Westlands
Water Quality
Coalition

2016 Comprehensive Groundwater Quality Management Plan

Irrigated Lands Regulatory Program

Central Valley Regional Water Quality Control Board

Submitted September 20, 2016

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LIST OF ACRONYMS/ABBREVIATIONS

AB	Assembly Bill
CDPH	California Department of Public Health
COC	Constituent of Concern
CTR	California Toxics Rule
CURES	Coalition for Urban Rural Environmental Stewardship
CVHM	Central Valley Hydrologic Model
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
DAC	Disadvantaged Community
DAU	Detailed Analysis Unit
DBCP	1,2-dibromo-3-chloropropane
DEA	Diethyl-atrazine
DEM	Digital Elevation Model
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
EC	Electrical Conductivity
EPA	U.S. Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FEP	Farm Evaluation Plan
GAR	Groundwater Assessment Report
GAMA	Geotracker database
GIS	Geographic Information System
GQMP	Groundwater Quality Management Plan
GQTM	Groundwater Quality Trend Monitoring
HVA	High Vulnerability Area
HHVA	Hydrogeologic High Vulnerability Area
HR	Hydrologic Region
I	Irrigated
ILP	Irrigated Lands Program
ILRP	Irrigated Land and Regulatory Program
IPNI	International Plan Nutrition Institute
MCL	Maximum Contaminant Level

MLJ-LLC	Michael L. Johnson, LLC
MPEP	Management Practice Evaluation Program
N	Nitrogen
NA	Not Applicable
NED	USGS National Elevation Dataset
NI	Non-irrigated
NOA	Notice of Applicability
NMP	Nitrogen Management Plan
NRCS	Natural Resource Conservation Service
NWIS	National Water Information System
PA	Planning Area
PAM	Polyacrylamide
PCA	Pesticide Control Adviser
pH	Power of Hydrogen
PLSS	Public Land Survey System
SB	Senate Bill
SC	Specific Conductance
SNMP	Salt and Nitrate Management Plan
SWRCB	State Water Resources Control Board
TAF	Thousand Acre Feet
TDS	Total Dissolved Solids
TRS	Township Range Section, Public Land Survey System
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WDL	Water Data Library
WDR	Waste Discharge Requirements General Order r5-2014-0001
WQO	Water Quality Objective
WQTL	Water Quality Trigger Limit
WWD	Westlands Water District
WWQC	Westlands Water Quality Coalition

LIST OF UNITS

af	acre feet
°C	degrees Celsius
cm	centimeter
ft	foot
L	Liter
mg	milligram
µg	microgram
µmhos	microsiemens

1 Introduction and Background

The Comprehensive Groundwater Quality Management Plan (GQMP) outlined in this document, addresses the requirements of the Waste Discharge Requirements General Order (WDR or General Order; No. R5-2014-0001) for Growers within the Western Tulare Lake Basin Area. The GQMP presents the Coalition's approach to reducing/eliminating impairments of beneficial uses of groundwater. The Management Plan approach involves three activities: 1) a broad spectrum method of identification of whether or not constituents of concern are related to agricultural practices and the identification of potential agricultural sources, 2) outreach to all members whose parcels lay above groundwater identified as exceeding water quality parameters, providing recommendations of management practices with the potential to be effective in managing discharges, and 3) monitoring to evaluate the efficacy of those implemented management practices.

1.1 Background

The Central Valley Regional Water Quality Control Board (the Regional Water Board or CVRWQCB) initiated the Irrigated Lands Program (ILP) in 2003 (and renewed in 2006) with the adoption of a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands. The ILP, later the Irrigated Lands Regulatory program (ILRP), was developed to regulate discharges from irrigated agriculture to surface waters. The Waste Discharge Requirements General Order for Growers within the Western Tulare Lake Basin Area (WDR or General Order; No. R5-2014-0001), along with other orders adopted for the irrigated lands within the Central Valley, constitute the long- term ILRP, an expansion of the initial ILRP to include discharges to groundwater.

The Westlands Stormwater Coalition submitted a Notice of Intent (NOI) in October 2003 and received a Notice of Applicability (NOA) from the Executive Officer in 2004. The NOA approved the Westlands Stormwater Coalition's request to operate as a lead entity under the previous Coalition Group Conditional Waiver (Order R5-2006-0053) within its boundaries. Similar to the Coalition Group Conditional Waiver, General Order No. R5-2014-0001 was written for a third-party to provide a lead role in conducting monitoring, educating member growers (Members), developing water quality management plans, and interacting with the Central Valley Water Board on behalf of Members. Due to a substantial number of new requirements, General Order No. R5-2014-0001 required that the third-party submit a new application to serve as a third-party representing growers under this General Order to continue representing Members.

The Westlands Water Quality Coalition (WWQC or Coalition) was selected as the third-party group representing Coalition Members in the Western Tulare Lake Basin Area. Members of the WWQC are those landowners and/or operators of irrigated lands who have enrolled an irrigated land parcel(s) under the General Order within the area represented by the WWQC. By enrolling an irrigated land parcel under the General Order, members obtain regulatory coverage for operational discharges and agree to comply with the terms and conditions of the General Order. Some growers in the Coalition region may elect to be regulated as individuals. According to the General Order, the Western Tulare Lake Basin Area has approximately 528,000 acres of irrigated cropland, and approximately 1,070 growers with "waste discharges from irrigated lands." Also, nearly all of these irrigated acres are currently regulated under the Coalition Group Conditional Waiver; however, it is anticipated that some additional irrigated acres will require regulatory coverage under the General Order or other WDRs or waivers.

Following the Regional Water Board's adoption of the WDR on January 9, 2014, the NOA was conditionally approved By the Regional Water Board on February 14, 2014 for the WWQC. The conditional approval date associated with the NOA started the timeline for several requirements, including submittal of an NOI from entities wishing to join the Coalition and for the Coalition to submit an outline of the Groundwater Assessment Report (GAR) (General Order, Section IV. A). The due date for the GAR outline was May 15, 2014; and for the GAR itself the submission deadline was February 16, 2016. The GAR provides the basis for the GQMP, the Groundwater Quality Trend Monitoring Program (GQTMP), and the Management Practices Evaluation Program (MPEP). Work plans for both the GQTMP and MPEP are due one year following the approval of the GAR.

The GAR outline was submitted May 16, 2014 and the CVRWQCB issued a review of the outline on August 18, 2014, making the next step to prepare the GAR based on the approved outline. The GAR was submitted to the CVRWQCB on February 16, 2016 and conditionally approved on June 8, 2016. The CVRWQCB's conditional approval of the GAR established the Comprehensive GQMP's required submittal date to be August 7, 2016, 60 days after the review and conditional approval of the GAR. An extension of the GQMP submittal date to September 20, 2016 was approved on July 18, 2016.

The GQMP is developed following the requirements listed in the General Order using existing groundwater data and a review of current regional groundwater management plans. The overarching goal of the GQMP is to improve the groundwater quality within the Coalition region. Requirements of the General Order and their location within the GQMP are listed in Table 1.

1.2 Coalition and Comprehensive Groundwater Quality Management Plan Boundaries

Geographically, the Western Tulare Basin Area encompasses the Westlands Water District (WWD) and Westside subbasin, portions of the Pleasant Valley subbasin, portions of the eastern Coast Ranges, and some small inter-montane basins to the crest of the Coast Ranges. It is bound on the north by the WWD's northern boundary and portions of the Panoche-San Luis Reservoir watersheds, on the east by the WWD's boundary, to the south by the WWD's boundary and portions of Upper Los-Gatos-Avenal and Tulare-Buena Vista Lakes watersheds, and to the west by the crest of the Coast Ranges (Figure 1) (CVRWQCB, 2014). The GQMP covers the entire area within the Coalition boundary, as it applies to irrigated agriculture.

1.2.1 Groundwater Basin(s) within Coalition Region

The Western Tulare Lake Basin Area lies within the San Joaquin Valley Groundwater Basin, as defined in Bulletin 118 from the Department of Water Resources (DWR) (DWR, 2003) (Figure 2). The Coalition region also includes the Panoche Valley Basin and the Vallecitos Creek Basins to the west of the Central Valley floor, within the Coast Range mountains. The Western Tulare Lake Basin Area is part of the larger Tulare Lake Basin, which is normally a hydrologically closed basin except during periods of above average surface water flows, when flood control waters are diverted out of the basin through Fresno Slough and James Bypass into the San Joaquin River (CVRWQCB, 2014). From north to south, all or portions of seven groundwater basins/subbasins lie within the Coalition region: Delta-Mendota, Westside, Panoche Valley, Vallecitos Creek Valley, Kings, Pleasant Valley, and Tulare Lake (Figure 3). The Westside, Panoche Valley, and Vallecitos Creek Valley basins/subbasins are entirely or almost entirely (in the case of the Westside subbasin) within the Coalition boundaries while narrow slivers of the Delta-Mendota,

Kings, Tulare Lake, and Pleasant Valley subbasins lie to the north, east, southeast, and south of the Coalition boundary, respectively.

Table 1. WDR requirements for groundwater quality monitoring plans and their corresponding sections within the WWQC GQMP.

Required Element (Appendix MRP-1)	Groundwater Quality Management Plan Sections
A. Introduction and Background	**Introduction and Background**
Previous work conducted to identify occurrence of COCs	Summary of Water Quality Data and Groundwater Quality Concerns within the Coalition
B. Physical Setting and Information	**Physical Setting and Geographical Characteristics**
B.1.a. Land use maps	Land Use
B.1.b. Identification of potential agricultural sources of COCs	Groundwater Constituents of Concern
B.1.c. Beneficial uses	Groundwater Beneficial Uses
B.1.d. Baseline of management practices	Existing Agricultural Management Practices
B.1.e. Summary, discussion, and compilation of ground water quality data	Previous Work to Identify Constituents of Concern in Groundwater
B.3. a. Soil information	Geology and Hydrology
B.3.b. Geology and hydrology	Geology and Hydrology
B.3.b.i. Regional geology	Geology and Hydrology
B.3.b.ii. Groundwater basins and sub-basins in area	Coalition Boundaries / Geology and Hydrology
B.3.b.iii. Known water bearing zones	Geology and Hydrology
B.3.b.iv. Identify water bearing zones used for domestic, irrigation, and municipal water	Geology and Hydrology
B.3.b.v. Aquifer characteristics	Geology and Hydrology
B.3.c. Identification of water chemistry	Geology and Hydrology
B.3.c. Identification of irrigation water sources	Land Use
C. Management Plan Strategy	**Management Plan Strategy**
C.1. Description of approach	Description of Approach
C.2. Actions to meet goals and objectives	Actions to Meet Goals and Objectives
C.2.a. Compliance with receiving water limitations	Actions to Meet Goals and Objectives
C.2.b. Educate members	Outreach Methods
C.2.c. Identify, validate and implement management practices	Identify Management Practices that are Protective of Groundwater/Management Plan Effectiveness
C.3 Duties and responsibilities of individuals	Duties and Responsibilities
C.4. Strategies to implement the management plan tasks	Strategies to Implement Management Plan Tasks
C.4.a. ID entities or agencies	Agencies Contacted for Data and/or Assistance
C.4.b. ID management practices	Management Practices to Control COCs
C.4.c. ID outreach	Outreach Methods
C.4.d. Specific schedule and milestones	Specific Schedule and Milestones for Implementing Management Practices
C.4.e. Measurable performance goals with specific targets	Performance Goals and Performance Measures
D. Monitoring Methods	**Monitoring Methods**
D.3 Management Practice Evaluation Program and Groundwater Quality Trend Monitoring	Identify Management Practices that are Protective of Groundwater
E. Data Evaluation	**Data Evaluation**
F. Records and Reporting	**Records and Reporting**
G. Source Identification Study Requirements	**Strategies to Implement Management Plan Tasks**

Figure 1. Westlands Water Quality Coalition boundary.

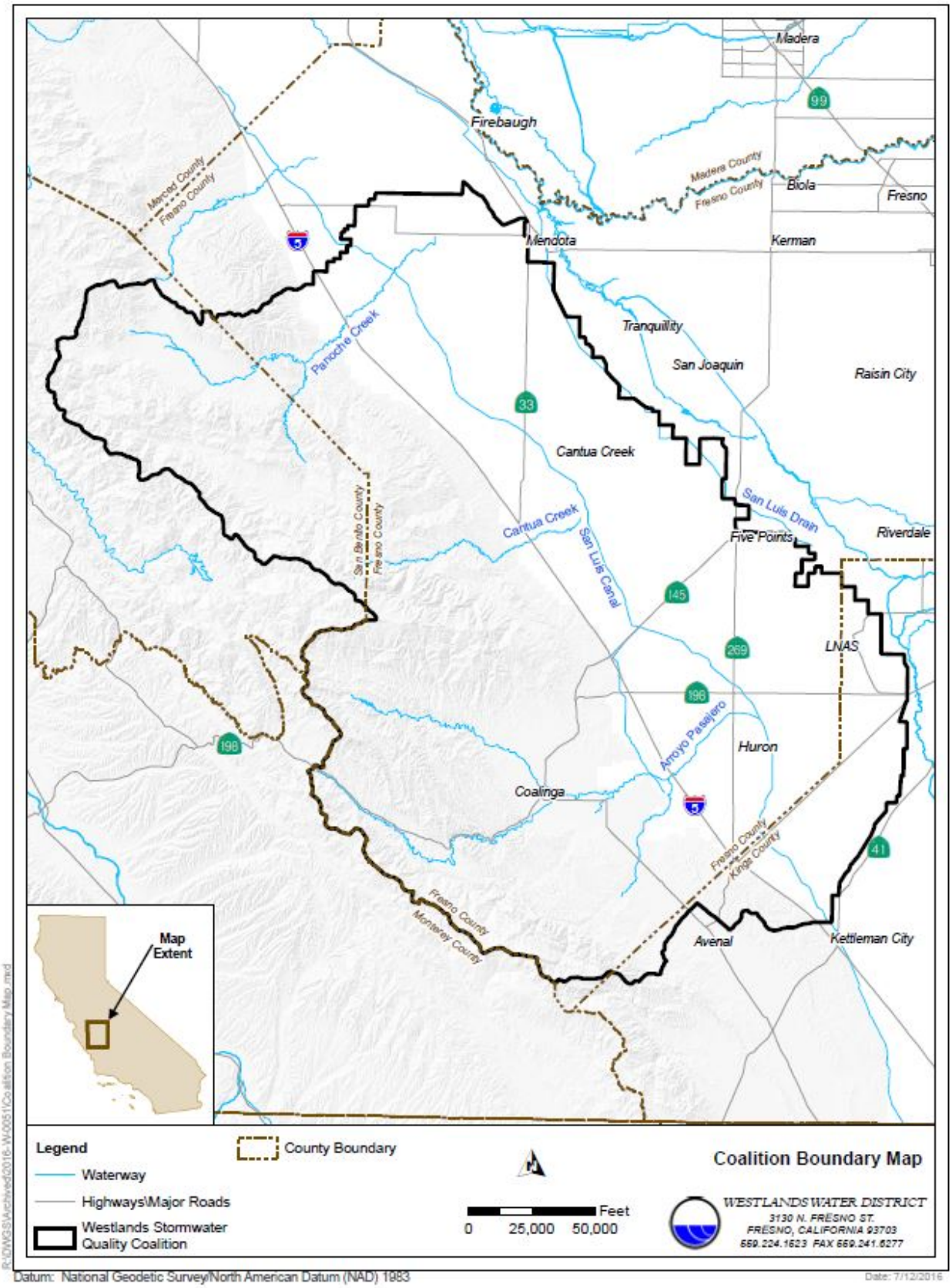
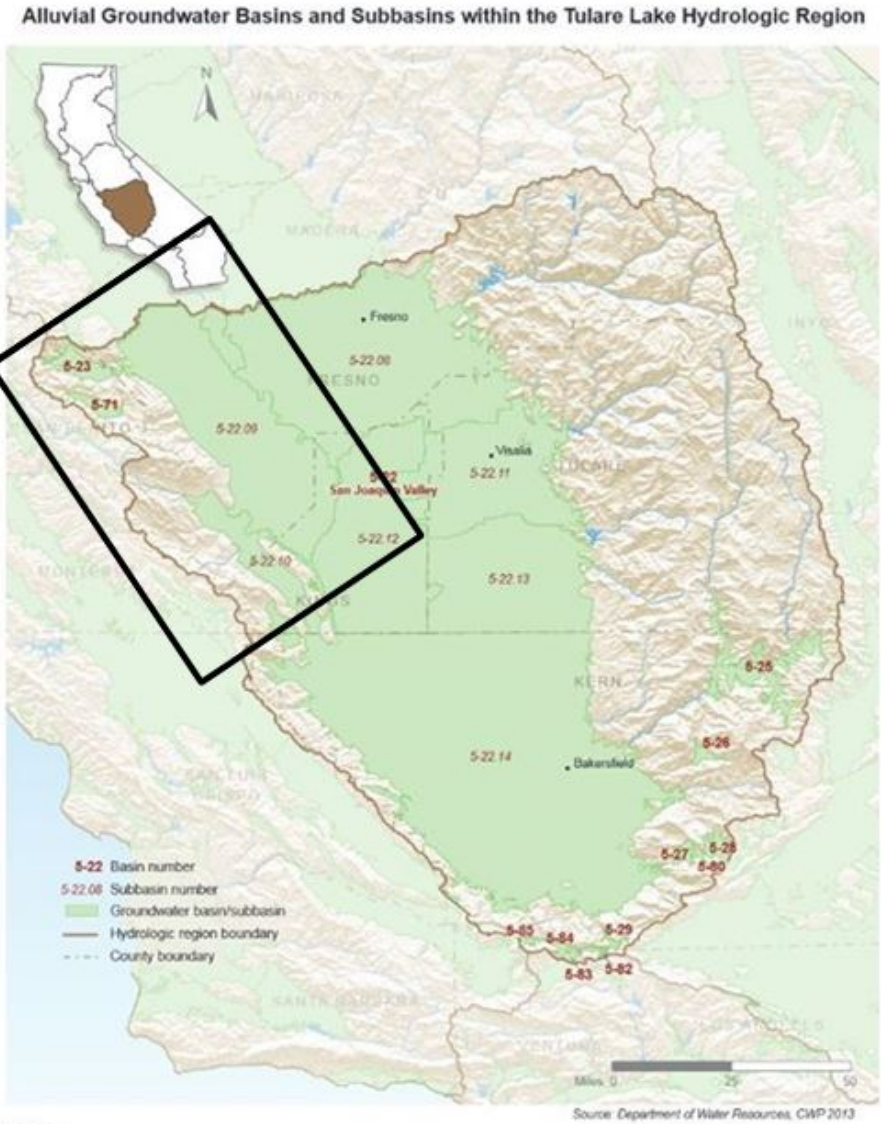
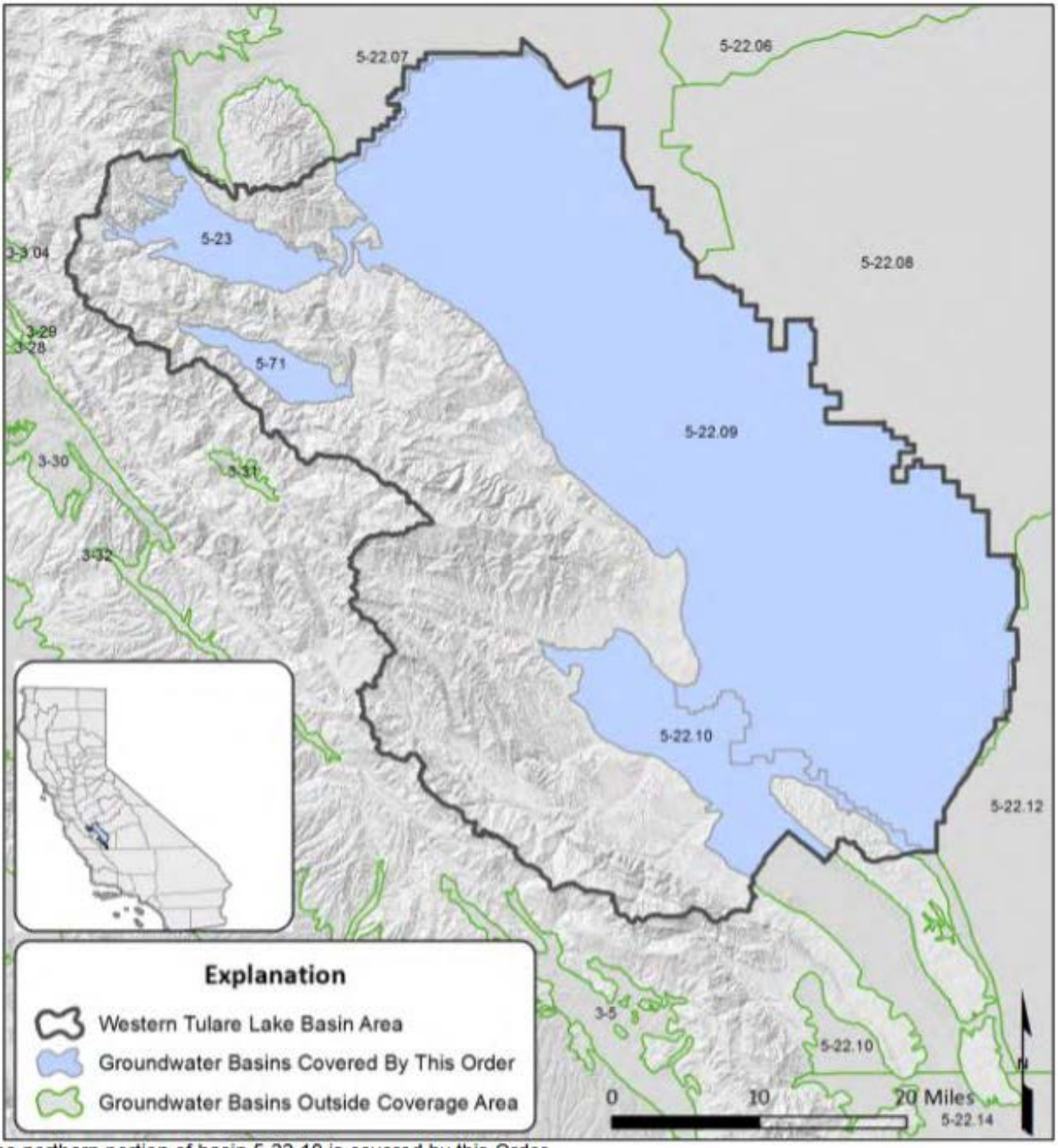


Figure 2. DWR Designated Groundwater Basins and Subbasins within the Coalition region (DWR, 2013)



Basin/subbasin	Basin name
5-22	San Joaquin Valley
5-22.08	Kings
5-22.09	Westside
5-22.10	Pleasant Valley
5-22.11	Kaweah
5-22.12	Tulare Lake
5-22.13	Tule
5-22.14	Kern County
5-23	Panoche Valley
5-25	Kern River Valley
5-26	Walker Basin Creek Valley
5-27	Cummings Valley
5-28	Tehachapi Valley West
5-29	Castac Lake Valley
5-71	Vallecitos Creek Valley
5-80	Brite Valley
5-82	Cuddy Canyon Valley
5-83	Cuddy Ranch Area
5-84	Cuddy Valley
5-85	Mil Potrero Area

Figure 3. Groundwater Basins/sub-basins within the Western Tulare Lake Basin Area (CVRWQCB, 2014).



*The northern portion of basin 5-22.10 is covered by this Order

Groundwater Basins covered by this Order	
5-22 .09 Westside	5-22 .10 Pleasant Valley
5-23 Panoche Valley	5-71 Vallecitos Creek Valley
5-22 .12 Tulare Lake	5-22 .08 Kings
5-22 .07 Delta-Mendota	

1.3 Summary of Water Quality Data and Groundwater Quality Concerns within the Coalition

The Coalition's GAR summarizes current and historic groundwater quality data (dating back to 1929) in the Western Tulare Lake Basin area using data from local, state, and federal agencies. The GAR lists groundwater quality data relevant to irrigated agricultural practices, provides a spatial and temporal assessment of constituents in the groundwater, and serves as the survey of current, available groundwater quality data necessary to develop effective GQMPs for the Coalition region. Review of the groundwater quality data compiled from a variety of well depths throughout the Coalition region, indicates the primary groundwater quality concerns within the WWQC are nitrate, total dissolved solids (TDS), and the pesticide simazine. The California Department of Public Health's (CDPH) Primary Maximum Contaminant Level (MCL) for nitrate and simazine were used as the thresholds for establishing an exceedance of those constituents; 10 and 4 mg/L, respectively. The CDPH's Secondary MCL for TDS of 500 mg/L was used as the threshold for establishing an exceedance of that constituent.

High salts can be attributed to marine sediments in the Coast Range in the west side of the San Joaquin Valley and a culmination of evaporation and poor drainage resulting in increased salt concentrations within the Central Valley floor. In the central and west-side portions of the valley, where the Corcoran Clay confining layer exists, water quality is generally better beneath the clay than above it. Nitrates may occur naturally or as a result of anthropogenic sources such as human/animal waste or fertilizers. As described in Bulletin 118, agricultural pesticides and herbicides have been detected in groundwater throughout the Central Valley, especially along the east side, where soil permeability is higher and depth to groundwater is shallower. Areas of high nitrate concentrations are known to exist near the town of Shafter and other isolated areas in the San Joaquin Valley. High levels of arsenic occur locally and appear to be associated with lakebed areas.

1.3.1 Groundwater Vulnerability Area Boundaries

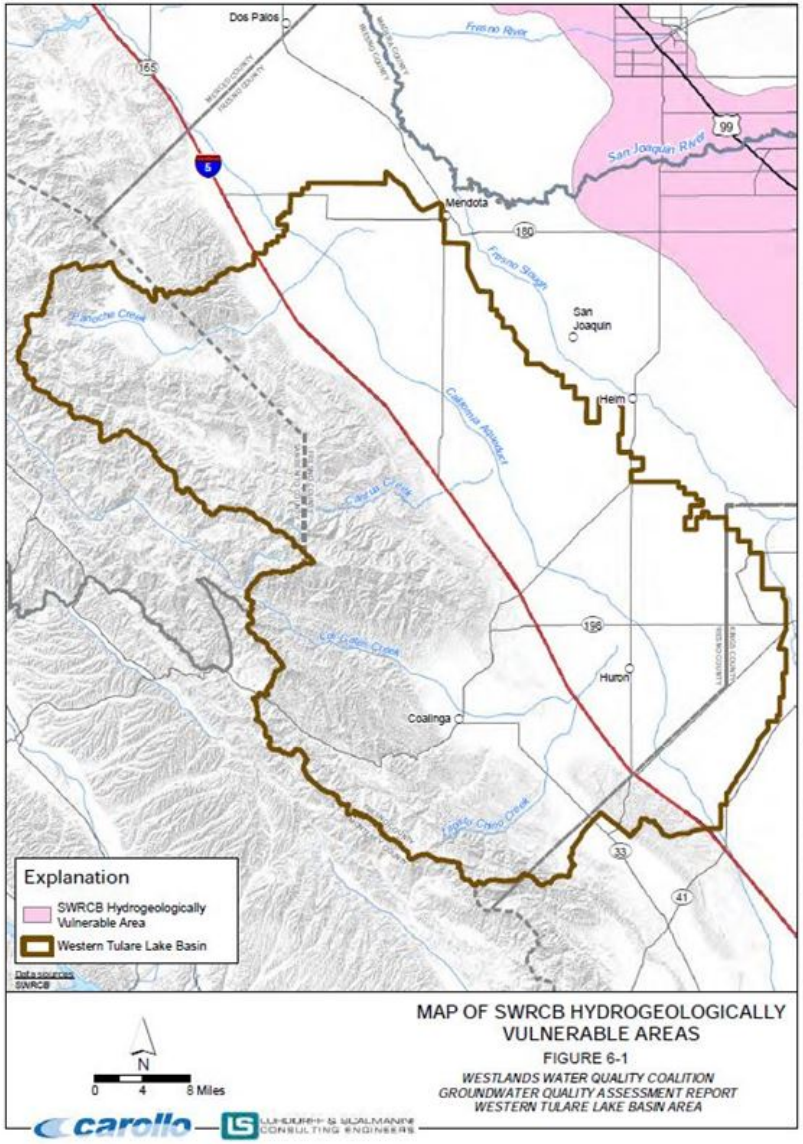
The Coalition performed an analysis of groundwater vulnerability to contamination from agricultural discharge in the Coalition region. Results of the analysis were presented in the GAR (WWQC, 2015). As part of the determination of groundwater vulnerability, the DPR's and the SWRCB's designations of high vulnerability areas were reviewed but ultimately rejected as the footprint for the High Vulnerability Areas (HVAs) because the SWRCB's hydrogeologically vulnerable areas and the DPR's groundwater protection areas are outside of the Coalition's boundaries (Figure 4). Areas designated as HVAs and their related Priority (1-4) areas are shown in Figure 5. Groundwater quality impairment from constituents of concern related to agriculture (nitrate, TDS, and pesticides) was addressed in the delineation of HVA Priority Areas. The rational for the HVA prioritization scheme includes consideration of the variables listed in Table 6-6 of the GAR and here in the 'WWQC High Vulnerability' section of this document. The HVA Priority Areas provide a spatial focus for management plan activities. However, given that nitrate and TDS are the most prevalent constituents of concern within the Coalition region, prioritization of actions taken as part of this management plan will not only include consideration of the HVA Priority Area scheme presented in the GAR as a way of staging the timing of outreach, but will also prioritize outreach efforts to grower Members on high acreage commodities within those Priority Areas, such that the issues of nitrate and TDS may be addressed to the widest, most applicable audience possible. The GAR will be revised every five years (next revision is due in 2020) and the

footprint of the HVAs will be reevaluated based on the most recent water quality data, including those data sets provided by the DPR.

1.3.2 Existing Groundwater Management Plans within the WWQC Region

In 1992, the State Legislature provided structure for more formal groundwater management with the passage of Assembly Bill (AB) 3030, the Groundwater Management Act (Water Code §10750 et seq.). Groundwater management, as defined in DWR's Bulletin 118 Update 2003, is the planned and coordinated monitoring, operation, and administration of a groundwater basin, or portion of a basin, with the goal of long-term groundwater resource sustainability. Under AB 359, introduced in 2011, local agencies are required to provide a copy of their groundwater management plan to DWR and for DWR to provide public access to those plans. According to the DWR website (Accessed on August 18, 2016; https://gis.water.ca.gov/app/boundaries/), the only groundwater management plan for areas within the Coalition, was submitted to the DWR by the Westlands Water District in 1996 (WWD, 1996), under AB 3030. In a report to the Fresno Local Agency Formation Commission (Pleasant Valley Water District, 2016), the Pleasant Valley Water District reported that although it does not own or manage facilities or infrastructure, it is currently taking an active role in the implementation of the Sustainable Groundwater Management Act, it intends to develop groundwater banking projects and coordinate partnerships with agencies to obtain a source of water supply, and that it is securing funding for future programs necessary to study its groundwater resources.

Figure 4. SWRCB Hydrogeologically Vulnerable Areas and the Department of Pesticide Regulation Groundwater Protection Areas, relative to the WWQC Coalition region (Figures 6-1 and 6-2, WWQC, 2015).



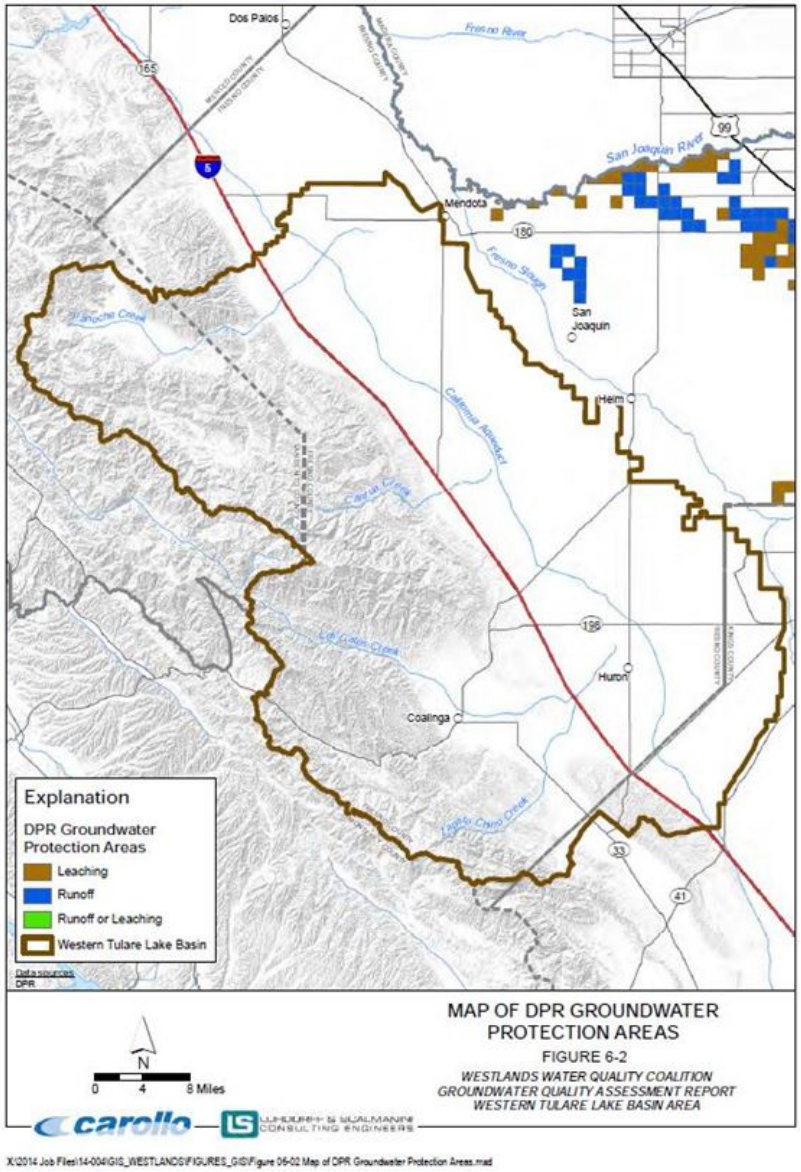
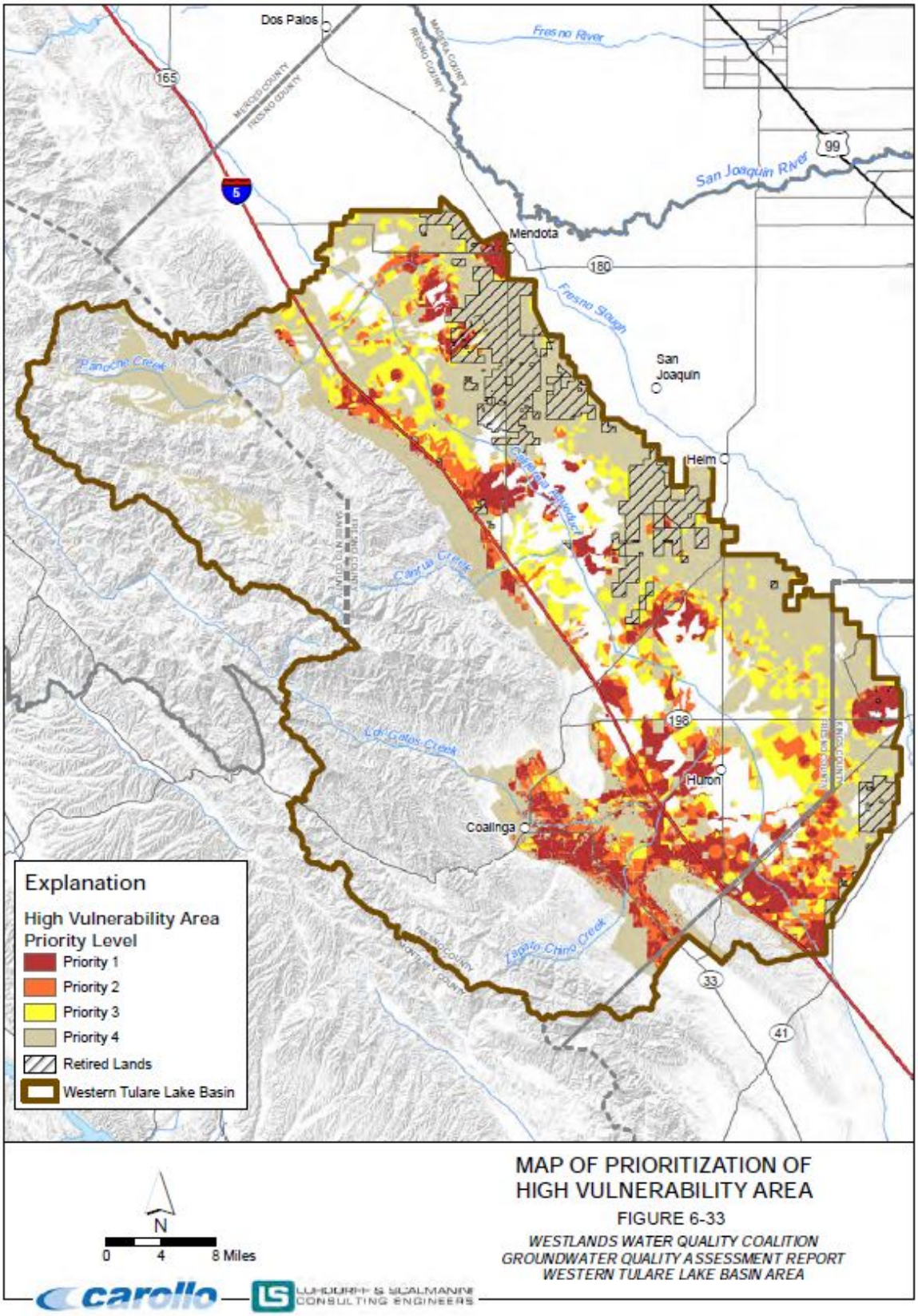


Figure 5. High Vulnerability Areas of the WWQC broken down in to Priority Levels 1 through 4, within the Coalition region (Figure 6-33, WWQC, 2015).



\\sceexser\clerical\2014 Job Files\14-004\GIS_WESTLANDS\FIGURES_GIS\Figure 06-33 Map of Prioritization of High Vulnerability Area.mxd

2 Physical Setting and Geographical Characteristics

The Coalition region includes portions of the southeastern edge of San Benito County, the western edge of Fresno County, and a sliver of the western edge of Kings County (Figure 1). To the north and south of the Coalition region, the major population centers include the cities of Mendota and Avenal, respectively. Within the Coalition boundaries, the cities of Huron and Coalinga make up the largest population centers according to 2015 data from the US Census Bureau (http://www.census.gov/quickfacts/table/PST045215/0646828,06019). Several smaller communities (often unincorporated) are also spread throughout the Central Valley Floor and in to the Coastal Mountain Range. The Coalition consists of approximately 2,000 square miles of prime farmland and open space between the Diablo Range of the California Coastal Range and the trough, or lowest point, of the San Joaquin Valley in western Fresno and Kings Counties. The Coalition region averages 35 miles in width and stretches 70 miles from Mendota on the north to Kettleman City on the south (WWQC, 2015).

Many of the physical setting, geographical, geological, and hydrogeological descriptions presented below are summarized or taken directly from the GAR. Reproductions of the figures presented in the GAR are included here for ease of reference.

The Western Tulare Lake Basin Area lies on the western side of the Central Valley and encompasses an area extending from near the Fresno Slough, along the axis of the Valley to the east, to the Coast Range divide on the west side. Ground surface elevations within the Western Tulare Lake Basin area range from less than 200 feet along the eastern edge towards the Central Valley axis to greater than 3,000 feet in the Coast Range (Figure 6). Lower elevation areas are generally limited to the eastern part of the Coalition area, east of Interstate 5, although some notable lower elevation areas extend into Pleasant Valley around Coalinga. Low elevation areas generally coincide with the extent of the San Joaquin Valley Groundwater Basin which defines the Central Valley Floor portion of the Coalition area. The Coalition area is characterized by low topographic slopes across the Central Valley floor, where slopes are generally less than 2 percent, with steeper slopes of greater than 6 percent comprising much of the mountainous Coast Range areas to the west (Figure 7).

The climate of the Western Tulare Lake Basin region is arid with average annual precipitation generally totaling between five and eight inches on the Valley Floor with greater annual precipitation amounts exceeding 20 inches at higher elevations in the Coast Range mountains. The considerably higher elevations in the Coast Ranges along the western edge of the Western Tulare Lake Basin area create a rainfall shadow along the eastern slope of the mountains and the adjacent Valley Floor. Figure 8 shows the spatial distribution of average annual precipitation in the area. Most precipitation occurs during winter and spring with very little precipitation occurring during summer and fall. Figure 9 illustrates seasonal trends in average annual precipitation on the Valley Floor. The major surface-water features in the Coalition include the California Aqueduct and numerous streams that intermittently flow after rainstorms from the Coast Ranges eastward. The largest of these intermittent streams are the Panoche, Los Gatos, and Zapato Chino Creeks. When flowing, these streams usually lose their water to seepage and evaporation before reaching the San Joaquin River (Methany, 2013). Since about 1967, water has been imported into the study area from the Sacramento-San Joaquin Rivers Delta through the California Aqueduct.

Figure 6. Elevation map within the Coalition region (Figure 2-1, WWQC, 2015).

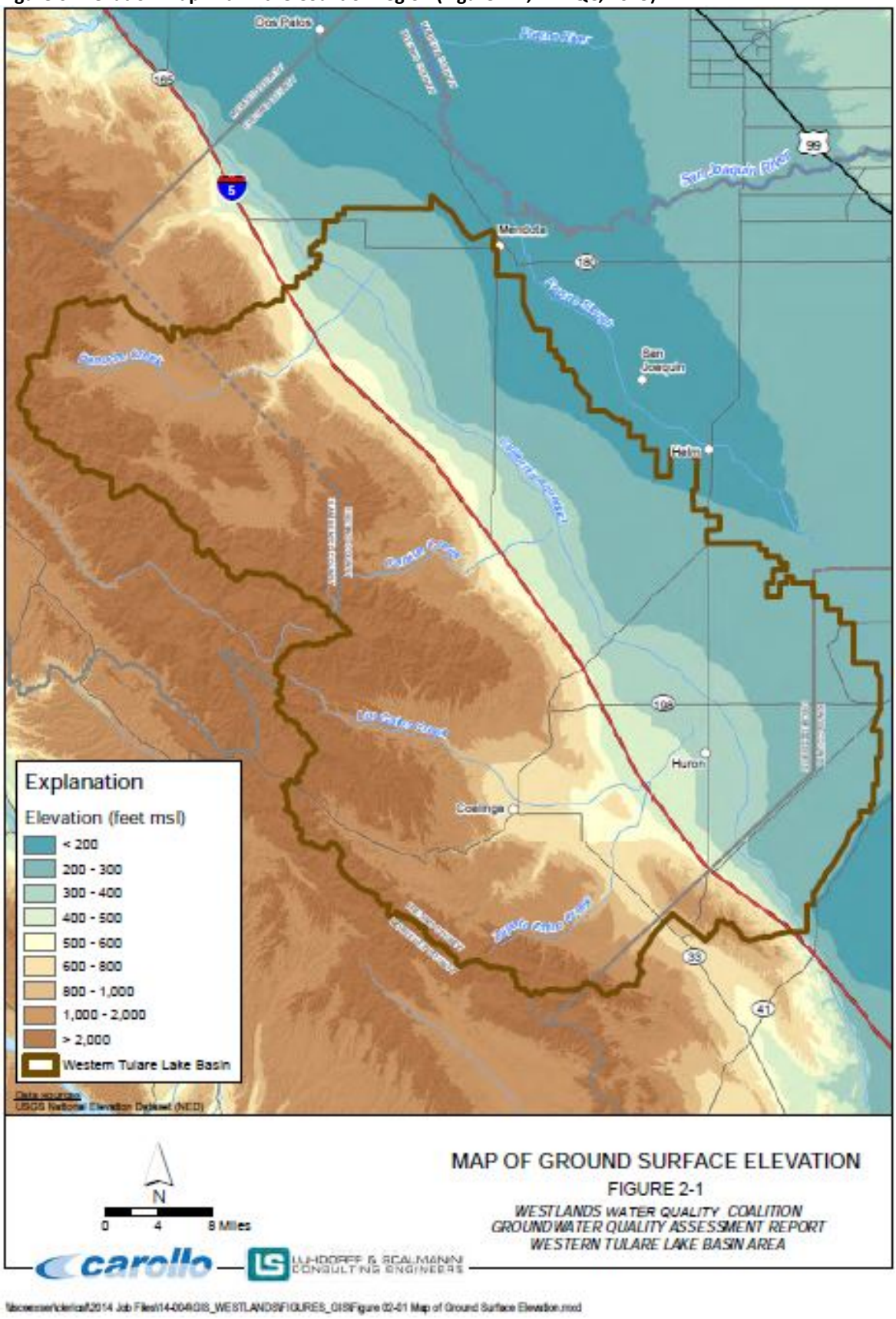


Figure 7. Slope map of the irrigated lands within the Coalition region (Figure 2-2, WWQC, 2015).

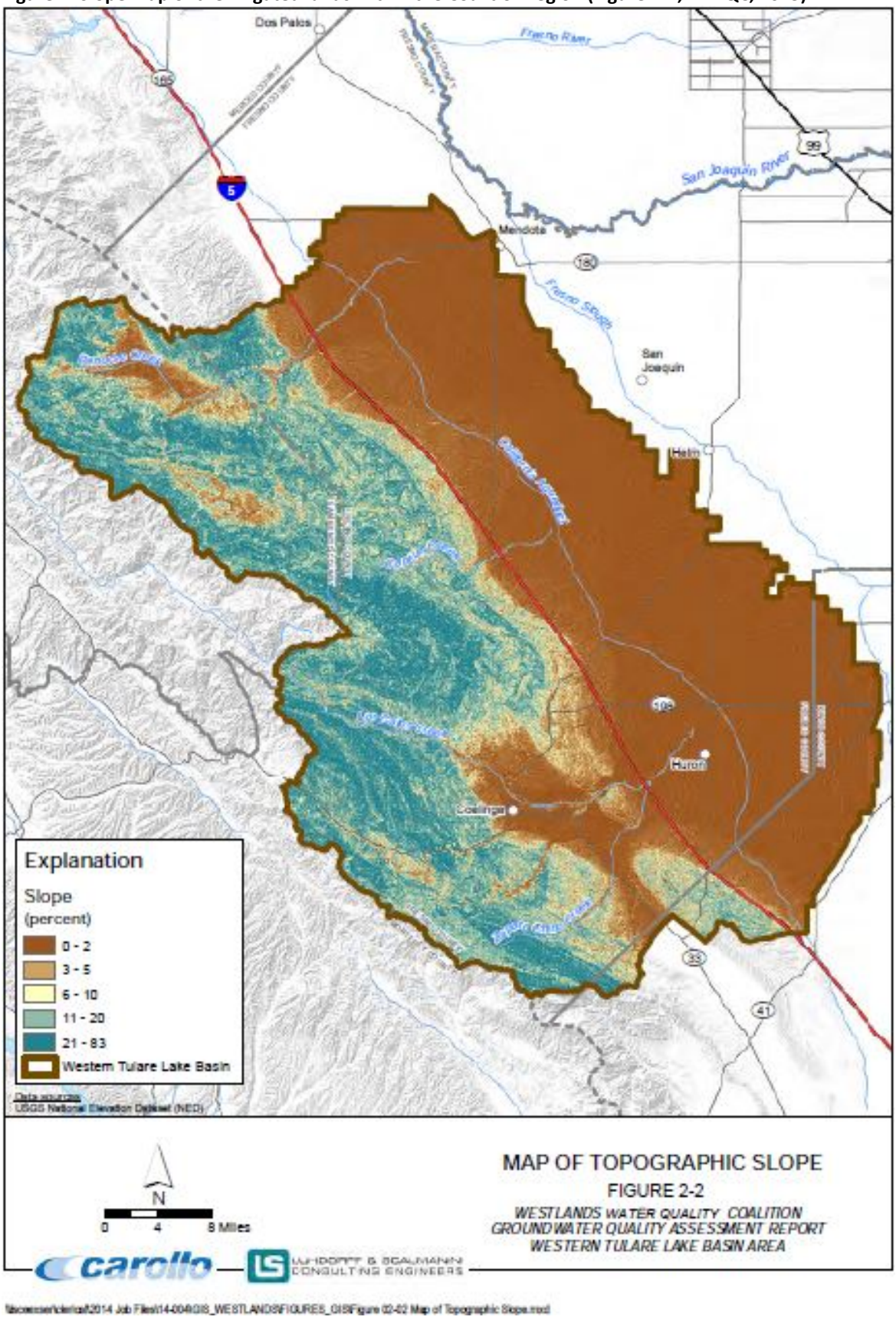


Figure 8. Annual average precipitation within the Coalition region (Figure 2-3, WWQC, 2015).

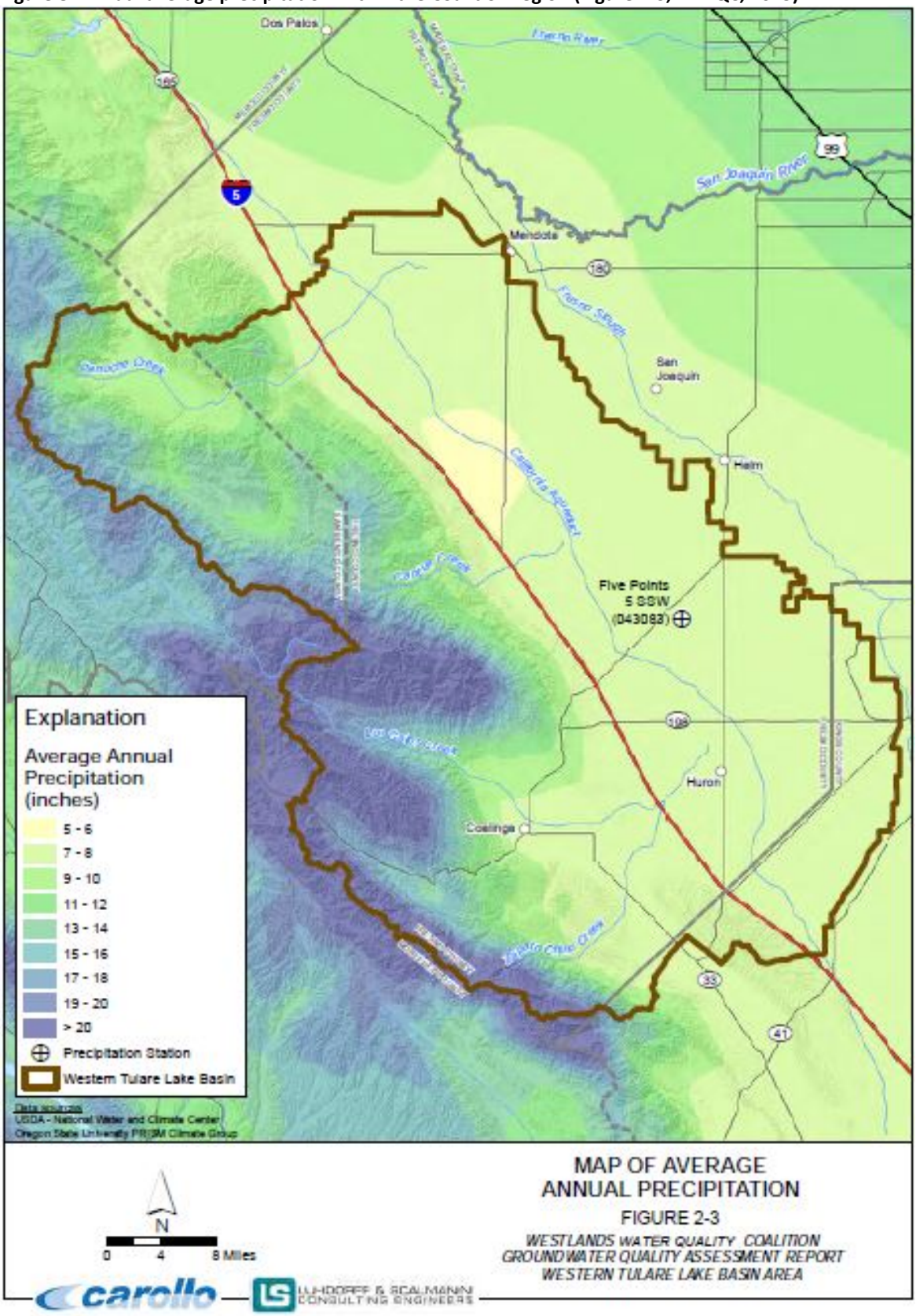
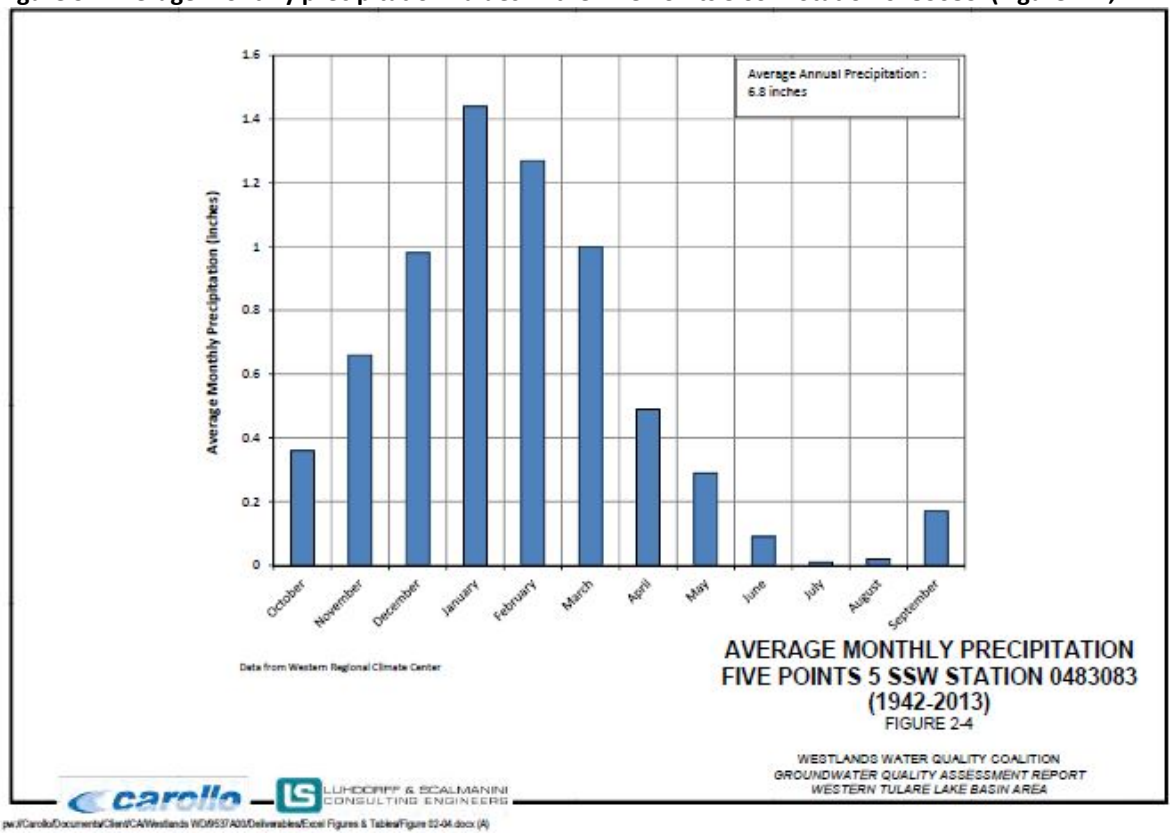


Figure 9. Average monthly precipitation values in the Five Points 5 SSW Station 0483083 (Figure 2-4, WWQC, 2015).



2.1 Geology and Hydrogeology

The Coalition region is located within the San Joaquin Valley, near the southern end of the Central Valley of California in the Great Valley Geomorphic Province. The trough-shaped Central Valley has been filled with interlayered sediments of sand, gravel, silt, and clay derived from erosion of the Sierra Nevada and Coast Range mountains. Figure 10 shows the generalized geology within the Coalition region while Figure 11 and Figure 12 illustrate more detailed geologic mapping. The fill deposits mapped throughout much of the valley extend vertically for thousands of feet and the texture of sediments varies in the east-west direction across the valley. Coalescing alluvial fans have formed along the sides of the valley created by continuous shifting of distributary stream channels over time. This process has led to the development of thick fans of generally coarse texture along the margins of the valley and a generally fining texture towards the axis of the valley. Lacustrine and flood plain deposits also exist closer to the valley axis as thick silt and clay layers. Lakes present during the Pleistocene epoch in parts of the San Joaquin Valley deposited great thicknesses of clay sediments.

Figure 10. Generalized geologic map of the Coalition region (Figure 2-6, WWQC, 2015).

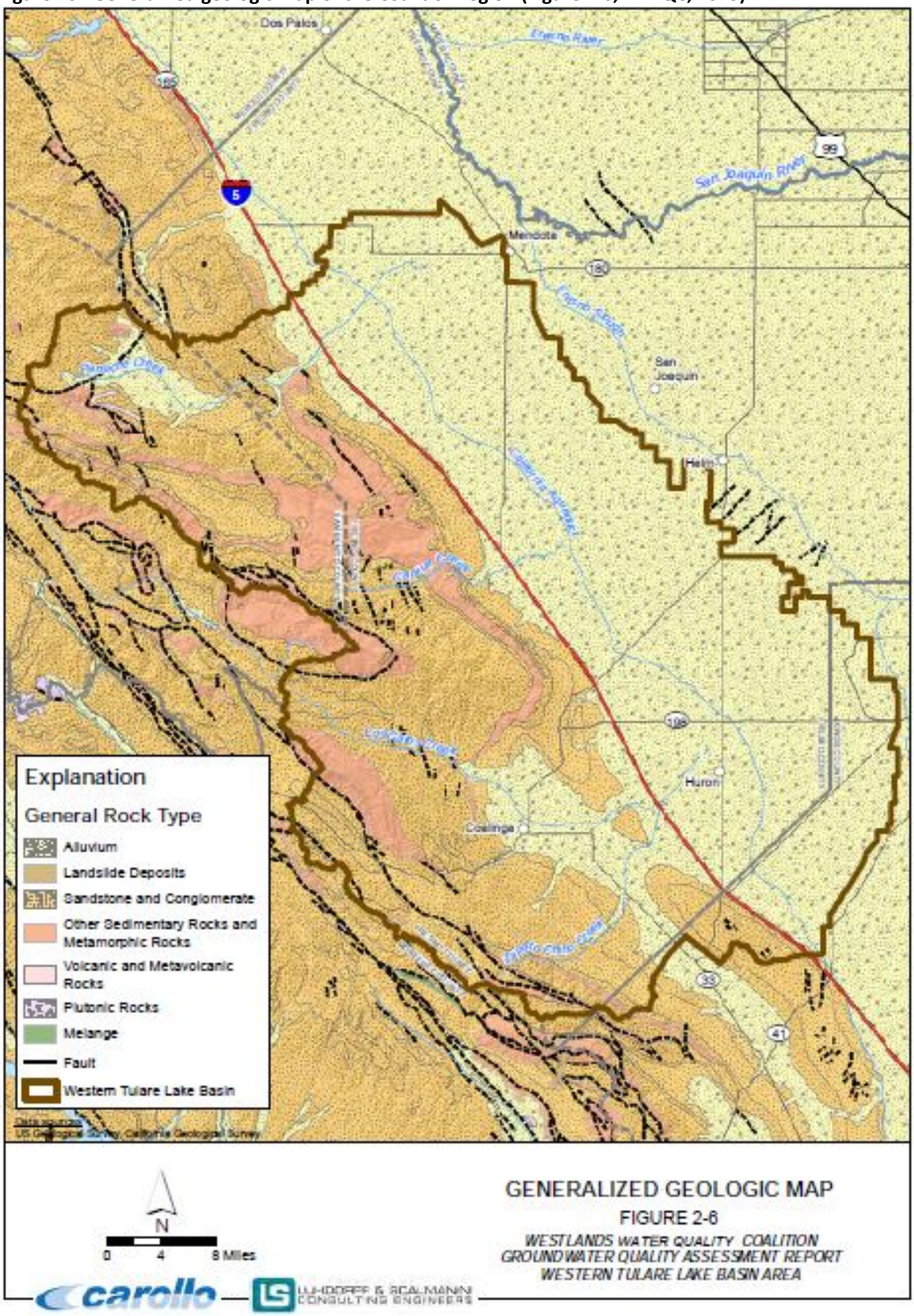


Figure 11. Geologic Map of the Central Valley floor area (Figure 2-7A, WWQC, 2015).

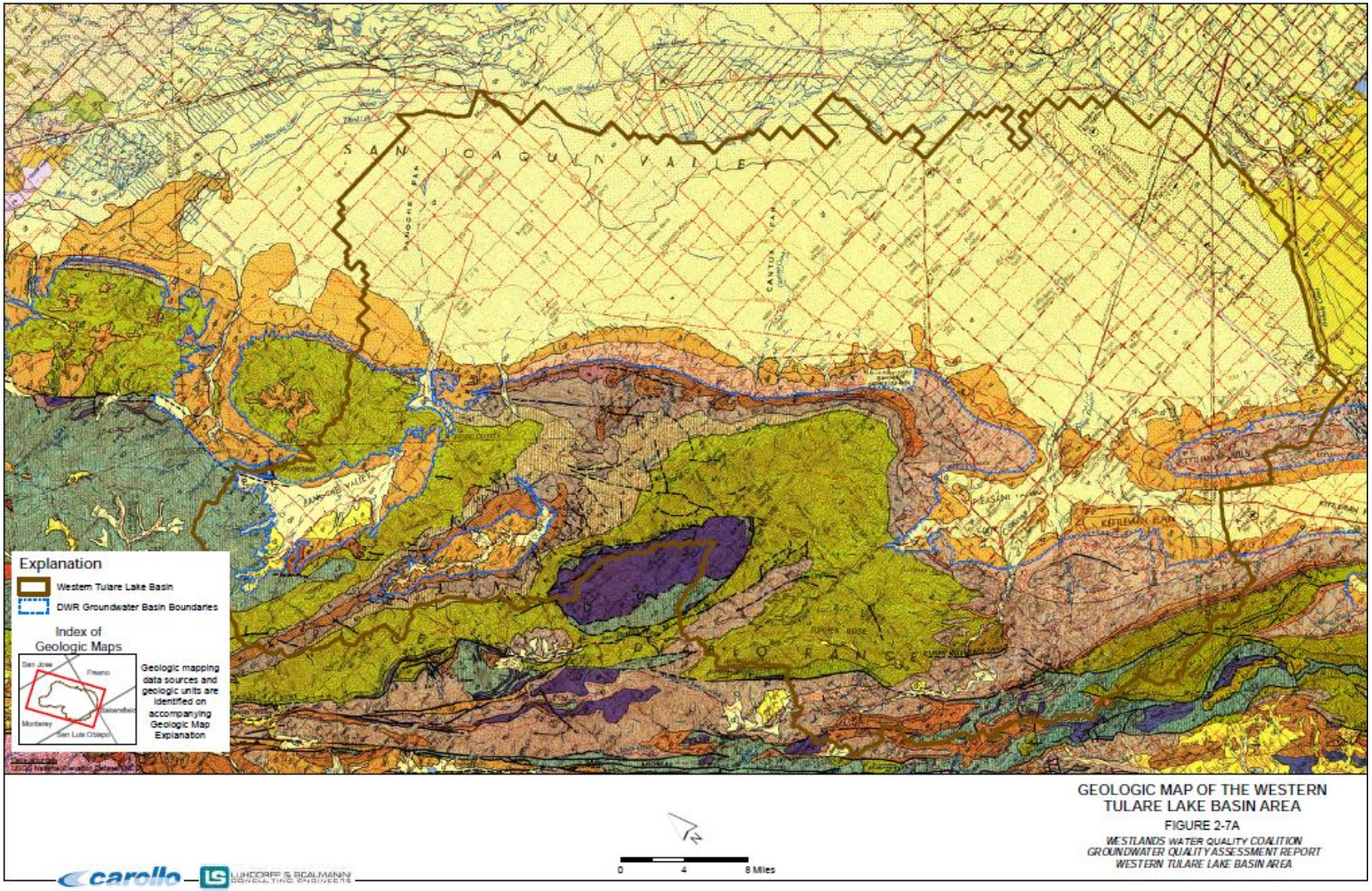
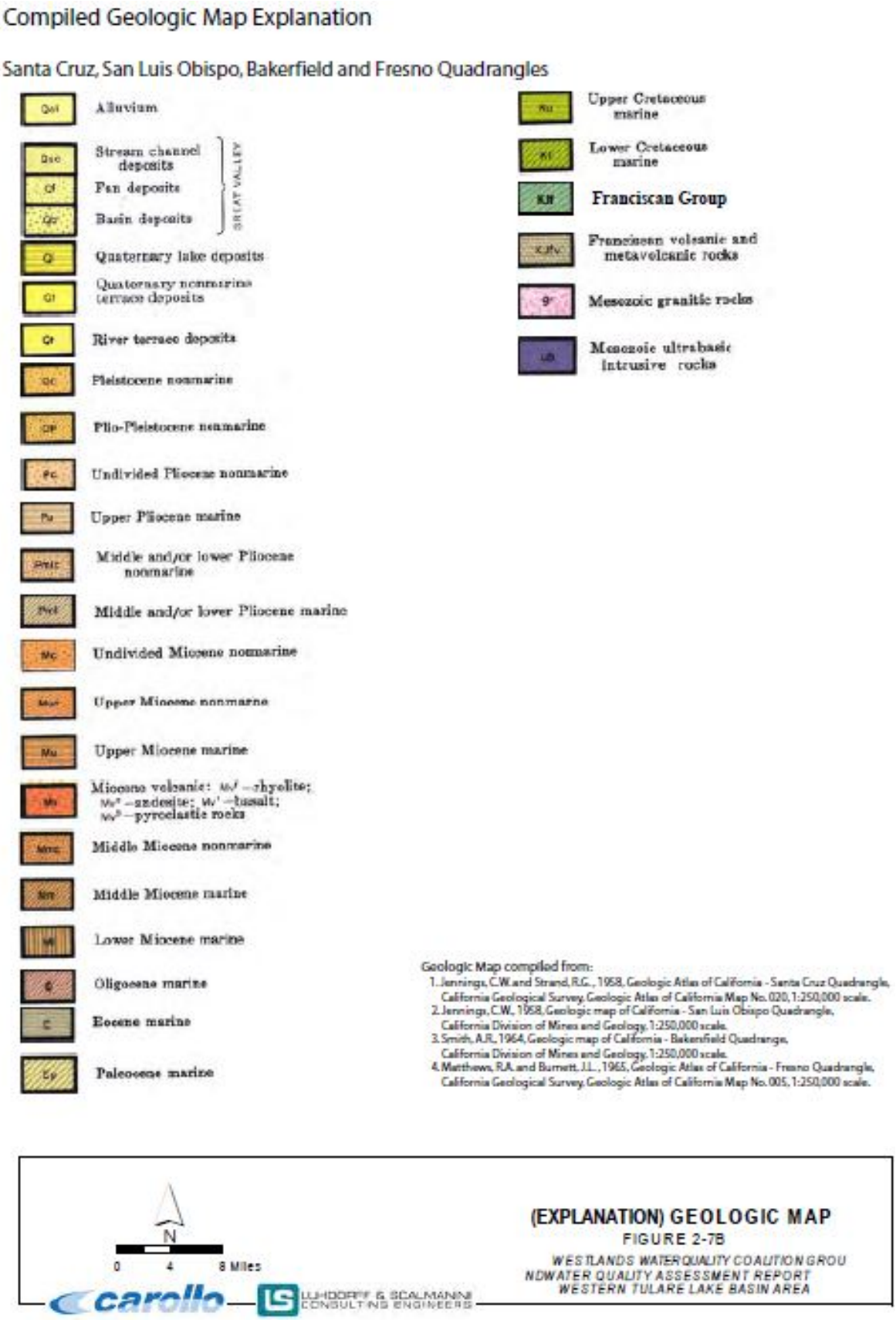


Figure 12. Geologic Map of the Central Valley floor area (Figure 2-7B [Explanation], WWQC, 2015).



2.1.1 General Hydrogeological Setting

Within the Coalition region, the Central Valley Floor consists of Tertiary and Quaternary- aged alluvial and basin fill deposits (Figure 10 and Figure 11). In contrast to the east side of the valley, the more irregular and ephemeral streams on the west side have less energy and transport smaller volumes of sediment resulting in less-developed alluvial features, including alluvial fans, which are less extensive, although steeper, than alluvial fan features on the east side. The largest two alluvial fans of the western San Joaquin Valley fans were formed by the Panoche and Los Gatos Creeks in the north and south of the Westlands Coalition region respectively. The Panoche Creek has deposited the largest alluvial fan complex of the western San Joaquin Valley with sediments and soils that are generally more permeable than the other fan alluvium and soils. The three primary alluvial fan landforms within the Coalition associated with the Panoche, Cantua, and Los Gatos/Zapato Chino Creeks have prominent topographic expressions evident as bulges extending northeast from the Coast Ranges (Figure 6)

Within the Westside and Pleasant Valley Subbasins and the Central Valley Floor, the primary groundwater bearing units consist of Tertiary and Quaternary-aged unconsolidated continental deposits and older alluvium. The continental and alluvial deposits consist of layers of sand, gravel, silt, and clay that increase in thickness away from the margins of the valley. The hydrogeologic system in the Coalition region is characterized by the presence of three distinct groundwater zones, including a very shallow perched groundwater zone, an upper semi-confined zone (Upper Aquifer), and a lower confined zone (Lower Aquifer) (Figure 13).

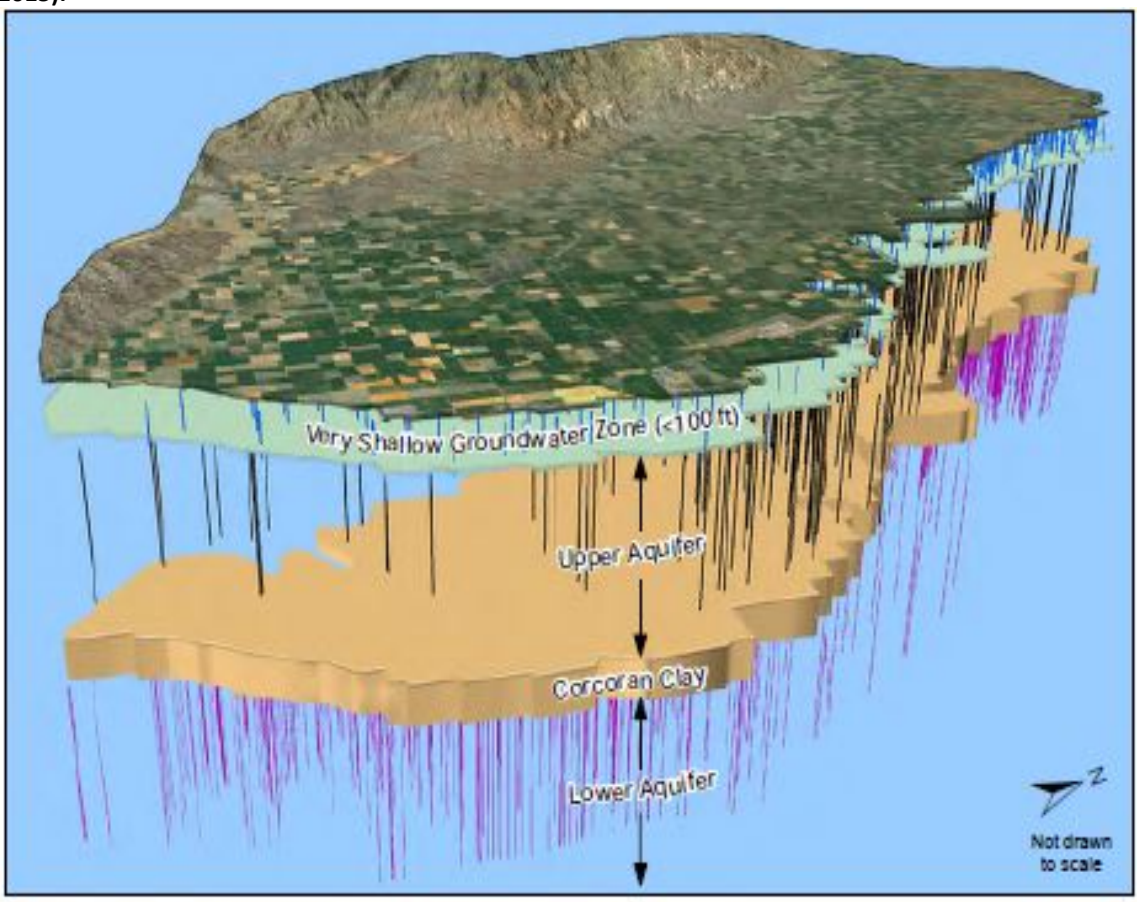
Subsurface hydrogeologic materials within the Central Valley Floor consist of lenticular and generally poorly sorted clay, silt, and sand that make up the younger and older alluvium and underlying Tulare Formation (DWR, 2003). The Tulare Formation, which extends to the base of freshwater throughout most of the area, extends to as much as 2,400 feet deep in parts of the Coalition region and is comprised of stratigraphic layers of clays, silts, sands, and gravels and includes the Corcoran Clay (E-Clay) member, a diatomaceous clay or silty clay of lake bed origin which is a prominent aquitard in the region that separates the upper zone from the lower zone and distinguishes the Upper Aquifer from the Lower Aquifer. However, the depth and thickness of the Corcoran Clay are variable and it is not present in all areas of the Westside Subbasin and does not exist at all in the Pleasant Valley Subbasin. Within the Upper Aquifer, clay layers including that “A” Clay and “C” Clay members of the Tulare Formation are variable in extent and thickness, and present varying degrees of confinement. The unconsolidated continental deposits within the Tulare Formation along the western side of the San Joaquin Valley consist largely of lenticular tongues and beds of sand, silt, and clay that differ widely in extent and thickness and grade abruptly both laterally and vertically into one another. The Coast Range alluvial deposits are generally oxidized and divided into three parts: the coarser fan apex (80 to 100 percent sand with 20 percent clay), the variable mid to lower fan margins, and the distal fan (≤20 percent sand and ≥80 percent silt and clay). Midfan deposits are typically coarser textured proximal to present-day stream channels and paleochannels.

2.1.2 Surface and Shallow Subsurface Sediments Characterization of the Coalition Region

The Panoche Valley and Vallecitos Creek basins are located in the Coast Range Mountains, peripheral to the Central Valley Floor, while Pleasant Valley and Westside subbasins lie along the eastern edge of the Coast Range Mountains and the western margin of the Valley Floor (Figure 3). Because of the generally low water-bearing nature of the rocks and lack of irrigated agriculture within the Coast Range, the characterization of subsurface materials and groundwater vulnerability assessment in the GAR was generally limited to the Central Valley Floor area within the Westlands Coalition region (WWQC, 2015). The subsurface sediment description below is taken directly from the GAR. Reproductions of the figures presented in the GAR are included here for ease of reference. Source of data used in the GAR to characterize the surface and subsurface sediments in the area consisted of descriptions provided in the literature with mapped data sources consisting primarily of county soil surveys completed by Natural Resource Conservation Service (NRCS), subsurface sediment texture model data, and data relating to hydraulic properties of layers and Corcoran Clay properties from the Central Valley Hydrologic Model (CVHM)**.**

Subsurface sediment texture data from CVHM indicate the upper 450 feet of sediment consist of large areas with thick zones of coarser materials east of the Westlands Coalition region with some localized areas of higher percentages of coarse material present within the Westlands Coalition region, particularly in the northern area west of Mendota and in the Pleasant Valley vicinity and near Huron to the south. The presence of generally fine-grained sediments (<25 percent coarse) is apparent within interior areas of the Coalition region throughout much of the depth interval to 500 feet. Textural data between 500 and 1,000 feet depth show relatively finer-grained sediments (<25 percent coarse) generally corresponding with the range of depths at which the Corcoran Clay Is found. Below 1,000 feet, a pattern of sediment coarsening emerges within the Westlands Coalition region, with spreading extent of these coarse-grained materials across the region, and particularly in the southeast, with greater depths. Areas and intervals with the highest percentages of coarse sediments are largely zones of Sierra-sourced alluvial fan materials. Figure 14 is a map of basins and subbasins within the Central Valley which was used for textural soils analysis in the CVHM. Figure 15 and Figure 16 are maps depicting the percentage of coarse-grained material at various depths (Faunt, 2009). Figure 17 through Figure 19 also depict sediment texture using the CVHM starting at land surface and continuing through to 2,100 feet. Several wells listed within the dataset used in the analysis of the GAR, extend beyond 2,100 feet in the Lower Aquifer.

Figure 13. Conceptual illustration of the Western Tulare Lake Basin Area hydrogeologic system (Figure 2-8, WWQC, 2015).



Very Shallow Groundwater Zone: Ground surface to 100 feet deep
thickness range = 100 feet

Upper Aquifer: From 100 feet to top of Corcoran Clay (where present), to depth of 500 feet outside extent of Corcoran Clay
thickness range = less than 100 feet to greater than 700 feet

Corcoran Clay: E Clay member of the Tulare Formation, from Faunt et al. (2009)
depth range = less than 200 feet to greater than 800 feet
thickness range = zero feet to greater than 100 feet

Lower Aquifer: Below Corcoran Clay (where present), below depth of 500 feet outside extent of Corcoran Clay
depth range = less than 500 feet to greater than 900 feet

CONCEPTUAL ILLUSTRATION OF THE WESTERN TULARE LAKE BASIN AREA HYDROGEOLOGIC SYSTEM

FIGURE 2-8

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GROUNDWATER QUALITY ASSESSMENT REPORT
WESTERN TULARE LAKE BASIN AREA

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Figure 14. Groupings of basins and subbasins within the Central Valley used for textural soils analysis in the CVHM (Figure A10, Faunt, et. al., 2009). The WWQC region lies within the Westside (number 21) spatial province or domain.

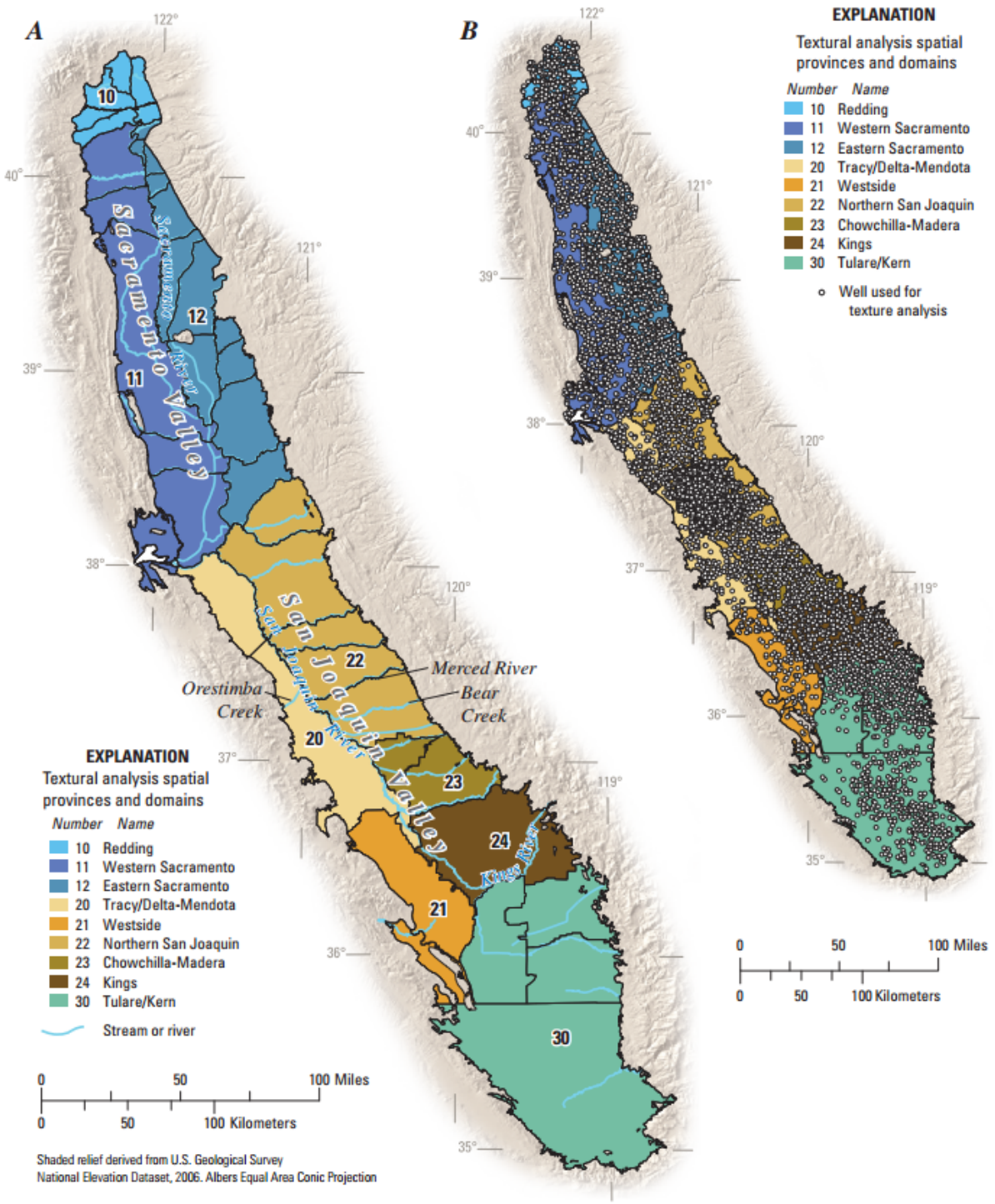


Figure A10. *A*, Central Valley showing groundwater basins and subbasins, groupings of basins and subbasins into spatial provinces and domains for textural analysis. *B*, Distribution of wells used for mapping texture. *C*, Count of wells for each depth increment by domains through 1,200 feet. Because less than 1 percent of the logs extend past 1,200 feet, increments below 1,200 feet were not shown. Detailed description of the spatial provinces and domains are in *table A2*.

Figure 15. Layer 1 of the CVHM depicting the percentage of coarse-grained material within the top 50 feet of the Central Valley (Fig. A12, Faunt, et. al., 2009). The WWQC region lies within the Westside (number 21) spatial province or domain.

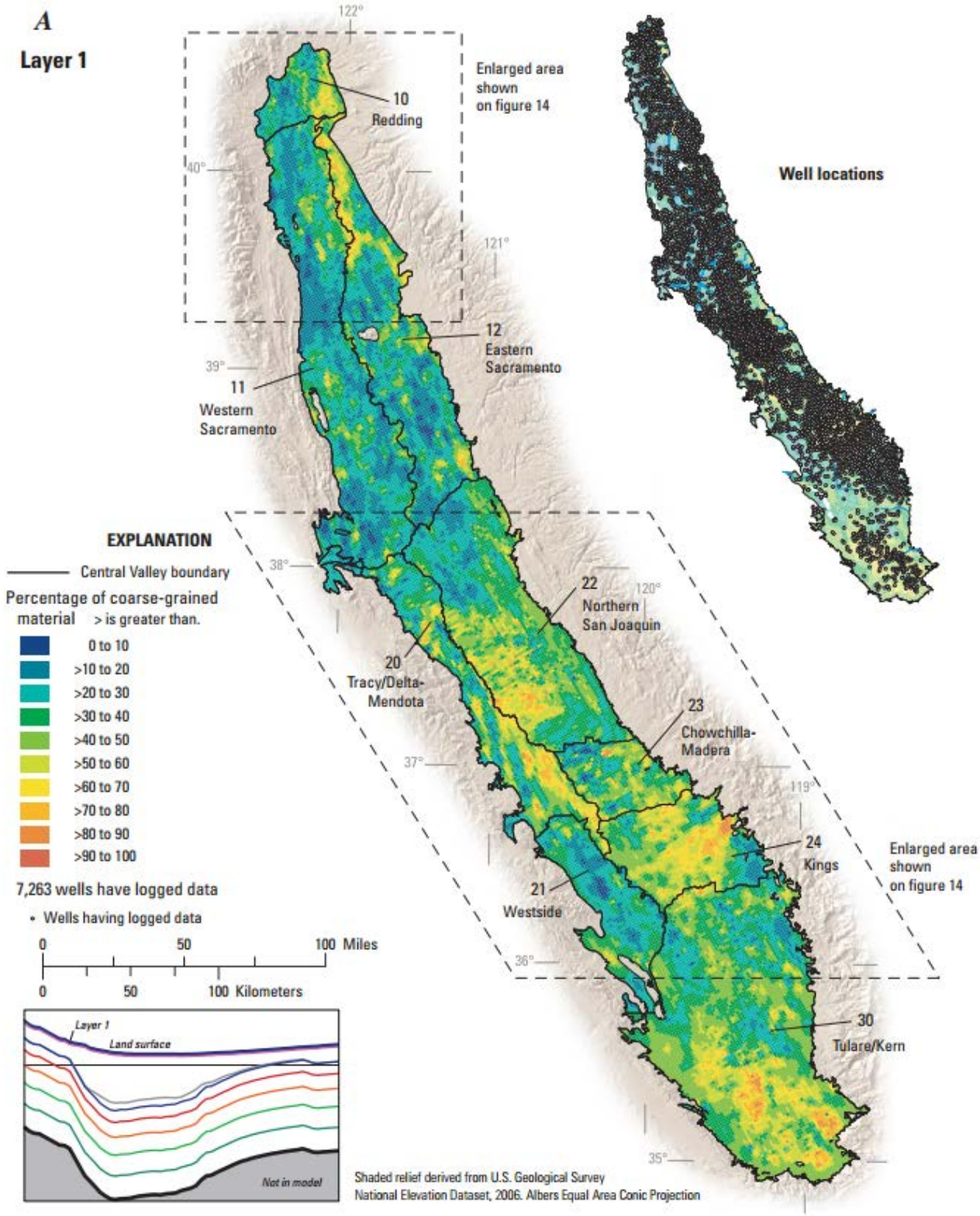


Figure 16. Layer 3 of the CVHM depicting the percentage of coarse-grained material within the top 150 feet of the Central Valley (Fig. A12 continued, Faunt, et. al., 2009). The WWQC region lies within the Westside (number 21) spatial province or domain.

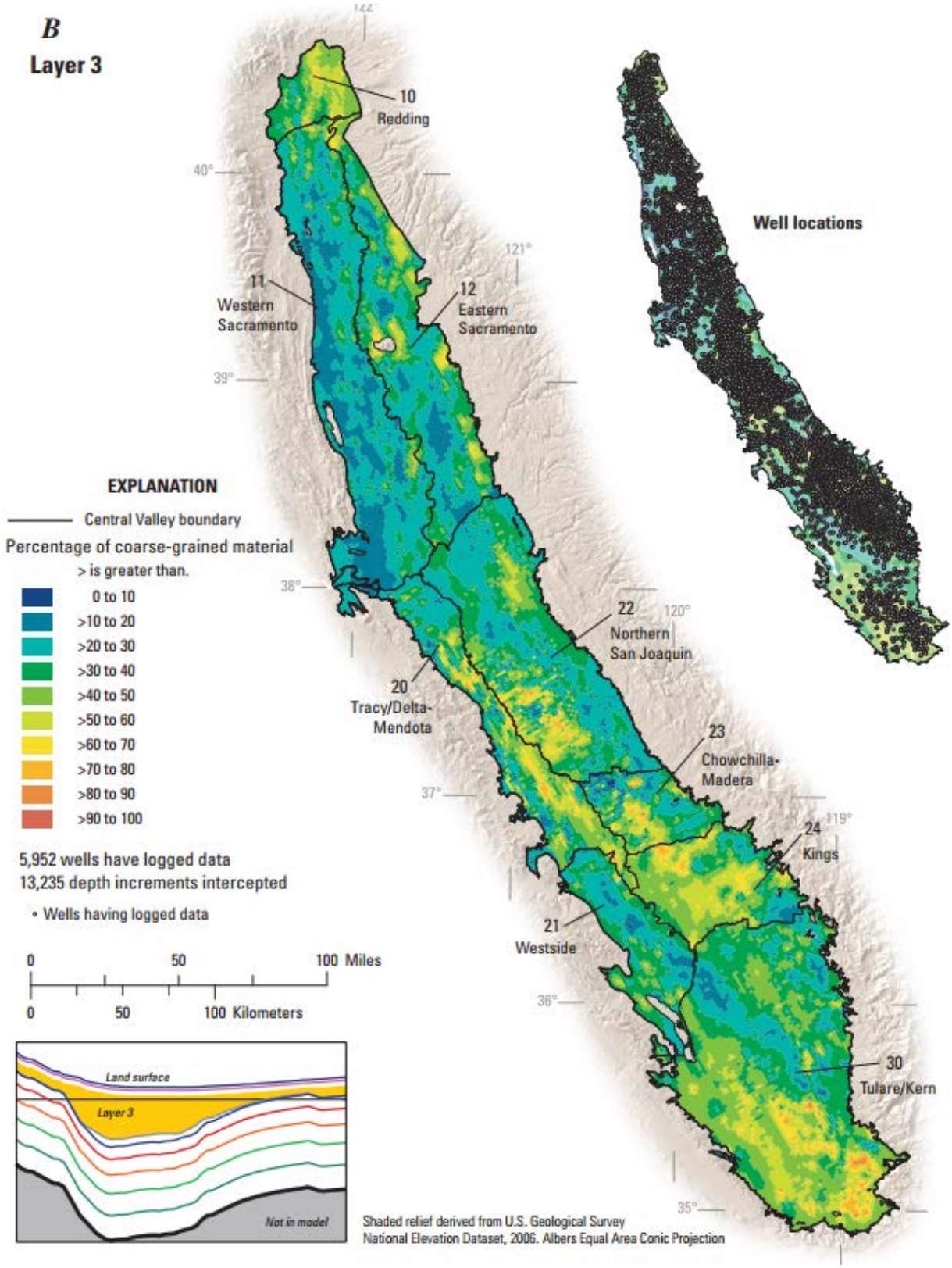


Figure 17. Sediment texture model from 0-700 feet, using the CVHM (Figure 2-38A, WWD, 2015).

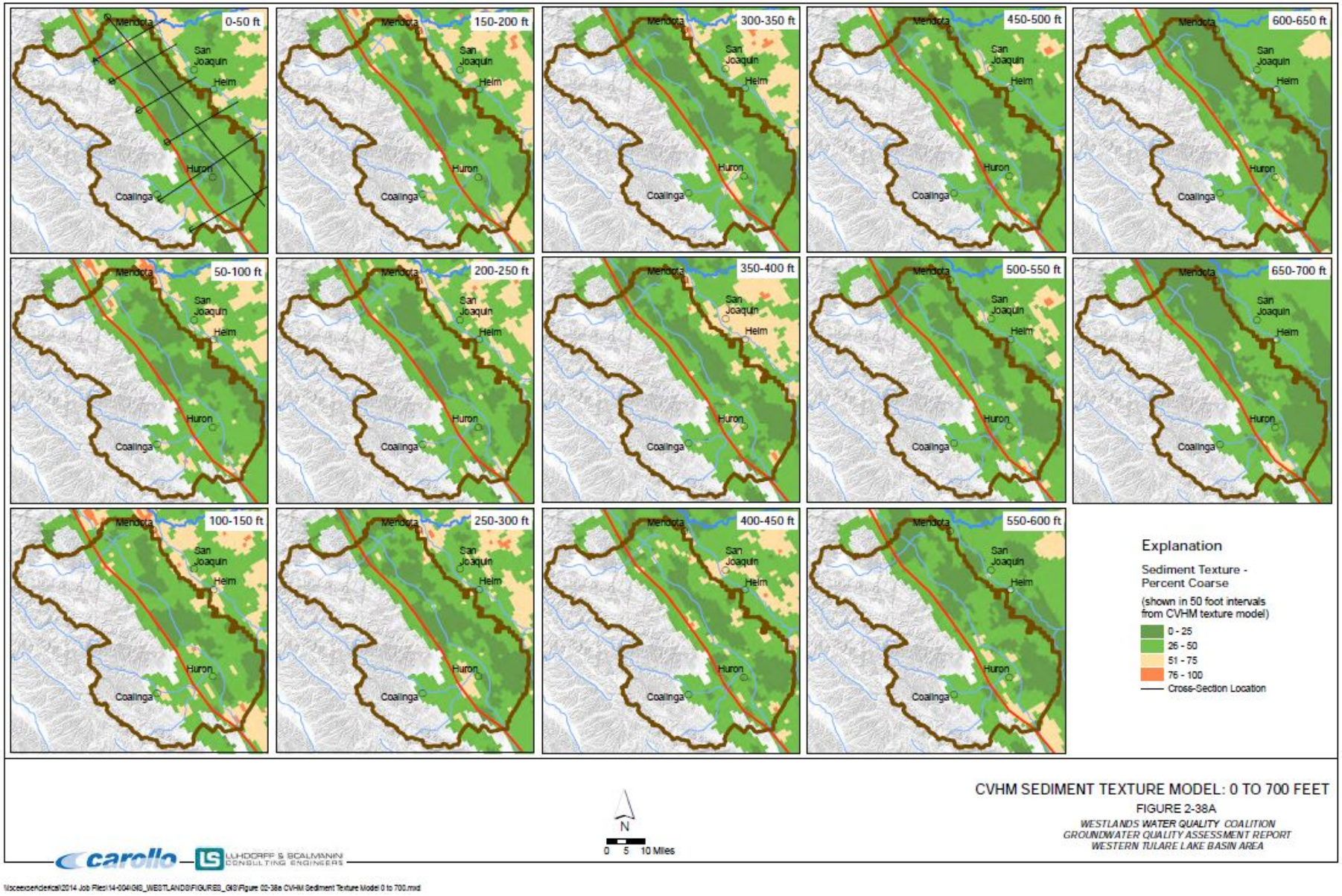


Figure 18. Sediment texture model from 700 to 1,400 feet, using the CVHM (Figure 2-38B, WWD, 2015).

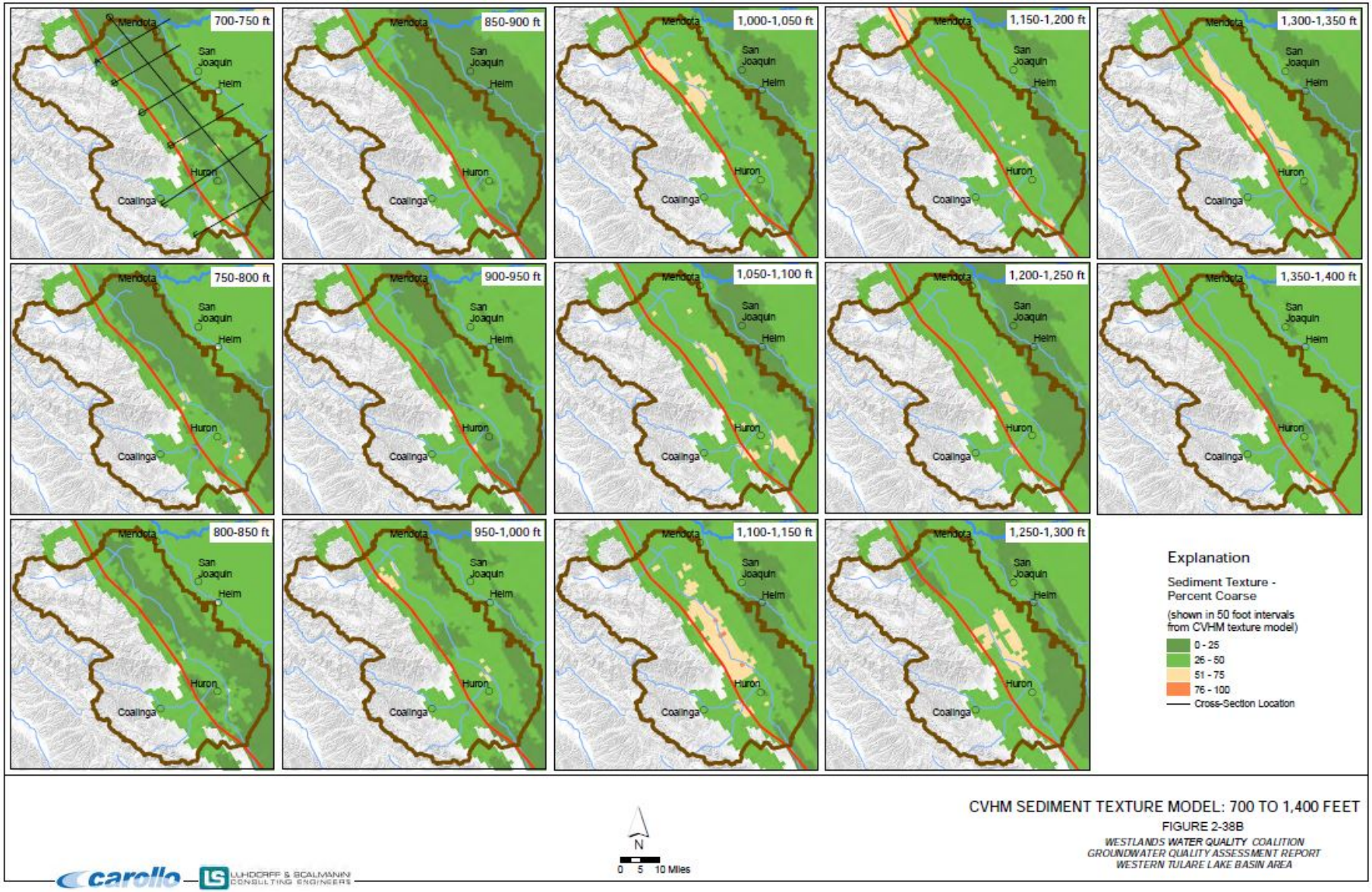
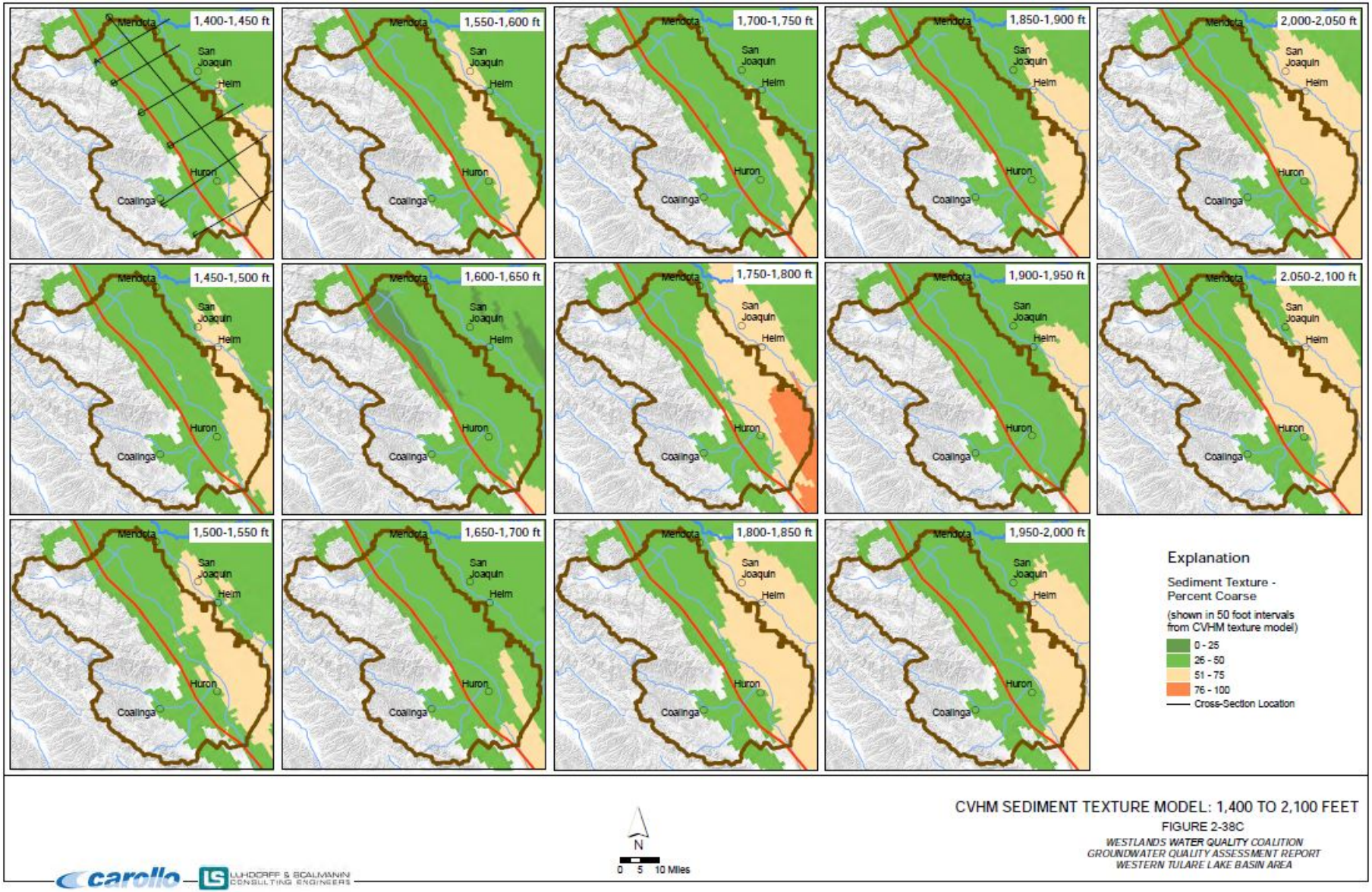


Figure 19. Sediment texture model from 1,400 to 2,100 feet, using the CVHM (Figure 2-38C, WWD, 2015).



CVHM SEDIMENT TEXTURE MODEL: 1,400 TO 2,100 FEET

FIGURE 2-38C

WESTLANDS WATER QUALITY COALITION
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WESTERN TULARE LAKE BASIN AREA

\\sceexcelerical\2014 Job Files\14-004\GIS_WESTLANDS\FIGURES_GIS\Figure 02-38c CVHM Sediment Texture Model 1400 to 2100.mxd

Soil Hydraulic Conductivity

Figure 20 shows the saturated hydraulic conductivity of surficial soils within the Coalition region as mapped by the NRCS. As part of the NRCS soil surveys, soil map units are defined to express similarities between soils within similar landform and landscape positions. Each soil map unit is assigned ranges of physical properties by aggregating data collected for each soil map unit. Vertical hydraulic conductivity of soils tends to decline the further away one travels along hill slopes (Figure 20). The presence of soils of higher conductivity in combination with underlying coarser sediments, make the potential for groundwater recharge highest in areas along the hill slopes on the west side of the Central Valley Floor. Soils associated with fan deposits and along and immediately surrounding stream channels have relatively higher hydraulic conductivity. Examples of these areas of relatively higher hydraulic conductivity include those areas surrounding Panoche Creek, channels within Pleasant Valley, Los Gatos Creek, and Zapato Creek. Large areas near Huron also exhibit soils with high vertical hydraulic conductivity while floodplain deposits blanketing much of the eastern portion of the Coalition region, particularly along Fresno Slough, have lower hydraulic conductivity soils in Figure 20. In areas peripheral to the Central Valley Floor, soils tend to be characterized by low hydraulic conductivity, although soils of higher hydraulic conductivity are present along active surface watercourses within the peripheral area.

Soil Chemistry

Figure 21 displays soil salinity and soil pH as mapped by NRCS. Salinity is a measurement of the amount of salt present in soil and is estimated by measuring the electrical conductivity (EC) of the soil. With regards to agriculture, soil salinity can greatly impact crops. While crops vary in their tolerance for elevated soil salinity, the productivity of most crops becomes impacted when EC levels are above 4 decisiemens per meter (dS/m), although some more sensitive crops may have declining yields at lower salinity levels. Soil salinity values for individual map units Figure 21, were calculated using a weighted arithmetic mean, weighted by the thickness of soil horizons. Areas of highest soil salinity (red) in Figure 21 (Figure 2-30 in the GAR) are located across much of the eastern portion of the Coalition region where vertical hydraulic conductivity of soils is low. This is consistent with the hydrologic properties of these soils which inhibit salts from flushing through. Finer-textured soils with low hydraulic conductivity are also capable of holding more water by capillarity, which can increase bare soil evaporation resulting in shallow salt accumulation over time. Relatively lower patterns of soil salinity are exhibited across much of the western and southwestern portion of the Coalition region.

The spatial distribution of soil pH within the Coalition region, as derived from available NRCS soil surveys, is shown in Figure 21. A pH in the range of 7 is considered neutral with increasing pH levels indicating more alkaline soil conditions and decreasing pH values indicating more acidic soil conditions. With regards to agriculture, most crops grow best when the soil pH is slightly acidic (pH 6-7), while highly alkaline soils (pH > 7.8) can affect plant health. A prominent difference in soil pH is evident between more alkaline soils (higher pH) present within the Central Valley Floor and neutral to acidic soils (lower pH) present in the peripheral areas as shown on Figure 21. The most alkaline soils are generally located in the western portion of the Central Valley Floor and where carbonates and hydroxides exist within near surface soils derived from Coast Range rock formations along the minor surface drainage channels into Pleasant Valley, the Los Gatos Creek channel, and the Zapato Chino Creek channel.

Figure 20. Soil hydraulic conductivity and drainage characteristics in the Coalition region (Figures 2-28 and 2-29, WWQC, 2015).

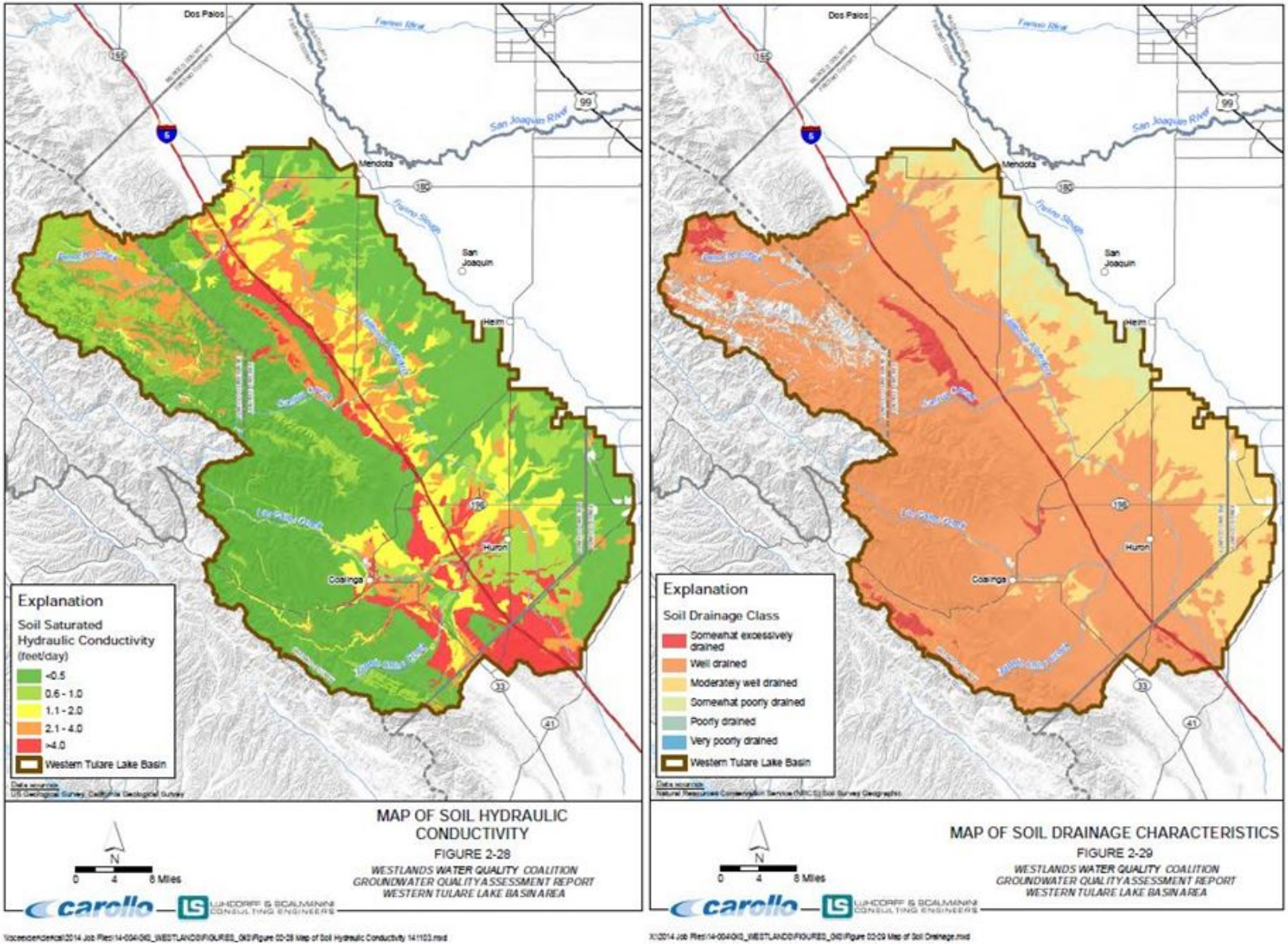
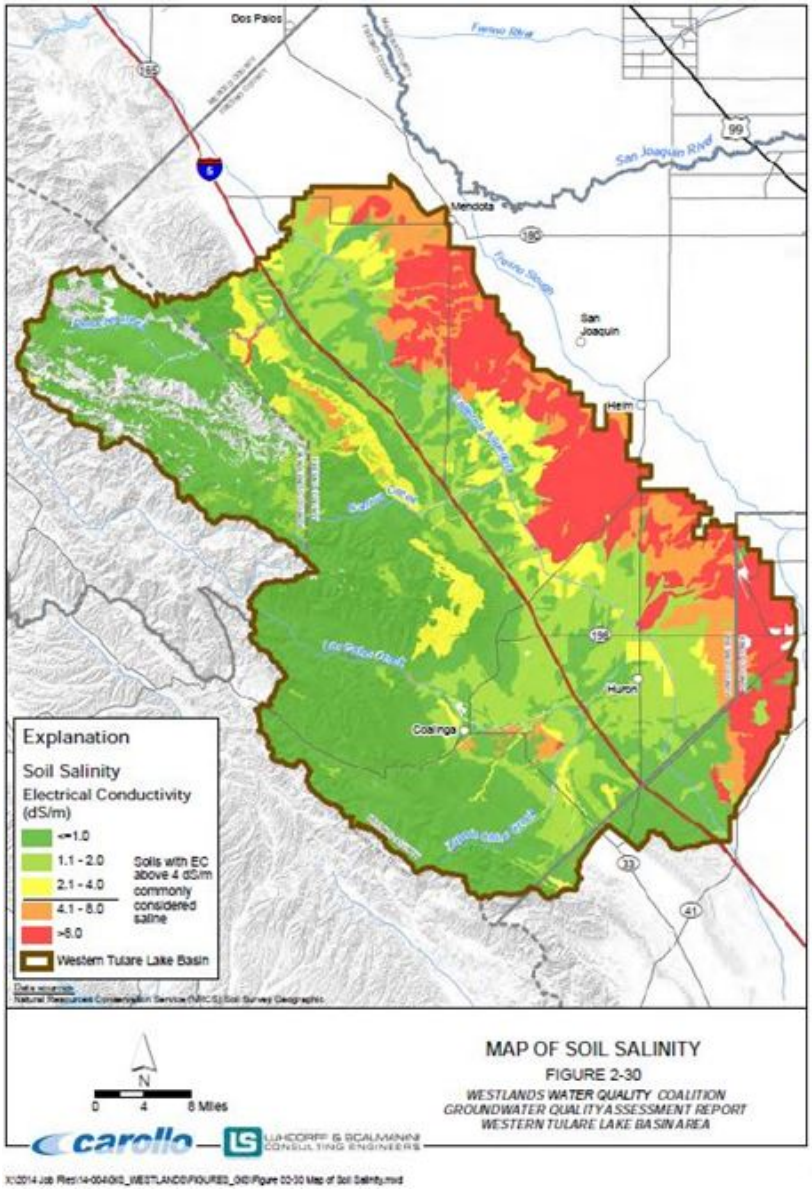
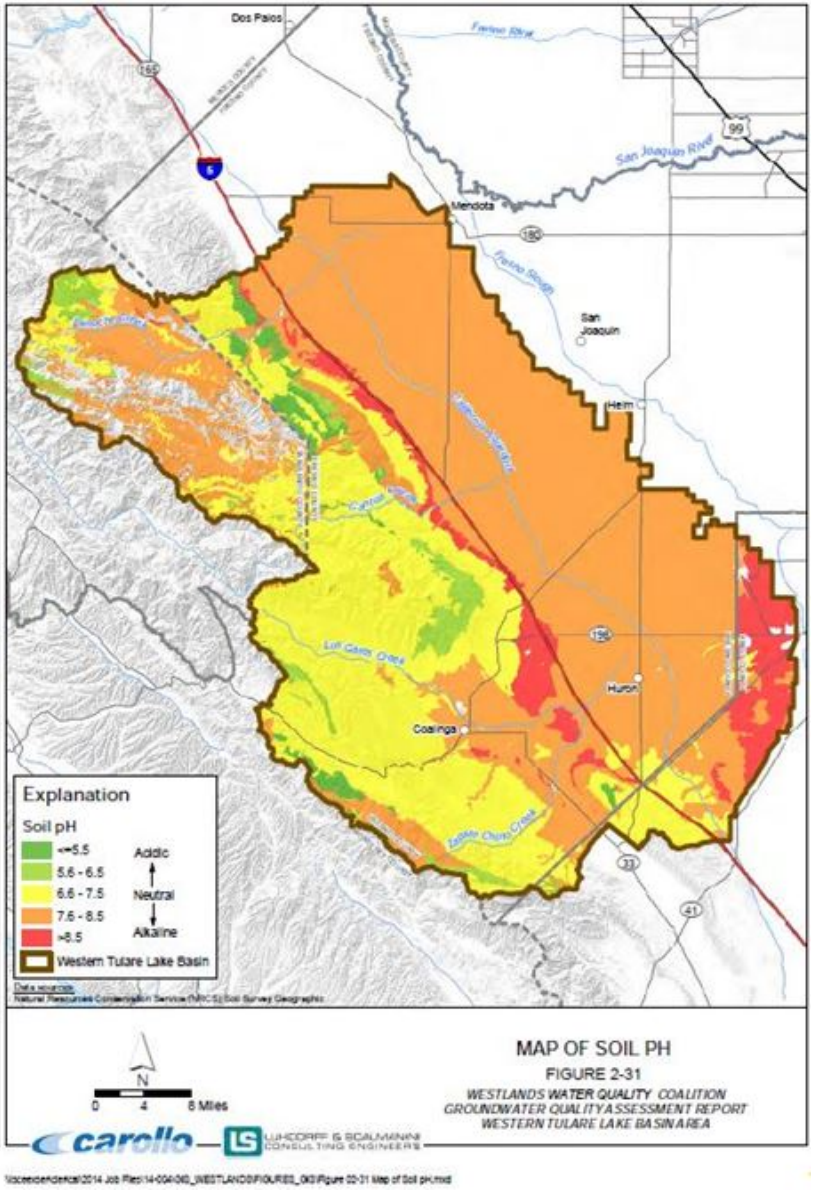


Figure 21. Soil salinity and pH in the Coalition region (Figures 2-30 and 2-31, WWQC, 2015).





Subsurface Sediments

The subsurface sediment description below is either summarized from or taken directly from the GAR. Reproductions of the figures presented in the GAR are included here for ease of reference.

CVHM Hydraulic Conductivity

A three-dimensional sediment texture model was created as part of the CVHM to characterize the valley-fill deposits (Faunt, et al., 2009). Data derived from the CVHM and associated sediment texture model were used to evaluate the subsurface geologic conditions. Figure 22 through Figure 24 display some of the relevant hydraulic properties for the very shallow zone, Upper Aquifer, Lower Aquifer, and Corcoran Clay, as outlined in the conceptual model above (Figure 13).

Very Shallow Groundwater Zone / Upper Aquifer / Corcoran Clay / Lower Aquifer

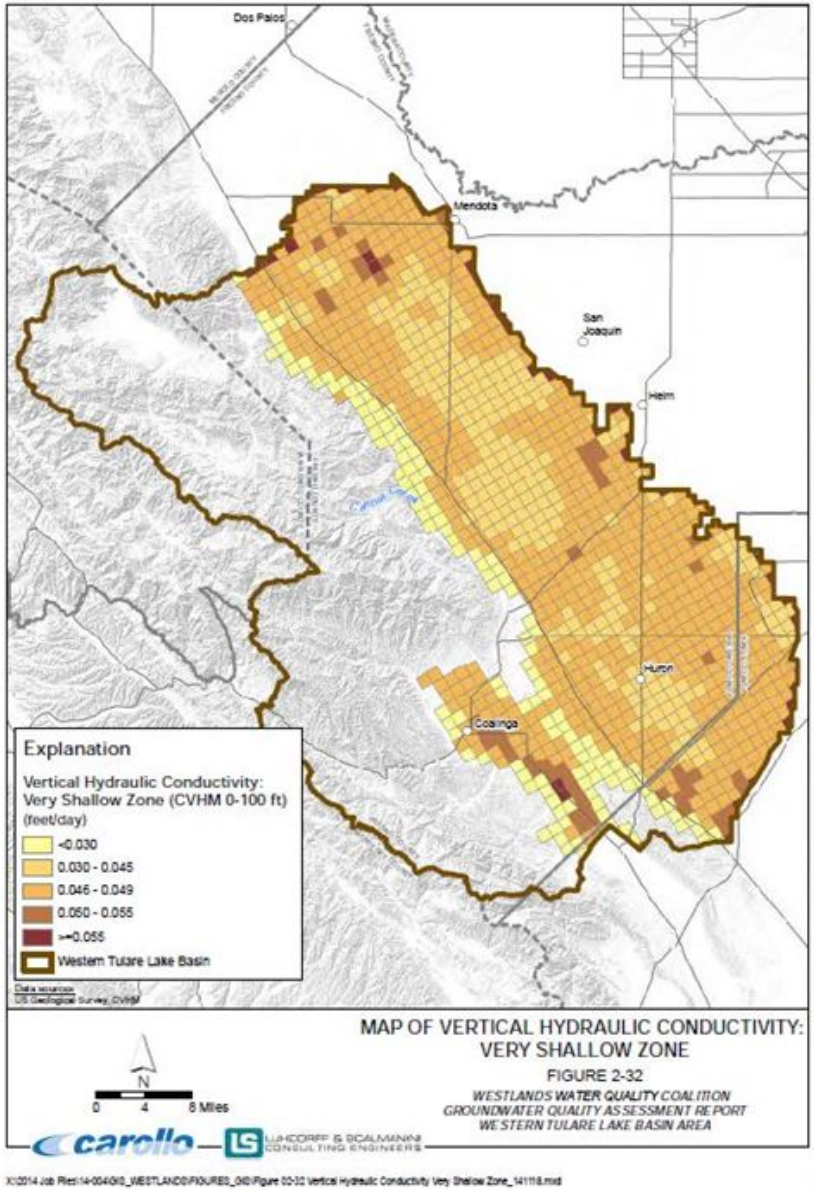
Figure 22 shows the vertical and horizontal hydraulic conductivities within the very shallow groundwater zone. Similar spatial patterns and ranges of magnitude in values are evident in the vertical and horizontal hydraulic conductivity of the very shallow zone. In general, areas of lower hydraulic conductivity exist in the interior parts of the Central Valley Floor area of the Coalition region, with several localized areas of higher conductivity apparent, specifically within Pleasant Valley and along the base of the Coast Range Mountains.

Figure 23 displays vertical and horizontal hydraulic conductivities within the Upper Aquifer. Although spatial patterns in these data are not clearly evident, several areas of notably higher horizontal hydraulic conductivity values within the Upper Aquifer are apparent along the western edge of the Central Valley Floor and the eastern edge of the Coalition. Another area of higher horizontal conductivity within the Upper Aquifer is shown in the vicinity of Huron, which is likely related to the alluvial fan associated with Los Gatos and Zapato Chino Creeks.

Figure 24 illustrates the low vertical hydraulic conductivity of the Corcoran Clay, with several areas of slightly higher vertical hydraulic conductivities are shown where the Cantua Creek and California Aqueduct intersect and south of Huron.

The overall horizontal hydraulic conductivity of the Lower Aquifer is less than that in the very shallow groundwater and the Upper Aquifer. These data show the horizontal hydraulic conductivity to be highest along the western edge of the Central Valley Floor and decreasing toward the Valley axis on the east side (Figure 24). This representation is consistent with historical interpretations of the alluvial fan depositional environments, including decreasing coarse materials toward the axial areas.

Figure 22. Vertical and Horizontal hydraulic conductivity of the very shallow zone within the Coalition region (Figures 2-32 and 2-33, WWQC, 2015).



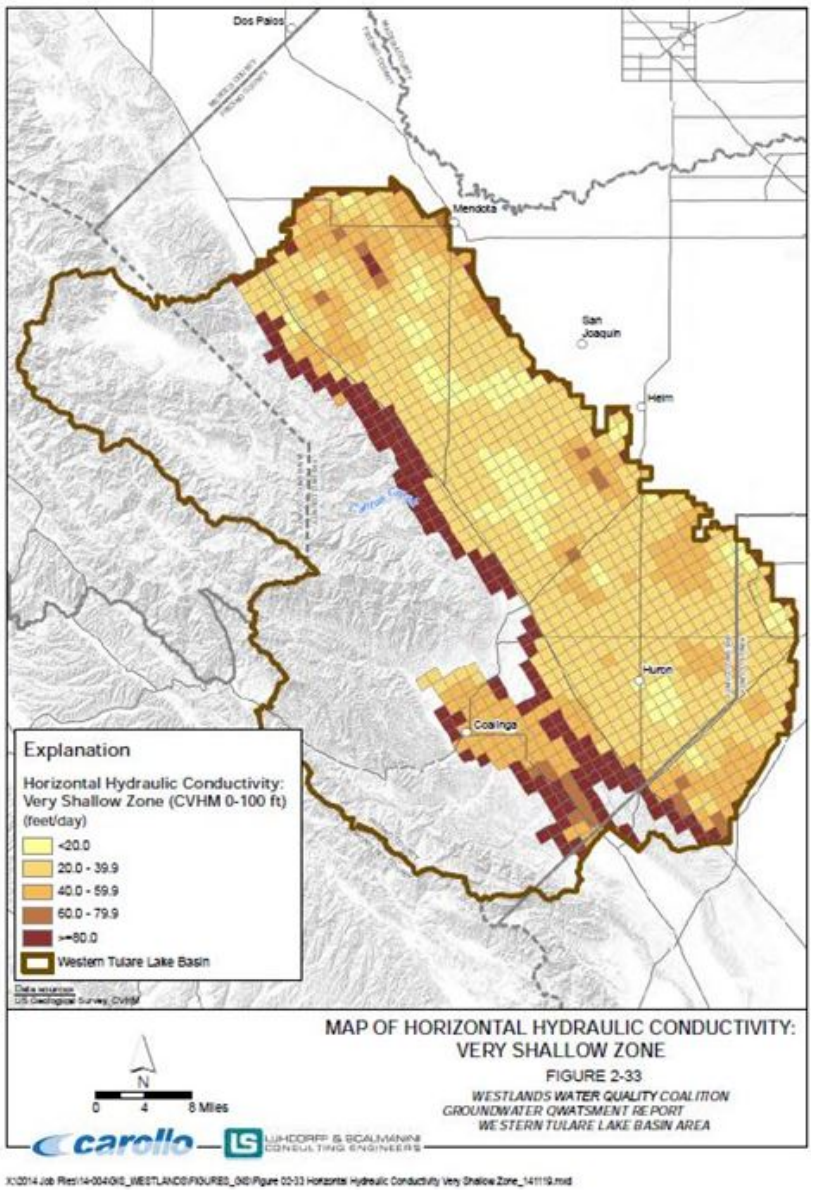
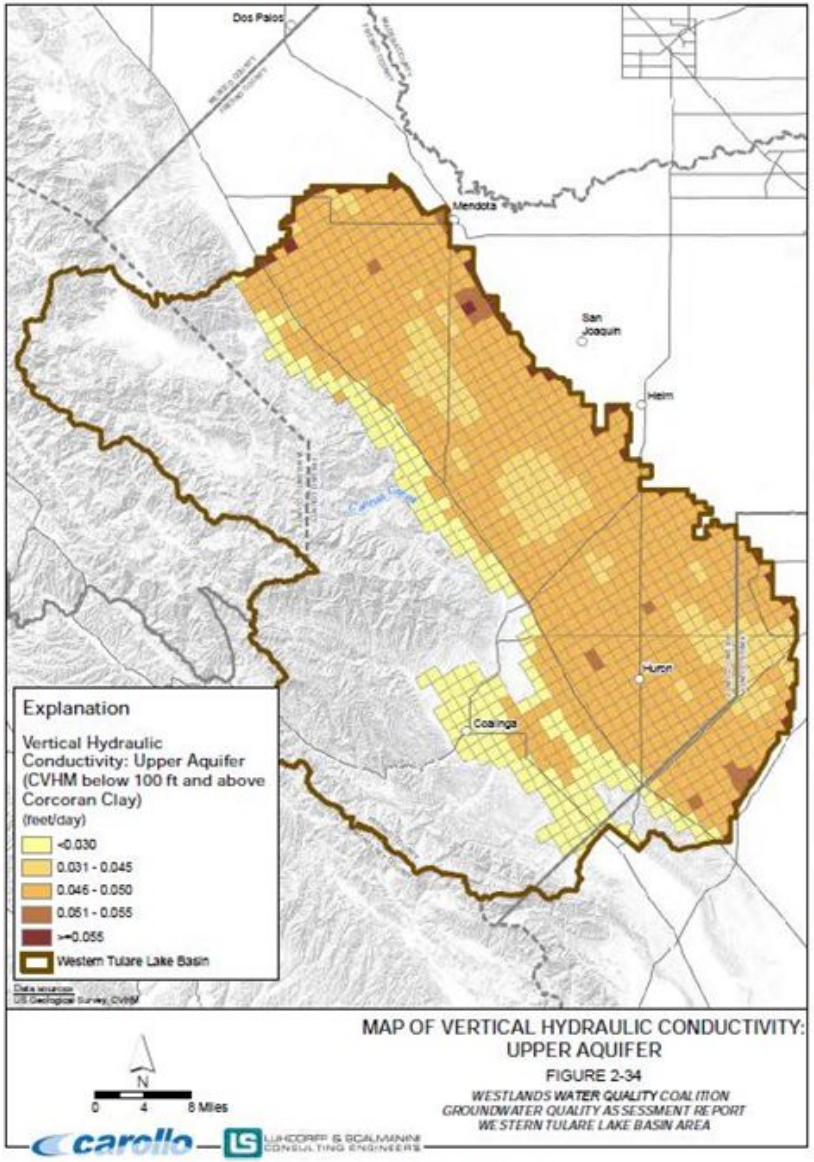


Figure 23. Vertical and horizontal hydraulic conductivity of the Upper Aquifer within the Coalition region (Figures 2-34 and 2-35, WWQC, 2015).



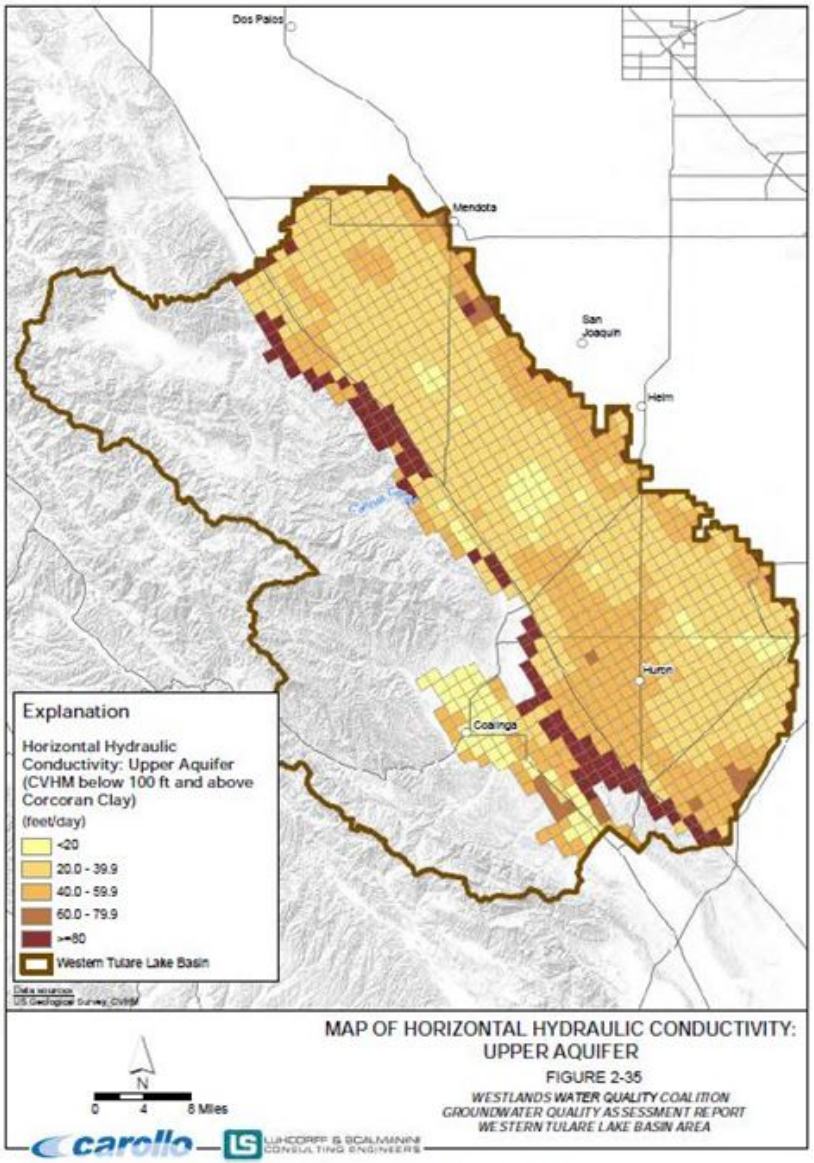
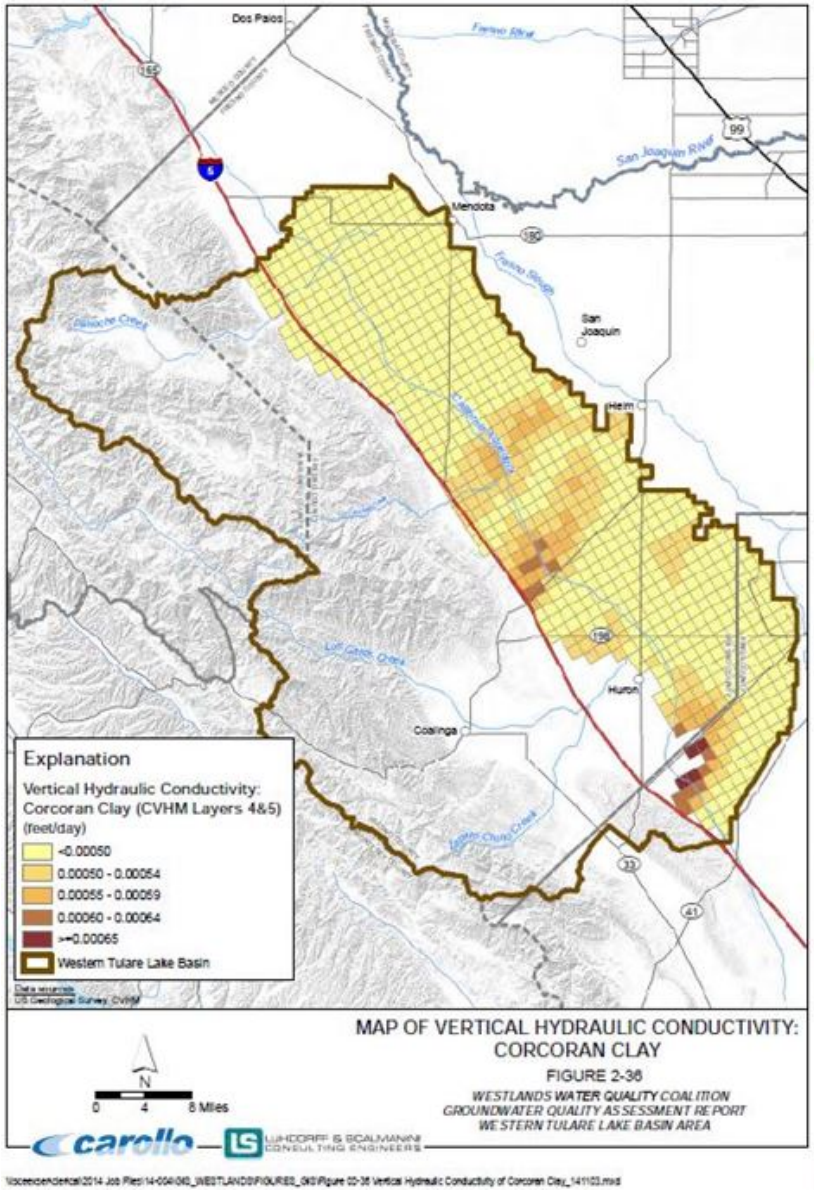
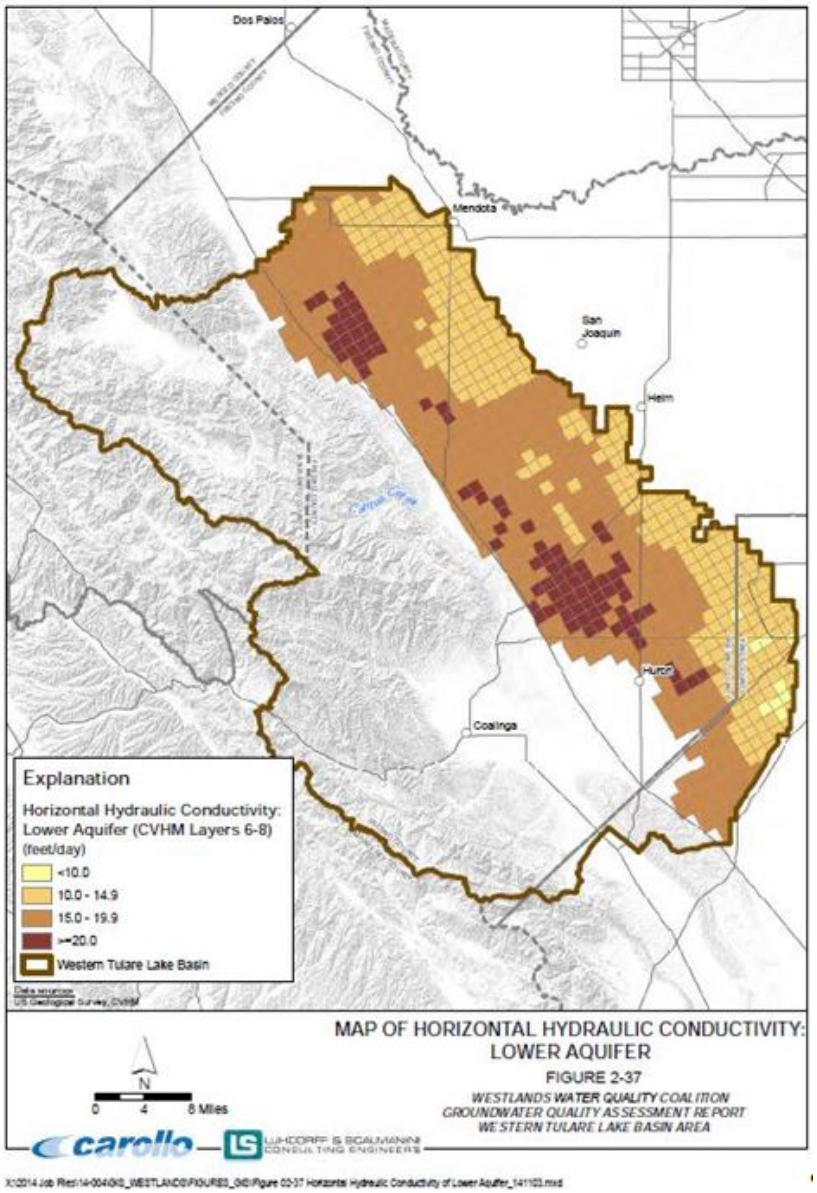


Figure 24. Vertical hydraulic conductivity of the Corcoran Clay and horizontal hydraulic conductivity of the Lower Aquifer within the Coalition region (Figures 2-36 and 2-37, WWQC, 2015).





2.1.3 Groundwater Basins and Sub-Basins – Bulletin 118

Portions of seven basin/subbasins have been delineated within the Coalition region according to Bulletin 118 (DWR, 2003) and the General Order (CVRWQCB, 2014) (Table 2, Figure 3): Delta-Mendota, Kings, Pleasant Valley, Tulare Lake, and Westside subbasins and Panoche Valley and Vallecitos Creek basins. Over half of the northern portion of the Pleasant Valley subbasin (54.8%), almost the entire Westside subbasin (99.5%), and all of the Panoche Valley and Vallecitos Creek basins lie within the footprint of the Coalition region. One percent or less of the Delta-Mendota (1%), Kings (0.4%), and Tulare Lake (0.4%) subbasins lie within the Coalition boundaries; all lie adjacent to the Westside subbasin. As one percent or less of the Delta-Mendota, Kings, and Tulare Lake subbasins lie within the Coalition boundaries, the characteristics of those subbasins are assumed to the same as those of the Westside subbasin.

Table 2. Basins/subbasins (partial or entire) and counties overlaying the GQMP region within the irrigated land in WWQC.
Primary basins/subbasins within the Coalition are **bolded**.

Groundwater Basin/Subbasin Number	Basins/Subbasins[1]	Associated County(s)[2]
5-22.07	Delta-Mendota	Fresno
5-22.08	Kings	Fresno
5-22.09	**Westside**	**Fresno/Kings**
5-22.10	**Pleasant Valley**	**Fresno/Kings**
5-22.12	Tulare Lake	Kings
5-23	**Panoche Valley**	**San Benito**
5-71	**Vallecitos Creek Valley**	**San Benito**

[1]Table contents based on DWR's Bulletin 118.
[2]For those basins/subbasins which span more than one county, only the county associated with that basin/subbasin and within the WWQC is listed above.

Descriptions are taken directly from DWR's Bulletin 118 (DWR, 2003) for the Pleasant Valley and Westside subbasins and the Panoche Valley and Vallecitos Creek basins and are listed below. Characteristics of those portions of the Delta-Mendota, Kings, and Tulare Lake subbasins within the Coalition boundaries are assumed to be the same as those of the adjacent Westside subbasin.

2.1.3.1 Panoche Valley Groundwater Basin

- Groundwater Basin Number: 5-23
- County: San Benito
- Surface Area: 33,100 acres (52 square miles)

Basin Boundaries and Hydrology

Panoche Valley is an elongate northwest-southeast trending basin in the Coast Range Mountains of eastern San Benito County. The elevation ranges from 1,000 to 1,300 feet. The basin is comprised of shallow alluvium, Quaternary nonmarine terrace deposits and Plio-Pleistocene nonmarine sediments. The basin is bounded to the northwest by the Franciscan Formation, to the northeast and southeast by Upper Cretaceous marine sedimentary rocks and to the southwest by Lower Miocene marine rocks (Jennings and Strand 1959). Panoche

Creek, Griswold Creek, and their tributaries drain the valley eastward to the San Joaquin Valley. Average precipitation values range from nine inches for the majority of the valley to 13 inches at the western margin.

Hydrogeologic Information

2.1.3.1.1.1 Water Bearing Formations

No specific published information on the water bearing deposits was found. Review of San Joaquin District well completion report files produced drillers logs for nine wells in the basin. These wells ranged in depth from 171 feet to 1,500 feet. They generally penetrate alluvial materials including gravels, sands, silts and clays. Additional descriptive units include shale, clay and rocks, and hard sand. From this information it seems likely that the water bearing units may include the alluvium, Quaternary nonmarine terrace deposits and Plio-Pleistocene nonmarine sediments.

2.1.3.1.1.2 Groundwater Level Trends

Water level measurements for 48 wells were found in the San Joaquin District water level data files. These measurements range in time from 1967 to 2000. Depth to water ranges from 30 to over 300 feet, with most of the measurements being in the 30 to 80 foot range. There is a general trend of rising water levels from the 1970's to 2000. Water levels have risen as much as 130 feet and typically over 40 feet throughout the basin. Field reconnaissance in August 2001determined that irrigated agriculture is limited to one vineyard of less than 20 acres and one walnut orchard of less than 20 acres. A discussion with Don Hennigan (2001), a 76-year-old life-long resident of Panoche Valley, determined that in the 1940's extensive areas of alfalfa were in production and in the 50's and 60's cotton was extensively grown in the basin. It appears that groundwater levels are recovering from a past period of groundwater pumping.

2.1.3.1.1.3 Groundwater Storage

No information on groundwater storage was found. Well logs and water level information indicate that significant volumes of water existed at one time in the basin, however, development of wells and agriculture may have outpaced the ability of the basin to replenish itself and led to the discontinuation of widespread use of the groundwater resource.

2.1.3.1.1.4 Groundwater Budget (Type C)

There is not enough information to provide an estimate of this basin's budget.

Well Characteristics / Active Monitoring Data / Basin Management

No well characteristics are listed. Monitoring efforts in the basin have included DWR measuring groundwater levels and miscellaneous water quality parameters in the past, but monitoring efforts have since have been discontinued. No groundwater management agencies, either public or private, are listed.

2.1.3.2 Vallecitos Creek Valley Groundwater Basin

- Groundwater Basin Number: 5-71
- County: San Benito
- Surface Area: 15,100 acres (24 square miles)

Basin Boundaries and Hydrology

Vallecitos Creek Valley Groundwater Basin is a northwest-southeast trending synclinal valley in the Coast Range Mountains of eastern San Benito County. The elevation ranges from 1,600 to 2,000 feet. The middle of the valley is occupied be Quaternary Alluvium surrounded by Plio-Pleistocene nonmarine sediments and Lower Miocene to Paleocene marine sediments (Jennings and Strand 1959). The basin is drained to the northwest and to the east from the syncline divide near the center of the basin. Vallecitos Creek drains to the northwest to Panoche Valley by way of Griswold Canyon and finally to the San Joaquin Valley via Panoche Creek. Los Pinos Creek drains the basin to the east and exits the mountains via Silver Creek. Average precipitation values range from 11 to 15 inches.

Hydrogeologic Information

2.1.3.2.1.1 Water Bearing Formations

No information was found in published literature regarding the occurrence of groundwater within the basin. Review of San Joaquin District well completion report files revealed records for three wells. The three wells were all located in the northwest portion of the basin. Well depths ranged from 80 to 122 feet, with initial water levels at 15 to 40 feet. No yield data was provided. There were no well records for the main body of the basin. Review of the USGS topographic maps of the area and a field reconnaissance revealed several stock wells. It is likely that the water bearing units are restricted to the shallow alluvium in the center of the valley.

2.1.3.2.1.2 Groundwater Level Trends

No information on groundwater level trends is available. Since wells are shallow it is likely that water levels fluctuate with the seasons and flow of the adjacent creeks.

2.1.3.2.1.3 Groundwater Storage

No information on groundwater storage is available. The shallow alluvium limits the amount of storage.

2.1.3.2.1.4 Groundwater Budget (Type C)

No information on groundwater budget is available.

2.1.3.2.1.5 Groundwater Quality

No information on groundwater quality is available. The surrounding marine rocks make it likely that water quality in the basin is marginal.

Well Characteristics / Active Monitoring Data / Basin Management

No well characteristics are listed. No monitoring efforts in the basin are listed. No groundwater management agencies, either public or private, are listed.

2.1.3.3 Pleasant Valley Subbasin

- Groundwater Basin Number: 5-22.10
- County: Fresno, Kings
- Surface Area: 146,000 acres (227 square miles)

Basin Boundaries and Hydrology

The San Joaquin Valley is surrounded on the west by the Coast Ranges, on the south by the San Emigdio and Tehachapi Mountains, on the east by the Sierra Nevada and on the north by the Sacramento-San Joaquin Delta and Sacramento Valley. The northern portion of the San Joaquin valley drains toward the Delta by the San Joaquin River and its tributaries, the Fresno, Merced, Tuolomne, and Stanislaus Rivers. The southern portion of the valley is internally drained by the Kings, Kaweah, Tule, and Kern Rivers that flow into the Tulare drainage basin including, the beds of the former Tulare, Buena Vista, and Kern Lakes.

The Pleasant Valley subbasin lies along the west side of the San Joaquin Valley, north of the Kings-Kern County line. It straddles the Fresno-Kings County Line. The subbasin is surrounded throughout most of its perimeter by Tertiary continental and marine sediments of the Coast Ranges and west flank of the Kettleman Hills. The subbasin includes the older and younger alluvium of the San Joaquin Valley. The eastern boundary of the subbasin abuts the Westside and Tulare Lake subbasins. The southern boundary abuts the Kern County subbasin. These subbasin boundaries have been derived from both hydrologic and political criteria. Several small, ephemeral streams enter the basin from the surrounding mountains; these streams include Los Gatos, Warthan, Jacalitos, Avenal, and Zapato Chino Creeks. Average precipitation values range from 7 in. for a majority of the basin with 9 in along the western margin.

Hydrogeologic Information

The San Joaquin Valley represents the southern portion of the Great Central Valley of California. The San Joaquin Valley is a structural trough up to 200 miles long and 70 miles wide filled with up to 32,000 feet of marine and continental sediments deposited during periodic inundation by the Pacific Ocean and by erosion of the surrounding mountains, respectively. Continental deposits shed from the surrounding mountains form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough. This depositional axis is below to slightly west of the series of rivers, lakes, sloughs, and marshes which mark the current and historic axis of surface drainage in the San Joaquin Valley.

2.1.3.3.1.1 Water Bearing Formations

Geologic units comprising the Pleasant Valley subbasin include Holocene alluvium, the Plio-Pleistocene Tulare Formation, and possibly the upper part of the San Joaquin Formation. Specific yield is estimated to be 8.4 percent for the subbasin from DWR, San Joaquin District internal data. Williamson, Prudic, and Swain (1989) estimated water in storage in Pleasant Valley using a specific yield of 9.9 percent. For a study in Pleasant Valley WD, Summers Engineering, Inc. (1986) estimated the specific yield at 10.3 percent. In another study for Pleasant Valley WD, Kenneth D. Schmidt and Associates (2000) estimated the average specific yield of deposits below the water table at 10 percent.

Holocene Alluvium. The alluvium consists of highly lenticular deposits of poorly sorted clay, silt, and sand with occasional interbeds of well-sorted fine-to-medium-grained sand. The thickness is unknown, but it is doubtful that it is more than 300 feet.

Plio-Pleistocene Tulare Formation. The alluvium consists of highly lenticular deposits of poorly sorted clay, silt, and sand with occasional interbeds of well-sorted fine-to-medium-grained sand. The thickness is unknown, but it is doubtful that it is more than 300 feet.

San Joaquin Formation. The San Joaquin Formation consists of unfossiliferous silt and clay beds alternating with beds of sandstone and conglomerate and contains marine, brackish water and nonmarine fossils (Kahanovit and Manning 1954).

2.1.3.3.1.2 Recharge Areas

Groundwater recharge is primary from seepage from the various streams that cross the subbasin. The cities of Coalinga, in the northern portion of the subbasin, and Avenal, near the longitudinal midpoint, import water for municipal purposes. The state prisons near Coalinga and Avenal also use imported water. Additional recharge may occur as a consequence of this water use. No recharge occurs as a result of the WWD conveyance structures. Because of the scarcity of water in the District, all conveyance structures are underground pipes which eliminates losses of irrigation supply water due to seepage or evaporation.

2.1.3.3.1.3 Groundwater Level Trends

Summers Engineering, Inc. (1986) calculated the rate of water level decline between the mid-1960s and early 1980s in Pleasant Valley WD as 4.8 feet per year. Schmidt (2000) estimated the annual decline for the previous four decades at approximately 4 feet per year. The slower decline was attributed to recent reductions in groundwater pumping. In the past decade water levels have generally continued their long historic decline, with hydrographs on file with DWR indicating water level changes of -5 to -25 feet. Localized areas however have shown some rebound from 1995 to 2001.

2.1.3.3.1.4 Groundwater Storage

As part of the Bulletin 118 update, the total subbasin storage capacity is estimated to be 14,100,000 af. This estimate assumes an average thickness of 1,150 feet (base of fresh water), a specific yield of 8.4 percent, and

an area of 146,000 acres. Williamson, Prudic and Swain (1989) estimated the volume of water in storage to a maximum depth of 1,000 feet and a groundwater elevation in 1961 with a specific yield of 9.9 percent to be 4,000,000 af.

2.1.3.3.1.5 Groundwater Budget (Type B)

The budget presented below is based on data collected as part of DWR's Bulletin 160 preparation. The basis for calculations include a 1990 normalized year and land and water use data, with subsequent analysis by a DWR water budget spreadsheet to estimate overall applied water demands, agricultural groundwater pumpage, urban pumping demand and other extraction data. No data for subsurface inflow or outflow exists. Applied water recharge is estimated at 4,000 af per year, there is no known artificial recharge, and natural recharge has not been determined. Estimated extractions include urban pumping at 5,700 af per year, agricultural pumping at 90,000 af per year, and oil industry related extractions 8,830 af per year**.**

2.1.3.3.1.6 Groundwater Quality

Schmidt (2000) estimated the TDS of groundwater in Pleasant Valley WD ranged from 1,000 to 3,000 mg/L with an average of 1,500 mg/L. The constituents in groundwater include calcium, magnesium, sodium, bicarbonates, chlorides, sulfates, and boron. The high TDS concentrations limit the usability of groundwater in the subbasin for most uses.

Well Characteristics

WELL YIELDS (GAL/MIN)		
Municipal/Irrigation	Range: 35-3,300 (DWR unpublished data)	
TOTAL DEPTHS (FT)		
Domestic	Range: Not Determined	Average: Not Determined
Municipal/Irrigation	Range: 300-1,760	Average: 1,000(DWR - unpublished data and Pleasant Valley Water)

Active Monitoring Data

AGENCY	PARAMETER	NUMBER OF WELLS / MEASUREMENT FREQUENCY
DWR and cooperators	Groundwater levels	151 / Semi-annually
Department of Health Services and cooperators	Title 22 water quality	2 / Varies

Basin Management

GROUNDWATER MANAGEMENT	The County of Fresno adopted in 2000 an ordinance, which includes a permit process for groundwater transfers. Pleasant Valley Water District adopted a groundwater management plan on May 9, 2000 and is currently working on an update of the plan.
WATER AGENCIES	
Public	Pleasant Valley Water District, City of Coalinga, Devil's Den WD, Green Valley WD
Private	

2.1.3.4 Westside Subbasin

- Groundwater Basin Number: 5-22.09

- County: Fresno, Kings
- Surface Area: 640,000 acres (1,000 square miles)

Basin Boundaries and Hydrology

The San Joaquin Valley is surrounded on the west by the Coast Ranges, on the south by the San Emigdio and Tehachapi Mountains, on the east by the Sierra Nevada and on the north by the Sacramento-San Joaquin Delta and Sacramento Valley. The northern portion of the San Joaquin Valley drains toward the Delta by the San Joaquin River and its tributaries, the Fresno, Merced, Tuolumne, and Stanislaus Rivers. The southern portion of the valley is internally drained by the Kings, Kaweah, Tule, and Kern Rivers that flow into the Tulare drainage basin including the beds of the former Tulare, Buena Vista, and Kern Lakes.

The Westside Subbasin consists mainly of the lands in Westlands Water District. It is located between the Coast Range foothills on the west and the San Joaquin River drainage and Fresno Slough on the east. The subbasin is bordered on the southwest by the Pleasant Valley Groundwater Subbasin and on the west by Tertiary marine sediments of the Coast Ranges, on the north and northeast by the Delta-Mendota Groundwater Subbasin, and on the east and southeast by the Kings and Tulare Lake Groundwater Subbasins. Average annual precipitation varies across the subbasin from 7 inches in the south to 9 inches in the north.

Hydrogeologic Information

2.1.3.4.1.1 Water Bearing Formations

The aquifer system comprising the Westside Subbasin consists of unconsolidated continental deposits of Tertiary and Quaternary age. These deposits form an unconfined to semi-confined upper aquifer and a confined Lower Aquifer. These aquifers are separated by an aquitard named the Corcoran Clay (E-Clay) member of the Tulare Formation.

The unconfined to semi-confined aquifer (upper zone) above the Corcoran Clay includes younger alluvium, older alluvium, and part of the Tulare Formation. These deposits consist of highly lenticular, poorly sorted clay, silt, and sand intercalated with occasional beds of well-sorted fine to medium grained sand. The depth to the top of the Corcoran Clay varies from approximately 500 feet to 850 feet (DWR 1981).

The confined aquifer (lower zone) consists of the lower part of the Tulare Formation and possibly the uppermost part of the San Joaquin Formation. This unit is composed of lenticular beds of silty clay, clay, silt, and sand interbedded with occasional strata of well-sorted sand. Brackish or saline water underlies the usable groundwater in the lower zone.

Unpublished DWR (San Joaquin District) information indicates specific yield ranges from 5.1 to 17.8 percent to a depth of 300 feet. The highest specific yields are associated with coarser sediments distributed along the eastern portion of the subbasin from the Sierra Nevada Mountains. The USGS (Williamson and others 1989) used a subbasin average specific yield of 10.3 percent for groundwater modeling purposes. Earlier USGS work estimated an average specific yield of 9 percent from a depth of 10 to 200 feet (Davis and others 1959).

2.1.3.4.1.2 Restrictive Structures

The alluvium consists of highly lenticular deposits of poorly sorted clay, silt, and sand with occasional interbeds of well-sorted fine-to-medium-grained sand. The thickness is unknown, but it is doubtful that it is more than 300 feet.

Recharge Areas

The alluvium consists of highly lenticular deposits of poorly sorted clay, silt, and sand with Recharge Areas.

Groundwater recharge is primary from seepage from the various streams that cross the subbasin. The cities of Coalinga, in the northern portion of the subbasin, and Avenal, near the longitudinal midpoint, import water for municipal purposes. The state prisons near Coalinga and Avenal also use imported water. Additional recharge may occur as a consequence of this water use. No recharge occurs as a result of the WWD conveyance structures. Because of the scarcity of water in the District, all conveyance structures are underground pipes which eliminates losses of irrigation supply water due to seepage or evaporation.

2.1.3.4.1.3 Groundwater Level Trends

Summers Engineering, Inc. (1986) calculated the rate of water level decline between the mid-1960s and early 1980s in Pleasant Valley WD as 4.8 feet per year. Schmidt (2000) estimated the annual decline for the previous four decades at approximately 4 feet per year. The slower decline was attributed to recent reductions in groundwater pumping. In the past decade water levels have generally continued their long historic decline, with hydrographs on file with DWR indicating water level changes of -5 to -25 feet. Localized areas however have shown some rebound from 1995 to 2001.

2.1.3.4.1.4 Groundwater Storage

Groundwater Storage Capacity

Davis and others (1959) estimated the groundwater storage capacity at 10,940,000 af in the depth zone from 10 to 200 feet of the Mendota-Huron storage unit. This was over an area of 639,000 acres and a specific yield varying from 8.0 to 9.6 percent. This occupies a portion of the upper aquifer.

Using an average thickness of 675 feet (ground surface to top of Corcoran Clay), specific yield of 9 percent, over an area of 600,000 acres; the storage capacity of the upper aquifer is approximately 36,500,000 af.

Using a thickness of 1,200 feet from the average base of the Corcoran Clay to the average base of fresh groundwater, a specific yield of 9 percent, over 600,000 acres; the storage capacity of the Lower Aquifer is approximately 65,000,000 af.

Groundwater in Storage

The USGS estimated the water in storage in 1961 was 52,000,000 af (Williamson 1989). This estimate was to a depth of less than or equal to 1,000 feet.

Using an average depth to water in October 1984 of 111 feet, a specific yield of 9 percent, over an area of 600,000 acres; the available storage is estimated to be 6,000,000 af.

2.1.3.4.1.5 Groundwater Budget (Type C)

Davis and Poland (1957) estimated seepage from west side streams amounted to 30,000-40,000 af per year. For 1951, secondary recharge from the east into the upper aquifer was 20,000-30,000 af and was 150,000-200,000 af into the Lower Aquifer (Davis and Poland 1957).

Westlands Water District (1999) estimated the average deep percolation between 1978 and 1996 was 244,000 af per year. The District (1998) also estimated the average applied groundwater between 1978 and 1997 was 193,000 af per year**.**

2.1.3.4.1.6 Groundwater Quality

Characterization

Groundwaters of the west side of the San Joaquin Valley are generally of the sulfate or bicarbonate type (Davis and others 1959). The waters of the upper aquifer, generally, are high in calcium and magnesium sulfate (Davis and Poland 1957). Groundwater below 300 feet and above the Corcoran Clay shows a tendency of decreased dissolved solids with increased depth. Most of the groundwater of the Lower Aquifer is of the sodium sulfate type (Davis and Poland 1957). The difference in quality between the Upper and Lower Aquifers is that the confined zone contains less dissolved solids (Davis and others 1959). Groundwater in western Fresno County can have an upper range between 2,000 and 3,000 mg/L (Davis and others 1959).

DHS data indicates an average TDS of 520 mg/L in the subbasin with a range from 220 mg/L to 1,300 mg/L based on the analyses of six Title 22 monitoring wells.

Dubrovsky and others (1993) indicated the concentration of dissolved solids in shallow groundwater can be greater than 10,000 mg/L at some locations in the lower fan areas. One sample had a TDS of 35,000 mg/L.

Impairments High concentrations of total dissolved solids is one cause of impairment of groundwater in the subbasin. Groundwaters at certain locations contain selenium and boron that may also affect usability.

Water Quality in Public Supply Wells

Constituent Group[1]	Number of Wells Sampled[2]	Number of Wells with a Concentration above an MCL[3]
Inorganics - Primary	2	0
Radiological	1	0
Nitrates	2	0
Pesticides	2	0
VOCs and SVOCs	2	0

Inorganics - Secondary	2	2

[1] A description of each member in the constituent groups and a generalized discussion of the relevance of these groups are included in *California's Groundwater – Bulletin 118* by DWR (2003).
[2] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 through 2000.
[3] Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. This information is intended as an indicator of the types of activities that cause contamination in a given basin. It represents the water quality at the sample location. It does not indicate the water quality delivered to the consumer. More detailed drinking water quality information can be obtained from the local water purveyor and its annual Consumer Confidence Report.

Well Characteristics

WELL YIELDS (GAL/MIN)		
Municipal/Irrigation	Range: 560-2,000	Average: 1,100 (Davis and Poland 1957)
TOTAL DEPTHS (FT)		
Domestic	Range: Not Determined	Average: Not Determined
Municipal/Irrigation	Range: 120-3,000	Average: 600-1,000 Varies by type and location

Active Monitoring Data

AGENCY	PARAMETER	NUMBER OF WELLS / MEASUREMENT FREQUENCY
Westlands Water District	Groundwater levels	960 / Annually and may vary
Westlands Water District	Miscellaneous Water Quality	Varies
Department of Health Services and cooperators	Title 22 water quality	50 / Varies

Basin Management

GROUNDWATER MANAGEMENT	
AB3030 Plan adopted by Westlands Water District	
WATER AGENCIES	
Public	Westlands Water District
Private	

2.2 Groundwater Hydrology

The groundwater hydrology description below is either summarized or taken exclusively from the GAR. Reproduction of the figures presented in the GAR is included here for ease of reference. A discussion of the extent and various restrictions of the well data are presented at length in the GAR in Section 3.3.1.1.

2.2.1 Groundwater Levels

Data presented in the GAR on groundwater levels within the Coalition was collected from readily available groundwater level data from DWR and the SWRCB's Geotracker database. These data were used in conjunction with considerable groundwater level data provided by the WWD.

To develop an understanding of the groundwater conditions and trends, data were collected and mapped for the Coalition region and vicinity. Available data within five miles of the Coalition region were allowed for control points for interpolation along the edge of the Coalition region. Therefore, more data were used than

just the data within the Coalition region (Table 3). These data consisted of more than 260,000 measurements from over 8,200 wells within and around the Coalition region. DWR data consisted of 3,965 wells with 42,024 measurements; SWRCB Geotracker data consisted of 184 wells with 3,350 measurements; and WWD data consisted of 4,081 wells with 215,905 measurements (though some of these likely overlap with the DWR data). Of these assembled data for 8,230 wells, 4,510 wells have information available on well construction such as depth or screened interval.

Table 3. Summary of assembled groundwater level data (all data since 1910) (Table 3-1, WWQC, 2015).

Table 3-1 Summary of Assembled Groundwater Level Data (all data since 1910)

Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area

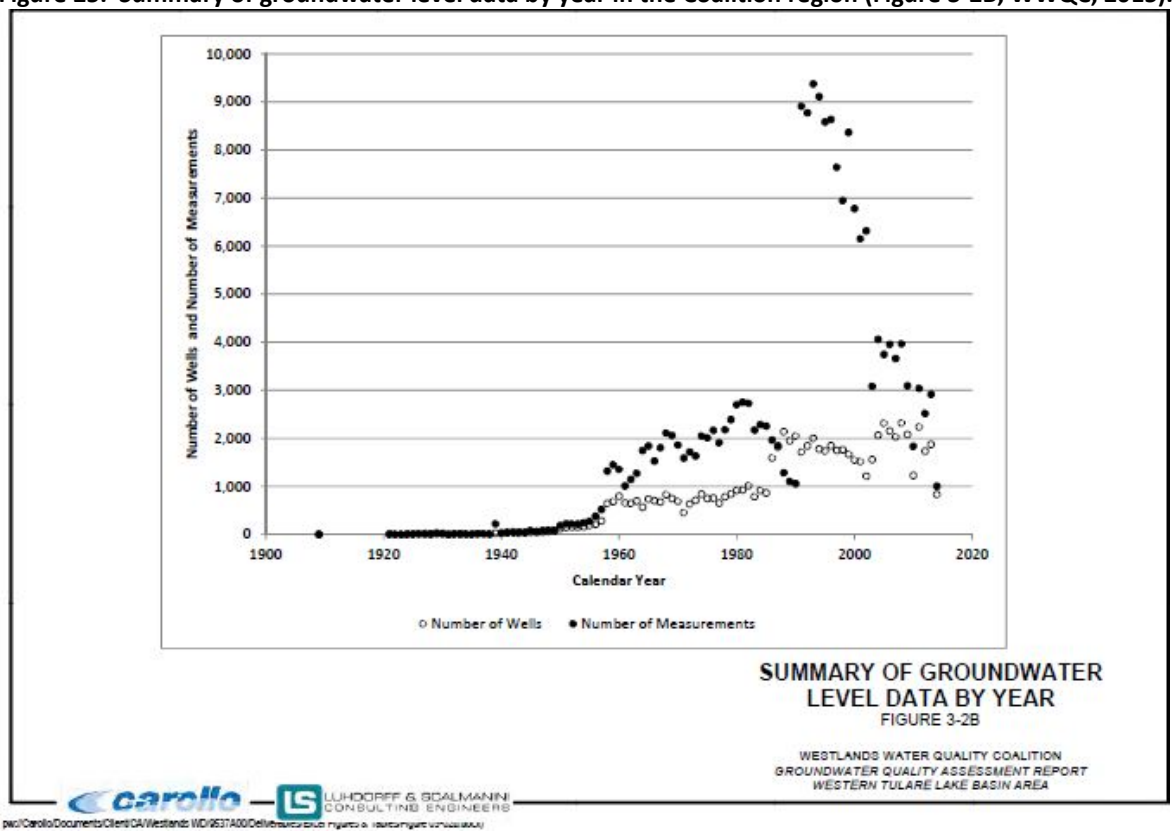
Westlands Water Quality Coalition

Monitoring Entity	Number of Wells	Number of samples	Number with known depth	Irrigation Wells	Monitoring Wells	Domestic Wells	Unknown Well Type	Very Shallow Zone	Upper Aquifer	Lower Aquifer	Composite	Unkown Depth Zone	Samples Pre-1970s	Samples in 1970s	Samples in 1980s	Samples in 1990s	Samples in 2000s	Samples in 2010s
WWD	3,612	195,806	3,206	1,432	1,547	11	622	2,040	344	883	345	0	6,633	12,829	67,333	73,216	29,923	5,867
DWR	3,100	25,689	722	942	64	0	2,094	31	132	881	0	2,056	7,001	3,219	3,007	2,423	7,019	3,020
SWRCB	47	673	30	0	0	0	47	28	13	0	0	6	0	0	0	0	390	283
Total	6,759	222,168	3,958	2,374	1,611	11	2,763	2,099	489	1,764	345	2,062	13,634	16,048	70,340	75,639	37,332	9,170

Both the groundwater level and groundwater quality data were classified into interpreted depth zones. The same procedures were utilized for both datasets. Groundwater level data were grouped into five well depth categories indicating the depth zone which they are interpreted to represent. These depth categories include very shallow, Upper Aquifer, Lower Aquifer, composite wells (Upper and Lower Aquifers), and wells of unknown depth. Very shallow wells were defined as wells with depths less than 100 feet and also wells called monitoring wells in the source database. Wells with depths deeper than 100 feet but above the top of the Corcoran Clay, as indicated by Central Valley Hydrologic Model (CVHM) data (Faunt, 2009), were classified as Upper Aquifer. In areas outside the extent of the Corcoran Clay, wells with depths less than 500 feet were considered Upper Aquifer wells. Wells known to be domestic wells were also included in the Upper Aquifer depth category even if well depth information was not provided. The depth of the bottom of the Corcoran Clay was used to differentiate wells interpreted to be in the Lower Aquifer. All wells with depths greater than the bottom of the Corcoran clay layer were classified as Lower Aquifer wells. Wells known to be irrigation wells were also classified as Lower Aquifer. Wells interpreted to be screened in both the Upper and Lower Aquifer were classified as composite wells. Wells lacking any information that could be used to classify them in the above categories, either by well type or well depth, were designated as unknown depth.

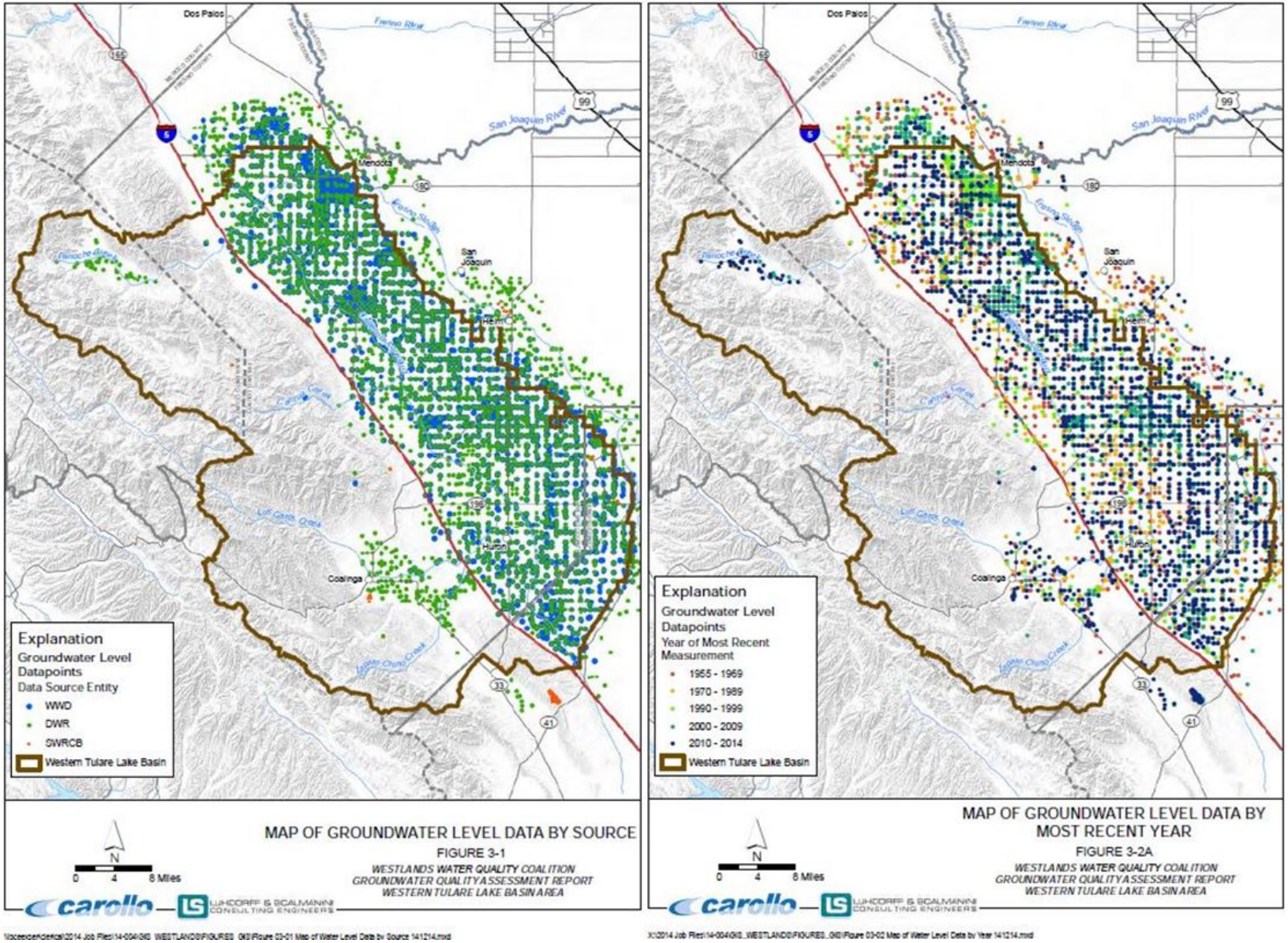
Figure 25 shows the distribution of all water level measurements used over time, and indicates that sampling efforts doubled every five years between 1930 and 1960, doubled again by 1980, and have increased more slowly since, although the number of wells sampled doubled quickly in the early 1990s. The distribution of groundwater level data by year is shown in Figure 26. In general, there is a good distribution of data from all decades back to the 1960s. Prior to that decade, the dataset becomes sparse and poorly distributed across the Coalition region.

Figure 25. Summary of groundwater level data by year in the Coalition region (Figure 3-2B, WWQC, 2015).



The spatial distribution of groundwater level data by data source is presented in Figure 26. This map shows the wide distribution of both DWR and WWD datasets, and the relatively localized nature of the SWRCB Geotracker dataset. Groundwater level data are lacking in the western portion of the Coalition region, with relatively few data points available within the Peripheral Area. These limitations restrict the extent of the groundwater level contours that were developed for this project to within the Central Valley Floor portion of the Coalition region. Consistent and continuous representations of groundwater levels in groundwater zones can reasonably be interpreted within the valley fill deposits comprising much of the San Joaquin Valley Groundwater Basin and the Central Valley Floor. However, more consolidated rocks of the Coast Range, including uplifted, rotated, and faulted geologic units in which groundwater occurrence and movement is less predictable, limit the ability to develop similar representations of conditions in these areas at the scale appropriate for the GAR.

Figure 26. Groundwater level data by source and most recent year (Figures 3-1 and 3-2A, WWQC, 2015).



2.2.1.1 Trends in Groundwater Levels

Groundwater levels can fluctuate greatly through time due to numerous natural and anthropogenic factors, including long-term climatic conditions, adjacent well pumping, nearby surface water flows, and seasonal groundwater recharge/depletion. Spatial trends in current groundwater levels under spring and fall seasonal conditions across the Central Valley Floor area and peripheral area of the Coalition region are presented in Figure 27 through Figure 30. Spatially continuous depth to groundwater surface datasets were limited to the Central Valley Floor, largely due to the location of available data, but also because this is where the majority of irrigated agriculture exists, and the hydrogeologic environment within the Central Valley Floor area is different from the Peripheral Area of the Coalition region. Individual groundwater level data points for the Panoche Creek and Pleasant Valley areas are presented in Figure 30.

For each aquifer (Figure 13), two sets of well water level data were analyzed, one for fall and one for spring, beginning with data from 2005. Fall was defined as the months of September, October, and November. Spring was defined as the months of January, February, March, and April. An in-depth discussion on the process of data analysis is presented in the GAR. As discussed above, the extent of the groundwater level contours for each depth zone were limited by the spatial distribution of available groundwater level data and further limited to the Central Valley Floor, area were geologic conditions make interpolations between well points more appropriate.

2.2.1.2 Depth to Groundwater

Regionally, depth to groundwater decreases from the valley perimeter to the valley axis – in the Coalition region this translates to a west-to-east decrease in depth to water. Depth to groundwater is influenced by local elevation of the land surface and does not indicate flow direction; it is important to recognize that although depth to water decreases in the eastward direction, this does not imply that the groundwater gradient is from east to west. Groundwater flow directions in the Upper and Lower Aquifers are controlled by the piezometric head gradient, which is generally from west to east in the Coalition region. The results produced in this analysis agree well with depth to water maps provided by WWD, which generally show the shallowing trend from west to east.

Very Shallow Groundwater / Upper Aquifer / Lower Aquifer

Spring data from wells classified as terminating in very shallow groundwater indicate that water levels range between very close to the ground surface and approximately 55 feet, with generally deeper water tables in the western side of the valley portion of the Coalition region and a shallower water table in the eastern areas (Figure 27). The influence of the alluvial fans of Panoche, Cantua, and Los Gatos Creeks is apparent, as the accumulated alluvium at the mouths of these streams have produced elevated land surfaces in those regions, resulting in greater depths to water. Fall depths to water (Figure 27) show a similar pattern to spring groundwater levels, though generally slightly deeper.

The Upper Aquifer ranges from relatively shallow piezometric head in the range of 20 to 60 feet below ground surface, occurring in the most northern region of the Coalition region, to much deeper head values in the

southern region, around 200 to 240 feet below ground surface. When local depressions are ignored, fall (Figure 28) depths to potentiometric surfaces are greater than those in the spring (Figure 28).

The Lower Aquifer exhibits more dramatic variation between spring and fall (Figure 29), with most of the aquifer presenting reduced piezometric heads in the fall. On the eastern edge of the Coalition region, in the northern portion, near the Mendota Pool and the San Joaquin River, the depth to potentiometric surface was lower in fall than spring, swinging from 160 feet below ground in fall to 120 or less in spring. In the southeastern corner of the Coalition region, the fall depth to potentiometric surface was around 140 feet, but in the spring this was closer to 200 feet.

Peripheral Area

Depths to water in the Panoche Valley range from over 100 feet to less than 25 feet, but with no obvious trend in relation to the creek or the valley axis (Figure 30). The deepest water was found throughout the valley, as were the lesser depths to groundwater. The likelihood of great variability in the subsurface hydrogeological properties, coupled with lack of screen-depth data for most of the wells in the area limits the usefulness of this dataset. In Pleasant Valley, depths to water ranged from over 400 feet to less than 100 feet (Figure 30). The greatest depth to water was found in the uppermost (northwest) portion of the valley, likely reflecting the sharp increase in land surface elevation at that end of the valley.

2.2.1.3 Temporal Groundwater Level Trends

In both the Upper and the Lower Aquifers and the very shallow groundwater zone, the wetter period in the mid-1990s is evident in groundwater level trends. The recent drought appears to have impacted water levels in the Upper and Lower Aquifers more than in the very shallow groundwater zone. Hydrograph data sets begin after the 1960s but those that start in the early 1960s or before reflect the higher extraction rates of the mid and late 1950s. The hydrographs illustrated in the GAR (not presented here) show a long-term trend in increasing water levels from the 1960s through the 1970s due to the increased use of surface water for irrigation.

Very Shallow Groundwater / Upper Aquifer / Lower Aquifer

During the period from the 1970s to the late 2000s, wells in the western part of the Valley Floor within the Coalition region tended to see an increase of around 10 feet in groundwater elevation, whereas in the eastern portion of the Coalition region, the very shallow wells saw a slight decrease, if any change, in groundwater elevation. Wells in the Upper Aquifer exhibit decreasing to somewhat stable longer-term trends in piezometric heads over the period from the 1970s through the early 2000s. In the Lower Aquifer, piezometric head typically has increased during the period from the 1970s through the late 1990s or early 2000s, but, since the early 2000s, water levels appear to have remained relatively stable.

Figure 27. Most recent spring and fall depths to groundwater in the very shallow groundwater zone (Figures 3-3 and 3-4, WWQC, 2015).

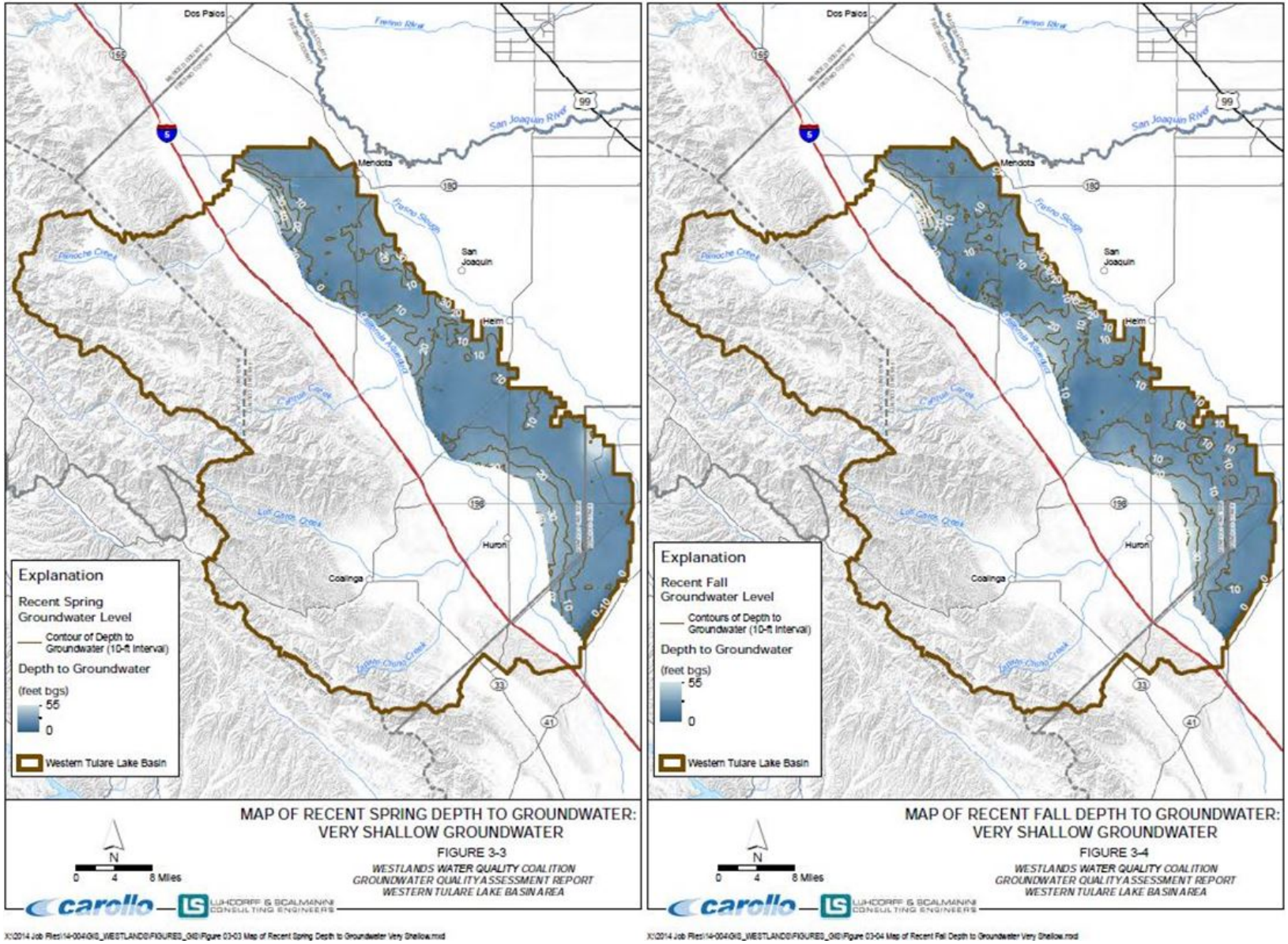


Figure 28. Most recent spring and fall depths to groundwater in the upper aquifer (Figures 3-5 and 3-6, WWQC, 2015).

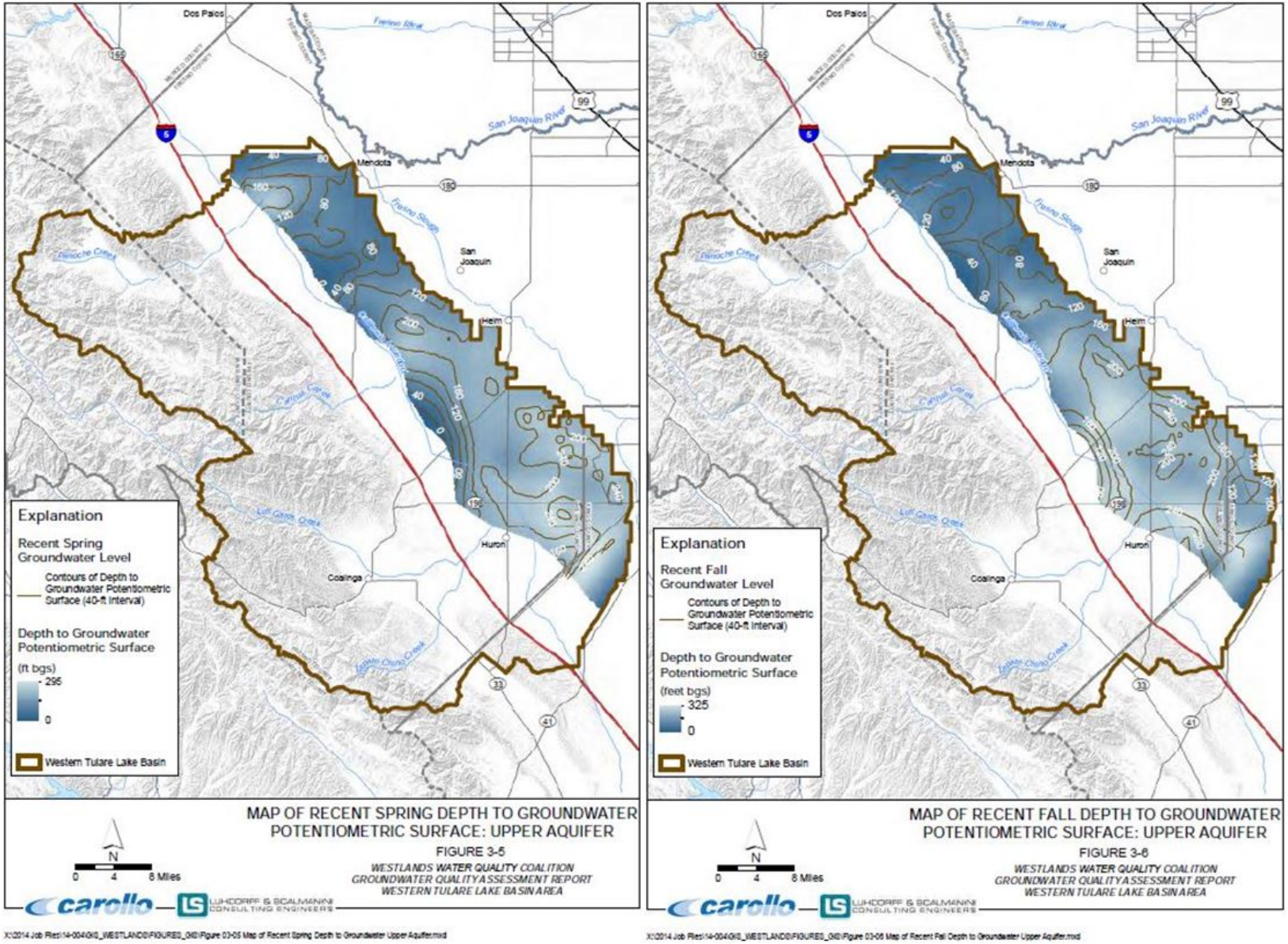
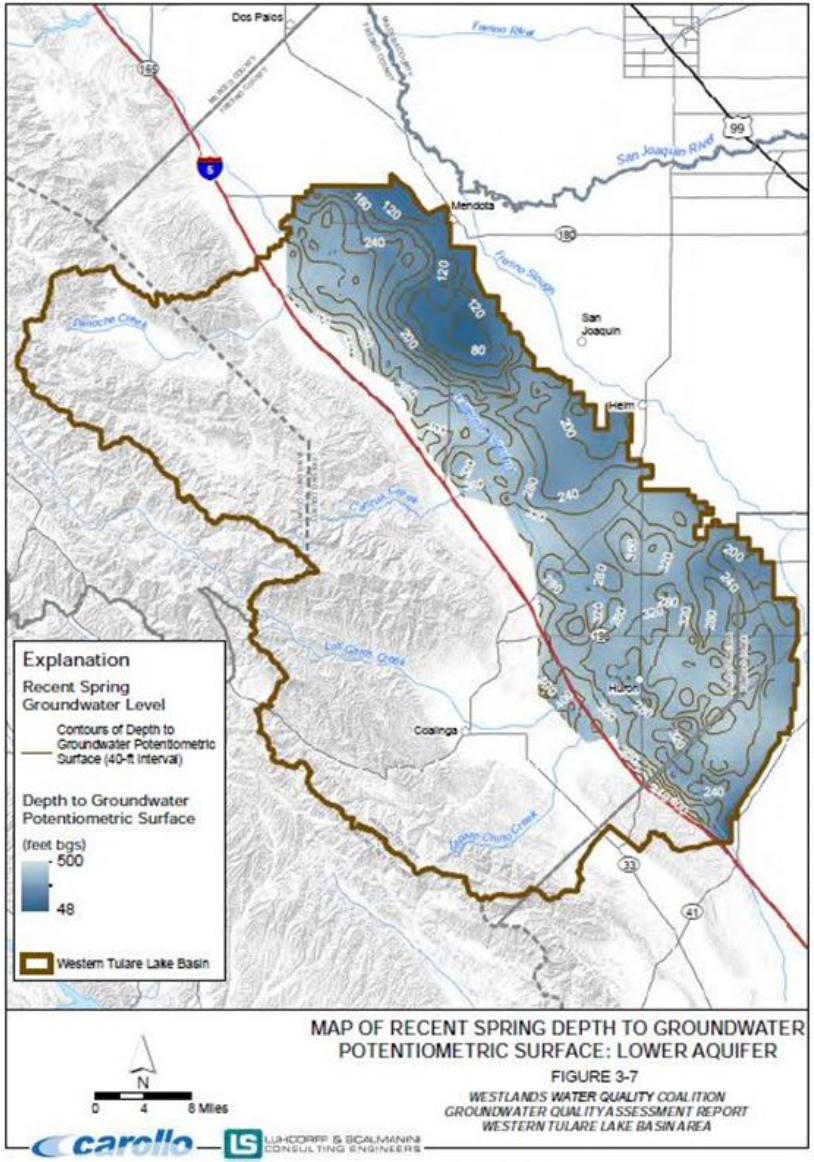


Figure 29. Most recent spring and fall depths to groundwater in the Lower Aquifer (Figures 3-7 and 3-8, WWQC, 2015).



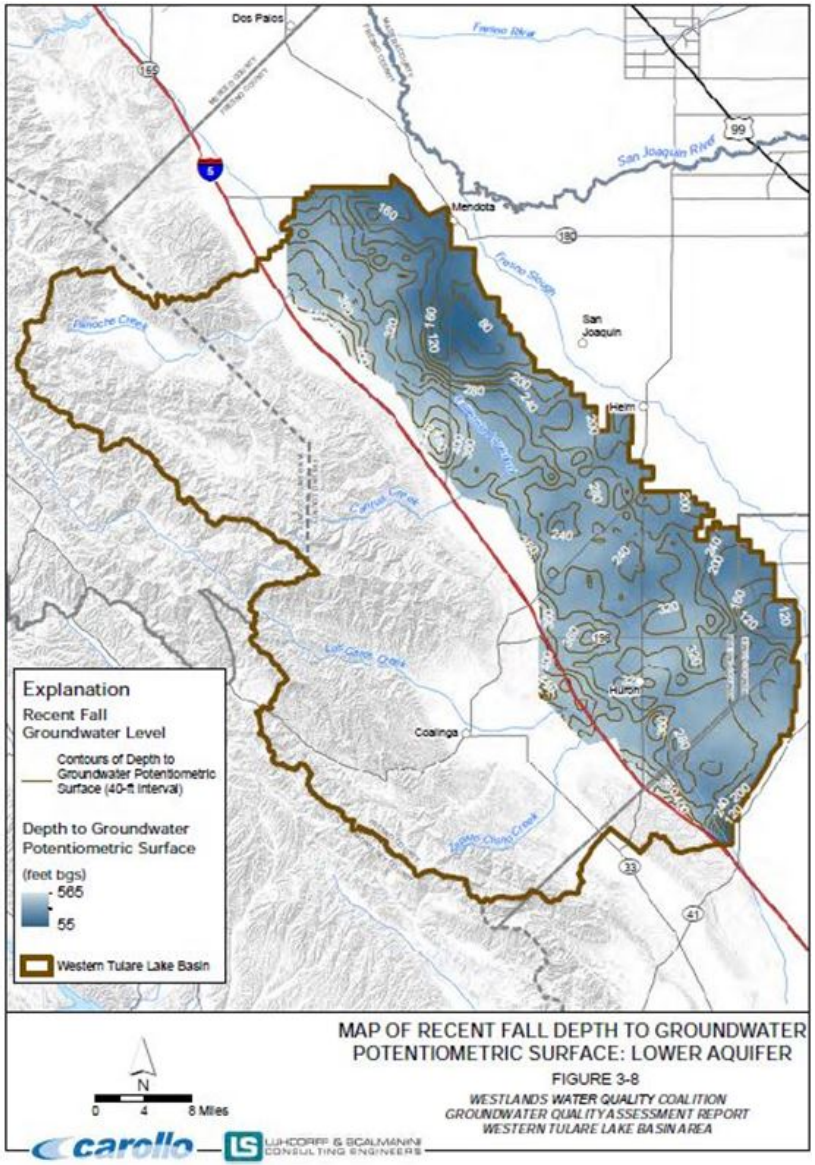
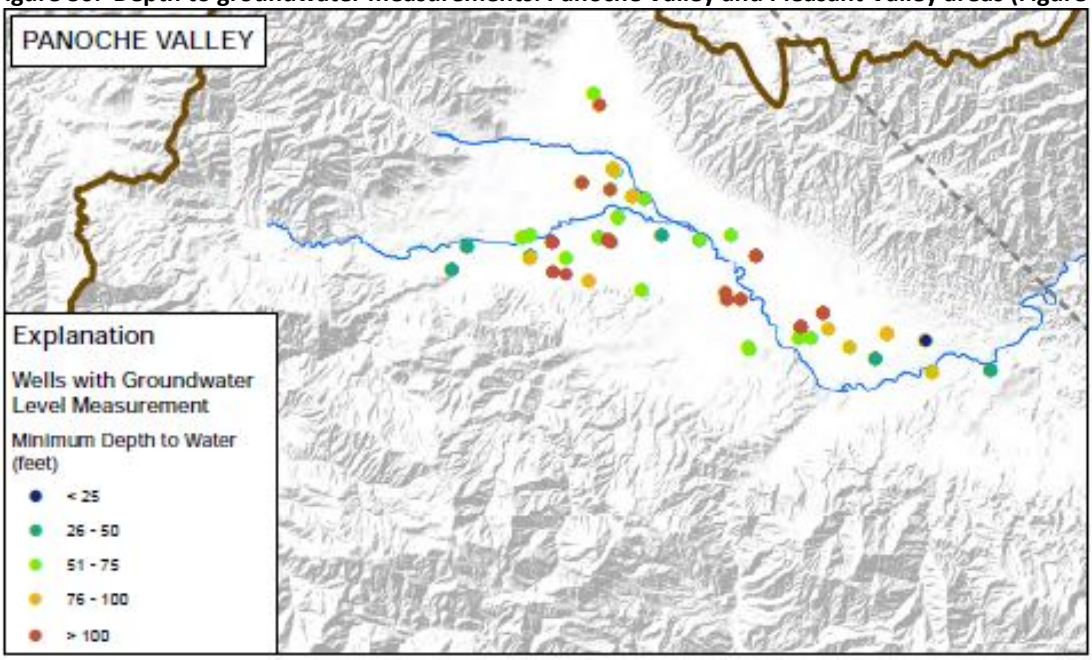
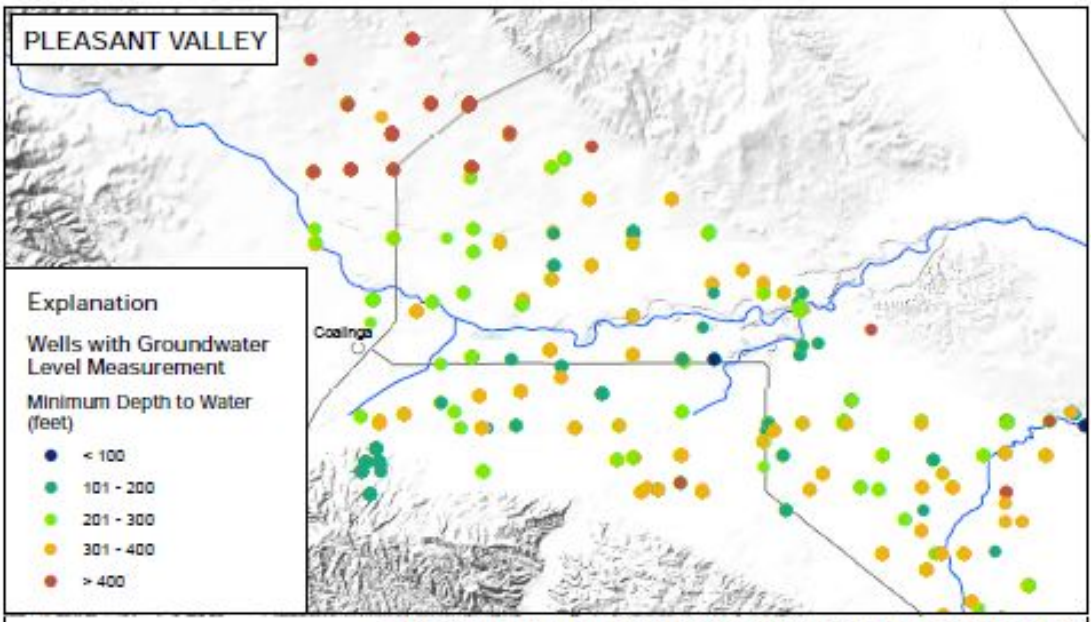


Figure 30. Depth to groundwater measurements: Panoche Valley and Pleasant Valley areas (Figure 3-9, WWQC, 2015).





MAPS OF DEPTH TO GROUNDWATER MEASUREMENTS: PANOCHE VALLEY AND PLEASANT VALLEY AREAS

FIGURE 3-9

WESTLANDS WATER QUALITY COALITION
GROUNDWATER QUALITY ASSESSMENT REPORT
WESTERN TULARE LAKE BASIN AREA

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LUHDORFF & SCALMANINI CONSULTING ENGINEERS

\\sceexce\clerical\2014 Job Files\14-004\GIS_WESTLANDS\FIGURES_GIS\Figure 03-09 Map of Depth to Groundwater Measurements Peripheral Area.mxd

Figure 31. Spring and fall groundwater elevations in the very shallow groundwater zone (Figures 3-13 and 3-14, WWQC, 2015).

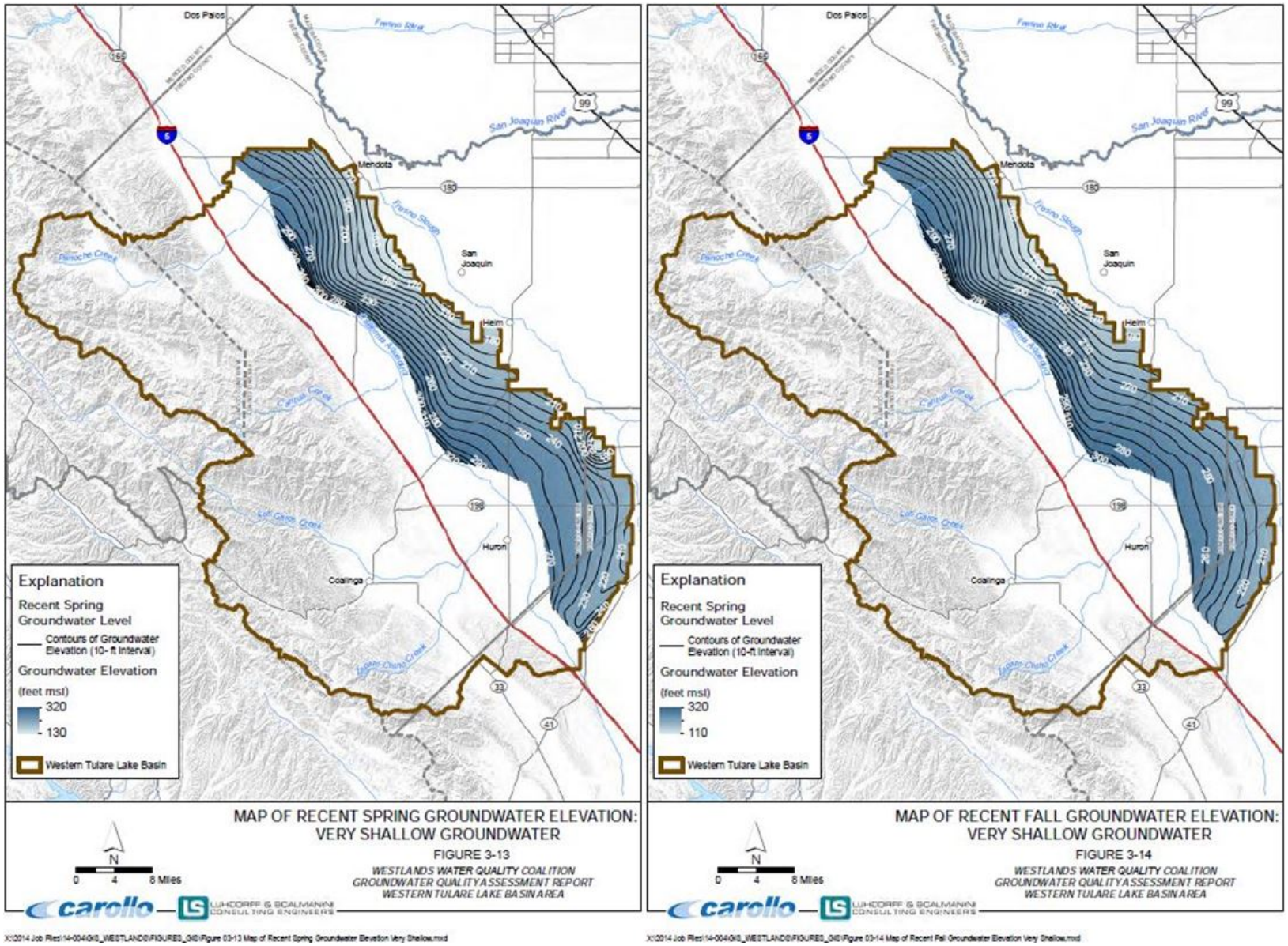


Figure 32. Spring and fall groundwater elevations in the upper aquifer (Figures 3-15 and 3-16, WWQC, 2015).

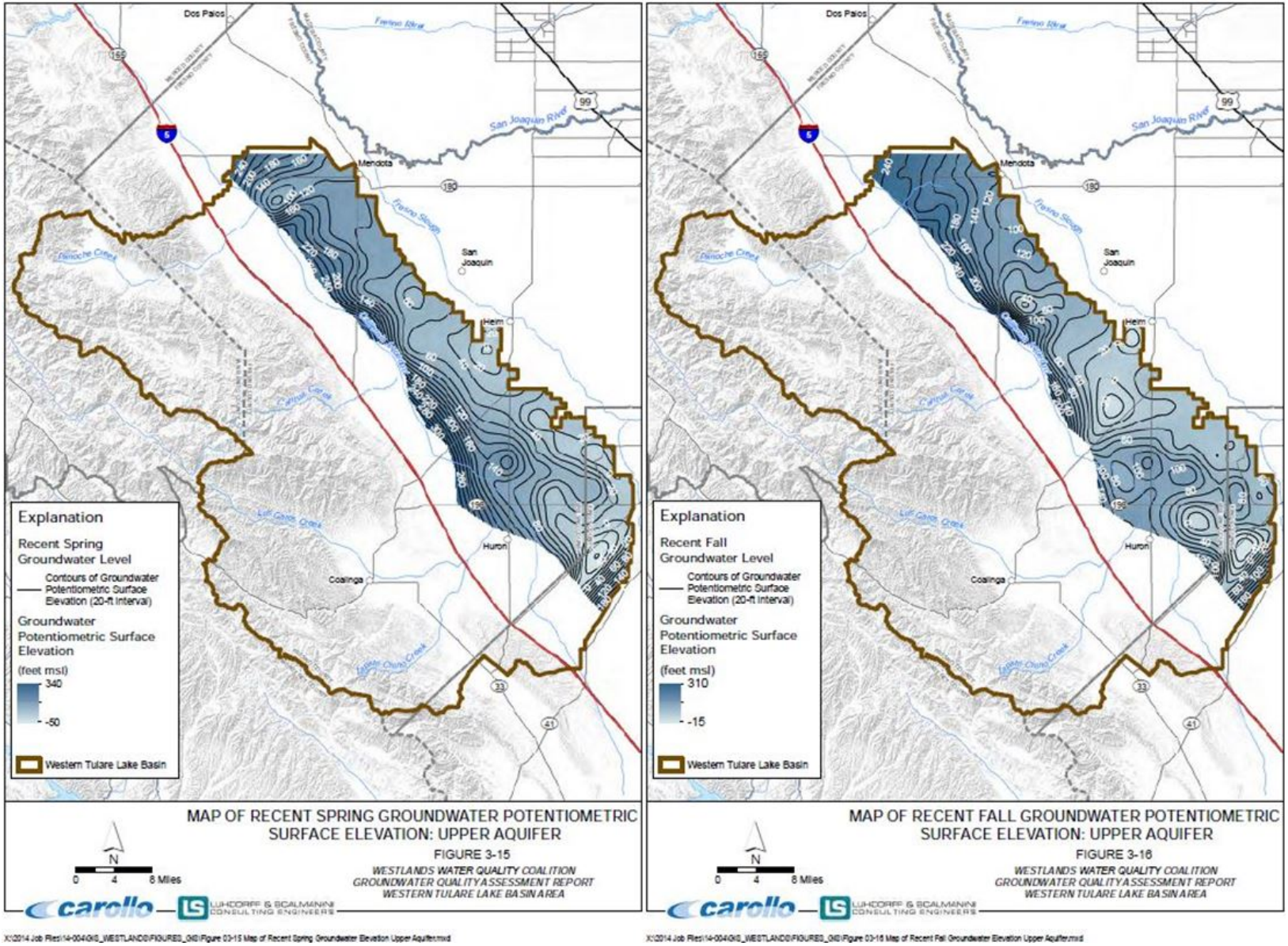
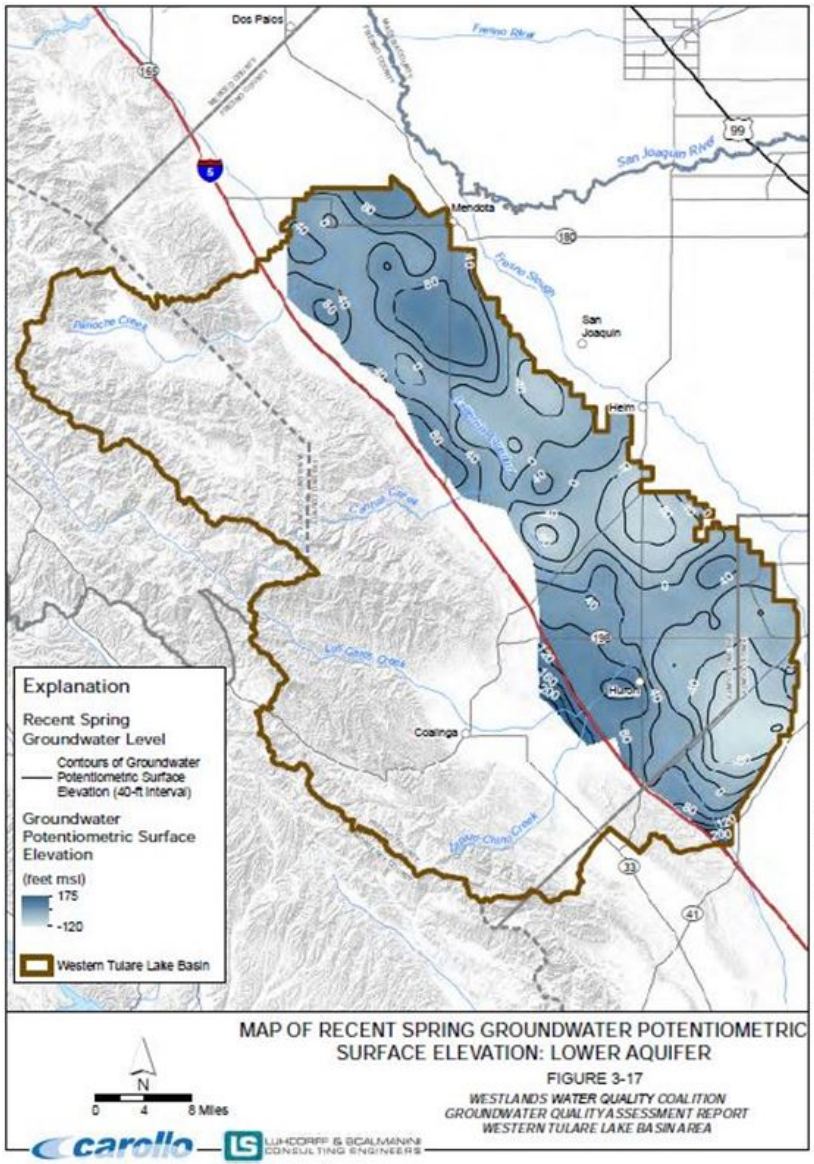
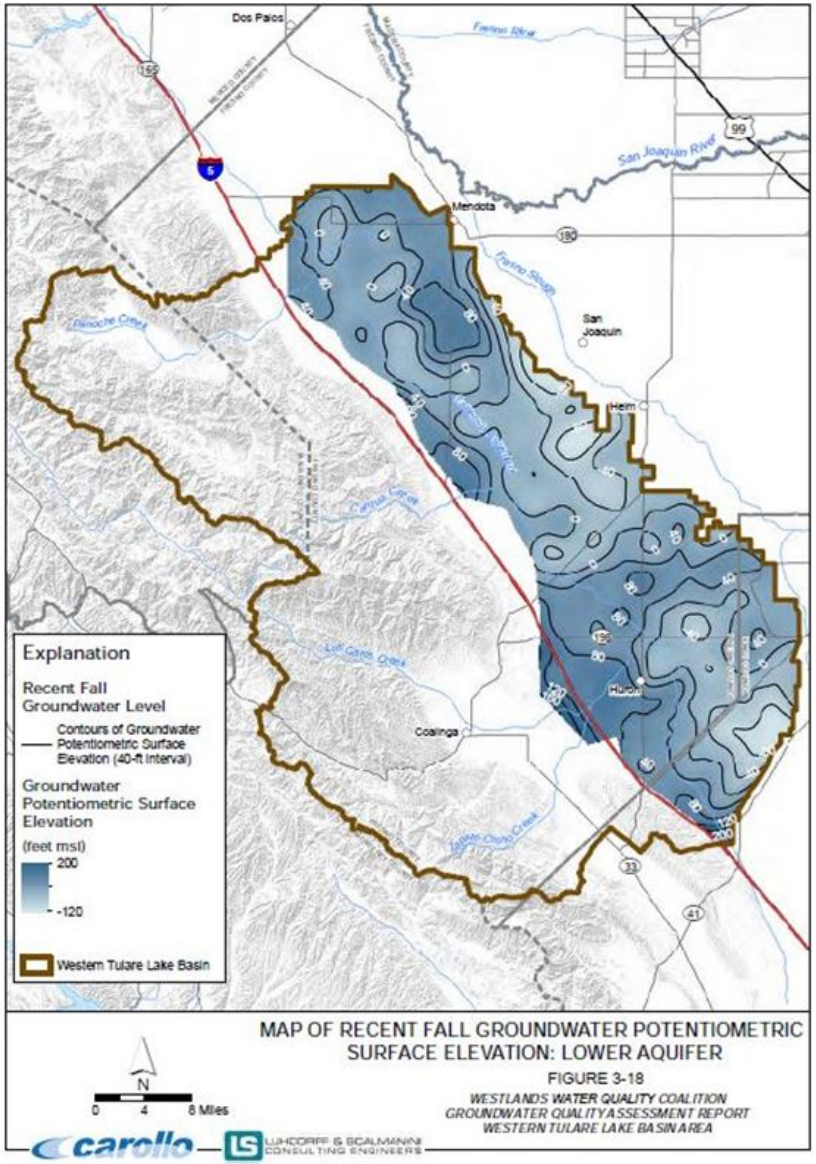


Figure 33. Spring and fall groundwater elevations in the Lower Aquifer (Figures 3-17 and 3-18, WWQC, 2015).





2.2.1.4 Groundwater Flow

Groundwater flow direction is controlled by piezometric head gradient. This section describes the results of the groundwater elevation analysis.

Groundwater Elevation

Groundwater elevations were calculated by subtracting the depth to groundwater spatial dataset from the land elevation surface. Continuous depth to groundwater spatial datasets were generated for recent spring and fall time periods as described above and the depth to groundwater level datasets were subtracted from the USGS National Elevation Dataset (NED) 10-meter resolution digital elevation model (DEM) to calculate the groundwater elevation within the Central Valley Floor area of the Coalition region. Representations of groundwater elevations are important for understanding hydrogeologic relationships and interpreting groundwater flow directions.

Very Shallow Groundwater / Upper Aquifer / Lower Aquifer

Figure 31 shows contours of groundwater elevations in the very shallow groundwater zone for recent spring and fall time periods. Both maps indicate higher groundwater elevations within the very shallow groundwater zone in the southwest with lower elevations in the northeast. In general, groundwater elevation increases slightly in spring relative to fall, most noticeably in the western part of the Coalition region.

Contour maps of groundwater elevation in the Upper Aquifer for recent spring and fall time periods are presented in Figure 32. The Upper Aquifer exhibits a gradient in a northeasterly direction, though that gradient flattens toward the east within the Central Valley Floor. Spring piezometric heads were generally higher than those in the fall throughout most of the Coalition region.

Patterns in recent spring and fall groundwater elevations within the Lower Aquifer are illustrated in Figure 33. The Lower Aquifer exhibits the greatest seasonal difference in groundwater elevations with relatively higher spring and relatively lower fall elevations. Throughout the Coalition region, the Lower Aquifer shows lower piezometric heads than the Upper Aquifer suggesting that potential exists for downward movement of water where subsurface geologic condition provide lesser hydraulic separation between these zones.

2.2.1.5 Groundwater Flow Directions

Groundwater flow directions in the very shallow groundwater zone and Upper Aquifer tend to be towards the valley axis. In the Lower Aquifer, horizontal flow may be dominated by extraction practices more than regional trends.

2.2.1.6 Areas with Higher Potential for Groundwater Recharge

The primary process for groundwater recharge within the Central Valley Floor area is from percolation of applied irrigation water. Groundwater recharge estimates made by DWR (2003) for the Westside groundwater

subbasin, encompassing the Valley Floor portion of the Coalition region, indicate that natural groundwater recharge represents a relatively small fraction of total recharge when compared with estimates of recharge from applied water.

Figure 34 (Figure 3-19 from the GAR) shows factors relating to the potential for recharge of groundwater from the land surface. Areas of higher soil hydraulic conductivity indicate increased recharge potential, especially for the very shallow groundwater zone (top 15 ft). CVHM data for the minimum percent of coarse materials in the upper 200 feet of substrate indicate areas with higher potential for recharge to the Upper Aquifer. The extent of the Corcoran Clay is also shown on Figure 34. The Corcoran Clay restricts vertical flow between the Upper and Lower Aquifer. Therefore, recharge of the Lower Aquifer is most likely restricted where the Corcoran Clay is present, including across most of the Valley Floor portion of the Coalition region. Primary recharge areas to the Lower Aquifer are most likely in western parts of the Central Valley Floor, particularly in the vicinity and west of Huron and in Pleasant Valley, where the Corcoran Clay is not present.

2.2.1.7 Recharge Areas Upgradient of Communities Reliant on Groundwater

Table 4 lists all the communities located within the Coalition region and the status with respect to reliance on groundwater, as determined through the procedure outlined above. A detailed discussion of delineation of this dataset is available in the GAR (pg. 3-7). The resulting community areas identified to be reliant on groundwater are shown on Figure 34 (Figure 3-21 from the GAR).

Disadvantaged Unincorporated Communities (DUCs) were also incorporated into the analyses. All DUCs were identified by location. In some cases, DUC boundaries were limited to residential areas through review of aerial photographs. All residential areas associated with DUCs were entirely encompassed by PWSs or CDPs previously evaluated for reliance on groundwater as indicated in Table 4. Incorporating DUCs into the analysis resulted in no new areas being added to the set of communities identified to be reliant on groundwater. The status of all DUCs and their reliance on groundwater is indicated in Table 4.

Contributing areas to communities reliant on groundwater (Figure 34), were developed for both the Upper and Lower Aquifers. Figure 34 (Figure 3-21 from the GAR) shows these contributing areas with the communities they supply, where applicable.

Table 4. Located public water systems reliant on groundwater (Table 3-2, WWQC, 2015).

Table 3-2	Located Public Water Systems Reliant on Groundwater Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area Westlands Water Quality Coalition			
Name of Boundary	Meets DAC Criteria	Included as Community Reliant on Groundwater?	Explanation of Final Boundary Status as Community Reliant on Groundwater	Addition Information Sources Reviewed
Groundwater-Supplied Public Water System (PWS) Boundaries (CDPH, 2014)				
Cantua Creek (1000359)	N/A	Yes	See Cantua Creek CDP (listed below)	
Casaca Vineyards (1000175)	N/A	Yes	Adjusted to residential area	DRINC, aerial imagery
Coit Ranch (1009131)	N/A	Yes	Adjusted to residential area	DRINC, aerial imagery
El Porvenir (1000019)	N/A	Yes	See Three Rocks CDP (listed below)	
Five Points Ranch (1009020)	N/A	Yes	Adjusted to residential area	DRINC, aerial imagery
Houlding Farms (1009051)	N/A	Yes	See Cantua Creek CDP (listed below)	DRINC
Mendota (1010021)	N/A	Yes	Adjusted to residential area	DRINC, aerial imagery
Murrieta/Hernandez Farms (1000585)	N/A	Yes	Adjusted to residential area	DRINC, aerial imagery
Linda Vista Farms (1000445)	N/A	No	Residential area outside Coalition region	DRINC, aerial imagery
Census Designated Places 2010 (Census, 2014)				
Cantua Creek	Yes	Yes	Served by Cantua Creek (1000359) PWS and Houlding Farms (1009051) PWS; reliant on groundwater; adjusted to residential area	DRINC, aerial imagery
Kettleman City	Yes	Yes	Served by Kettleman City (1610009) PWS; reliant on groundwater; adjusted to residential area	DRINC, aerial imagery
Lemoore Station	Yes	Yes	Served by Lemoore (1610700) PWS; reliant on groundwater; adjusted to residential area	DRINC, aerial imagery
Three Rocks	Yes	Yes	Served by El Porvenir (1000019) PWS; reliant on groundwater; adjusted to residential area	DRINC
Avenal City	Yes	No	Served by Avenal (161002) PWS; not reliant on groundwater	DRINC, aerial imagery
Coalinga	Yes	No	Served by Coalinga (1010004) PWS; not reliant on groundwater	DRINC
Huron City	Yes	No	Served by Huron (1010044) PWS; not reliant on groundwater	DRINC, aerial imagery
Disadvantaged Unincorporated Communities (PolicyLink, 2013)				
Cantua Creek	Yes	Yes	Within Cantua Creek CDP (listed above)	
Kettleman City	Yes	Yes	Within Kettleman City CDP (listed above)	
Mendota	Yes	Yes	Served by Coit Ranch (1009131) PWS (listed above); DUC is not co-located with Mendota PWS	
Three Rocks	Yes	Yes	Within Three Rocks CDP (listed above)	
Calflax	Yes	No	Served by Farming D (1009147) PWS; not reliant on groundwater	DRINC, aerial imagery
Ora	Yes	No	Served by Coalinga (1010004) PWS; not reliant on groundwater	DRINC
Turk	Yes	No	Served by Pappas and Co (1009006) PWS and Coalinga (1010004) PWS; not reliant on groundwater	DRINC

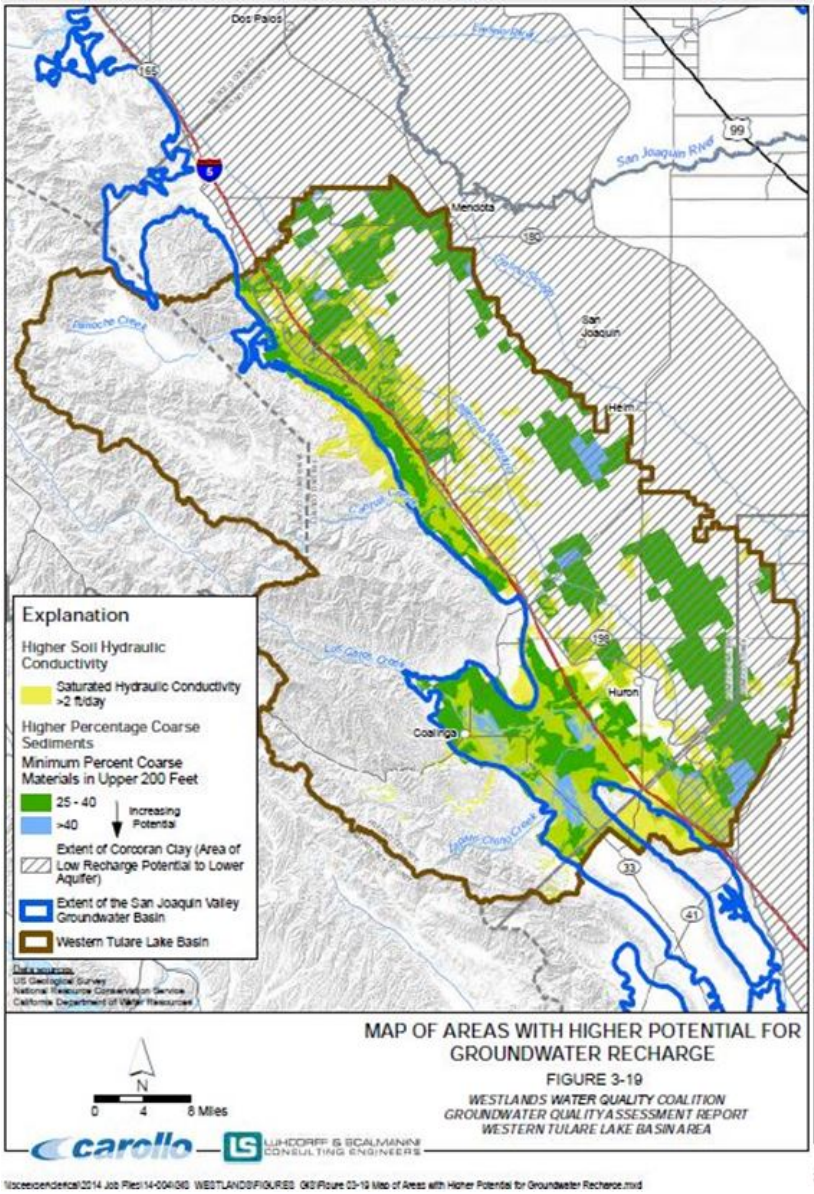
2.2.2 Areas of Potential Evapoconcentration in Very Shallow Groundwater

Figure 35 shows locations of very shallow groundwater within the Coalition region indicating areas where a higher potential exists for atmospheric communication with the very shallow groundwater zone. Areas with a potential for atmospheric communication represent areas where evaporative processes from the water table are most likely to occur, resulting in evapoconcentration of salts in the very shallow groundwater zone. As illustrated in Figure 35, the areas where the groundwater is very near the land surface are distributed along the eastern edge of the Coalition region and generally coincide with locally low land surface elevations.

2.2.3 Tile Drains

The presence of shallow or perched groundwater in parts of the San Joaquin Valley has led to the installation of tile drains in some areas. Readily available data sources, for current tile drains, were researched in an attempt to identify locations of known tile drains within the Coalition region. Locations of tile-drained fields were found based on DWR water quality sampling points. Figure 35 shows the presence of tile drains just to the north of the Coalition region, outside the Coalition boundary. The DWR study area did not extend throughout the Coalition region, as shown in Figure 35, so it is possible that other tile-drained areas exist within the Coalition region, although no tile drains were identified from within the Coalition region. Coalition Members are not queried as part of the Farm Evaluation Survey whether or not tile drains are associated with their parcels and therefore this information is not readily available in public or private datasets.

Figure 34. Areas with a higher potential for groundwater recharge and those groundwater areas contributing to communities reliant on groundwater, including disadvantaged communities and Census designated places (Figures 3-19 and 3-21, WWQC, 2015).



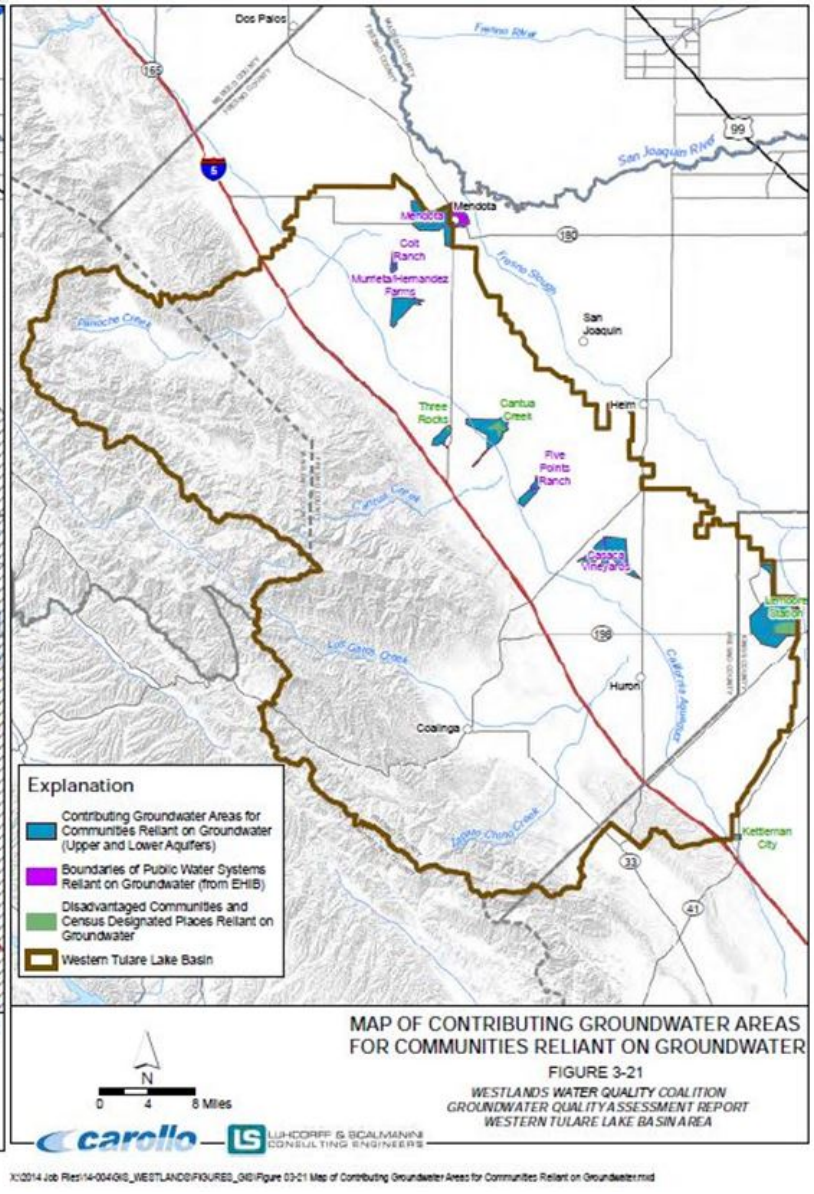
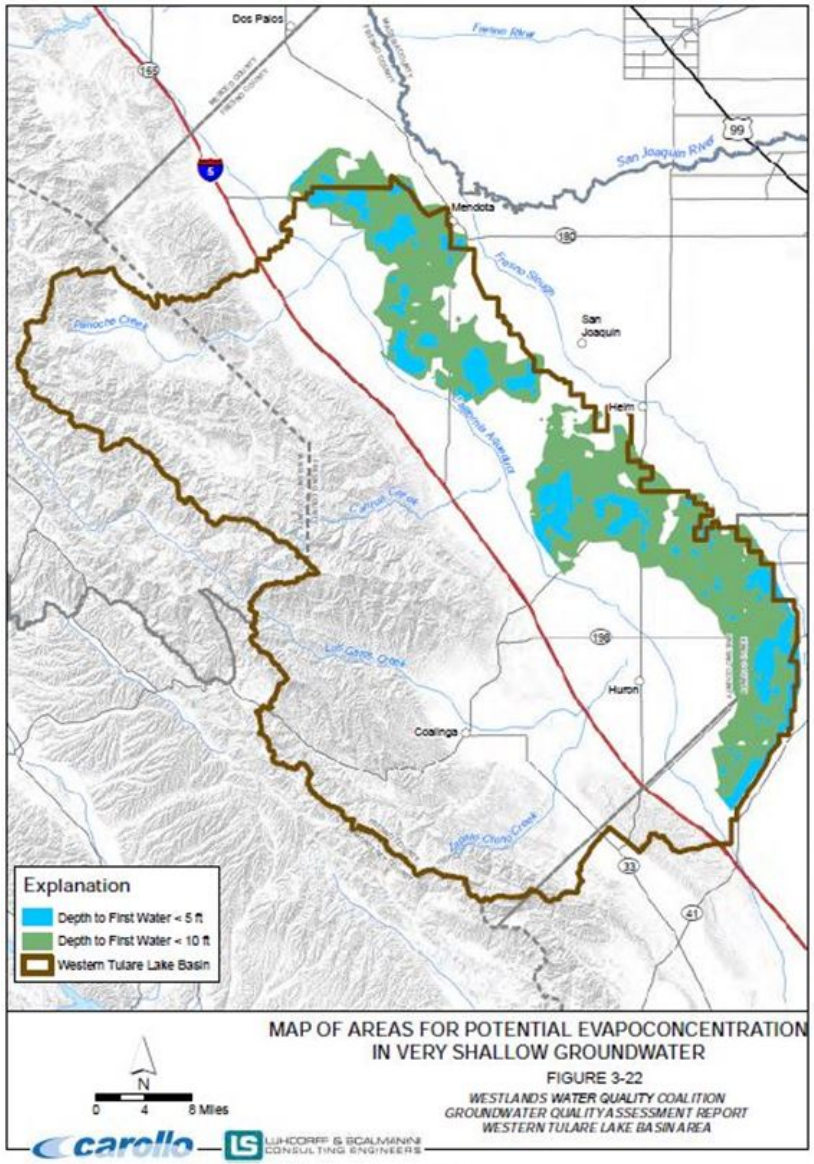
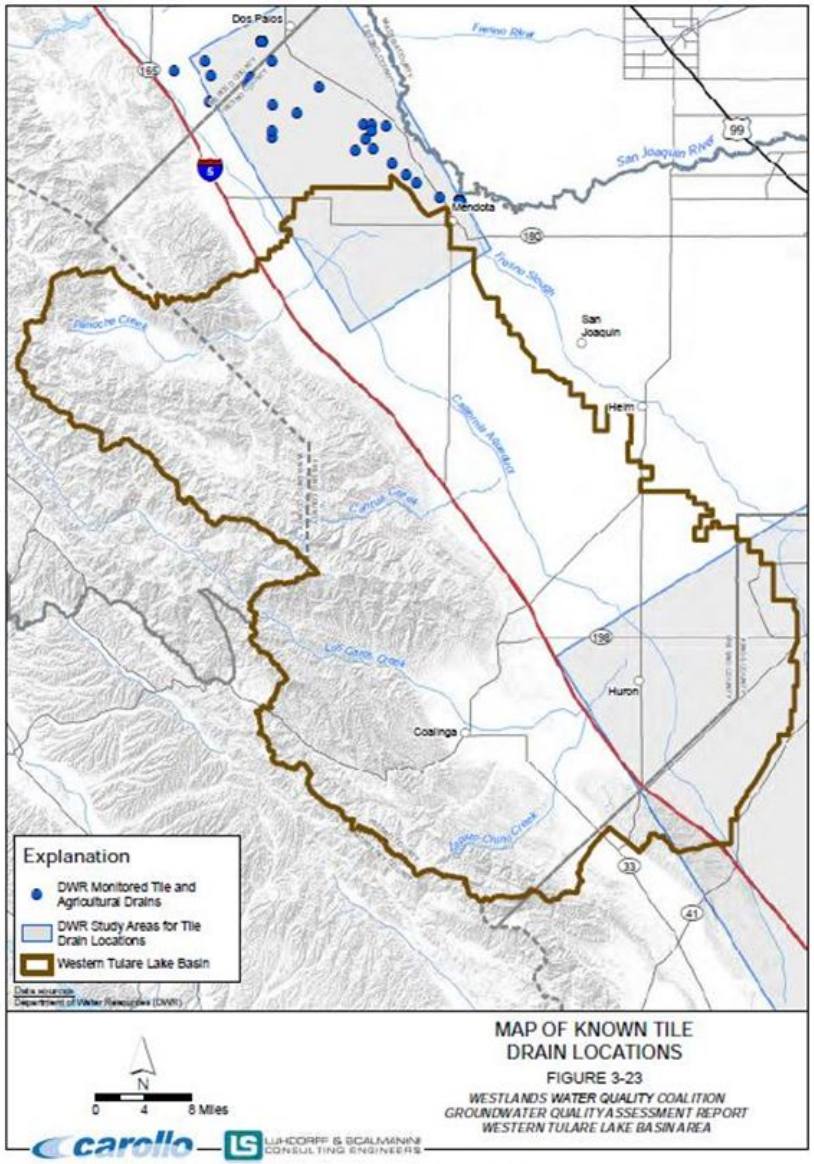


Figure 35. Areas with potential for evapoconcentration in the very shallow groundwater zone and known locations of tile drains (Figures 3-22 and 3-23, WWQC, 2015).





2.2.4 General Groundwater Chemistry

In a report prepared for the SWRCB, Boyle et al. (2013) analyzed nitrate concentrations in California's drinking water. As part of that analysis, the authors split the Tulare Lake Basin area into three geologic groundwater regions based on sediment origins. The cation-anion balance from groundwater sampled by the CDPH within two of the three groundwater regions, the Basin and Westside Alluvial Fans regions (Figure 36), is depicted with Piper diagrams relative to nitrate concentrations (Figure 37).

Boyle et al. (2013) point out considerable scatter in the data, however, groundwater samples generally reflect the aquifer sediments present in the respective regions. The major ions present in water are calcium (Ca^{2+}), magnesium ($Mg2^{+}$), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), sulfate (SO_4^{2-}), carbonate (CO_3^{2-}), and bicarbonate (HCO_3^{-}). The relative amounts of each constituent, when plotted on a piper diagram, provide information on regional flow paths and origins of the water. For example, Ca^{2+} and Mg^{2+} concentrations are often elevated in shallow groundwater and decrease along flow paths due to exchange for Na^{+} present on clay-rich sediments, resulting in more Na^{+} and less Ca^{2+} and Mg^{2+} the longer water has spent traveling through the subsurface. Additionally, groundwater tends to continuously dissolve carbonate and other minerals found naturally in geological materials as it travels through the aquifer system. This results in greater amounts of HCO_3^{-}in older groundwater. Samples from Eastside Alluvial Fans sediments, while covering the broad spectrum of water types, are concentrated in the left portion of the figure, meaning that the water contains little sulfate, and higher portions of calcium and magnesium. This is a reflection of the granitic sediments coming from the Sierra Nevada Mountains.

While the number of samples is significantly less than those from the Eastside Alluvial Fans sediments, the majority of the samples plot in the upper portion of the piper diagram (Figure 37). This signifies that the groundwater samples contain elevated levels of sulfate compared to the samples taken from the Eastside Alluvial Fans sediments. This reflects the origin of the Westside Alluvial Fans sediments, having primarily a marine origin. The Basin sediments represent a mixture of both west and east fans sediments. The Tulare Lake Basin as a whole, however, is dominated by Eastside Alluvial Fans sediments. The samples taken from the basin sediment region shows that the water chemistry is more similar to the water found in the east fans as compared to the water found in the west sediments. Groundwater from this region generally contains more calcium and magnesium and less sulfate. In all three regions, nitrate is also plotted with the major ion chemistry. As mentioned before, as water travels through aquifer sediments, it generally exchanges calcium and magnesium for sodium. Water containing more sodium compared to calcium and magnesium can generally be assumed to have been present in groundwater longer than water containing little sodium, compared to calcium and magnesium. In the basin and Eastside Fans sediments the piper plots show that the "older" water generally contains lower nitrate than the "young" water.

Figure 36. Sediment type distribution within the Tulare Lake Basin (Figure 6, Boyle et. al., 2012) with the Coalition region highlighted.

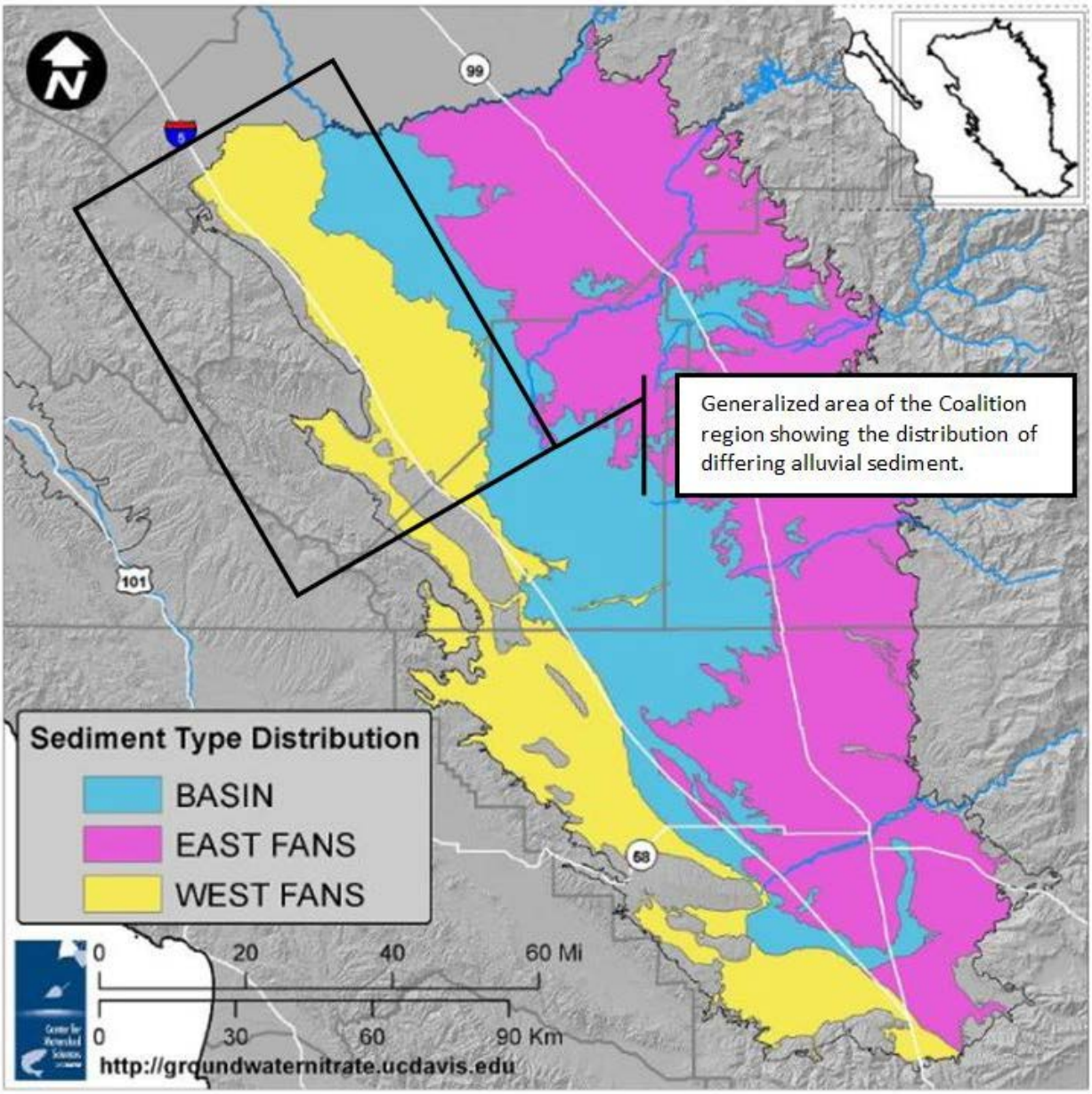


Figure 6. Based on the sediment origins, the TLB is divided into three groundwater regions: the Eastside Alluvial Fans, the Basin, and the Westside Alluvial Fans region.

Figure 37. Piper diagrams of water chemistry within Tulare Lake Basin Westside Fan and Basin alluvial sediments relative to nitrate as nitrate concentrations (Figures 8 and 9, Boyle et. al., 2012).

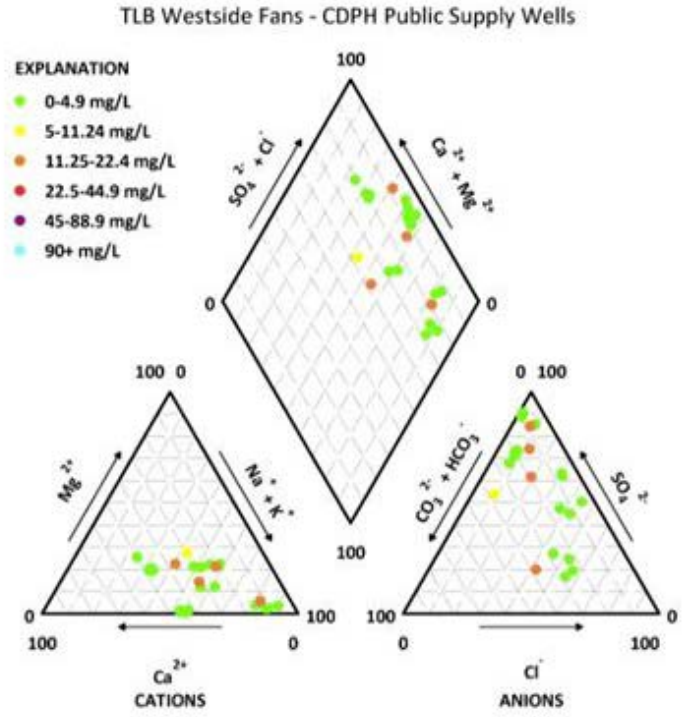


Figure 8. Piper diagram of groundwater samples from Westside Fans sediments. Concentrations are of nitrate as nitrate.

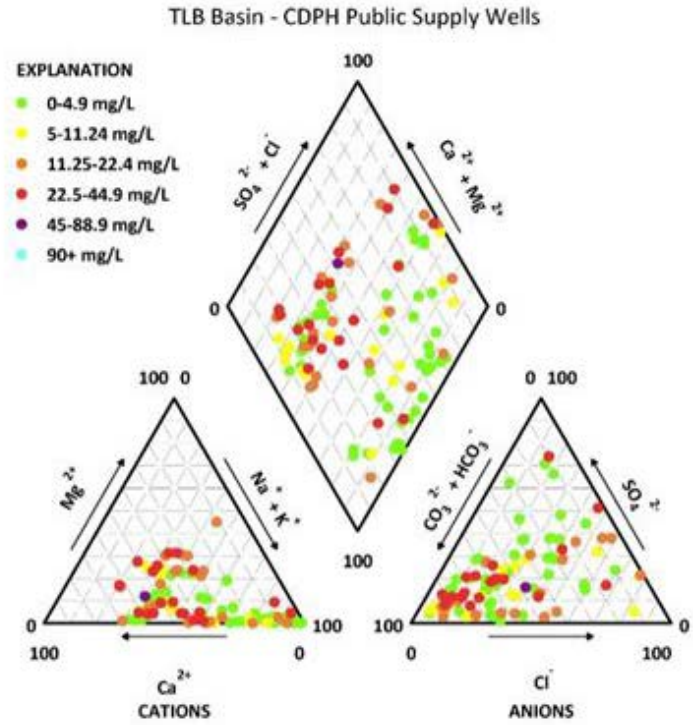


Figure 9. Piper diagram of groundwater samples from Basin sediments. Concentrations are of nitrate as nitrate.

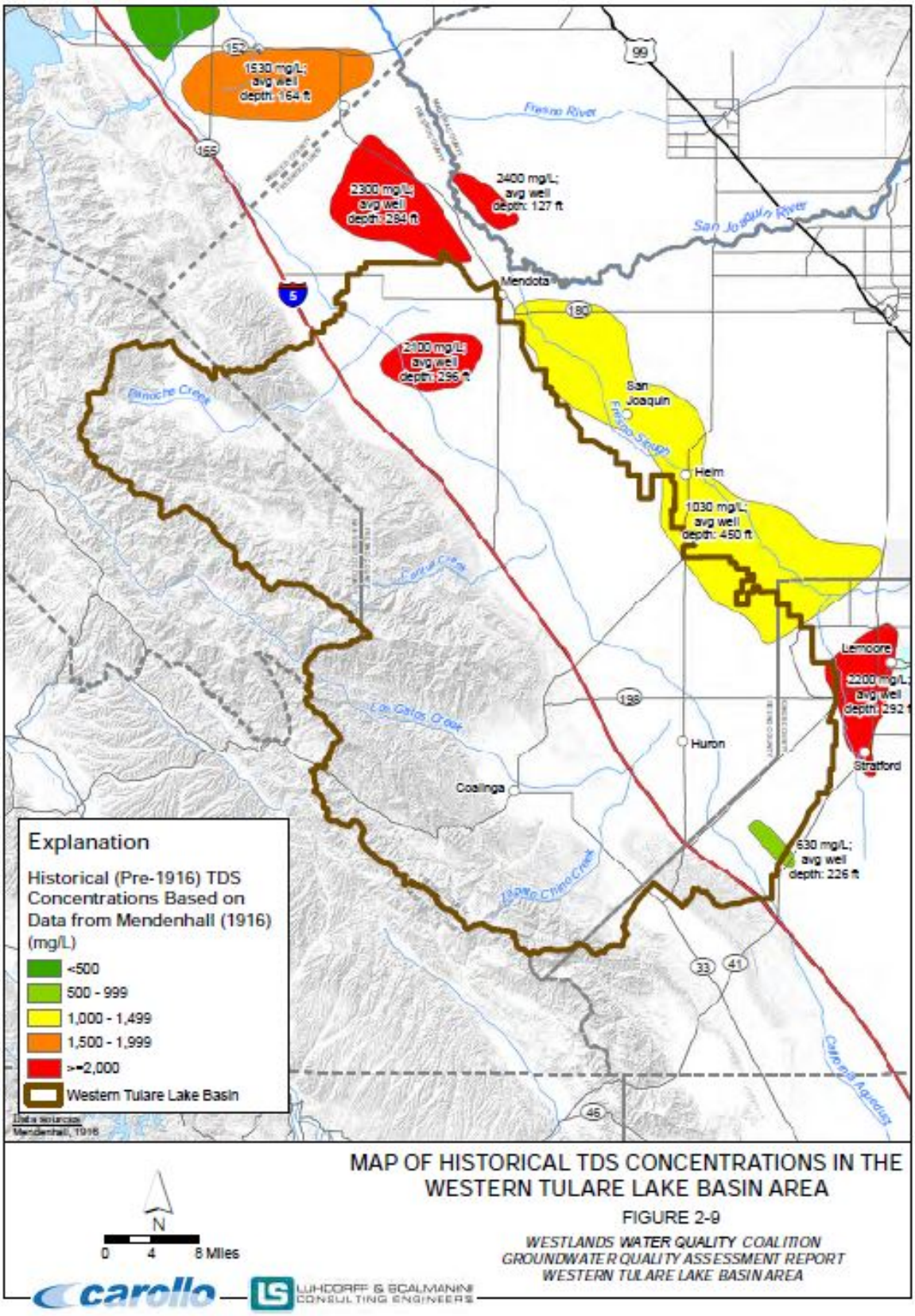
A similar description water chemistry within the Coalition region is provided in the GAR (WWQC, 2015) and summarized here. Alluvial sediments derived from west-side streams are composed of material derived from serpentine, shale, and sandstone parent rock, resulting in soil and groundwater types entirely different from those on the east side of the San Joaquin Valley. In contrast with the coarser alluvial sands and gravels derived from the Sierra granitic rocks on the eastern side of the Valley, which are more resistant to chemical dissolution, the sulfate and carbonate shales and sandstones of Coast Range sediments on the western side are more susceptible to dissolution processes. Naturally high concentrations of TDS in groundwater within the Westlands Coalition region are due to the geochemistry of the Coast Range rocks, the resulting naturally high TDS of recharge derived from Coast Range streams, the dissolvable materials within the alluvial fan complexes, and the naturally poor draining conditions which tend to concentrate salts in the system. The water quality and chemical makeup in west side streams is generally highly saline. Historical base flow TDS concentrations as high as 5,250 mg/L have been observed in Panoche Creek (WWQC, 2015). Naturally high salinity in the groundwater within and around the Westlands Coalition has long been recognized (Figure 38).

The chemical quality of waters in the Coast Range streams can be closely correlated with the geologic units in their respective drainage basins, falling into two general chemical types. Streams that drain extensive areas of Paleogene sediments generally carry sulfate water of the calcium or sodium type, while streams that drain the older Franciscan Formation and the post-Franciscan Cretaceous sediments generally carry bicarbonate water, which is in agreement with the water chemistry analysis provided above by Boyle, et al. (2012). The Panoche Creek watershed consists largely of older Franciscan Group rocks, whereas Cantua and Los Gatos Creeks have drainage areas consisting of more Paleogene and Cretaceous marine rocks. The Panoche Creek Valley and the Pleasant Valley represent areas where the surface waters have incised through a sequence of Cretaceous into younger Pleistocene rocks (Figure 11).

Groundwater flows discharging from either marine and non-marine rocks result in variable groundwater types within alluvial fans. Some areas of the Upper Aquifer along the eastern border of the Westlands Coalition region within the immediate vicinity of the San Joaquin River, Fresno Slough, and Kings River area are influenced by lower salinity surface water discharging from the east side of the San Joaquin basin.

The general chemical composition of groundwater in the Westlands Coalition region is variable based on location and depth. Groundwater types in the area range from calcium sulfate to sodium chloride type. Generally, carbonate is predominant in groundwater in the eastern portion of the region while sulfate is predominant in groundwater further west. The Upper Aquifer, within the uppermost 200 to 300 ft in Westlands Coalition region, is predominantly calcium and magnesium sulfate type. Along the valley axis in the area between Mendota and Huron, groundwater containing extremely high sulfate and chloride concentrations occurs in the basal portion of the Upper Aquifer just above the Corcoran Clay. The junctions at depth of the east and west encroachments of alluvium deposited during the formation of the valley reflects the position of the San Joaquin and Kings Rivers, which coincides closely with the transition of saline to fresh groundwater types along the west side of the valley. In the area west of Huron and along the western margin of the Central Valley Floor, deep wells (2,000 to 2,200 ft) have historically been characterized by high sulfate concentrations, which is generally associated with the quality of the Upper Aquifer suggesting enhanced recharge from the Upper Aquifer to the Lower Aquifer may occur in this area because of the absence or discontinuous character of the Corcoran Clay.

Figure 38. Historical concentrations of TDS in the Western Tulare Lake Basin Area (Figure 2-9, WWQC, 2015).



\\sceexcendfcal\2014 Job Files\14-004\GIS_WESTLANDS\FIGURES_GIS\Figure 02-09 Map of Historical TDS Concentrations in the Western Tulare Lake Basin Area.mxd

2.3 Land Use

Land use analyses in the GAR reported the temporal change of crop and land use in the area using: WWD land use data (WWQC service area); WDR's land use survey data (Fresno County [1986, 1994, 2000, 2009 East], Kings County [1991, 1996, 2003], San Benito County [1997 and 2002]); and the United States Department of Agriculture (USDA) cropland data from 2013, the most recent data available when the GAR was written. Due to the large number unique land uses and crop types listed in the datasets analyzed, (e.g., over 70 crop types and land uses listed in the DWR land use survey data), authors of the GAR grouped the land use data into 10 main categories based on some general similarities in agricultural practices and estimated typical nitrogen application rates.

Changes in land use over time (Figure 39) were tracked across data sets using the 10 main categories listed in Table 5. This grouping facilitated the evaluation of spatial and temporal patterns of land use across data sets and in the assessment of groundwater vulnerability. When authors of the GAR analyzed the most recent land use data, they used WWD's land use data for the area within the WWD's boundaries, and USDA cropland data for the remaining area of the Coalition. Within the Coalition region, the largest land use is non-agricultural followed by vegetables. Non-agricultural acreage has generally increased over the years with some periods of significant fluctuations (Figure 39). The increase in non-agricultural acreage is in part due to the WWD acquiring land within the district's boundaries, which it then retires as a way to address the drainage issues in the area (Figure 40).

Figure 39. Change in Land use since the mid-1990s (Figure 4-6, WWQC, 2015).

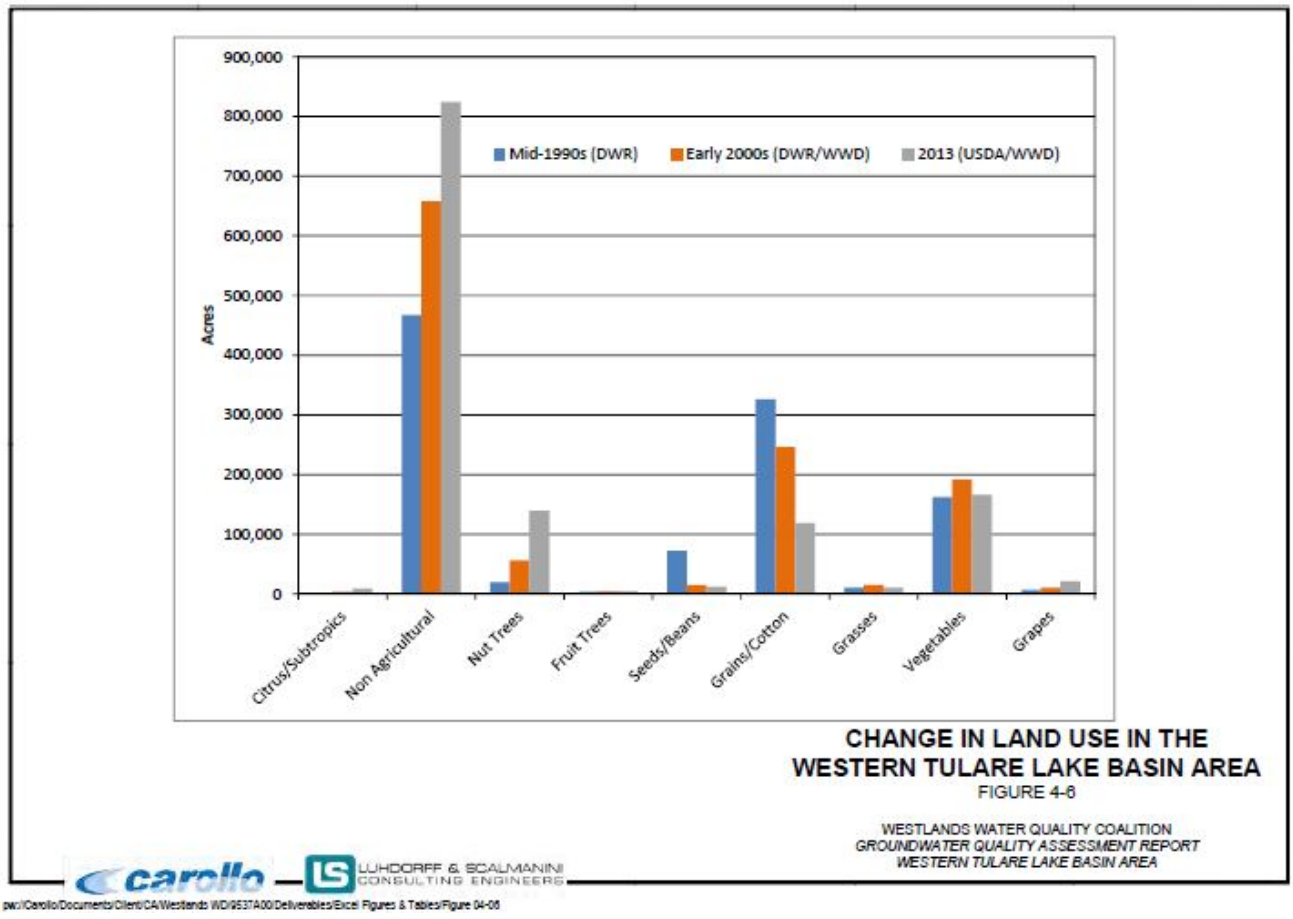


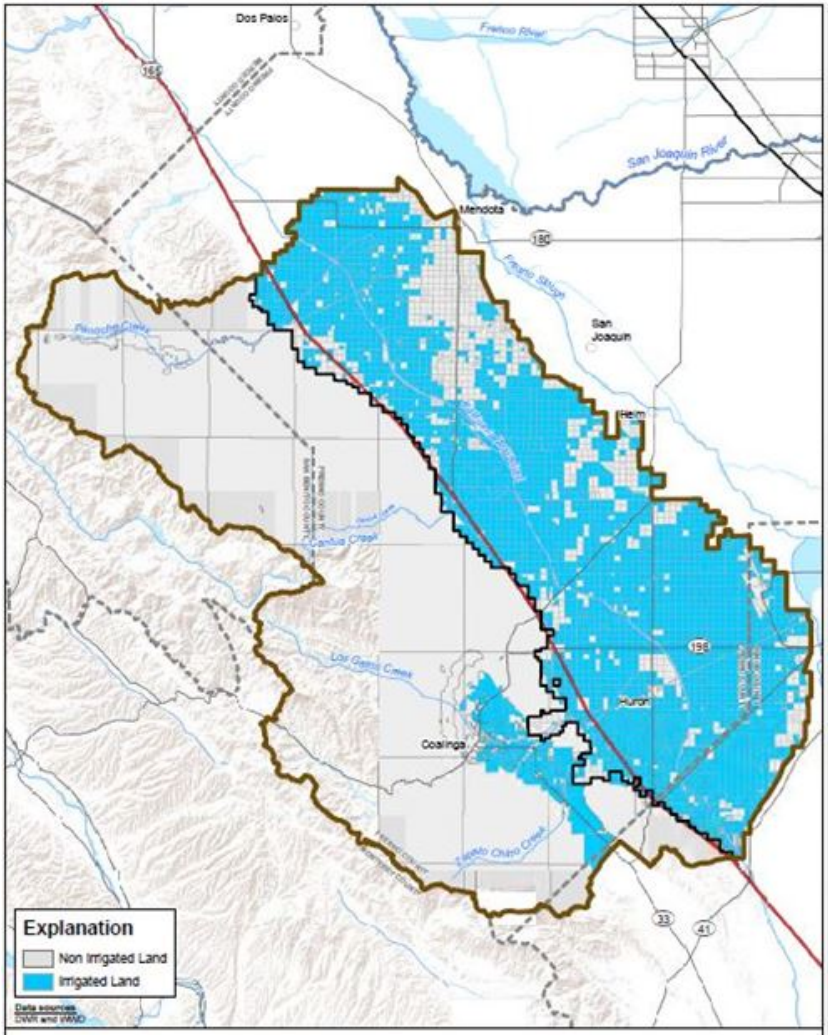
Table 5. Land use categories for WWD, DWR, and USDA data sets as presented in the GAR (Table 4-3, WWQC, 2015).

Table 4-3 — Land Use Classification System
Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

LSCE	DWR			WWD		USDA		WWD & DWR	WWD & USDA	Applied Nitrogen[c] (lbs/nitrogen/ac/year)	
Group Description	Land Use Codes	Land Use Description	Mid-1990s[a] % of Coalition Area[b]	Codes	Land Use Description	Codes	Land Use Description	2005 % of Coalition Area[b]	2013 % of Coalition Area[b]	1973	2005
Non Agricultural	All"U"codes,#,L,NV,NR,NS,NV,NW	Native vegetation, urban, water surface, riparian vegetation, other.	43.6%	21D	Grasslands, Idle crop land, Wildlife area, Developed, barren, forest, water, wetlands, shrubland	61, 111, 121, 122, 123, 124, 131, 141, 142, 143, 152, 171, 190, 195	Grasslands herbaceous, Developed, barren, forest, water, wetlands, shrubland	54.8%	53.7%		
Nut Trees	D12,D13,D14	Almonds, walnuts, pistachios	1.8%	27A, 27C, 27D	Almonds, pecans, walnuts, pistachios	74, 75, 76, 204	Almonds, walnuts, pistachios	4.6%	0.3%	120-148	138-179
Grasses	All"P"codes	Alfalfa, pasture, (mixedandnative),clover, turffarms	0.9%	1, 2	Alfalfa, Pasture, Sudan	27, 36, 58, 59	Alfalfa, Pasture	1.2%	0.8%	20[d]	11[d]
Vegetables	F6 (corn) and all "T" codes	Corn, tomatoes, sweet potatoes, artichokes, beans (green), broccoli, bushberries, cabbage, cauliflower, celery, cucumbers, flowers, nursery, Christmas tree farms, lettuce, melons, squash, onions, garlic, peppers, strawberries	15.2%	6B, 10DB, 10E, 10N, 10H, 10J, 10AA, 10P, 10FF, 10SS, 10D, 10TF, 10AG, 10U, 10R, 16, 17	Cantaloupes, corn, tomatoes, garlic, blueberries, broccoli,, carrots, greens, herbs, flowers, pumpkins, honeydew melons, lettuce, misc vegs & fruits, onions, peppers, sugarbeets, sweetcorn, watermelons	1, 12, 41, 43, 44, 46, 47, 48, 49, 50, 53, 54, 57, 206, 207, 208, 209, 213, 214, 216, 219, 221, 227, 242	Corn, tomatoes, blueberries, broccoli, cantaloupes, carrots, garlic, greens, herbs, flowers, honeydew melons, lettuce, misc vegs & fruits, onions, peppers, sugarbeets, sweetcorn, watermelons	16.0%	12.7%	Canteloupe: 95, Tomatoes: 142, Lettuce: 159, Corn: 145	Canteloupe: 163, Tomatoes: 180, Lettuce: 193, Corn: 213
Grapes	All"V"codes	Vineyards	0.6%	14A, 14B, 14C	Grapes	69	Grapes	0.8%	1.6%	53-57	27-44
Grains/Cotton	All "G"codes and also F1 (Cotton)	Cotton, grain and hay crops, barley, wheat, oats, misc.	30.6%	6D, 6E, 6F, 23A, 25, 25A	Cotton, barley, wheat, oats, grain hay, other hay	2, 21, 22, 23, 24, 28, 37, 205	Cotton, barley, wheat (Durum,Spring,Winter), oats, other hay/nonalfalfa	20.5%	9.1%	88-109	174-177
Seeds/beans	All "F" codes except F1 (Cotton) and F6 (Corn)	Field crops, dry beans, safflower, sugar beets, grain sorghum, sudan	6.7%	A2, 4S, 6C, 6M, 6HG, 6G, 6S	Garbanzo, alfalfa seed, dry beans, safflower, sorghum, sugar beets, sunflowers	4, 5, 6, 42, 33	Dry beans, safflower, sorghum, sugar beets, sunflowers	1.3%	0.9%	51	91
Fruit Trees	D1, D2, D3, D5, D6, D7, D8, D9, D10, D, D**	Peaches and nectarines , apples, apricots, cherries, pears, plums, prunes, figs, misc. deciduous, deciduous fruit, and nuts	0.3%	11A, 11B, 11F, 11H, 11L, 11T	Cherries, apples, apricots, nectarines, other tree crops, peaches, pluots, plums, prunes	66, 67, 68, 71, 77, 218, 220, 223	Cherries, apples, apricots, nectarines, other tree crops, peaches, plums	0.3%	0.9%	95-133	102-130
Citrus/Subtropics	All"C"codes	Oranges, grapefruit, eucalyptus, olives, kiwis	0.1%	11K, 12A, 12C, 12D, 12G	Citrus, oranges, pomegranates, other citrus	72, 211, 212, 217	Citrus, olives, oranges, pomegranates	0.3%	0.6%	65-166	95-123
Rice	All "R" codes	Rice		5	Rice	3	Rice			86	130
Total			100%					100%	80.6%		

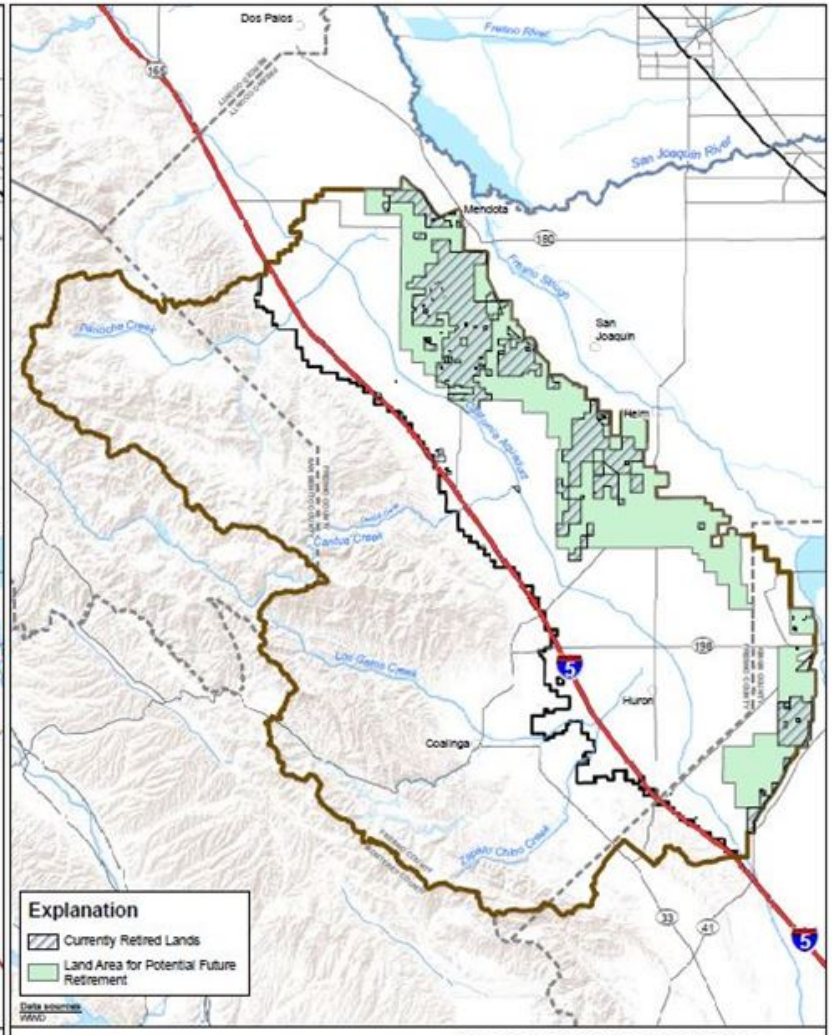
Notes
[a] Mid-1990s DWR land use combines data for Fresno County (1994) and Kings County (1996)
[b] Land cover values are shown as percent of the Coalition area.
[c] Source of applied nitrogen rates: Rosenstock, T.S. and others, 2013, Nitrogen fertilizer use in California: assessing the data, trends and a way forward, California Agriculture, Vol 67 No. 1. pgs 68-79. Online: http://californiaagriculture.ucant.edu/landingpage.cfm?article=ca.E.v067n01p68&fulltext=yesDPI:10.3733/ca.E.v067n01p68
[d] Source of applied nitrogen rates for alfalfa, 2005: Viers, J.H. and others, 2012, Nitrogen Sources and Loading to Groundwater, Technical Report 2, Assessing Nitrate in California's Drinking Water with a focus on Tulare Lake Basin and Salinas Valley Groundwater, Center for Watershed Sciences, University California, Davis, prepared for California State Water Resources Control Board.

Figure 40. Irrigated land and current and future retired land in the Coalition region (Figures 4-1 and 4-2, WWQC, 2015).



MAP OF IRRIGATED LANDS
FIGURE 4-1
WESTLANDS WATER QUALITY COALITION
GROUNDWATER QUALITY ASSESSMENT REPORT
WESTERN TULARE LAKE BASIN AREA

C:\Users\groundwater\Desktop\Westlands\Irrigated Lands Map.mxd



MAP OF CURRENT AND FUTURE RETIRED LANDS IN WWD
FIGURE 4-2
WESTLANDS WATER QUALITY COALITION
GROUNDWATER QUALITY ASSESSMENT REPORT
WESTERN TULARE LAKE BASIN AREA

C:\Users\groundwater\Desktop\Westlands\2013 Crop Map with retired land.mxd

2.3.1 Irrigated Land

The Coalition region has approximately 1,305,004 acres with approximately 555,260 acres of that as irrigated cropland (Figure 40), including 517,373 acres in WWD; 34,136 acres in Pleasant Valley; 2,327 acres in the Western Central Valley floor outside WWD, and 1,424 acres outside the Central Valley Floor (Table 6).

Table 6. Irrigated versus non-irrigated lands in the WWQC (Table 4-1, WWQC, 2015).

Table 4-1 Comparison Between Irrigated and Non-Irrigated Areas
Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

Area	Acres	Percent
Westlands Water District	517,373	39.64
Pleasant Valley	34,136	2.62
Western Central Valley Floor (outside WWD)	2,327	0.18
Peripheral Area	1,424	0.11
Total Irrigated Land	**555,260**	**42.55**
Westlands Water District Retired Land	72,174	5.53
Non-Irrigated	677,570	51.92
Total	**1,305,004**	**100.00**

Notes:
(1) Data from 2013 USDA Cropscape Data and WWD 2013 Data.

2.3.1.1 Crop Analysis in the GQMP

The acreage associated with the majority of the crop categories haves stayed relatively consistent over roughly 45 years, including grapes, fruit trees, seeds and beans, grasses, and citrus (WWQC, 2015). Grains/cotton peaked around 1980 and have been generally decreasing since then. Vegetables and tree nuts have been steadily increasing over the years. Currently, the top three crop categories representing 88% of the total irrigated acreage in the Coalition region are vegetables, nut trees, and grains/cotton (Table 7) (Figure 41).

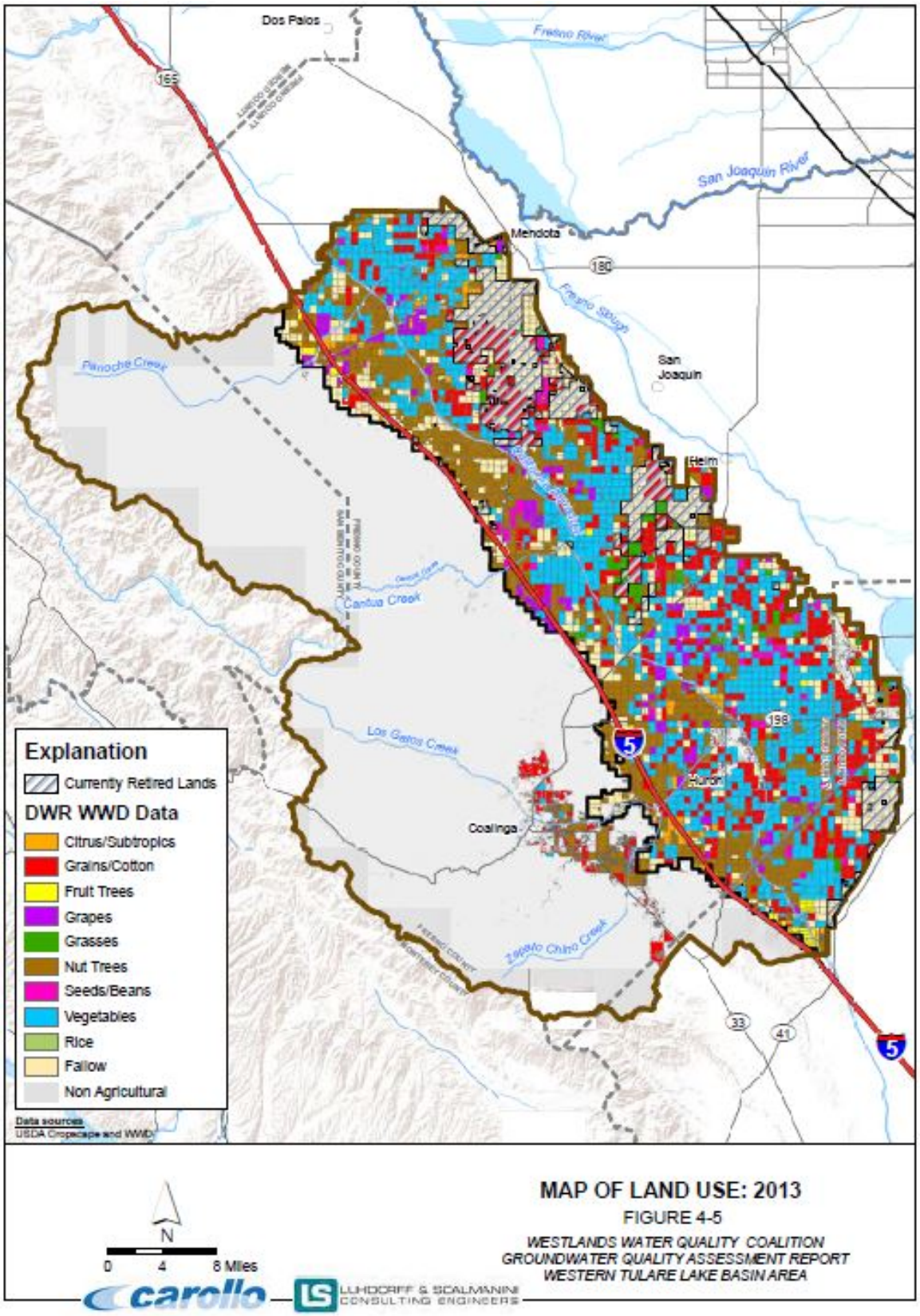
Table 7. WWD and USDA 2013 land use acreage within the entire GQMP area (Table 4-5, WWQC, 2015).

Table 4-5 Top Agricultural Crop Categories in 2013
Groundwater Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

Crop Category	Acres	Cumulative Percent	Top 80 percent Category
Vegetables	165,957.99	35	Yes
Nut Trees	138,909.71	64	Yes
Grains/Cotton	118,275.05	88	Yes
Grapes	21,178.44	93	Yes
Seeds/Beans	11,741.60	95	Yes
Grasses	9,897.50	97	Yes
Citrus/Subtropics	8,232.82	99	Yes
Fruit Trees	4,307.29	100	Yes
Rice	0.40	100	Yes

Notes:
(1) Data from 2013 WWD crop layer and USDA data.

Figure 41. Land use in the WWQC region using 2013 data.



C:\Users\groundwater\Desktop\Westlands\2013 Crop Map.mxd

2.3.1.2 Source of Irrigation Water

The water demands for the Tulare Lake region are met through a combination of local surface water supplies, federal (Central Valley Project) and State (State Water Project) surface water deliveries, groundwater, and reused/recycled water. Groundwater resources play a key role in meeting the annual water demand for the Tulare Lake region. Approximately 53 percent of the total overall supply of water is contributed by groundwater, 20 percent is contributed by local projects, 15 percent is met by the Central Valley Project, and 8 percent from SWP (DWR, 2013). The source of surface water used for irrigation within the Coalition is primarily from water deliveries provided by the California Aqueduct (San Luis Canal) and from the San Joaquin and Kings Rivers during very wet years (WWQC, 2015). The WWD has been receiving surface water deliveries from the Central Valley Project since 1967 (CVRWQCB, 2014).

The DWR subdivides California into study areas for planning purposes. The largest study areas are the ten Hydrologic Regions (HR), corresponding to California's major drainage basins. The next levels of delineation are the Planning Areas (PA), which in turn are composed of multiple Detailed Analysis Units (DAU). The DAUs are often split by county boundaries, so the smallest study area used by the Department is the DAU/county. Many planning studies begin at the DAU or PA level, and the results are aggregated into hydrologic regions for presentation. Table 8 includes the names of the DAUs and PAs within the Coalition boundary and the percentage of those DAUs and PAs that are located within the Coalition boundary. Acreage data for DAUs and PAs were obtained from layers available on DWR's website: http://www.water.ca.gov/waterplan/gis/index.cfm. Within the Coalition boundaries there are seven DAUs and two PAs, some of which may only be partially within the Coalition boundaries.

No data were found for the specific irrigation water ratios (groundwater vs. surface water) within the Coalition boundaries after a review of available literature. However, the DWR's California's Groundwater Update 2013 (DWR, 2013) lists agricultural water use met by groundwater for various PAs within the Tulare Lake Hydrologic Region (Table 9). Table 9 includes the average thousand acre foot (TAF) values and approximate percentages of water supplied by groundwater for a given PA. The data are an approximation of the percentage of irrigation needs that are met by groundwater within a PA. Figure 42 compares the total water use with the use met by groundwater for the PAs within the Tulare Lake Hydrological Region between 2005 and 2010.

Table 8. Percentages of Detailed Analysis Units (DAUs) and Planning Areas (PAs) within WWQC Boundaries.

DAU Code	DAU Name	Portion of DAU within WWQC Boundary	PA Number	PA Name	Portion of PA within WWQC Boundary	Total Portion of PA within WWQC Boundary
248	Panoche Creek	99.94%	701	Western Uplands	18%	Portion of 701 in WWQC= 53%
249	Ciervo Hills	99.85%	701	Western Uplands	10%	
250	Los Gatos Creek	100.02%	701	Western Uplands	21%	
251	Reef Ridge	36.61%	701	Western Uplands	4%	
244	Westlands	99.88%	702	San Luis West Side	68%	Portion of 702 in WWQC= 78%
245	Kettleman Plain	48.72%	702	San Luis West Side	9%	
247	Kettleman Hills	28.40%	702	San Luis West Side	1%	

Table 9. Average annual total water supply met by groundwater, by Planning Area (PA), for the Tulare Lake Hydrologic Region (2005-2010) (Table 9-5, DWR, 2013). PAs within the Coalition region include 701 and 702.

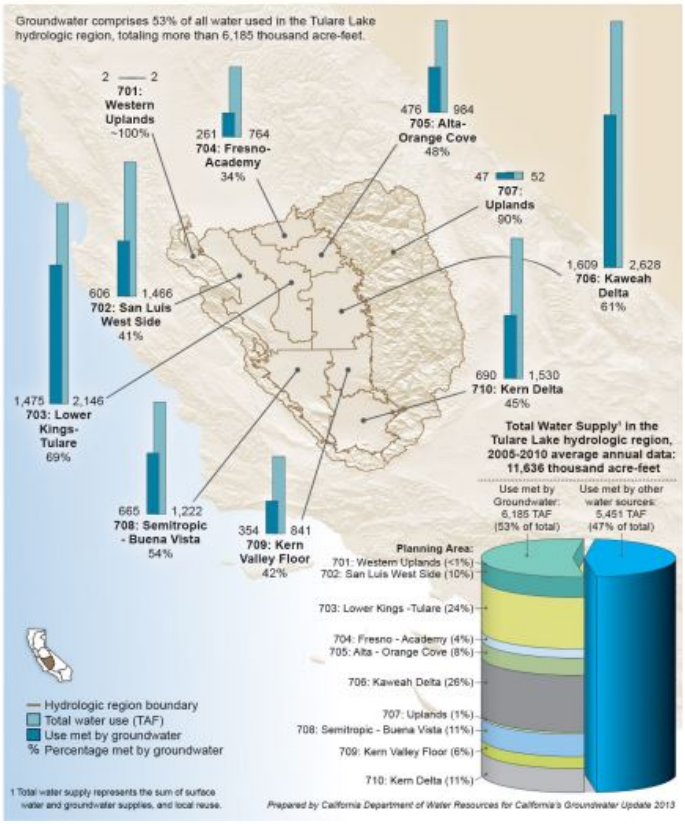
Table 9-5 Average Annual Total Water Supply Met by Groundwater, By Planning Area and Type of Use, for the Tulare Lake Hydrologic Region (2005-2010)

Tulare Lake Hydrologic Region		Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use[a] Met by Groundwater	
PA Number	PA Name	taf	%[b]	taf	%[b]	taf	%[b]	taf	%[b]
701	Western Uplands	0.3	100%	2.0	100%	0.0	0%	2.3	100%
702	San Luis West Side	598.5	41%	7.5	42%	0.0	0%	606.0	41%
703	Lower Kings-Tulare	1,429.0	69%	44.5	100%	1.1	4%	1,474.6	69%
704	Fresno - Academy	56.8	11%	204.5	78%	0.0	0%	261.2	34%
705	Alta - Orange Cove	417.2	45%	59.3	97%	0.0	0%	476.5	48%
706	Kaweah Delta	1,492.6	59%	112.8	97%	3.2	100%	1,608.7	61%
707	Uplands	32.6	97%	14.3	76%	0.0	0%	46.9	89%
708	Semitropic - Buena Vista	622.7	54%	17.7	74%	24.7	55%	665.0	54%
709	Kern Valley Floor	322.0	40%	31.9	97%	0.0	0%	353.9	42%
710	Kern Delta	580.3	42%	109.7	68%	0.0	0%	690.0	45%
2005-2010 Annual Average HR Total		**5,551.8**	**51%**	**604.1**	**82%**	**28.9**	**37%**	**6,184.8**	**53%**

Notes:
HR = hydrologic region; PA = planning area; taf = thousand acre-feet
[a]Total water use = groundwater + surface water + reuse
[b]Percent use is the percentage of the total water supply that is met by groundwater, by type of use.
2005-2010 precipitation equals 93 percent of the 30-year average for the Tulare Lake Hydrologic Region.

Figure 42. Groundwater Use and Total Water Supply Met by Groundwater, by Planning Area, the Tulare Lake Hydrological Region (2005-2010).

Figure 9-7 Groundwater Use and Total Water Supply Met by Groundwater, by Planning Area, for the Tulare Lake Hydrologic Region (2005-2010)



3 Existing Agricultural Management Practices

Member growers within the WWD portion of the Coalition region have benefitted from the increased efficiency, groundwater stabilization, and advanced irrigation practices that have been studied, modified, improved, and implemented for over 40 years by the Westlands Water District through a multifaceted sustainability program. WWD supports sustainable management practices through providing the following services to its growers:

- Providing individually-tailored satellite imagery to growers on a bimonthly basis, allowing them to adjust irrigation accordingly based on visual, accurate imagery of each of their fields.
- Providing growers with current Irrigation Guides detailing water requirements for crops based on actual weather and computer modeling. A separate weekly Guide is sent to growers providing detailed information on the three climatic regions throughout Westlands.
- Providing growers with The Water Conservation and Management Handbook, containing specific water management information on Westlands' farming conditions.
- Organizing regular workshops and meetings with small groups of growers to facilitate a two-way flow of water management information. These seminars grant growers firsthand access to Westlands' staff, private sector water management experts, scientists, and government figures as they share innovative and advanced information on water supply, equipment, and available resources.
- Providing technical assistance and conservation computer programs to growers, allowing growers to personally study irrigation management issues and solutions.
- Maintaining an aggressive program to install, upgrade and repair water meters.
- Monitoring groundwater to provide growers with up-to-date information on the quality and depth of groundwater.
- Ongoing efficiency testing for Westlands' pumps, preventing potentially catastrophic system downtime and reducing electrical consumption and costs.
- Improving overall water supply reliability through the efficient use of surface and groundwater to extract maximum benefit and preserve environmental resources.
- Offering opportunities to growers to lease or own innovative equipment such as drip, micro-spray, sprinkler, and aluminum piping to encourage conversion to more efficient irrigation technology.

One of the primary goals of the Coalition is to gather information on management practices that are demonstrated to benefit water quality and to provide information and support to growers to facilitate the implementation of these management practices. The Coalition does not have a catalog of the BMPs currently being employed by the growers in the Coalition region. However, Coalition members have direct access, via the WWD's web site, to a library of the latest BMPs employed worldwide. Many of the BMPs used by growers to maximize water use also have an added value as water quality BMPs. The Westlands Water District has developed an Irrigation Guide which provides real-time crop evapotranspiration (ET) to all its members using the Bureau of Reclamation Irrigation Management Service computer program. Crop ET information is necessary to develop efficient crop irrigation schedules, both real-time and average yearly values. In addition, the WWD has also developed and updates a Water Management Handbook which

includes information on irrigation practices, improving irrigation efficiency, fertigation and assessing crop water demands.

More recently, the Coalition received management practice information from members within high and low vulnerability areas (surface or groundwater) based on the Farm Evaluation Plan surveys. Farm Evaluations Plans are designed to collect the following information from each grower:

1. Crops grown and acreage of each crop,
2. Location of the member's farm,
3. Identification of on-farm management practices implemented to achieve the WDR farm management performance standards,
4. Potential for erosion during storm events and/or during irrigation (sediment and erosion risk areas) and a description of where within the property this occurs,
5. Identification of whether water leaves the property and is conveyed downstream and a description of where within the property this occurs,
6. Location of active wells and abandoned wells, and
7. Identification of whether wellhead protection and installation of backflow prevention devices have been implemented.

Farm Evaluation Surveys were due beginning 1 March 2016, and will be updated by 1 March annually thereafter. As analysis and aggregation is on-going, no current patterns or trends have been determined. The Coalition anticipates completing a baseline analysis for the Annual Monitoring Report Hydrologic Water Year 2015 – 2016 (WWQC, 2016). Table 10 lists the management practice questions queried of members in 2016 to protect surface and groundwater quality.

Table 10. WWQC member management practices addressed in the 2016 Farm Evaluation Surveys. Data from the Farm Evaluation Surveys had not yet been aggregated at the time this GQMP was written.

Management Practice Category		Management Practices
Irrigation Management Practices	Irrigation Efficiency Practices	Laser Leveling
		Pressure Bomb
		Soil Moisture Neutron Probe
		Use of ET in scheduling irrigations
		Use of moisture probe
		Water application scheduled to need
	Primary (and/or secondary) Irrigation Practices	Border Strip
		Drip
		Flood
		Furrow
		Sprinkler
		Micro Sprinkler
Sediment Management Practices	Cultural Practices to Manage Sediment and Erosion	Berms are constructed at low ends of fields to capture runoff and trap sediment.
		Cover crops or native vegetation are used to reduce erosion.
		Creek banks and stream banks have been stabilized.
		Crop rows are graded, directed and at a length that will optimize the use of rain and irrigation water.
		Field is lower than surrounding terrain.
		Hedgerows or trees are used to help stabilize soils and trap sediment movement.

Management Practice Category		Management Practices
		Minimum tillage incorporated to minimize erosion.
		Sediment basins / holding ponds are used to settle out sediment and hydrophobic pesticides such as pyrethroids from irrigation and storm runoff.
		Soil water penetration has been increased through the use of amendments, deep ripping and/or aeration.
		Storm water is captured using field borders.
		Subsurface pipelines are used to channel runoff water.
		Vegetated ditches are used to remove sediment as well as water soluble pesticides, phosphate fertilizers and some forms of nitrogen.
		Vegetative filter strips and buffers are used to capture flows.
	Irrigation Practices for Managing Sediment and Erosion	In-furrow dams are used to increase infiltration and settling out of sediment prior to entering the tail ditch.
		PAM (polyacrylamide) used in furrow and flood irrigated fields to help bind sediment and increase infiltration.
		Shorter irrigation runs are used with checks to manage and capture flows.
		Tailwater Return System.
		The time between pesticide applications and the next irrigation is lengthened as much as possible to mitigate runoff of pesticide residue.
		Use drip or micro-irrigation to eliminate irrigation drainage.
		Use of flow dissipaters to minimize erosion at discharge point.
Pesticide & Nutrient Management	Pesticide Application Practices	Avoid Surface Water When Spraying
		Chemigation
		End of Row Shutoff When Spraying
		Follow County Permit
		Follow Label Restrictions
		Monitor Rain Forecasts
		Monitor Wind Conditions
		Reapply Rinsate to Treated Field
		Sensitive Areas Mapped
		Target Sensing Sprayer used
		Use Appropriate Buffer Zones
		Use Drift Control Agents
		Use PCA Recommendations
		Use Vegetated Drain Ditches
	Nitrogen Management Methods to Minimize Leaching Past the Root Zone	Cover Crops
		Fertigation
		Foliar N Application
		Irrigation Water N Testing
		Soil Testing
		Split Fertilizer Applications
		Tissue/Petiole Testing
		Variable Rate Applications using GPS
Well Management Practices	Wellhead Protection Practices	Air Gap (for non-pressurized systems
		Backflow Preventive / Check Valve
		Good “Housekeeping” Practices*
		Ground Sloped Away from Wellhead
		Standing water avoided around wellhead
	Abandoned Wells Practices (if abandoned well is known to be present on site)	Destroyed – certified by county
		Destroyed - Unknown method
		Destroyed by licensed professional

*Good housekeeping practices include keeping the area surrounding the wellhead clean of trash, debris and any empty containers

3.1 Irrigation Management Practices

The GAR provides a detailed analysis of publicly available data (DWR) and private data (WWD) of irrigation management practices in WWD specifically, and the Coalition region in general. Table 11 and Table 12 and Figure 43 and Figure 44 show the trends in irrigation methods within the WWD from the mid-1980s to 2013. Approximately 74% of reported watering systems are drip and trickle by 2013 while furrow irrigation has dropped from 60% in 1985 to 7% in 2013.

Table 11. On-Farm irrigation practices annual percentage (Table 4-7; WWQC, 2015).

Table 4-7 WWD On-Farm Irrigation Practices Annual Percentage
Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

	Percent of Land Irrigated																						
Irrigation Practice	1985	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Surface																							
Furrow	60	38	32	36	34	34	32	31	29	28	26	22	22	23	20	19	18	11	9	8	10	7	7
Border Strip	3	5	1	4	2	2	2	2	2	2	2	3	2	2	3	2	3	5	4	3	3	2	2
Combination Sprinkler/Furrow	15	38	46	40	43	43	44	43	45	44	44	45	42	39	34	28	24	19	10	11	10	9	5
Pressurized																							
Sprinkler	21	16	17	15	15	15	14	15	13	13	13	12	12	11	10	10	9	13	15	11	12	11	11
Drip/Trickle	1	3	4	5	6	6	8	9	11	13	15	18	22	25	33	41	46	52	62	67	65	71	75
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 12. On-farm irrigation practices annual acreage (Table 4-8, WWQC, 2015).

Table 4-8 WWD On-Farm Irrigation Practices Annual Acreage
Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

	Total Acreage of Land Irrigated																				
Irrigation Practice	1985	1990	1993	1994	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Surface	*	*																			
Furrow	322,785	196,021	124,259	127,741	176,370	169,362	157,834	141,581	124,377	104,509	117,475	101,784	95,681	90,529	86,541	49,118	33,019	31,480	46,314	30,184	30,956
Border Strip	16,139	25,792	3,053	12,352	9,300	10,490	8,446	8,352	6,885	11,760	9,656	9,891	11,896	9,063	11,139	21,585	16,334	9,642	11,491	10,641	8,574
Combination Sprinkler/Furrow	80,696	196,021	178,714	143,304	241,716	231,386	235,505	224,758	203,165	214,480	227,604	174,445	163,280	135,995	111,667	84,864	35,833	42,879	47,779	42,286	21,237
Pressurized																					
Sprinkler	112,975	82,535	66,651	54,669	77,239	83,914	69,949	72,161	65,500	56,456	68,269	48,671	47,677	47,936	44,213	58,511	56,701	42,356	56,673	49,281	44,979
Drip/Trickle	5,380	15,475	14,118	17,235	40,122	48,489	57,718	65,929	68,325	86,249	118,963	110,534	157,247	196,994	216,142	224,767	230,665	254,750	297,737	331,078	321,183
Total	537,975	515,845	386,795	355,301	544,747	543,641	529,452	512,781	468,252	473,454	541,967	445,325	475,781	480,517	469,702	438,845	372,552	381,107	459,994	463,470	426,929

Notes:
* Acreage estimated from on-farm irrigation system percentage.

Figure 43. Trends in irrigation practice percentages within the WWD from mid-1980s to 2013 from WWD surveys (Figure 4-15, WWQC, 2015).

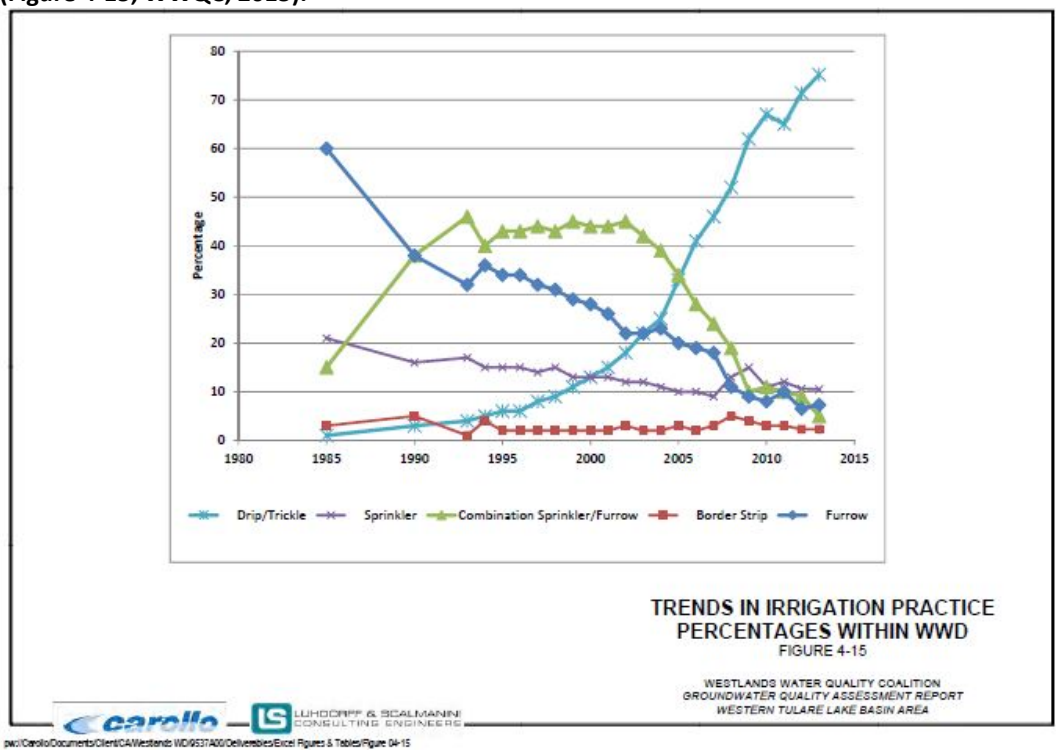
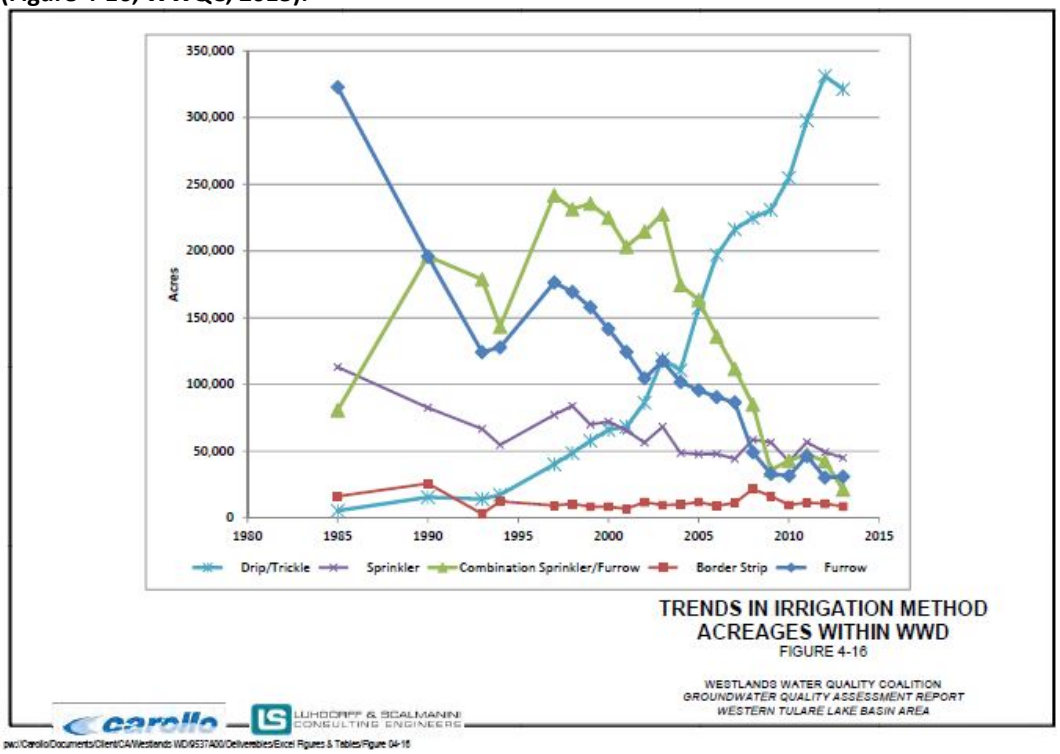


Figure 44. Trends in irrigation practice by acreage within the WWD from mid-1980s to 2013 from WWD surveys (Figure 4-16, WWQC, 2015).



The spatial and temporal distribution of irrigation practices in the WWD and the Coalition region are shown in Figure 45 through Figure 47 using both WWD and WDR survey data. Figure 46 includes Figure 4-10 from the GAR, which uses DWR data from the early 2000s to include the entire Coalition region. Figure 46 and Figure 47 include Figures 4-9, 4-11, and 4-12 from the GAR, which use WWD data and only cover the WWD service area. Outside of the WWD, there is a small portion of irrigated land above the Pleasant Valley subbasin, surrounding the City of Coalinga (34,136 acres) (WWQC, 2015).

Figure 45. Summary of changes in irrigation practices in Westlands Water District (Figure 4-13, WWQC, 2015).

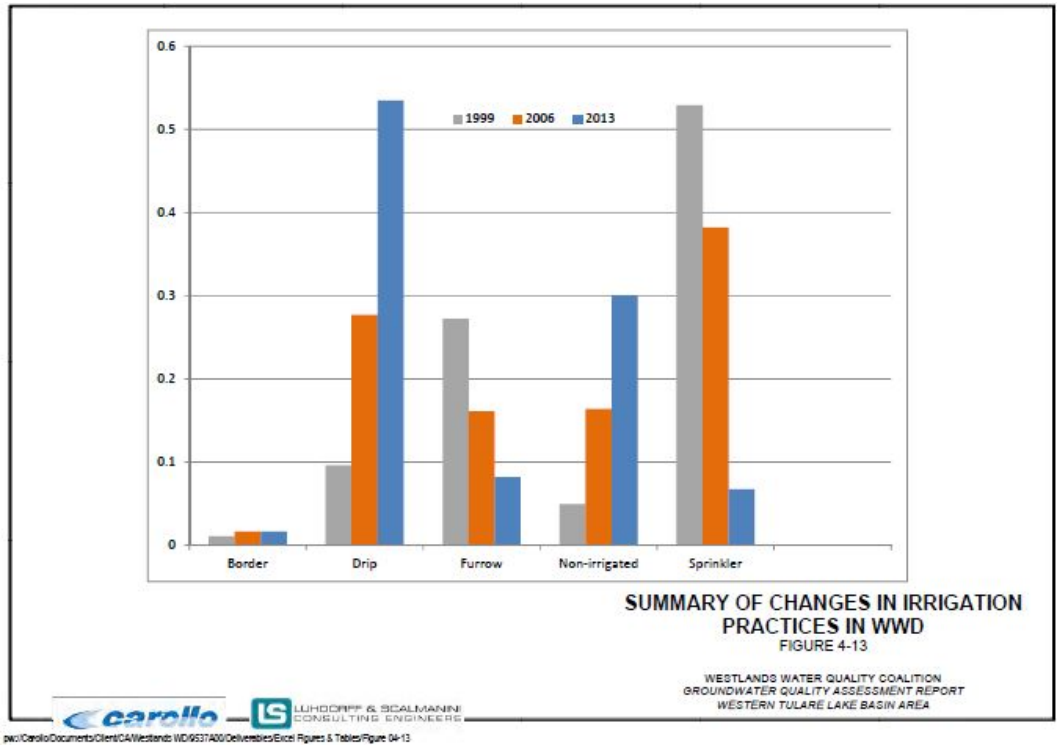


Figure 46. Irrigation practices in 1999 in the WWD (WWD data) and early 2000s (DWR data) in the Coalition region (Figures 4-9 and 4-10, WWQC, 2015).

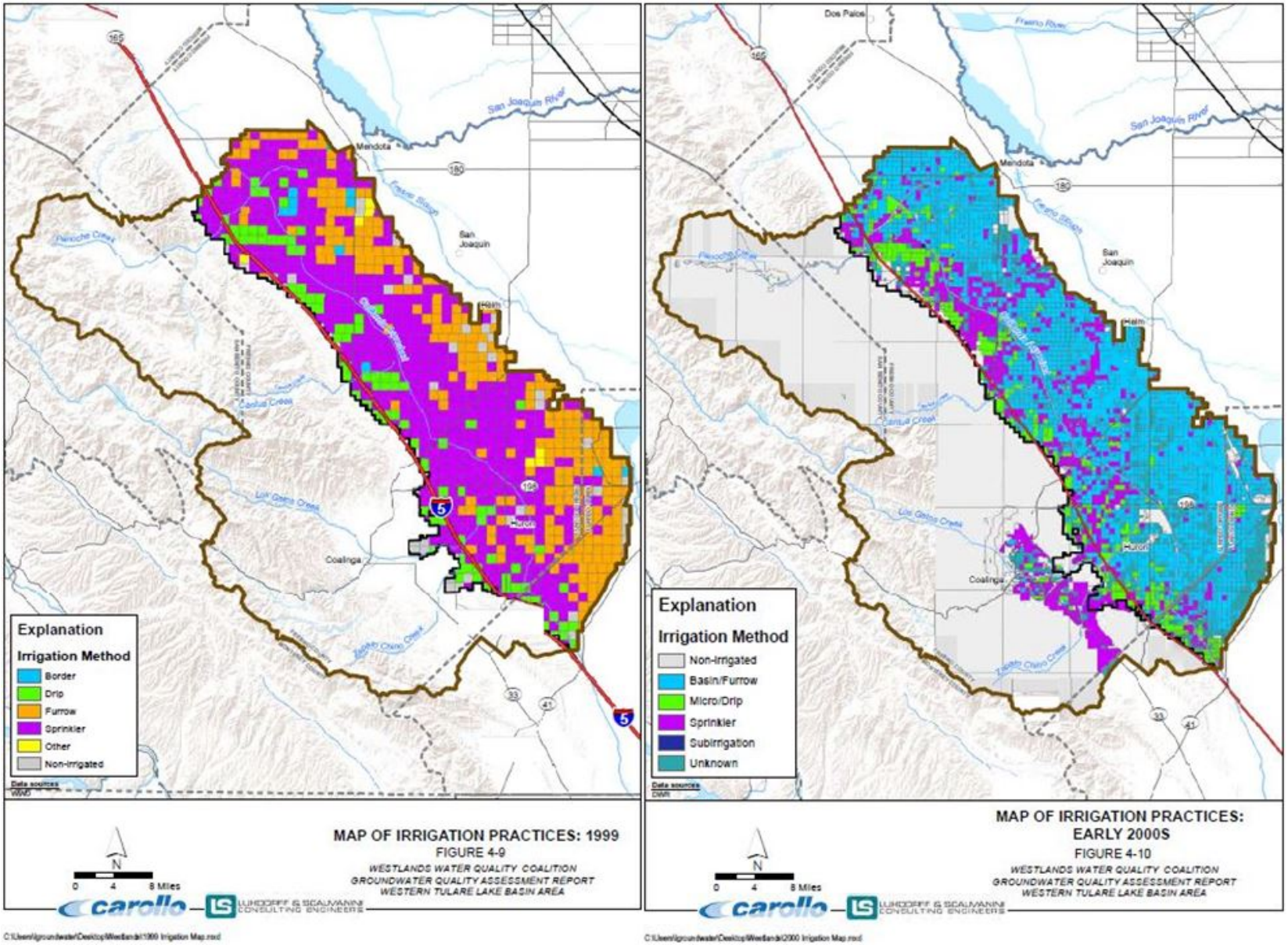


Figure 47. Irrigation practices in 2006 and 2013 in the WWD service area (WWD Data) (Figures 4-11 and 4-12, WWQC, 2015).

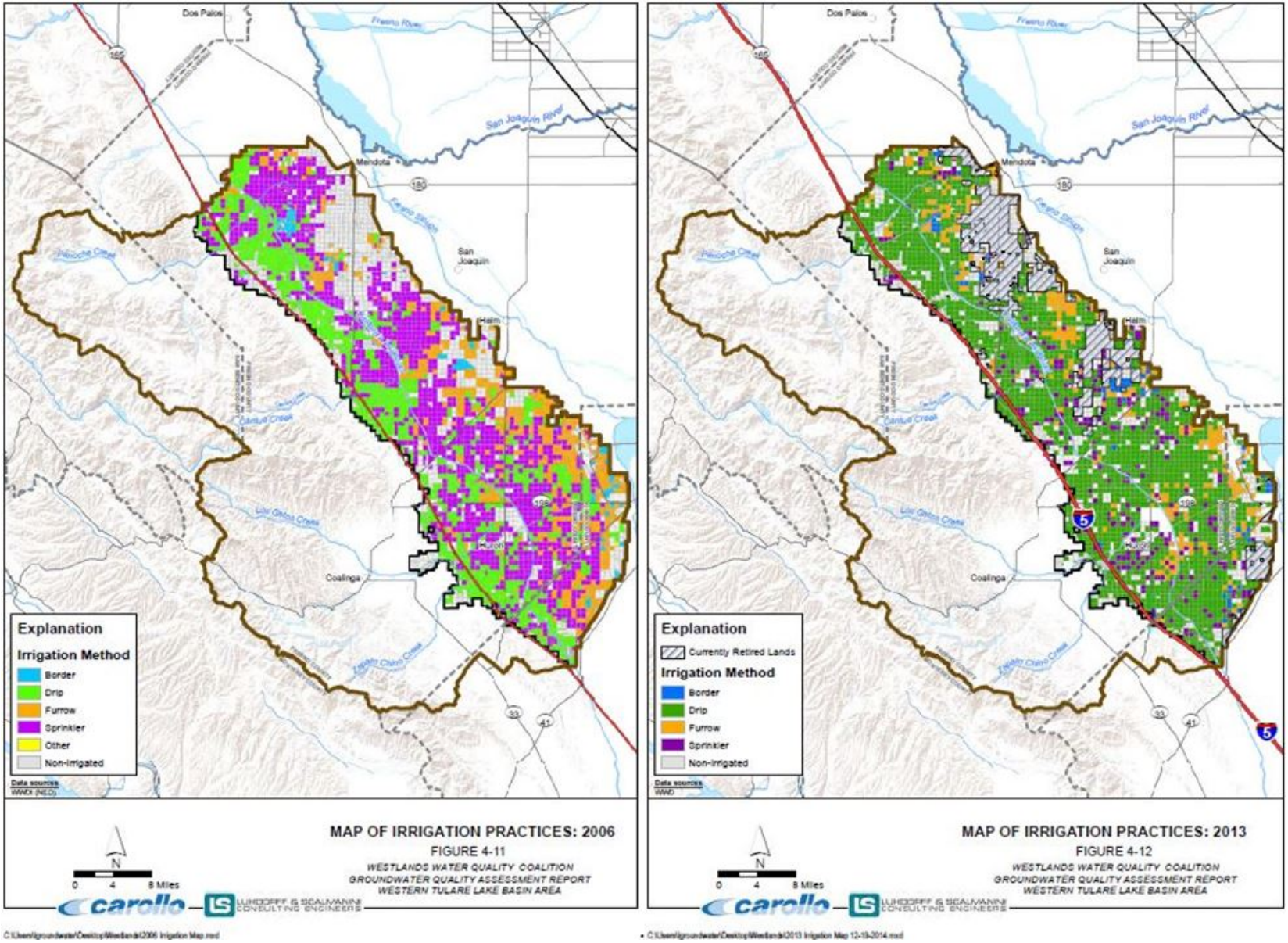


Table 13 and Figure 48 summarize the irrigation practices in the WWD boundary by agricultural crop category based on the 2013 WWD data. In 2013, the predominant irrigation practice was drip, representing the irrigation method used on approximately 74 percent of the irrigated lands area. Basin/furrow irrigation and sprinkler irrigation represented the irrigation method used on 15 percent and 11 percent of the irrigated area, respectively. By crop category, grasses and seeds/beans relied the most on micro/drip irrigation. The remaining crops also used mostly micro/drip irrigation, while grasses and seeds/beans accounted for over 88% of micro/drip irrigation systems.

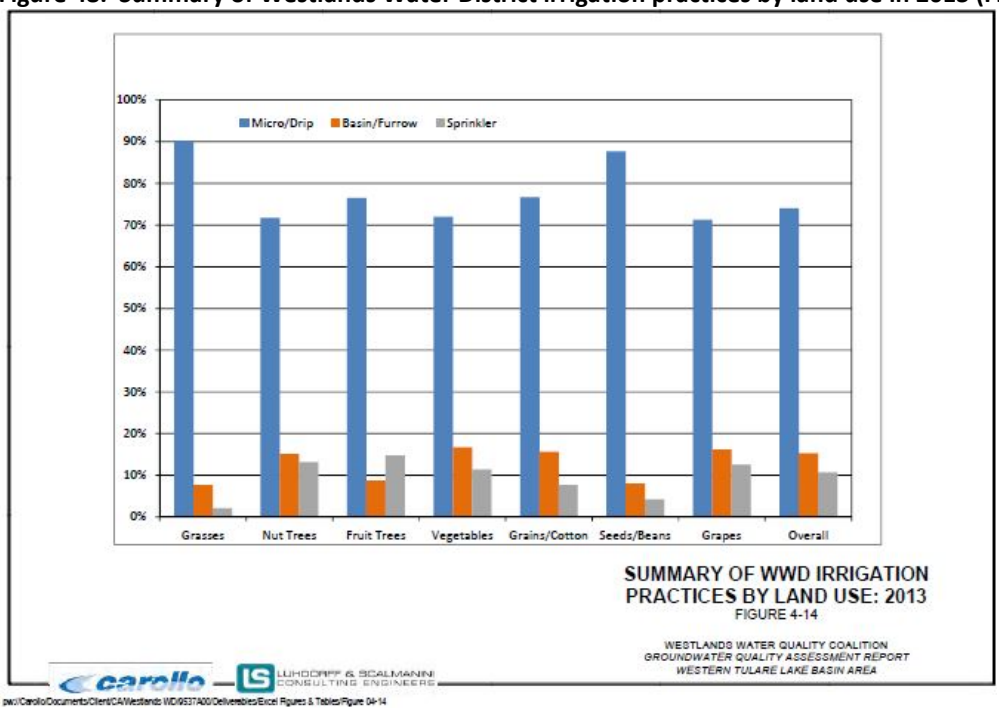
Table 13. Summary of Irrigation Practices by crop in 2013 for the WWD within the Western Tulare Lake Basin Area (Table 4-6, WWQC, 2015).

Table 4-6 Summary of Irrigation Practices 2013
Groundwater Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

	Irrigation Method		
Land Use Category	Micro/Drip	Basin/Furrow	Sprinkler
Grasses	90 percent	8 percent	2 percent
Nut Trees	72 percent	15 percent	13 percent
Fruit Trees	77 percent	9 percent	15 percent
Vegetables	72 percent	17 percent	11 percent
Grains/Cotton	77 percent	16 percent	8 percent
Seeds/Beans	88 percent	8 percent	4 percent
Grapes	71 percent	16 percent	13 percent
Overall	**74** percent	**15** percent	**11** percent

Notes:
(1) Data from 2013 WWD irrigation data layer.

Figure 48. Summary of Westlands Water District irrigation practices by land use in 2013 (Figure 4-14, WWQC, 2015).



4 Groundwater Quality Data

4.1 Previous Work to Identify Constituents of Concern in Groundwater

In the characterization of current groundwater quality and the identification of constituents of concern (COCs) for the GQMP area, the Coalition relied on the findings of the GAR, which presented previous work, studies, and monitoring programs conducted throughout GQMP area. Several sources were cited in the GAR for water quality data and COCs including: California Department of Public Health (CDPH) Water Quality Analyses Database Files, California Department of Water Resources (DWR) Water Data Library, United States Geological Survey's (USGS) National Water Information System (NWIS), SWRCB's Geotracker database (GAMA), data acquired from the RWQCB from wells on dairy permitted lands, the California Department of Pesticide Regulation (DPR) pesticide sampling database, and WWD. Pesticide concentration data for the GAR were limited to data obtained from DPR (WWQC, 2015). Consultation with DPR staff (personal communication with Joy Dias, Senior Environmental Scientist, DPR, August 19, 2016) provided verification that the public agencies contributing groundwater quality data to SWRCB's Geotracker, i.e. SWRCB, RWQCBs, CDPH, DPR, DWR, USGS, and LLNL, also provide those pesticide concentration data to the DPR. According to DPR, aside from point source monitoring (e.g. SWRCB regulated monitoring programs, etc.), all groundwater monitoring results within the state pertaining to pesticides applied during legal agricultural use, are reported to the DPR by those agencies listed above. In addition, once DPR receives the pesticide concentrations data, QA/QC of the data and follow-up procedures for all detections are performed by DPR. The GAR contains data obtained from public and private data sources and is due to be updated every five years (next update due in 2020).

4.2 Groundwater Constituents of Concern

Constituents of concern in groundwater are those materials that could impact beneficial uses and that have been applied by agricultural operations, including constituents in irrigation supply water (e.g., pesticides, fertilizers, soil amendments, etc.). Typically, shallow groundwater is that water most recently entering the groundwater recharge cycle and is representative of more recent overlaying land use activities. Due to the extended transport time of downward-moving irrigation return water (years) to even shallow groundwater aquifers, any management practice applied to land use during a given year could take years to result in improvements in groundwater quality. Agricultural management practices recommended by this GQMP are designed to prevent future degradation of groundwater quality by agricultural operations.

The Groundwater Monitoring Advisory Workgroup for the Regional Water Board determined "that the most important constituents of concern related to agriculture's impacts to the beneficial uses of groundwater are nitrate (NO_3-N) and salinity" (WDR, Attachment A, page 13). According to Bulletin 118 (DWR 2003), in general, the primary constituents of concern present in the Tulare Lake Hydrologic Region with the potential to impact or cause degradation state waters are salts (TDS), nitrate, arsenic, and organic compounds, such as pesticides.

The following constituents are identified in the GAR exceeding the threshold for the Drinking Water Standards MCLs: nitrate, TDS, and the pesticide, simazine (Table 14 through Table 16). Only those constituents associated with agricultural management practices and with concentrations above the MCLs were retained as potential COCs. A review of GAMA's Geotracker database (http://geotracker.waterboards.ca.gov/gama/data_download.asp) will be included in the annual Groundwater Management Plan Progress Report (due May 1) in order to determine if additional GQMPs are required and as part of the groundwater quality trend monitoring effort.

Naturally high salinity in groundwater exists throughout all groundwater zones (shallow groundwater, Upper Aquifer, and Lower Aquifer) of the Coalition region, due to groundwater recharge off the Coast Range sediments of marine origin to the west. Additional sources of increased salinity in groundwater include capillary action of water through the soil profile of very shallow groundwater, thereby concentrating the salts in the groundwater below, and through direct evaporation and evapotranspiration by using saline groundwater as irrigation water. TDS is the focus of the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) process and a management plan for salt is being developed for the entire Central Valley region. The Coalition participates in CV-SALTS and when management practices are established through that process, the Coalition will initiate outreach to members on salt management.

Nitrogen (N) can occur naturally in soils and groundwater, but in elevated concentrations generally assumed to be 3 mg/L and above, is most likely due to leaching from dairy operations, applications of fertilizers through agricultural practices or from the point source pollution of leaking septic tanks. Elevated levels of nitrate (above the MCL) have been found mainly in the shallow groundwater throughout the Coalition, with a cluster of wells with concentrations of nitrate (measured as N) above 10 mg/L south and southwest of Mendota. According to data presented in the GAR, the instances of nitrate concentration exceeding the MCL decreases with the increasing depth of the well, with few exceedances of the MCL for nitrate in the Upper Aquifer and

still fewer in the Lower Aquifer. It is believed the presence of the Corcoran clay layer along the eastern half of the WWQC prevents the downward movement of nitrate as nitrogen through the zones of groundwater (WWQC, 2015). In addition to being involved in the CV-SALTS process, the Coalition is also involved in the process of developing a Basin Plan Amendment (BPA) for salt and nitrate that will include implementation options that may result in the use of specific management practices to prevent leaching of nitrate in some or the entire Coalition region. The Coalitions participation in the MPEP will also generate specific practices that can be recommended to growers as ways to reduce or eliminate leaching of nitrate through the root zone.

Three exceedances of the simazine MCL occurred in two unique well locations within the eastern half of the Coalition region. These exceedances were reported in 1985 and, due to a lack of follow-up actions/sampling from the DPR, are determined by DPR to be "unconfirmed/not from legal agricultural use" (see Management Plan Strategy and Constituent of Concern sections of this document for further discussion).

Table 14. Summary of Groundwater Quality Data for nitrate as N (Since 2005; Table 5-1b, WWQC, 2015).

Nitrate Data																
Monitoring Entity	Number of wells	Number of sample tests	Number of wells with known depth	Irrigation Wells	Monitoring Wells	Domestic Wells	Public Supply Wells	Unknown Well Type	Very Shallow Zone	Upper Aquifer	Lower Aquifer	Composite	Unknown Depth Zone	Wells with results over 5 mg/L (as N)	Wells with results over 10 mg/L (as N)	Wells with results over 20 mg/L (as N)
CDPH	25	253	0	0	0	0	25	0	0	0	25	0	0	7	3	1
DWR	640	1318	0	0	3	0	0	637	3	0	0	0	637	71	37	21
SWRCB	27	164	0	0	18	0	9	0	18	0	9	0	0	8	3	3
USGS	242	549	193	0	0	0	0	242	106	36	51	0	49	154	129	103
WWD	391	516	322	358	0	10	0	23	0	39	292	51	9	19	7	3
Total	1,325	2,800	515	358	21	10	34	902	127	75	377	51	695	259	179	131

Table 15. Summary of Groundwater Quality Data for TDS (Since 2005; Table 5-1b, WWQC, 2015).

Total Dissolved Solids Data																
Monitoring Entity	Number of wells	Number of sample tests	Number of wells with known depth	Irrigation Wells	Monitoring Wells	Domestic Wells	Public Supply Wells	Unknown Well Type	Very Shallow Zone	Upper Aquifer	Lower Aquifer	Composite	Unknown Depth Zone	Wells with results over 500 mg/L	Wells with results over 1,000 mg/L	Wells with results over 1,500 mg/L
CDPH	21	114	0	0	0	0	21	0	0	21	0	0	0	17	4	3
DWR	1197	3062	0	0	4	0	2	1191	4	2	0	0	1191	1186	719	308
SWRCB	27	353	0	0	18	0	9	0	18	9	0	0	0	27	23	18
USGS	327	1259	266	0	0	0	0	327	155	56	55	0	61	323	280	238
WWD	2197	3935	1917	1579	536	32	0	50	550	592	669	375	11	2184	1471	801
Total	3,769	8,723	2,183	1,579	558	32	32	1,568	727	680	724	375	1,263	3,737	2,497	1,368

Table 16. Summary of pesticide detections (Table 5-2, WWQC, 2015).
Constituents associated with exceedances have been **bolded** here.

Pesticide	Total Tests	Total Detections	Total Exceedances	Unique Wells with Detection	Unique Wells with Exceedance	Exceedance Threshold Used (µg/L)	Basis for Exceedance Threshold
Atrazine	113	2	0	2	0	1	CA Primary MCL
Carbon Disulfide	10	1	0	1	0	160	CA Notification Level
Chlorpyrifos	16	2	0	2	0	None	No value in database
Chlorthal-Dimethyl and degradates (total)	3	1	0	1	0	None	Chemical not in database
Diazinon	19	1	0	1	0	1.2	CA Notification Level
Prometon	98	2	0	2	0	None	No value in database
Simazine	**117**	5	3	4	2	**4**	**CA Primary MCL**
TOTAL	376	14	3	13	2		

Pesticide data are for the period 1984-2012 provided by DPR. As with the SWRCB's Geotracker, DPR receives groundwater quality data for pesticide concentrations from SWRCB, RWQCBs, CDPH, DPR, DWR, USGS, and LLNL for all pesticides used in legal agricultural use. In addition, once DPR receives the data, QA/QC of the data and follow-up procedures for all detections are performed by DPR.

*Exceedance thresholds used are based on values reported in the SWRCB Water Quality Goals Online Database (http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/search.shtml), when available. Selection of the threshold value for use to indicate an exceedance is based on a hierarchy consisting of the following order of preference: CA Primary MCL = California Primary MCL; EPA Primary MCL = EPA's Federal Primary MCL; CA Notification Level. No value in database = Chemical is in the database but no possible threshold value reported, Chemical not in database = Chemical was not located in the SWRCB database.

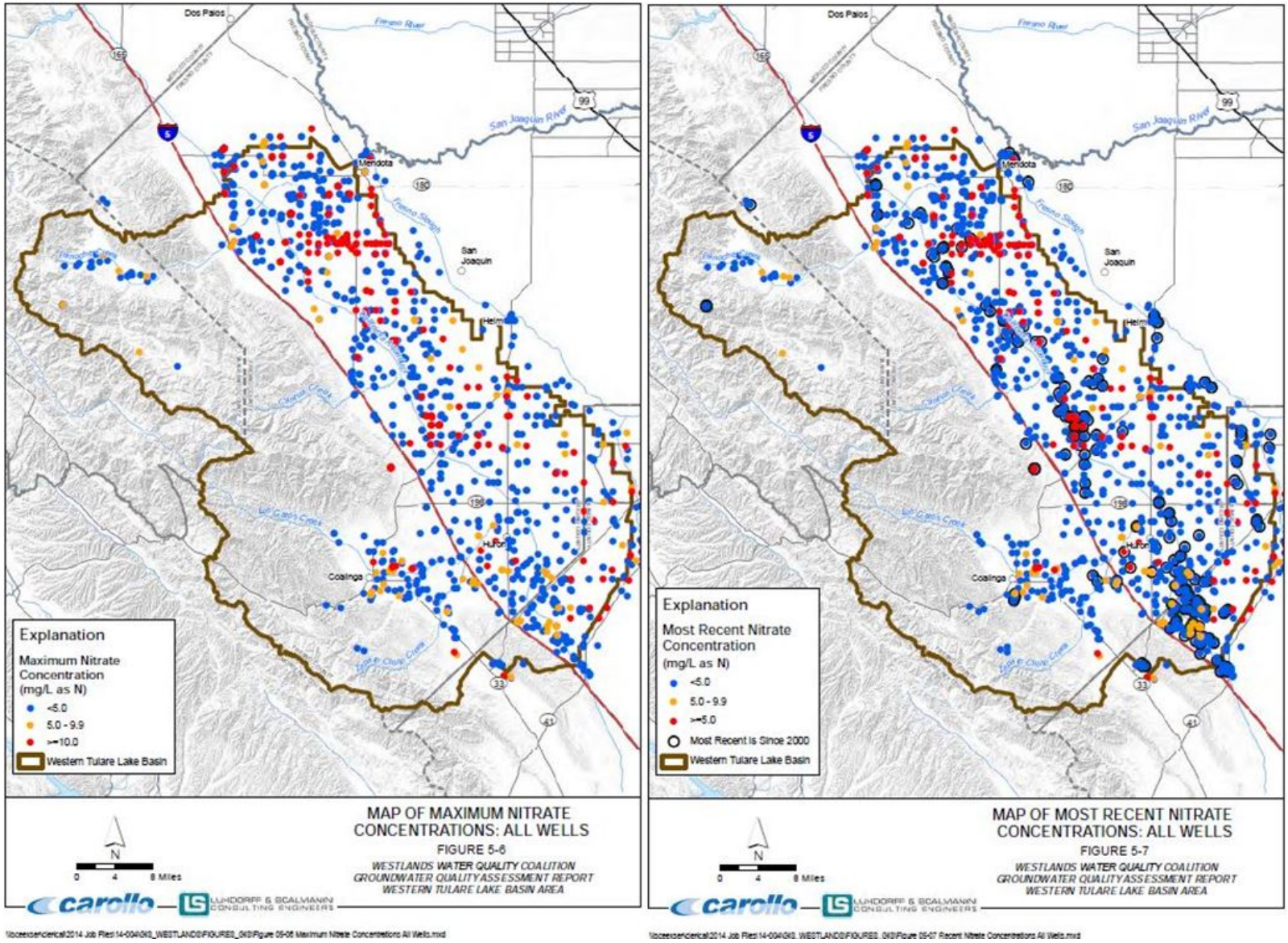
4.2.1 Spatial Distribution of Constituents of Concern

4.2.1.1 Nitrate

The maximum and most recent nitrate (as N) concentrations observed in all wells throughout the Coalition are depicted in Figure 49. The majority of wells have maximum concentrations below 5 mg/L; however, several areas exist where maximum concentrations exceed the MCL of 10 mg/L (as N), especially in the area south and southwest of Mendota. Several other areas with a greater number of wells with maximum nitrate concentrations above 10 mg/L also occur, including several wells in Pleasant Valley. There are no wells in Panoche Valley with maximum nitrate concentrations exceeding the MCL, although available groundwater quality data in this area pre-dates 2000.

The overall picture illustrated by the most recent nitrate data in Figure 49 (Figure 5-7 of the GAR) is very similar to that of the maximum nitrate concentrations, although the map of most recent nitrate concentrations shows a decreased number of wells with concentrations above 5 mg/L indicating improving groundwater quality conditions.

Figure 49. Maximum and most recent nitrate (as N) concentrations in all wells in the Coalition region (Figures 5-6 and 5-7, WWQC, 2015).



Very Shallow Groundwater / Upper Aquifer / Lower Aquifer

Figure 50 depicts maximum and most recent nitrate concentrations in very shallow groundwater. Nearly identical spatial patterns are evident in Figure 5-9 presenting the most recent nitrate concentrations in very shallow wells. Few very shallow wells have multiple tests for nitrate concentration and most nitrate data for very shallow wells are from prior to 2000. Generally high maximum concentrations of nitrate are evident in a majority of very shallow wells from the available data. The existence of high nitrate concentrations in these wells is not surprising given the hydrogeologic environment consisting of very shallow groundwater and poor drainage conditions. A notably higher density of very shallow wells with a maximum concentration greater than 10 mg/L is apparent in an area located south and southwest of Mendota with additional exceedances scattered throughout other parts of the Coalition region. One location with several very shallow wells exhibiting high maximum concentrations exists outside the Central Valley Floor in the hills along the southwestern edge of the Valley Floor approximately 10 miles northwest of Interstate 5. This location is the site of a SWRCB regulated facility with historical nitrate contamination from fertilizer drum disposal practices; nitrate concentrations here are not related to irrigated agriculture practices.

Figure 51 depicts maximum and most recent nitrate concentrations in Upper Aquifer groundwater. Many fewer wells interpreted to be in the Upper Aquifer have maximum nitrate concentrations exceeding the MCL, relative to the very shallow groundwater zone. The majority of these exceedances are located in the northeastern portion of the study area. Wells in the Upper Aquifer in more southern parts of the Coalition region tend to have lower concentrations of nitrate, typically below 5 mg/L. Most nitrate data for the Upper Aquifer pre-dates 2000 and exhibit similar patterns as the maximum nitrate concentration data.

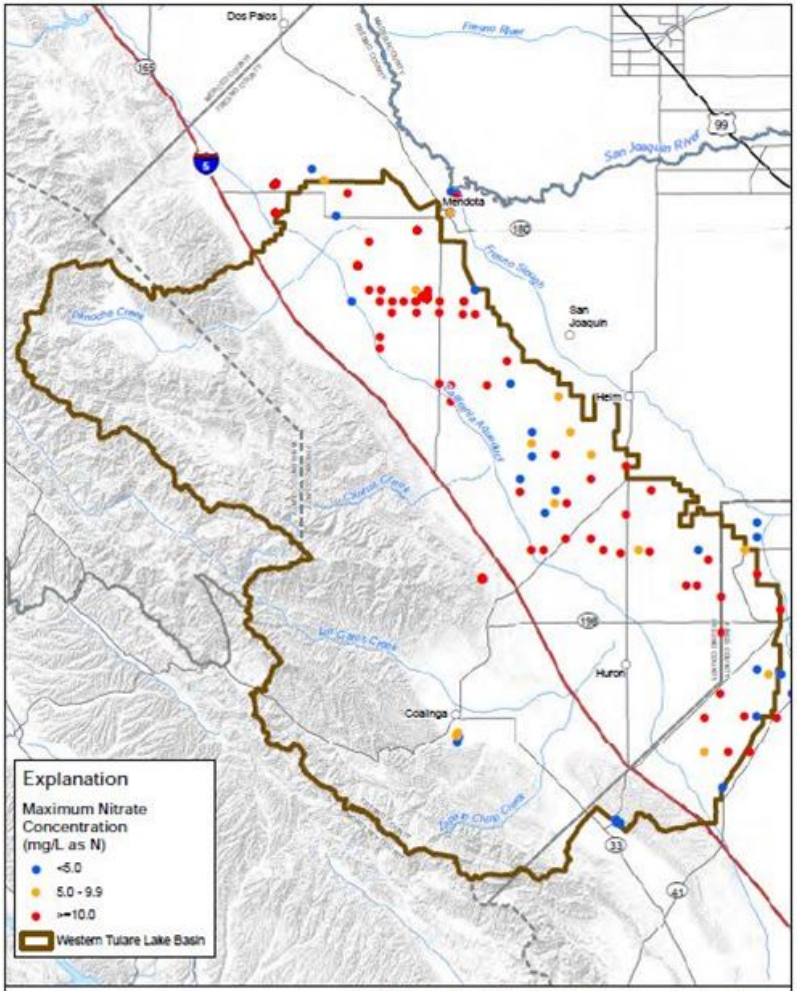
Figure 52 depicts maximum and most recent nitrate concentrations in Lower Aquifer groundwater. Very few wells in the Lower Aquifer have a maximum nitrate concentration above 5 mg/L with only eight wells classified as Lower Aquifer having maximum nitrate concentrations exceeding 10 mg/L. In the most recent nitrate data, even fewer wells have concentrations exceeding 10 mg/L in the Lower Aquifer. Localized areas of elevated nitrate levels in the Lower Aquifer tend to be concentrated in the vicinity of Huron to the south and southwest of Mendota, similar to the very shallow groundwater and Upper Aquifer. In contrast to data in the very shallow and Upper Aquifer zones, much of the nitrate data in the Lower Aquifer are more recent, since 2000. The few occurrences of high concentrations of nitrate in the Lower Aquifer wells suggest the continued role of the Corcoran Clay as an impediment to vertical migration of contaminants into the Lower Aquifer. Clusters of higher nitrate concentrations in the Lower Aquifer are generally concentrated in areas where the Corcoran Clay is either thin or non-existent, most notably to the west and in the vicinity of Huron.

Composite Wells / Wells of Unknown Depth

Figure 53 depicts maximum and most recent nitrate concentrations in composite wells within the Coalition. The maximum and most recent nitrate concentrations in the composite wells, which are interpreted to be screened across the Corcoran Clay in both the Upper and Lower Aquifers, are nearly all below 10 mg/L, with most below 5 mg/L. Many of the wells for which nitrate concentration data are available could not be classified into a depth category because of the lack of information relating to well construction and type.

The spatial distribution of maximum and most recent nitrate concentrations in wells of unknown depth is displayed in Figure 54. The majority of these wells have maximum nitrate concentrations below 5 mg/L, although a greater density of wells with maximum nitrate concentrations exceeding 10 mg/L can be seen in the area south of Mendota. The similarity between the distribution of elevated nitrate concentrations in wells of unknown depth with those wells in very shallow groundwater and the Upper Aquifer suggests that many of the wells in this area are likely screened in one of these shallower depth zones. Other wells exceeding 10 mg/L are more sparsely distributed throughout the study area. Many wells in the Panoche and Pleasant Valley areas lack depth information, although the data shown in Figure 54 indicate some nitrate impacts with concentrations greater than 5 mg/L and a few wells with nitrate exceedances in Pleasant Valley. The elevated concentrations of nitrate in the Panoche Valley are most likely the result of more point sources of nitrate such as septic systems because only minimal irrigated agriculture exists in this area. As with much of the available nitrate data in the Coalition region, the majority of nitrate data for wells of unknown depth pre-date 2000.

Figure 50. Maximum and most recent nitrate (as N) concentrations in the very shallow groundwater in the Coalition region (Figures 5-6 and 5-7, WWQC, 2015).



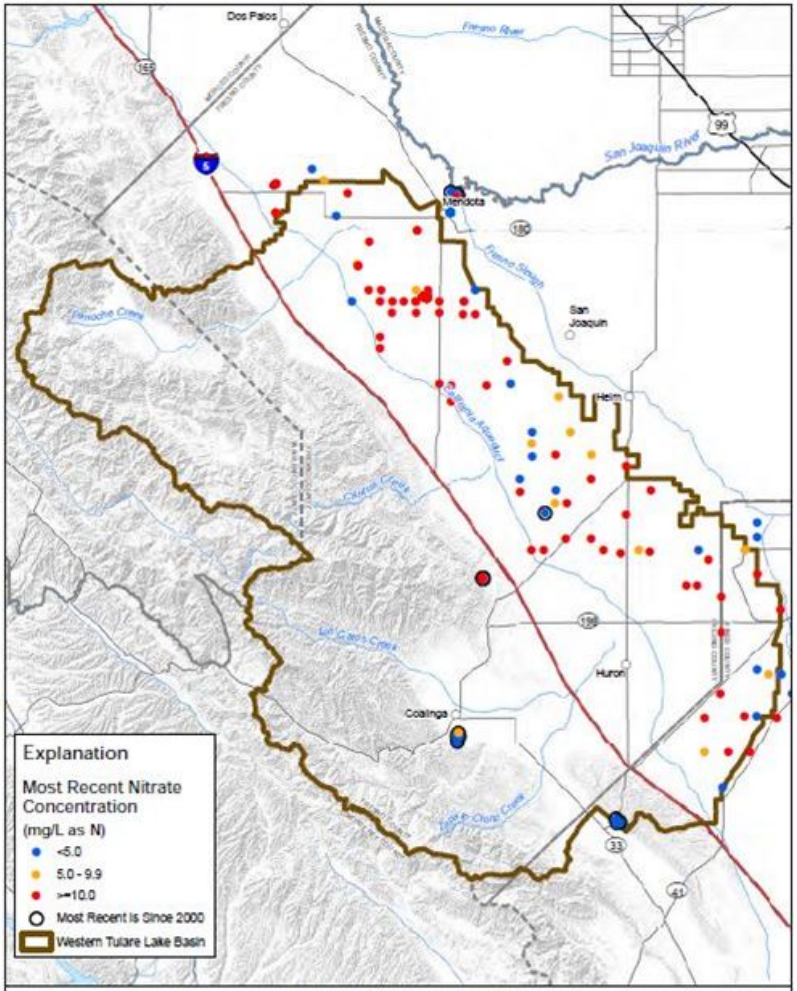
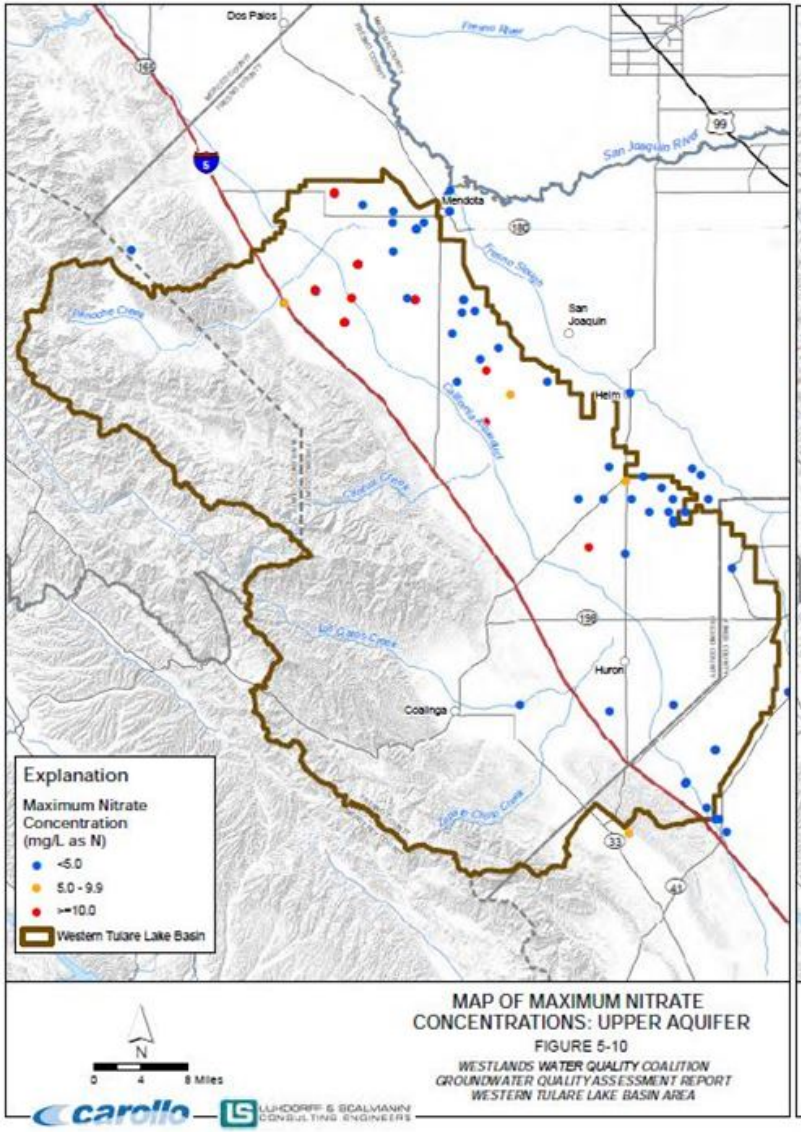


Figure 51. Maximum and most recent nitrate (as N) concentrations in the Upper Aquifer in the Coalition region (Figures 5-10 and 5-11, WWQC, 2015).



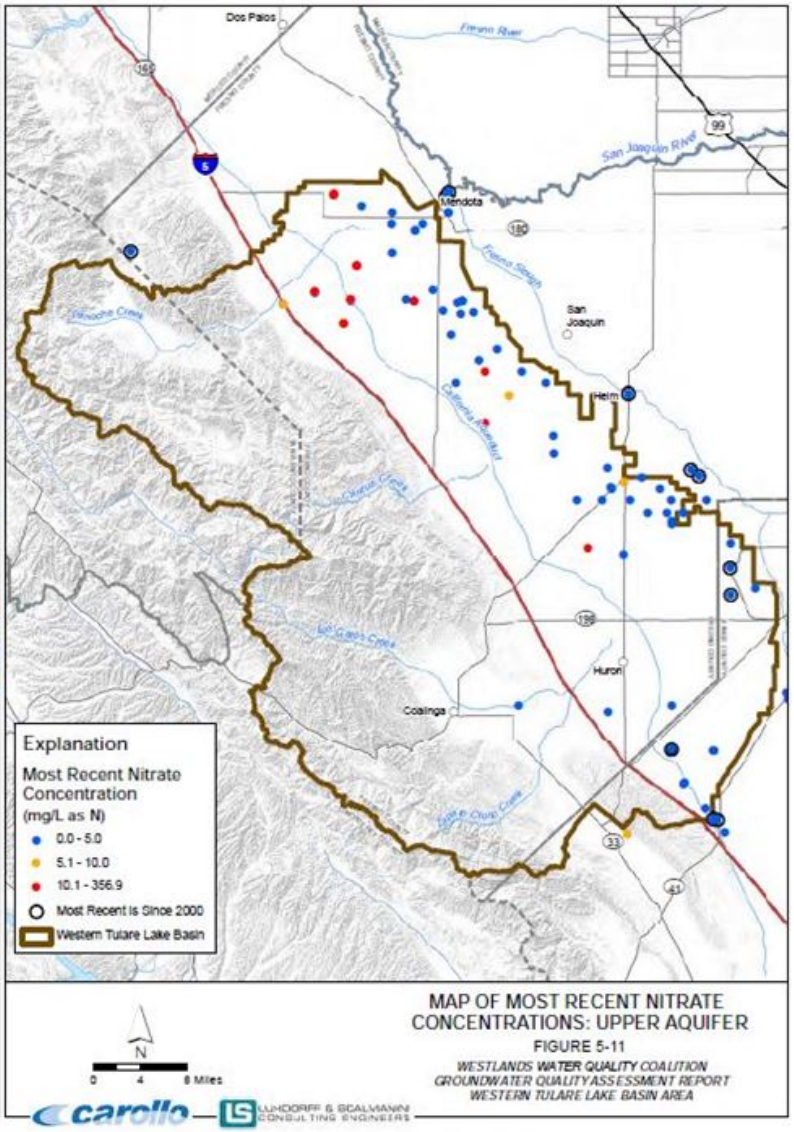
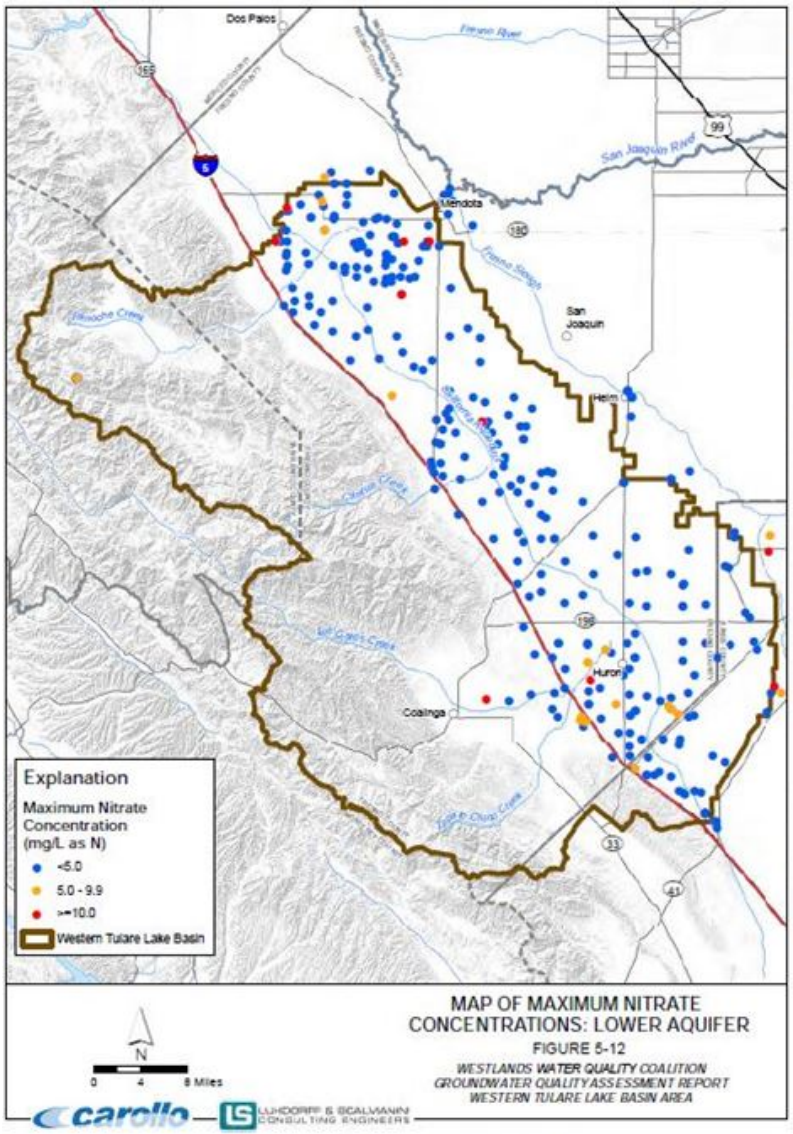


Figure 52. Maximum and most recent nitrate (as N) concentrations in the lower aquifer in the Coalition region (Figures 5-12 and 5-13, WWQC, 2015).



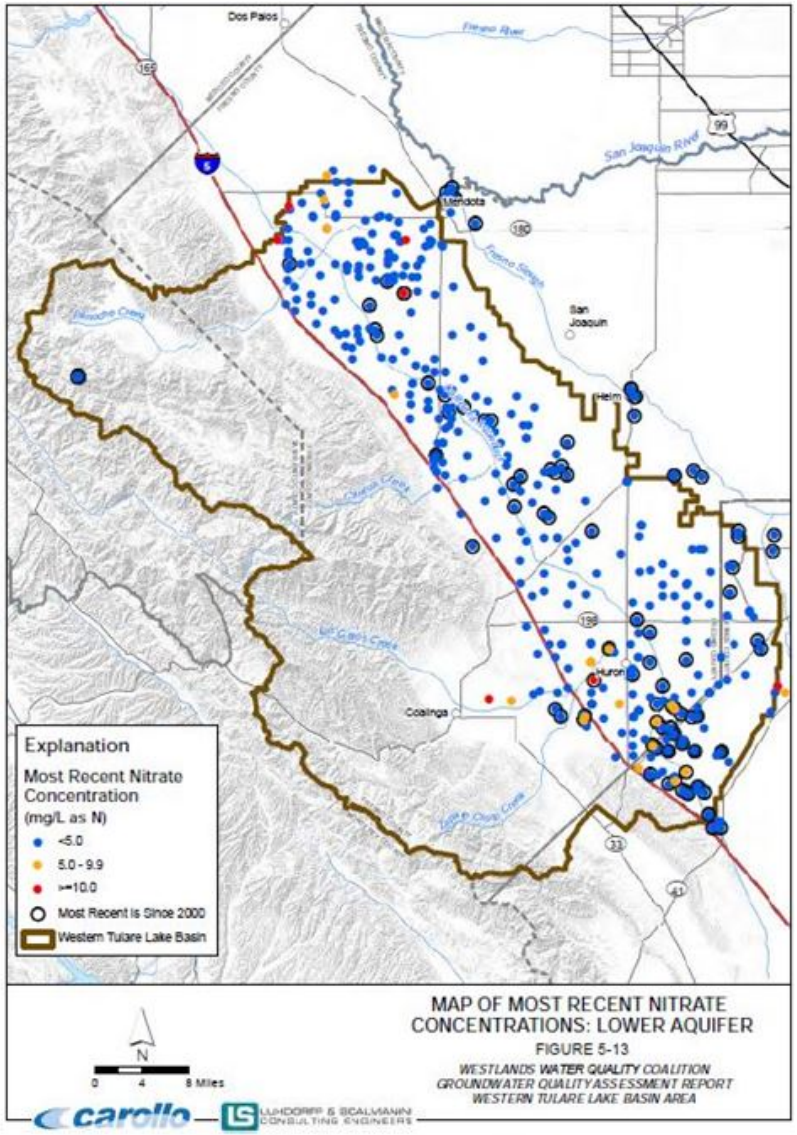
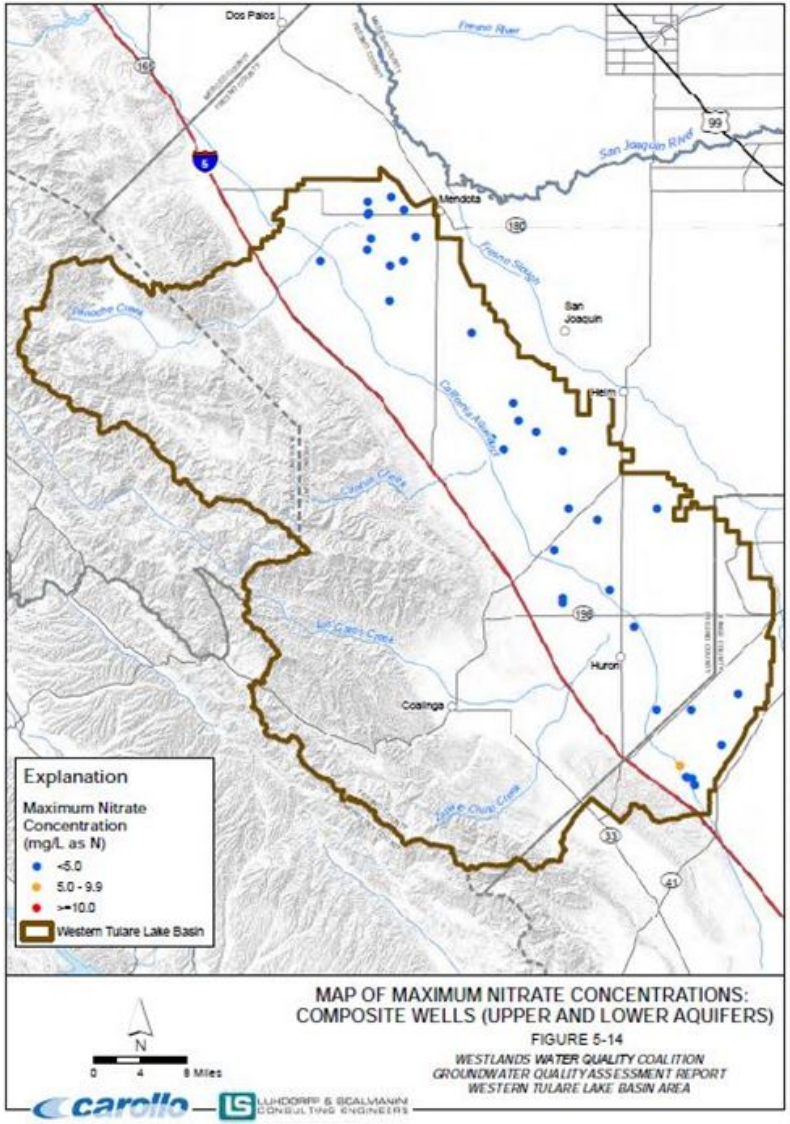


Figure 53. Maximum and most recent nitrate (as N) concentrations in composite wells in the Coalition region (Figures 5-14 and 5-15, WWQC, 2015).



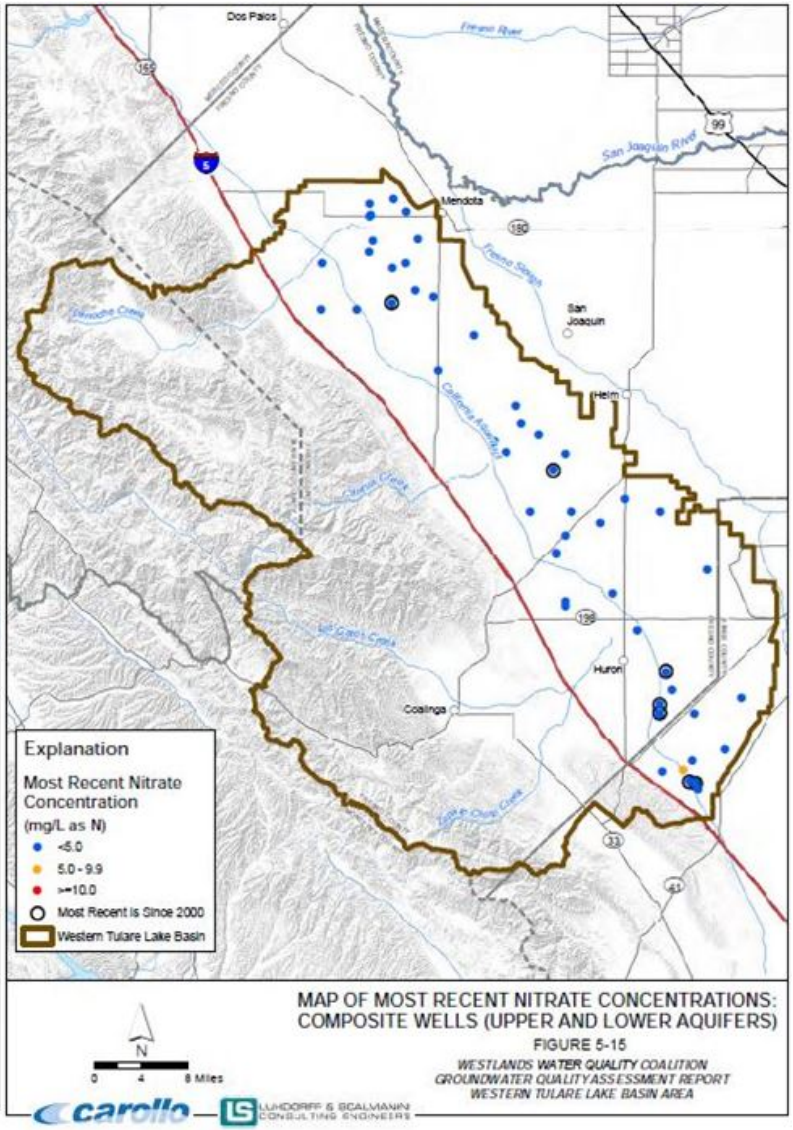
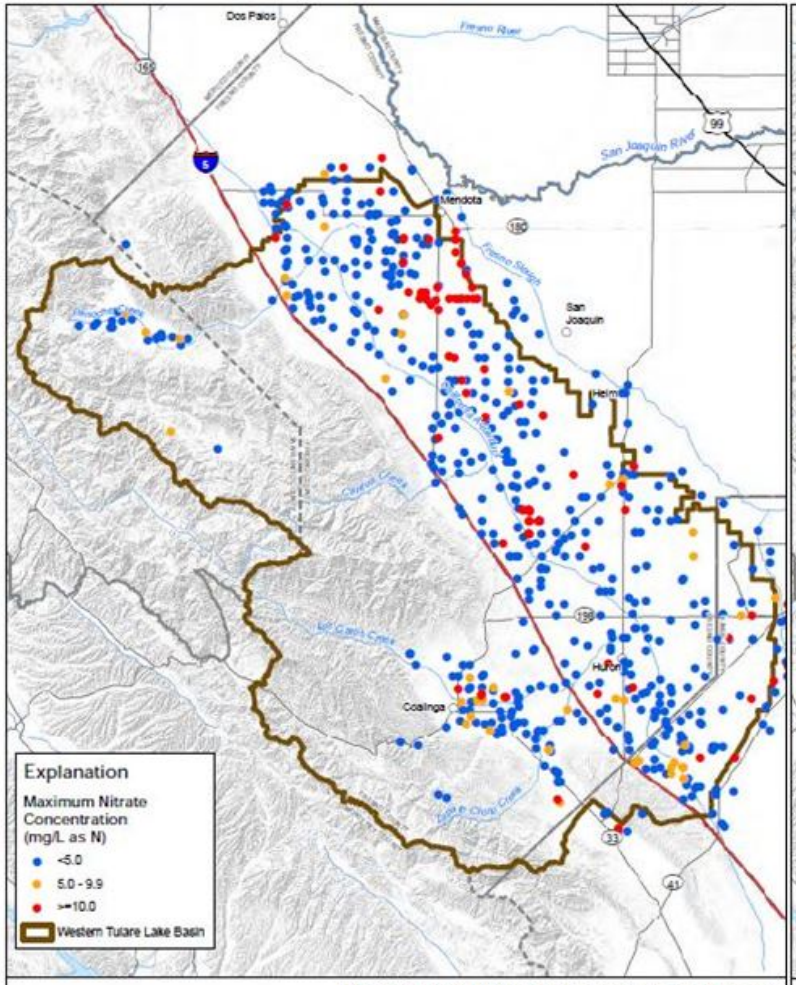
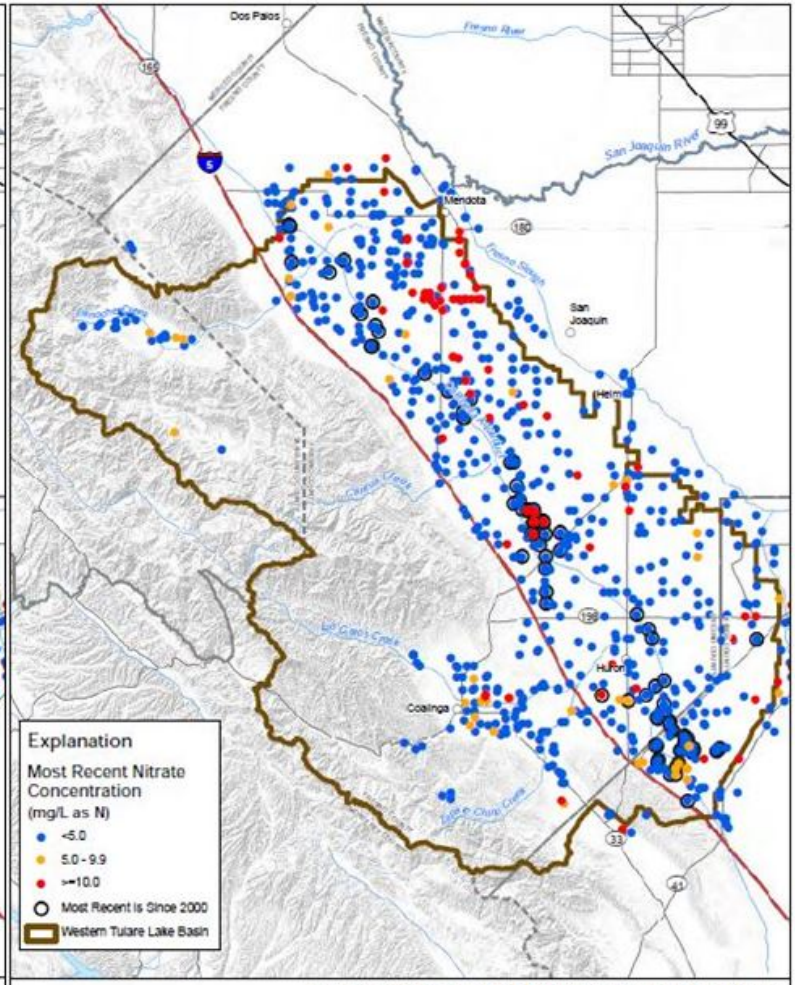


Figure 54. Maximum and most recent nitrate (as N) concentrations in wells of unknown depth in the Coalition region (Figures 5-16 and 5-17, WWQC, 2015).





4.2.1.2 TDS

Very Shallow Groundwater / Upper Aquifer / Lower Aquifer

Figure 55 through Figure 59 present the maximum and most recent TDS concentrations in wells by depth zone within the Coalition region and indicate the general salinity of groundwater. The concentration of TDS in drinking water is regulated as a Secondary Drinking Water Standard (Secondary MCL) and the standards are established for aesthetic reasons such as taste, odor, and color and not based on public health concerns. TDS concentrations in groundwater are symbolized by three classes: less than 1,000 mg/L (equivalent to the upper Secondary MCL); 1,000 to 2,000 mg/L; and greater than 2,000 mg/L. The majority of wells within the Coalition region have maximum TDS concentrations exceeding 1,000 mg/L, with a general spatial pattern of lower TDS towards the south. An apparent higher density of wells with TDS concentrations greater than 2,000 mg/L is evident in wells in the northern areas and towards the western margin of the Central Valley Floor with some wells in the areas of Panoche and Pleasant Valley having higher TDS concentrations.

As seen in Figure 56 the majority of the wells in the very shallow groundwater zone have TDS concentrations that are above 2,000 mg/L. The majority of these wells are located to the east of the California Aqueduct, which roughly defines the westernmost extent of the very shallow groundwater zone in the Coalition region. Although the very shallow wells with TDS concentrations above 2,000 mg/L are distributed throughout the area where very shallow groundwater occurs, there is a higher density of wells exceeding 2,000 mg/L in the northern region. In fact, numerous very shallow wells located south and southwest of Mendota exhibit TDS concentrations greater than 6,000 mg/L. The most recent TDS concentration data shown in Figure 56 displays a similar pattern although a notably greater number of very shallow wells exhibit have their most recent TDS concentrations below 1,000 mg/L. No TDS data for the very shallow zone are available for the Panoche Valley area and limited very shallow TDS data are available in Pleasant Valley, although several very shallow wells located south of Coalinga have TDS concentrations greater than 2,000 mg/L.

TDS concentration data for wells interpreted to be in the Upper Aquifer are limited, with most data occurring east of the California Aqueduct (Figure 57). Higher TDS concentrations in the Upper Aquifer are observed in the northern areas of the Coalition region with a notable area in the southeast where TDS concentrations are largely below 1,000 mg/L. This is likely indicative of higher-quality groundwater in sediments derived from Sierran sources. A pattern of higher TDS along the western margins of the Central Valley Floor area suggests influence of high salinity recharge from Coast Range streams and subsurface groundwater flow. A band of high salinity in the Upper Aquifer is also apparent along the eastern edge of the Coalition region, where poor drainage conditions exist resulting in very high salinity in the very shallow zone.

As seen in Figure 58, TDS concentration data for wells in the Lower Aquifer are much more widely distributed across the Central Valley Floor of the Coalition region. These data indicate overall lower salinity in the Lower Aquifer than is evident in the very shallow groundwater; although, a similar pattern of lower salinity conditions in groundwater in the south and southeast is apparent in the Lower Aquifer as is also observed in the very shallow and Upper Aquifer zones. A majority of the wells in the Lower Aquifer show maximum TDS concentrations below 2,000 mg/L with maximum TDS concentrations below 1,000 mg/L in many of these wells

along the southern and southeastern edge of the Coalition region. Areas with greater densities of high salinity conditions include the northern part of the Coalition region and also in the southeast in the vicinity of Huron. Higher TDS concentrations in the Upper Aquifer are seen along the western margin of the Central Valley Floor with generally lower concentrations towards the east, versus what is seen in the very shallow groundwater zone. This trend is particularly prominent in the central area of the Coalition region around and north of Huron and likely reflects the greater influence from Coast Range derived groundwater recharge. Additionally, the Corcoran Clay is thinner or non-existent in some of these areas which may result in increased vertical communication with overlying groundwater zones of higher salinity. Few TDS concentration data exist in the Panoche Valley and Pleasant Valley for the Lower Aquifer, although the minimally available data suggest deeper TDS concentrations in these areas are in the 1,000 to 2,000 mg/L range.

Composite Wells / Wells of Unknown Depth

Figure 59 depicts the most recent maximum TDS concentration data for composite wells screened in both the Upper and Lower Aquifers. The pattern of TDS concentrations for these wells is consistent with patterns evident in both the Upper and Lower Aquifer wells. Considerably fewer composite wells have TDS concentrations greater than 2,000 mg/L and these wells exhibit a similar trend of decreasing TDS concentrations from north to south.

As shown in Figure 60, a great deal of TDS concentration data exists for wells of unknown depth. Figure 60 indicates wells west of Mendota have higher TDS concentrations than wells further south in the vicinity of Huron. This is particularly evident in the density of wells with TDS concentrations greater than 2,000 mg/L. However, Figure 60 also shows that the Pleasant Valley area near Coalinga has high TDS concentrations with many wells exceeding 2,000 mg/L. Several areas with higher densities of wells with lower TDS concentrations can be seen in Figure 60, including an area southeast of Huron which has a particularly high density of wells of unknown depth with TDS concentrations of less than 1,000 mg/L.

4.2.2 Temporal Distribution of Nitrate and TDS

Because of a minimum data requirement of three sampling events for a statistical temporal trend analysis, there are relatively few wells for which statistically significant temporal trends in nitrate concentrations can be developed. Figure 61 illustrates that the majority of the wells showing statistically significant nitrate trends are located west and southwest of Mendota with others located along the California Aqueduct. A slightly greater number of wells show statistically significant decreasing temporal trends in nitrate concentrations versus increasing trends. Several areas of higher well density with either increasing or decreasing trends are found throughout the Coalition region, although in many instances there are adjacent wells with conflicting trends. In contrast to the nitrate data, many more statistically significant temporal trends were identified for TDS concentrations. As shown in Figure 61, the greatest amount of statistically significant TDS trend data is in the area south and west of Mendota where there are a large number of wells with increasing TDS concentration. However, wells with statistically significant decreasing TDS concentration trends are also interspersed with those showing increasing trends. To the south, most of the statistically significant trends indicate stable or decreasing TDS concentrations.

Figure 55. Maximum and most recent TDS concentrations in all wells in the Coalition region (Figures 5-18 and 5-19, WWQC, 2015).

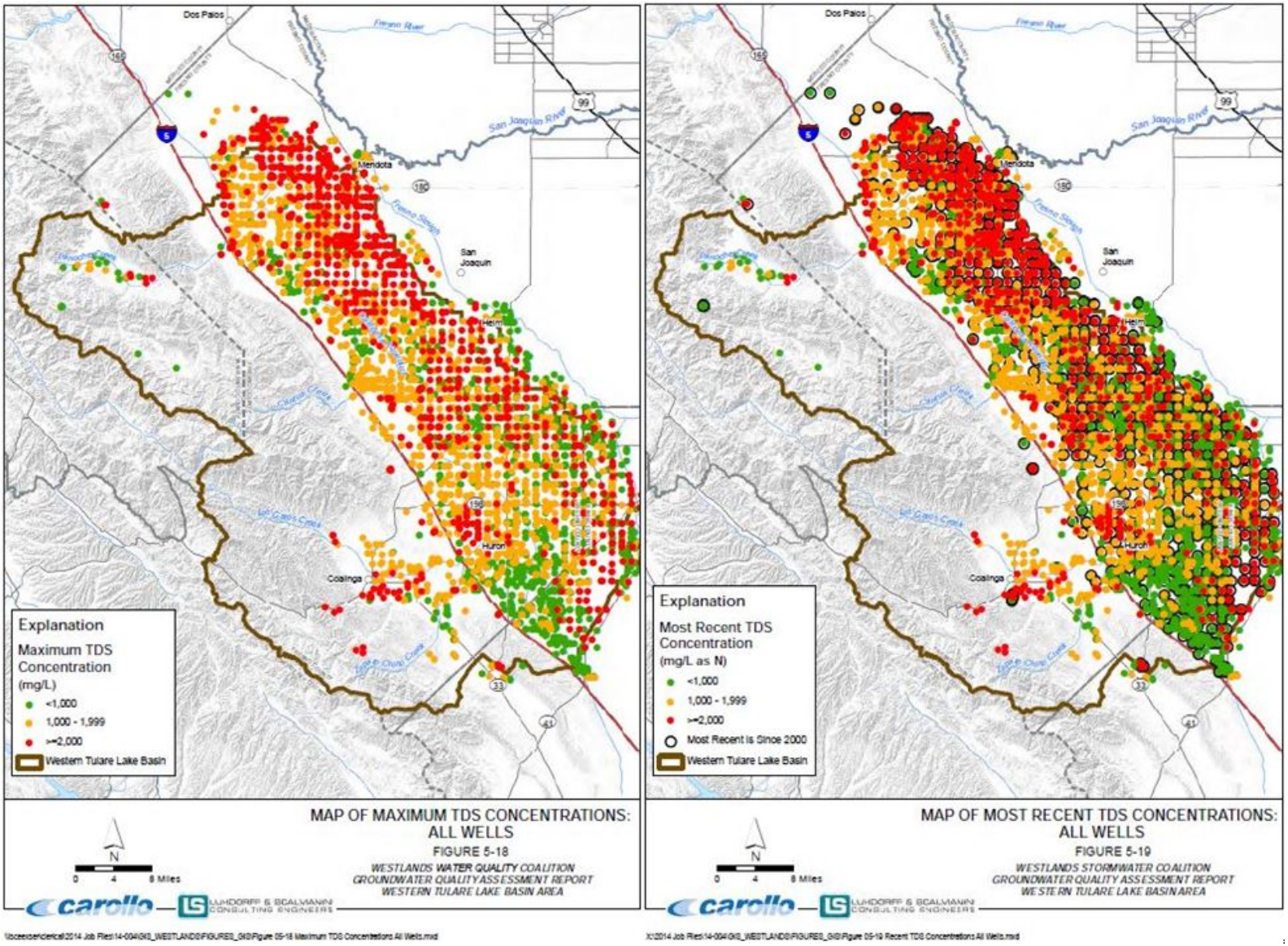
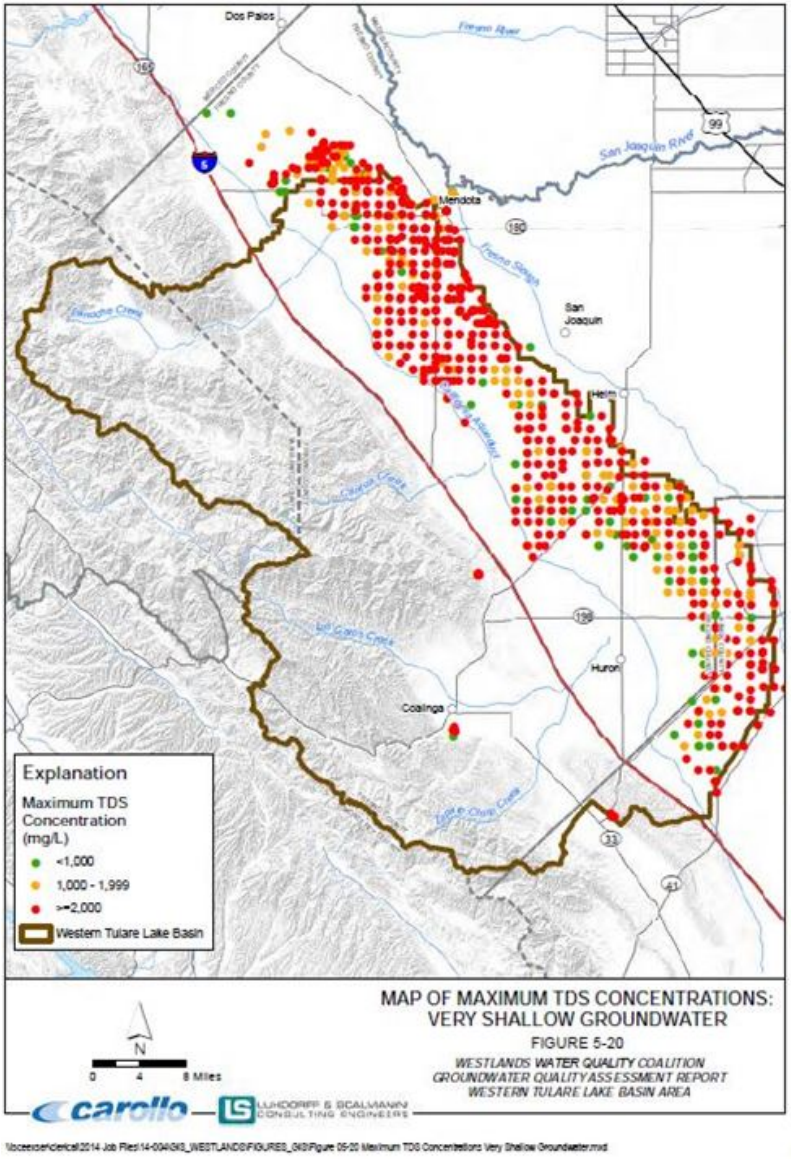


Figure 56. Maximum and most recent TDS concentrations in the very shallow groundwater zone in the Coalition region (Figures 5-20 and 5-21, WWQC, 2015).



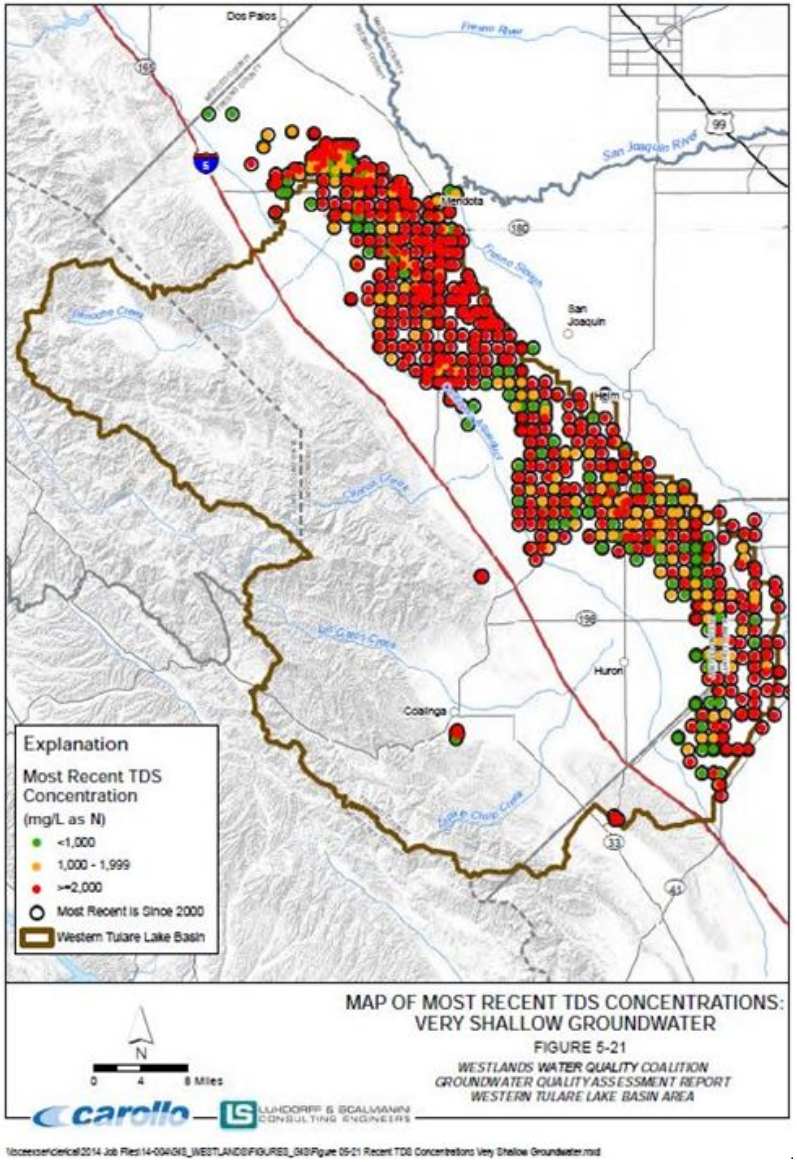
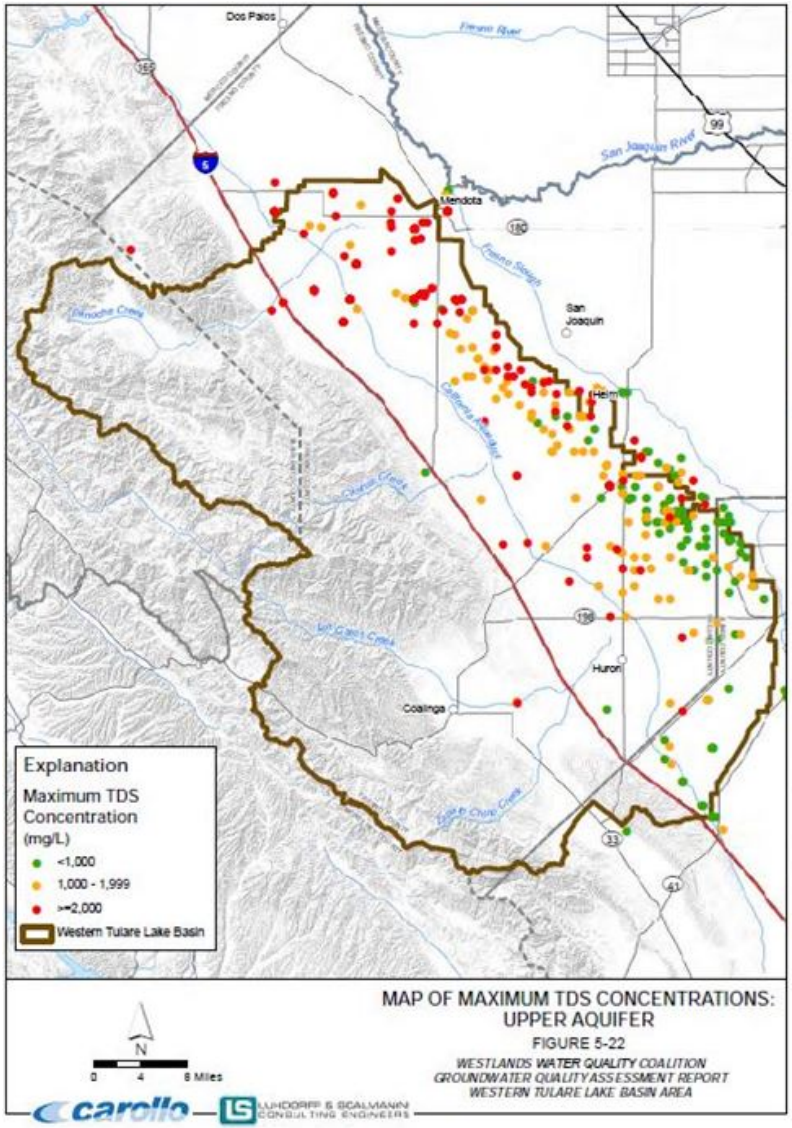


Figure 57. Maximum and most recent TDS concentrations in the Upper Aquifer in the Coalition region (Figures 5-22 and 5-23, WWQC, 2015).



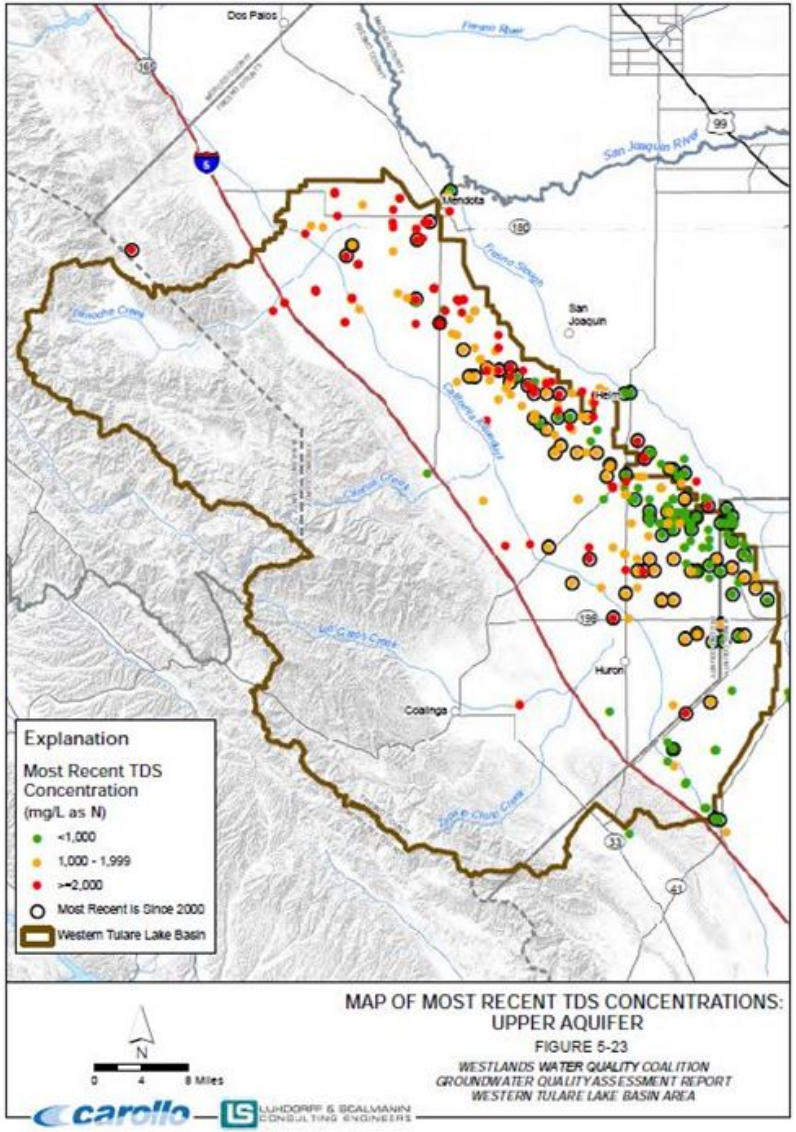
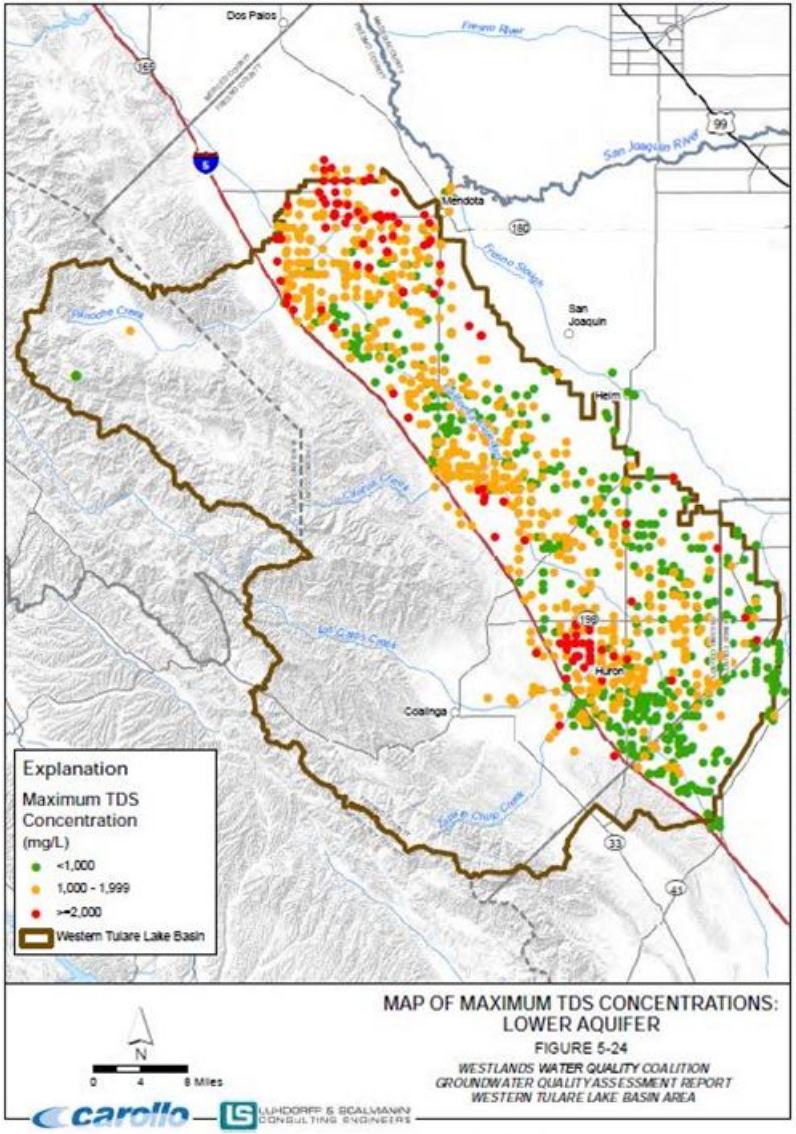


Figure 58. Maximum and most recent TDS concentrations in the Lower Aquifer in the Coalition region (Figures 5-24 and 5-25, WWQC, 2015).



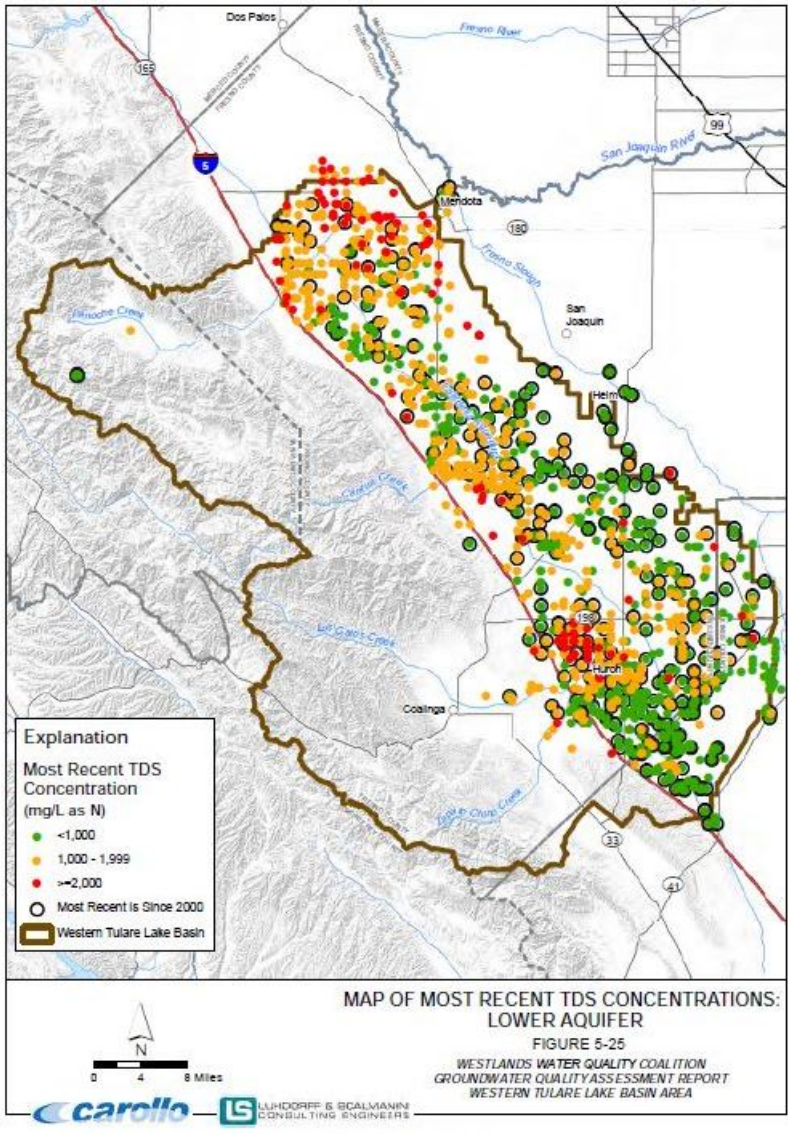
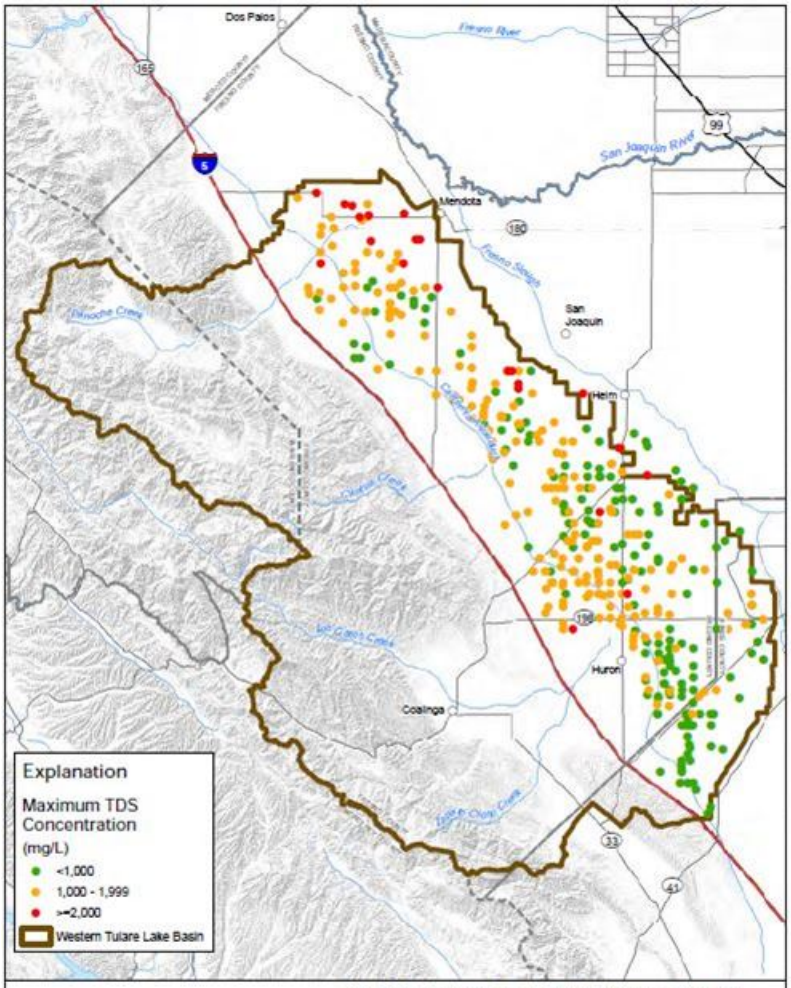


Figure 59. Maximum and most recent TDS concentrations in the upper and Lower Aquifers (composite) in the Coalition region (Figures 5-26 and 5-27, WWQC, 2015).



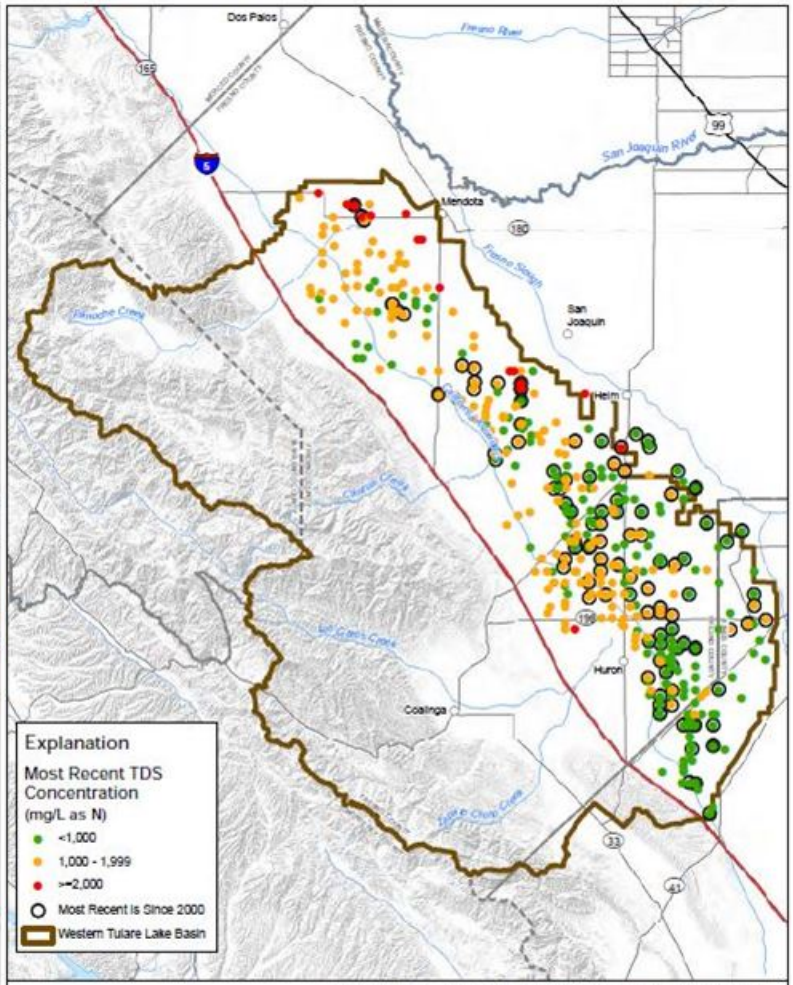
MAP OF MAXIMUM TDS CONCENTRATIONS: COMPOSITE WELLS (UPPER AND LOWER AQUIFERS)

FIGURE 5-26

WESTLANDS WATER QUALITY COALITION
GROUNDWATER QUALITY ASSESSMENT REPORT
WESTERN TULARE LAKE BASIN AREA

carollo — LUHDORFF & BALMANN CONSULTING ENGINEERS

\\bceexsercleral2014 Job Files\14-004\GIS_\WESTLANDS\FIGURES_GIS\Figure 05-26 Maximum TDS Concentrations Composite.mxd



MAP OF MOST RECENT TDS CONCENTRATIONS: COMPOSITE WELLS (UPPER AND LOWER AQUIFER)

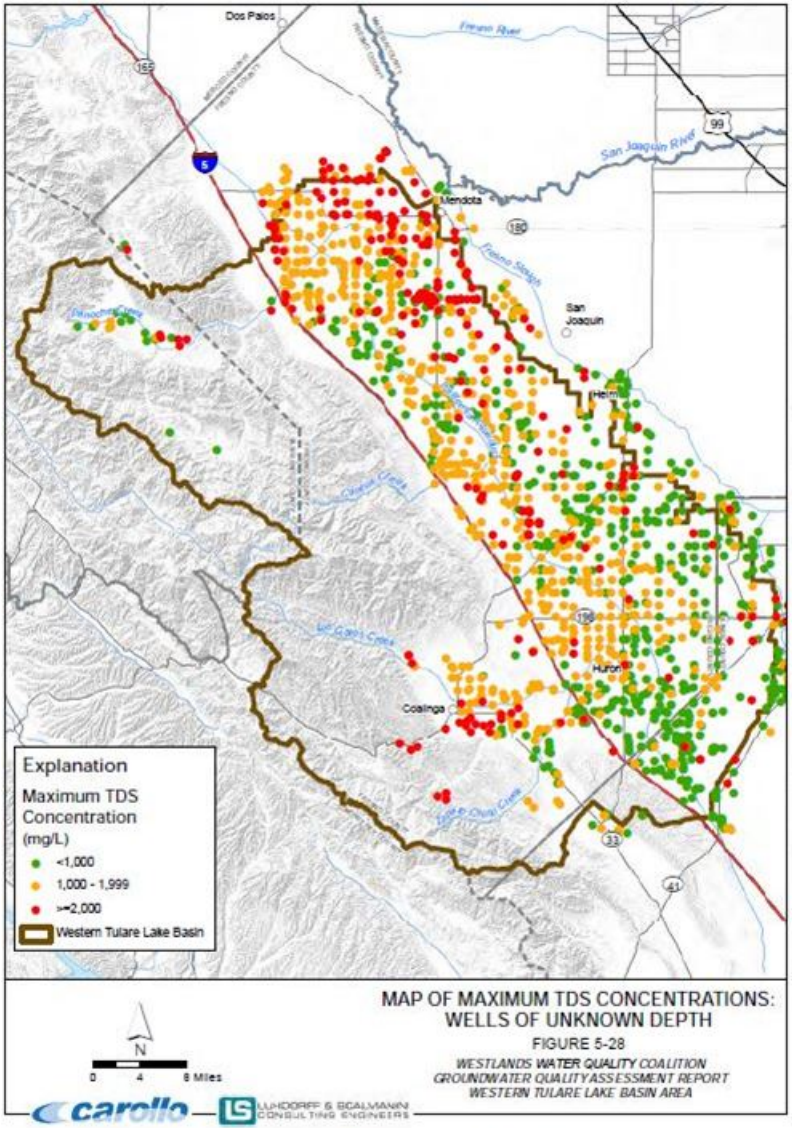
FIGURE 5-27

WESTLANDS WATER QUALITY COALITION
GROUNDWATER QUALITY ASSESSMENT REPORT
WESTERN TULARE LAKE BASIN AREA

carollo — LUHDORFF & BALMANN CONSULTING ENGINEERS

\\bceexsercleral2014 Job Files\14-004\GIS_\WESTLANDS\FIGURES_GIS\Figure 05-27 Recent TDS Concentrations Composite.mxd

Figure 60. Maximum and most recent TDS concentrations in the wells of unknown depth in the Coalition region (Figures 5-28 and 5-29, WWQC, 2015).



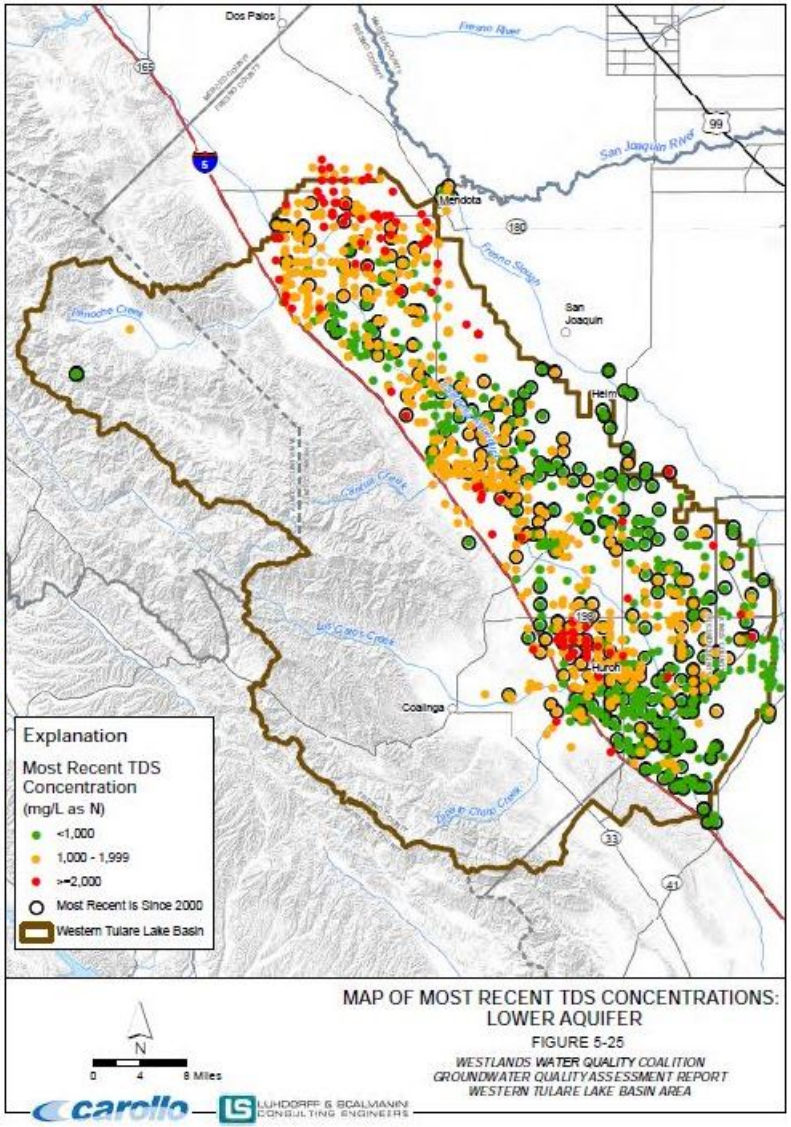
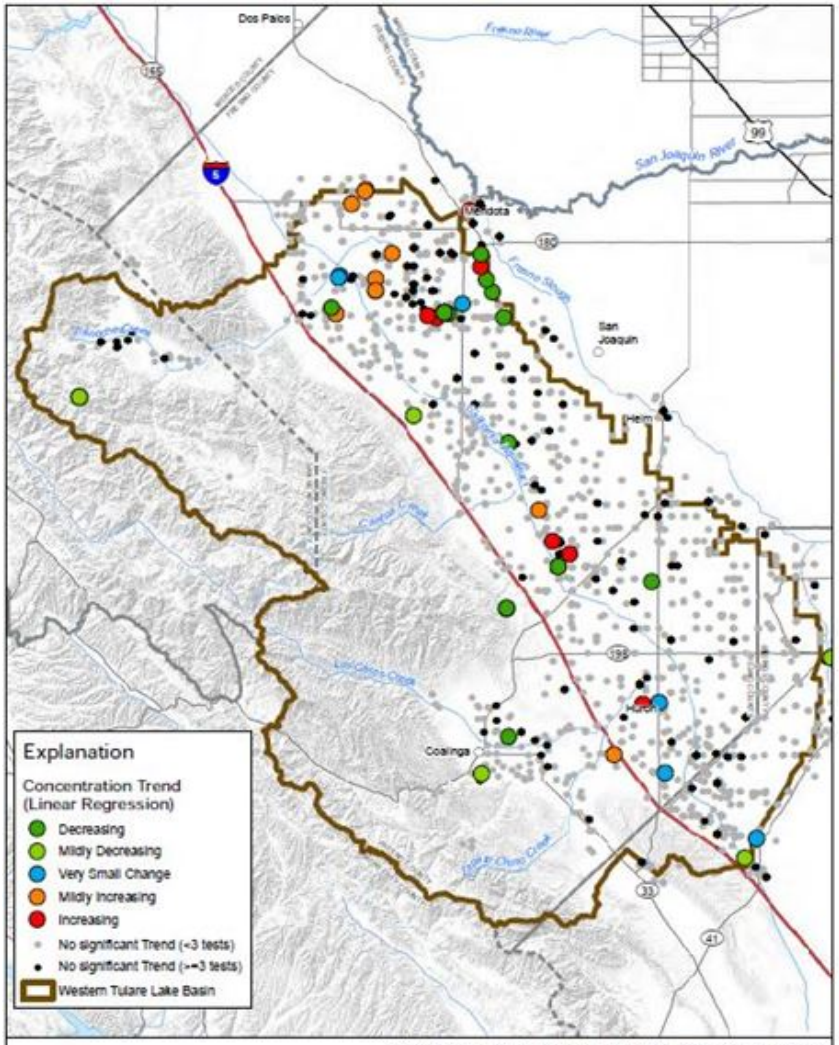
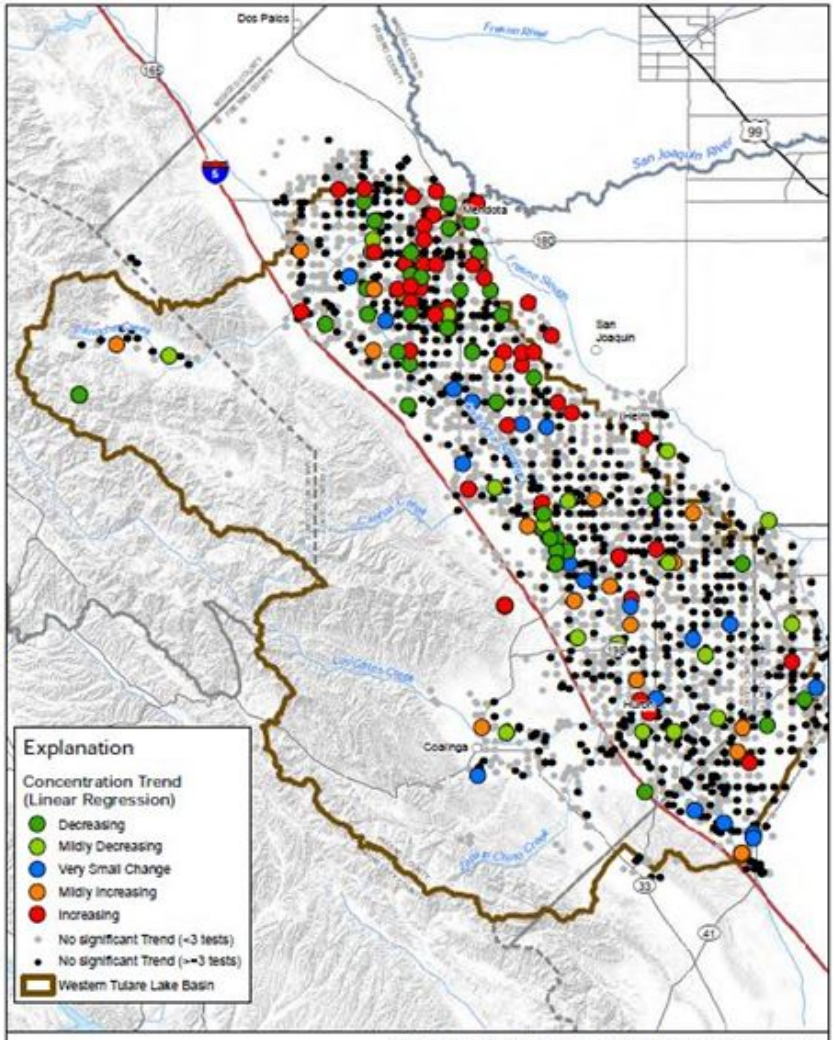


Figure 61. Significant temporal trends for both nitrate and TDS concentrations in all wells within the Coalition region (Figures 5-34 and 5-43, WWQC, 2015).





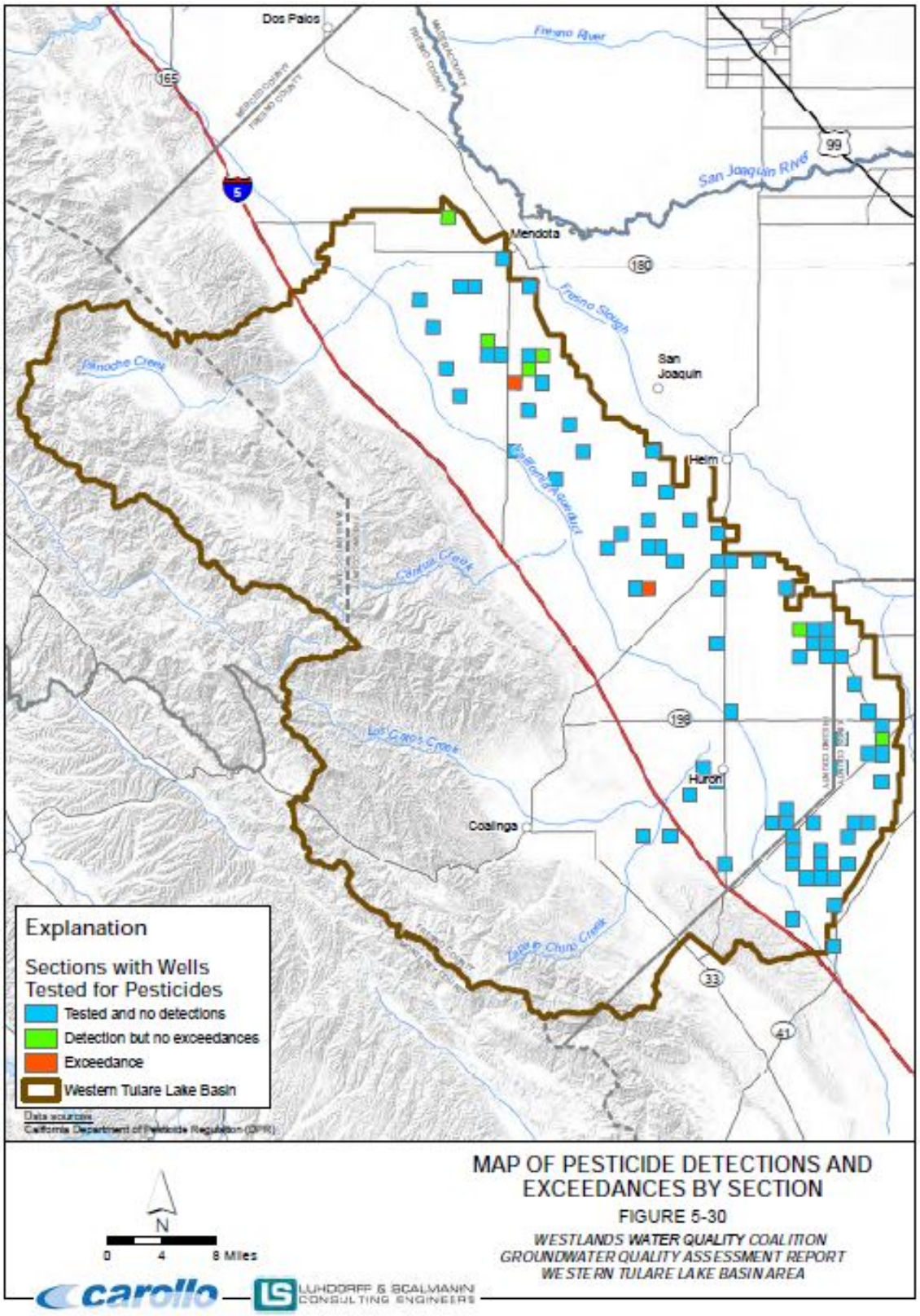
4.2.2.1 Pesticides

Pesticide concentration data in the GAR were limited to data obtained from DPR. Pesticide data available from DPR are for wells, but locations are only provided at the spatial resolution of the PLSS section in which the well is located. Figure 62 shows the locations of sections where wells have been sampled for pesticides and where pesticide test results are reported by DPR. These results include sections that may only be partially within the Coalition region. Because well locations are not provided with these pesticide data, it is possible that wells in sections that are only partly within the Coalition region actually fall outside of the Coalition area. Sections with detected concentrations of pesticides exceeding levels provided in the SWRCB Water Quality Goals Online Database (http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/search.shtml). Exceedances of the MCL are symbolized orange in Figure 62, and sections where pesticide detections have occurred at concentrations below the identified exceedance threshold are symbolized as green.

Table 16 summarizes well sampling data and number of pesticides that have been detected in wells that are in sections that overlap with the Coalition region to some degree. The threshold values used as a basis for identifying pesticide exceedances are also included in Table 16. Data for a total of 101 wells (in 84 PLSS sections) tested for pesticides in the study area were available from DPR. Of the 101 wells tested, nine unique wells had detectable concentrations of a pesticide. Fourteen pesticide detections were recorded within the Coalition area; however, some wells had detectable concentrations of multiple pesticides. Of the 84 sections that had wells tested, eight sections had wells with detectable concentrations of a pesticide. A total of three instances occurred in which a pesticide (simazine) was detected above the exceedance threshold, although only two unique wells had exceedances (Table 16). As shown in Figure 62, a higher number of pesticide detections and exceedances have occurred in the northern part of the Coalition region, with many of these detections clustered in an area south of Mendota.

Further investigation was performed on the three exceedances of the simazine MCL (4 µg/L MCL) reported in the GAR (49.2 and 10.4 µg/L from one well and 4.1 µg/L simazine from a separate well). According to the DPR (personal communication with Joy Dias, Senior Environmental Scientist, DPR, August 16, 2016) associated data for these simazine exceedances indicate both wells were sampled in 1985 by the USGS. The two simazine detections (10.4 and 49.2 µg/L) were from a 20-foot-deep well, as indicated in the GAR. Those data were accepted as-is by DPR, and no follow-up action was taken at the time. Studies conducted in a 420' well in an adjacent section in 1985 by the USGS resulted in a concentration of simazine of 0.1 µg/L. A similar study in 1988 by DWR detected no simazine; and a third study in 1992 by the DPR found no simazine. The DPR has no records of any wells being sampled in the nine-section area after 1992. The 4.1 µg/L detection of simazine was from a monitoring well with no associated well construction data. In 1984 this well was tested by the USGS and no simazine was detected. In 1985, 4.1 µg/L simazine was detected in this well. In 2010, the USGS sampled an irrigation well (no available well-construction data) in an adjacent section and found no simazine. No follow-up action was taken by zDPR as a result of the 4.1 µg/L detection of simazine in 1985. The 1985 simazine detections could be considered “unconfirmed/not from legal agricultural use” (personal communication, Joy Dias). The DPR has no record of any other sampling occurring for simazine in the sections surrounding either of the wells with the simazine detections from 1985 after 2010.

Figure 62. Distribution of pesticide detections and exceedances by section within the Coalition region (Figure 5-30, WWQC, 2015)



X:\2014 Job Files\14-004\GIS_WESTLANDS\FIGURES_GIS\Figure 05-30 Pesticide Detections and Exceedances by Section.mxd

4.3 Groundwater Beneficial Uses

The Water Quality Trigger Limits (WQTLs) in Table 14 are applied based on the protection of beneficial uses assigned to groundwater according to the Water Quality Control Plan for the Tulare Lake Basin (Basin Plan). According to the Basin Plan, "unless otherwise designated by the Regional Water Board, all ground waters in the Region are considered as suitable or potentially suitable, at a minimum, for municipal and domestic water supply, agricultural supply, industrial service supply, and industrial process supply" (Basin Plan, page II-2). These beneficial uses are described as:

- Municipal and Domestic Supply (MUN) – Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
- Agricultural Supply (AGR) – Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
- Industrial Service Supply (IND) – Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
- Industrial Process Supply (PRO) – Uses of water for industrial activities that depend primarily on water quality.

Table 17 lists the beneficial uses for those groundwater basins and subbasins within the Western Tulare Lake Basin area. According to the Basin Plan, the existing beneficial uses in Table 17 generally apply within the Detailed Analysis Units (DAU) listed. Due to the size of the DAUs, however, the beneficial uses listed within the Basin Plan for a given DAU may not exist throughout that DAU (CVRWQCB, 2015). Even though slivers of the Delta-Mendota, Kings, and Tulare Lake subbasins are listed as present within the WWQC by the General Order, based on GIS data from DWR (Accessed August 24, 2016; http://www.water.ca.gov/waterplan/gis/index.cfm), the DAU boundaries for those subbasins fall outside of the WWQC boundary. However, given that the slivers of the Delta-Mendota, Kings, and Tulare Lake subbasins all exists adjacent to the Westside subbasin, it is reasonable to assume the beneficial uses for those areas are the same as those listed for the Westside subbasin in Table 17. None of the Beneficial Use exceptions for groundwater listed on page II-7 of the Basin Plan are applicable to those areas within or adjacent to the WWQC region.

Table 17. Tulare Lake Basin groundwater beneficial uses within basin and subbasins of the Western Tulare Lake Basin (CVRWQCB, 2015).

Hydrologic Unit	Detailed Analysis Unit*	MUN	AGR	IND	PRO
Pleasant Valley Subbasin	245	X	X	X	NA
Westside Subbasin	244	X	X	X	NA
(*Satellite Basins*)					
Panoche Valley	248	X	NA	NA	NA
Vallecitos Creek Valley	248	X	NA	NA	NA

*Detailed Analysis Unit: "The Department of Water Resources subdivides California into study areas for planning purposes. The largest study areas are the ten Hydrologic Regions (HR), corresponding to California's major drainage basins. The next level of delineation are the Planning Areas (PA), which in turn are composed of multiple Detailed Analysis Units (DAU). The DAUs are often split by county boundaries, so the smallest study area used by the Department is the DAU/county. Many planning studies begin at the DAU or PA level, and the results are aggregated into hydrologic regions for presentation." (Accessed August 25, 2016; http://www.water.ca.gov/waterplan/gis/index.cfm)

NA – Not applicable

4.4 WWQC High Vulnerability Area

One of the objectives of the GAR was to "provide a basis for establishing groundwater quality management plans in high vulnerability areas and priorities for implementation of those plans" (WDR, Attachment B, page 13). As part of the focus on protection of regional groundwater quality, the relative vulnerability of groundwater to irrigated land practices was assessed in the GAR based on hydrogeologic sensitivity, overlying land uses and practices and groundwater quality data, historic and recent (Figure 63).

Determination of High Vulnerability Area

The Hydrogeologic High Vulnerability Area (HHVA) within the Coalition was determined utilizing a statistical model incorporating observed groundwater quality and hydrogeologic characteristics. The HHVA defines areas within the region where groundwater is most likely to be vulnerable to contamination based on current exceedances of the nitrate MCL, TDS concentration distributions used as a proxy for nitrate due to the limited nitrate data available, and select characteristics identified in the groundwater vulnerability model laid out in the GAR for the very shallow groundwater zone, the Upper Aquifer, and the Lower Aquifer. The combined high vulnerability areas for the very shallow groundwater zone, the Upper Aquifer, and the Lower Aquifer represent the HHVA within the Coalition region.

Most wells with elevated nitrate concentrations are located within the HHVA. The locations of wells with maximum historical nitrate concentrations of 10 mg/L (as N) or greater and also wells with maximum concentrations greater than or equal to 5 mg/L that exhibit statistically significant increasing trends in concentrations were incorporated through delineation of a High Well Vulnerability Area (HWVA) data layer, using minor adjustments to the outlines of the HHVA, when possible, and through inclusion of a quarter mile radius around outlier wells when they are located away from the HHVA. The HVA for the Western Tulare Lake Basin Area ultimately includes the combined HHVA and HWVA areas (Figure 63). In total, the HVA (the combined HHVA and HWVA areas), includes 620,781 acres as summarized in Table 18. A total of three wells with nitrate concentrations of nitrate (as N) at or above 10 mg/L are located outside of the final WWQC HVA; all of these wells are located outside of irrigated lands, at a single regulated fertilizer drum disposal facility (WWQC, 2015). A total of 37 wells with TDS concentrations at or greater than 3,000 mg/L are located outside of the final WWQC HVA; the majority of these wells are located within the very shallow groundwater zone (WWQC, 2015).

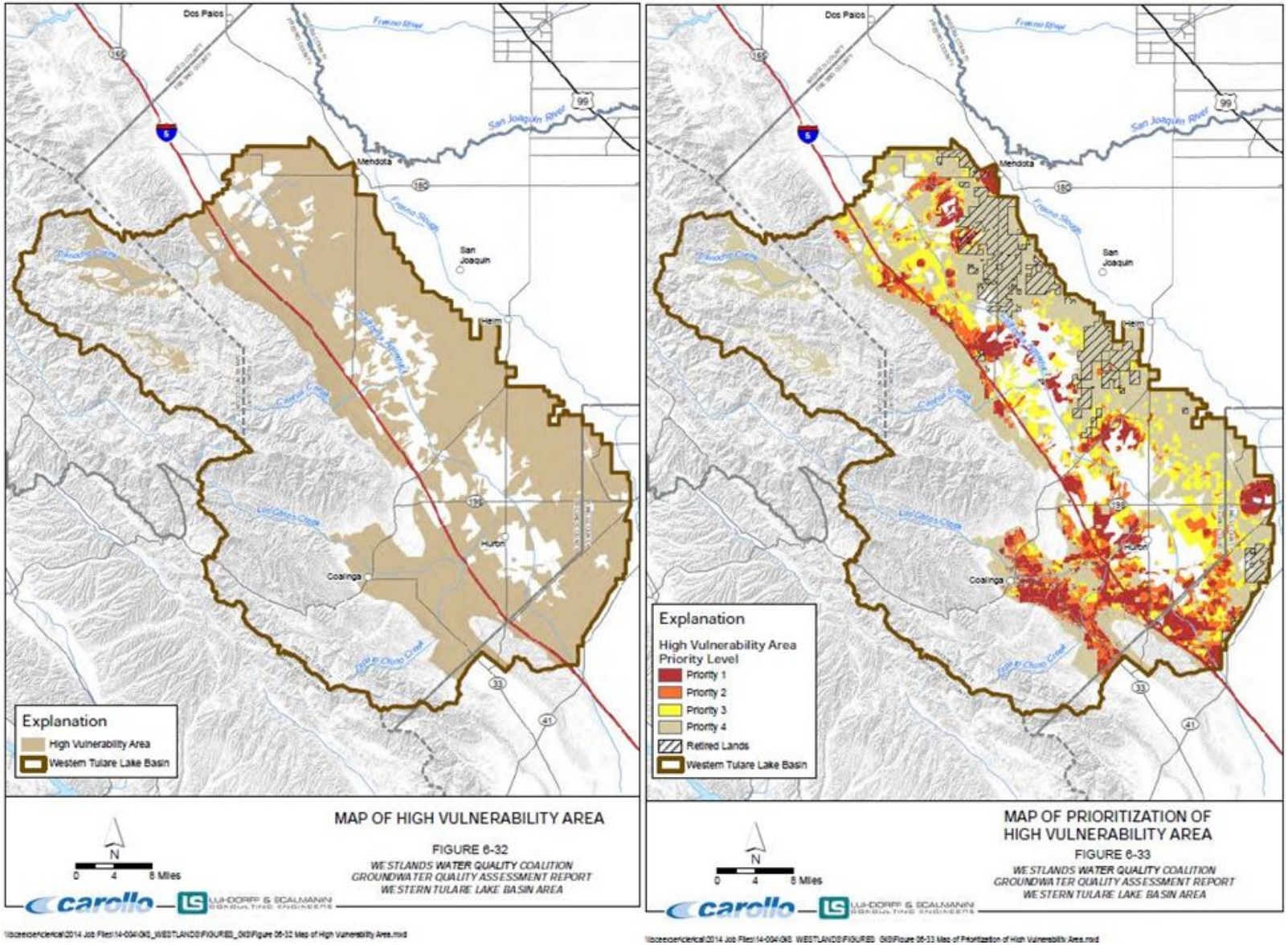
Table 18. Summary of acreages for the HVA of the WWQC region (Table 6-5, WWQC, 2015).

Table 6-5 Summary of Acreages for High Vulnerability Area
Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

	Westlands Water District			Pleasant Valley		Other Areas within Central Valley Floor		Peripheral Area (*Panoche Valley and Vallecitos Creek Valley*)		Total Coalition Region	
	Total WWD (Acres)	Irrigated Area[1] (Acres)	Retired Lands[2] (Acres)	Total Pleasant Valley (Acres)	Irrigated Area (Acres)	Total Other Areas Central Valley Floor (Acres)	Irrigated Area (Acres)	Total Peripheral Area (Acres)	Irrigated Area (Acres)	Total Coalition (Acres)	Irrigated Area (Acres)
Hydrogeologic High Vulnerability Area	483,213	402,413	70,298	69,720	34,001	40,166	2,764	26,977	2	619,140	438,311
High Well Vulnerability Area	1,641	1,486	18	0	0	0	0	0	0	1,641	1,486
High Vulnerability Area (Total)	**484,855**	**403,899**	**70,316**	**69,720**	**34,001**	**40,166**	**2,764**	**26,977**	**2**	**620,781**	**439,797**

Notes:
[1] Includes all agricultural land as indicated in 2013 land use conditions compiled from WWD and USDA, except for within WWD retired lands where no irrigation occurs.
[2] Includes land already retired as of January 2015; retired land is not irrigated.

Figure 63. Westlands Water Quality Coalition High Vulnerability Areas and Priority Areas (1-4) (Figures 6-32 and 6-33, WWQC, 2015).



Determination of Prioritization of WWQC's HVA

The WDR requires that several factors be considered when prioritizing the high vulnerability areas within the WWQC HVA:

- Exceedances of water quality objectives
- Proximity to areas contributing recharge to urban and rural communities that rely on groundwater as a source of supply
- Existing field and operational practices identified as associated with irrigated agricultural waste discharges that are the cause or source of groundwater quality degradation
- The largest acreage commodity types comprising up to at least 80 percent of irrigated agriculture in the high vulnerability areas
- Legacy and ambient groundwater conditions
- Groundwater basins currently proposed to be under review by Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)
- Identified constituents of concern

Several additional considerations were incorporated in the matrix (Table 19) developed to rank the priority areas (1-4) of the WWQC's HVA (Figure 46). Distribution of the Priority Areas within the HVA is illustrated in Figure 5; included in the introduction section of this document and again here in Figure 63. The percentage of the HVA for the Priority Areas (1-4), in descending order of priority, is approximately 14%, 11%, 17%, and 58%, respectively (Table 20). The top crops Priority 1 Area are nut trees (31,979 acres), vegetables (19,065 acres), and grains/cotton (14,756 acres) (Table 21).

Table 19. Matrix for Prioritization of HVA as presented in the WWQC's GAR (Table 6-6, WWQC, 2015).

Table 6-6	Matrix for Prioritization of High Vulnerability Area Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area Westlands Water Quality Coalition					
Prioritization Component Category	Prioritization Component Identified in the Order (Att. B)	Description of Component Used in Prioritization Method	Ranking Factors		Component Weighting	
			Ranking Metric	Range of Ranking	Percent	Comments
Hydrogeologic Groundwater Vulnerability	Additional component not directly specified in order for prioritization purposes	**Soil Vulnerability** Includes ranking of the vulnerability based on soil hydraulic conductivity.	Soil saturated hydraulic conductivity	0 to 10 (low to high) based on soil hydraulic conductivity; (Ksat in ft/day: <1 = 0, 1-2=2.5, 2-3=5, 3-4=7.5, >4=10)	5%	High - Collectively represents weighting of importance of hydrogeologic characteristics
		Subsurface Sediment Vulnerability Includes ranking of the vulnerability based on subsurface sediment texture	Minimum percentage of coarse sediments indicated for 50 foot intervals in the upper 200 feet	0 to 10 (low to high) based on minimum percent coarse (PC) for 0 to 200 feet; 5 (neutral) for locations outside Central Valley Floor; (minimum PC: <20 = 0, 20-25=2, 25-30=4, 30-35=6, 35-40=8, >40=10)	5%	
		Role of Corcoran Clay Includes ranking of vulnerability based on characteristics of the Corcoran Clay	Corcoran Clay thickness	0 to 10 (low to high) based on CC thickness; 0 for locations outside Central Valley Floor; (thickness in feet: >80=0, 60-80=2, 40-60=4, 20-40=6, 10-20=8, 0-10=10)	5%	
Existing Groundwater Quality Conditions	Legacy or ambient conditions of the groundwater.	**Observed Groundwater Quality Concentrations** Includes an evaluation and ranking of areas based on recent observed groundwater NO3 concentrations. >2000, most recent test	Average concentration for location based on wells within 1/2 mile	0 to 10 (low to high) based on average concentration; 5 (neutral) for locations without any concentration data within 1/2 mile; (NO3 [mg/L as N]: <1=0, 1-2=1, 2-3=2, 3-4=3, 4-5=4, 5-6=5, 6-7=6, 7-8=7, 8-9=8, 9-10=9, >10=10)	10%	High Upper Aquifer=7.5% Very Shallow=2.5%
		Temporal Trend in Groundwater Quality Includes evaluation and ranking of areas based on recent trend (degrading, improving, etc.) in groundwater NO3 concentration.	Average trend for location based on wells within 1/2 mile	0 to 10 (low to high) based on average water quality trend; 5 (neutral) for locations without any trend data within 1/2 mile (mg/L/yr: <-1=0, -1–0.5=1, -0.5–0.1=2, -0.1-0.1=5, 0.1-0.5=8, 0.5-1=9, >1=10)	10%	Moderate Upper Aquifer=7.5% Very Shallow=2.5%
		Salinity of Very Shallow Groundwater Includes evaluation and ranking of areas based on salinity in the very shallow groundwater. Low salinity in very shallow groundwater receives higher value.	Average TDS concentration for location based on very shallow wells within 1/2 mile	0 to 10 (low to high) based on average concentration; 5 (neutral) for locations without any concentration data within 1/2 mile; (TDS [mg/L]: >6,000=0, 4,500-6,000=2.5, 3,000-4,500=5, 1,500-3,000=2.5, <1,500=0)	5%	Low-Moderate
	Identified exceedances of water quality objectives for which agricultural waste discharges are the cause, or a contributing source.	**MCL Exceedances** Includes evaluation and ranking of areas according to presence/absence of NO3 concentrations observations that are above the drinking water MCL.	Distance from nearest NO3 MCL Exceedance	0 to 10 (low to high) inversely related to distance from nearest NO3 exceedance; 5 (neutral) for locations without any WQ observations within specified distance; (miles: >2=0, 1.5-2=2, 1-1.5=4, 0.5-1=6, 0.25-0.5=8, <0.25=10)	2.5%	Low - weighting is low to avoid double-counting since measured concentration is considered in ambient water quality component
	Identified constituents of concern.	**Pesticide Detections** Includes evaluation and ranking of areas based on presence/absence of detectable concentrations of pesticides in groundwater samples.	Percent of wells with a pesticide detection within a section	0 to 10 (low to high) based on percent of wells with a pesticide detection; 5 (neutral) for sections without any pesticide observations; (percent: 0%=0, 0.1-10%=2, 10-20%=4, 20-30%=6, 30-40%=8, >40=10)	2.5%	Low - Pesticide detection data from DPR are at coarse spatial accuracy
Land Use	Existing field or operational practices identified to be associated with irrigated agriculture water discharges that are the cause, or a contributing source.	**Typical Nitrogen Application Rate** Includes evaluation and ranking of areas based on typical nitrogen application rates for land uses (Rosenstock and others, 2013; Viers and others, 2012) using 2012 USDA land use designation.	Typical nitrogen application rate for land use	0 to 10 based on typical nitrogen application rate; (lbs/ac/yr: <50=0, 50-100=3, 100-150=7, >150=10)	7.5%	Low-Moderate
		Typical Irrigation Method Includes ranking of areas based on typical irrigation method for land uses (using 2012 USDA land use designation) in accordance with irrigation method statistics derived from DWR land use survey irrigation method data (2001-2004) and Coalition membership irrigation method data.	Typical irrigation method for land use	0 to 10 based on typical irrigation method; (micro=3, sprinkler=6, gravity=10)	12.5%	Moderate-High
	The largest acreage commodity types comprising up to at least 80% of the irrigated agricultural acreage in the high vulnerability areas and the irrigation and fertilization practices employed by these commodities.	**Top Commodities** Includes evaluation and ranking of areas based on percent of land area that is of a land use category comprising 80% of the high vulnerability (based on 2012 USDA land use designation).	Presence/absence of top 80% land use category	0 = Absent 10 = Present; (Top 80% land use category=10, Other land use category=0)	2.5%	Low
Other Factors	Proximity of high vulnerability areas to areas contributing recharge to urban and rural communities where groundwater serves as a significant source of supply.	**Proximity to Public Groundwater Supply** Includes evaluation and ranking of areas by proximity to public water systems and communities reliant on groundwater.	Distance, within 2 miles, from community reliant on groundwater Within Contributing Area/Not Within Contributing Area	0 to 10 (low to high) inversely related to distance from community reliant on groundwater; multiplier of 1 for locations within contributing area and multiplier of 0.5 for locations outside of contributing area; (miles: >2=0, 1.5-2=2, 1-1.5=4, 0.5-1=6, 0.25-0.5=8, <0.25=10)	30%	High
	Groundwater basins currently or proposed to be under review by CV-SALTS.	**CV-SALTS Priority Areas** Includes Initial Analysis Zones (IAZ) that were identified by CV-SALTS as being high priority with respect to nitrate in groundwater.	Location within or not within IAZ identified as high priority by CV-SALTS	0 = Not within priority IAZ 10 = Within priority IAZ	2.5%	Low

Table 20. Summary of acreages for the priority areas within the HVA of the Coalition region (Table 6-7, WWQC, 2015).

Table 6-7 Summary of Acreages for Priority Areas within High Vulnerability Area
Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

	Westlands Water District			Pleasant Valley		Other Areas within Central Valley Floor		Peripheral Area (*Panoche Valley and Vallecitos Creek Valley*)		Total Coalition Region	
	Total WWD (Acres)	Irrigated Area[1] (Acres)	Retired Lands[2] (Acres)	Total Pleasant Valley (Acres)	Irrigated Area (Acres)	Total Other Areas Central Valley Floor (Acres)	Irrigated Area (Acres)	Total Peripheral Area (Acres)	Irrigated Area (Acres)	Total Coalition (Acres)	Irrigated Area (Acres)
High Vulnerability Area	484,855	403,899	70,316	69,720	34,001	40,166	2,764	26,977	2	620,781	439,797
Prioritization of High Vulnerability Area[3]											
Priority 1	67,040	64,683	1,301	18,613	16,981	857	464	0	0	86,152	81,778
Priority 2	58,556	57,106	755	11,239	10,479	880	518	0	0	70,300	67,729
Priority 3	98,502	96,251	1,331	3,854	3,437	910	588	0	0	103,163	100,178
Priority 4	260,757	185,860	66,928	36,014	3,103	37,518	1,194	26,977	2	361,167	190,112

Notes:
[1] Includes all agricultural land as indicated in 2013 land use conditions compiled from WWD and USDA, except for within WWD retired lands where no irrigation occurs.
[2] Includes land already retired as of January 2015; retired land is not irrigated.
[3] Priority areas are in order from highest (1) to lowest (4).

Table 21. Summary of the land uses within the priority areas (1-4) of the HVA in the Coalition region (Table 6-8, WWQC, 2015).

Table 6-8 Summary of Land Uses within Priority Areas
Groundwater Quality Assessment Report for the Western Tulare Lake Basin Area
Westlands Water Quality Coalition

Description	Priority 1 (Acres)	Priority 2 (Acres)	Priority 3 (Acres)	Priority 4 (Acres)	Total (Acres)
High Vulnerability Area (HVA)	86,152	70,300	103,163	361,167	**620,781**
Irrigated Lands Within HVA (from 2013 WWD and USDA land use data)	81,778	67,729	100,178	190,112	**439,797**
Land Use Category Within HVA (from 2013 WWD and USDA land use data)					
*All Irrigated Land Use Categories**	*81,778*	*67,729*	*100,178*	*190,112*	***439,797***
Nut Trees	*31,979*	*23,578*	*29,261*	*21,728*	***106,546***
Vegetables	*19,065*	*17,771*	*36,754*	*50,231*	***123,821***
Grains/Cotton	*14,756*	*11,905*	*15,292*	*39,059*	***81,012***
Grapes	*866*	*177*	*484*	*12,400*	***13,927***
Fruit Trees	*637*	*759*	*963*	*1,250*	***3,608***
Citrus/Subtropics	*624*	*816*	*1,382*	*4,168*	***6,989***
Grasses	*212*	*54*	*175*	*7,978*	***8,419***
Seeds/Beans	*45*	*45*	*228*	*9,451*	***9,769***
Rice	*0.2*	*0.0*	*0.0*	*0.0*	***0.2***
Double Crops	*0.4*	*0.2*	*0.2*	*2.1*	***3***
Temporarily Fallow/Idle	*13,616*	*12,641*	*15,653*	*43,795*	***85,704***
Non Agricultural	*3,051*	*1,800*	*1,638*	*104,176*	***110,665***
Retired Land	*1,323*	*771*	*1,346*	*66,879*	***70,319***

Notes:
* Total of irrigated area may not equal sum of individual categories due to rounding and resolution in spatial analysis calculations.

5 Management Plan Strategy

5.1 Description of Approach

The approach of the WWQC to its management plans involves three linked processes; 1) identifying potential sources of discharges that impair beneficial uses, 2) providing education to those growers on management practices to minimize/eliminate their discharge, and 3) monitoring to verify that water quality is improved. These processes, in the context of the management of groundwater quality, present some unique challenges. With the exception of nitrogen fixing crops (e.g. alfalfa), all crops need nitrogen and almost all growers apply nitrogen in some form. Consequently, almost all growers farm land that is a potential source of nitrogen to groundwater. However, because growers apply different amounts at different times during the year and in different places, there is the potential for some growers to have greater discharges to groundwater or, no discharges at all. The Coalition is concerned about those growers that have a greater potential for discharging nitrogen to groundwater. The challenge is identifying those potential sources and determining the cause of the increased risk for discharge. Groundwater monitoring to verify improved water quality is also a challenge because the potentially decadal time lag between implementation of management practices on the farm and changes in groundwater quality. Consequently, to document the potential for improvement of groundwater quality, the WWQC will utilize groundwater quality data generated by the Groundwater Trend Monitoring Program and also metrics developed for reporting nitrogen applied and removed from member's fields. The demonstration that nitrogen applications are managed effectively relative to the amount of nitrogen removed will be used as the short term indicator of the potential improvement of groundwater quality. However, improved groundwater quality will also be documented over time.

The ultimate goals of the WWQC GQMP process are to motivate growers to adopt management practices that are protective of groundwater quality, and minimize the discharge of nitrate below the root zone. The WWQC developed four objectives to achieve the GQMP goals.

The objectives of the WWQC GQMP are:

- Understand current level of management practice implementation by growers to prevent discharge to groundwater.
- Identify additional management practices that could be implemented that are protective groundwater quality.
- Develop a management practice implementation process and schedule for growers (based on priority).
- Evaluate the effectiveness of existing and new management practices.

To facilitate achieving these objectives, the Coalition will implement performance goals with corresponding performance measures. These are presented in detail. A compliance schedule and milestones are also provided.

5.2 Identify COCs in the GQMP Region

To understand which management practices could be implemented, the constituents of concern (COCs) for leaching to groundwater should be identified. The WWQC identified COCs based on analyses for constituents

known to have the potential to be found in groundwater. As identified in the GAR there have been exceedances of water quality objectives for nitrate, TDS, simazine, and additional trace elements (arsenic, benzene, boron, chloride, manganese, and sulfate). The primary source of benzene is gasoline. Arsenic, boron, chloride, manganese, and sulfate are naturally occurring. Arsenic, benzene, chloride, manganese, sulfate, and boron are not ingredients in any currently registered pesticide in California. These constituents are not applied in agricultural operations and therefore cannot be controlled with current management practices. These constituents are not COCs and will not be considered further.

Three exceedances of the simazine MCL (4 µg/L MCL) are listed in the GAR from two different well locations (49.2 and 10.4 µg/L from one well and 4.1 µg/L simazine from a separate well). According to the Department of Pesticide Regulation (DPR) (personal communication with Joy Dias, Senior Environmental Scientist, DPR, August 16, 2016) data associated with these simazine exceedances indicate both wells were sampled in 1985 by the USGS, in Fresno County. The two simazine detections (10.4 and 49.2 µg/L) were from a 20-foot-deep well. Those data were accepted as-is, and no follow-up action was taken by the DPR at the time. Studies conducted in a 420' well in an adjacent section in 1985 by the USGS resulted in a 0.1 µg/L detection of simazine. A similar study in 1988 by DWR resulted in no detection of simazine; and a third study in 1992 by the DPR found no detection of simazine. The DPR has no records of any wells being sampled in the nine-section area after 1992. The 4.1 µg/L detection of simazine was from a monitoring well with no associated well construction data. In 1984 this well was tested by the USGS and no simazine was detected. In 1985, 4.1 µg/L simazine was detected in this well. In 2010, the USGS sampled an irrigation well (no available well-construction data) in an adjacent section and found no simazine. No follow-up action was taken by the DPR as a result of the 4.1 µg/L detection of simazine in 1985. The 1985 simazine detections could be considered "unconfirmed/not from legal agricultural use" (Pers. Comm., Joy Dias). The DPR has no record of any other sampling occurring for simazine in the sections surrounding either of the wells with the simazine detections from 1985 after 2010.

All available water quality data were reviewed for simazine in Fresno County from the SWRCB's Geotracker GAMA (http://geotracker.waterboards.ca.gov/gama/data_download.asp). Data from Geotracker GAMA were reviewed to analyze for trends in simazine concentrations in groundwater in Fresno County since the 1985 simazine detections were recorded. The available sampling events listed for simazine span from June 1982 to December 2015 with concentrations ranging from 0 -2 µg/L (below the 4 µg/L MCL); no concentrations of simazine above its MCL were found. As the exceedances of simazine listed in 1985 can be considered unconfirmed/not from legal agricultural use, and due to the lack of subsequent exceedances in Fresno County in the 20 years since the detections (per data listed in the Geotracker GAMA), simazine is not included as a COC in this management plan. The remaining constituents that qualify as COCs are TDS and nitrate. TDS and nitrate are the focus of the CV SALTS process and management plans are being developed for the entire Central Valley region. The Coalition participates in CV SALTS and is involved in the development of the Salt and Nitrate Management Plan. When management practices are established, the Coalition will initiate outreach on salt and nitrate management to members. Nitrate and TDS are the primary drivers behind the specification of the HVAs in the Coalition region and will be the focus of this GQMP. Table 22 lists the WQTLs for the GQMP COCs.

Table 22. GQMP COC WQTLs

All Water Quality Objectives and Limits listed in this table are based on the protection of the following beneficial uses: Agricultural Supply and Municipal and Domestic Supply

Constituent	Water Quality Trigger Limit (WQTL)	Standard Type	Beneficial Use (BU) with most protective limit	Reference for the Trigger Limit	Category (see footnotes)
Total Dissolved Solids	450 mg/L	Narrative	Agricultural Supply	Water Quality for Agriculture (Ayers & Westcot)	3
Nitrate as NO_3 Nitrate as N	45 mg/L as NO3 10mg/L as N	Numeric	Municipal and Domestic Supply	Tulare Lake Basin Plan Chemical Constituents Objective: California Primary MCL	1

Category 1: Constituents that have numeric water quality objectives in the Tulare Lake Basin Plan or other WQO listed by reference such as MCLs (Page III-7) and CTRs (Page V-2.01) Other numeric objectives may only apply to specific water bodies sections, or during specified time periods (see Basin Plan for more details).

Category 3: Constituent does not have numeric WQO or primary MCL. WQ Trigger Limit exceedance is based on implementation of narrative objective*. All detections should be tracked. None are default exceedances.

(*) Narrative WQTLs are based on Water Quality Goals Database. Updated by Jon Marshack on 16 July 2008.

5.3 Current Level of Management Practice Implementation

Growers can implement numerous practices that are known to prevent movement of nitrate to groundwater, e.g. adequate wellhead protection, backflow prevention on pressurized irrigation systems, and the proper timing of nitrogen applications (see below). Many, although not all of these practices are captured on the Farm Evaluation Plans (FEPs) that must be completed and submitted to the WWQC by growers in HVAs every year. The Coalition will evaluate each member's FEP to determine if they are implementing practices that are considered to be protective of groundwater. In particular, information on destruction of abandoned wells and wellhead protection will be one of the points of emphasis.

The Coalition maintains a database with individual grower responses from their FEP, and can identify growers that the Coalition believes could improve wellhead protection with the implementation of additional practices. Because growers from the entire Coalition region submit FEPs, this review can occur for all growers, not just those in HVAs. If the Coalition believes that growers in HVAs can improve their wellhead protection, they will be encouraged to adopt additional practices and the Coalition will review the grower's FEP the next year as a follow-up to determine if those practices were implemented, and if not, why. For growers outside HVAs, the review will occur with each FEP submission, every five years. If after reviewing the FEP submission, the Coalition believes that growers outside of HVAs can improve their wellhead protection, they will be encouraged to adopt additional practices. The Coalition will follow-up with these growers the next year to determine if those practices were implemented, and if not, why.

At a macro scale, the Coalition tracks management practices for irrigation, pesticide, and fertilizer management practices in the FEP, and changes in practices can be tracked over time. To promote efficient irrigation practices that reduce over-application and leaching, the Westlands Water District has developed an Irrigation Guide which provides real-time crop ET to all its members using the Bureau of Reclamation Irrigation Management Service computer program. Crop ET information is necessary to develop efficient crop irrigation schedules, both real-time and average yearly values. In addition, the Westlands Water District also developed and periodically updates a Water Management Handbook, which includes information on irrigation practices, improving irrigation efficiency, fertigation and assessing crop water demands.

5.3.1 Identify Additional Management Practices that are Protective of Groundwater

Improper applications of nitrate fertilizer, i.e. improper placement, at the wrong time, and/or the wrong rate can lead to the potential for leaching of nitrate to groundwater. The International Plant Nutrition Institute (IPNI) is a leader in developing practices to optimize fertilizer applications and efficient use of nitrogen. The IPNI recognizes that there is not one set of universal fertilizer BMPs. By definition, BMPs are site and crop-specific and vary depending on soils, climate, cropping history, and management expertise. There are many uncontrollable factors such as temperature, moisture, and soils that can change the effectiveness of management practices. Controllable factors include fertilizer type, soil amendments, tillage, and other cultural practices. Uncontrollable factors introduce uncertainty into the system which can make management of nutrients difficult.

The Coalition does not have a catalog of the BMPs currently being employed by the growers in the Coalition region. However, growers in the Coalition region have direct access, via the Westland Water District's web site, to a library of the latest BMPs employed worldwide. The Coalition has conducted many site surveys in the areas of influence to "ground-truth" the cultural farming practices and BMPs thought to be employed throughout the Coalition region.

The Coalition will utilize the 4Rs (see below) to guide its general approach for managing nutrients in the field. The 4Rs were developed in the late 1980's at the Potash and Phosphate Institute, which is the predecessor of the IPNI. The original authors included a fertilizer industry agronomist and a university scientist who developed the concept to promote agricultural sustainability. Although developed specifically for fertilizers, these practices are also applicable to the management of other soluble constituents.

The 4Rs include right time, right place, right rate, and right source (product):

- Right time – nutrients are made available when the plant needs them, can be accomplished by providing when the plant needs them by synchronizing their application with crop demand, properly managing applications e.g. pre-plant or split applications, controlled release technologies, and product stabilizers
- Right rate – match the amount of fertilizer applied to the crop need to reduce losses to leaching or surface water runoff; BMPs include realistic yield goals, soil testing, crop nutrient budgets, tissue testing, plant analysis, applicator calibration, good record keeping and nutrient management plans
- Right place – keep nutrients where the crop can use them. Incorporation or fertigation are usually the best methods of doing this
- Right source (product) – match the fertilizer source and product to crop need and soil properties. Be aware of nutrient interactions and balance nitrogen, phosphorus, potassium, and other nutrients

The transport paths/mechanisms resulting in movement of nitrate to groundwater include: leaching with infiltrating rain water or irrigation water, direct injection to operational wells lacking proper backflow prevention, and improperly abandoned or improperly cased wells that are located near to where nitrate is applied. Because of the scarcity of water, the Westland's Water District has educated its members on irrigation efficiency, thereby addressing the first transport pathway listed above. Coalition members benefit

from WWD's educational materials and resources regarding best management practices and irrigation efficiency (explained above). Coalition members are required to document well ID, wellhead protection practices, and presence of abandoned wells annually in FEPs. The Coalition believes that no additional practices (beyond those documented in the FEPs) need to be identified to adequately prevent the wellhead and abandoned wells from being conduits for the transport of nitrate to groundwater. Education regarding management practices geared to optimize irrigation efficiency, minimize the percolation of irrigation water beyond the root zone, prevent backflow in wells is provided to growers via the Westlands Water District website, is part of WWD's Water Management Plan (WWD, 2012), and is included in the WWD's Water Management Handbook (WWD, 2013).

Preventing leaching of nitrate by either rainfall or irrigation water requires management of both fertilizer applications and irrigation water. Consequently, the Coalition will focus their outreach on management practices that address both of these aspects that determine discharge of nitrate to groundwater. Although not all of the methods by which growers can manage nitrogen are well vetted, some practices can be recommended now. The confidence to recommend other practices will require additional research conducted through the Management Practices Evaluation Program (MPEP) to fully understand which management practices are most effective and under what conditions.

The Coalition is currently partnering with San Joaquin County and Delta Water Quality Coalition, Westside San Joaquin River Water Quality Coalition, East San Joaquin Water Quality Coalition, and the Sacramento Valley Water Quality Coalition to implement the MPEP. The first phase of that program is a literature review to identify practices that are known to be protective of groundwater. Although the efficacy of these practices may not be known under all conditions (e.g. soil types, rainfall regimes, irrigation methods), there is certainly a sufficient amount known to recommend specific management practices to a subset of growers. MPEP field studies will be initiated in late 2016 and the efficacy of additional management practices will be evaluated within the first two years of the MPEP Work Plan approval. Using computer models to estimate the effectiveness of other practices is expected to begin by year two of the MPEP, providing additional early information on protective management practices. The Coalition will use the results of the literature review and the MPEP studies/modeling to compile a list of management practices with descriptions of the conditions under which they are effective. The list will grow as more becomes known about protective practices. A matrix will be developed that addresses the 4Rs and crop specific information on nitrogen application rates, the timing, and placement of nitrogen fertilizer.

Growers will start receiving information on protective management practices in the first year after the GQMP is approved; within two years the Coalition will provide information to all members on management practices that are considered to be protective of groundwater. In the longer term, the emphasis of the Coalition's outreach will be expanded to include the outcome of the MPEP studies which will provide information that is specific to crops, soils, and climatic regions within the Coalition region.

5.4 Adoption of Management Practices by Members

The GQMP strategy prioritizes growers in HVAs who have the greatest potential to impair groundwater quality. All growers within HVAs must return NMP Summary Reports which record the amount of nitrogen applied

compared to the crop yield (A/Y). If data on nitrogen removed for the commodity are available, the Coalition will convert the yield to the amount of nitrogen removed and calculate the ratio of nitrogen applied to nitrogen removed (A/R). The Coalition conducts an analysis of the NMP Summary Reports to determine statistical outliers by crop and township/range as well as the statistical distribution of A/Y values (mean, median, and upper and lower 90th percentiles). If a field has an A/Y that is greater than the 90th percentile of the mean, that field will be designated as a statistical outlier. This designation indicates that this field could be receiving more nitrogen then the crop needs relative to other fields growing the same crop in the same area. For the statistical outliers, both the amount applied (A) and the amount of crop yield (Y) are evaluated to determine the cause behind the statistical outlier status. The Coalition can evaluate the current nitrogen management practices for these growers based on their FEPs, but will also request additional information.

Members with fields that are A/Y outliers will be contacted and required to attend a NMP Focused Outreach meeting on crop specific nitrogen needs and management practices. At the meeting, the growers will be asked to report on more specific management practices such as types of nitrogen fertilizer applied (e.g. synthetic fertilizer, compost, manure, irrigation water), whether they use split applications, and timing of applications, and more details about irrigation practices such as timing of fertigation during an irrigation event. During the NMP Focused Outreach meetings, the GQMP Strategy and progress of the MPEP will be discussed in addition to information about nitrogen fertilizer use and efficiency, nitrogen removed information for their specific crop (if known), and crop specific nitrogen management practices that are protective of groundwater.

Based on the additional management practice information obtained from growers during these NMP Focused Outreach seminars, the Coalition will re-evaluate each member's A/Y to determine if the statistical outliers are verified as a member who may need to improve practices by either reducing A, increasing Y, or both. In some instances, members with an elevated A/Y may not be able to reduce the applied nitrogen because the majority, or all of the nitrogen, is applied in their irrigation water. Practices will be recommended that help the grower save money (less nitrogen applied), increase their nitrogen use efficiency, maintain or increase their yield, or reduce the potential for leaching of nitrogen to groundwater.

Growers will be asked to indicate which practices they plan to implement during the next crop year based on the information obtained during the NMP Focused Outreach meetings (see further description below). Review of the following year's FEP will be used to determine if additional practices were implemented. If necessary, follow-up surveys will be sent to growers to request information on implemented practices. If practices were not implemented the grower will indicate why the practice were not implemented and whether they will be implemented in the future. The NMP Focused Outreach management practice information will be recorded in a database maintained by the Coalition.

5.5 Evaluate Effectiveness of New Management Practices

The Coalition will evaluate the effectiveness of the GQMP strategy by 1) documenting nitrate and wellhead management practices implemented (or already in place) by members, 2) use of the NMP Summary Report information to assess nitrogen use by growers, 3) evaluating the need for implementation of additional practices by individual growers, and 4) assessing groundwater quality improvements using monitoring data generated by the Groundwater Quality Trend Monitoring Program.

5.5.1 FEPs and NMPs - Tracking of Management Practices

Farm Evaluation Plan surveys (FEPs) are required of members to report the management practices implemented on their farming operation. Completed yearly by members farming in HVAs, the FEPs address constituents of concern in both surface and groundwater. For groundwater, the FEPs provide information on wellhead protection, irrigation practices, and nitrogen applications. More specific information on nitrogen management is provided in the Nitrogen Management Plan (NMP) which is completed yearly by members in HVAs. The NMP requests very specific information about the amount of nitrogen applied, additional sources of nitrogen available (e.g. irrigation water) to the crop, and anticipated yield. Growers in HVAs submit NMP Summary Reports annually which includes information from the previous crop year's NMP. The Coalition will use a combination of the FEPs and NMP Summary Reports to track implementation of management practices in HVAs from year to year.

5.5.2 NMP Summary Reports - Outlier's Improvement Goals and Time Schedule

Growers with fields identified as verified outliers will each receive their A/Y and A/R (if available) information compared to other growers of the same crop, an assessment of their nitrogen use, the potential improvement in nitrogen use efficiency that can occur without loss of yield, management practices that can be used to achieve the improvement, a survey and follow-up to determine which practices were implemented, and the time frame over which the improvement should occur. Each grower is unique and will have an individualized improvement goal and schedule. Some growers will be outliers because they apply too much nitrogen fertilizer, some because they irrigate with groundwater that has an extremely high nitrate concentration, and others because their irrigation practices push nitrate past the root zone too rapidly and their yield suffers. The first scenario can be corrected provided the grower can be convinced that their fertilizer application rate is unnecessarily high, the second scenario can't be corrected with any management practice, and the third scenario is corrected if the cause of the leaching can be eliminated with appropriate education about the timing of the fertilizer application relative to irrigation. Each of these is a unique scenario and until additional information is received from all statistical outliers, the management practices recommended and the time necessary for implementation are unknown. In some circumstances, recommendations about appropriate management practices will need to await the outcome of the MPEP field and modeling studies and CV-SALTS.

Understanding all of the various scenarios that result in verified outlier status will provide input to the MPEP process; however, providing the correct nitrogen management advice to growers may take a few years to initiate and complete the appropriate MPEP study. A delay in recommending protective management practices is not expected to occur in a significant percentage of growers identified as verified outliers and all fields identified as verified outliers are expected to reduce the A/R (or A/Y) associated with that field by a significant amount within five years.

Progress toward achieving the improvement goals will be tracked by reviewing various metrics including follow-up surveys documenting additional practices implemented, change in overall nitrogen applied, and changes in A/Y or A/R ratios. Statistics detailing progress will be compiled and reported to the Regional Water Board each year in the Groundwater Quality Management Plan Update section of the Annual Report. Members whose fields do not make sufficient progress will be flagged for additional outreach and eventual communication with the Regional Water Board.

5.5.3 GQTMP - Evaluating Groundwater Quality Trend Monitoring Results

The WDR specifies that one year from the approval of the GAR the Coalition shall develop a work plan for conducting trend monitoring that meets the objectives and minimum requirements of the Monitoring and Reporting Program (MRP). The objectives for the trend monitoring program include:

1. Determine current water quality conditions of groundwater relevant to irrigated agriculture.
2. Develop long-term water quality information that can be used to evaluate the regional effect (i.e., no site-specific effects) of irrigated agriculture and its practices.

Changes in groundwater quality, even first encountered groundwater which may be shallow, are very difficult to document for several reasons including infiltration rate, depth to groundwater, seasonal variation in groundwater quality and depth, yearly variation due to changes in weather (drought years vs. above normal rainfall years), volume of the aquifer, flow rate and path, and the spatial and temporal sample sizes (potentially years) needed to demonstrate a trend. However, the Coalition's Groundwater Quality Trend Monitoring Program will generate groundwater quality data that can be used to evaluate groundwater quality for nitrate over an extended period of time. Even in shallow groundwater, reductions in nitrate leaching to groundwater may not be identifiable for many years. The nitrate in the vadose zone may take several years to reach groundwater, and the volume of groundwater and concentration of nitrate in that groundwater may make any changes difficult to document. Consequently, the first few years of monitoring will establish a baseline from which future trends can be determined and linked to the implementation of management practices as reported in the FEPs and NMPs. The time needed to measure changes in groundwater quality is expected to vary across the Coalition region and therefore it is not known how long it will take to detect trends in groundwater quality. Once changes are detectable, it will be possible to analyze for any correlations between changes in groundwater quality, changes in the crop-specific A/Y and A/R statistics, and management practices implemented by growers. The results of the A/R analyses are reported in the Coalition's NMP Summary Report update in the Annual Report.

5.5.4 GAR Updates - Reporting Trends in Groundwater Quality

The Coalition will submit an update to the Groundwater Assessment Report in five-year intervals. Although the content of the updates is not fully detailed in the Order, the Coalition expects that reporting on trends in groundwater quality will be the focus of the updates. A summary of the changes measured in the years between GAR updates will be developed from the information provided in the Annual Reports.

5.6 Actions to Meet Goals and Objectives

The Coalition conducts outreach meetings regularly throughout the year at various locations in the Coalition region. At these meetings, Coalition monitoring results including exceedances of water quality objectives are discussed as well as management practices that can be implemented to reduce surface water runoff, sediment discharge, and leaching of COCs to groundwater. These practices include but are not limited to wellhead protection, irrigation system maintenance and calibration, and nitrogen management planning.

In addition to the annual grower meetings, the Coalition will present information about management practices at crop-specific meetings targeted to growers with verified A/Y outlier fields. The MPEP will provide substantial information about crop-specific management practices that can be provided to growers. The Coalition will provide information to growers of specific commodities at meetings in the Coalition region focused on conclusions from the MPEP studies. The Coalition will work with the MPEP GCC to secure funding for studies on priority crops in HVAs as well as funds for creating additional outreach materials and tools that can be utilized by members to assist with nitrogen application planning relative to the 4Rs.

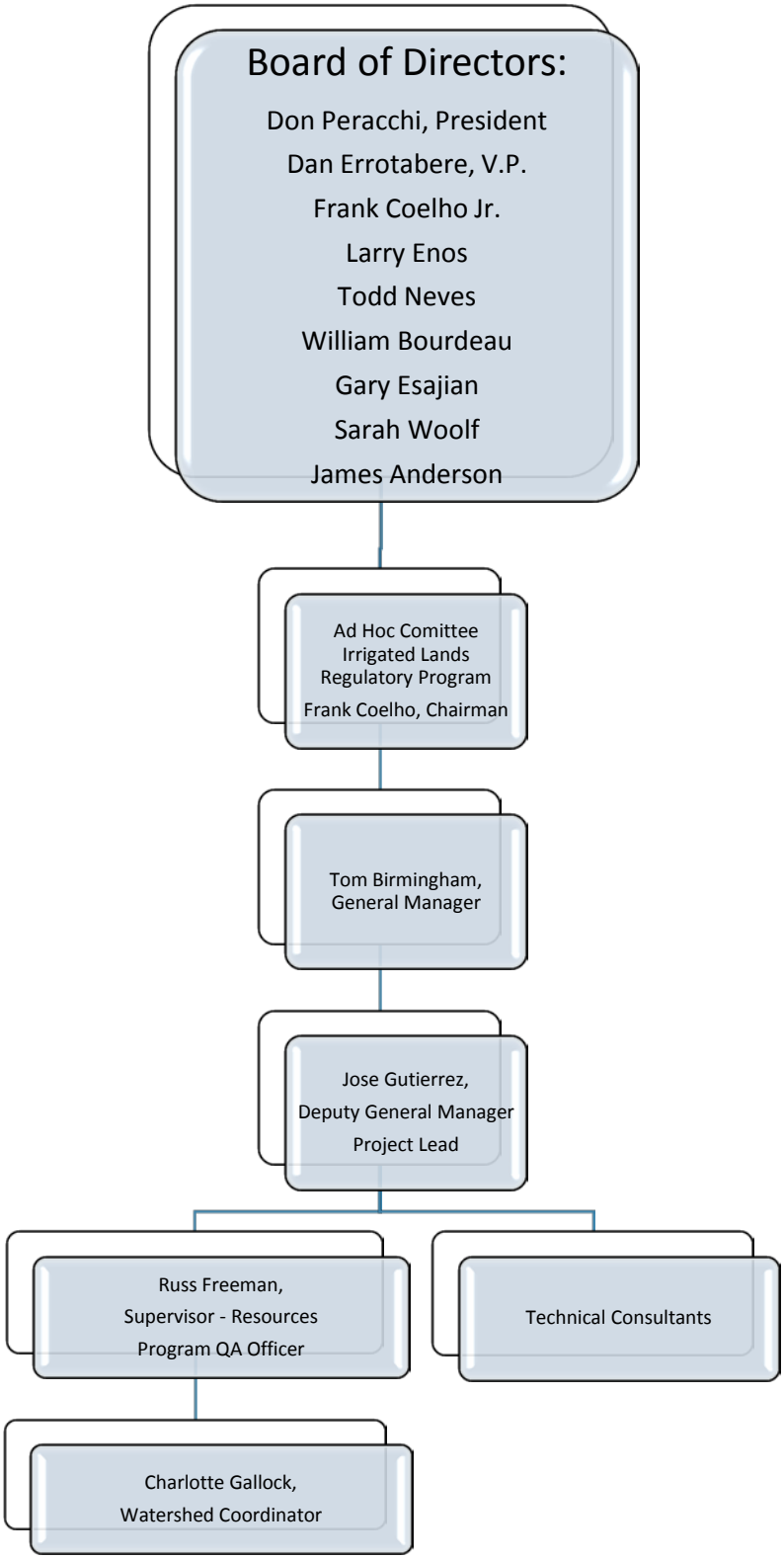
5.7 Duties and Responsibilities

The responsible parties are provided in organizational chart provided below (Figure 64).

Data developed for the GQMP include information obtained from the FEPs, additional surveys completed by members with verified outlier fields, follow-up survey information, and NMP summary information. Because no groundwater monitoring is proposed as part of this program, there are no analytical data to manage. Groundwater monitoring will be conducted as part of the GQTMP, and the MPEP in selected studies performed in areas with shallow groundwater. Data management for the GQTMP will be discussed in the GQTMP QAPP to be submitted to the Regional Water Board prior to the initiation of monitoring. The data management for the MPEP was discussed in the MPEP QAPP submitted to the Regional Water Board in June 2016. Because contractors are not yet selected for the MPEP studies, the individuals who will serve as the data manager, sample collection lead, and QA manager have not yet been identified. Those positions will be identified in the MPEP QAPP amendment submitted to the Regional Water Board prior to the initiation of the first MPEP field study.

The data collected for the GQMP, i.e. FEPs, NMP Summary Reports, and additional survey information, will be managed by WWQC. The WWQC currently manages the data obtained through the submission of the FEPs and future NMP Summary Reports on-line through 4Creeks Creative Consulting. The Regional Water Board can request a detailed description of the SQL databases if interested.

Figure 64. Identification of key responsible parties involved in major aspects of the GQMP.



5.8 Strategies to Implement Management Plan Tasks

5.8.1 Agencies Contacted for Data and/or Assistance

The Coalition is participating in a joint effort to conduct MPEP studies. Other coalitions participating are the East San Joaquin Water Quality Coalition, Sacramento Valley Water Quality Coalition, San Joaquin County and Delta Water Quality Coalition, and the Westside San Joaquin River Watershed Coalition. The Coalitions have met and developed an administrative structure to manage the MPEP studies, and have convened a technical advisory group consisting of several representatives from UC Cooperative Extension, the fertilizer industry, and commodity groups. The Coalitions selected CURES as the administrative contractor, and have developed grant proposals to fund MPEP studies. One proposal was funded to evaluate nitrate leaching past the root zone in walnut orchards on sandy soil and the study was initiated in spring of 2016.

In addition, the Coalitions worked with CDFA to develop a nitrogen management curriculum that allows members who successfully complete the course to certify their Nitrogen Management Plans. CURES submitted a grant proposal to CDFA to fund the development of the curriculum of the self-certification course. The proposal was funded and the courses will continue to be delivered through the winter of 2016 – 17.

The Central Valley Salinity Alternatives for Long Term Solutions (CV-SALTS) process and the Central Valley Salinity Coalition are in the process of assisting the Regional Water Board in developing a Basin Plan Amendment (BPA) for salt and nitrate that will involve the development of a Salt and Nitrate Management Plan (SNMP). This SNMP will include implementation options that may result in the use of specific management practices in some or the entire Coalition region. The CV-SALTS process is anticipated to be completed by 2017 and when that BPA is finalized, the Coalition will re-evaluate its GQMP to determine its compatibility with the requirements of the BPA and the SNMP(s) developed for the Coalition region.

5.8.2 Management Practices to Control COCs

The Coalition uses the information provided by different state and federal agencies when making recommendations to growers about how to eliminate discharges from their farming operation. Recommended practices include a range of actions from reducing the amount of nitrogen fertilizer applied to installation of pressurized irrigation systems. Some of the management practices are not technically feasible on some crops. Some practices may be technically feasible but for some members, the practices may not be economically feasible. For these members, the Coalition provides additional practices that can be implemented to reduce leaching as well as information about programs that provide a cost share of the purchase and installation improving the affordability of these more expensive systems.

5.8.3 Education and Outreach Activities

Outside of a formal meeting setting, the Coalition provides information to growers throughout the year through mailings, emails, and newsletters. Through these media the Coalition presents information to members concerning the Coalition's progress in achieving water quality goals, monitoring results and management practices proven to be effective to reduce the discharge of nutrients and pesticides to

groundwater. All outreach and education activities are reported in the WWQC Annual Report submitted by May 1 of each year.

The Westlands Water District hosts a website (http://wwd.ca.gov/resource-management/irrigated-lands-management-program/), which serves as a clearing house for Coalition activities and outreach on management practices. Information provided through the website is utilized as a supplement to regular grower contacts and meetings.

5.8.3.1 Education and Outreach Activities Schedule

Workshops

The Coalition hosts informational workshops during the year emphasizing requirements of the ILRP and any changes in requirements due to updates of the WDR by the Regional Water Board. During the 2015 Water Year, the Coalition hosted two information workshops (February 18 and 20, 2015) focused on the requirements of the Nitrogen Management Plan for Members. The two workshops hosted a combined attendance of over 105 individuals representing over 675 organizations/entities.

Notifications/Mailers

In addition to offering free informational workshops to Members, the Coalition also provides notifications and mailers through email and the postal service. The Westlands Water District sends monthly email notices reminding Members of workshops and important Coalition dates. Mailer notifications are sent to members and/or non-members in January, February, and August.

5.8.3.2 Content Summary

Workshop

The Workshops held in February 2015 included the following information:

- Current Coalition News and Activities
- Nitrogen Management Plan Deadlines
- Nitrogen Management Plan Worksheet
    - Instructions
    - Examples
    - Certification Requirements
- Nitrogen Management Plan Additional Resources
    - Westlands Website Resources
    - Fertilization Guideline Resources
    - Nitrogen Conversions
- Nitrogen Management Summary Report
- Farm Evaluation Plans
- Questions/Comments

Mailers

Members in High Vulnerability Areas

In January 2015, the Coalition sent notification to Members enrolled with High Vulnerability Parcels that were required to complete a Nitrogen Management Plan by the March 2015 deadline. Additionally, the notification provided information on the two February 2015 informational workshops that would be offered to discuss the requirements of the Nitrogen Management Plans. Enclosed with the notification was the Nitrogen Management Plan worksheet/template. Members were also asked to verify parcel enrollment in the Coalition.

Members in Low Vulnerability Areas

In a February 2015 notification, the Coalition provided information to growers for Low Vulnerability Parcels enrolled but not required to complete a Nitrogen Management Plan by the March 2015 deadline. Members were also asked to verify parcel enrollment in the Coalition.

Non-Members

In August 2015, the Coalition sent notification to identified landowners with irrigated lands and no regulatory coverage (non-enrollment). Landowners were provided with a list of parcels that were not currently enrolled in the Coalition and procedures for enrollment. Additionally, links to the GO, Coalition enrollment materials, Coalition contact information, and Regional Board compliance outreach activities were provided.

5.9 Performance Goals and Performance Measures

The Coalition's Performance Goals are built on actions critical for successful completion of the Management Plan strategy. The Performance Goals reflect the steps necessary to guarantee that the objectives of the Management Plan program are met and that groundwater quality improves in the WWQC region.

The following section describes the Performance Measures associated with each Performance Goal (Table 23). These Performance Measures are the actions the Coalition will perform to meet the Performance Goals. Included in the table of Performance Goals and Performance Measures are the parties responsible for performing the actions described by the Performance Measures. A more detailed description of the Performance Goals and Performance Measures has been provided below.

Performance Goal 1. Review each member's Farm Evaluation Plan (FEP) to determine number/type of management practices in place

Performance Measures

1.1 *Analyze FEPs to track implementation of wellhead protection practices on member irrigation supply wells*
1.2 *Analyze FEPs to track destruction of abandoned wells on member fields*

1.3 *Analyze FEPs to track changes in well, irrigation, pesticide, and nitrogen fertilizer management practices*

The WWQC will review information about member parcels reported in the FEPs from growers in groundwater high vulnerability areas and trend monitoring results (if applicable). Information on wellhead protection, destruction of abandoned wells, and management practices will be reported on in the annual Management Plan Progress Report.

Performance Goal 2. Develop a list of practices associated with the 4Rs.

Performance Measures

2.1 *Within two years, provide all Coalition members information on management practices that are considered to be protective of groundwater*
2.2 *Within two years, develop and distribute to members a summary of appropriate nitrogen application rates, timing, and placement for crops that cover 90% of the acreage in the HVAs*

The Coalition is currently funding a literature review as part of the MPEP to compile a summary of management practices currently considered to be protective of groundwater. Within two years the Coalition will compile a matrix of crop-specific nitrogen application rates, appropriate timing of applications, and appropriate placement of fertilizer applications. The matrix will be based on guidelines developed by CDFA, UCCE, and/or commodity groups. Although this information is available through numerous sources online, some Coalition members do not have computers or do not have the time to search all of these sources for the right information. The Coalition will bring the information together in a single location which can then be a resource for growers and their CCAs when nitrogen management is discussed. The Coalition will update the information over time as more studies are reported.

Performance Goal 3. Members adopt additional management practices when appropriate to reduce potential leaching of nitrate to groundwater

Performance Measures

3.1 *Analyze distribution of crop-specific A/Y and A/R (when available) values to evaluate performance of growers*
3.2 *Identify individual fields that are statistical outliers in the crop-specific distribution of A/R values*
3.3 *Conduct crop-specific meetings for members with outlier parcels in HVAs to obtain additional information on management practices*
3.4 *Develop field-specific A/Y or A/R (when available) improvement goals, a timeline to achieve goals, and identify appropriate actions/management practices to achieve goals*

Using data collected through return of the NMP Summary Reports, the Coalition will develop box and whisker plots and supporting statistics (mean, 10th, 25th, 50th, 75th, and 90th percentiles) for A, Y, A/Y, and A/R for each crop (N removed information may not be available for all crops). Fields that are statistical outliers will be identified. The Coalition will provide all members, regardless of their outlier status, with their A/Y and A/R (if

available) information relative to all other members who grow the same crop in the Coalition region. Included in these packets will be information regarding crop-specific 4Rs, nutrient uptake information and published fertilizer recommendations. Each year within the Groundwater Management Plan Progress Report, the Coalition will evaluate changes in A/Y and A/R values to evaluate the performance of growers. It is expected that multiple year averages will need to be evaluated to get a better understanding of performance (see Performance Goal 4).

All members associated with an NMP Summary Report statistical outlier will be contacted and asked to attend a meeting during which additional management practice information will be obtained. Once additional information is received, the Coalition will 1) determine if the field is a verified outlier as well as a statistical outlier, and 2) develop a Nitrogen Use Assessment for each grower. The Nitrogen Use Assessment will identify the potential cause(s) for the verified outlier status for each field (A is too large, Y is too small), and appropriate management practices that assist the member in reaching their reduction goal will be provided. Depending on the situation, a reduction goal may include reducing the overall amount of nitrogen applied during the crop year (e.g. applying rates according to CDFA or UCCE recommendations) and/or reducing the overall A/Y ratio (either by reducing A or increasing Y). In some cases, these two metrics cannot be reduced. In these cases, the documentation of management practices may be all that is required as part of the Nitrogen Use Assessment. Each Nitrogen Use Assessment and reduction goal will include a grower specific timetable for reaching the goal. Based on the reduction goals for verified outliers, a crop-specific A/R improvement goal will be developed for the Coalition region.

As the A/Y values are reduced for fields that are verified outliers, the overall mean and median A/Y and A/R values for all fields will decrease and new fields could be identified as outliers. Additionally, simply because a field is not identified as an outlier does not imply that the grower's A/Y or A/R is appropriate for that crop. Even fields at or near the median could require additional management practices if the median A/Y or A/R is considered too high based on nitrogen application rates developed by CDFA, UCCE, commodity groups, or studied through MPEP. The crop-specific statistics will be reviewed to determine where fields are performing relative to the accepted nitrate applications guidelines. Those growers farming fields that are above the accepted nitrogen application rates will be identified, contacted, and provided an improvement goal based on accepted nitrogen application rates.

Performance Goal 4. Evaluate the effectiveness of new management practices

Performance Measures

- *4.1 Reduce the 3-year running average A/Y or A/R for all fields to the level established by the crop-specific improvement rates*
- *4.2 Evaluate groundwater quality monitoring results from the Groundwater Trend Monitoring Program on an annual basis*
- *4.3 Evaluate trends in groundwater quality every five years in the Groundwater Assessment Report*

The Coalition will use the information from the FEPs, NMP Summary Reports, and surveys completed during the NMP Focused Outreach meetings to track implementation of management practices and progress towards

changing A, Y, A/Y, and A/R. Three-year running averages for A/Y and A/R (when available or when an annual crop is in a multiyear rotation schedule) will be used to evaluate long-term progress towards reducing the amount of nitrogen applied compared to the amount of nitrogen removed with crop harvest. Groundwater quality results from the GQTMP will be reviewed on an annual basis to assess nitrate concentrations in wells sampled from year to year. Every five years, trends in groundwater quality will be assessed for nitrate and documented in the GAR. Annual updates will be summarized in the Groundwater Management Plan Progress Report submitted annually to the Regional Water Board, and will also be disseminated to members.

Table 23. Performance Goals and Measures for the WWQC GQMP.
The WWQC will be responsible for all Performance Goals and Measures listed below.

PERFORMANCE GOAL/PERFORMANCE MEASURE	OUTPUTS
Performance Goal 1: Review each member's Farm Evaluation Plan (FEP) to determine number/type of management practices in place	
Performance Measure 1.1 - *Analyze FEPs to track implementation of wellhead protection practices on member irrigation supply wells*	Report in Management Plan Progress Report the wellhead protection practices on member irrigation supply wells.
Performance Measure 1.2 - *Analyze FEPs to track destruction of abandoned wells on member fields*	Report in Management Plan Progress Report the number of abandoned wells that are destroyed.
Performance Measure 1.3 - *Analyze FEPs to track changes in well, irrigation, pesticide, and nitrogen fertilizer management practices*	Report in Management Plan Progress Report the changes in member practices that are more protective of groundwater quality.
Performance Goal 2: Develop a list of management practices associated with the 4Rs	
Performance Measure 2.1 – *Within two years, provide to all Coalition members information on practices are considered to be protective of groundwater*	A compilation of information on management practices that is provided to growers.
Performance Measure 2.2 – *Within two years, develop and distribute to members a summary of appropriate nitrogen application rates, timing, and placement for crops that cover 90% of the acreage in the HVAs*	A matrix of crop-specific nitrogen application rates, timing, and placement based on guidelines developed by CDFA, UCCE, and commodity groups.
Performance Goal 3: Members adopt additional management practices when appropriate to reduce potential leaching of nitrate to groundwater	
Performance Measure 3.1 – *Analyze distribution of crop-specific A/Y and A/R (when available) values to evaluate nitrogen management performance of growers for all crops*	The mean and supporting statistics of the crop-specific distributions of A, Y, A/Y, and A/R.
Performance Measure 3.2 – *Identify all fields that are statistical outliers in the crop-specific distribution of A/R values*	Member-specific nitrogen use assessment that provides their field-specific A/Y and A/R values, identifies all statistical outliers of the crop-specific distribution of A/R.
Performance Measure 3.3 - *Conduct crop-specific meetings for all members with outlier parcels in HVAs to obtain additional information on management practices*	Supplemental information from all outliers on A, Y, A/Y including fertilizer and irrigation management practices, and identify true outliers.
Performance Measure 3.4 – *Develop field-specific A/Y or A/R (when available) improvement goals, a timeline to achieve goals, and identify appropriate actions/management practices to achieve goals for all fields identified as a true outliers*	Field-specific improvement targets for all fields identified as true outliers and document crop-specific A/Y and A/R improvement goals and timelines for achieving the goals.
Performance Goal 4: Evaluate the effectiveness of new management practices	
Performance Measure 4.1 – *Reduce the 3-year running average A/Y or A/R for all fields to the level established by the crop-specific improvement rates*	Documented reduction in crop-specific A/Y and A/R statistics.
Performance Measure 4.2 – *Evaluate groundwater quality in wells monitored during the Groundwater Trend Monitoring Program*	Groundwater quality monitoring results in the Groundwater Trend Monitoring Update Report
Performance Measure 4.3 – *Evaluate trends in groundwater quality every five years in the GAR Update*	Trend in groundwater quality in Coalition HVAs

5.9.1 Specific Schedule and Milestones for Implementing Management Practices

As detailed by the Outputs in Table 23, each year the Coalition will evaluate and report on the management practices implemented the previous year by members within the HVAs. During the year, the Coalition will conduct outreach and education to members regarding effective management practices that can be implemented to reduce the transport of COCs to groundwater. As data gaps regarding the 4Rs for specific crops are filled, this information will be included in the Coalition's outreach and education efforts. The following milestones were developed based on this strategy and supplemented with target dates based on the objectives of this GQMP.

Milestone 1: Within two years of the approved GQMP, provide to all members, information on practices that are considered protective of groundwater.

Milestone 2: Within three years of the approved GQMP, develop and distribute to members a summary of appropriate nitrogen application rates, timing, and placement for crops that cover 90% of the acreage in the HVAs.

Milestone 3: Within the first year (and annually thereafter), meet with members whose fields have been identified as verified outliers to obtain additional information about nitrate applications, management practices and yields.

Milestone 4: Within 5 years, demonstrate that the 3-year running average crop-specific A/Y and A/R goals are being met for crops making up 90% of the acreage in the Coalition HVAs.

Staggering the work associated with Performance Goals and Measures over the next 2 – 5 years will allow the Coalition to maintain lower costs, provide excellent service to its members, and will result in improved groundwater quality.

Despite staggering the work associated with the GQMP over the next five years, the milestones and the schedule to reach the milestones is very aggressive. The Coalition is currently working with four other Coalitions through the MPEP process to conduct a literature review that will identify some practices that are currently thought to be protective of groundwater quality. The Coalition expects that the results of the literature review will be available within the next several months but will provide the list to a selected group of technical experts from the MPEP Technical Advisory Committee and the University of California to confirm that the practices can be recommended to growers as protective. This process is expected to take at least a year and as soon as the practices receive endorsement from the technical experts, the information will be distributed to all Coalition members.

Similarly, the Coalition will initiate the compilation of practices on appropriate nitrogen application rates, timing, and placement for 90% of the crop acreage in the HVAs. A large amount of this information is readily available but needs to be compiled and placed into a format that is easily understandable by growers. Compilation and formatting is expected to take 12 months, and delivery to the members in the HVAs will be

accomplished within the second year. The Coalition does not have staff to accomplish this task and it will become the responsibility of the technical consultants for the Coalition. Spreading the work over a year will help maintain the economic feasibility of the entire program.

The Coalition has initiated actions that will jump start the work needed to accomplish the Performance Goals and Performance Measures, but to develop 3-year running averages of nitrate applications and yields, it is not possible to reach the initial milestones until Year 5. Providing useful feedback to members on the implementation of additional management practices and the effectiveness of those practices will take at least five years. Additionally, after examining a grower's management practices that are in place, it may be difficult or impossible to recommend additional practices until the MPEP process is farther along. If the Coalition understood all management practices that will allow all members to reach their A/R goals, there would be no need for the MPEP. The GQMP and the MPEP are parallel process that are interlinked.

5.9.2 Technical and Economic Feasibility

The Coalition is implementing several new processes concurrently; the NMP Summary Report and FEP reporting processes, the GQMP, the MPEP, and the GQTMP. All are interconnected and important components that will result in improved surface and groundwater quality. However, the expense and workload associated with all of these required elements has greatly impacted the Coalition. The Coalition's budget has grown substantially over the last few years and the workload on Coalition staff has required the hiring of additional personnel. Additional costs associated with the initiation of the MPEP, the implementation of the GQMP, and the GQTMP will require increases in the fees associated with Coalition membership. Increases in membership fees provide a disincentive to Coalition membership as well as a financial hardship for many growers of minor crops. In addition, the costs associated with the implementation of the practices may not be economically feasible for many growers. In these instances, the Coalition will work with the growers to find a suite of lower cost, but effective, management practices to minimize the discharge of nitrate to groundwater. The Coalition will also help growers identify opportunities to obtain funding to offset the cost of expensive systems that can facilitate achieving the member's A/Y goals.

5.9.3 Performance Goals and Disadvantaged Communities (DACs)

The Coalition used a large set of parameters when developing its HVAs. A description of these parameters are provided in detail in the GAR (WWQC, 2015). Once the HVAs were established, HVA Priority Areas (1-4) were developed to help facilitate the temporal implementation of management plan activities. Communities that rely on groundwater for their source of drinking water were considered within matrix for prioritization of the HVAs (Table 6-6 of the GAR) (WWQD, 2015). Additional disadvantaged communities were identified for this analysis (County of Tulare, 2014), and the majority of those communities are located near or within HVAs. Consequently, improvements in groundwater quality expected from the GQMP will immediately benefit residents of the DACs and those communities reliant on groundwater for drinking water. In addition, those DACs not readily included within the HVA, and that are not reliant on groundwater, will also benefit from outreach activities provided by the Coalition as growers of those crops adjacent to their communities will receive education on the BMPs for the protection of groundwater.

The top six crops by acreage in the HVAs in the Coalition region are vegetables, nut trees, grains/cotton, grapes, seeds/beans, and grasses (Figure 4-5 of the GAR, 2015). Fertilizer guidelines are available for all of these crops through CDFA allowing the Coalition to establish goals for fertilizer applications and individual goals for growers for reduction of their A/Y and A/R. Consequently, the Coalition believes that A/Y improvement goals can be developed for the overwhelming majority of the acreage in the HVAs which can be evaluated and monitored for progress in achieving goals. The GQTMP strategy is designed to have the greatest impact on groundwater improvement as a result of focusing first on large acreage crops with documented fertilizer recommendations and nitrogen removed values to establish practical and effective reduction goals. As growers achieve their improvement goals, a reduction is expected to occur in the amount of nitrate leaching from the root zone for crops grown across the HVAs. As a result of decreased leaching, the groundwater supply of DACs and surrounding communities reliant on groundwater for drinking water will improve.

6 Monitoring Methods

6.1 Monitoring design

The Coalition's groundwater monitoring strategy is currently being developed through the GQTMP and the MPEP. The GQTMP will include a comprehensive monitoring program for groundwater quality and is due to be submitted one year after the approval of the GAR. In addition, the MPEP will develop several studies of management practices to determine if they are protective of groundwater. A conceptual work plan for the MPEP was submitted July 31, 2015 and the final work plan was submitted on June 4, 2016.

6.1.1 Minimum Groundwater Monitoring Requirements

According to the General Order, "Trend monitoring wells will be sampled, at a minimum, annually at the same time of the year for the indicator parameters identified in Table 24 below."

Table 24. Groundwater monitoring parameters (WDR, Attachment B, pg. 20).

CONSTITUENTS, PARAMETERS, AND TESTS	
ANNUAL MONITORING	
Dissolved Oxygen* (mg/L)	**Physical Parameters and General Chemistry**
Electrical Conductivity* (µmhos/cm)	
pH* (in pH units)	
Temperature* (˚C)	
Nitrate* as nitrogen (mg/L)	
TREND MONITORING	
Total Dissolved Solids (SC, field measure)	**Physical Parameters and General Chemistry**
Carbonate	Anions
Bicarbonate	
Chloride	
Sulfate	
Boron	Cations
Calcium	
Sodium	
Magnesium	
Potassium	

*Field parameters

7 Data Evaluation

7.1 Information needed to quantify program effectiveness

To quantify management plan program effectiveness, there are several types of data that will be collected by the Coalition over the next year including:

- Management practices used by members in high vulnerability regions,
- Management practices recommended to growers for implementation in the future, and
- Recommended management practices actually implemented by members.

The Coalition currently maintains independent relational databases for water quality monitoring data, management practices reported in the Farm Evaluation Reports, practices recommended by Coalition representatives, and pesticide use information received from the office of the County Agricultural Commissioners. In addition, the Coalition maintains a database of pesticides applied in the Coalition region including physical, chemical, and toxicological information that is used to identify applications that have the potential to cause toxicity.

8 Records and Reporting

The Coalition will submit each year by May 1 in a Management Practice Progress Report as part of the Annual Monitoring Report, also submitted by May 1. The report will contain the 13 components listed in Appendix MRP-1 of the WDR. All reports are submitted electronically and shapefiles are either submitted with the reports, or available upon request.

9 References

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