Kaweah Basin Water Quality Association

Comprehensive Groundwater Quality Management Plan

Tulare County, California • February 2015

Prepared for:

Kaweah Basin Water Quality Association

Prepared by:

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Provost & Pritchard Consulting Group
An Employee Owned Company

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Tulare County, California
February 7, 2015

Prepared for:
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Certifications

This Comprehensive Groundwater Quality Management Plan is signed by the following certified professional:

Provost & Pritchard Consulting Group

Project Team

This Comprehensive Groundwater Quality Management Plan was prepared by the following project team members:

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Abbreviations

A/R ... Applied/Removed

AGR ... Agricultural

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

CASGEM ... California Statewide Groundwater Elevation Monitoring

CDFA ... California Department of Food and Agriculture

CDPH ... California Department of Public Health

CGQMP ... Comprehensive Groundwater Quality Management Plan

CIMIS ... California Irrigation Management Information Systems

Coalition ... Kaweah Basin Water Quality Association

COC ... Constituent of Concern

CVHM ... Central Valley Hydrologic Model

CVRWQCB ... Central Valley Regional Water Quality Control Board

DAC ... Disadvantaged Community

Dairy GO ... RWQCB Order R5-2013-0122 Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies

DPR ... California Department of Pesticide Regulation

DWR ... California Department of Water Resources

EC ... Electrical Conductivity

EDF ... Clean Up Sites

ET ... Evapotranspiration

FREP ... Fertilizer Research and Education Program

GAMA ... Groundwater Ambient Monitoring & Assessment Program

GAR ... Groundwater Quality Assessment Report

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

GIS ... Geographic Information Systems

GQMP ... Groundwater Quality Management Plans

HVAs ... High Vulnerability Areas

ILRP ... Irrigated Lands Regulatory Program

IND ... Industrial

ITRC ... Cal Poly Irrigation Training and Research Center

KBWQA ... Kaweah Basin Water Quality Association

KCWD .... Kings County Water District

KDWCD .... Kaweah Delta Water Conservation District

LUST .... Leaking Underground Storage Tank

MCL .... Maximum Contaminant Limit

Mg/L .... Milligrams Per Liter

MPEP .... Management Practices Evaluation Program

MRP .... Monitoring and Reporting Program

MUN .... Municipal

N .... Nitrogen

NO_3 .... Nitrate

NRCS .... Natural Resources Conservation Service

Order No. R5-2007-0035 .... Waste Discharge Requirements General Order for Existing Milk Cow Dairies

SAR .... Sodium Absorption Ratio

SCID .... Stone Corral Irrigation District

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

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

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

TDS .... Total Dissolved Solids

TID .... Tulare Irrigation District

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

UCCE .... University of California Cooperative Extension

UCD .... University of California, Davis

USDA .... United States Department of Agriculture

USEPA .... U.S. Environmental Protection Agency

USGS .... United States Geological Survey

VK .... Vertical conductivity

WDR .... Waste Discharge Requirements

1 Introduction and Background

This Comprehensive Groundwater Quality Management Plan (**CGQMP**) has been prepared on behalf of the Kaweah Basin Water Quality Association (**KBWQA** or **Coalition**) in response to Waste Discharge Requirements (**WDR**) General Order R5-2013-0120 (**General Order**). Groundwater Quality Management Plans (**GQMP**) are required in areas of confirmed exceedances of water quality objectives, defined as high vulnerability areas (**HVAs**) by the Groundwater Quality Assessment Report (**GAR**), as required by the Central Valley Regional Water Quality Control Board (**CVRWQCB**) Water Quality Control Plan for the Tulare Lake Basin (**Tulare Lake Basin Plan**) for a constituent discharged by agriculture, and/or when a CVRWQCB Executive Officer determines trends of degradation contributed to by irrigated agriculture will threaten applicable beneficial uses. In accordance with the outline in Attachment A and the specifications in Attachment B, Monitoring and Reporting Program (**MRP**), to the General Order, this GQMP shall;

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

Rather than submitting separate management plans for noted exceedances, the KBWQA has elected to submit a single comprehensive plan along with the KBWQA GAR. In fulfilling these requirements the KBWQA will implement a process to encourage adoption of effective practices by Members of the KBWQA. The conclusions of this CGQMP express the necessity of extensive outreach and education to support the implementation of effective irrigation and nutrient management throughout the Coalition area. This CGQMP also outlines the limitations of available data, the physical barriers to representative groundwater monitoring, and the complex dynamics of decreasing the potential to leach nitrate from irrigated agriculture.

The KBWQA covers the watershed from the Sierra Nevada Mountains to the valley floor in northern Tulare County within the Tulare Lake Basin. The KBWQA is comprised of the valley floor area as its Primary Area with a majority of the irrigated agricultural activity, while the foothill and mountain regions are considered as the Supplemental Area due to significantly reduced irrigated agricultural activity (**Figure 1**).

The northern boundary roughly follows the Kaweah Delta Water Conservation District (**KDWCD**) northern border, but has been extended further north to include Stone Corral Irrigation District (**SCID**) and portions of Cottonwood Creek. The western boundary generally follows the Kings County Water District (**KCWD**) and Tulare Irrigation District (**TID**) borders. The southern boundary generally follows the KDWCD southern border, but approximately follows the Avenue 212 alignment as it heads towards the foothills. In total, the KBWQA's service area approximately encompasses 958,000 acres.

Within the KBWQA, there are approximately 356,000 total acres in the Primary valley floor and 602,000 total acres in the Supplemental foothill and mountain areas, (Figure 2). Of these areas, approximately 163,000 and 4,000 acres, respectively, are enrolled as grower members in compliance with the ILRP as of October 2014.

1.1 Constituents of Concern (COC)

1.1.1 Nitrates

Nitrate (**NO_3**) is a naturally occurring form of nitrogen that can be formed from atmospheric nitrogen or decomposing organic matter. Nitrate can also be found in groundwater as a result of excess application of nitrogen fertilizers in irrigated agricultural and landscaped areas, percolation from feedlots or dairies, wastewater and food processing waste percolation, and leachate from septic system drainfields (Harter T., et al. 2012).

1.1.1.1 Previous Studies and Monitoring

Data from multiple sources was collected and compiled into a comprehensive groundwater quality database for the KBWQA area to fulfill the requirements of the GAR. This water quality data included available groundwater quality analysis results from 1909 through 2014. Some of the available groundwater quality data was associated with wells for which location information was not available; these data were not included in the analyses presented below. The maximum contaminant limit **(MCL)** of 45 mg/L nitrate as nitrate has been used to identify nitrate impacted groundwater in the KBWQA area. For this analysis, it is assumed that all groundwater quality results represent first encountered groundwater; however, most samples were retrieved from production wells and, overall, construction information is unavailable for most wells. Future monitoring programs should include the collection of well construction data to provide additional information on the vertical distribution of these constituents over time.

1.1.1.2 Geographic Boundaries of Comprehensive Groundwater Quality Management Plan

Areas to be covered by the KBWQA CGQMP include all irrigated acreage, on a field by field basis, identified in the KBWQA GAR as HVAs. High vulnerability lands are identified and prioritized in the GAR by inputting a combination of parameters into an additive and overlay system constructed using geographic information systems (**GIS**) that assigned point values based on parameter sub-categories. These factors are defined as:

- Detections of MCL exceedances in nitrates or pesticides within the last 10 years indicating a condition of groundwater pollution;
- Longer-term detections of groundwater quality indicating a condition of active degradation defined as statistically significant up-trending nitrate detections; and
- Groundwater impacted areas upgradient of a disadvantaged community (**DAC**) or small water system that is reliant on groundwater.

Cropped or potentially cropped areas are classified as located within an HVA if at least 50 percent of a parcel is within a designated Central Valley Hydrologic Model **(CVHM)** grid cells identified as containing adverse water quality conditions. Groundwater quality attributes of each well are assigned to the entire individual 1-mile CVHM grid cell. Additionally, areas within identified groundwater impact cells that are located directly upgradient of a DAC or small water system that is reliant on groundwater are specifically included in the HVA designation.

1.1.2 Water Quality Exceedances

In map preparations for groundwater quality, it is clear that well locations for water quality data are imprecise. Mapping buffers based on well location inaccuracies are created as follows:

- 100 foot radius for data from the Tulare County dataset, University of California, Davis (**UCD**), and Groundwater Ambient Monitoring and Assessment (**GAMA**) data not derived from the State Water Resources Control Board Department of Drinking Water (**SWRCB-DDW**);
- 1 mile section squares for California Department of Pesticides Regulation (**DPR**) data; and
- 2 mile squares for DDW data derived from the GAMA database.

Once the buffers are set, the GIS layer is underlain by the CVHM 1-mile grid. Where a buffer lies within a CVHM grid cell, the cell is considered to be within the sphere of influence of that groundwater quality detection. With this approach, the extent of groundwater quality exceedances and up-trending impacts are considered to be conservative and err on the side of groundwater quality protection.

Recent test results within the last 10 years for the constituents of focus were each mapped in this manner. It was subsequently determined that mapped electrical conductivity/total dissolved solids (**EC/TDS**) exceedances were redundant to the nitrate/pesticide issues and not necessarily indicative of potential groundwater impacts due to irrigated agriculture within the KBWQA area.

1.1.3 Groundwater Trend Analysis

Nitrates appear to be the primary groundwater quality issue within the KBWQA area. MCL exceedances are illustrated as red-hashed squares in **Figure 3**. For wells with detections that remain below the MCL, an analysis was performed to determine if there was a statistically significant increasing trend within a well dataset. Wells identified with a statistically significant increasing trend appear as blue-filled red-hashed squares in the same figure. The remaining cells are either of known good groundwater quality or did not have available groundwater quality data. These areas are rectified during the HVA analysis to determine if they should be included in the HVA.

To calculate statistically significant up-trends in the water quality data, a Theil-Sen analysis was performed using the U.S. Environmental Protection Agency (**USEPA**) ProUCL software program which has a 95 percent confidence interval. The Theil-Sen analysis does not require normally-distributed data, can deal with some non-detect data points and is a recommended method of determining if statistically significant trends are found in the dataset. To ensure that all of the available nitrogen concentration data was captured and not duplicated, the UCD dataset was used for the calculations. This dataset included the wells from the GAMA data in addition to other wells not provided in the GAMA system. Because both the GAMA and UCD dataset did not provide exact well locations and used different well naming conventions, it was impossible to correlate the two datasets. Although the data ends in 2010, the length of the dataset is sufficient for the calculations.

1.1.4 HVA Data Gap Resolution

Spatial gaps where water quality exceedances were not found were assessed to determine if they should be included or excluded from the HVAs based on the following criteria:

- Groundwater quality testing over the most recent 10 year time frame indicating a lack of groundwater impacts from nitrate or pesticides;
- Endangered species critical habitat;
- Residential or industrial; and
- Other incompatible land use areas such as gravel mining, landfills, wetlands, and water storage or waterways.

If not excluded from the HVA due to the above criteria, the remaining cropped or potentially cropped areas in both the Primary and Supplemental areas are assessed for inclusion in or exclusion from the HVAs using several factors including geologic, hydrologic, soil, cropping, irrigation and proximity to a DAC reliant on groundwater. Ground-truthing was performed in the Primary area by a professional geologist and an agricultural specialist in instances where data was insufficient to make a determination.

1.1.5 HVA Designation

The assessment criteria results, after resolving the data gaps, are illustrated in **Figure 4**. DACs and small water systems that are reliant on groundwater are illustrated as black-hashed polygons with cropped or potentially cropped areas underlain as dark gray. Identified CVHM grids cells having nitrate or pesticide water quality exceedances are illustrated as pink areas, uptrending nitrate cells are identified as yellow-hashed, and non-impacted areas identified as green. These are overlain by the groundwater elevation contour lines from spring 2014 (which are reasonably consistent with historical groundwater contour maps). Cropped or potentially cropped areas with nitrate or pesticide groundwater quality impacts (both exceedances and uptrending), that are located upgradient of a DAC or small water system that is reliant on groundwater, are included as HVA properties. To augment this designation, these particular HVA properties are designated as the highest priority. A map showing the locations of current grower members, as of October 2014, with applied HVA designation is included as **Figure 5**.

2 Physical Setting and Information for CGQMP Area

2.1 Land and Hydrology Characteristics

2.1.1 Land Use

Numerous information sources were investigated for the land use section of the GAR. The most useful information found for the KWBQA area was obtained from the Tulare County Agriculture Commissioner, U.S. Department of Agriculture (**USDA**) and California Department of Water Resources (**DWR**). In general, there is very limited irrigated agriculture in the Supplemental Area. Along the eastern border of the Primary Area, crops grown are generally citrus and other permanent crops. West of this area, crops are generally field crops including alfalfa. This area is also dominated by dairies that are covered under the Waste Discharge Requirements General Order for Existing Milk Cow Dairies (**Order No. R5-2007-0035**) and RWQCB Order R5-2013-0122 Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies (**Dairy GO**).

Irrigated agriculture and dairies are the primary land use within the KBWQA Primary area. Citrus crops dominate land use in the eastern portion. The center of the association has deciduous fruit and nut crops as the primary crops with urban areas also located in the vicinity. In the western half of the study area, dairy land dominates the land use with forage crops dominating the types of crops grown.

Citrus, alfalfa, hay and forage, fruit and nuts, stone fruit, and vegetables make up 85 percent of the crops grown within the KBWQA Primary area. Citrus is the primary crop grown within the Supplemental area. Most crops in this area are located adjacent to the border between the two areas. **Figure 6** provides the cropping information from the Tulare County Agricultural Commission from 2013.

2.1.2 Soils

Soil information for the Primary study area is well documented. However, information for the Supplemental area is limited, with the eastern portion of the area unmapped in soil surveys. The soil textures for the KBWQA are provided as **Figure 7**.

The predominant soil texture in the Primary KBWQA area is loam at approximately 52 percent. Sandier soils are found near streams and channels. In general, the areas to the east are more subject to hardpan with coarser soils along the riverbeds atop the alluvial fan and clay deposits off to either side of the fan.

Soils in the Supplemental area are generally coarser than the soils found in the Primary study area. The majority of the soils are sandy loam and coarse sandy loam. Rock outcroppings are also found in this area with most of the areas lying near the eastern border of the available information.

Areas of higher permeability are located within the study area near ancient and modern stream channels, consistent with the CVHM well log texture analysis (**Figure 8**). Areas of higher runoff potential are located predominantly in the northeastern area and along the eastern border.

There are limited soils within the KBWQA range with high electrolytic conductivity and/or sodium absorption ratio (**SAR**) located primarily along the central north and central south borders of the area.

These soils are located coincident to highly alkaline soils and mostly coincident to silty clay textures in the same areas (**Figure 9**).

Soils within the KBWQA range from extremely acidic to moderately alkaline with the majority of the soil being slightly alkaline in the Primary area and acidic in the Supplemental study area. In general soils become more acidic in the eastern portion of the study area, near the base of the Sierras.

The steepest portion of the KBWQA is in the Supplemental area, generally with slopes between 20 and 50 percent. The land surface becomes more level as the foothills transition to the valley floor with the Primary area having little slope and topography.

2.1.3 Geology

2.1.3.1 Regional Stratigraphy

Information obtained from reports prepared for irrigation and water districts in the area, CVHM well log texture data, and National Resources Conservation Service **(NRCS)** soils reports were summarized for the preparation of this CGQMP.

The KDWCD covers approximately 71 percent of the Primary KBWQA area. A report prepared by Fugro West, Inc. indicates that most of the fresh groundwater pumped within the KDWCD is from unconsolidated deposits of Pliocene, Pleistocene, and Recent Age. Consolidated marine rocks of Pliocene age and older which contain brackish or salty water constitute the effective base of fresh water (or permeable sediments).

Geologic units that affect the occurrence and movement of groundwater in the KDWCD are generally classified and described as follows:

a. Basement Rocks of pre-Tertiary age consisting of non-water-bearing granitic and metamorphic rocks. In the subsurface, they slope steeply westward from the Sierra Nevada beneath the deposits of Cretaceous age and younger rocks that compose the valley fill.

b. Marine Rock of Tertiary age consisting of non-water-bearing marine sediments including the San Joaquin Formation which overlap the basement complex and underlie the unconsolidated deposits.

c. Unconsolidated Deposits of older and younger alluvium consisting of non-marine, water-bearing material comprised of the Tulare Formation and equivalent units which thicken from zero along the western front of the Sierra Nevada to a maximum of about 10,000 feet at the west boundary of the KDWCD.

d. Alluvial Deposits consisting of coarse-grained, water-bearing alluvial fan and stream deposits including older oxidized and reduced units, and younger alluvium which underlie the older alluvium. The 200 to 500 feet thick oxidized deposits are red, yellow, and brown, consist of gravel, sand, silt and clay, and generally have well-developed soil profiles. Reduced deposits which extend to about 3,000 feet below land surface are blue, green, or gray, calcareous, and generally are finer grained than oxidized deposits, and commonly have a higher organic content than the oxidized deposits.

e. Lacustrine and Marsh Deposits consisting of fine-grained sediments representing a lake and marsh phase of equivalent continental and alluvial fan deposition. Only the "E" Clay (or

Corcoran Clay member) of the Tulare Formation, one of the laterally continuous clay zones in the southern San Joaquin Valley, is found within the KDWCD, extending from Tulare Lake Bed to U.S. Highway 99 with vertical bifurcation near Goshen. It is about 140 feet thick near Corcoran and the average thickness is about 75 feet.

Soils developed on younger alluvium show little or no profile development and are generally free of underlying clay subsoil or hardpan. Very coarse soils can be found beneath the channels of the Kaweah, Tule and Kings Rivers, with fine-grained deposits occurring in the channel of Cross Creek.

In the eastern portion of the KDWCD the Rocky Hill fault disrupts pre-Eocene deposits and may locally penetrate older alluvial deposits, potentially restricting the hydrologic connection of aquifers.

A thickening section of unconsolidated deposits is indicated moving west across the KDWCD with modest warping of the Tulare Formation's surface, suggesting regional folding during and after deposition, but having little effect on the patterns of groundwater flow within or at the perimeter boundaries of the KDWCD.

Other local irrigation districts include Alta, Stone Corral, Ivanhoe, Exeter and Lindmore. These districts surround the KDWCD along the north and east borders. Most of the districts are sloped ranging from 1 to 30 percent and have some form of shallow hardpan. Adobe clay is commonly found on the smooth valley plain near the foothills with coarser materials along current or old streambeds.

The Sierra Nevada Mountain range, partially located within the KBWQA Supplemental area, is the result of initial and continued uplifting of the Pacific and North American tectonic plates. As illustrated in **Figure 10**, the area is predominately plutonic rocks of the Mesozoic era, interspersed with outcrops of mixed rocks of pre-Cambrian to Mesozoic era. Portions of the Sequoia and Kings Canyon National Parks are located in the uppermost elevations of the area.

Lake Kaweah is centrally located near the western border. Small areas of Quaternary alluvium are located up- and down-stream of the lake, with larger areas along the foothill borders.

2.1.4 Hydrogeology

The Kaweah sub-basin is located on the east side of the south-central portion of the San Joaquin Valley within the Tulare Lake Basin (**Figure 11**). The San Joaquin Valley, which is the southerly part of the great Central Valley of California, extends about 250 miles from the Sacramento-San Joaquin Delta area at the north end to the Tehachapi Mountains at the south end. In the vicinity of the KBWQA, the Valley is approximately 65 miles wide. The Valley is bordered on the east by the Sierra Nevada mountains which range in elevation from about 1,000 feet or less to more than 14,000 feet above sea level. The Coast Range, which borders the Valley on the west, rises to about 6,000 feet above sea level. The southern end of the San Joaquin Valley, also known as the Tulare Lake Basin, is a closed feature separated from the Sacramento-San Joaquin Bay-Delta system and without external surface drainage.

2.1.4.1 Groundwater Basins and Subbasins

The Tulare Lake Basin as referenced by the General Order is bounded by the crest of the Sierra Nevada Mountain Range to the east, the San Joaquin River to the north, the Westlands Water Quality Coalition and the crest of the Southern Coast Ranges to the west, and the crest of the San Emigdio and Tehachapi Mountains to the south. Tributary streams drain to depressions, the largest of which is the Tulare Lake bed located to the west of the KBWQA boundary. The Kings, Kaweah, and Tule Rivers and, on occasion, the Kern River, discharge into the Tulare drainage basin including the beds of the former Tulare, Buena Vista, and Kern Lakes at times when flows exceed the capacity of foothill reservoirs and of the irrigation diversion systems.

The Kaweah sub-basin lies between the Kings Groundwater sub-basin on the north and west, the Tule Groundwater sub-basin on the south, and crystalline bedrock of the Sierra Nevada foothills on the east. The sub-basin generally comprises lands in the Kaweah Delta Water Conservation District and is the approximate extent of the Primary KBWQA area. The sub-basin's watershed is to the east and is the approximate extent of the Supplemental KBWQA area. Major rivers and streams in the sub-basin include the Kaweah and St. Johns Rivers (**Figure 12**). The Kaweah River is the primary source of recharge to the area.

2.1.4.2 General Groundwater Chemistry

The KBWQA Primary area includes the majority of the Kaweah Subbasin of the San Joaquin Groundwater Basin, which is an inland groundwater basin with no significant outflow. The Kaweah subbasin lies primarily on the valley floor with crystalline bedrock of the Sierra Nevada foothills on the east. The subbasin generally comprises lands in the Kaweah Delta Water Conservation District with the Kaweah River as the primary source of recharge to the area.

As an inland basin, salts will generally tend to increase in concentration over time in groundwater, but areas within the basin are regularly recharged by the local river systems allowing for some dilution. The groundwater in this basin is generally of a calcium bicarbonate type, with sodium bicarbonate waters near the western margin. The 2003 DWR Bulletin 118 indicates the following groundwater quality impairments:

- TDS values range from 35 to 1,000 mg/L, with a typical range of 300 to 600 mg/L within the basin;
- there are localized areas of high nitrate on the eastern side of the basin; and
- high salinity groundwater is present between Lindsay and Exeter.

2.1.4.3 Water Bearing and Discharge/Recharge Zones

Recent depth to groundwater was determined based on a combination of KDWCD and California Statewide Groundwater Elevation Monitoring (**CASGEM**) information. In general, the depth-to-water is shallowest in the northeast and southeast with an overwhelmingly southwest regional direction of flow. A groundwater ridge occurs along the Kaweah River footprint with troughs on either side. The deepest groundwater is found in the eastern area between the cities of Exeter and Lindsay. The affects of pumping are apparent in groundwater contours. The Supplemental area has limited data available, but it can be assumed that, other than within fractured bedrock, groundwater will generally follow the topography.

The Terminus Dam was constructed in 1962, coinciding with a regional drop in groundwater levels of 40 feet or more. Recent high water years can be noted in the mid- to late-1980s with water levels generally not reaching those elevations in the years following. The State of California is currently in a drought state of emergency and the Central Valley, in particular, is in a severe overdraft condition, as is apparent in the hydrographs for the valley floor wells. Groundwater levels have generally been in decline since 1999 with a recent decline of up to 100 feet in some wells since approximately 2008.

Recharge areas within the Primary valley floor area were identified and mapped using a combination of publicly available resources. To determine relative recharge rates, identified recharge areas were layered over CVHM vertical conductivity (**VK**) layers of varying thicknesses (**Figure 13**). The fastest VK values are found in the areas near the mouths of the Kaweah River and the current Yokohl Creek and extending northwestward. The slowest VK values include the areas to the north and south of the two alluvial fans (Kaweah and Yokohl creek locations) and the better part of the south-central and southeast areas.

The most significant recharge area is at and near the mouth of the Kaweah River due to the shallowest groundwater at less than 50 feet and the upgradient position to the majority of the KBWQA area. The second most significant recharge area is the northwest-southeast trending belt of relatively high VK values and multiple surface waterways and impoundments. Depth-to-water in this area ranges from 50 to 150 feet and less of the KBWQA area is downgradient.

2.1.4.4 Water Sources and Water Chemistry

The water bearing zones which supply domestic, irrigation, and municipal beneficial uses vary throughout the KBWQA region. Typically, domestic wells use shallower aquifers due to the cost of drilling deeper wells, but there is no comprehensive record for domestic well depth ranges. Due to their shallower depths domestic wells typically experience groundwater quality issues associated with surface level activities.

Municipal and agricultural wells have been estimated by the DWR to be drilled to depths that range to depths exceeding 2,000 feet. Currently, agricultural irrigation wells are being drilled through all usable water bearing zones.

2.1.4.5 Aquifer Characteristics

Based on fall 2013 groundwater elevation contours, depth-to-water is shallowest to the northeast and southeast with typical levels ranging from approximately 16 to 45 feet (**Figure 14**). A groundwater ridge occurs along the Kaweah River footprint with troughs apparent to either side. The deepest groundwater in the eastern area is approximately 127 feet located between the cities of Exeter and Lindsay.

The topography to the east is the steepest in the Primary area. Combined with the Kaweah River ridge, steep declines in groundwater levels can be noted within the eastern regions. Topography through the central and western portions is relatively flat with groundwater levels exhibiting an apparent greater reaction to pumping activities.

The deepest groundwater is located in the western portions typically ranging from approximately 140 to 180 feet with a maximum of 188 feet. The western portions are pock-marked with seemingly anomalous groundwater depths but these points only serve as evidence of the pumping effects.

Based on the spring 2014 groundwater elevation contours, depth-to-water is again shallowest to the northeast and southeast with levels ranging from approximately 13 to 34 feet (**Figure 15**). These levels are slightly shallower than in the previous fall. The groundwater ridge and side troughs are again apparent along the Kaweah River footprint. The deepest groundwater in the eastern area is approximately 113 feet located between the cities of Exeter and Lindsay, 14 feet shallower than in fall 2013.

The deepest groundwater is located in the western portions typically ranging from approximately 130 to 170 feet, approximately 10 feet shallower than in fall 2014. Pumping effects are still apparent in the region.

For the Supplemental area it can be reasonably presumed that, other than within fractured bedrock, groundwater will generally follow the topography. With limited cropped acreage located within the Supplemental area, the lack of data is not considered to be a major issue.

2.2 Identification of Constituent of Concern (COC) Source

2.2.1 Irrigated Agriculture

Nitrate migration to groundwater occurs with deep percolating water as it travels through the unsaturated zone (deep percolation). As such, in irrigated agriculture, the application of water and the method of irrigation is a key factor influencing nitrate impacts. Some deep percolation is required to allow salts to be leached away from the root zone, which is necessary to sustain agricultural production. Irrigation efficiency and nutrient management can help to minimize nitrate impacts, but they cannot be completely avoided due to salt leaching requirements.

2.2.2 Alternative Sources

Nitrate can also be found in groundwater as a result of percolation from feedlots or dairies, food processing facility discharges, or from wastewater. According to CVRWQCB data, as of 2012 there were approximately 71,000 acres of dairy associated land (dairy facility and manure land application areas) located within the Primary KBWQA area. Dairies are currently regulated under the Dairy GO.

It is unknown how many acres within the KBWQA boundary are under the regulatory jurisdiction of other WDR's or conditional waivers of WDR's (i.e. effluent wastewater, food processing, recycled water, etc). The locations of CVRWQCB-supervised programs with monitoring systems within the KBWQA were mapped. These programs include leaking underground storage tank (**LUST**) and other cleanup sites, solid waste and wastewater treatment plant facilities, and food processor and dairy sites. The CVRWQCB-supervised sites are illustrated in **Figure 16** and listed in **Table 1**.

2.2.3 Source Identification Study

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

2.3 Beneficial Uses

The Tulare Lake Basin Plan designates groundwater aquifer beneficial uses to be protected, water quality objectives to protect those beneficial uses, and a program of implementation needed for achieving or sustaining these objectives. The four DWR groundwater basins included in the area of the KBWQA, noted previously, are designated for municipal (**MUN**), agricultural (**AGR**) and industrial (**IND**) beneficial uses (CVRWQCB, 2004).

2.4 Management Practices Baseline

Factors that influence nitrogen impacts from irrigated agriculture have been studied by numerous entities. And, continued research is underway to help aid in understanding the factors that affect nitrate leaching from farmland. The main contributors to nitrate leaching potential that interact within land-use decisions at the surface are soil type, crop type, and irrigation type (Letey et al., 1979; Plant Nutrient Management Technical Advisory Committee, 1994; and Wu et al, 2005). The combination of these factors with management decisions, such as fertilizer application methods, influences the impacts to groundwater from farming operations. These elements provide a framework for introducing nitrate leaching potential to members throughout the KBWQA area. Analysis of the interaction of these factors provides a foundational baseline for the implementation of reasonable management practices to reduce nitrate leaching risk.

2.4.1 Existing Practices

Irrigation type information for the KBWQA provided by the DWR for 2007 is presented on **Figure 17**. More current information regarding irrigation systems used is not available at this time. However, comparisons with past cropping patterns have shown that permanent crops are increasing significant in the region and, in nearly all cases, are developed with highly efficient drip and/or microspray irrigation systems. This is generally due to the scarcity and expense of water, as well as a shift to permanent crops in Tulare County. In recent years, decreased surface water supplies caused by California's drought have increased the use of pressurized irrigation systems on annual crops. This change reduces water requirements and increases yield by improving irrigation efficiency, minimizing plant water stress, and delivering nutrients through fertigation more efficiently.

Fertigation, where plant nutrients are delivered via irrigation water, is common in drip, micro-sprinkler, and impact head sprinkler irrigation systems. For example, most vegetables on drip and sprinkler systems are fertigated. Although not as common, fertigation can also be used in surface irrigation systems, where some, but not all, fertilizer is injected into the irrigation water. In this case, the fertilizer source is close to the field so that fertilizer travel time in the irrigation water is reduced. Because excess water in these systems is either captured in tile drains or collected in tail water, and returned to the irrigation system, excess fertilizer contained in this water is also recycled to the irrigation system.

2.5 Available Groundwater Data

2.5.1 Data Sources

The data employed to analyze the groundwater quality exceedances for the purpose of the CGQMP was collected and compiled into a comprehensive groundwater quality database. The sources of groundwater quality data available for this study include Water quality data was gathered from the State Water Resources Control Board's GeoTracker and GAMA databases which provided the most comprehensive dataset of water quality information, and others as listed below.

- SWRCB-DDW (formerly California Department of Public Health (**CDPH**) [through the GAMA];
- CDPH Archived Data;
- DWR;
- Cleanup Sites (**EDF**) (through the GAMA program);
- DPR CDPH (through the GAMA program);
- United States Geological Survey (**USGS**) (through the GAMA program);
- UCD; and
- CVRWQCB dairy management group.

Of the 950 GAMA system wells with available data for the KBWQA area, 819 are located in the 356,000 acre primary area and 131 in the 602,000 acre Supplemental area. It can be presumed that the largest percentage of data is from supply wells. Well construction information is not generally available for the wells for which groundwater quality data are available. As a result, the analyses presented in the CGQMP and GAR does not include any evaluation of depth or aquifer material associated with water quality results. As noted, it is assumed for the sake of this evaluation that all groundwater quality results represent first encountered groundwater. Some of the available groundwater quality data was associated with wells for which location information was not available; therefore, these data were not included in the analyses.

3 Management Plan Strategy

The focus of the KBWQA management plan relies on the understanding and acceptance that surface conditions and activities dictate the degree of nitrate leaching below the root zone of the crop. To effectively address the surface level decisions that influence nitrate leaching, a clear understanding of the nature of nitrate transport, the requirements of a range of agricultural management systems, and the factors which influence management choices is required. The KBWQA will not exclusively rely on contaminant loading, fate and transport modeling, or groundwater quality trends to validate the protective nature of specific management practices. Due to the nature of nitrate as a non-point source contaminant, large knowledge gaps, and inadequate data, it is infeasible to retroactively trace local nitrate impacts back to specific agricultural management system choices. Similar barriers exist in tracing the impacts of newly implemented practices and their nitrate impact on groundwater due to the spatial and temporal disconnects prevalent throughout the KBWQA.

As such, management plan implementation will focus efforts on addressing irrigation and nutrient management practices through extensive outreach and education for all irrigated lands included in the scope of the CGQMP. The outreach will also address multiple surface level metrics, including the education on the factors that influence nitrogen leaching and the nitrogen applied/removed (**A/R**) ratio, to help growers gauge the impact of agricultural system management decisions on farms and their potential impact on groundwater quality. See **Section 4** for a further description of the A/R ratio. Additional collaborative research will be required to improve the available data, particularly for estimating nitrogen removal, required for identifying nutrient ratios for a variety of agricultural systems.

3.1 Approach and Prioritization

To facilitate and focus groundwater quality monitoring and agricultural system management efforts, all identified KBWQA HVAs were prioritized. Priority values were calculated throughout the identified HVA to define a three tier system of Tier I, Tier 2, and Tier 3 priorities. Prioritization of the land within the high vulnerability zones for the GAR was accomplished using a matrix of factors that influence the potential for nitrogen impacts from irrigated crops.

3.1.1 Nitrogen Risk Categorization

Research on nitrogen leaching from irrigated agricultural land indicate that certain crop systems consistently fell into the higher nitrate leaching risk category. The following factors are considered when evaluating the potential for nitrogen pollution from crops:

- Crop nitrogen applications: crops that require larger nitrogen fertilizer applications have a greater likelihood of nitrogen migration.
- Soil texture: Course textured soils allow nitrogen to leach through the soil profile faster.
- Irrigation method: Surface irrigation methods have increased deep percolation due to lower irrigation efficiencies when compared with efficient irrigation methods.

All of these factors contribute to the likelihood of nitrogen impacts to groundwater and must be considered. For instance, almonds have a high nitrogen requirement, but are generally irrigated with drip or micro irrigation which reduces the amount of nitrogen leaching risk rate. The combination of these factors, as collected from publically available information and grower surveys will be used to prioritize and develop risk characterizations.

3.1.2 High Vulnerability Area (HVA) Prioritization Results

Prioritization of the land within the high vulnerability zones for the KBWQA area was accomplished for the current grower members located within Primary and Supplemental HVA designated areas as of October 2014 by using a combination of critical, secondary, and contributing parameters. Critical parameters include properties with groundwater quality issues and properties with groundwater quality issues that are upgradient of a DAC or small water system that is reliant on groundwater. Secondary parameters include physical properties of the soil and hydrogeology that are not expected to change significantly in the foreseeable future. Contributing parameters include factors that are generally expected to experience temporal variations. These factors include crop type, irrigation type, and other management decisions. **Table 2** provides a summary of the factors used for prioritization. The prioritization results are shown in **Figure 18**.

Although all of the critical, secondary, and contributing parameters add to the priority designations for the area, their relative importance varies. Therefore, the point values assigned to the parameters and associated sub-categories varies. For instance, land located adjacent to a DAC that is reliant on groundwater with nitrate exceedances is more likely to be a higher priority than an area with shallow groundwater and nitrate exceedances that is not located near a DAC.

Information supplied by growers in the grower surveys regarding on-farm management practices will be combined with the prioritization zones to determine areas where improvements should be further investigated.

3.2 Actions Taken

There has been extensive research on California agricultural management practices, particularly for irrigation and nutrient management, including publications such as Nitrogen Source Reduction to Protect Groundwater Quality (Dzurella et al., 2012). The KBWQA, along with other coalitions, will attempt to unify formerly conducted research, best practices, and current knowledge to determine realistic time frames for implementation, decipher where data gaps truly exist, and assess the barriers to implementation in a variety of scenarios. This effort is particularly necessary because, generally, the data required to determine A/R ratios, as well as the impacts of specific management practices, is not currently available.

After establishing the relevance of previously conducted research and the barriers to implementation, outreach and education will be designed to address these barriers and provide the requisite knowledge to improve irrigation and nutrient management and facilitate pump and fertilize practices. Further research will undoubtedly be required to fill in the data gaps which may further hinder implementation or limit efficacy of practices in different crop types. The A/R ratio will be defined on a management unit-specific basis as a self evaluation and a tracking tool for member participation and a gauge of the implementation of new management practices.

Groundwater monitoring will be standardized through the Groundwater Quality Trend Monitoring Program to further satisfy the need for trend analysis, although, as noted in the State Water Resources

Control Board Agricultural Expert Panel (**SWRCB-AEP**), trends must be evaluated over a multi-year basis and may not be representative of current practices.

3.2.1 Member Education to Maintain and Improve Water Quality

Outreach and education efforts will focus on the integration of research relevant to nutrient and irrigation management. Additional education efforts will elaborate on the opportunities to mitigate and remediate current nitrate impacts to groundwater through techniques including, but not limited to, pump and fertilize (Harter et al 2012).

3.2.2 Management Practices Identification, Validation, and Implementation

The KBWQA intends to conduct a thorough literature review of current knowledge pertaining to efficient irrigation and nutrient management practices, particularly as they relate to priority crops and scenarios. Despite noted data gaps, there is currently a body of work with which to develop effective and relevant outreach and education materials. University of California Cooperative Extension (**UCCE**) and commodity group resources and assistance will be instrumental in this effort.

There is no one-size-fits-all combination of management practices to protect groundwater quality that can account for the dynamic interactions observed across the extensive range of cropping scenarios and agricultural system characteristics. Individual cropping scenarios will necessarily require different combinations of agricultural system management practices to optimize protection of groundwater quality in the most cost effective and efficient manner. A great deal of research and theory has been compiled on California agricultural irrigation and nutrient management. A review of relevant knowledge is likely sufficient to initially identify practices to suggest for implementation and to formulate effective outreach and education materials.

For instance, Dzurella et al (2012) provides numerous practices, compiled for California agriculture, that decrease or potentially decrease nitrogen (**N**) leaching. While these practices may be promising, the specific decrease in nitrate leaching or increase in nitrogen uptake efficiency is not currently quantified. These resources will be employed to develop outreach and education materials to challenge growers to improve nitrogenous fertilizer application efficiency and irrigation efficiency. Ultimately, the success of outreach and education is dependent on application customized to a specific cropping system, most likely through certified nutrient management plans and site specific irrigation management plans. Much of the work of tailoring improvements must necessarily be done by those who are most familiar with all of the details of the respective cropping scenarios; namely, growers and their consultants. Validation of achieved improvements is planned to ultimately come from the A/R ratio, once requisite data gaps have been filled.

3.2.2.1 Management Practices Evaluation Program (MPEP)

As specified in the General Order, the purpose of the MPEP is to determine the effects, if any, irrigated agricultural practices may 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 practice). Therefore, the MPEP can theoretically help provide validation of groundwater protection for new or existing practices.

Overall, the objective of the MPEP, to establish a direct relationship between the nitrogen mass balance and nitrate discharge beneath the root zone, as related to specific representative management practices, is extremely difficult to achieve. In defining nitrate discharge beneath the root zone, numerous scientific studies corroborate the difficulty of tracking nitrogen as well as the error in extrapolating nitrate leaching between sites. Additionally, particular management practices may contribute to theoretically good irrigation and nutrient management, but overall the interaction of the practices with one another is what influences nitrate leaching. As such, it is the position of the KBWQA that implementing practices which are protective of groundwater quality requires good overall irrigation and nutrient management, which considers how the practices work in concert with one another, under the particular field circumstances.

3.3 Duties and Responsibilities

3.3.1 Identification of Project Administration

Donald Ikemiya, PE is the Executive Director of the KBWQA and will be responsible for administering the Comprehensive Groundwater Quality Management Plan under the direction of the KBWQA Board. The KBWQA Board may change project administration duties from time to time.

3.3.2 Individual Responsibilities

An initial evaluation of potential KBWQA partners includes organizations and programs which have missions that prioritize the implementation of effective nutrient and irrigation management. Although these organizations are well suited to working in conjunction with the KBWQA and have been actively involved in aspects of the Long-Term Irrigated Lands Regulatory Program (**ILRP**), there have been no formal agreements to collaborate in implementation efforts.

3.3.3 Organizational Chart

The Comprehensive Groundwater Quality Management Plan Organizational Chart is included as **Figure 19**.

3.4 Implementation Strategy

3.4.1 Partner Agencies and Entities

The KBWQA will compile background information for management practices, facilitate training programs, and produce outreach and educational materials appropriate to various aspects of farm management and growers that are involved in the identified priority cropping scenarios. Partners available to support development of these resources include, but are not limited to:

1. California Department of Food and Agriculture (**CDFA**);
2. Fertilizer Research and Education Program (**FREP**);
3. Tulare County Agricultural Commissioner;
4. NRCS;
5. Cal Poly Irrigation Training and Research Center (**ITRC**);
6. UCCE; and,

7. Cooperating coalitions and the Southern San Joaquin Valley Water Quality Coalition (**SSJVWQC**).

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

The missions of programs such as the UCCE, ITRC, and FREP position them as optimal partner organizations to help accomplish the objectives of the CGQMP. Existing training programs and outreach materials developed by these programs will be employed to the greatest extent possible. This will prevent redundant efforts by the KBWQA while strengthening the impact and network of the existing programs.

3.4.2 Protective Management Practices

To define a specific management practice, or set of management practices, as protective of groundwater is an over simplification of the hydrology, hydrogeology, and the interacting physical and biological systems within agricultural management systems. There is no benefit in prescribing management practices as inherently protective in isolation of the unique context of an irrigated agricultural management system at the field level. Quite possibly, the prescription of particular practices may contribute to an increase in nitrate leaching potential if growers are required to adopt practices which may not be relevant to their unique context.

As such the role of the KBWQA is to facilitate the execution of effective irrigation and nutrient management plans. Comprehensive plans will take into account the impact of management practices within the full context of individual agricultural management systems, accounting for farm operations and physical factors. The KBWQA will also focus on irrigation and nutrient management tools which may improve the implementation of effective irrigation and nutrient management plans. This will include integrating, promoting, and training with tools and methods such as the California Irrigation Management Information System (**CIMIS**), evapotranspiration (**ET**) tracking, and irrigation scheduling. The KBWQA will incorporate and disseminate new information on promising practices as it becomes available from the MPEP or other sources. Finally, improvement in long term A/R ratios will provide a metric that indicates systems which are cumulatively beneficial.

3.4.2.1 Technically and Economically Feasible Practices

As described previously, the proven effectiveness of a given management practice can vary between nearly identical cropping systems. Technically and economically feasible practices should be prioritized by cropping scenarios defined as having a high nitrate leaching potential. The practices outlined by research specific to California agriculture, such as those outlined by Dzurella et. al (2012), define an initial starting point for identifying practices applicable to these priority cropping systems. Technically and economically feasible practices cannot be defined outside of the context of a cropping system, so it is beyond the scope of current knowledge and does not yield itself to a summary list.

3.4.2.2 Practice Effectiveness and Limitations

Generally, practices do not have an associated quantifiable decrease in nitrate loading to groundwater, so the absolute protectiveness or effectiveness of a given management decision generally cannot be calculated without extensive time, effort, and funding. This can be seen in the long term investigation undertaken in the Woodstock study where the effects of changing agricultural management practices on nitrate concentrations in groundwater needed for municipal uses were examined (Haslauer et al., 2004). Quantifying changes in nitrate leaching as a direct result of changes in management is a complex study and may take more resources than are available at this time. If a reduction in N leaching can indeed be quantified for a particular practice, it would be site specific and may or may not apply to other sites.

The general limitation, as defined, is the impossibility of completely eliminating the potential to leach nitrate. Practice effectiveness is also limited by correct implementation of the management practices; although effective outreach and education will seek to mitigate incorrect implementation, management errors may still occur.

3.4.3 Outreach Strategy

Outreach events will focus on providing resources to members and improving practices associated with irrigation and nutrient management. Outreach events are planned to occur twice yearly and will include presentations of applicable information from resources evaluated or created by the KBWQA. Irrigation management and nutrient management trainings will be organized by the KBWQA in partnership with the UCCE, NRCS, CDFA, commodity groups, or Tulare County Agricultural Commissioner to educate growers in efficient and effective management practices. Additional outreach efforts will extend resources required for mitigation endeavors, including pump and fertilize methods, which requires knowledge of the nitrate content of irrigation water sources and how the nitrogen can be used to meet crop needs and offset other fertilizer application. The KBWQA will also assist in efforts by members to receive nutrient management plan self certification.

3.4.4 Management Practices Implementation Schedule

3.4.4.1 Timetable to Identify Management Practices

The identification of management practices is dependent on the compilation of comprehensive resources for California agriculture and the subsequent evaluation within high priority cropping scenarios. Realistic timetables for the analysis of protective practices relevant to unique cropping scenarios will be determined after the requisite literature review and consultation with the UCCE, NRCS, CDFA, commodity groups, and Tulare County Agricultural Commissioner. As discussed, initial analyses of relevant practices are available for consideration and can be presented within the first year.

3.4.4.2 Timetable for Management Practices Implementation

Some practices may be able to be adopted as soon as 2 to 3 years from the initial notification of high vulnerability status and subsequent outreach and education. Other practices may be linked to the timeline of the MPEP, funding opportunities, and the completion of relevant training.

3.4.5 Performance Goals

Considering the noted limitations, the efficient application of nitrogen and irrigation water is considered a primary performance goal. Implementing effective management must take into account the economic and technical barriers inherent in changes to existing agricultural management systems. Baseline performance data for A/R ratios will need to be developed before relevant performance goals can be set.

3.4.5.1 Targets/Expected Progress

The significance of the potential changes in management practices cannot be neglected, especially in terms of cost, and assuming an unrealistic timeline for implementation poses an additional barrier to compliance and fulfilling the goals of the ILRP. From a scientific perspective, given the physical setting and parameters, significant improvement in groundwater quality may take decades to achieve (Harter 2012). Even once improvements are made at the surface it can take decades before groundwater quality changes are observed at depth. Additionally, fluctuations in groundwater quality, including degradation or improvement, may still indicate legacy impacts.

4 Monitoring Methods

4.1 Measure Achievement of CGQMP Goals

4.1.1 Compliance Rates

To evaluate the compliance rates of members to implement practices protective of groundwater the KBWQA proposes to employ a metric recommended by the SWRCB-AEP, the A/R ratio. The A/R ratio evaluates the approximate nitrogen use efficiency, and indirectly provides feedback on irrigation efficiency, as a favorable A/R ratio is less likely to be achieved with poor irrigation efficiencies.

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

Multi-year averages of A/R ratios provide a method to evaluate the shift in agricultural management practices at the farm level. The distribution of A/R ratio averages for all KBWQA members provides a tool to educate growers on achievable nitrogen management to motivate self-regulation. A lower A/R ratio represents a more efficient cropping system. A/R ratios would begin to be evaluated after extensive education and development of a basis for estimating N removed.

Currently there is very little data on ranges of A/R ratio values, but it is an appropriate and beneficial area of research for commodity groups and associated research groups. Research and intimate knowledge of on-farm systems will be required to define achievable A/R ratios, which includes estimating the nitrogen removed for various crops. It may not be possible to set strict A/R ratios for compliance, particularly with the use of organic nitrogen and its availability over time. However, as the SWRCB-AEP pointed out, long term averages will help factor out such sources of variability and assess overall compliance.

Feedback on compliance will be summarized from additional data provided by members in accordance with the Nitrogen Management Plan Summary Reports and the Farm Evaluation, which will provide statistics on adoption of other promoted practices.

4.2 Measure Effectiveness of CGQMP Practices

4.2.1 Groundwater Improvement

Compliance cannot be gauged by direct measurement of nitrate discharge beneath the root zone from irrigated lands, particularly from year to year (SWRCB-AEP). Improving the efficiency of irrigation can lead to increased nitrate concentrations in deep percolation, and depending on mixing, at first encountered groundwater. As such the recommended trend monitoring will be long term, with multi-year values as recommended by the SWRCB-AEP.

4.2.1.1 Groundwater Quality Trend Monitoring Program

The intent of the Groundwater Quality Trend Monitoring Program is to evaluate long-term groundwater quality trends. However, at this time, the region does not have a dedicated comprehensive groundwater monitoring network to track groundwater conditions beneath irrigated agricultural land.

Existing wells that have been tested for groundwater quality generally do not have well construction information available, complicating the determination of representativeness of first encountered groundwater. Future activities within the KBWQA associated with the ILRP related to tracking groundwater conditions will be integrated with the CGQMP. At the current time, only a general evaluation of the regional impact of irrigated agriculture is possible with the existing data.

4.3 Additional Monitoring Required to Validate Management Practices

The KBWQA does not plan to institute any additional monitoring at this time.

5 Data Evaluation and Reporting

After implementation of nutrient and irrigation management plans, and after relevant data gaps have been filled, A/R ratios will be collected annually and values will populate a long term data set for summarization and interpretation. Averaging A/R ratios over time for KBWQA members provides a representative distribution of varying practices throughout the KBWQA primary area. The analysis and resulting distribution will be shared with growers through outreach events to educate members on regional A/R ratios. This information will be included in the Management Plan Status Report, due as of May 1st every year, for the review of the CVRWQCB.

Figures and Tables

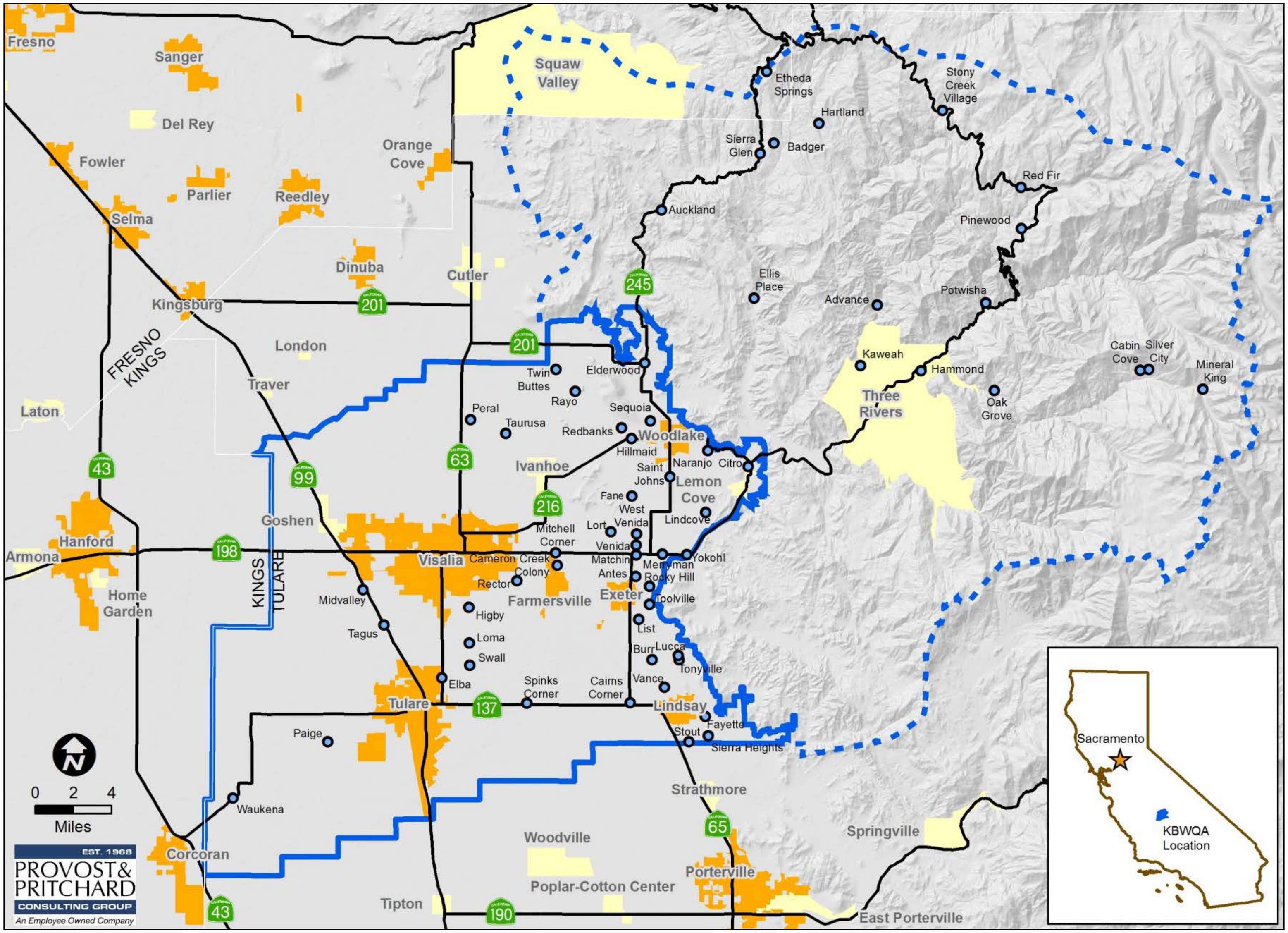

Figure 1. KBWQA Vicinity Map

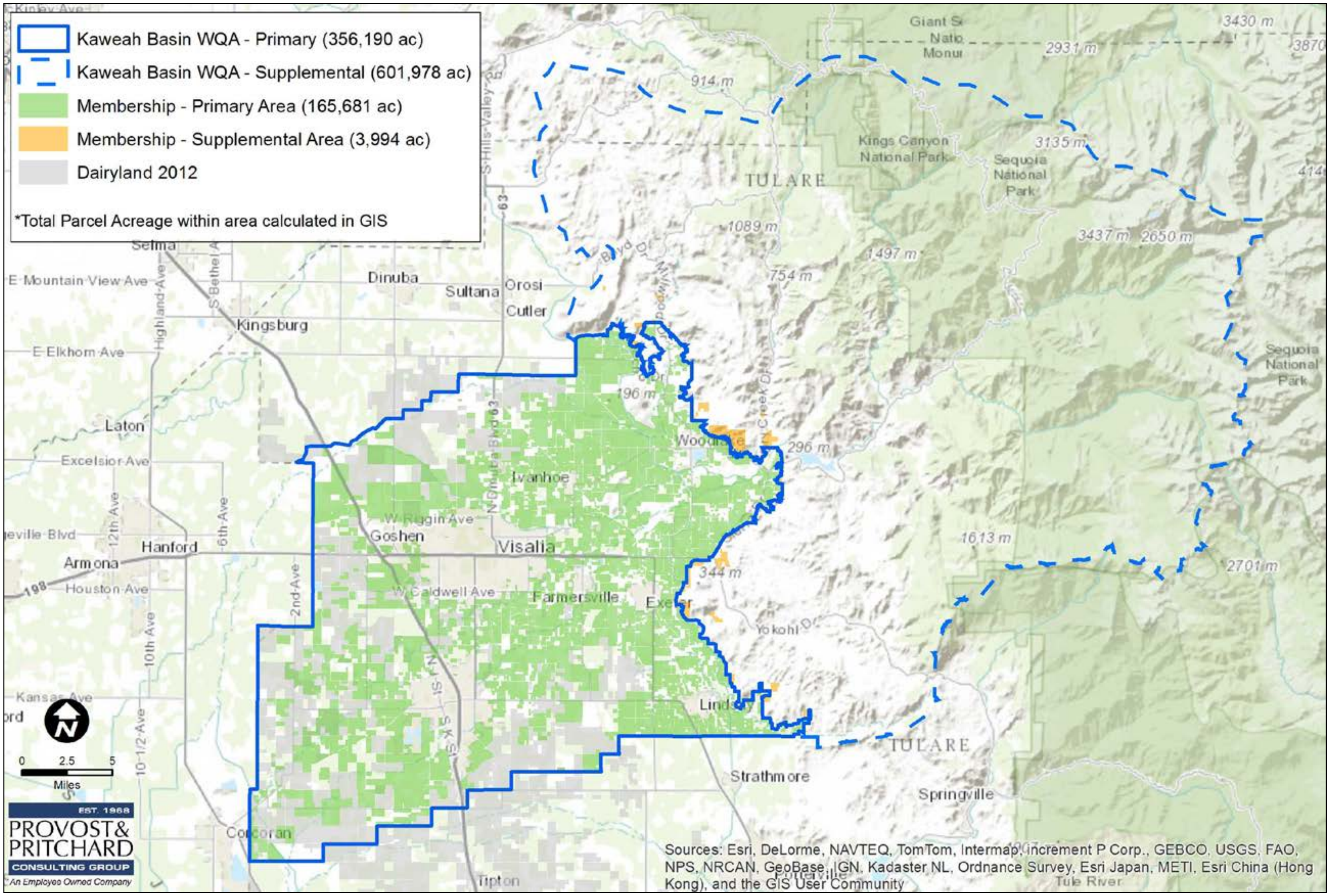

Figure 2. KBWQA Boundary Map

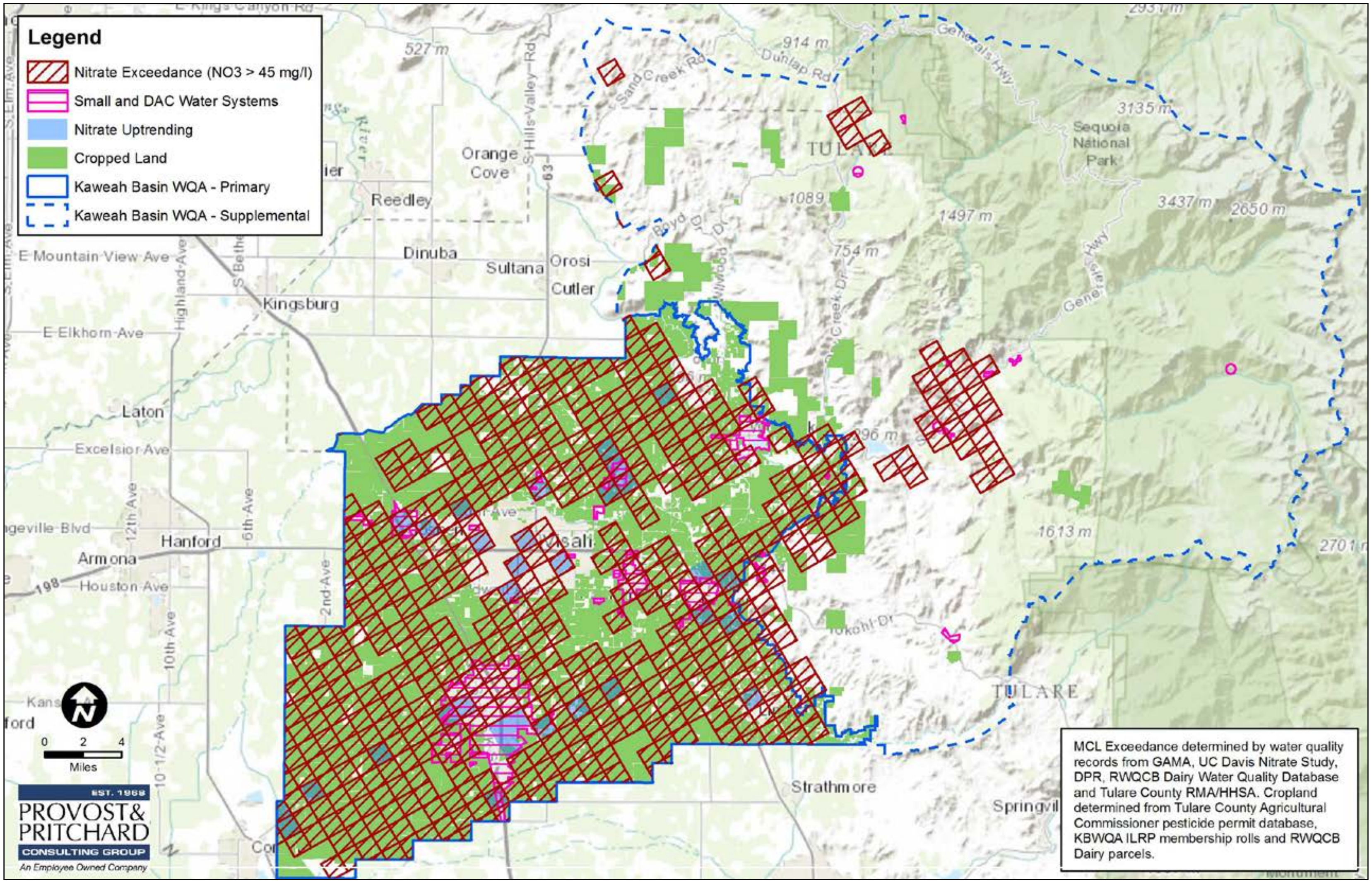

Figure 3. Nitrate Exceedance and Uptrending

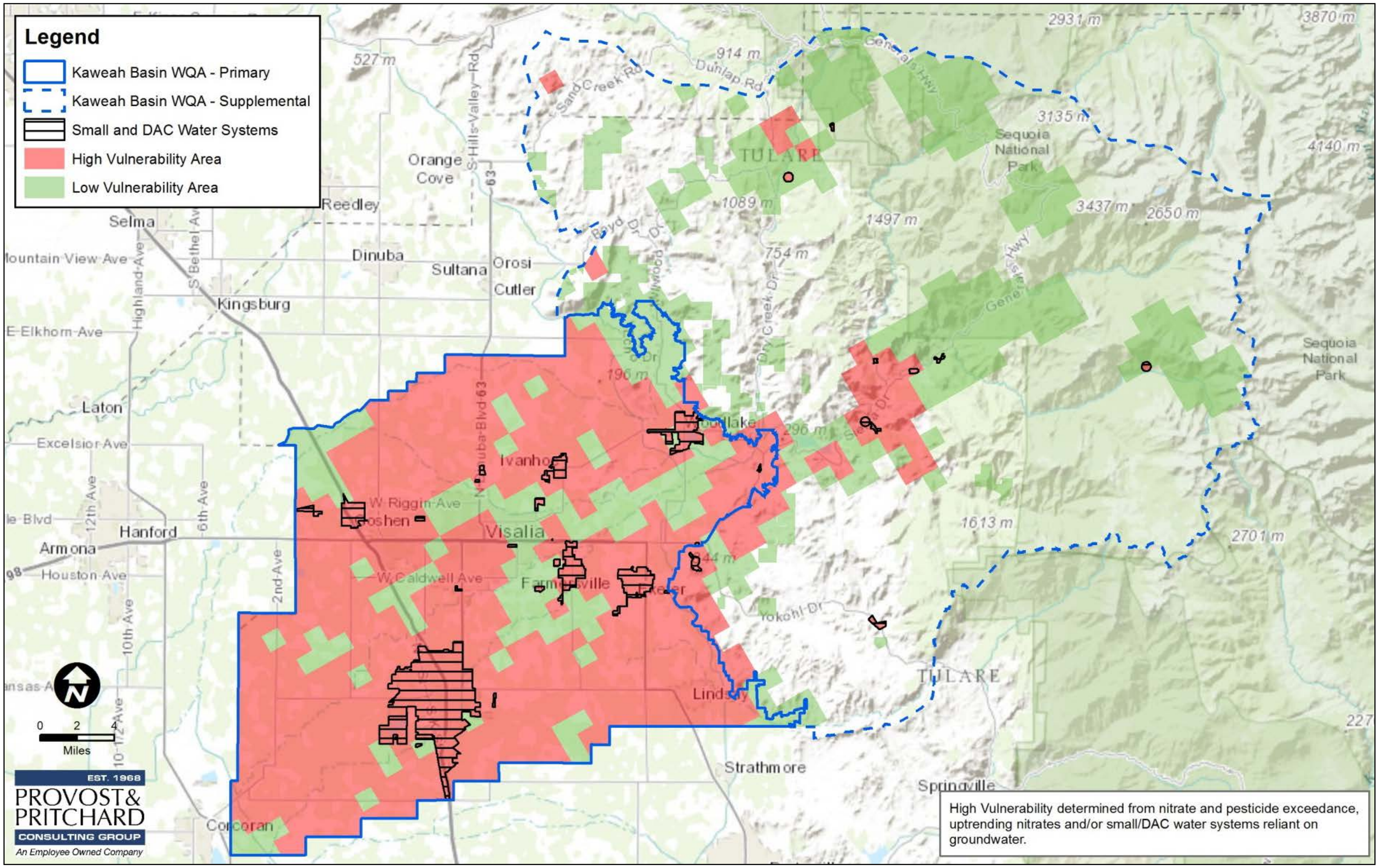

Figure 4. High Vulnerability Area

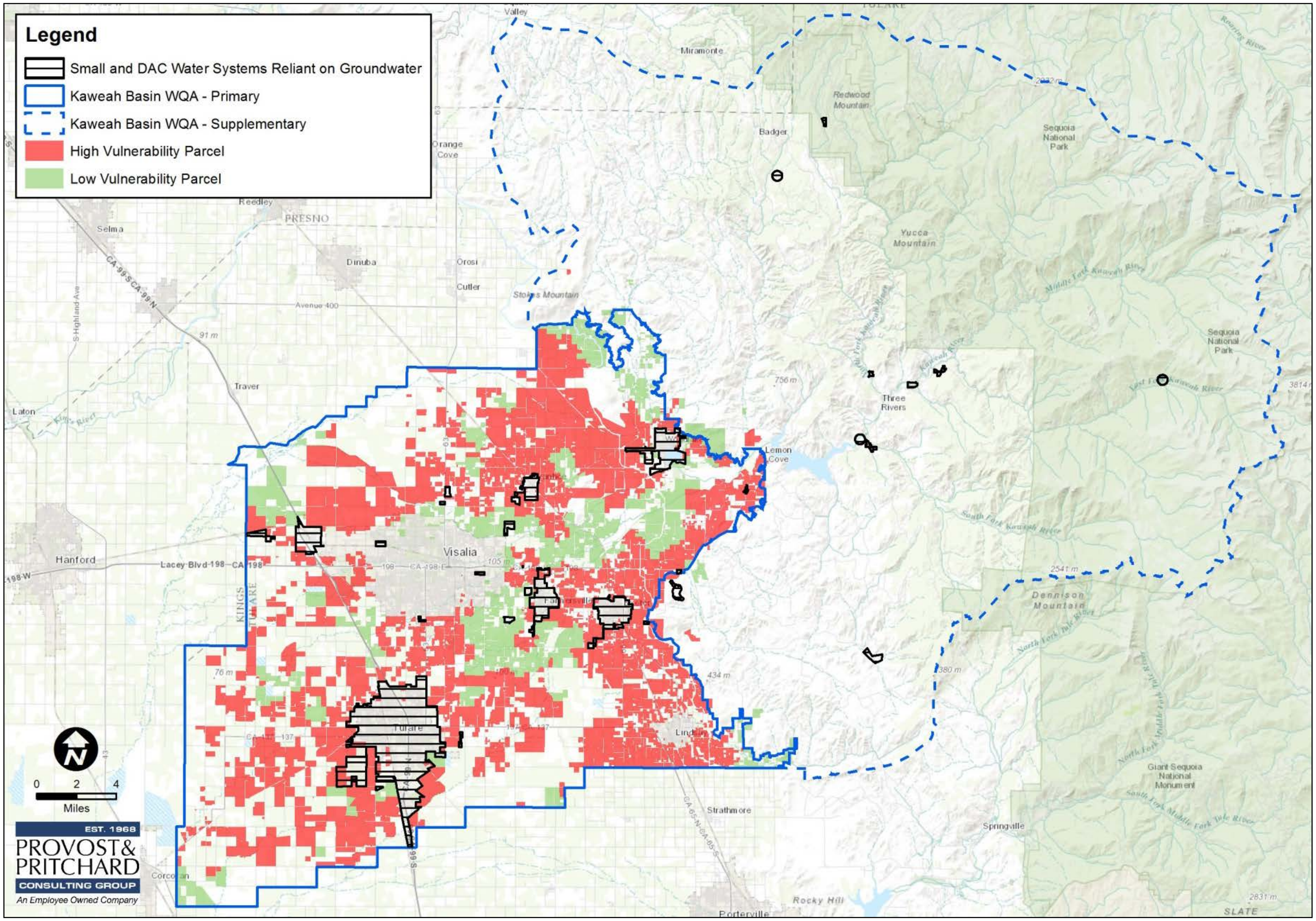

Figure 5. High Vulnerability Area Membership Area

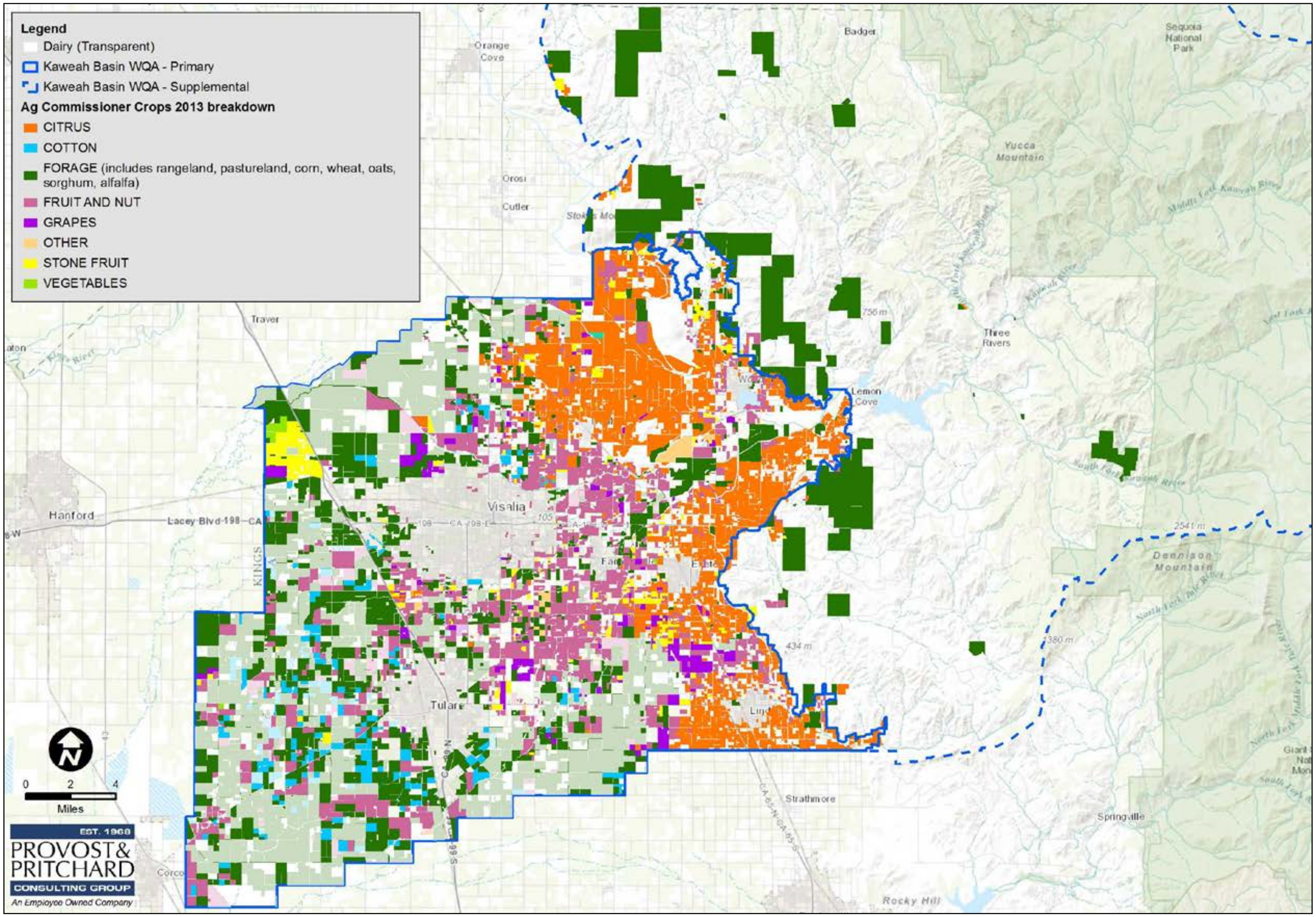

Figure 6. Agricultural Commissioner Crops 2013

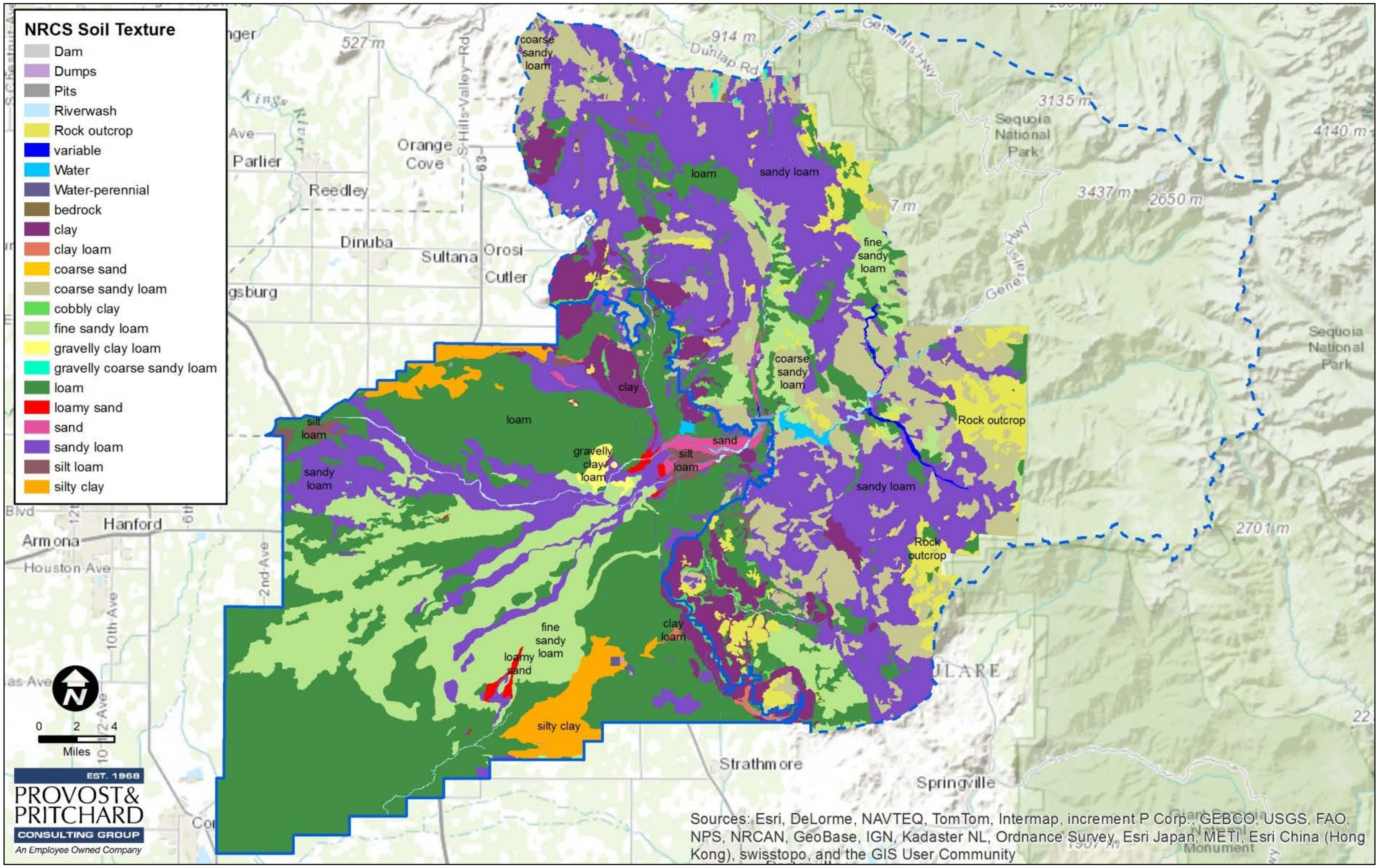

Figure 7. Soil Texture

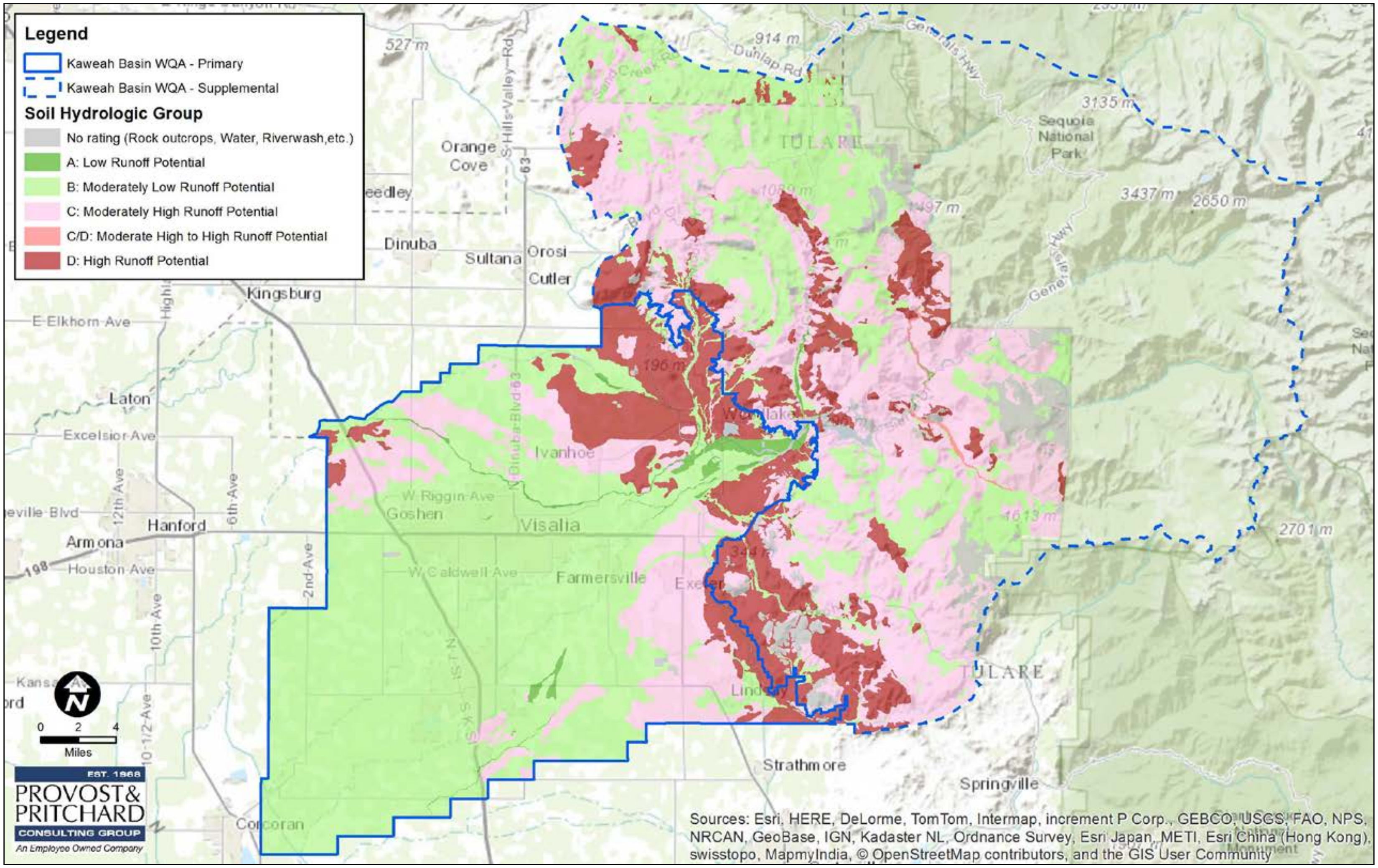

Figure 8. Runoff Potential

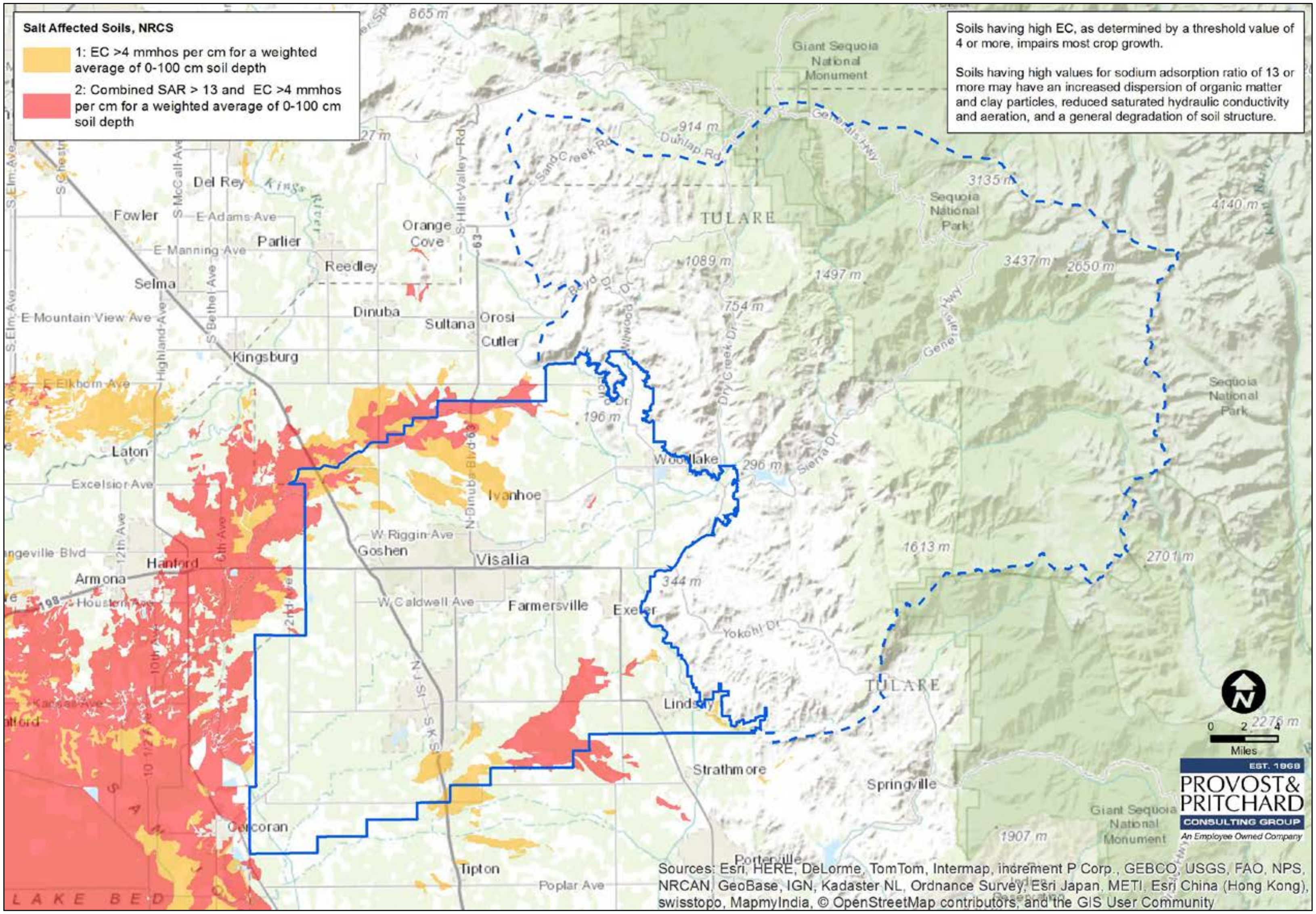

Figure 9. Soil Salinity

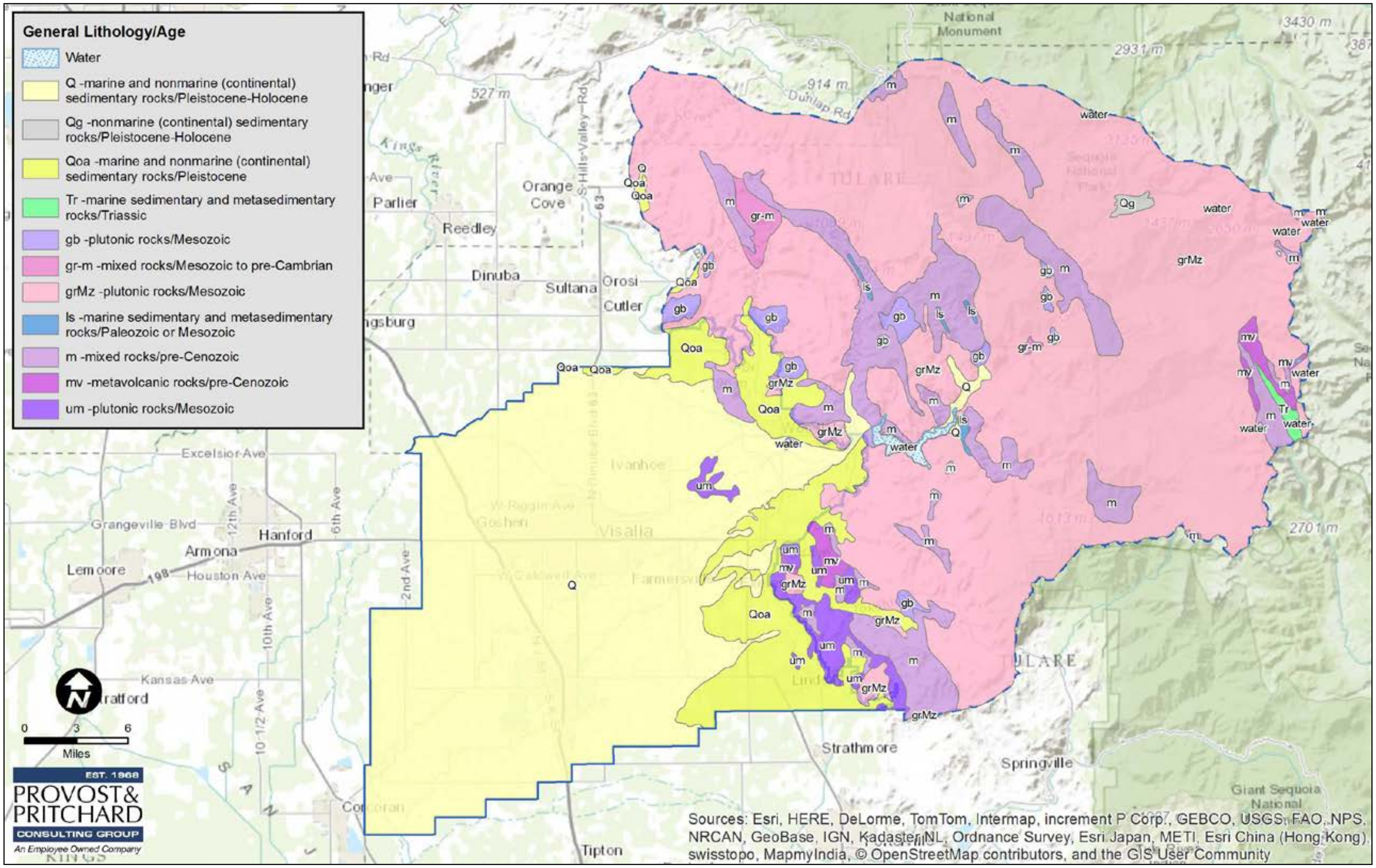

Figure 10. Geology Map

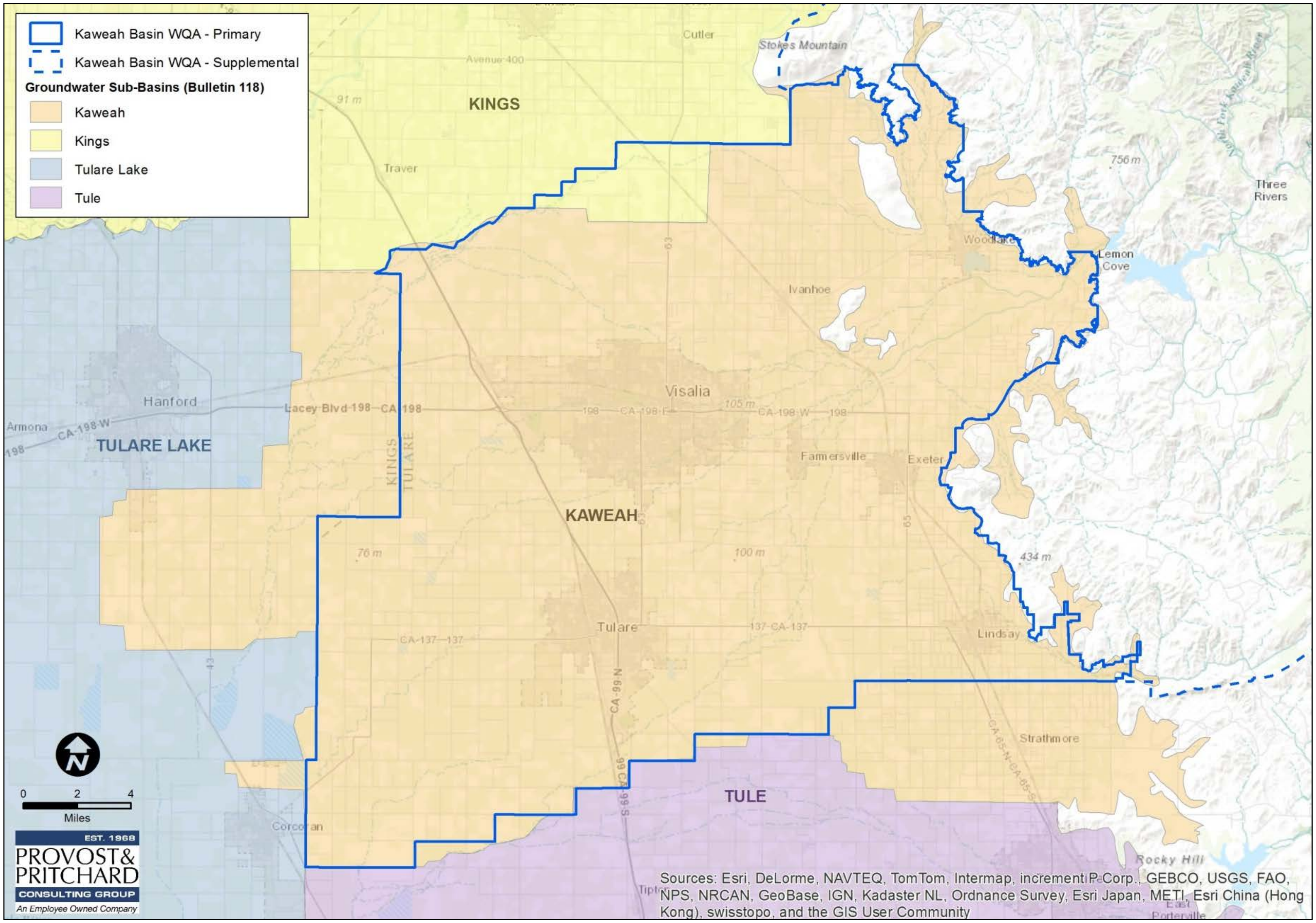

Figure 11. Groundwater Basins

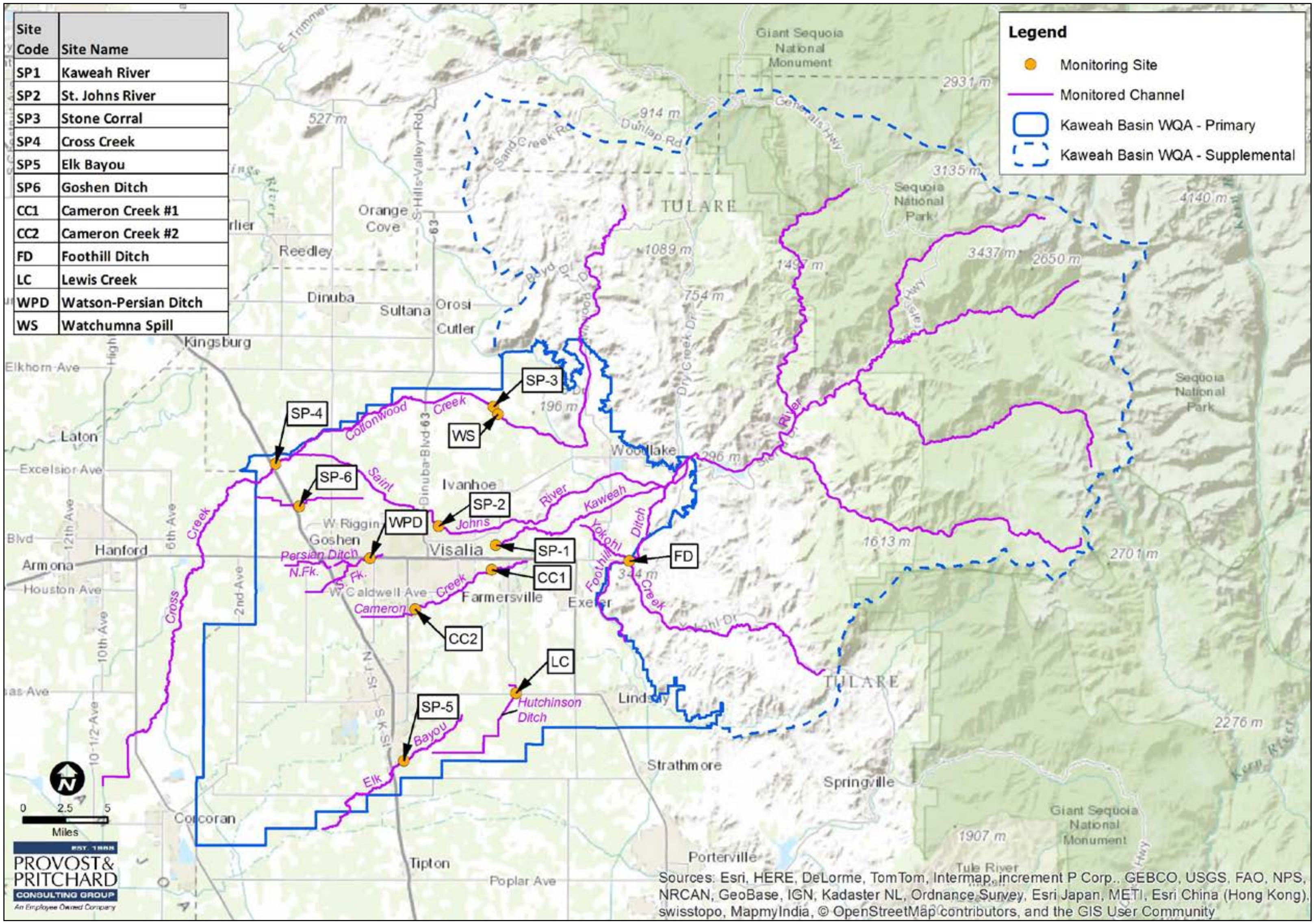

Figure 12. Major Hydrology

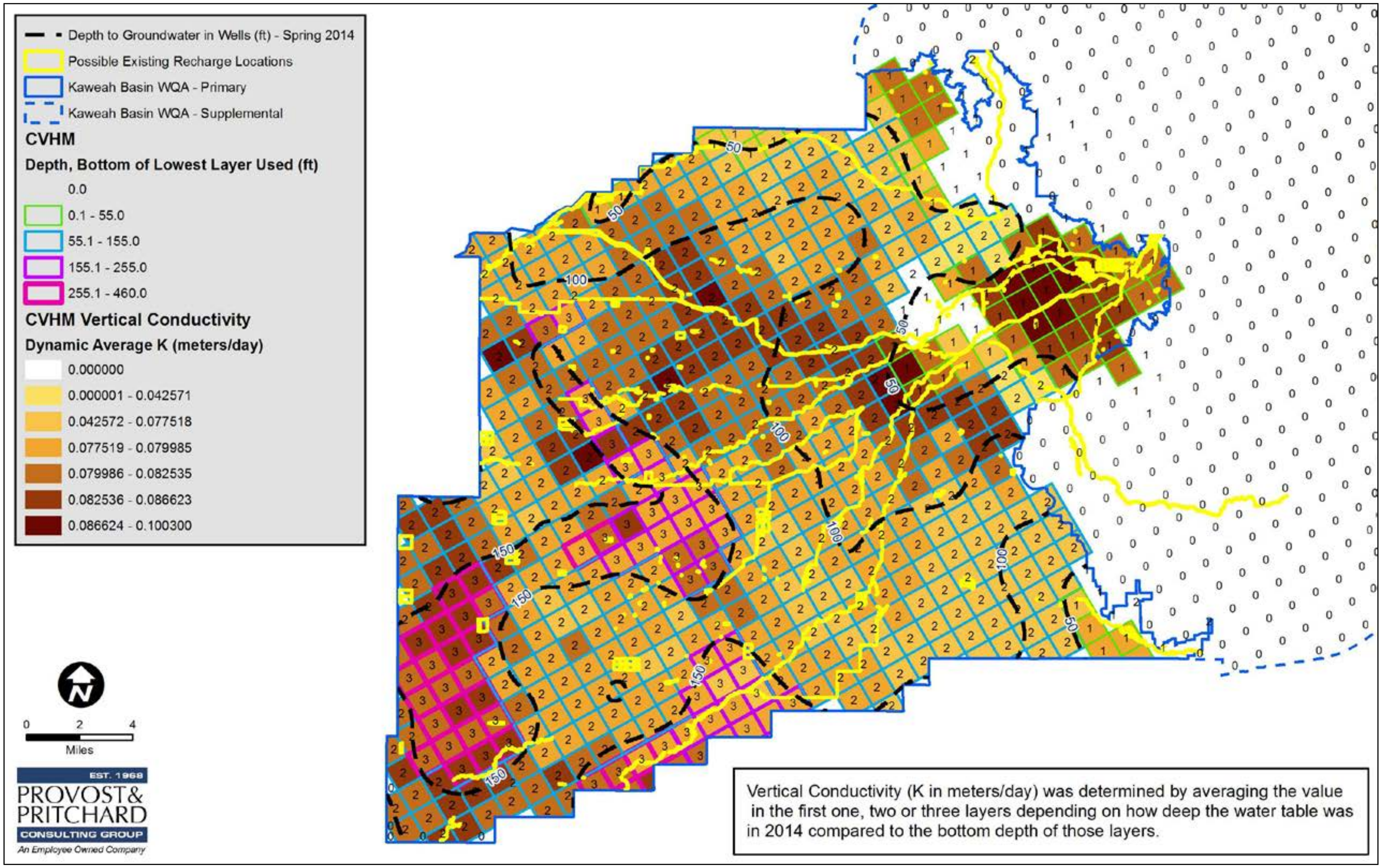

Figure 13. Vertical Conductivity and Potential Recharge Areas

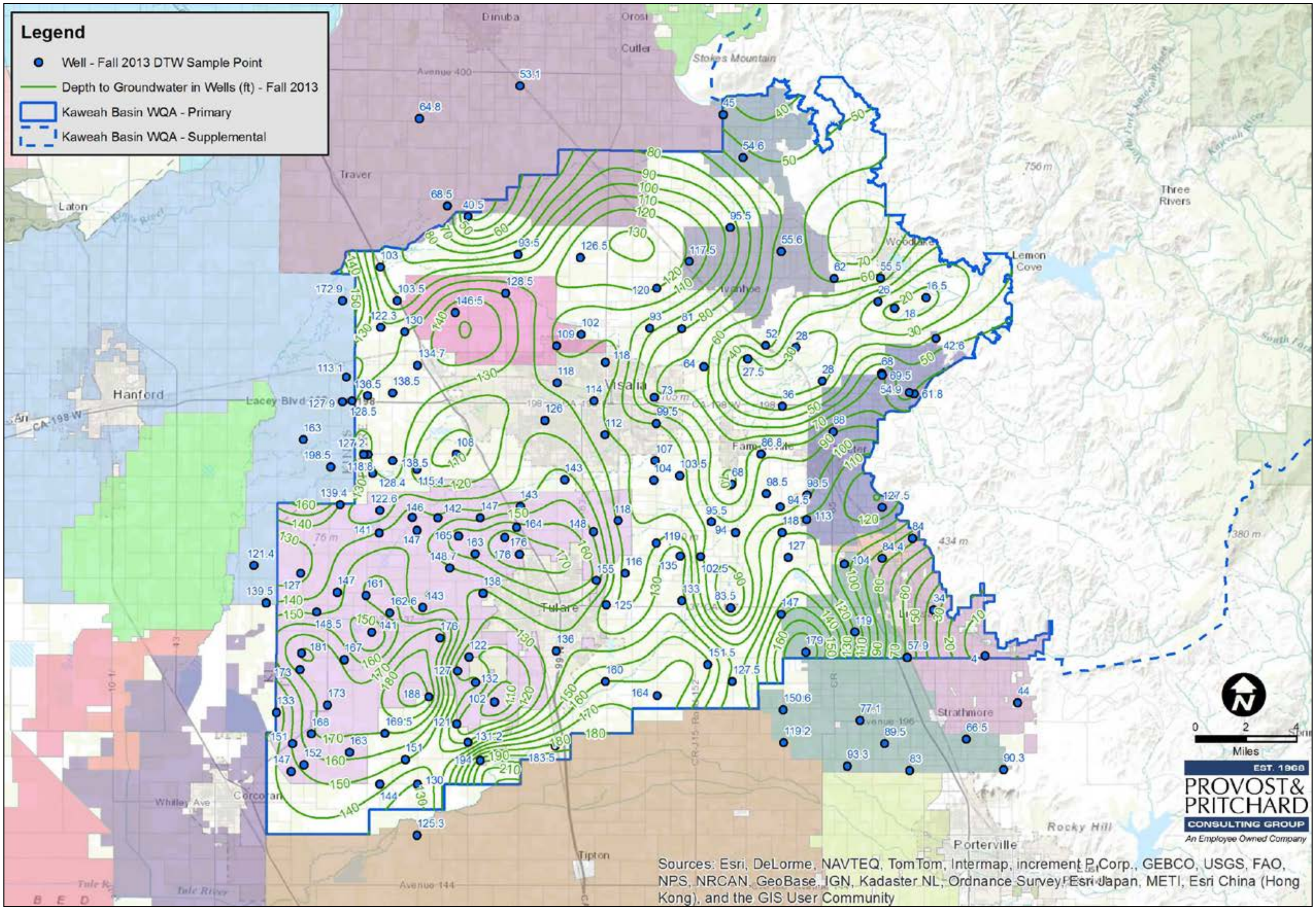

Figure 14. Fall 2013 - Depth to Water

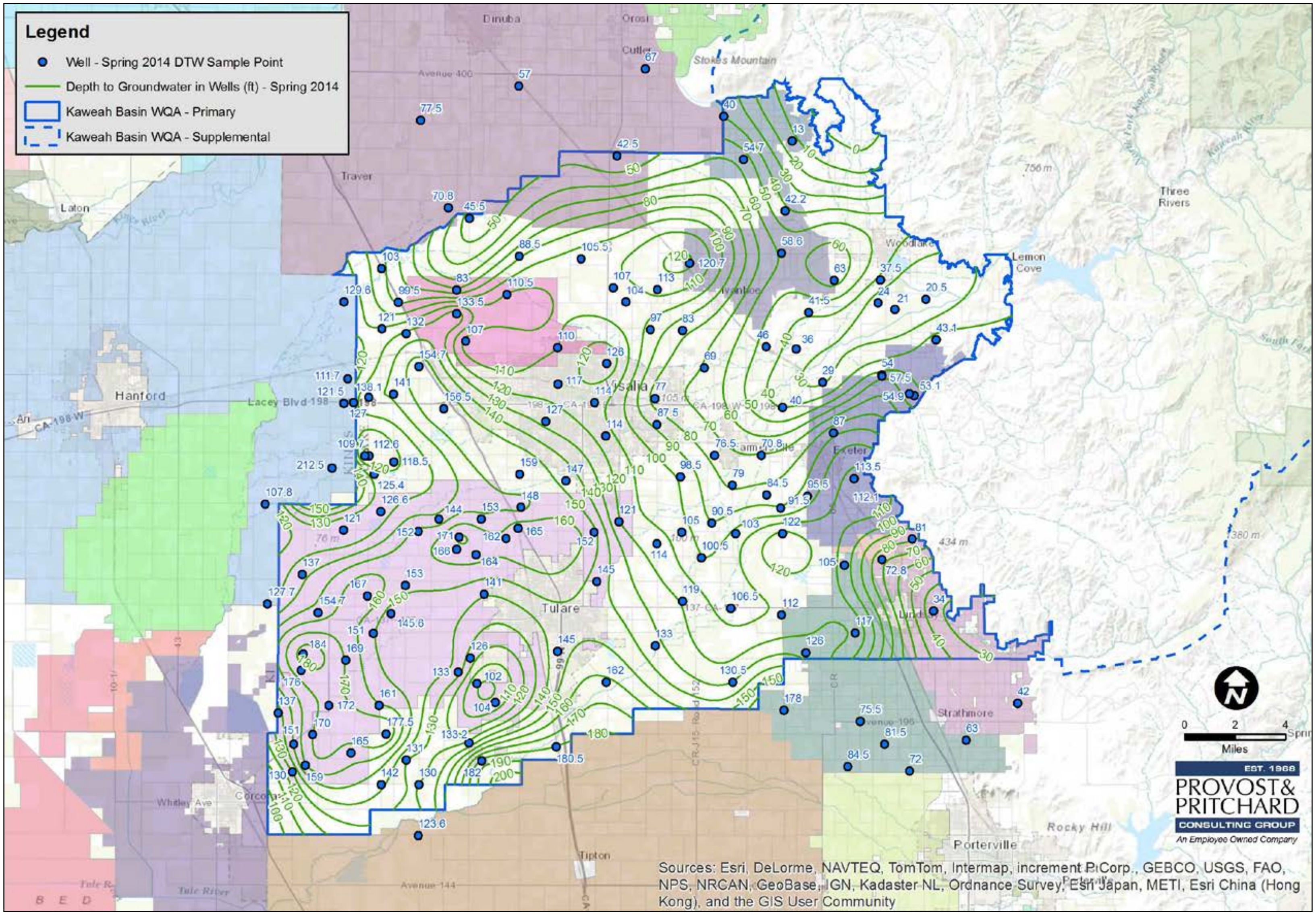

Figure 15. Spring 2014 - Depth to Water

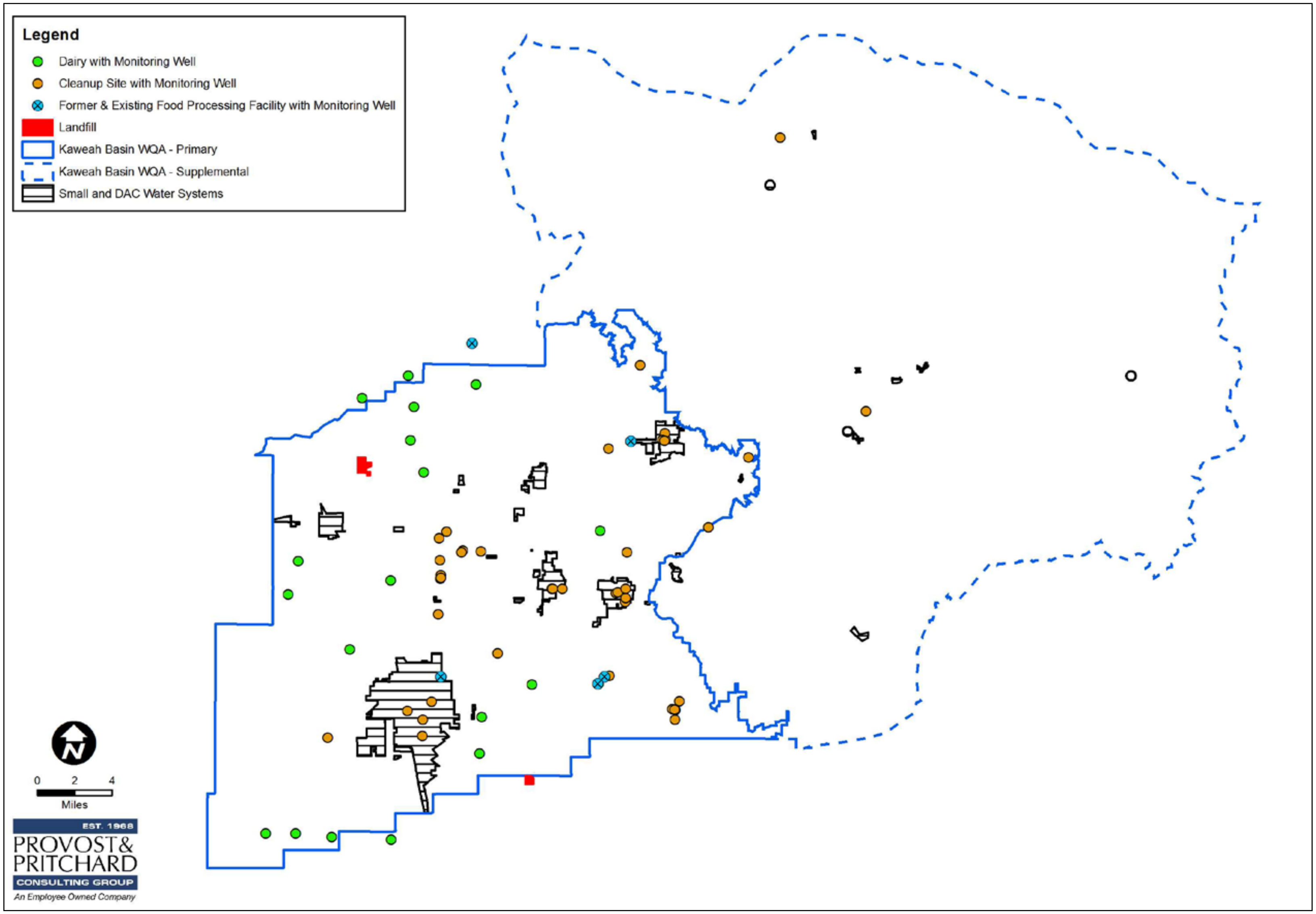

Figure 16. Monitored Dischargers

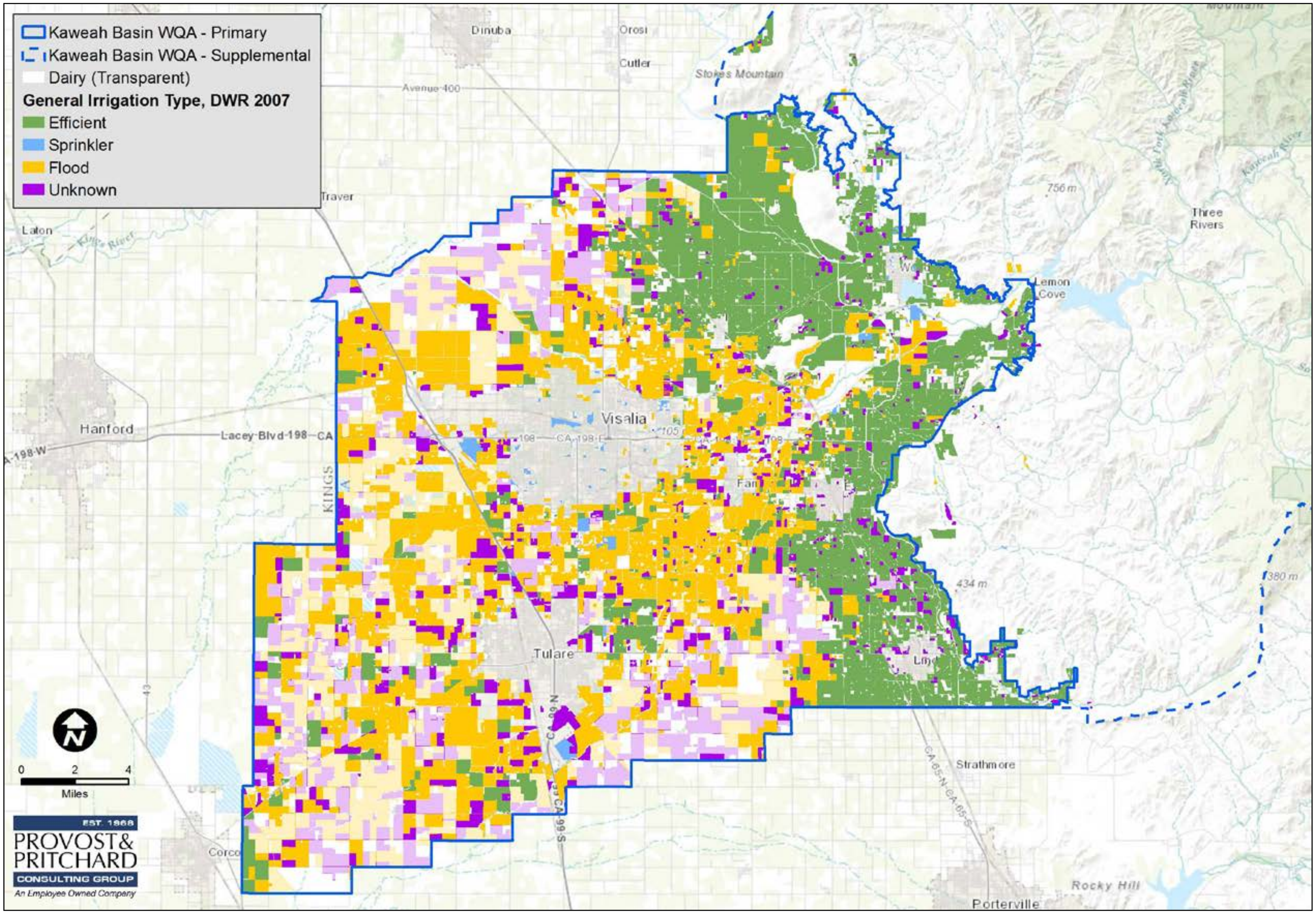

Figure 17. Irrigation Methods

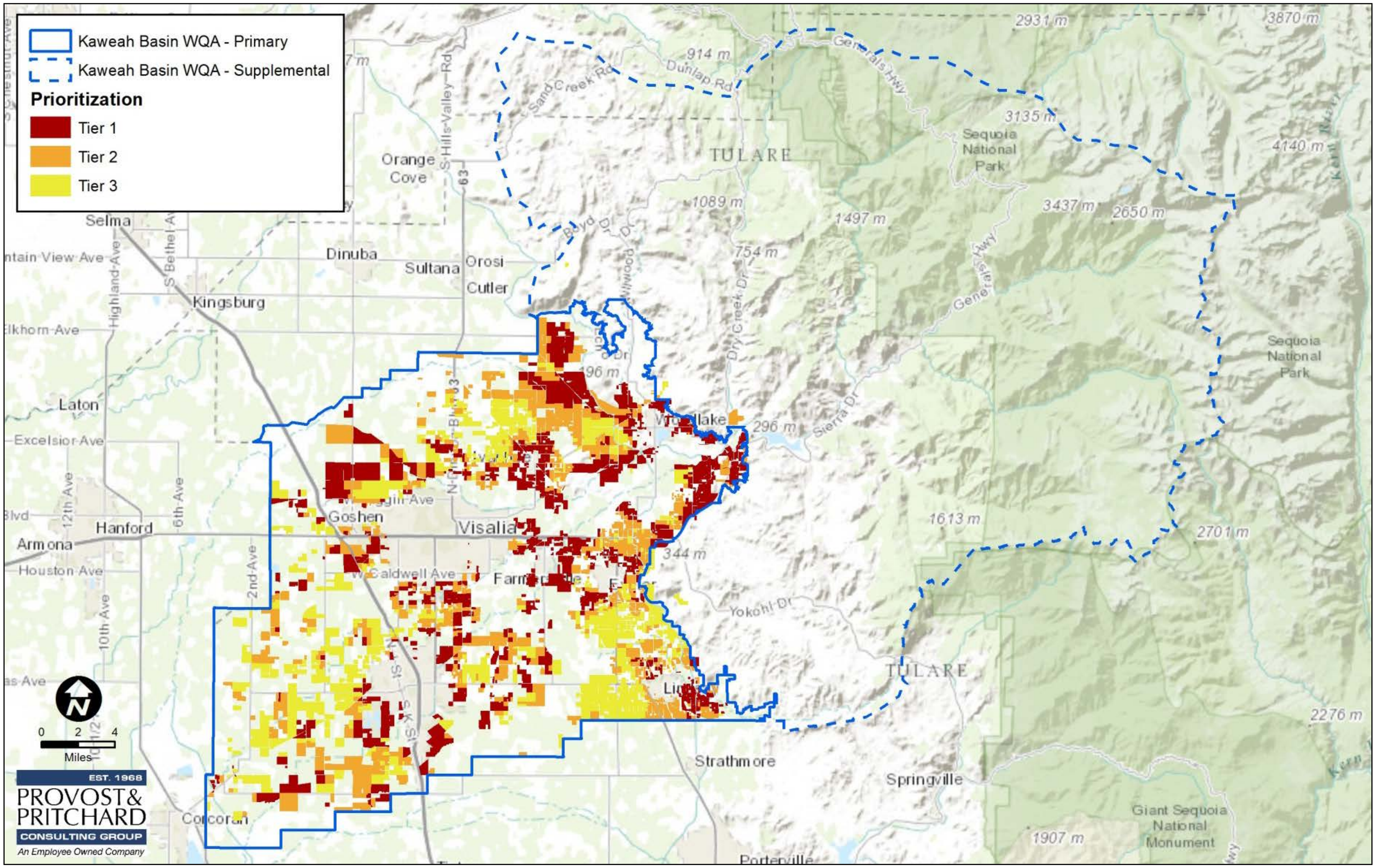

Figure 18. Final Prioritization

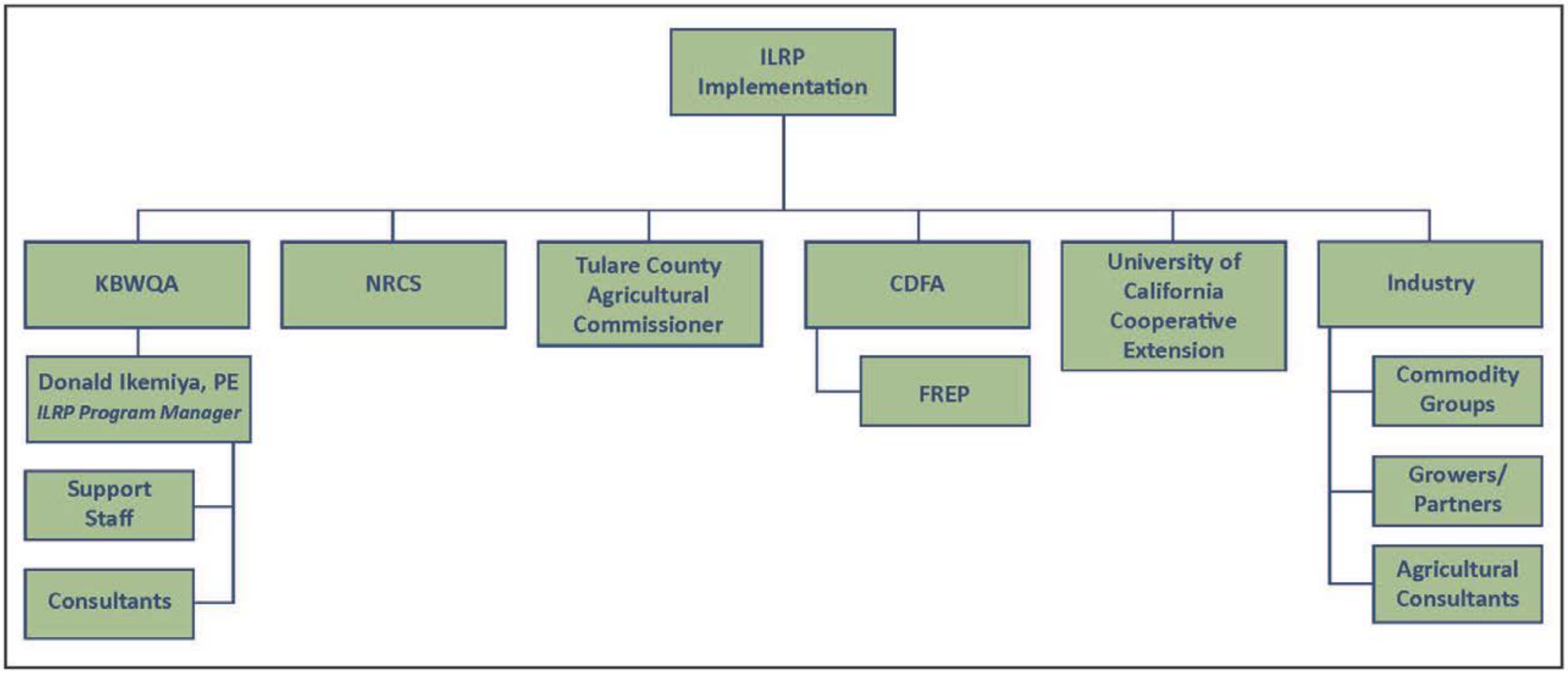

Figure 19. KBWQA Organizational Chart

Table 1. RWQCB-Supervised Sites with Monitoring Well Networks

RWQCB-Supervised Sites with Monitoring Well Networks				
ID #	**# of MWs**	**Business Name**	**City**	**Case Type**
Open Sites – Primary				
SL205194270	15	Sprague Electric Co. (Former)	Visalia	Cleanup Program Site
T0610700157	12	Elderwood Market	Woodlake	LUST Cleanup Site
T0610700193	12	El Rancho Market	Woodlake	LUST Cleanup Site
T0610700279	28	Jack Griggs Inc.-Bulk Plant	Exeter	LUST Cleanup Site
T0610700290	34	Sub Station	Woodlake	LUST Cleanup Site
T0610700327	20	Valley Convenience Store #9	Exeter	LUST Cleanup Site
T0610700407	12	Villicana's Gasoline Alley	Woodlake	LUST Cleanup Site
T0610700464	6	Banti Market	Tulare	LUST Cleanup Site
T0610779138	3	Caltrans Right-of-Way	Exeter	LUST Cleanup Site
T0610793750	13	Chief Enterprises	Lindsay	LUST Cleanup Site
T10000001159	10	Union Pacific Railroad	Tulare	Cleanup Program Site
L10008919544	52	Visalia Landfill	Visalia	Solid Waste Facility
L10001207790	11	Woodlake Landfill - Closed	Woodlake	Solid Waste Facility
L10001505773	21	Exeter Landfill - Closed	Exeter	Solid Waste Facility
L10001873737	37	Woodville Landfill - just south of boundary	Woodville	Solid Waste Facility
	14	Visalia WWTP	Visalia	Wastewater Treatment Plant
	29	Tulare WWTP	Tulare	Wastewater Treatment Plant
	19	City of Lindsay (Lindsay Brine Ponds East)	Lindsay	Food Processors
	25	Sierra Cattle (Lindsay Brine Ponds West)	Lindsay	Food Processors
	6	The Wine Group	Tulare	Food Processors
	3	Aukeman Dairy	Tulare	Dairy Facility
	3 - 6	De Jong Heifer Feed Lot	Visalia	Dairy Facility
	3 - 6	Dykstra Dairy	Tulare	Dairy Facility
	3 - 6	Edwin Brasil Dairy	Visalia	Dairy Facility
	3 - 6	Elkhorn Dairy	Visalia	Dairy Facility
	3	FM Ranch #4 Dairy	Visalia	Dairy Facility
	3	Friesian Farms	Tulare	Dairy Facility
	3 - 6	Highstreet Dairy	Tulare	Dairy Facility
	3	Holstein Farms	Tulare	Dairy Facility
	3 - 6	Homestead Dairy	Visalia	Dairy Facility
	3 - 6	Hynes Dairy	Tulare	Dairy Facility

RWQCB-Supervised Sites with Monitoring Well Networks				
ID #	**# of MWs**	**Business Name**	**City**	**Case Type**
	3 - 6	Rancho Sierra Vista	Visalia	Dairy Facility
	3	Mineral King Dairy	Vislia	Dairy Facility
	3 - 6	Moonlight Dairy	Visalia	Dairy Facility
	3 - 6	Shirk Dairy	Visalia	Dairy Facility
	3 - 6	Sierra View Dairy	Tulare	Dairy Facility
	3	Triple H Dairy	Tulare	Dairy Facility
	3 - 6	Vanderham Dairy	Visalia	Dairy Facility
Open Sites – Supplemental				
T0610700237	35	Sequoia Grocery	Exeter	LUST Cleanup Site
Closed Sites – Primary				
T0610700014	15	Time Oil Co./Mooney Mart	Visalia	LUST Cleanup Site
T0610700028	17	Caltrans Lemon Cove	Lemon Cove	LUST Cleanup Site
T0610700035	21	R. E. Havens Lease Property	Lindsay	LUST Cleanup Site
T0610700038	18	Value & Convenience (Exeter Mini Mart)	Exeter	LUST Cleanup Site
T0610700043	12	Sierra Citrus Packing	Lindsay	LUST Cleanup Site
T0610700108	7	City of Lindsay	Lindsay	LUST Cleanup Site
T0610700170	7	Private Residence	Tulare	LUST Cleanup Site
T0610700175	5	Gong's Market	Farmersville	LUST Cleanup Site
T0610700244	4	Souza Property	Tulare	LUST Cleanup Site
T0610700245	6	J. A. Fischer Inc.	Visalia	LUST Cleanup Site
T0610700248	11	Tosco - Facility #4318	Visalia	LUST Cleanup Site
T0610700288	7	Lonestar Canteen	Exeter	LUST Cleanup Site
T0610700331	15	Roche Oil	Tulare	LUST Cleanup Site
T0610700332	8	Felix's Chevron	Woodlake	LUST Cleanup Site
T0610700363	35	Gas Ranch	Woodlake	LUST Cleanup Site
T0610700381	6	Visalia Unified School District	Visalia	LUST Cleanup Site
T0610700399	4	Tosco - Facility #5389	Visalia	LUST Cleanup Site
T0610700402	11	Quality Mart	Lindsay	LUST Cleanup Site
T0610700426	4	Shell Service Station	Visalia	LUST Cleanup Site
T0610700433	13	Tosco - Facility #2177	Visalia	LUST Cleanup Site
T0610700435	8	Double D Mini Mart	Visalia	LUST Cleanup Site
T0610700436	24	Quick Stop Food Market	Woodlake	LUST Cleanup Site
T0610700453	6	C. P. Phelps	Tulare	LUST Cleanup Site
T0610709906	3	Tri Mart Chevron	Exeter	LUST Cleanup Site

RWQCB-Supervised Sites with Monitoring Well Networks				
ID #	**# of MWs**	**Business Name**	**City**	**Case Type**
T0610741247	3	AA Gas-N-Grub #2	Farmersville	LUST Cleanup Site
T0610752851	12	Shell Service Station	Visalia	LUST Cleanup Site
T0610799010	11	Farmersville Chevron	Farmersville	LUST Cleanup Site
Closed Sites – Supplemental				
T0610700234	3	Private Residence	Three Rivers	LUST Cleanup Site
T0610793753	3	Badger Forest Fire Station	Badger	LUST Cleanup Site

Table 2. Prioritization Matrix

Prioritization Matrix	
	Score
Critical (Score 0-75)	
Nitrate or Pesticide Water Quality over MCL	75 points
Upgradient of a DAC or Small Water System	0.25 miles away – 75 points 0.5 miles away – 25 points >0.75 miles away – 0 points
Nitrate Water Quality Trends	Upward – 50 points Stable – 0 points Downward – minus 25 points
Secondary (Score 0-50)	
NRCS Hydraulic Conductivity	Sand, Loamy Sand, Riverwash – 50 points Sandy Loam, Gravelly Clay Loam, Fine Sandy Loam, Course Sandy Loam, Loam, Silt Loam – 25 points Clay, Clay Loam, Cobbly Clay, Silty Clay – 10 points
CVHM Vertical Hydraulic Conductivity	75-100% – 50 points 50-75% – 30 points 25-50% – 15 points 0-25% – 0 points
Upgradient of Recharge Area	0.25 miles away – 50 points 0.5 miles away – 25 points >0.75 miles away – 0 points
Depth to Groundwater	<50 feet – 50 points 50-100 feet – 25 points >100 feet – 0 points
Groundwater Gradient	Steep – 25 points Moderate – 15 points Fairly Flat – 5 points
Contributing (Score 0-25)	
Irrigation Method	Flood – 25 points Sprinkler – 15 points Efficient – 0 points
Crop	Onion/Cilantro/Cabbage – 25 points Melons/Tomatoes – 14 points Citrus/Alfalfa/Corn/Stone Fruit/Grain & Hay/Walnuts – 7 points Grapes/Olives/Fallow – 0 points
Proximity to Permitted Discharger	0.25 miles away – minus 10 points 0.5 miles away – minus 5 points >0.75 miles away – 0 points
Farm Size	Large – 10 points Small – 0 points

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