Evaluate feasibility of field studies as part of their source identification study proposal. We anticipate that we will rely heavily on MPEP work.
    - Identify a reasonable number and variety of field study sites that are representative.
g) Alternative source identification – if not performing a source ID study:
    - Demonstrate how method will produce data/information.
    - Determine contributions from irrigated agricultural sources.

8. Implementation

a) Registered pesticides. There are minimal Groundwater Protection Areas (GWPAs) in Kern. Some follow-up may be triggered, depending on what the data looks like.
b) Toxicity.
c) Contingency / as-required phase on high priority items (covers the first two years).
    - Quarterly progress reports.
    - Meetings with RWQCB staff.
    - Addressing issues that may arise.
d) Legacy pesticides and trace metals.
e) DO and pH.
f) Salinity and pathogens.

- Quarterly progress reports.
- Meetings with RWQCB staff.
- Addressing issues that may arise.

g) Nitrates – groundwater management plan items. This is assumed to require one person-year to monitor grower nitrogen ratios, research acceptable values, meet with growers, do outreach, interact with and support MPEP work, and provide support for growers and answer questions. We assumed that 600 growers would be in the high vulnerability area. Each grower or their representative would attend one outreach per year for their crop.

For more detail, see the corresponding cost estimation spreadsheet.

Our cost estimate does not include grower time or expense to implement practices. None of our costs include farm level management practices that may be indirectly triggered. (Direct compliance practices, such as the NMP were estimated).

5

MONITORING WELL INSTALLATION, SAMPLING PLAN AND COMPLETION REPORT MRP-2 OF GENERAL ORDER

The costs associated with the Third-Party requirements to comply with Monitoring Well Installation, Sampling Plan, and Completion Report in MRP-2 are described in this section. **Table 5 – 1 "MRP-2 – MWISP"** summarizes possible Kern Coalition costs. The costs associated with monitoring wells are closely linked with the Management Practice Evaluation Program (MPEP). Please refer back to section 3 for a discussion of the MPEP. The costs estimated here are for a Kern only MPEP option (not the group option).

Table 5 – 1 MRP-2 MWISP

Report Heading	MRP-2 Section	Description	Third Party (Upfront)		Third-Party (Annual Costs)	
			Hours	Phase Cost	Hours	Phase Cost
B.	II	Per Phase Monitoring Well Installation and Sampling Plan (MWISP)	6480	$777,600	0	0
C.	III	Monitoring Well Installation Completion Report (MWICR) and implementation, including well construction, monthly sampling and analysis, and quarterly reporting.	6192	$8,087,040	0	$5,932,800
		MRP-2 Subtotal	**4,224**	**$8,864,640**	**0**	**$5,932,800**

A. ASSUMPTIONS

- 6 crop groups, 8 management practices, and 3 site conditions will result in 144 combinations to monitor for first encountered groundwater quality as part of the MPEP. This is associated with the highest cost option for carrying out the MPEP. The MPEP can be done cooperatively with other coalition areas, representing the lower possible cost option. This was estimated separately in the MPEP section.
- A minimum of 3 wells are required to ascertain impacts up/down gradient of a potential source. Therefore, a total of 432 wells would be needed at an average depth to groundwater of 220 ft in Kern.

B. MONITORING WELL INSTALLATION AND SAMPLING PLANS (MWISP) (MRP-2.II)

The following information is required in an MWISP.

1. Stipulations

2. MWISP Required Elements:

a) General Information:
   - Topographic map, site plan.
   - Rationale for number of monitoring wells proposed.
   - Local permitting information.
   - Drilling details.
   - Health and safety plan.

b) Proposed drilling details:
   - Drilling techniques.
   - Well/soil sample collection and logging method(s).

c) Proposed monitoring well design.
d) Proposed monitoring well development.
e) Proposed surveying.
f) Monitoring according to QAPP.

We estimated the cost of an MWISP at approximately $5400 per site. For 144 sites, the cost is $777,600.

C. MONITORING WELL INSTALLATION COMPLETION REPORT (MWICR) (MRP-2.III)

The following information is required in an MWICR.

1. General Information

a) Brief overview of field activities.
b) Site plan.
c) Period of field activities and milestone events.

2. Monitoring Well Construction

3. Monitoring Well Development

We estimated the cost of an MWICR at approximately $3480 per site. For 144 sites, the cost is $501,120.

4. Monitoring Well Survey

We estimated the cost of a monitoring well survey at approximately $1680 per site. For 144 sites, the cost is $241,920.

5. Implementation Costs

a) Well construction, project management and oversight. With depths in the Kern sub-watershed, a direct rotary rig will be needed in most places. We estimated approximately $17,000 per well with e-log, project management, and oversight. For 432 wells, the cost would be $7,344,000.

b) Sampling and analysis cost, assuming monthly sampling. We estimated $1000 per site for sampling and $1100/site for analysis, to include pesticides. Thus, the cost for 144 sites would be $302,400 per month or $3,628,800 per year.

c) Quarterly reporting of results to RWQCB. We estimated $4000 per site for reporting event. With 144 sites and quarterly reporting, the cost is estimated to be $2,304,000 per year.

More detail regarding the calculations can be found on the MRP-2 sheet from the attached spreadsheet.

6

CONCLUSIONS & SUMMARY

A. COST SUMMARY

a) This Report provides a vigorous and in-depth assessment of the Kern Coalition's Third Party and Member costs to comply with the March 2013 Tentative Order. Upon request, additional background and information can be provided to the Water Board.

b) The $1.90 per acre incremental cost estimate provided under Finding No. 39 in the Order and in Attachment A Information Sheet are summarized in **Table 6-1 Water Board Estimated Costs**.

Table 6-1

Water Board Estimated Costs.

	Tulare Lake Basin Area Order	Current Surface Water Program	Change from Groundwater Program
Administration	$1.19	$0.91	**$0.28**
Farm Plans	$0.29	$0.00	**$0.29**
Monitoring/Reporting/Tracking	$2.11	$0.79	**$1.31**
Management Practices	$15.87	$15.84	**$0.02**
Total	**$19.46**	**$17.54**	**$1.90**

c) The Management Practice Evaluation Program and Workplan are subject to significant variation in costs. As stated in Section 3 of this Report, a lower and higher cost was determined.

d) The upfront costs are expected to be a one-time cost that could be required in year one (1) or beyond year five (5). For comparative purposes, the upfront costs per acre were divided by five years to provide an annualized per acre cost. The actual year of upfront cost expenditures will vary.

e) For the lower cost scenario, the upfront cost of $3.65/acre divided by 5 years = $0.73/acre/year + the annual cost of $16.04/acre/year = $16.77/acre/year for the first five years. After five years the annual cost would be $16.04/acre/year.

f) For the higher cost scenario, the upfront cost of $14.21/acre divided by 5 years = $2.84/acre/year + the annual cost of $20.84/acre/year = $23.68/acre/year for the first five years. After five years the annual cost would be $20.84/acre/year.

g) **Table 6-2 Kern Coalition Lower Estimated Costs** and **Table 6-3 Kern Coalition Higher Estimated Costs** depict the summary totals of costs.

Table 6-2

Kern Coalition Lower Estimated Costs

Costs	Up-Front Costs		Annual Costs	
	Third-Party	Member	Third-Party	Member
Waste Discharge Requirements General Order				
Third-Party - Provisions	$177,840	--	$340,640	--
Third-Party - Required Reports & Notices	$231,300	--	$163,400	--
Member - Notice of Confirmation/Intent/Application	--	$549,660	--	$0
Member - Farm Evaluation	$19,400	$688,633	--	$110,354
Member - Sediment & Erosion Control Plan	$8,200	$117,500	--	$6,000
Member - Nitrogen Management Plan (NMP)	$19,400	--	--	$13,547,646
Member - CEQA Mitigation Monitoring (Attachment C)	--	$348,000	--	$14,800
Member - Notice of Termination	--	$0	--	$6,200
Member - Annual Fees	--	$0	--	$582,500
Attachment B - Monitoring & Reporting Program				
Groundwater Quality Assessment Report (GAR)**	$304,500	--	--	--
Management Practice Evaluation Program (MPEP)	$171,429	--	--	--
Groundwater Quality Trend Monitoring	$19,400	--	$288,000	$31,200
Management Practices Evaluation Workplan	$171,429	--	--	--
Trend Monitoring Workplan	$244,000	$48,000	--	--
Attachment B - Groundwater Monitoring Report (GWMR)	--	--	$155,480	--
MRP-1 Quality Management Plan Requirements Groundwater Quality Management Plan (GQMP)	$146,400	--	$274,200	$216,000
MRP-2 Monitoring Well Installation, Sampling Plan, and Completion Report	$515,657	--	$941,714	--
Total	**$2,028,954**	**$1,751,793**	**$2,163,434**	**$14,514,700**
Total	**$3,780,748**		**$16,678,135**	
Cost per Acre ***	**$1.95**	**$1.68**	**$2.08**	**$13.96**
Total Cost per Acre	**$3.63**		**$16.04**	

*** Assumes workplan portion, not the alternative*

**** Per acre cost is based on the total costs divided by the Kern Coalition irrigated acres*

Table 6-3

Kern Coalition Higher Estimated Costs

Costs	Up-Front Costs		Annual Costs	
	Third-Party	Member	Third-Party	Member
Waste Discharge Requirements General Order				
Third-Party - Provisions	$177,840	--	$340,640	--
Third-Party - Required Reports & Notices	$231,300	--	$163,400	--
Member - Notice of Confirmation/Intent/Application	--	$549,660	--	$0
Member - Farm Evaluation	$19,400	$688,633	--	$110,354
Member - Sediment & Erosion Control Plan	$8,200	$117,500	--	$6,000
Member - Nitrogen Management Plan (NMP)	$19,400	--	--	$13,547,646
Member - CEQA Mitigation Monitoring (Attachment C)	--	$348,000	--	$14,800
Member - Notice of Termination	--	$0	--	$6,200
Member - Annual Fees	--	$0	--	$582,500
Attachment B - Monitoring & Reporting Program				
Groundwater Quality Assessment Report (GAR)**	$304,500	--	--	--
Management Practice Evaluation Program (MPEP)	$1,500,000	--	--	--
Groundwater Quality Trend Monitoring	$19,400	--	$288,000	$31,200
Management Practices Evaluation Workplan	$1,500,000	--	--	--
Trend Monitoring Workplan	$244,000	$48,000	--	--
Attachment B - Groundwater Monitoring Report (GWMR)	--	--	$155,480	--
MRP-1 Quality Management Plan Requirements Groundwater Quality Management Plan (GQMP)	$146,400	--	$274,200	$216,000
MRP-2 Monitoring Well Installation, Sampling Plan, and Completion Report	$8,864,640	--	$5,932,800	--
Total	**$13,035,080**	**$1,751,793**	**$7,154,520**	**$14,514,700**
Total	**$14,786,873**		**$21,699,220**	
Cost per Acre ***	**$12.53**	**$1.68**	**$6.88**	**$13.96**
Total Cost per Acre	**$14.21**		**$20.84**	

*** Assumes workplan portion, not the alternative*

**** Per acre cost is based on the total costs divided by the Kern Coalition irrigated acres*

B. CONCLUSIONS

a) The Kern Coalition's upfront annualized costs plus the annual costs result in the following comparative values to the Tentative Order and summarized in **Table 6-4 Comparative Estimated Costs.**

Table 6-4

Comparative Estimated Costs

	Tulare Lake Basin Area Order Groundwater Program	Kern Coalition Lower Cost Scenario	Kern Coalition Higher Cost Scenario
	($/acre/year)	($/acre/year)	($/acre/year)
Total Cost - First 5 Years	**$1.90**	**$16.76**	**$23.68**
Total Cost – Year 6+	**$1.90**	**$16.04**	**$20.84**

b) The Tentative Order (at $1.90) is significantly lower than the results from this Report. The high cost scenario (at $23.68) is over 12 times higher than the $1.90.

c) The Water Board must take into consideration the detailed costs of this Report and work with the Kern Coalition to reduce the cost burdens of the March 2013 Tentative Order.

Kern Coalition ILRP - Lower Cost Estimate*

Assumptions:

Kern Third-Party Potential Members	902	members (estimate)
Kern Coalition Current Members	350	members (about 40%)
Members Needing to Enroll	552	members (about 60%)
Kern Coalition Irrigated Acres	1,040,000	acres
South San Joaquin Valley Irrigated Acres	2,640,000	acres
Member Hourly Rate	$120	per hr
Coalition Hourly Rate (Coalition Staff)	$120	per hr
Average Farm Acres	1,438	acres
Low vulnerability area (estimated)	300,000	acres
Member Water Board Fee	$0.56	per acre

**Based on Kern Coalition Acres and the March 2013 Tulare Lake Basin Area Tentative WDR's General Order (Groundwater only)*

Costs	Up-Front Costs		Annual Costs	
	Third-Party	Member	Third-Party	Member
Waste Discharge Requirements General Order				
Third-Party - Provisions	$177,840	--	$340,640	--
Third-Party - Required Reports & Notices	$231,300	--	$163,400	--
Member - Notice of Confirmation/Intent/Application	--	$549,660	--	$0
Member - Farm Evaluation	$19,400	$688,633	--	$110,354
Member - Sediment & Erosion Control Plan	$8,200	$117,500	--	$6,000
Member - Nitrogen Management Plan (NMP)	$19,400	--	--	$13,547,646
Member - CEQA Mitigation Monitoring (Attachment C)	--	$348,000	--	$14,800
Member - Notice of Termination	--	$0	--	$6,200
Member - Annual Fees	--	$0	--	$582,500
Attachment B - Monitoring & Reporting Program				
Groundwater Quality Assessment Report (GAR)**	$304,500	--	--	--
Management Practice Evaluation Program (MPEP)	$171,429	--	--	--
Groundwater Quality Trend Monitoring	$19,400	--	$288,000	$31,200
Management Practices Evaluation Workplan	$171,429	--	--	--
Trend Monitoring Workplan	$244,000	$48,000	--	--
Attachment B - Groundwater Monitoring Report (GWMR)	--	--	$155,480	--
MRP-1 Quality Management Plan Requirements Groundwater Quality Management Plan (GQMP)	$146,400	--	$274,200	$216,000
MRP-2 Monitoring Well Installation, Sampling Plan, and Completion Report	$515,657	--	$941,714	--
Total	**$2,028,954**	**$1,751,793**	**$2,163,434**	**$14,514,700**
Total	**$3,780,748**		**$16,678,135**	
Cost per Acre ***	**$1.95**	**$1.68**	**$2.08**	**$13.96**
Total Cost per Acre	**$3.63**		**$16.04**	

*** Assumes workplan portion, not the alternative*

**** Per acre cost is based on the total costs divided by the Kern Coalition irrigated acres*

Kern Coalition ILRP - Higher Cost Estimate*

Assumptions:

Kern Third-Party Potential Members	902	members (estimate)
Kern Coalition Current Members	350	members (about 40%)
Members Needing to Enroll	552	members (about 60%)
Kern Coalition Irrigated Acres	1,040,000	acres
South San Joaquin Valley Irrigated Acres	2,640,000	acres
Member Hourly Rate	$120	per hr
Coalition Hourly Rate (Coalition Staff)	$120	per hr
Average Farm Acres	1,438	acres
Low vulnerability area (estimated)	300,000	acres
Member Water Board Fee	$0.56	per acre

**Based on Kern Coalition Acres and the March 2013 Tulare Lake Basin Area Tentative WDR's General Order (Groundwater only)*

Costs	Up-Front Costs		Annual Costs	
	Third-Party	Member	Third-Party	Member
Waste Discharge Requirements General Order				
Third-Party - Provisions	$177,840	--	$340,640	--
Third-Party - Required Reports & Notices	$231,300	--	$163,400	--
Member - Notice of Confirmation/Intent/Application	--	$549,660	--	$0
Member - Farm Evaluation	$19,400	$688,633	--	$110,354
Member - Sediment & Erosion Control Plan	$8,200	$117,500	--	$6,000
Member - Nitrogen Management Plan (NMP)	$19,400	--	--	$13,547,646
Member - CEQA Mitigation Monitoring (Attachment C)	--	$348,000	--	$14,800
Member - Notice of Termination	--	$0	--	$6,200
Member - Annual Fees	--	$0	--	$582,500
Attachment B - Monitoring & Reporting Program				
Groundwater Quality Assessment Report (GAR)**	$304,500	--	--	--
Management Practice Evaluation Program (MPEP)	$1,500,000	--	--	--
Groundwater Quality Trend Monitoring	$19,400	--	$288,000	$31,200
Management Practices Evaluation Workplan	$1,500,000	--	--	--
Trend Monitoring Workplan	$244,000	$48,000	--	--
Attachment B - Groundwater Monitoring Report (GWMR)	--	--	$155,480	--
MRP-1 Quality Management Plan Requirements Groundwater Quality Management Plan (GQMP)	$146,400	--	$274,200	$216,000
MRP-2 Monitoring Well Installation, Sampling Plan, and Completion Report	$8,864,640	--	$5,932,800	--
Total	**$13,035,080**	**$1,751,793**	**$7,154,520**	**$14,514,700**
Total	**$14,786,873**		**$21,669,220**	
Cost per Acre ***	**$12.53**	**$1.68**	**$6.88**	**$13.96**
Total Cost per Acre	**$14.21**		**$20.84**	

*** Assumes workplan portion, not the alternative*

**** Per acre cost is based on the total costs divided by the Kern Coalition irrigated acres*

WDRs - Third-Party Provisions

Based on the March 2013 Tulare Lake Basin Area Tentative WDRs General Order

Hourly Costs $120

	Third-Party Provisions - Costs WDR Section IV.C (Provisions, Requirements for the Third-Party)	Third-Party - Upfront Costs			Third-Party - Annual Costs			
		Hours	Expenses	Cost	Hours	Expenses	Cost	
IV.C.1.	**Organizational Documentation**							
	a. Documentation of organization or management structure	24	$1,000	$3,880	--	--	--	Water Board approval of new third party entity
	b. Identify responsible persons	8	$1,000	$1,960	--	--	--	Hires, identify individuals, ranks
	c. Documentation made readily available to members	40	$5,000	$9,800	--	--	--	Website updates, email, hardcopies for members
IV.C.2.	**Prepare Annual Summaries**							Accounting staff
	a. Expenditures of fees and revenue used to comply	--	--	--	120	$3,000	$17,400	Higher first year fee notices, collection, receipts, expenditures, but annualized over 5 years
	b. Summaries made readily available to members	--	--	--	24	$1,000	$3,880	Summary and mailer
IV.C.3.	**Response to Notice of Violation (NOV)**							Assuming 1 NOV per year
	a. Provide members information regarding reason(s) of violation	--	--	--	20	$500	$2,900	Assume 20 members in violation
	b. Provide notification to all Members in areas covered by the NOV	--	--	--	20	$1,000	$3,400	Within 30 days
	c. Provide confirmation to Water Board of each notification	--	--	--	8	$100	$1,060	
	d. Annual summary of all notices	--	--	--	20	$1,000	$3,400	Annual summary of notices
	e. Respond and resolve NOV	--	--	--	40	$20,000	$24,800	Hire consultant/engineer
IV.C.4.	**Develop, implement, track and evaluate effectiveness of:**							May 1 each year
	a. Groundwater Quality Management Plans (GQMP)	200	$100,000	$124,000	100	$40,000	$52,000	Annually for 5 years 45,000 acres of 436,000 acres May 1 each year
IV.C.5.	**Submittals**							
	a. Provide timely & complete submittal of any plans or reports required by this Order	--	--	--	100	$5,000	$17,000	
IV.C.6.	**Quality Assurance/Quality Control**							
	a. Conduct water quality monitoring & assessments in conformance with QA/QC	--	--	--	100	$1,000	$13,000	
IV.C.7.	**Receipt of Notice of Applicability (NOA)**							
	a. Inform members of NOA requirements within 30 days of receipt	60	$2,000	$9,200	--	--	--	
	b. Send a notice of confirmation form to each Member	200	$5,000	$29,000	--	--	--	
IV.C.8.	**Conduct Education and Outreach activities**							
	a. Inform Members of program requirements							2 classes/yr and Qrt newsletter @ 4 d/class and 3 d/ltr
	i. Program requirements							
	ii. Water quality problems	--	--	--	240	$10,000	$38,800	
	iii. Exceedances of water quality objectives							
	iv. Degradation of water quality							
	b. Maintain attendance lists for outreach events	--	--	--	40	$1,000	$5,800	
	c. Provide Members with information on							
	i. Water quality practices	--	--	--	160	$10,000	$29,200	
	ii. Environmental impacts of water quality practices							
	d. Provide annual summary of education and outreach activities to Board, including:							
	i. Copies of educational and management practice information provided							
	ii. Report the total number of Members attended	--	--	--	60	$3,000	$10,200	
	iii. Describe the process used to provide information to non-attendees							
IV.C.9.	**Annual Membership Participation Report**							
	a. Work with RWQCB to ensure all Members are addressing exceedances or degradation				250	$5,000	$35,000	
	b. As part of the Membership List submittal, identify growers who have <u>failed to</u>:							
	1 Implement improved water quality management practices as specified (GQMP)							
	2 Respond to an information request associated with the GQMP or this Order							
	3 Participate in third-party studies where the third-party is the lead				250	$6,000	$36,000	
	4 Provide confirmation in an outreach event							
	5 Submit required fees to the Third-Party							
IV.C.10.	**Ensure activities performed by subsidiary groups meet requirements**				80	$2,000	$11,600	5 days per group
IV.C.11.	**Fees**							
	a. Transmit RWQCB fees from Members and submit to Board				105	$5,000	$17,600	40% enrolled in surface water Coalition, need to enroll 60%
	b. Collect fees from Members for reimbursement of Third-Party activities				105	$5,000	$17,600	21 Districts x 5 hours each
	Totals	**532**	**$114,000**	**$177,840**	**1,842**	**$119,600**	**$340,640**	

WDRs - Third-Party Requirements

Based on the March 2013 Tulare Lake Basin Area Tentative WDRs General Order Hourly Costs $120

Third-Party Requirement Costs		Third-Party - One Time Cost			Third-Party - Annual Costs			
WDR Section VIII (Required Reports and Notices - Third-Party)		Hours	Expenses	Cost	Hours	Expenses	Cost	
VIII.A.	**Third-Party Application**							
	1 Submit request to Board within 30 days of Order effective date & follow-up actions	40	$2,000	$6,800				Formation costs in IV.C.1.
VIII.B.	**Membership (Participant) List**							
	1 Submit list of Members to Board							
	a. Within 180 days of receiving NOA	20	$100	$2,500				
	b. Annually by July 31 of each year				20	$100	$2,500	
	2 List shall contain, at minimum							
	a. All parcel numbers covered under the membership							
	b. County of each parcel							
	c. Section, Township, Range associated with each parcel							
	d. Number of irrigated acres for each parcel	700	$3,000	$87,000	70	$500	$8,900	Annual updates
	e. Members names, mailing address, and contact name and phone number (can use Third-Party contact)							
	f. Name of farm operator for each parcel if different from the Member							Identification of the crops grown and acreage of each crop.
	g. Identification of each parcel that is a part of a Small Farming Operation, if applicable							• Location of the farm.
VIII.C.	**Templates**							
	1 Farm Evaluation Template							• Identification of on-farm management practices implemented to achieve the Order's farm management performance standards. Specifically track which management practices recommended in management plans have been implemented at the farm.
	a. Farm Evaluation Template - Group Option, to Water Board within 90-days of NOA				20	$250	$2,650	• Identification of whether or not there is movement of soil during storm events and/or during irrigation drainage events (sediment and erosion risk areas) and a description of where this occurs.
	b. Central Valley Water Board - Farm Evaluation Template			$0			$0	• Identification of whether or not water leaves the property and is conveyed downstream and a description of where this occurs.
	2 Nitrogen Management Plan Template							• Location of in-service wells and abandoned wells. Identification of whether wellhead protection and backflow prevention practices have been implemented.
	a. Nitrogen Management Plan Template - Group Option				20	$250	$2,650	
	b. Central Valley Water Board - Nitrogen Management Plan Template			$0			$0	
	c. Nitrogen Management Plan Summary Report				10	$100	$1,300	
	3 Sediment and Erosion Control Plan Template							
	a. Sediment and Erosion Control Plan Template - Group Option				5	$100	$700	
	b. Central Valley Water Board - Sediment and Erosion Control Plan Template			$0			$0	
VIII.D.	**Groundwater Quality Assessment Report and Evaluation/Monitoring Workplans**							
	1 Groundwater Quality Assessment Report (GAR), submitted 1 year after NOA (Attachment B, IV.A.)			$0			$0	Cost is included in MRP, Attachment B Sheet
	2 Management Practice Evaluation Program (MPEP) Workplan (Attachment B, IV.B.)							
	a. Management Practices Evaluation Program - Group Option			$0				Cost is included in MRP, Attachment B Sheet
	b. Third Party Only - Management Practices Evaluation Program							
	1 Objectives, Implementation, Report,							
	2 Implementation			$0				Cost is included in MRP, Attachment B Sheet
	3 Report							
	4 Management Practices Evaluation Report - 6 years after implementation of MPEP							
	3 Groundwater Quality Trend Monitoring Workplan - submit 1 year after approval of GAR (IV.E.)			$0				Cost is included in MRP, Attachment B Sheet
VIII.F.	**Sediment Discharge and Erosion Assessment Report**							
	1 Submit 1 year after receiving NOA (Attachment B, VI), notify impacted Members to prepare Plan	200	$70,000	$94,000				
VIII.H.	**Monitoring Report (Attachment B, V.C. by 1 May every year)**							
	1 Submit monitoring reports to State Board GeoTracker database, due May 1st of each year 2014			$0	800	$5,000	$101,000	Annually
VIII.I.	**Groundwater Quality Management Plans (GQMP)**							
	1 Newly triggered **GQMP**						$0	
	a. Submit to Board within 60 days						$0	
	b. Submit to CV-SALTS Chair if addresses salt or nitrate	Included in MRP-1					$0	
	c. Implement outreach or monitoring before approval						$0	
	2 Ensure compliance and continued implementation of management plans until completed			$0			$0	
	3 Comprehensive Groundwater Quality Management (CGQM) Plan			$0			$0	Assuming comprehensive option
	a. Third-Party may submit CGQM plan instead of GQMP			$0			$0	Submitted with GAR
	b. CGQM must be updated at same time as Management Plan Progress Report			$0			$0	
VIII.J.	**Technical Reports - Where monitoring is not effective, provide technical reports**			$0	350	$2,000	$44,000	1 report per year
VIII.K.	**Notice of Termination**			$0			$0	Not applicable or expected.
VIII.L.	**Total Maximum Daily Load (TMDL) Requirements**							
	1 Approved TMDLs in the Basin Plan as applicable shall be implemented	300	$5,000	$41,000				
	Totals	**1,260**	**$80,100**	**$231,300**	**1,295**	**$8,300**	**$163,700**	

WDRs - Member Requirements

Based on the March 2013 Tulare Lake Basin Area Tentative WDRs General Order

No. of Members	Small (<60 ac)		Other (60+ ac)		Total
	Low Vul	High Vul	Low Vul	High Vul	
Farm Evaluation	60	122	216	504	902
Nitrogen MP	60	122	216	504	902
Sediment & Erosion	10		40		50
Mitigation Monitoring	10				10

Member Hourly Costs: $120

Member Requirement Costs WDR Section VII (Required Reports and Notices - Member)	Upfront Cost Member No. of Members	Hours/ Member	Total Hours	Expenses	Cost	Annual Cost Member No. of Members	Hours/ Member	Total Hours	Expenses	Cost	
VII.A. Notice of Confirmation (NOC) / Notice of Intent (NOI) / Membership Application											
1 NOC submitted to Third-Party within 120 days of Third-Party NOA by the Executive Officer (EO)											
a. If enrolled under Order R5-2006-00xx Southern San Joaquin Water Quality Coalition											Members in the 2006 Coalition (350 estimated)
b. Third-Party will provide NOC form to Member within 30 days of receiving NOA	350	2	700	$9,000	$93,000						
c. Provide certification written notice was provided of enrollment to other parties											
2 All other growers must become Members within 120 days of Third-Party NOA by EO											
a. Complete Third-Party membership application	500	4	2,000	$102,000	$342,000						Growers who were not in the Coalition (estimate 500 will join within 120 days). One time $200 fee
b. Provide certification, written notice was provided of enrollment to non-Member parties	500	0.5	250	$500	$30,500						
c. Third-Party will confirm membership	500	0.0	0	$0	$0						
3 121 days after the EO's issuance of the NOA to the Third-Party, Growers not yet members must											
a. Completed NOI application to Board	52	6	312	$11,000	$48,440						Growers who miss the 120 day deadline (estimate 52)
b. NOI processing fee	52	1.5	78	$600	$9,960						
c. Membership application to Third-Party	52	4	208	$800	$25,760						
4 Alternatively, a Grower may submit to the Board											
a. Report of Waste Discharge (RWD)	0	0	0	$0	$0						Costs for individual RWD (estimate $0)
b. NOI for coverage under applicable general waste discharge req for individuals	0	0	0	$0	$0						
VII.B. Farm Evaluation											
1 Members in Low Vulnerability Areas											
a. With Small Farming Operations (<60 ac) by 1 March 2017, update every 5 years	60	4.75	285	$1,526	$35,726	60	0.27	16	$0	$1,944	4.75 hrs per member plus 45 miles trip to meeting, recurring .27 hrs/yr annualized w/ no meeting.
b. Farming Operations not qualifying as Small by 1 March 2015, update every 5 years	216	6.25	1,350	$5,492	$167,492	216	0.27	58	$0	$6,998	6.25 hrs per member plus 45 miles trip to meeting, recurring .27 hrs/yr annualized w/ no meeting.
2 All Members in High Vulnerability Areas (Surface/Groundwater) by 1 March 2014											
a. Farm Evaluations and submit to Third-Party and update annually 1 March	626	6.25	3,913	$15,916	$485,416	626	1.35	845	$0	$101,412	6.25 hrs per member plus 45 miles trip to meeting, recurring 1.35 hrs/yr w/ no meeting.
VII.C. Sediment and Erosion Control Plan											
Required Members in areas potential to cause erosion & discharge sediment to surface waters											
a. With Small Farming Operations (<60 ac) within one year of SDEAR	20	1.25	25	$44,000	$47,000	20	1.0	20	$0	$2,400	Assume 1.25 hrs per member and $2160 consultant, 1 hr annually to review
b. Farming Operations not qualifying as Small within 180 days of SDEAR	30	1.25	38	$66,000	$70,500	30	1	30	$0	$3,600	Assume 1.25 hrs per member and $2160 consultant, 1 hr annually to review
											Does not include costs to fix identified problems
VII.D. Nitrogen Management Plan (NMP)											
1 All Members within a High Vulnerability Groundwater Area must prepare, certify, and implement an NMP											
a. With Small Farming Operations (<60 ac) by 1 March 2016, update annually thereafter						122	8.5	1,037	$172,386	$296,826	Estimate 122 members, 8.5 hrs + consultant $1,300 + testing $113, annual
b. Farming Operations not qualifying as Small by 1 March 2014, update annually thereafter						504	125.0	63,000	$2,174,256	$9,734,256	Estimate 504 members, 125 hrs + consultant $3,000 + testing $1,314, annual
2 Members in Low Vulnerability Groundwater Areas											
a. Small farming operations						60	14.3	855	$6,780	$109,380	Estimate 60 members, 14.25 hrs + consultant $0 + testing $113, annual
b Farming Operations not qualifying as small						216	120.5	26,028	$283,824	$3,407,184	Estimate 216 members, 120.5 hrs + consultant $0 + testing $1314, annual
VII.E. Mitigation Monitoring - Certain Members required to implement mitigation measures in Attachment C											
1 Submit mitigation monitoring by March 1 of each year to Third-Party	10	40	400	$300,000	$348,000	10	4	40	$10,000	$14,800	Estimate 10 members Year 1 (40 hrs+consultant $30,000), Annually (4 hrs + consultant $1,000)
2 Shall include information on:											
a. Implementation of CEQA mitigation measures (cultural resources, veg & wildlife, fisheries, ag resources, GHG emissions											
b. Measures implemented											
c. Potential environmental impact measures addressed											
d. Location of measures (parcel number, county)											
e. Steps taken to monitor success of measure											
VII.F. Notice of Termination						5	10	50	$200	$6,200	Estimate 5 terminations/year, mostly due to change in ownership
XI. Annual Fees - Paid by Member									$582,500	$582,500	Tier I - Water Board Fee $100 per group + $0.56/acre
Totals			9,558	$556,833	$1,703,793			91,980	$3,229,946	$14,267,500	

Attachment B - MRP - Monitoring & Reporting Program Section IV

These costs are totaled in WDR VIII.D. Hourly Costs $120

Based on the March 2013 Tulare Lake Basin Area Tentative WDRs General Order

Groundwater Quality Assessment Report (GAR) MRP, Attachment B (Monitoring and Reporting Program) Section IV	Third-Party - Upfront		
	Hours	Expenses	Cost
IV.A. Groundwater Quality Assessment Report (GAR)			
- Submit proposed GAR outline within 3 months after receiving NOA	100	$1,000	$13,000
- Submit completed GAR within 1 year of receiving NOA	100	$49,000	$61,000
2 GAR components obtained by review of existing federal/state/county/local databases and documents:			
a Detailed land use information			
b Depth to groundwater map			
c Groundwater recharge information			
d Soil survey information	50	$53,500	$59,500
e Shallow groundwater constituent concentrations (potential COCs)			
f Existing groundwater data collection and analysis efforts			
g Discuss geological and hydrogeologic information			
3 GAR data review and analysis			
a Determine high vulnerability areas based on potential impacts from irrigated ag activities			
b Determine merit of incorporating existing data collection efforts to achieve objectives	50	$43,500	$49,500
c Prepare ranking of high vulnerability areas for prioritization of workplan activities			
d Utilize GIS mapping applications, graphics, tables to convey data, analysis and results			
4 Groundwater vulnerability designations			
a Designate high/low vulnerability areas	50	$21,500	$27,500
b Modify designations every five years after approval of GAR			
5 Prioritization of high vulnerability groundwater areas			
a Identify exceedances of water quality objectives			
b Proximity of high vulnerability area to areas contributing to recharge to urban and rural communities			
c Identify existing irrigated agriculture field or operational practices			
d Consider largest commodity types comprising up to at least 80% of irrigated ag acreage	100	$82,000	$94,000
e Consider legacy or ambient conditions of groundwater			
f Identify groundwater basins currently or proposed to be under review by CV-SALTS			
g Identify constituents of concern, e.g. relative toxicity, mobility			
Subtotal	**450**	**$250,500**	**$304,500**

Management Practice Evaluation Program (MPEP) MRP, Attachment B (Monitoring and Reporting Program) Section IV	Third-Party - Upfront		
	Hours	Expenses	Cost
IV.B. Management Practice Evaluation Program (MPEP)			
- Determine effects, if any, irrigated ag have on groundwater quality			
- MPEP is required in high vulnerability areas and must address CoCs described in the GAR			
1 Objectives of the MPEP			
a Identify whether existing site and/or commodity specific practices are protective of GW quality		Use different approach	
b Determine if newly implemented management practices are improving or may improve GW quality			
c Develop an estimate of the effect Members' discharges of CoCs using a mass balance model		See MPEP high and low	
d Utilize results of evaluated to determine if management practices need to be improved			
2 Implementation - on a watershed or regional commodity basis with other third party groups			
a Prepare and submit a master schedule of the rank or priority for investigation of high-v areas			
3 Reports of the MPEP - Information to complete the MPEP schedule to meet deadline			
4 Management Practices Evaluation Report (MPER)			
- No later than 6 years after implementation of each phase			
a Identify management practices that are protective of GW quality			
b Identify management practices that are appropriate for site conditions on farms			
c Include maps and types of management practices that should be implemented			
d MPER to include adequate technical justification for identifying protective management practices			
e Propose and implement new/alternative management practices if existing are not protective			
f GQMPs are to be updated to be consistent with the findings of the MPER			
Subtotal	**0**	**$0**	**$0**

Groundwater Quality Trend Monitoring MRP, Attachment B (Monitoring and Reporting Program) Section IV	Third-Party - Upfront			Third-Party - Annual			
	Hours	Expenses	Cost	Hours	Expenses	Cost	
IV.C. Groundwater Quality Trend Monitoring							
1 Objectives							
a Determine baseline GW quality relevant to irrigated ag	120	$5,000	$19,400			$0	Board input to guide workplan.
b Develop long-term GW quality info that can be used to evaluate regional effects of irrigated ag							
2 Implementation							
a Develop a groundwater monitoring network over high & low vulnerability areas							
b Employ existing shallow wells but not necessarily wells in the upper zone of 1st encountered GW			$0	2,000	$10,000	$250,000	Estimate 130 existing wells to be monitored
c Submit proposed Trend Groundwater Monitoring Workplan (MRP IV.E)							
3 Reporting							
a Maps, tabulation of data, time of concentration charts, submitted electronically to GeoTracker			$0	300	$2,000	$38,000	
b Evaluate data for trends as proposed in MRP IV.E							
Subtotal	**120**	**$5,000**	**$19,400**	**2,300**	**$12,000**	**$288,000**	

Management Practices Evaluation Workplan MRP, Attachment B (Monitoring and Reporting Program) Section IV	Third-Party - Upfront		
	Hours	Expenses	Cost
IV.D. Management Practices Evaluation Workplan			
- Submit workplan within 2 years after GAR approval			
1 Workplan approach			
a Groundwater monitoring - must be first encountered GW			
b Modeling			
c Vadose zone sampling			
d Other scientifically sound and technically justifiable methods for meeting objects of the MPEP			
2 Groundwater quality monitoring - constituent selection (when GW monitoring is proposed)		Use different approach	
a Constituents to be assessed			
b Frequency of data collection for each constituent			
3 Workplan implementation and analysis		See MPEP high and low	
a Explain how data at evaluated farms will be used to assess GW impacts on farms not evaluated			
4 Master workplan - prioritization			
a If high vulnerability areas are ranked in GAR, prepare workplan timeline, priority, for areas/commodity			
b Submittal dates for addendums proposing the details of each area's investigation			
5 Installation of monitoring wells			
a Upon approval of workplan, prepare and submit a Monitoring Well Installation & Sampling Plan (MWISP) as described in MRP-2			
Subtotal	**0**	**$0**	**$0**

Trend Monitoring Workplan MRP, Attachment B (Monitoring and Reporting Program) Section IV	Third-Party - Upfront			
	Hours	Expenses	Cost	
IV.E. Trend Monitoring Workplan - following MRP IV.C.				
- Submit workplan within 1 year after GAR approval				
1 Workplan approach				1.00E+06 acres
a Discussion of rationale for number of proposed monitoring wells and locations				43.402778 townships
b Consider variety of ag commodities produced	500	$5,000	$65,000	4 wells per township
c Consider conditions discussed/identified in GAR related to vulnerability prioritization				174 wells total at above density
d Areas identified as recharge to urban and rural communities				
2 Well details for wells included in trend monitoring				
a GPS coordinates				Estimate using data for 130 existing wells
b Physical address of property				
c CA State well number (if known)				
d Well depth	1200	$10,000	$154,000	
e Top and bottom perforation depths				
f A copy of the water well drillers log, if available				
g Depth of standing water (static), if available				
h Well seal information (type of material, length of seal)				
3 Proposed sampling schedule				
a Annual sampling (MRP Table 3)	100	$500	$12,500	
4 Workplan implementation and analysis				
a Proposed method(s) to be used to evaluate trends in the GW monitoring data over time	100	$500	$12,500	
Subtotal	**1,900**	**$16,000**	**$244,000**	

	Hours	Expenses	Cost	Hours	Expenses	Cost
Total	**2,470**	**$271,500**	**$567,900**	**2,300**	**$12,000**	**$288,000**

Hourly Costs = $120 /hr

Table 3.1 Attachment B - MRP Section IV Low Estimate

Report Heading	MRP Section	Description	Third Party - Upfront			Third Party - Annual		
			Total Hours	**Expenses**	**One Time Upfront Costs**	**Total Hours**	**Expenses**	**Annual Costs**
1.	IV.A	Groundwater Quality Assessment Report (GAR)	450	$250,500	$304,500			
2.	IV.B	Management Practice Evaluation Program (MPEP)	**253**	**$141,028**	$171,429			
3.	IV.C	Groundwater Quality Trend Monitoring IV.C	**120**	$5,000	**$19,400**	2,300	$12,000	**$288,000**
4.	IV.D	Management Practices Evaluation Workplan IV.D	**253**	**$141,028**	$171,429			
5.	IV.E	Trend Monitoring Workplan - following MRP IV.E	1,900	$16,000	**$244,000**			
		Section IV Subtotal	**2,977**	**$553,556**	**$910,758**	**2,300**	**$12,000**	**$288,000**

Table 3.2 Attachment B - MRP Section IV High Estimate

Report Heading	MRP Section	Description	Third Party - Upfront			Third Party - Annual		
			Total Hours	**Expenses**	**One Time Upfront Costs**	**Total Hours**	**Expenses**	**Annual Costs**
1.	IV.A	Groundwater Quality Assessment Report (GAR)	**450**	**$250,500**	**$304,500**			
2.	IV.B	Management Practice Evaluation Program (MPEP)	**1,250**	**$1,350,000**	$1,500,000			
3.	IV.C	Groundwater Quality Trend Monitoring IV.C	**120**	$5,000	**$19,400**	2,300	$12,000	**$288,000**
4.	IV.D	Management Practices Evaluation Workplan IV.D	**1,250**	**$1,350,000**	$1,500,000			
5.	IV.E	Trend Monitoring Workplan - following MRP IV.E	1,900	$16,000	**$244,000**			
		Section IV Subtotal	**4,970**	**$2,971,500**	**$3,567,900**	**2,300**	**$12,000**	**$288,000**

Indicates values match results from 'Att B MRP - IV' Sheet calculations

82% *Percentage of GAR that is accounted for in 'Expenses', assumed to be contract costs for consultants. Consultants are assumed to account for same percentage of IV.B & IV.D costs

90% *Using 82% as in the Low Estimate results in 2,250 hours, increased the percentage to 90% to account for the increased aggregation and complexity of the High Estimate

Low MPEP estimate (Group option, worst case per Clay Rodgers)								
Crop groups	4			Workplan per crop	$300,000			
Management Practices	8			Analysis per crop	$300,000	More aggregation, higher cost per crop (or converse)		
Site Conditions	5							
Sites	160	0.5%	of 33,000 growers					
Wells per site	3							
Dairy RMP cost	$ 1,300,000	per year						
				One time cost (front or back end)		Annual cost		
				Central Valley Coalitions	Kern Share (1/7th)	Central Valley Coalitions	Kern Share (1/7th)	
MWISP	$ 5,400	per site		$ 864,000	$ 123,429			
MWICR	$ 3,480	per site		$ 556,800	$ 79,543			
Survey	$ 1,680	per site		$ 268,800	$ 38,400			
Wells	$ 4,000	per well		$ 1,920,000	$ 274,286			
Monthly sampling	$ 2,100	per site per instance				$ 4,032,000	$ 576,000	
Quarterly reporting	$ 4,000	per site per report				$ 2,560,000	$ 365,714	
Workplan				$1,200,000	$ 171,429			
Analysis / MPEPR				$1,200,000	$ 171,429			
				$ 6,009,600	$ 858,514	$ 6,592,000	$ 941,714	
						$ 0.94	per acre	
						507%	of dairy RMP cost	
						5.1	times dairy RMP cost	

High MPEP estimate (Kern only option)

Crop groups	6			Workplan per crop	$250,000	More aggregation, higher	
Management Practices	8			Analysis per crop	$250,000	cost per crop (or converse)	
Site Conditions	3						
Sites	144	16.0%	of 902 growers				
Wells per site	3						
Dairy RMP cost	$ 1,300,000	per year					
				One time cost (front or back end)		**Annual cost**	
				Kern Coalition		**Kern Coalition**	
MWISP	$ 5,400	per site		$ 777,600			
MWICR	$ 3,480	per site		$ 501,120			
Survey	$ 1,680	per site		$ 241,920			
Wells	$ 17,000	per well		$ 7,344,000			
Monthly sampling	$ 2,100	per site per instance				$ 3,628,800	
Quarterly reporting	$ 4,000	per site per report				$ 2,304,000	
Workplan				$1,500,000			
Analysis / MPEPR				$1,500,000			
				$ 11,864,640		$ 5,932,800	
						$ 5.70	per acre
						456%	of dairy RMP cost
						4.6	times dairy RMP cost

Attachment B - MRP - Monitoring & Reporting Program Section V

Based on the March 2013 Tulare Lake Basin Area Tentative WDRs General Order Hourly Costs $120

Groundwater Monitoring Report (GWMR)		Third-Party - Upfront			Third-Party - Annual		
MRP, Attachment B (Monitoring and Reporting Program) Section V		Hours	Expenses	Cost	Hours	Expenses	Cost
V.B.	**Annual Groundwater Monitoring Results - Annually by May 1**						
1	Submit prior year's GW monitoring results in Excel and/or export into GeoTracker			$0	40	$15,000	$19,800
2	Explanation of why some data is missing			$0	4	$1,000	$1,480
V.C.	**Monitoring Report - Annually by May 1**						
1	Signed transmittal letter			$0	4		$80,480
2	Title page			$0	2		$240
3	Table of contents			$0	4		$480
4	Executive Summary			$0	16		$1,920
5	Description of third-party geographical area			$0	16		$1,920
6	Monitoring objectives and design			$0	16		$1,920
7	Sampling site / monitoring well descriptions and rainfall records			$0	16		$1,920
8	Location map(s) of sampling sites/monitoring wells, crops and land uses			$0	16		$1,920
9	Tabulated results summary of analyses			$0	40		$4,800
10	Discussion of data relative to water quality objectives and water quality management plan milestones			$0	40		$4,800
11	Sampling and analytical methods used			$0	16	$80,000	$1,920
12	Summary of Quality Assurance Evaluation results (from QAPP)			$0	24		$2,880
13	Specification of the method(s) used to obtain estimated surface water flow estimation, at each monitoring site during each monitoring event			$0	16		$1,920
14	Summary of water quality objectives exceedances			$0	24		$2,880
15	Actions taken to address water quality exceedances			$0	24		$2,880
16	Evaluation of monitoring data to identify spatial trends and patterns			$0	24		$2,880
17	Summary of Nitrogen Management Plan information			$0	32		$3,840
18	Summary of management practice information collected as part of Farm Evaluations			$0	24		$2,880
19	Summary of Mitigation Monitoring			$0	16		$1,920
20	Summary of education and outreach activities			$0	16		$1,920
21	Conclusions and recommendations			$0	24		$2,880
VIII.	**Water Quality Triggers for Development of Management Plans**			$0	0	$0	$0
XI.	**Quality Assurance Project Plan (QAPP)**	0	$0	$0			$5,000
	Totals	**0**	**$0**	**$0**	**454**	**$96,000**	**$155,480**

MRP-1 - Groundwater Management Plan Requirements

Assumptions:
The average hourly rate is meant to cover district staff time and consultant time in addressing management plan issues. Ther e are many inherent uncertainties, most significant of which are details on what wil actually be found to be in exceedance of water quality standards, and the areal extent of those exceedances. This assumes that Kern will submit a Comprehensive GW Management Plan with our GAR.

Average Hourly Costs $120

MRP-1 Groundwater Management Plan Requirements	Groundwater Mgmt Plan								
	Third Party				Member				
	Up-front		Annual		Up-front		Annual		
Monitoring and Reporting Program R5-2013-XXXX	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Notes
A Introduction and Background Section									
1 Discussion of COCs, water quality objective(s) or trigger(s)	8	$960							Draw from GAR on a lot of this.
2 Identification (narrative & map format) of boundaries to be covered by the management plan	8	$960							
Can include all areas or separate management plans for each area where plans are req	0	$0							
3 Discussion how boundaries were delineated	8	$960							
B Physical Setting and Information									
1 General Requirements									
a. Land use maps - partially satisfied in GAR	20	$2,400							
i. Crop information by square-mile section (TRS) level	8	$960							
ii. Maps in electronic format using ArcGIS format	8	$960							
b. Identification of potential irrigated ag sources of COCs	20	$2,400							
i. If potential sources unknown, conduct source identification study - Triggers G	0	$0							See below under implementation
ii. **or** Develop management plan for COCs - Triggers C									
c. List of designated beneficial uses for impacted water	12	$1,440							
d. Baseline inventory of existing management practices	20	$2,400							Draw from Farm Evaluation.
i. Location of practices to TRS level	40	$4,800							
e. Available surface and/or groundwater quality data - partially satisfied in GAR									
i. Summary, discussion, and compilation of available data	20	$2,400							While groundwater is a bigger job, assume that much of this information is available from the GAR.
ii. For COCs in the management plan	20	$2,400							
iii. Acceptable sources of quality data:	0	$0							
CA State Water Board Groundwater Ambient Monitoring Assessment (GAMA) program	20	$2,400							
US Geological Survey (USGS)	20	$2,400							
CA Department of Public Health (DPH)	20	$2,400							
CA Department of Pesticide Regulation (DPR)	16	$1,920							
CA Department of Water Resources (DWR)	16	$1,920							
Local groundwater management programs	0	$0							
Groundwater Assessment Report (GAR) developed by Third-Party	40	$4,800							
3 Groundwater - Additional Requirements									
a. Soil types and soils data as described by NRCS soil survey	20	$2,400							
b. Description of geology and hydrogeology for area	20	$2,400							
i. Regional and area specific geology	8	$960							
ii. Groundwater basin and sub-basins in the area	16	$1,920							
1 General water chemistry known	16	$1,920							
2 Concentrations of major anions, cations, nutrients, TDS, pH, DO, and hardness	16	$1,920							
3 Provide Piper (tri-linear), Stiff, and/or Durov diagrams for the area	16	$1,920							
iii. Hydrogeology, including	8	$960							
1 Known water bearing zones	8	$960							
2 Areas of shallow and/or perched groundwater	8	$960							
3 Areas of discharge and recharge to basin	8	$960							
iv. Identify water bearing zones utilized for domestic, irrigation, and municipal water	8	$960							
v. Aquifer characteristics known from existing information	8	$960							
1 Depth to groundwater	8	$960							
2 Groundwater flow direction	8	$960							
3 Hydraulic gradient and conductivity	8	$960							
c. Identification of irrigation water sources and general water chemistry	8	$960							
C Management Plan Strategy - this is probably the norm but can be short-circuited by performing a source ID study (G)									
1 Description of approach and prioritization	4	$480							
2 Goals and Objectives	4	$480							
a. compliance with water quality objectives	2	$240							
b. Education and outreach	2	$240							
c. Identify, validate, and implement management practices	2	$240							
3 Identify duties and responsibilities of individuals/groups	8	$960							
a. Identification of key individuals	8	$960							
b. Discussion of each individual's responsibilities	8	$960							
c. Organizational chart with identified lines of authority	8	$960							
4 Strategies to implement Management Plan tasks	8	$960							
a. Identify entities/agencies contacted to obtain data and assistance	8	$960							
b. Identify management practices used to control COC that are	32	$3,840							
i. Technically feasible	8	$960							
ii. Economically feasible	8	$960							
iii. Proven to be effective at protecting water quality	8	$960							
iv. Complies with Sections III.A. and B. of the Order	8	$960							
v. Practices to be implemented by Members	16	$1,920							NMP, outreach on accounting for N in well water
vi. Estimation of effectiveness and know limitation of implemented measures	16	$1,920							
c. Identify outreach to participants	8	$960							
i. Strategy for informing growers of water quality problems	8	$960							
ii. Method for disseminating information on management practices	4	$480							Websites, district correspondence, etc.
iii. Description of how effectiveness of outreach to be evaluated	8	$960							Monitor ratios
d. Schedule and milestones for implementation of management practices and tasks	8	$960							
i. time estimated to identify new management practices	4	$480							
ii. Timetable for implementation of identified management practices	4	$480							
e. Establish measurable performance goals	8	$960							
D Monitoring Methods		$0							
1 General Requirements	8	$960							
a. Designed to measure effectiveness at achieving goals and objectives	4	$480							
b. Capable of determining management practice made in response to plan are effective	4	$480							
2 Surface Water - Additional Requirements									
a. Location(s) of monitoring site and schedule representative of COC discharges									
b. Monitoring data submitted electronically									
3 Groundwater - Additional Requirements									
a. May include commodity-based representative monitoring	40	$4,800							Rely on MPEP efforts
b. Conducted to determine effectiveness of management practices implemented	20	$2,400							
E Data Evaluation									
1 Methods utilized to perform data analysis	4	$480							
2 Identify information necessary to quantify program effectiveness	4	$480							
i. Tracking of management practice implementation	4	$480							
ii. Describe approach used to determining effectiveness of management practices	12	$1,440							
iii. Describe process for tracking implementation of management practices	12	$1,440							
iv. Description of how information is collected from growers	12	$1,440							
v. Type of information collected	8	$960							
vi. How information will be verified	8	$960							
vii. How information will be reported	8	$960							

MRP-1 Groundwater Management Plan Requirements	Groundwater Mgmt Plan								Notes
	Third Party				Member				
	Up-front		Annual		Up-front		Annual		
Monitoring and Reporting Program R5-2013-XXXX	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Notes
F Records and Reporting - Management Plan Progress Report - this is annual once a Mgmt Plan is implemented.									
1 Front Pages			1	$120					
2 Executive Summary			20	$2,400					
3 Location map(s) and brief summary			14	$1,680					
4 Table with exceedances for the management plans			20	$2,400					
5 New management plans triggered since previous report			0	$0					Assume that we will use a comprehensive plan.
6 Status update on preparation of the new management plans			0	$0					
7 Summary and assessment of data collected during reporting period			40	$4,800					
8 Summary of grower outreach conducted			30	$3,600					
9 Summary of implementation of management practices			60	$7,200					
10 Results of evaluation of management practice effectiveness			60	$7,200					
11 Evaluation of progress in meeting performance goals and schedules			20	$2,400					
12 Recommendations for changes			20	$2,400					
G Source Identification Study Requirements - this is a triggered report - not always included									
1 Evaluation of types of practices, commodities, and locations that may be a source	32	$3,840							Use NHI for this.
2 Continued monitoring at site/area and increased monitoring, if appropriate	8	$960							Monitor mostly nitrogen ratios.
3 Assessment of potential pathways through waste discharge can occur	8	$960							
4 Schedule for conducting study	16	$1,920							
5 Field Studies									
a. Evaluate feasibility of field studies as part of their source identification study proposal	0	$0							Rely on MPEP work.
b. Identify a reasonable number and variety of field study sites that are representative	0	$0							
6 Alternative Source Identification - if not performing a source ID study									
a. Demonstrate how method will produce data/information	16	$1,920							Reference MPEP work.
b. Determine contributions from irrigated ag operations	16	$1,920							
Subtotal - Documentation of the plans	970	$ 116,400	285	$ 34,200	0	$ -	0	$ -	
IMPLEMENTATION ESTIMATE									
Registered pesticides									
Source ID	80	$9,600							We have minimal GWPA's in Kern. Might have some follow-up, depending on what data looks like.
Identification of potential management practices	40	$4,800							
Management practice implementation	50	$6,000							
Effectiveness evaluation	80	$9,600							
Toxicity									
Source ID									
Identification of potential management practices									
Management practice implementation									
Effectiveness evaluation									
Contingency / As-required phase on high priority items (covers first two years of implementation)								$0	
Legacy pesticides and trace metals									
Source ID									
Identification of potential management practices									
Management practice implementation									
Effectiveness evaluation									
DO and pH									
Source ID									
Identification of potential management practices									
Management practice implementation									
Effectiveness evaluation									
Salinity and pathogens									
Source ID									
Identification of potential management practices									
Management practice implementation									
Effectiveness evaluation									
Contingency / As-required phase on lower priority items (covers last three years of 5 year plan)								$0	
Nitrates - groundwater management plan items (KRWCA staff time)			2000	$240,000					Assumed to require one person-year to monitor grower nitrogen ratios, research acceptable values, meet with growers, do outreach, interact with and support MPEP work, and provide support for growers and answer questions. This is uncertain.
Nitrates - grower attendance at outreaches.							1800	$216,000	Assume 600 high vulnerability growers/personnel. Each grower would attend one outreach for their crop. 3 hours per outreach plus travel expenses. This doesn not include grower time to implement practices.
Subtotal - Implementation	250	$ 30,000	2000	$ 240,000	0	$ -	1800	$ 216,000	These costs do not include farm level management practices that may be required. For example, pressurized irrigation systems, etc.
GRAND TOTAL	**1,220**	**$ 146,400**	**2,285**	**$ 274,200**	**0**	**$ -**	**1,800**	**$ 216,000**	

MRP-2 - Monitoring Well Installation, Sampling Plan, and Completion Report

Crop groups	6
Management practices	8
Site conditions	3
Sites	144

Based on the March 2013 Tulare Lake Basin Area Tentative WDRs General Order

Hourly Costs $120

MRP-2 Monitoring Well Installation, Sampling Plan, and Completion Report Monitoring and Reporting Program R5-2013-XXXX	Third-Party (up-front costs)		Third-Party (annual costs)		
	Hours	Phase Cost	Hours	Phase Cost	Notes
II. Per Phase Monitoring Well Installation and Sampling Plan (MWISP)	6480	$777,600			This includes all of the below.
A Stipulations					Approximately $5,400 per site.
B MWISP Required Elements					
1 General Information					
a. Topographic map					
b. Site plan					
c. Rationale for number of monitoring wells proposed					
d. Local permitting information					
e. Drilling details					
f. Health & Safety plan					
2 Proposed Drilling Details					
a. Drilling techniques					
b. Well / soil sample collection and logging method(s)					
3 Proposed Monitoring Well Design					
4 Proposed Monitoring Well Development					
5 Proposed Surveying					
6 Monitoring according to QAPP					
III. Monitoring Well Installation Completion Report (MWICR)	4176	$501,120			Includes A-C below.
A General Information					Approximately $3,480/site
a. Brief overview of field activities					
b. Site Plan					
c. Period of field activities and milestone events					
B Monitoring Well Construction					
C Monitoring Well Development					
D Monitoring Well Survey	2016	$241,920			Approximately $1,680 per site
Implementation costs					
Well construction, project management and oversight		$7,344,000			Direct rotary, approximately $17k per well with e-log, project mgmt and oversight.
Sampling and analysis cost, assuming monthly sampling.				$3,628,800	$1000/site for sampling. $200/site for normal analysis. $900/site for pesticide analysis.
Quarterly reporting of results to RWQCB				$2,304,000	$4000/site for reporting event
Totals		**$8,864,640**		**$5,932,800**	

Exhibit C

Assessment of Potential for Nitrate Migration in Kern Sub-Basin

NewFields Agricultural & Environmental Resources
2020 L Street, Suite 110
Sacramento, CA 95811
T: 916.265.6350
www.newfields.com

Kern River Watershed Coalition Authority

Assessment of Potential for Nitrate Migration in Kern Sub-Basin

TO:

Ernest Conant/Young Wooldridge

John Schaap/Provost & Pritchard

FROM:

Joel Kimmelshue, PhD, CPSS/NewFields Agricultural & Environmental Resources

Stephanie Tillman, MS, CPSS/Ag/NewFields Agricultural & Environmental Resources

April 11, 2013

Executive Summary

Background

The California Regional Water Quality Control Board – Central Valley Region (CVRWQCB) has issued Tentative Order R5-2013-XXXX titled, Waste Discharge Requirements General Order for growers within the Tulare Lake Basin Area that are members of a Third Party Group, dated March 15, 2013,"Tentative Order". This technical memorandum has been developed in support of the comments submitted by the Kern River Watershed Coalition Authority (KRWCA).

The purpose of this technical memorandum is two-fold: (1) to document on-going technical work that addresses the unique nature of the Kern Sub-Basin area, and (2) to provide an explanation of an alternative and modified methodology (using a Nitrate Hazard Index, or "NHI") to rank, track, and manage the potential for nitrate leaching to groundwater.

Approach

The overall approach of the work performed for the KRWCA was to:

- Develop and explain representative leaching conditions using a Soil Moisture Root Zone Balance (SMB) and understand the inherent variability associated with those estimates with specific conditions related to the Kern Sub-Basin area.

- Develop a unique Nitrate Hazard Index (NHI) as a comprehensive tool to use in assessing large landscape areas on a field by field basis in order to estimate relative potential nitrate contributions to groundwater based on surface agricultural activities and conditions unique to the Kern Sub-Basin area.

Results and Conclusions

The results and conclusions listed below, while part of an on-going investigation, are consistent with the conclusions from various researchers and approaches. NewFields used specific information applicable to the Kern Sub-Basin area.

- Currently, the Tentative Order suggests that agriculture in the Kern sub-basin is to be regulated similarly across all cropping systems in large areas regardless of irrigation method, N management, soil type, crop type, location, etc. The results of this preliminary evaluation indicate that within the Kern Sub-Basin there are significant differences between crop types and resultant potential contributions of N to groundwater resources which will require more flexible and perhaps crop- or area-specific considerations in order to develop effective regulations.

- For a variety of reasons (e.g. water availability, water cost, soil type, crop mix, market conditions, effective rainfall, etc.) the relative water use and nitrogen use in the Kern Sub-Basin is generally more efficient as compared to other areas of the Southern San Joaquin Valley and the remainder of the Central Valley as a whole. This is also supported by research conducted by others (Pettygrove, et al, 2012) (Boyle, et al, 2011) as contracted by the State Water Quality Control Board.

- Regardless of the methodology employed, estimating nitrate leaching, even under specified conditions, is a highly complex task with many variables. Therefore, the results of any N leaching estimating method should be interpreted as precisely that – estimates only – and are subject to modification with new information.

- The most significant effort related to broad land-based estimates of nitrate leaching potential to date focused on assessing nitrate contamination in groundwater from agricultural sources in California and resulted in the UC Nitrate Hazard Index. This effort intentionally avoided any attempt to place absolute values on total amounts of nitrate leached, due to the known variability (Wu et al, 1995). This work was developed and reviewed by some of the foremost experts in this multi-disciplinary subject, and should serve as an indication of the caution with which estimates of nitrate leaching must be interpreted and how variable they can be.

- A preliminary NHI was developed for the Kern Sub-Basin (specific to its conditions) and compared to previous years. In relative comparisons, the potential for nitrate leaching has decreased significantly over the past 20 years and in many areas is negligible due to the rapid conversion to highly-efficient irrigated perennial crops from historic surface irrigated row and field crops. The NHI approach allows for comprehensive assessment for the potential of nitrate leaching on large landscapes at the field level.

- From a hydraulic perspective, for purposes of our investigations, the Kern Sub Basin area was successfully separated into 6 regions that offered like soil, crop, water supply and overall production system similarities and a spatial dataset was developed from recent crop mapping (Kern Co., 2011) as the basis for analysis.

- This spatial dataset coupled with detailed literature resources and local expert knowledge specific to the Kern Sub-Basin was used in creation of inputs used for the analysis performed.

- Major crop type systems were evaluated from both a hydraulic (agronomic water balance focusing on return flows to groundwater) and nutrient use efficiency standpoint.

- In general, results confirm that perennial crops on high efficiency irrigation systems (common to the Kern sub basin) result in limited return flows to groundwater.

- Largest return flows occur under corn/wheat, sudan/wheat or other forage crop rotations that are commonly associated with feeding operations for dairies. The majority of these systems are currently regulated under the Dairy General Order (2007-035).

- Other row crops such as cotton/wheat and carrot/potato rotations result in moderate return flow estimates mostly because of the types of irrigation methods and management employed.

- The variation in nitrate leaching estimates for diverse cropping scenarios is significant, as irrigation method and soil combinations result in a wide range of nitrate leaching estimates. This finding is substantiated by numerous authors, whose work contributes to the scientific literature on N dynamics in cropping scenarios (Viers et al., 2012), and reinforces the point that nitrate leaching from various cropping systems cannot be considered or treated as similar systems.

- As a result of this preliminary evaluation, it is evident that a continued significant contributor to nitrate concentrations in groundwater is forage cropping systems predominantly used for dairy feed sources. The conclusion is supported by work performed by UC Davis (Pettygrove, et al., 2012). Much of this forage crop production is currently regulated under the existing Dairy General Order 2007-035 (the "Dairy Order").

- As a result of our preliminary NHI evaluation, drip/micro irrigated perennials have a low risk due to limited return flow and effective precipitation. These results also agree with work performed by UC Davis (Pettygrove, et al., 2012) that also show that the nitrate risks to groundwater in the Kern Sub-Basin is significantly less than other areas to the North.

- Development and utilization of a modified, Kern Sub Basin-specific NHI as a comprehensive tool to use in assessing large landscape areas on a field by field basis is a preferred methodology in estimating relative potential nitrate contributions to groundwater based on surface agricultural activities and conditions. The NHI should be employed within the proposed Waste Discharge Requirements Tentative Order for members of a third-party group within the Tulare Lake Basin, at least for the Kern Sub-Basin, as a means of simplifying and prioritizing the regulatory scheme.

General Introduction

The subject of this review is the proposed California Regional Water Quality Control Board – Central Valley Region (CVRWQCB) Order R5-2013-XXXX titled, Waste Discharge Requirements Tentative Order.

NewFields Agricultural & Environmental Resources has been retained by Young Wooldridge, LLP, on behalf of the Kern River Watershed Coalition Authority, to assist in development of scientific-based, comments and suggestions to the Tentative Order. Some focus areas will include:

- irrigation and drainage management
- nutrient use efficiencies
- soil/nutrient dynamics
- crop production
- root zone moisture management
- other related scientific approaches

Our project team has focused efforts on estimated hydraulic and nitrogen components of the varied agricultural systems within the Kern Sub-Basin of the Southern San Joaquin Water Quality Coalition (SSJWQC). A comparison to other directly applicable published work will also be provided.

More specifically, the technical tasks that have been completed include:

- Review of the Tentative Order and Other Appropriate Literature
- Development of Spatial Data Resources
- Development of Representative Scenarios and Soil Moisture Budgets
- Development of a Preliminary NHI for the entire Kern Sub-Basin

In addition to these tasks, an attempt to compare existing agronomic conditions to past trends has been developed both from a water use efficiency and nitrogen (N) use efficiency standpoint.

Finally, the results of this work were compared to agronomic-focused research in the same area conducted by other researchers (e.g. Pettygrove, et al., 2012 and Boyle, et al, 2011). These researchers and others have developed components of an overall study performed by UC Davis (Harter, et. al. 2012) and support the work performed here.

Development of Spatial Data Resources

Introduction

The first step in assessing a region of this size is to partition "like" or more "manageable" areas that may be similar in soil type, crop type, irrigation supply and management, climate, etc. The information below provides the detailed documentation as to the methods used to separate the Kern sub-basin into six regional components for the purpose of our investigations.

Methods

Determination of Regions

The following descriptions outline the features that were used to determine the boundaries between each region. Names of KRWCA agencies (water districts, irrigation districts and water storage districts) are also included to ensure all KRWCA agencies are accounted for in a region or multiple regions. Final results indicate six distinct areas with similar characteristics (Figure 1).

Clay Rim Region

This region was created in response to two dominant zones of fine-textured clay present within the valley. The region encompasses all of the Buena Vista WSD and Henry Miller WD, portions of the Wheeler Ridge-Maricopa WSD (from the districts northern border to Copus Rd), southwest portions of the Kern Delta WD (from I-5 west and Herring Rd south), the northwestern portion of the Semitropic WSD (from Gun Club Rd. west and CA-46 north) and the northeastern corner of the Lost Hills WD (East of I-5).

Foothills Region

The Foothills region contains portions of the Southern San Joaquin MUD (east of the Famoso-Porterville Hwy), a portion of the Delano-Earlimart ID, Kern-Tulare WD, the Olcese WD, the Cawelo WD and a portion of the Arvin-Edison WSD. The eastern boundary of the region follows the Kern-Tulare WD and the Cawelo WD boundaries. The western boundary was determined based on the distribution of crop types due to the limited difference between soil mapping units found. A noticeable shift in crop types occurs immediately to the east of the city of Delano and the Famoso-Porterville Hwy/Richgrove Dr. from Vestal south to Famoso. This shift along Famoso-Porterville Hwy/Richgrove Dr from predominantly annuals, almonds, and grapes to the west and predominantly citrus to the east necessitates deviating from coalition agency boundaries to define the western edge of the Foothill region. The eastern and western boundaries head south along Poso Creek until it reaches the eastern border of Cawelo WD. The inclusion of a northern portion of the Arvin-Edison WSD is due to the density of citrus in this area. The northern boundary is formed by the Kern-Tulare WD northern border south of the city of Ducor near Vestal.

Kern Fan Region

The Kern Fan region contains the Rosedale-Rio Bravo WSD and the Kern Delta WD. The boundary was determined using differences in soil texture from the USGS SSURGO soil database and WSD boundaries. The orientation of soil map units (directionality of sediment deposition based on historic water flow characteristics) and the horizontal stratification associated with alluvial fans (coarse textured soils near the mouth of the stream and finer textured soils as distance increases away from the mouth of the stream) clearly shows the extent of the Kern River Fan. The southern boundary is formed along the Clay Rim region and a small section of the Arvin-Edison WSD The northern boundary is found along the Rosedale-Rio Bravo WSD northern border. The eastern edge is found along the Kern Delta WD and Arvin-Edison WSD boundary and extends north along CA-99 to Oildale. The western boundary is found running south from the Clay Rim region at Buttonwillow to the California Aqueduct at the Tule Elk State Reserve and south along the Aqueduct to Ironback Rd.

Westside Region

The Westside region contains the Belridge WSD, Dudley Ridge WD, Lost Hills WD and Berrenda Mesa WD. The boundary extends west to the edge of the Kern Sub-Basin, down to the bottom of Belridge WSD. The Eastern boundary follows the Clay Rim region which closely coincides with the Semitropic WSD and Buena Vista WSD western boundaries. More specifically, the eastern boundary mirrors that of the Clay Rim region to the bottom of Belridge WSD. The northern boundary extends to the northern most portion of the Dudley Ridge WD. The southern boundary of the region is shared by the southern boundary of the Belridge WSD and terminates near Lokern Rd by Missouri Triangle. The southern end of this region neighbors land that is not cropped and was therefore excluded. The interface between all of these coalition agency boundaries also corresponds closely with differences in soil texture distribution with the north end of this region being more heterogeneous in the textures found and the neighboring region (Northern region) being more homogeneous.

Northern Region

The North region contains portions of the Semitropic WSD (with the exception of the northwest corner from approx. CA-46, north and Gun Club Rd, west), the Southern San Joaquin MUD (west of Famoso-Porterville Hwy), Shafter-Wasco ID and the majority of the North Kern WSD (omitting the portion of the North Kern WSD that follows the Kern River). The western boundary respects the border established by the Clay Rim region. The eastern boundary follows the Famoso-Porterville Hwy to near the city of Famoso where it then follows Poso Creek and meets the Cawelo WD. The southern boundary lies along the northern border of the Rosedale-Rio Bravo WSD which happens to follow differences in soil texture found between the Northern region and Kern Fan region. The northern boundary is shared with the northern boundary of the Delano-Earlimart ID. The distinguishing characteristics that merit including this area as a separate region are the widespread presence of almonds and the divergent soil textures when compared to neighboring WSD's and regions.

Wheeler Ridge/Arvin-Edison Region

The Wheeler Ridge/Arvin–Edison region contains both of these water districts. The boundary follows the Arvin-Edison WSD and Wheeler Ridge-Maricopa WSD borders. Slight modifications to the boundary were made based on differences in soil texture and crop distribution when compared to surrounding areas, specifically coarser textured soils and citrus establishment. As a result, a portion of the northeastern section of Arvin-Edison WSD has been included in the Foothills WSD. Additionally, the dominant crop type in the area differed from other zones and overall crop diversity was increased in this region versus others. Furthermore, because of differences in soil texture and crop type in the northern part of the Wheeler Ridge-Maricopa WSD, the section from Copus Rd north to the district boundary is included in the Clay Rim region.

Approximately 935,000 acres were irrigated within the Kern Sub-Basin in 2011 (Table 1).

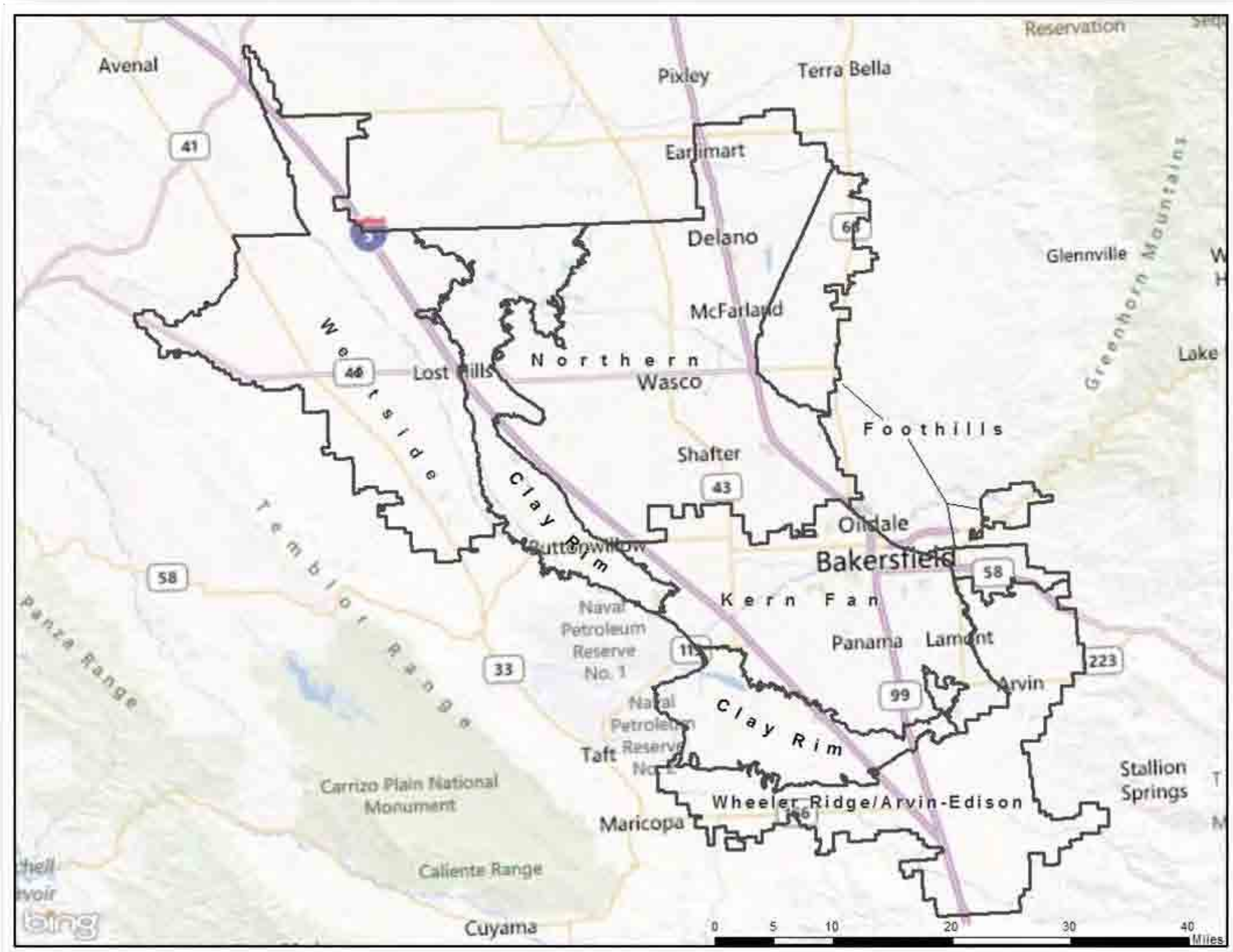


Figure 1. Six distinct regions based on differences in soil type, crop types and management

Table 1. Acreage summary for each region (includes irrigated lands only)

Region (AOI) Name	Acres
Clay Rim	114,809
Foothills	68,861
Kern Fan	106,032
Northern	321,360
Westside	152,013
Wheeler Ridge/Arvin-Edison	172,290
Total	935,365

Determination of Soil Type

The complexity and diversity of soil type over approximately 935,000 irrigated acres in the Kern sub-basin is substantial. The main driving force behind determining soil type was for the purpose of accounting for soil water holding capacities and relationships to crop types and modifications in irrigation management practices. The national SURRGO spatial soils database was initially used to partition the multitude of map unit classifications into three main categories (fine, medium and coarse) based on dominant surface texture within the expected rooting zone of the crops (Figure 2). It should be noted that soil types may also be categorized by drainage classification. Fine textured soils included mostly clays and any sandy clays and silty clays as defined by USDA textural classifications. Coarse textured soils included sands, loamy sands and coarse sandy loams. For the purposes of this evaluation, all other sandy loams (e.g. medium and fine sandy loams) were grouped with the medium classification due to similar water holding capacities and other hydraulic characteristics. Soil type and drainage classification was ultimately used as a variable in the calculation of both SMB and NHI.

Determination of Crop Type

Crop type was determined predominantly through the use of the Kern County crop distribution spatial data resources (Figure 3) for 2011 (Kern County, 2011). This annual data resource is detailed by crop type and even within various crop rotations within a single field. It offers a recent summary of existing crop distribution in an area of the state that is rapidly changing from lower water use efficiency annual row crops to higher water use efficiency perennial crops. In this regard, there is plentiful and timely data and as compared to other counties. Kern County has excellent crop distribution spatial data as do many of the water service entities within the county. In some areas, however, annual and forage crops still persist. This is especially true in areas within the Clay Rim and locations associated with dairy operations. The following figures represent all crop distribution within the Kern sub basin (Figure 3) as well as individual major crop types (Figures 4-11).

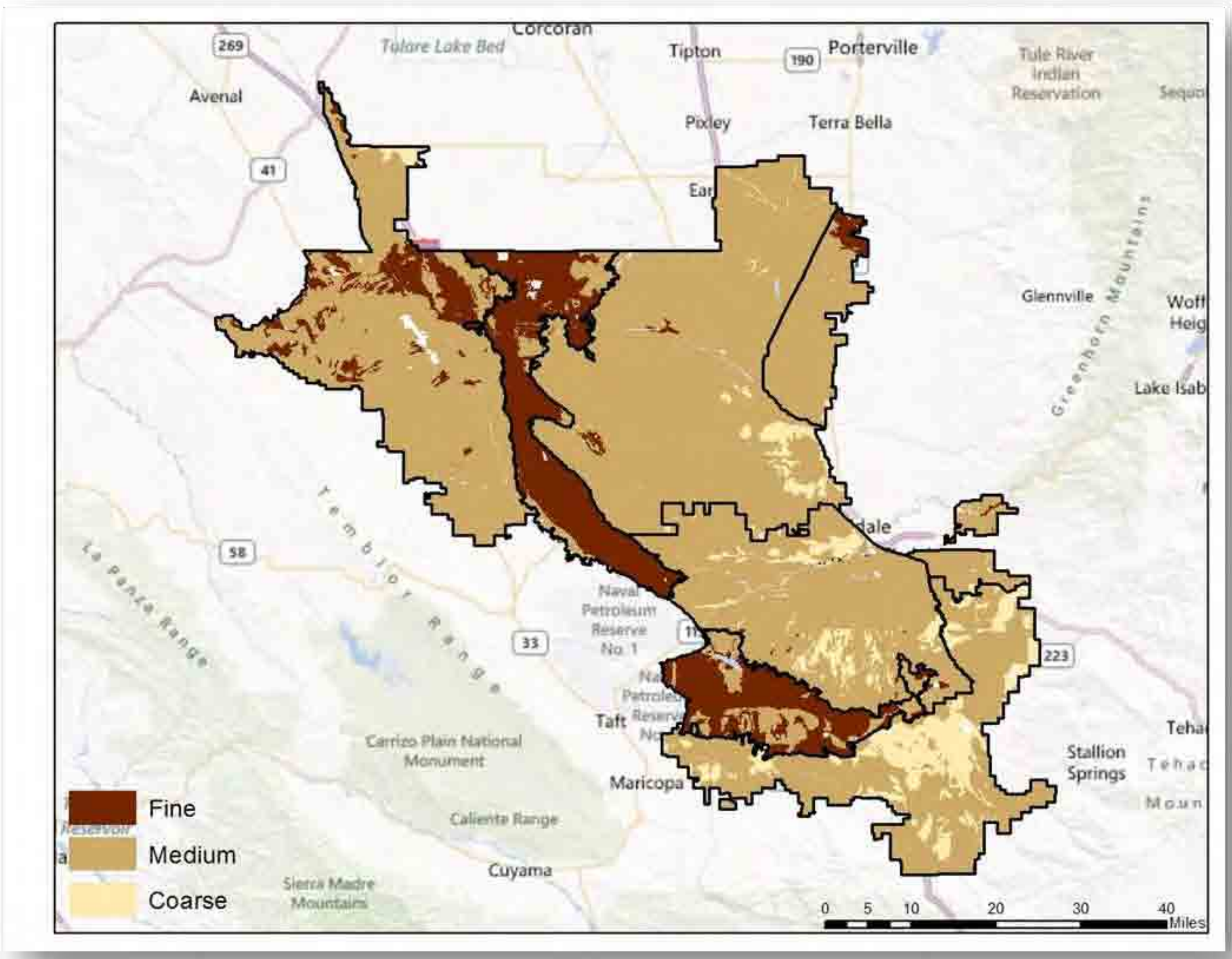


Figure 2. Generalized soil texture groupings derived from USDA SURRGO spatial soil data.

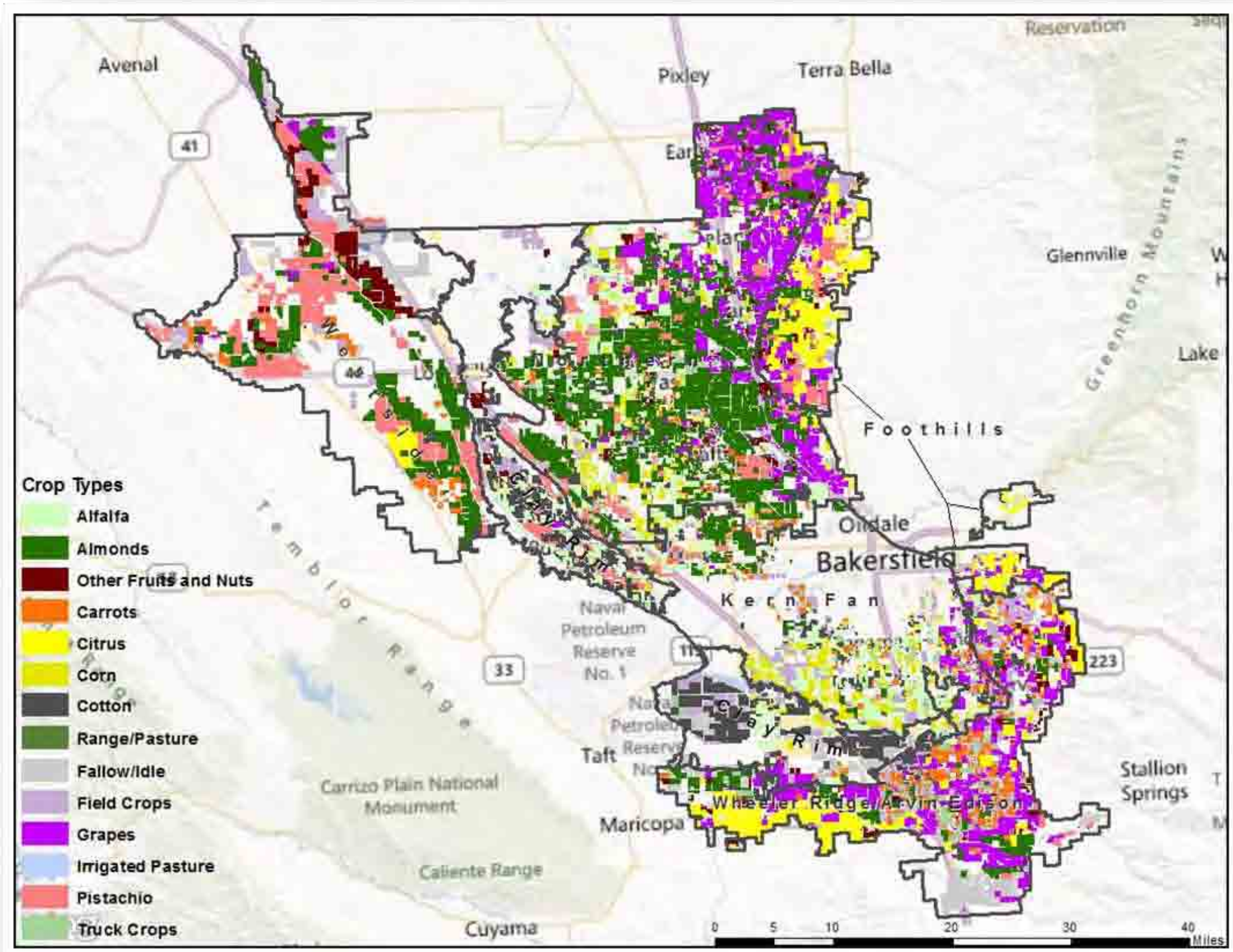


Figure 3. Comprehensive crop types and crop groupings in the KRWCA Sub-Basin.

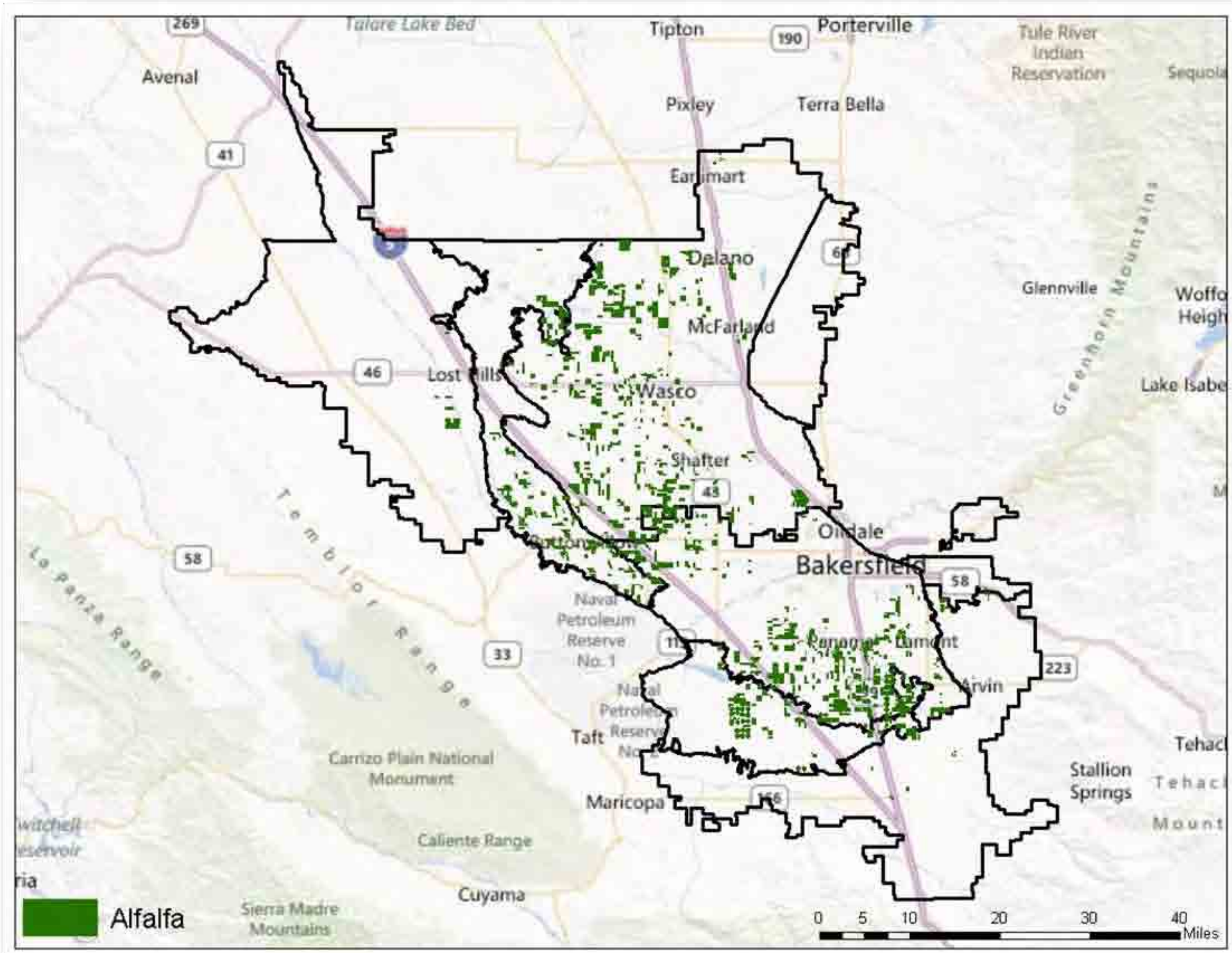


Figure 4. Alfalfa production within the KRWCA Sub-Basin.

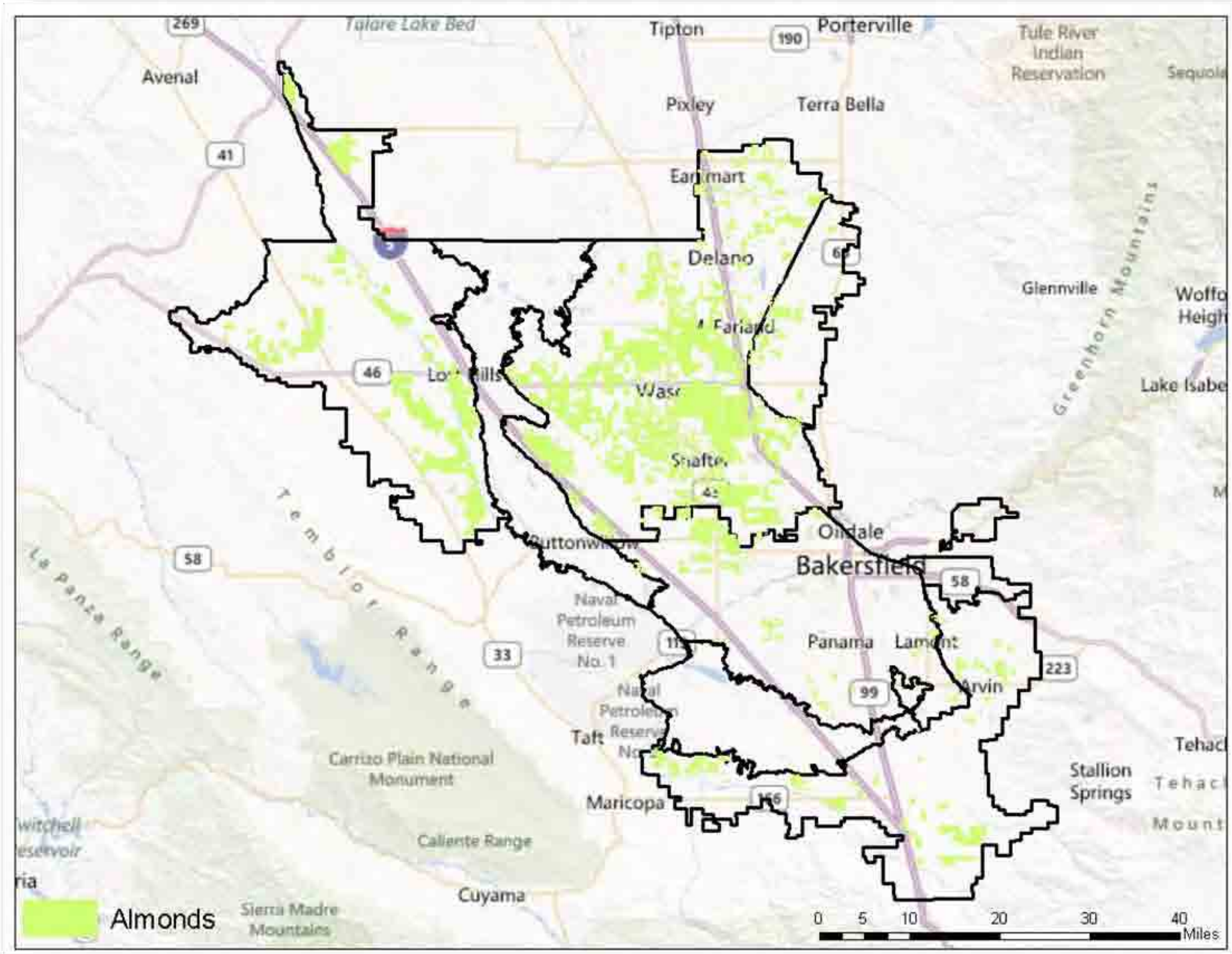


Figure 5. Almond production within the KRWCA Sub-Basin.

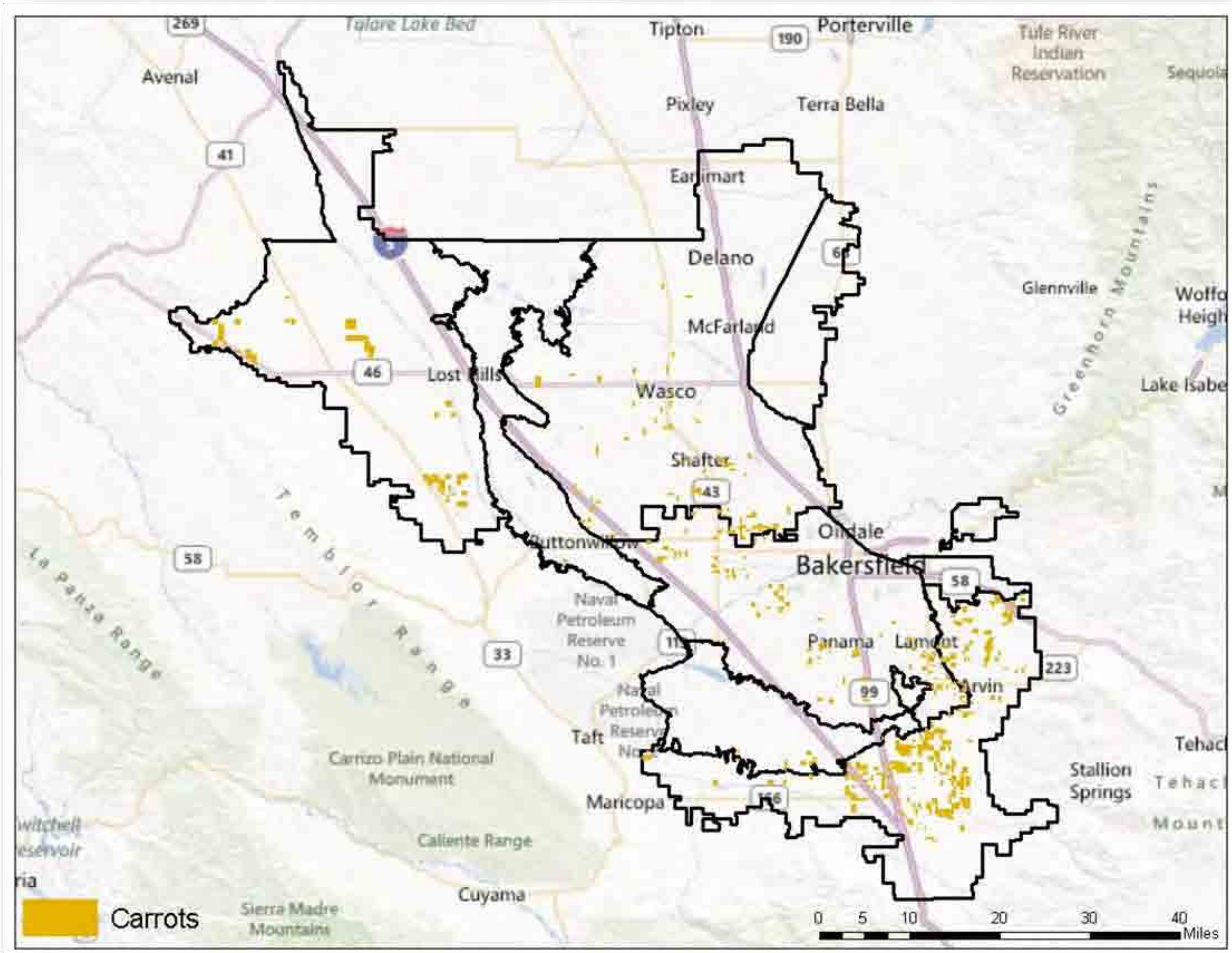


Figure 6. Carrot production within the KRWCA Sub-Basin.

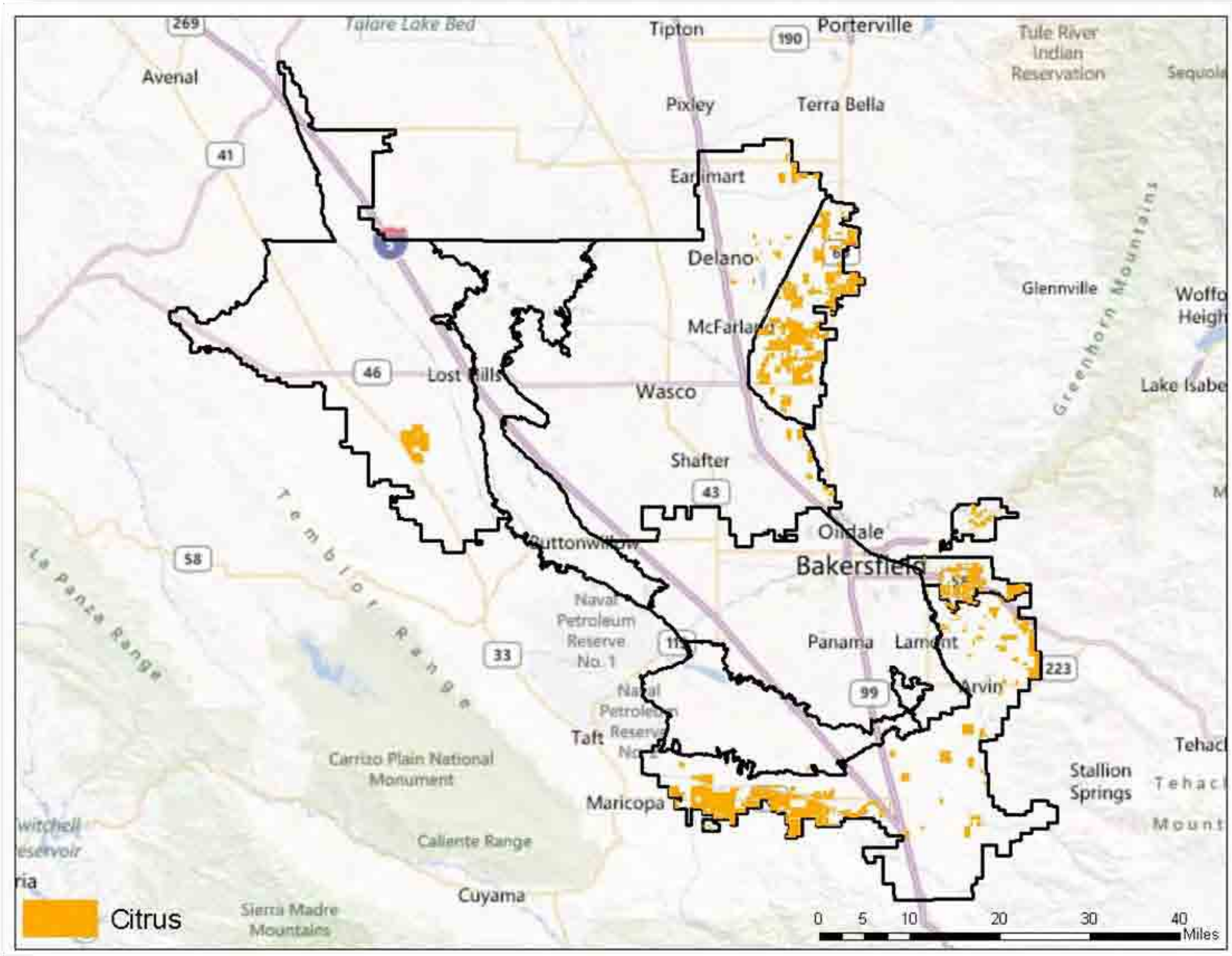


Figure 7. Citrus production within the KRWCA Sub-Basin.

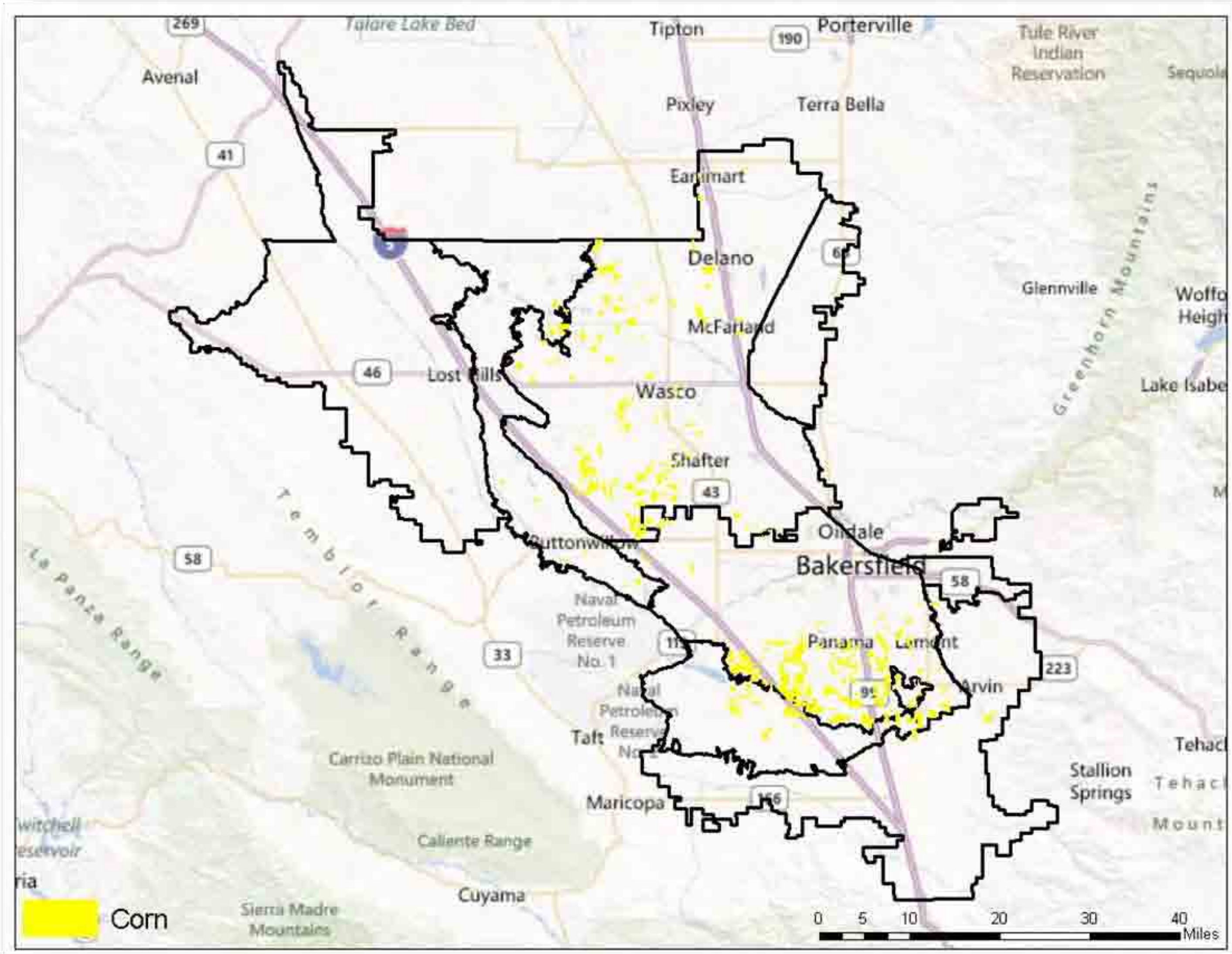


Figure 8. Corn production within the KRWCA Sub-Basin.

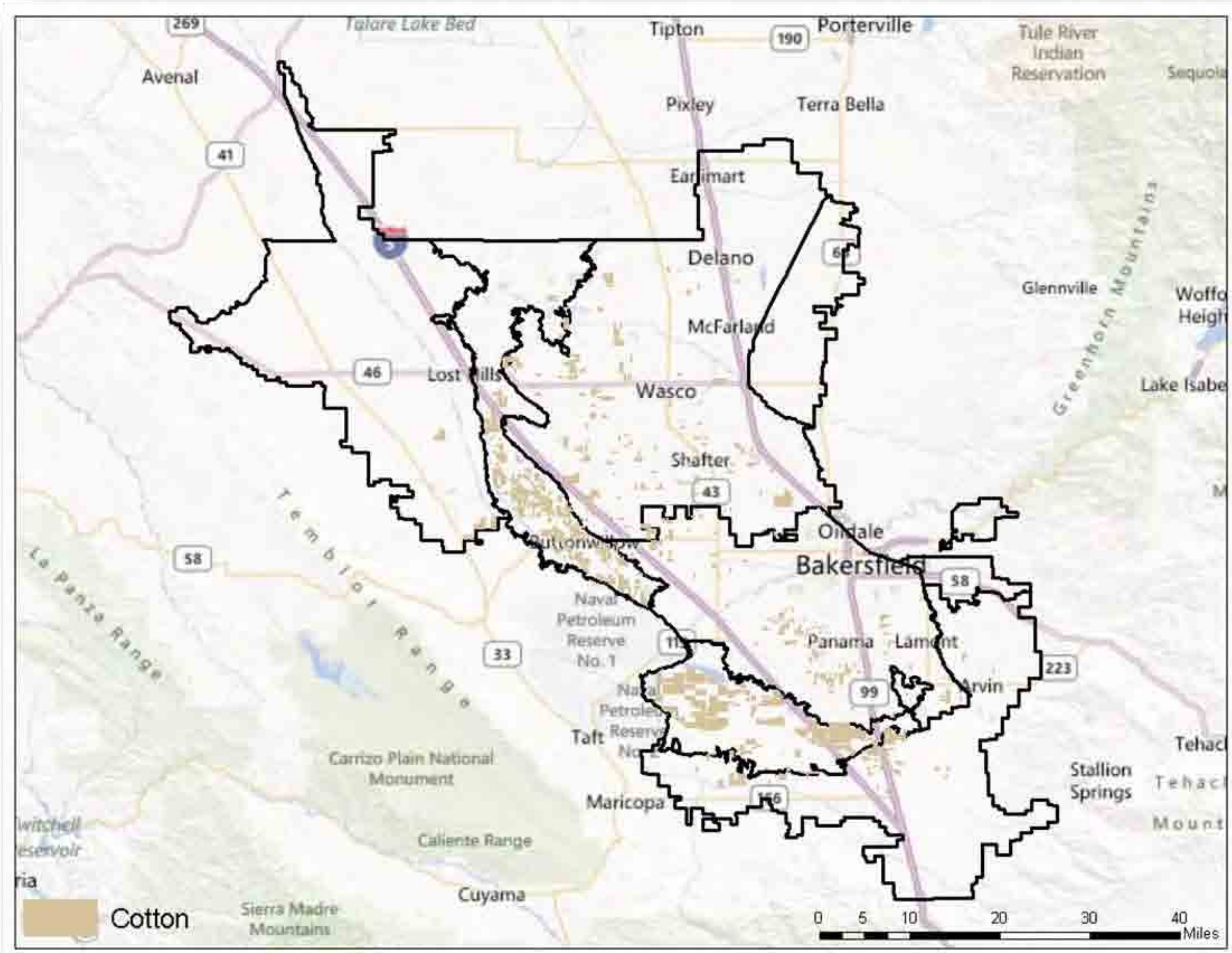


Figure 9. Cotton production within the KRWCA Sub-Basin.

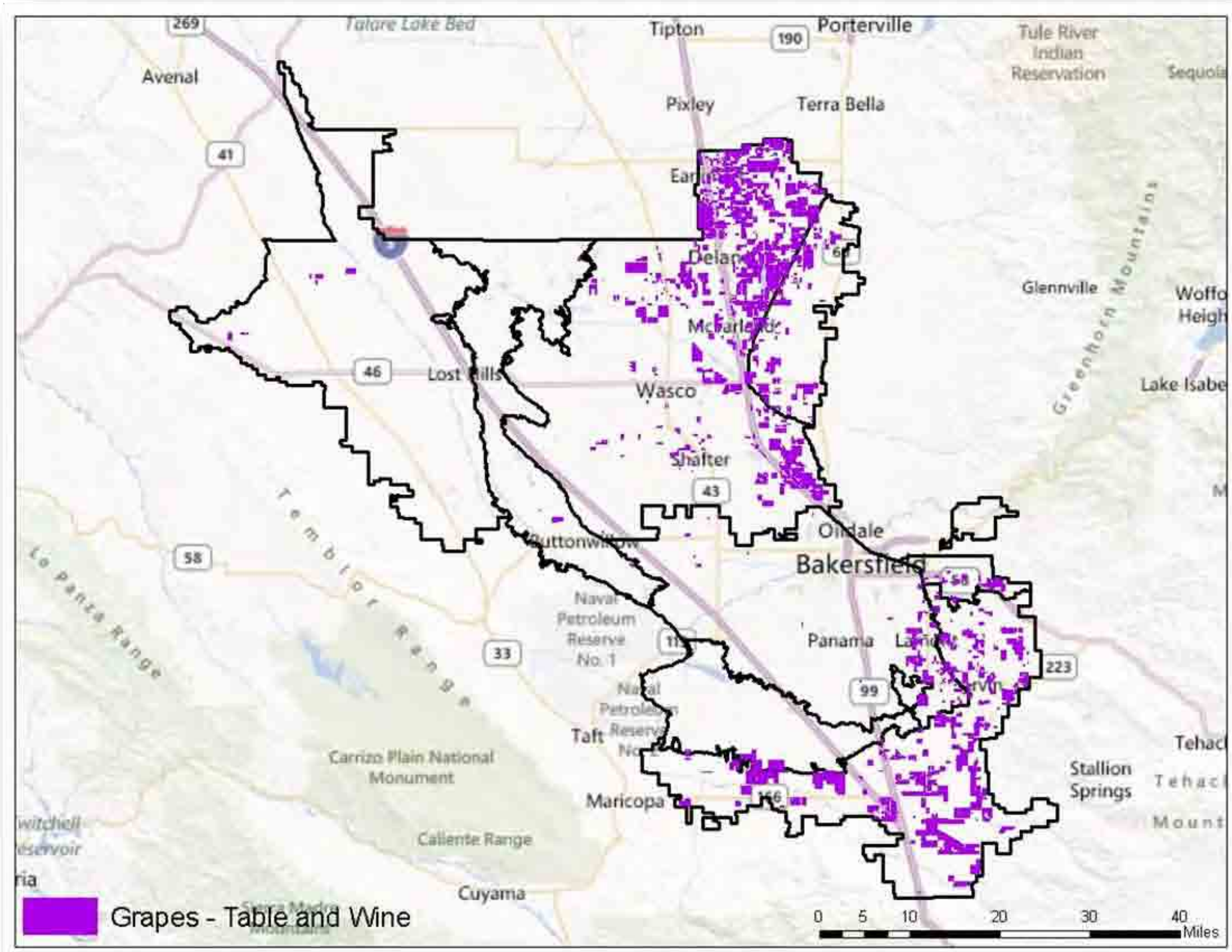


Figure 10. Grape production within the KRWCA Sub-Basin.

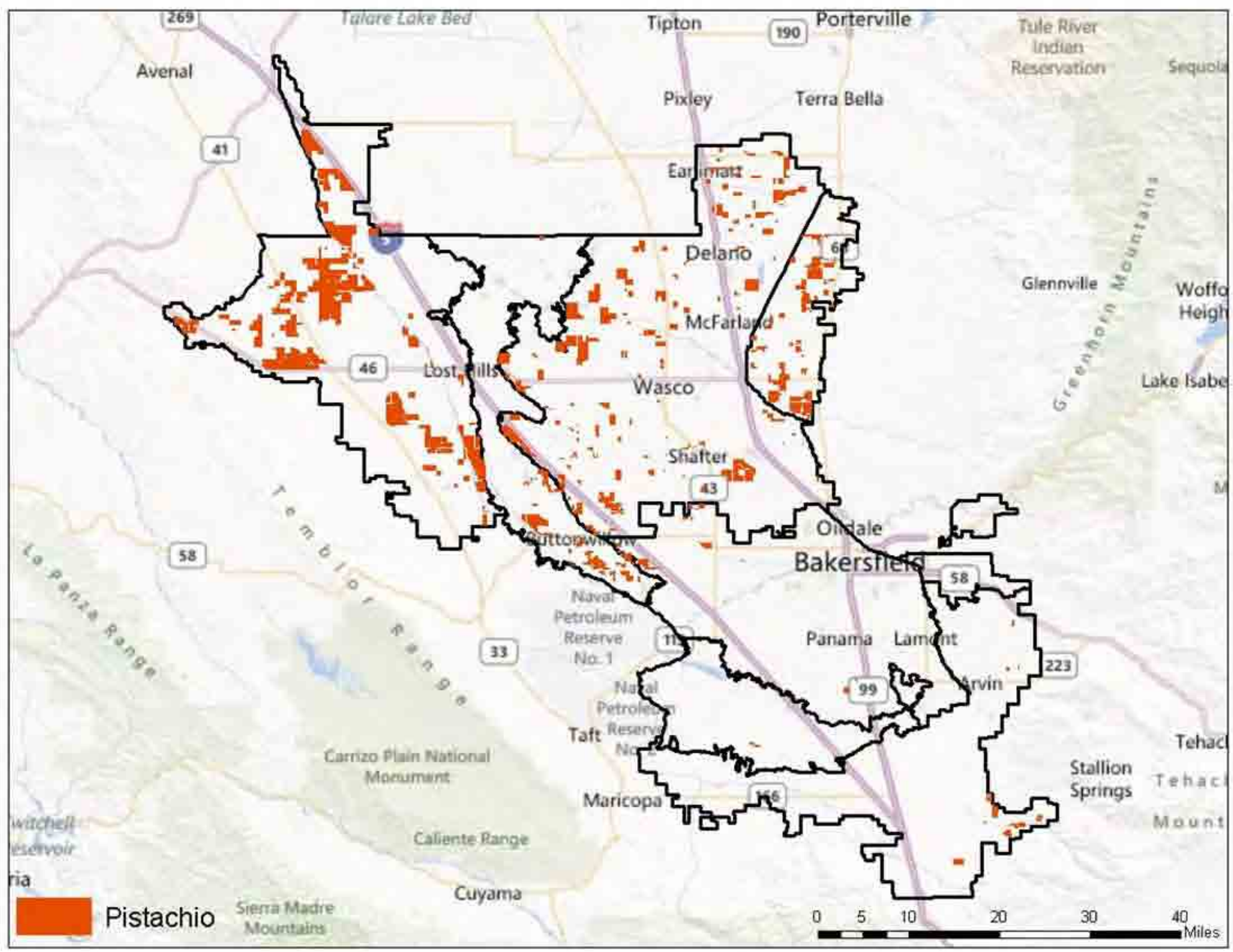


Figure 11. Pistachio production within the KRWCA Sub-Basin.

Historic Cropping Trends and Conversions

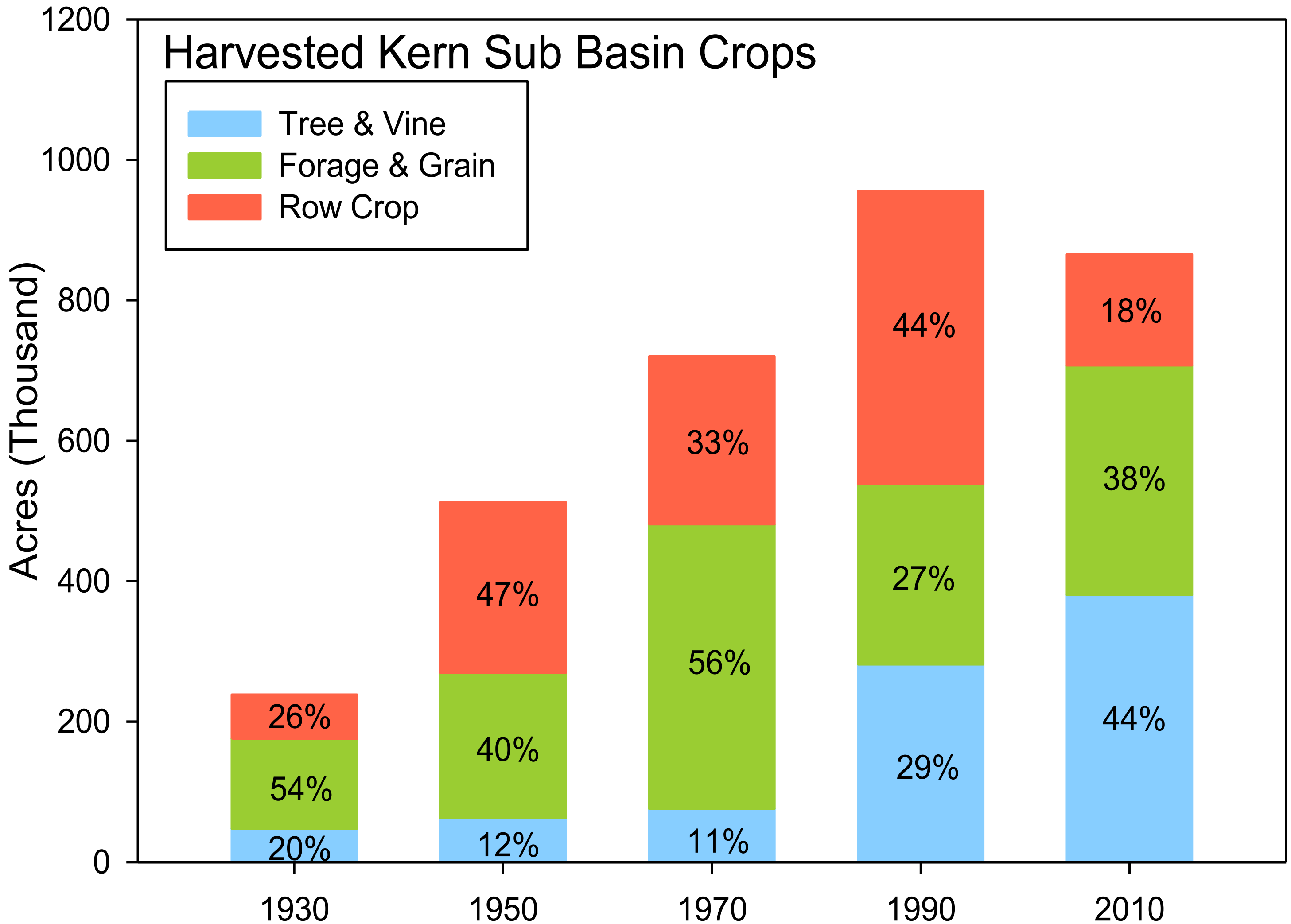
Historic crop trends for Kern Sub-Basin were summarized (Ag Commissioner Records) once every 20 years (1930-2010) to show the growth of agriculture in the county as well as the transition to permanent crops and also the recent (1990-2010) increase in forage crops associated with diaries (Figure 12). Cotton and to a lesser extent other row crops, have significantly been replaced by almonds and other permanent tree crops. This also has resulted in a corresponding shift in irrigation practices from gravity (mostly furrow) to pressurized (mostly drip/micro) systems. This has undoubtedly resulted in a significant reduction of return flows to groundwater and also associated nitrate contributions. The nitrate is allowed to remain in the deeper root zone for longer periods of time with a greater potential uptake by the crop. It is likely that Kern County is utilizing most of its irrigable land at this point. In fact, the total irrigated acreage actually dropped in 2010 as compared to 1990. Kern County does stretch into agricultural areas of the Antelope Valley; however this area is only sparsely irrigated as related to the remaining part of Kern County within the San Joaquin Valley.

Dairy production has also increased in Kern County over the past 20 years and, as a result so has a significant amount of forage crop production land (Figure 12). For the most part, the lands associated with dairy production are receiving manure as a nutrient source and are, therefore regulated by the CVRWQCB through the Dairy Order. There is, however, forage producing ground that is not regulated under the Dairy Order due the fact that it does not receive manure but does serve as a feed source.

Permanent Crop Irrigation Efficiencies

Irrigation efficiencies in the Kern Sub-Basin are, overall, some of the highest in the entire Central Valley. Various resources were used to show the increase in drip/micro irrigation systems in permanent crops (Figure 13). Overall, permanent crops are increasing significantly in the Sub-Basin and in nearly all cases are developed with highly efficient drip and/or micro spray irrigation systems.

This corresponding increase in highly efficient irrigation systems on permanent crops (e.g. grapes) is somewhat similar in other counties (Figure 14), however not to the degree as it has developed in Kern County. This is likely due to the scarcity and expense of water as well as a more dynamic and recent change to permanent crops in Kern County.



Source: Kern County Agricultural Commissioner Crop Reports – Does not include fallow land,1st leaf orchards and is Kern County only

Figure 12. Kern Sub-Basin harvested crop groupings.

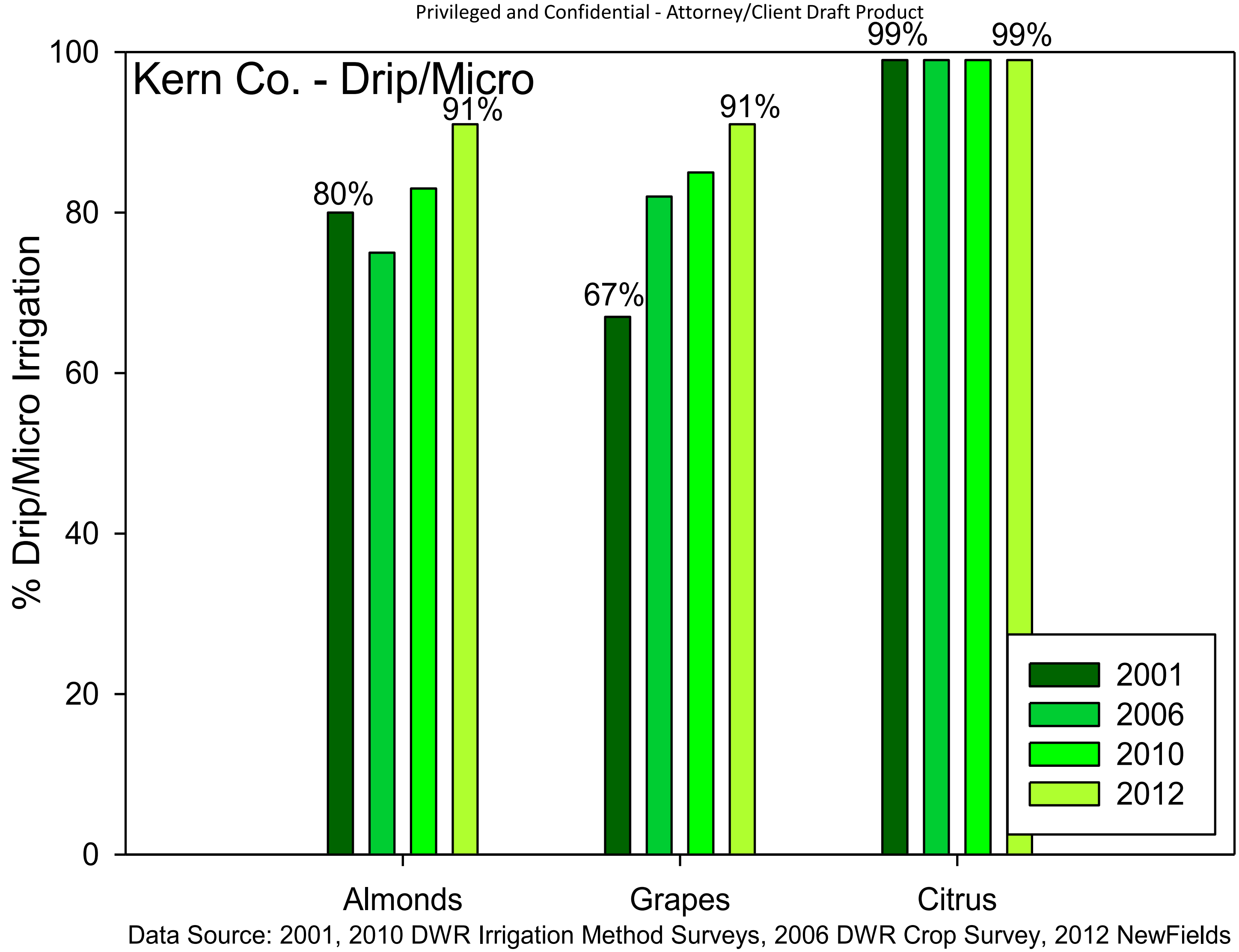


Figure 13. Increase in drip/micro irrigation systems on various permanent crops in Kern

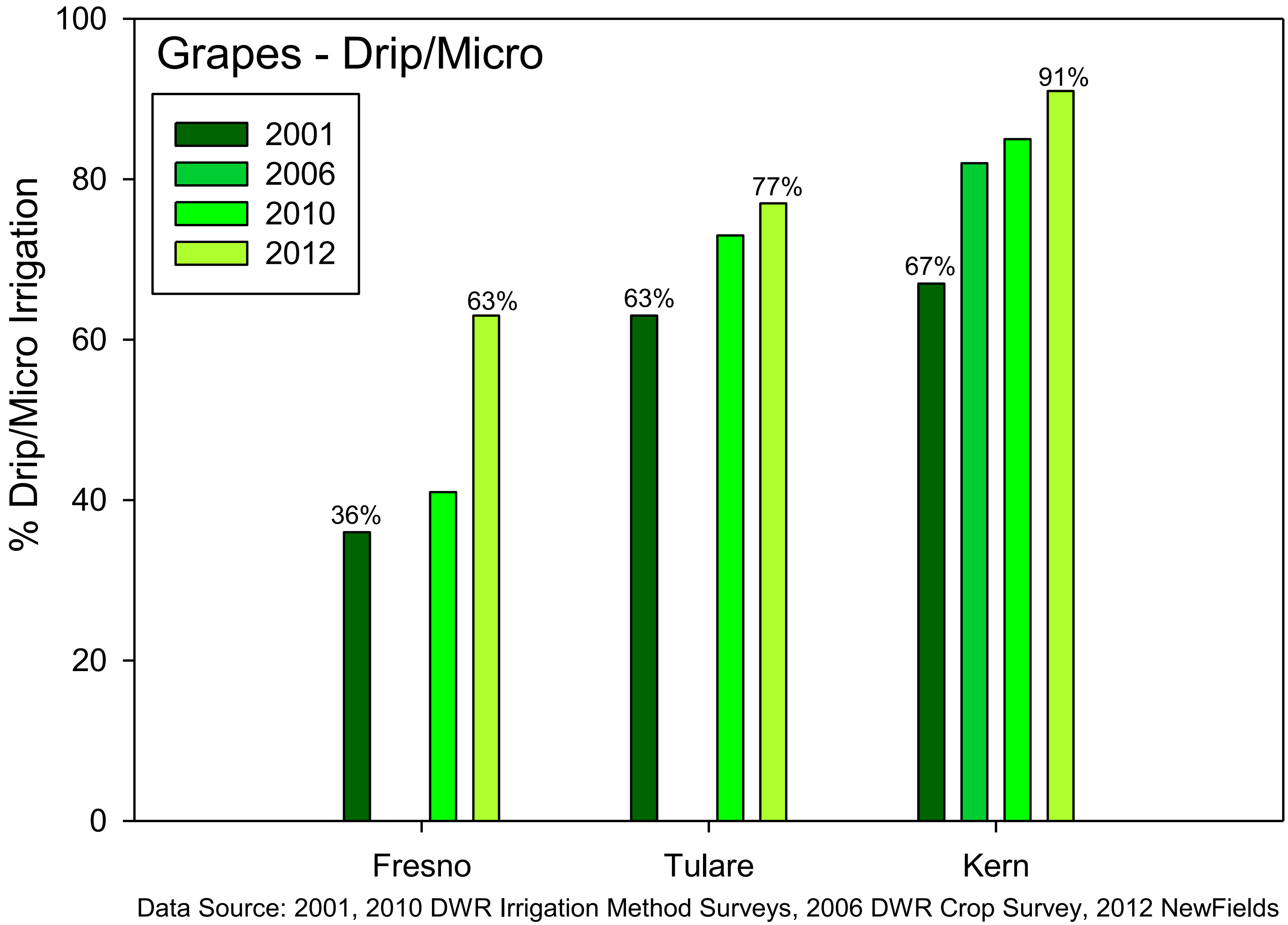


Figure 14. Example (in grapes) of shift to higher efficiency irrigation systems in Fresno, Tulare and Kern Counties County.

General Concepts of Nitrogen Fertilizer Recovery and Losses

Introduction

It is imperative to note that estimating nitrate leaching, even under specified conditions, is a highly complex task. Therefore, the results of any N leaching estimating method should be interpreted as precisely that – estimates only – and are subject to modification with new information.

The significance of the nitrate leaching estimates for diverse cropping scenarios is simply that they are different; crop, irrigation method and soil factors in combination with one another result in a wide range of nitrate leaching estimates. This finding is substantiated by numerous authors whose work contributes to the scientific literature on N dynamics in cropping scenarios (Viers, 2012), and implies that nitrate leaching from various cropping systems cannot be considered or treated as similar systems.

The most significant effort to date focused on assessing nitrate contamination in groundwater from agricultural sources in California resulted in the UC Nitrate Hazard Index (NHI). This effort intentionally avoided any attempt to place absolute values on total amounts of nitrate leached, for the reasons stated above (Wu et al., 2005). This work was developed and reviewed by experts in this multi-disciplinary subject, and should serve as an indication of the caution with which estimates of nitrate leaching must be interpreted. This approach was subsequently modified and used to identify agricultural areas in the Tulare Lake Basin and Salinas Valley that are vulnerable to nitrate contamination in groundwater (Dzurella et al., 2012).

A general description of nitrogen fertilizer recovery and losses from the literature and applied to the Kern Sub-Basin is provided (Appendix A) as background. The appendix was developed from reviewing scientific literature from peer-reviewed journals, extension publications, personal communications and privately-developed publications. No simulation models or statistical methods were used. The purpose of this information is to show the variability in the literature and impactful parameters that can significantly influence potential nitrate leaching.

Root Zone Soil Moisture Balance (SMB) Approach

Introduction and Purpose

Soil moisture conditions and nitrate leaching in agricultural systems can vary significantly throughout a year and are impacted primarily by irrigation practices and not necessarily rainfall in the Kern Sub-Basin area. This is because effective rainfall (1-3 inches) in this area is essentially insignificant as compared to the magnitude of irrigation water applied to meet crop and environmental demands (28-60 inches - depending on crop type, soil conditions and management practices).

A root zone soil moisture balance (SMB) calculator was used to model and predict potential leaching of available nitrate below the root zone. This was assumed to be nitrate that ultimately would be transported to the first encountered groundwater. It was assumed that any nitrate leached below the specified root zone of the crop was not recoverable by the crop and therefore transportable to groundwater.

The advantages of using a SMB approach include:

- a field- or smaller region-specific tool, commonly used to quantify hydraulic leaching below the root zone
- defensible and quantifiable results that can be used as input parameters for groundwater modeling purposes
- inclusion of various input parameters designed to optimize the results for a specific field, scenario, or a smaller area

The disadvantages of using the SMB approach for the Kern Sub-Basin include:

- relatively inaccurate representation of larger areas, thus why only representative scenarios can be developed
- difficultly in spatial application
- unwieldy number of iterations/options due to numerous and detailed input parameters
- complicated numerical applications and summary of results
- variable results over larger areas of land

The purpose of this effort was predominantly for:

- Development of representative scenarios (return flows) as input parameters for modeling work conducted by Rob Gailey/SGI Consultants.
- A better understanding of the unique nature of agricultural practices in the Kern Sub-Basin.
- A better understanding of the diversity of potential results for Basin-wide agricultural practices.

Approach

Twenty one scenarios were developed that represented major cropping systems across all six regions within the Kern sub basin. Ground truthing efforts were conducted throughout this area that documented irrigation practices on approximately 20% of all irrigated fields. This information was obtained spatially and overlain on the regional areas. When an irrigation practice on a certain crop type was documented greater than 90% of the time, that irrigation method was assigned to that crop type within a specified region. Where irrigation methods varied within crop type, a mix of methods was assumed. This resulted in correspondingly lower irrigation application efficiencies as well. Otherwise irrigation application efficiencies were used based on various sources including local knowledge (Sanden, personal communication, 2012) (Paramount Farms, 2012) and irrigation district reporting (Arvin Edison Water Use Report, 2012)

Representative scenarios were developed for common crop systems and soil types and represent the majority of cropping systems in the Kern Sub-Basin. For example, much of the Clay Rim area is cropped with cotton and to a much lesser relative extent, almonds. Therefore a "cotton on fine textured soils" scenario was developed for this area as was an "almond on medium textured soils" for other areas. A variety of other representative scenarios including other SMB inputs are summarized (Table 2). These scenarios were developed in conjunction with Blake Sanden, UC Cooperative Extension, Kern County and deemed as representative for the area.

It should be noted that certain set assumptions were developed for the 21 scenarios developed and modeled. Due to the variation in cropping systems, soil types, irrigation practice and management, rooting depths, etc., results for total return flow and to a lesser extent total applied water, should be considered as estimates only and specifically for the input parameters of each scenario only. It is entirely possible to find a combination of input parameters somewhere over the nearly 1,000,000 acres of irrigated land in the Kern Sub-Basin that result in less or more return flows or applied water. Again, this work was performed for the purpose of providing reasonable estimates as input parameters for the groundwater modeling work that are representative of the present-day Kern Sub-Basin, based on the best available data.

Results and Conclusions

In general, results indicate that perennial crops on high efficiency irrigation systems (common to the Kern Sub-Basin), result in limited return flows to groundwater. The largest return flows occur under corn/wheat, sudan/wheat or alfalfa crop rotations that are commonly associated with feeding operations for dairies. The majority of these systems are regulated under the dairy order. Other row crops such as cotton/wheat and carrot/potato rotations result in moderate return flow estimates mostly because of the types of irrigation methods and management employed.

Table 2. Scenario summary for common crop types, regions, soil types and irrigation methods. Summary table also includes assumed irrigation efficiencies, effective rooting depths and resultant return flows and applied water.

Scenario	Region	Crop	Soil	Irrigation Method	Irrigation Efficiency	Rooting Depth (Effective)	Total Return Flow	Total Applied Water
					(%)	(ft)	(in)	(in)
1	Foothills	Citrus	Medium	Drip/Micro	95%	4	2.3	45.6
2	Foothills	Grape	Medium	Drip/Micro	95%	4	1.9	31.9
3	Kern Fan	Alfalfa	Coarse	Border	85%	6	9.8	61.7
4	Kern Fan	Corn/Wheat	Coarse	Furrow/Border	75%	3	14.8	57.7
5	Kern Fan	Cotton	Coarse	Furrow/Border	80%	3	10.2	40.0
6	Northern	Almonds	Coarse	Drip/Micro (90%) & Flood (10%)	90%	7	5.0	46.2
7	Northern	Grape	Coarse	Drip/Micro (75%) & Flood (25%)	80%	5	7.9	38.1
8	Westside	Almonds	Medium	Drip/Micro	95%	6	2.4	46.6
9	Westside	Pistachio	Medium	Drip/Micro	95%	6	2.7	45.8
10	Westside	Pistachio	Coarse	Drip/Micro	90%	7	5.3	48.3
11	Wheeler Ridge/A-E	Grape	Medium	Drip/Micro	95%	4	2.0	34.1
12	Wheeler Ridge/A-E	Citrus	Medium	Drip/Micro	95%	4	2.9	48.3
13	Wheeler Ridge/A-E	Grape	Coarse	Drip/Micro	90%	5	3.9	36.0
14	Wheeler Ridge/A-E	Carrots/Potato	Coarse	Sprinkler	85%	2	8.2	51.7
15	Clay Rim	Cotton	Fine	Furrow	90%	3	5.2	34.4
16	Clay Rim	Cotton/Wheat	Fine	Furrow/Border	85%	3	8.7	55.2
17	Clay Rim	Alfalfa	Fine	Border	85%	5	9.6	60.3
18	Foothills	Pistachio	Medium	Drip/Micro	95%	6	2.8	42.1
19	Northern	Alfalfa	Medium	Border	85%	6	8.6	60.4
20	Westside	Almonds	Coarse	Drip/Micro	95%	7	2.8	46.6
21	Clay Rim	Pistachio	Fine	Drip/Micro	95%	5	2.6	41.2

Note: Irrigation efficiencies and rooting depths reviewed by Blake Sanden, UCCE Cooperative Extension, Kern County. Other input provided by Boswell and Paramount Farms, etc.

Nitrate Hazard Index (NHI) Approach

Introduction and Purpose

An NHI was developed by UC Davis and other researchers as a qualitative method to assess the potential for nitrate leaching to groundwater based on at least three initial variables (e.g. crop type, soil type and irrigation method). The NHI was developed for the southern San Joaquin Valley and the Salinas Valley.

The advantages of using a NHI approach include:

- Offers the ability to span and create a relative assessment over large areas of land with a spatial resource
- Easily shows change over time as a result in crop or irrigation method changes
- Easily modified, flexible, and understandable
- Based on a field by field assessment, therefore can be aggregated to a larger area
- Results in strategic and justified locations for monitoring and therefore cost savings
- Approved as an acceptable method for quantifying the potential for nitrate leaching by the State Water Resources Control Board

The potential disadvantages of using the NHI approach include:

- A qualitative assessment, however is based on quantitative/proven research and local knowledge
- Requires some grouping of input data (e.g. soil type) at times depending on the size of the area and data resources available
- Requires up-to-date crop mapping (readily available for Kern County on an annual basis, however less frequently available elsewhere)

An excellent discussion of the justification, use, strengths, limitations and results of the NHI for the Southern San Joaquin Valley (including the Kern Sub-Basin) can be found at the following reference below. The reader is particularly encouraged to review section 2.2.3 (pages 12-17) – Leaching Vulnerability Assessment.

http://groundwaternitrate.ucdavis.edu/files/139103.pdf

or at:

Dzurella, K.N., Medellin-Azuara, J., Jensen, V.B., King, A.M., De La Mora, N., Fryjoff-Hung, A., Rosenstock, T.S., Harter, T., Howitt, R., Hollander, A.D., Darby, J., Jessoe, K., Lund, J.R., & Pettygrove, G.S. 2012. Nitrogen Source Reduction to Protect Groundwater Quality. Technical Report 3 in: Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis.

The purpose of this effort was predominantly to develop a preliminary Kern Sub-Basin specific NHI that would demonstrate the changes over approximately 20 years as well as show the flexibility by addition of Nitrogen Use Efficiency (NUE) estimates.

Approach

The approach for the NHI assessment for the Kern Sub-Basin was similar to that performed by researchers at UC Davis (Dzurella, et al., 2012). The approach was modified for the unique attributes of the Kern Sub-Basin area. One of the major differences is that previous researchers used DWR crop mapping from 2006, while 2011 crop mapping from Kern County was used for our analysis. Also, irrigation practices specific to the Kern Sub-Basin were considered for this analysis including representative distribution of current irrigation methods.

An NHI was developed based on DWR crop mapping and associated irrigation practice for 1990 and Kern County crop mapping for 2011. Soil type remained constant for all analyses.

An additional NHI was developed for 2011 results only and attempted to incorporate three very broad NUE estimates of 25%, 50% and 75%. The purpose in conducting this analysis was to show the flexibility and additionality of the NHI approach, however is not intended to represent actual field conditions.

Results and Conclusions

A comparison of 1990 and 2012 NHI results (Figures 15 and 16) specifically for the Kern Sub-Basin indicate significant reduction in nitrate risk to groundwater. It is intuitive that this reduction has developed from the conversion of annual field and row crops (irrigated with less efficient surface methods) to permanent tree and vine crops (predominantly (>90%) irrigated with drip and micro-irrigation systems).

The results of this analysis also allow for field-specific location of areas where best use of monitoring and management practices can have the most impactful result. The "high vulnerability" areas can be shown at the field level, rather than at a regional level and better represent existing conditions. Identification of specific circumstances that warrant more than just a "high" and "low" vulnerability designation are possible using a modified NHI approach.

A second NHI analysis was conducted to show the flexibility and additionality of the NHI, by incorporating three sub basin-wide NUE estimates of 25, 50 and 75 percent (Figures 17, 18, and 19). Although this is neither realistic nor appropriate in this area due to the variation in crop type and management practices, it does provide an excellent demonstration of incorporation of additional variables to further refine the power of the NHI analysis. As would be expected, NHI is reduced with increasing NUE. The key result of this additional variable, however, is that results can be shown annually on a field by field basis.

Although we have not conducted specific analyses for areas beyond the Kern Sub-Basin related to this work, based on the information presented (Pettygrove, 2012), it is clear that the nitrate risk to groundwater is significantly less and, in many areas negligible for the Kern Sub-Basin as compared to other areas to the north.

It should be noted that additional variables can likely be included in a modified NHI calculation, thus strengthening its predictive capabilities. Some of these additional variables may include, but are not limited to:

- Nitrogen use efficiency
- Effective precipitation
- Depth to groundwater
- Variations in stratigraphy and soil type
- Specific best management practices

Overall the NHI approach is a powerful, flexible, and defensible tool that can be used for assessing large landscapes over time and documenting relative nitrate leaching hazards. It is preferable to the approach proposed in the Tentative Order because it specifically considers that contaminant of concern (N), and does not use other contaminants (pesticides) as an unsuitable proxy for N movement, and accounts for agricultural management, which is not a factor in the vulnerability assessment provided in the Tentative Order.

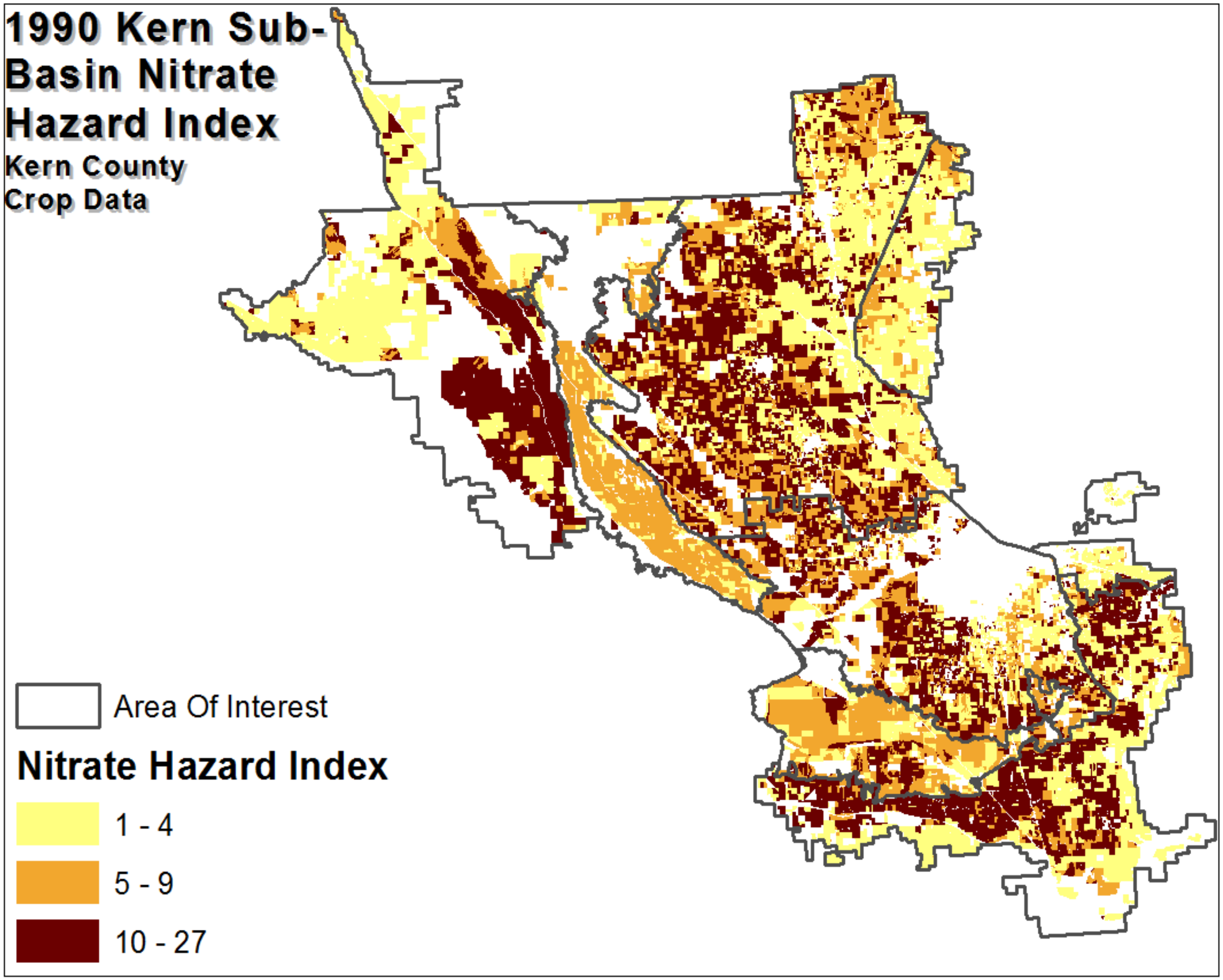


Figure 15. Kern Sub-Basin preliminary Nitrate Hazard Index – 1990

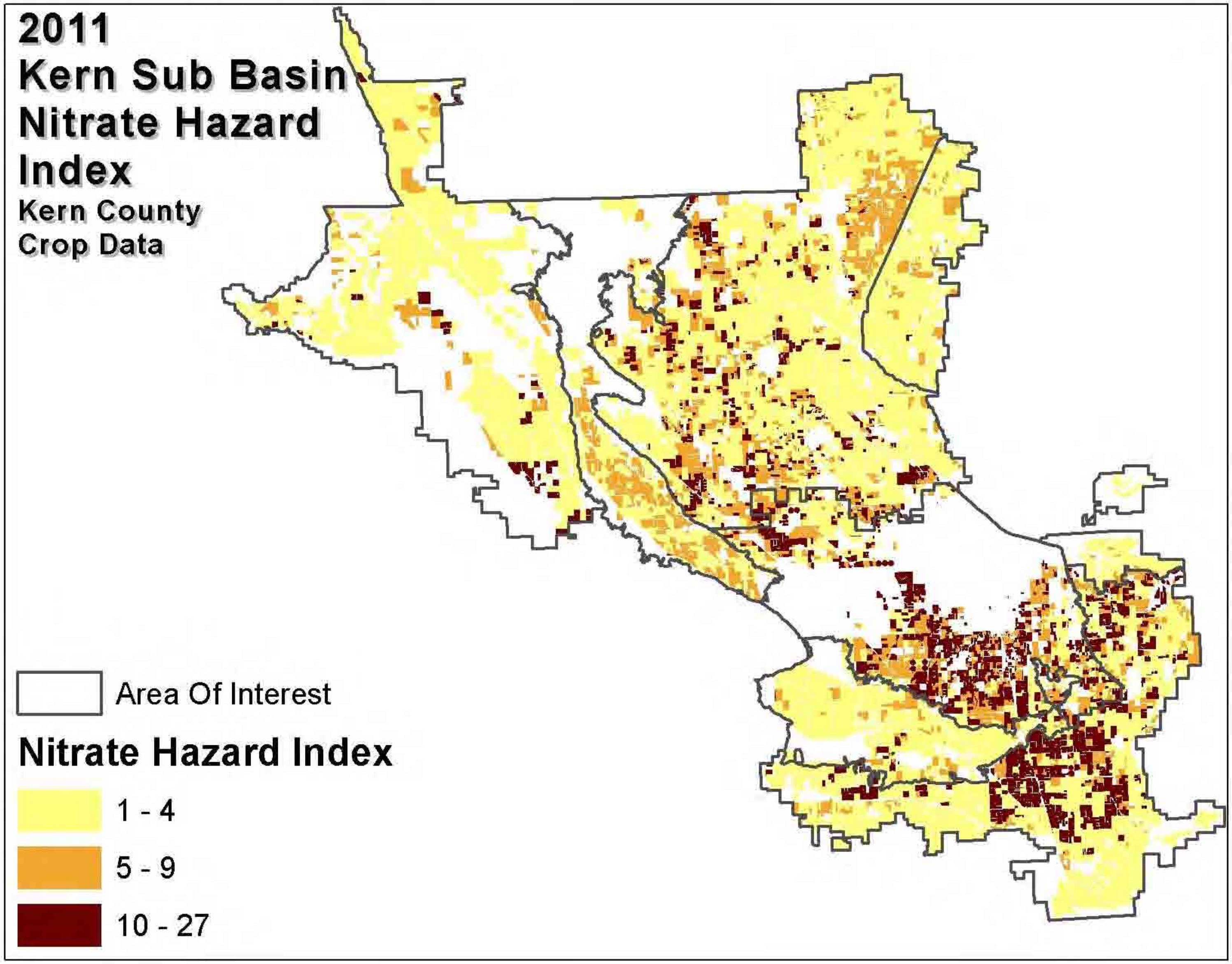


Figure 16. Kern Sub-Basin preliminary Nitrate Hazard Index - 2011

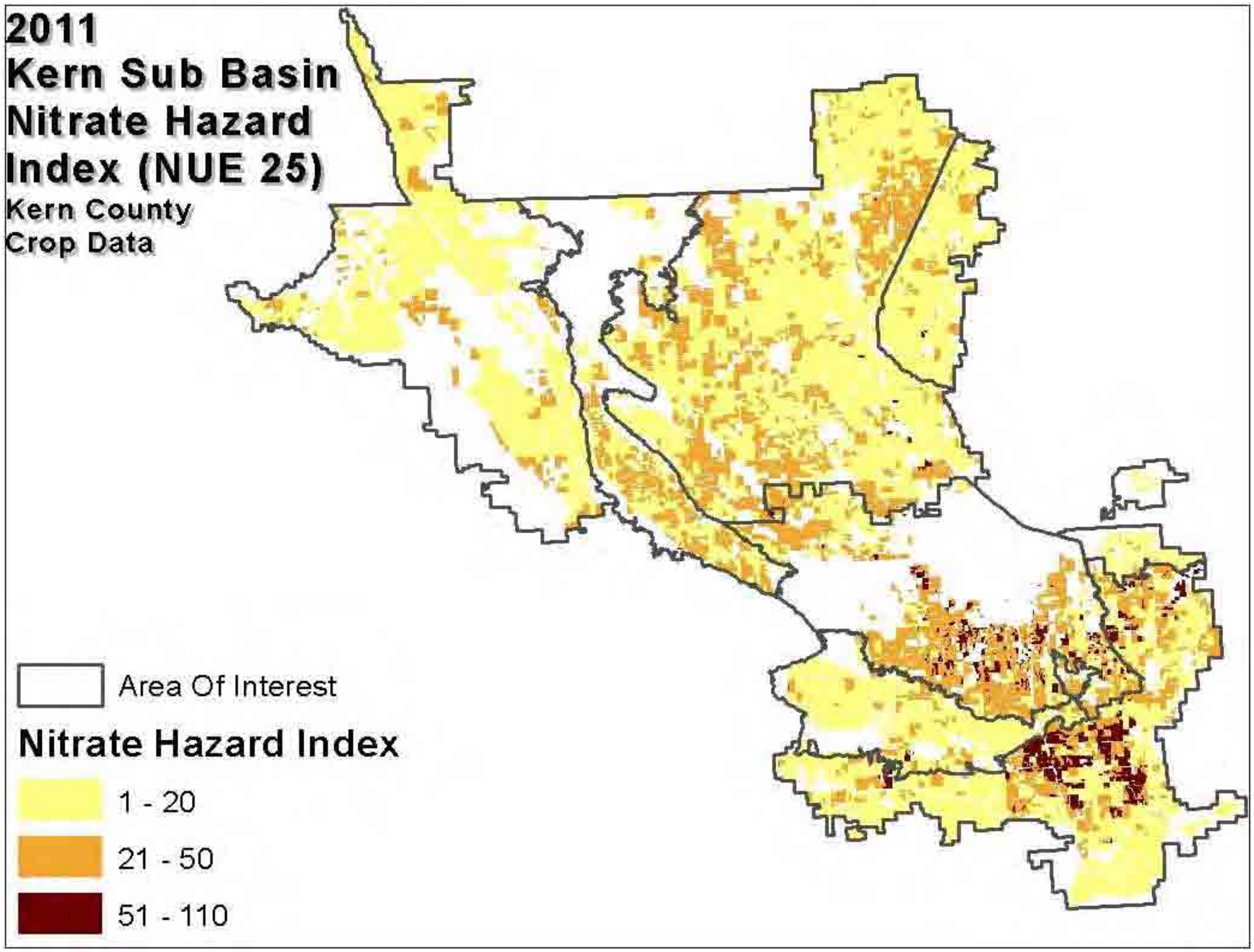


Figure 17. Kern Sub-Basin preliminary Nitrate Hazard Index, including 25% NUE estimate – 2011

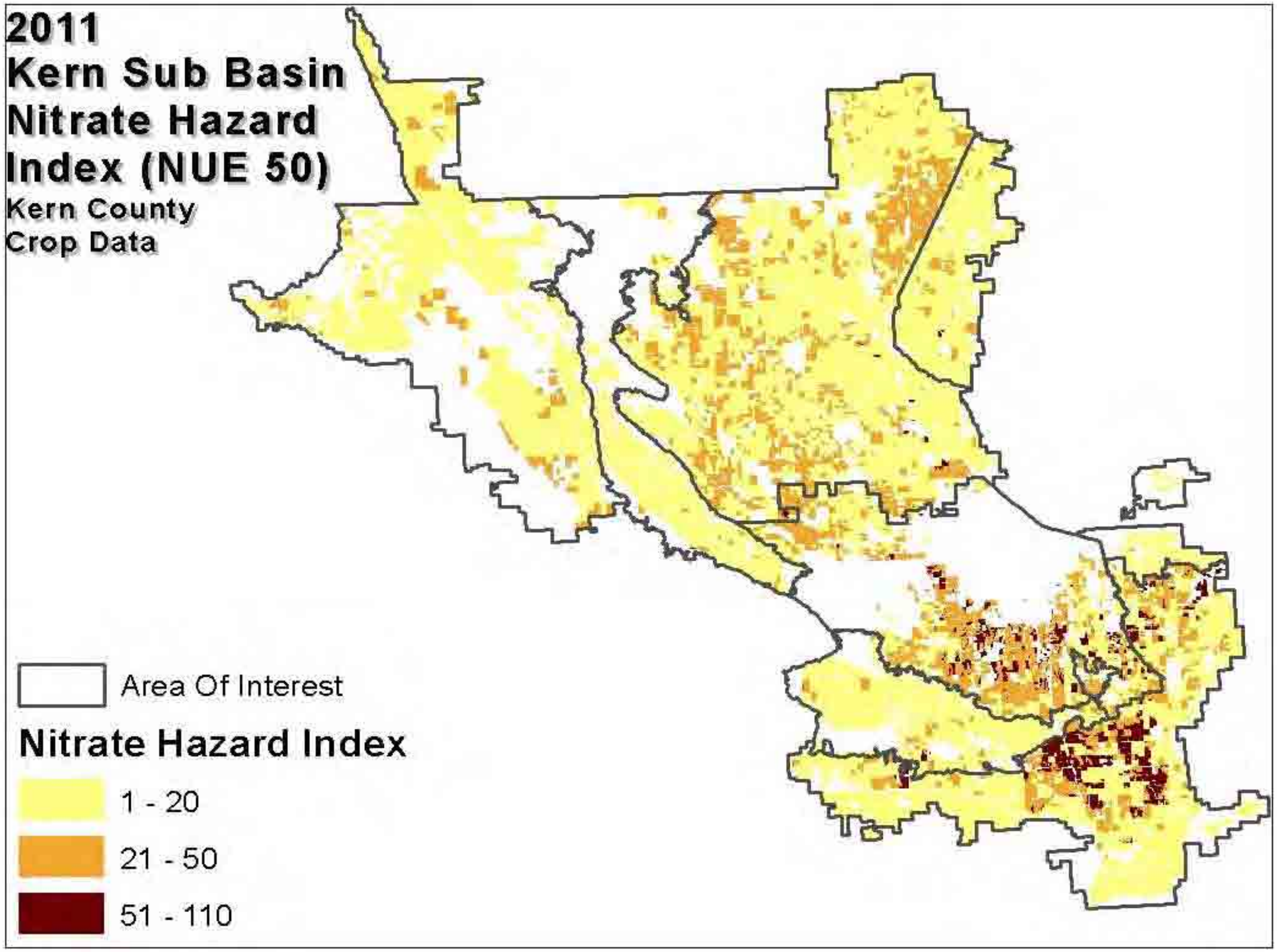


Figure 18. Kern Sub-Basin preliminary Nitrate Hazard Index, including 50% NUE estimate - 2011

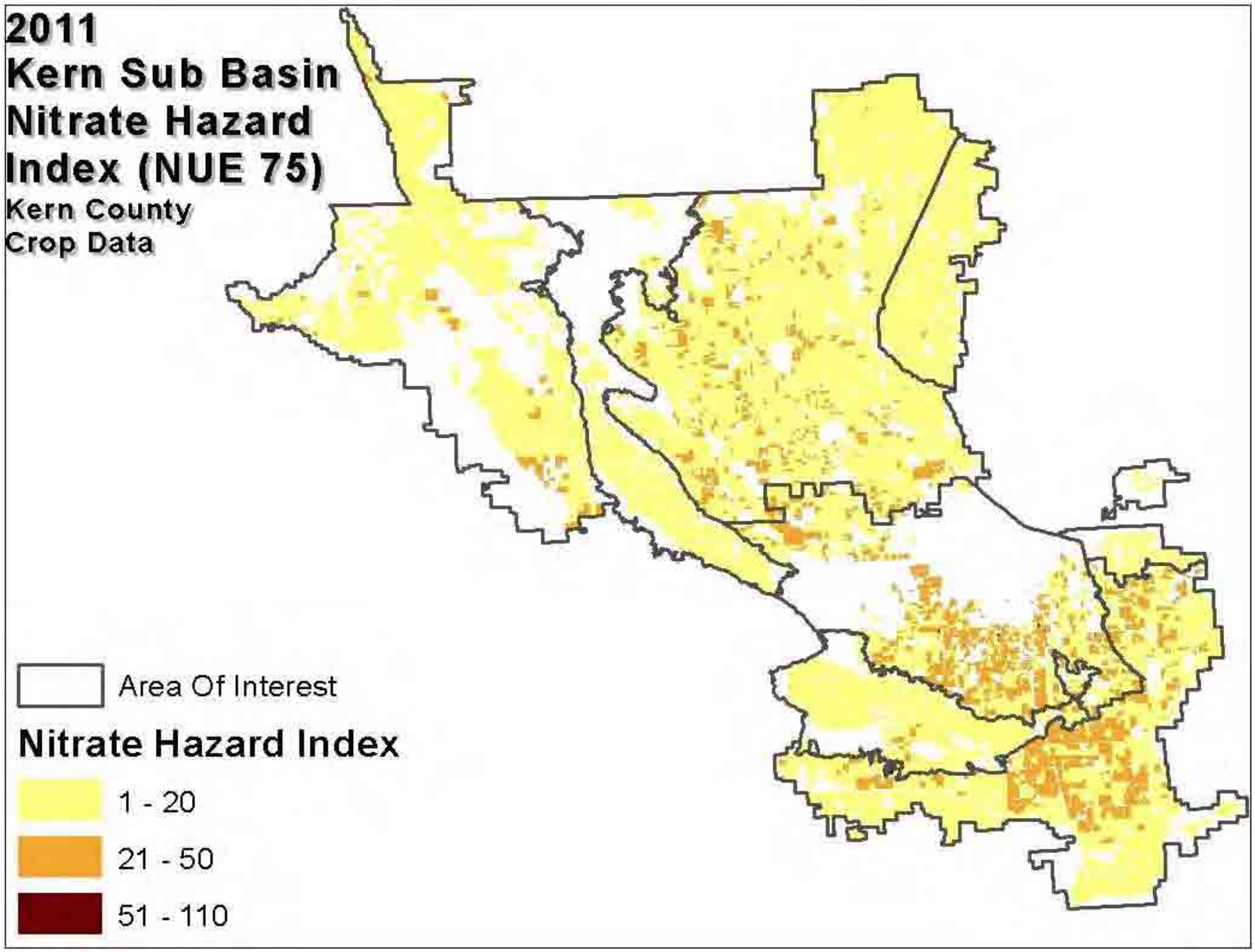


Figure 19. Kern Sub-Basin preliminary Nitrate Hazard Index, including 75% NUE estimate - 2011

References

Al-Jamal, M.S., T.W. Sammis, and S.T. Ball. A case study for adopting the nitrate chloride technique to improve irrigation and nitrogen practices in farmers' fields. Applied Engineering in Agriculture 17(5): 601-610.

Al-Jamal, M.S., T.W. Sammis, and T. Jones. 1997. Nitrogen and chloride concentration in deep soil cores related to fertilization. Agricultural Water Management 34: 1-16.

Allaire-Leung, S.E., L. Wu, J.P. Mitchell, B.L. Sanden. 2001. Nitrate leaching and soil nitrate content as affected by irrigation uniformity in a carrot field.

Arpaia, M.L. and L.J. Lund. 2003. Nitrogen management in citurs under low volume irrigation. Annual Report.

Balasubramanian V, Alves B, Aulakh M, Bekunda M, Cai Z, Drinkwater L, Mugendi D, van Kessel C, Oenema O, (2004) Crop, environmental and management factors affecting nitrogen use efficiency. In: Mosier AR, Syers JK, Freney JR (eds) Agriculture and the nitrogen cycle. The Scientific Committee on Problems of the Environment (SCOPE). Island Press, Covelo, California, USA, pp 19–34.

Bhargava, B.S. Potassium Nutrition of Grapes. http://www.ipipotash.org/udocs/Potassium%20Nutrition%20of%20Grapes.pdf. Accessed November 14, 2012.

Boaretto, R.M., D. Mattos Jr., J.A. Quaggio, H. Cantarella, and P. C.O. Trivelin. 2010. Nitorgen-15 uptake and distribution in two citrus species. 19th World Congress of Soil Science solutions for a changing World. Brisbane, Australia.

Bronson, K.F. 2008. Nitrogen Use Efficiency of Cotton Varies with Irrigation System. Better Crops 92(2008, No. 4).

Bronson, K.F., A Malapati, J.D. Booker, B.R. Scanlon, W.H. Hudnall and A.M. Schubert. 2009. Residual soil nitrate in irrigated Southern High Plains cotton fields and Ogallala groundwater nitrate. Journal of Soil and Water Conservation. 64(2):98-104.

Brown, P. 2011. Development of a Nutrient Budget Approach to Fertilizer Management in Almond. In 19th Annual Fertilizer Research and Education Program Conference Proceedings November 16-17. Tulare, California. Ed. E.A. Lewis. California Department of Food and Agriculture.

Cassman KG, Dobermann A, Walters DT (2002) Agroecosystems, nitrogen use efficiency, and nitrogen management. Ambio 31:132–140.

Chang, A., T. Harter, J. Letey, D. Meyer, R. Meyer, M. Campbell Mathews, F. Mitloehner, S. Pettigrove, P. Robinson, R. Zhang. 2005. Managing Dairy Manure in the Central Valley of California. University of California Division of Agriculture and Natural Resources Committee of Experts on Dairy Manure Management.

Dzurella, K.N., Medellin-Azuara, J., Jensen, V.B., King, A.M., De La Mora, N., Fryjoff-Hung, A., Rosenstock, T.S., Harter, T., Howitt, R., Hollander, A.D., Darby, J., Jessoe, K., Lund, J.R., &

Pettygrove, G.S. 2012. Nitrogen Source Reduction to Protect Groundwater Quality. Technical Report 3 in: Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis.

Embleton, T.W., C. O. Pallares, W.W. Jones, L.L. Summers and M. Matsumara. 1980. Nitrogen fertilizer management of vigorous lemons and nitrate pollution potential of groundwater. University of California Water Resource Center. Contribution 182.

Evaluation of soil and plant nitrogen tests for maize on manured soils of the Atlantic coastal plain. Agron. J. 87:213-222.

Follett (ed.) Nitrogen Management and Ground Water Protection. Elsevier Science.

Fritschi, F.B. B.A. Roberts, D. William Rains, R.L. Travis and R.B. Hutmacher. 2004. Fate of nitrogen-15 applied to irrigated Acala and pima cotton. Agron. J. 96:646–655.

Hanson, E.J. and G.S> Howell. 1995. Nitrogen accumulation and fertilizer use efficiency by grapevines in short-season growing areas. HortScience 30:504-507

Harter, T. Y.S. Onsoy, K. Heeren, M. Denton, G. Weissman, J.W. Hopmans, and W.R. Horwath. 2005. Deep vadose zone hydrology demonstrates fate of nitrate in eastern San Joaquin Valley. California Agriculture 59(2): 124-132.

Harter, T. and J.R. Lund. 2012. Addressing Nitrate in California's Drinking Water With a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of Davis, California.

Hermanson, R., W. Pan, C. Perillo, R. Stevens, C. Stockle. Undated. Nitrogen Use by Crops and the Fate of Nitrogen in the Soil and Vadose Zone. Washington State University and Washington State Department of Ecology Interagency Agreement No. C9600177. Publication No. 00-10-015

Holtz, B. Nitrogen efficiency in almond production. UDDE Field Notes May 2012. University of California Agriculture and Natural Resources.

Hutmacher, R.B., R.L. Travis, D.W. Rains, M.P. Keeley, and R. Delgado. 2005. Residual Soil Nitrogen and Nitrogen Management for Acala Cotton Summary Report. California Department of Food and Agriculture – Fertilizer Research and Education Program. http://www.cdfa.ca.gov/is/docs/00-0604Hutchmacher%2005.PDF. Accessed February 5, 2013.

Hutmacher, R.B., R.L. Travis, D.W. Rains, R.N. Vargas, B.A. Roberts, B.L. Weir, S.D. Wright, D.S. Munk, B.H. Marsh, M.P. Keeley, F.B. Frischi, D.J. Munier, R.L. Nichols, and R. Delgado. 2004. Response of recent acala cotton varieties to variable nitrogen rates in the San Joaquin Valley of California.

J. M. Powell,* W. E. Jokela, and T. H. Misselbrook. 2011. Dairy Slurry Application Method Impacts Ammonia Emission and Nitrate Leaching in No-Till Corn Silage. J. Environ. Qual. 40:383-392.

Jayasundara, S. C. Wagner-Riddle, G. Parkin, P. von Bertoldi, J. Warland, B. Kay and P. Voroney. 2007. Minimizing nitrogen losses from a corn-soybean-winter-wheat rotation with best management practices. Nutr Cycl Agroecosyst 79:141-159.

Jemison, John M. Jr., and Richard H. Fox. 1994. Nitrate leaching from nitrogen-fertilized and manured corn measured with zero-tension pan lysimeters. J. Environ. Qual. 23:337-343.

Krupnik TJ, Six J, Ladha JK, Paine MJ, van Kessel C (2004). An assessment of fertilizer nitrogen recovery by grain crops. In: Mosier AR, Syers JK, Freney JR (eds) Agriculture and the nitrogen cycle. The Scientific Committee on Problems of the Environment (SCOPE). Island Press, Covelo, California, USA, pp 193–207.

Lea-Cox, J.D. and J.P. Syvertsen. 1996. How nitrogen supply affects growth and nitrogen uptake, use efficiency, and loss from citrus seedlings. J. Amer. Soc. Hort. Sci. 121(1): 105-114.

Martínez-Alcántara, B., A. Quiñones, F. Legaz, E. Primo-Millo. 2012. Nitrogen-use efficiency of young citrus trees as influenced by the timing of fertilizer application. Journal of Plant Nutrition and Soil Science. 175:282-292.

Meyer, R.D. 1992. Potential nitrate movement below the root zone in drop irrigated almonds. FREP Contract #92-0631.

Meyer, R.D. 2008. Fertilizer Application Management. Pistachio Short Course presentation.

Morgan, K.T. and E.A. Hanlon. 2006. Improving citrus nitrogen uptake efficiency: understanding citrus nitrogen requirements. University of Florida Extension Publication SL-240.

Navarro J.C., J.C. Silvertooth, A. Galadina. 1997. Fertilizer nitrogen recovery in irrigated upland cotton. In Proc. Beltwide Cotton Conf., New Orleans, LA, 6–10 Jan. 1997. Natl. Cotton Counc., Memphis, pp 581–583.

Nitrate Groundwater Pollution Hazard Index Information. 2012. University of California. Regents of the University of California, Division of Agriculture and Natural Resources. http://ucanr.edu/sites/wrc/Programs/Water_Quality/Nitrate_Groundwater_Pollution_Hazard_Index/.

Peacock, B., P. Christensen, D. Hirschfelt. Undated. Best Management Practices for Nitrogen Fertilization of Grapevines. University of California Tulare County Cooperative Extension, Tulare County. Publication NG4-96.

Peacock, W.L., L.P. Christensen, and F.E. Broadbent. 1989. Uptake, storage and utilization of soil-applied nitrogen by Thompson Seedless as affected by time of application. Am J. Enol. Vitic. 40:16-20.

Rains, W. and R.L. Travis. Undated. Nitrogen budget in California cropping systems. FREP Contract #97-0365 M97-09.

Rotz, C.A. 2004. Management to reduce nitrogen …

Saman, Z., T. Sammis, R. Skaggs, N. Alkhatin and J. Deras. 2005. Measuring on-farm irrigation efficiency with chloride tracing under deficit irrigation. Journal of Irrigation and Drainage Engineering 131(6): 555-559.

Saint-Fort, R., J.S. Schepers, and R.F Spaulding. 1991. Potentially mineralizable nitrogen and nitrate leaching under different land-use conditions in western Nebraska. J. Environ. Sci. Health. A26(3), 335-345.

Sanden, B. 2012. Using soil chloride concentrations to identify the bottom of the root zone and estimate effective leaching fraction and nitrate leaching below the root zone: An example in Kern County almonds. Unpublished.

Sanden, B., B. Hockett and R. Enzweiler. 2003. Soil moisture sensors and grower "sense" Abilities: 3 years of irrigation scheduling demonstrations in Kern County. The Irrigation Association 2003 Conference Proceedings.

Scheppers, J.S., and R.H. Fox. 1989. Estimation of N Budgets for Crops. p. 221-246. In: R.F. Silvertooth, J.C., K.F. Bronson, E. R. Norton, and R. Mikkelson. 2011. Nitrogen Utilization by Western U.S. Cotton. Better Crops 95(2011, No. 2): 21-23.

Silvertooth, J.C., E.R. Navarro, E.R. Norton, and A. Galadina. 2001. Soil and plant recovery of labeled fertilizer nitrogen in irrigated cotton. Arizona Cotton Report. http://ag.arizona.edu/pubs/crops/az1224/. Accessed November 14, 2012.

Silvertooth, J.C., A. Galadina and E.R. Norton. 2006. Residual soil nitrogen evaluations in irrigated desert soils, 2005. Arizona Cotton Report (P-145) July 2006.

Sims, J. Thomas, Bruce L. Vasilas, Karen L. Gartley, Bill Milliken, and V. Green. 1995.

Syvertsen, J.P. 1996. Nitrogen uptake efficiency and leaching losses from lysimeter-grown citrus trees fertilizer at three nitrogen rates. J. Amer. Soc. Hort. Sci. 121(1): 57-62.

Viers, J.H., Liptzin, D., Rosenstock, T.S., Jensen, V.B., Hollander, A.D., McNally, A., King, A.M., Kourakos, G., Lopez, E.M., De LaMora, N., Fryjoff-Hung, A., Dzurella, K.N., Canada, H.E., Laybourne, S., McKenney, C., Darby, J., Quinn, J.F. & Harter, T. (2012) Nitrogen Sources and Loading to Groundwater. Technical Report 2 in: Addressing Nitrate in California's Drinking Water with a

Focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis.

Weinbaum. S.A. and D.A. Goldhamer. 1991. Nitrogen fertilizer management to reduce groundwater degradation.

Williams, L.E. Growth of "Thompson Seedless" grapevines: II. Nitrogen distribution. J. Amer. Soc. Hort. Sci. 112:330-333.

Wu, L., Letey, J., French, C., Wood, Y. & Birkle, D. (2005) Nitrate leaching hazard index developed for irrigated agriculture. Journal of soil and water conservation, 60, 90–95.

Zasoski, R.J. 1994. Nitrogen efficiency in drip irrigated almonds.

Appendix A. General Concepts of Nitrogen Recovery and Losses

Introduction

No biological system is 100% efficient. A general rule of thumb is that N fertilizer uptake efficiency is 50 percent, on average, for agricultural crops (Meyer, 2008). However, typical fertilizer N uptake efficiencies of major agronomic crops range from less than 30 to greater than 70% because of several factors. First, it is not possible for a plant to deplete the entire inorganic N from the soil solution. As the nitrate and ammonium concentrations decrease in solution, the rate of N uptake also decreases, in a relationship similar to substrate-enzyme reactions (Jackson et al., 1986).

Minimal N concentrations in the soil are required to drive the N influx into crop roots. In addition, some N losses (volatilization or leaching) from the root zone are inevitable during the season. As a result, not all of the N supplied will be available for plant uptake. Finally, and perhaps most importantly that to achieve maximum or near maximum yields, N must be supplied at high levels. According to Mitscherlich's Law, as N supply increases, there is a decrease in the incremental yield increase per unit of N input. As a result, N use efficiency invariably decreases at high levels of N input that are required to achieve maximum yield. On the other hand, if minimal N is supplied so that the soil N is depleted to near zero to minimize nitrate leaching potential, there is an insufficient concentration of soil N to drive maximal rates of N uptake, and crop yield will be limited. For this reason, the presence of residual soil N at the end of a growing season is inevitable in intensively managed cropping systems that are achieving near maximum or maximum economic yields (Hermanson, et al., (undated)).

Nitrogen Uptake and N Fertilizer Recovery

In general, the amount of N accumulated by a crop is affected by:

- the amount and location of N supplied by the soil or added as fertilizer
- the genetic potential of the species or cultivar to absorb N, which is influenced by genetic factors such as tolerance to biotic and abiotic stresses, rooting pattern and physiological N uptake efficiency
- the growth or yield potential under a set of environmental conditions and soil properties
- the ability to retain N in the root zone during the period of crop N uptake.

Nitrogen fertilizer recovery estimates for different fertilizer management and cropping systems are summarized in Table 1 and show varied and wide differences depending on crop type and timing of application.

Table 1. General guidelines for estimating N fertilizer recovery fraction when using N rates for maximum or near maximum yield [1] (Bock and Hergert, 1991).

Relative Efficiency of N-Application Timing	Perennial Grasses	Upland Cereal Grains	Shallow-rooted Crops	Flooded Crops
Low [2]	0.55	0.45	0.35	0.25
Medium [3]	0.70	0.60	0.50	0.40
High [4]	0.80	0.70	0.60	0.50

[1] N fertilizer recovery fraction values assume medium to high nitrate loss potential as determined by soil type and moisture regime and no or negligible NH3 volatilization losses.
[2] One N application (without nitrification inhibitor) well in advance of the growing season. When nitrate loss potential is low due to soil type or moisture regime, use nitrogen use efficiency values for medium to high efficiency of N application timing.
[3] One N application near beginning of growing season.
[4] Multiple N applications with first application near beginning of growing season; use of nitrification inhibitor may substitute for splitting N applications.

NITROGEN LOSSES

It should be clearly noted that N losses are extremely variable and are influence by a myriad of factors, some of which can be controlled or managed and some of which cannot. Estimating N use efficiencies (NUE) requires an understanding of field by field variables that impact N losses. Therefore, utilizing NUE across large landscapes to ultimately determine nitrate available for plant uptake or leaching is marginal at best. Rather, these approaches are more accurate at the field-scale level where a more detailed understanding of soil type, crop type, management practices, climatic conditions, soil chemistry, etc. can be determined.

The amount of N lost from an agricultural soil-plant system is also affected by many factors, all specific to different types of loss. These losses include volatilization, denitrification, and leaching.

Volatilization

Volatilization can occur whenever free ammonia is present near the surface of the soil. The ammonia concentrations in the soil solution will increase by applying ammonia-based fertilizers or decomposable organic materials to neutral or alkaline soils. The amounts of ammonia volatilized are small when N materials are incorporated into the soil, and ammonia losses are also low (≤15% of applied N) when ammonia-based fertilizers are applied in the surface of acidic or neutral soils.

Ammonia volatilization is a complex process involving chemical and biological reactions within the soil, and physical transport of N out of the soil. The method of N application, N source, soil pH, soil cation exchange capacity (CEC), and weather conditions influence ammonia emissions from applied N. Conditions favoring volatilization are surface applications, N sources containing urea, soil pH above 7, low CEC soils, and weather conditions favoring drying. Precise estimates of ammonia emissions are only possible with direct local measurements. Depending on application conditions, general ranges would be 2 to 50% emissions for soil pH > 7 and 0 to 25% emissions for soil pH < 7. If the N source is mixed into an acid soil, the emissions are usually greatly reduced (0 to 4% lost) (Meisinger and Randall, 1991).

Ammonia volatilization is a major pathway of N loss from livestock slurries following their application to land. Approximations of ammonia emissions from volatilized dairy manure are listed in Table 2 and shows the extreme variability as associated with ammonia volatilization under manure applied conditions. Research conducted on synthetic fertilizers show similar results.

Table 2. Approximate ammonia emissions of land-applied manure. These values are rough estimates of the percent of applied N lost; actual values depend on weather conditions after application, type of manure, ammonia content, etc. (Meisinger and Randall, 1991).

Manure Application Method	Type of Manure	Short-term Fate		Long-term Fate	
		N (%)			
		Lost	Retained	Lost	Retained
Broadcast, no incorporation	Solid	15-30	70-85	25-45	55-75
	Liquid	10-25	75-90	20-40	60-80
Broadcast, immediate incorporation	Solid	1-5	95-99	1-5	95-98
	Liquid	1-5	95-99	1-5	95-98
Knifed	Liquid	0-2	98-100	0-2	98-100
Sprinkler irrigated	Liquid	15-35	65-85	20-40	60-80

Denitrification

Compared to volatilization, denitrification emissions in agricultural systems are generally lower, however can be significant in some high water table/reduced soil environments. Emissions of N_2O were found to be lower than 5 to 7 % of the applied N, even at high application rates of 680 kg N/ha/year (Ryden and Lund, 1980). Similarly, Mosier et al. (1986) reported that, on well drained clay-loam soil sown with corn in 1982, 2.5% of the 200 kg N/ha applied as $(NH_4)2SO_4$ was lost as N_2O or N_2. The following year, only a loss of 1% could be measured from the same soil sown with barley. Denitrification estimates for soils with different organic matter contents and drainage classes are provided in Table 3. Clearly, poorly drained soils with high water tables and substantial organic matter can experience significant losses due to denitrification.

Again, it is imperative to understand each unique soil/crop/management system in order to somewhat reasonably estimate potential losses of N due to denitrification. The Kern Sub-Basin has a variety of soil types, management practices, and conditions that result in varied losses due to denitrification.

Table 3. Approximate denitrification estimates for various soils. (Meisinger and Randall, 1991).

Soil Organic Matter Content (%)	Soil Drainage Classification				
	Excessively well-drained	Well drained	Moderately well-drained	Somewhat poorly-drained	Poorly drained
	Inorganic Fertilizer N Denitrified (%)				
<2	2-5	3-9	4-14	6-20	10-30
2-5	3-9	4-16	6-20	10-25	15-45
>5	4-12	6-20	10-25	15-35	25-55

Note: Adjust as follows: for no-tillage use one class wetter drainage; for manure N double all values; for tile-drained soils use one class better drainage; for paddy culture use values under poorly drained; for irrigation or humid climates use value at upper end of range; for arid or semi-arid non-irrigated sites use values at lower end of range; for soils with compacted very slowly permeable layer below plow depth, but above 4-ft depth, use one class wetter drainage.

Leaching

The amount of nitrogen lost with percolating water through the root zone depends on the nitrate concentration in the soil profile. This nitrate concentration is strongly influenced by N application rates, methods and management. Cropping systems are a major factor in regulating nitrate movement below the root zone and toward the water table. Rooting depth, N placement, water requirement, climatic conditions, irrigation efficiency, water-use rate, N-uptake rate, and time of water and N uptake are all factors involved in nitrate leaching that can be affected by choice of cropping system. For nitrate leaching to occur, appreciable concentrations of nitrates must be present in the root zone at the time that water is percolating through that root zone. It is known from experiments with mineral N fertilizers that different cropping systems can influence the rate of leaching of N. Generally, the leaching of N is lower on grassland than on tillage land and is lower for plants with a longer vegetation period than those with a shorter vegetation period. This would also be consistent with the Kern Sub-Basin and the predominant population of permanent crops.

Altman et al. (1995) reported NO_3-N losses from crops amounting to 24 to 55% of the N applied at economic optimum rates (typically providing for near maximum crop yields). In Pennsylvania, the apparent recovery of N fertilizer (ammonium nitrate) applied at the economic optimum N rate in 42 experiments averaged 55% (Fix and Piekielek, 1983). Thus, even when using optimum fertilization rates, a potential exists for fertilizer N to accumulate in the soil with subsequent risk of loss through leaching. This risk is reduced in the Kern Sub-Basin due to the predominance of permanent crops, excessively low effective rainfall, and highly efficient irrigation and N uses.

Perhaps the greatest uncertainty when measuring or predicting deep water percolation and associated nitrate leaching in soil deals with the heterogeneous pore distribution in the root zone and below where microbial N cycling can greatly alter N availability for leaching. Large pores created by shrinking and swelling of clays, decomposition of roots, and faunal activity can accelerate water movement (two to five times higher for soils without obvious macropores, and as much as twenty times for soils with cracks). This increased water movement will have different effects on nitrate leaching depending on N concentration of those areas of the soil "bypassed" by infiltrating water, the rate of water application, the N concentration of infiltrating water, and other factors. The net result, however, is generally one of increased N amounts being transported beyond the reach of crop roots. Aschmann et al. (1992) detected flushes of nitrate and other ions and attributed them to preferential flow through the profile. The methods of highly efficient irrigation in the Kern Sub-Basin (e.g. drip/micro) coupled with deep-rooted permanent crops reduce this risk significantly.

Randall and Iragavarapu (1995) also showed that the amount of N leaching is highly related to the amount of percolating water. They conducted a study on a poorly drained clay loam in Minnesota with continuous corn and N fertilization rates of 200 kg N/ha for several years (fertilizer N was applied as one dose in the spring before planting). They found that annual losses of NO_3-N in the tile water ranged from 1.4 to 139 kg/ha. In dry years, losses generally were equivalent to less than 3% of the fertilizer N applied, whereas in the wet years, losses ranged from 25 to 70% of that applied. Pang et al (1997), in an irrigation quantity and uniformity study, concluded that N leaching was very low when the N application was close to crop N uptake and slightly higher when the uniformity coefficient of the irrigation was 90%. When N application exceeded N uptake, N leaching increased dramatically for all uniformity levels.

Hart et al (1993), working with labeled-N in winter wheat, indicated that most of the labeled-N was presumably mineralized during the fall and winter when the losses are high and crop demand is low. They concluded that leaching of NO_3-N from cereals comes predominantly from mineralization of organic N, not from residual unused N. Olson (1982), after working in the fate of N applied in the fall using labeled-N and agronomic rates in winter wheat, found that from all the leaching produced during the winter time, only about 10% of it came from the fertilizer nitrogen.

Gaines and Gaines (1994) indicated that soil texture affects NO_3-N leaching. In coarser soils, NO_3-N will leach faster than from finer ones. The addition of peat in sandy soils helps in reducing the velocity of N leaching. Tindall et al (1995), in a laboratory analysis, indicated that leaching of NO_3-N was significant in both clay and sandy soils. They concluded that in clay soils leaching occurred less rapidly than in sandy soils.

Crop production, irrigation practices and environmental conditions in the Kern Sub-Basin offer very unique attributes that will result in a relatively low nitrate leaching potential. For example much of the irrigated ground in the Kern Sub-Basin is continuing to rapidly transition from annual, relatively shallow rooted crops generally irrigated with lower efficiency irrigation systems to permanent, deep rooted, highly efficient irrigated systems.

One of the most significant contributors to leaching of nitrate is concentrated and significant rainfall, especially that which is considered as “effective rainfall.” Effective rainfall is defined as the amount of rain that is stored in the soil profile and available for leaching. The average annual rainfall in Bakersfield, Fresno, Merced and Sacramento is 6.5, 11.1, 13.1, and 18.7 inches respectively (National Climate Data Center). Saying that, the actual effective precipitation is likely 1-3 inches in Bakersfield, 5-8 inches in Fresno, 6-9 inches in Merced, and as much as 10+ inches in Sacramento. This is due to the fact that most of the rainfall occurs in the winter. The main difference is that 1-3 inches of effective rainfall over a number of months may not result in any leaching below the root zone in moderate to deep rooted crops, whereas this is not the case in other areas of the state. With deep rooted crops, this limited effective rainfall available to leach nitrate is usually stored within the root zone.