

### 3. Initial Assessment of Groundwater Conditions

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The initial assessment of nitrate groundwater conditions for the Preliminary Management Zone Proposal is based on readily available existing data and information. Where possible, information from the Central Valley SNMP (CV-SALTS 2016a) was used and updated with more recent groundwater quality data from publicly available sources. Key data sources for this assessment included:

- Supplemental information on groundwater within the Turlock Management Zone was obtained via DWR's Bulletin 118 (DWR 2003). This document provides an overview of groundwater conditions (both groundwater levels and groundwater quality) in specific subbasins including the Turlock Subbasin (DWR 2006). Bulletin 118 also contains descriptions of groundwater basins and subbasins in California, with many descriptions updated from their 2003 descriptions in 2016 (DWR 2016). DWR also released their statewide Groundwater Basin Prioritization in 2014 and 2015,<sup>1</sup> which contains basic information on each groundwater basin including population, population growth, total number of public supply wells, groundwater volume, percent of total water supply supplied by groundwater, irrigated acreage, and other comments on groundwater levels or quality specific to aquifers within the basin.
- GSAs are developing HCMs, which include details on groundwater conditions. The East and West Turlock GSAs are actively working within the proposed Management Zone (see Section 2.2.3).
- CV-SALTS completed a high-resolution mapping analysis of nitrate and total dissolved solids (TDS) groundwater quality in the Central Valley Region including within the proposed Management Zone (CV-SALTS 2016b). The high resolution mapping of salt and nitrate was completed for the Upper, Lower, and Production Zones of the groundwater system, which are defined in the documentation. Ambient TDS and nitrate conditions are provided, as well as assimilative capacity, groundwater quality trends, and predicted conditions (after 10, 20, and 50 years). The CV-SALTS high resolution dataset utilizes groundwater quality data from 2000-2016.

**Table 3-1** summarizes sources of data accessed to update the CV-SALTS nitrate groundwater dataset for completing the Initial Assessment of Groundwater Conditions for this Preliminary Management Zone Proposal.

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<sup>1</sup> [https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel\\_BasinRank\\_by\\_HR\\_5-18-15.pdf](https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel_BasinRank_by_HR_5-18-15.pdf)

**Table 3-1. Data Sources Accessed to Develop Initial Assessment of Groundwater Conditions in Proposed Management Zone**

| Data Source   | Link  |
|---|---|
| <b>General Groundwater Conditions</b>   |   |
| DWR Bulletin 118 overview of basin/subbasin conditions (groundwater levels and groundwater quality)     | <a href="https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118">https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118</a>   |
| DWR's Groundwater Sustainability Basin Prioritization   | <a href="https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel_BasinRank_by_HR_5-18-15.pdf">https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel_BasinRank_by_HR_5-18-15.pdf</a>   |
| Individual GSA's Hydrogeologic Conceptual Model, via request to the GSA Point of Contact                | <a href="https://sgma.water.ca.gov/portal/gsa/all">https://sgma.water.ca.gov/portal/gsa/all</a>   |
| CV-SALTS High Resolution Salt and Nitrate Mapping for Region 5  | <a href="https://www.cvsalinity.org/committees/technical-advisory/conceptual-model-developments/171-updated-groundwater-quality-analysis-for-central-valley.html">https://www.cvsalinity.org/committees/technical-advisory/conceptual-model-developments/171-updated-groundwater-quality-analysis-for-central-valley.html</a> |
| <b>Publicly Available Groundwater Quality Data Sources</b>  |   |
| GeoTracker GAMA   | <a href="http://geotracker.waterboards.ca.gov/gama/gamamap/public/">http://geotracker.waterboards.ca.gov/gama/gamamap/public/</a>   |
| DWR Water Data Library  | <a href="http://wdl.water.ca.gov/waterdatalibrary/waterquality/index.cfm">http://wdl.water.ca.gov/waterdatalibrary/waterquality/index.cfm</a>   |
| US Geological Survey National Water Information System  | <a href="https://waterdata.usgs.gov/nwis/qw">https://waterdata.usgs.gov/nwis/qw</a>   |
| GeoTracker Regulated Facilities   | <a href="http://geotracker.waterboards.ca.gov/">http://geotracker.waterboards.ca.gov/</a> and <a href="http://geotracker.waterboards.ca.gov/datadownload">http://geotracker.waterboards.ca.gov/datadownload</a>   |
| Division of Drinking Water  | <a href="https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.html">https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.html</a>   |
| <b>County-Specific Data Available by Request</b>  |   |
| Stanislaus County state small water systems and domestic/local small water systems (water quality data) | <a href="https://www.co.merced.ca.us/597/Environmental-Health">https://www.co.merced.ca.us/597/Environmental-Health</a>   |
| Merced County state small water systems and domestic/local small water systems (water quality data)     | <a href="http://www.stancounty.com/er/environmentalhealth/">http://www.stancounty.com/er/environmentalhealth/</a>   |

### 3.1 Hydrogeology

The Turlock Groundwater Subbasin GSAs were contacted for information regarding the development of their HCM, which is being developed to support the preparation of the Turlock Subbasin GSP that will be applicable to the two GSAs within the proposed Management Zone.<sup>2</sup> Information requested included hydrogeological information, description of the distribution of groundwater pumping (spatially and vertically), groundwater flow directions (with particular interest in the eastern portion of the Turlock Subbasin where DWR does not have groundwater elevation contour data), and any non-public groundwater quality data.

<sup>2</sup> Kevin Kauffman (Kevin Kauffman Consulting), point of contact for the East Turlock GSA, was contacted on February 26, 2019.

DWR's Bulletin 118 describes the Turlock Subbasin as located between the Tuolumne and Merced Rivers, and bounded by the San Joaquin River on the west and on the east by crystalline basement rock of the Sierra Nevada foothills (DWR 2006). The northern boundary of the Turlock Subbasin is shared with the Modesto Groundwater Subbasin; the western boundary shared with the Delta-Mendota Groundwater Subbasin; and the southern boundary with the Merced Groundwater Subbasin. The Turlock Subbasin receives 11 to 13 inches of average annual precipitation, increasing eastward, with 15 inches in the Sierran foothills (DWR 2006).

The primary hydrogeologic units in the Turlock Subbasin include both consolidated and unconsolidated sedimentary depositional materials. The consolidated deposits lie in the eastern portion of the subbasin and consist of the Ione Formation, Valley Springs Formation, and the Mehrten Formation (DWR 2006). These formations generally yield a low amount of water; although the Mehrten Formation is an important aquifer for water supply, consisting of up to 800 feet of sandstone, breccia, conglomerate, tuff siltstone, and claystone (DWR 2006).

The unconsolidated deposits are the primary water-bearing units in the subbasin and are present across the western portion of the subbasin. These continental deposits and older alluvial deposits consist of layers of sand, gravel, silt, and clay that increase in thickness away from the margins of the valley (the layers thin to the east). Continental deposits include the Turlock Lake Formation, North Merced Gravel, and Pleistocene non-marine sedimentary units. Soil survey data indicate the presence of numerous long, narrow coarser-textured, higher conductivity deposits resulting from modern and ancient stream channel depositional processes. **Figure 3-1** illustrates the hydrogeologic units in map and cross-sectional forms for the Turlock Subbasin (adapted from the Turlock Groundwater Management Plan 2008).

The Corcoran Clay, which is generally present in the western half of the Turlock Subbasin, is an important feature in the subbasin. Within the subbasin, the Corcoran Clay ranges in thickness from 20 to 40 feet on the eastern edge of its extent, to pockets of thicker areas up to 140 feet thick (west of Hilmar and west of the City of Turlock). The Corcoran Clay appears between approximately 100 to 200 feet below ground surface, where present (**Figure 3-2**).

A groundwater vulnerability assessment was completed as part of the East San Joaquin Water Quality Coalition's (ESJWQC) Groundwater Quality Assessment Report (GAR) (ESJWQC 2014). This assessment included the development of vulnerability mapping in portions of the Turlock Subbasin. The physical intrinsic vulnerability approach in this document considers land use and depends on the assumption that observed groundwater quality is the result of interactions between land use practices at the surface and the presence of physical hydrogeologic characteristics and processes occurring in the area. The presence of hydrogeologic characteristics that enable potential contaminants to reach groundwater more quickly make a location more vulnerable to groundwater contamination than a location with hydrogeologic characteristics that impede the ability of contaminants to reach groundwater or attenuate the contamination.

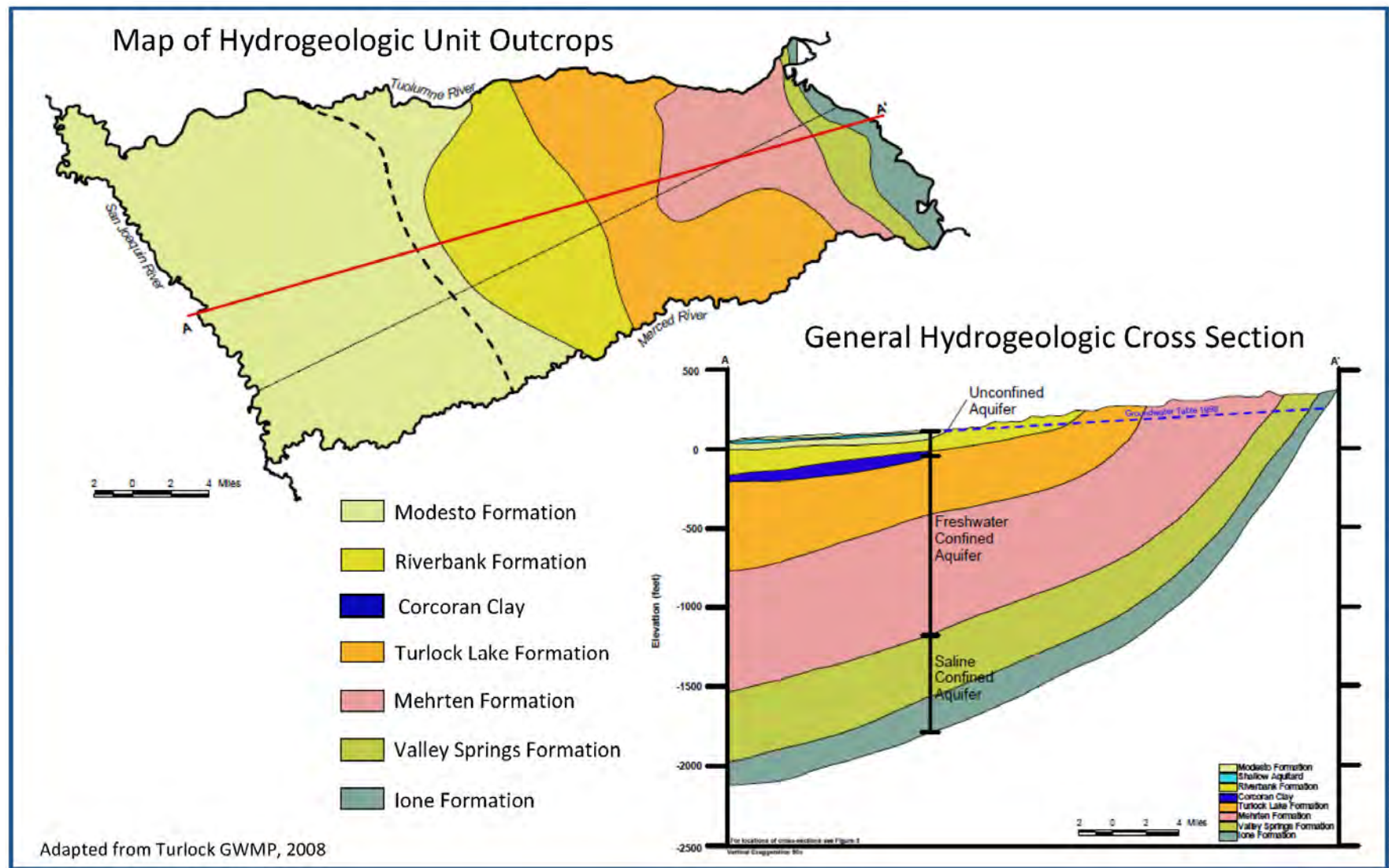


Figure 3-1. General Hydrogeologic Characteristics of the Turlock Groundwater Subbasin



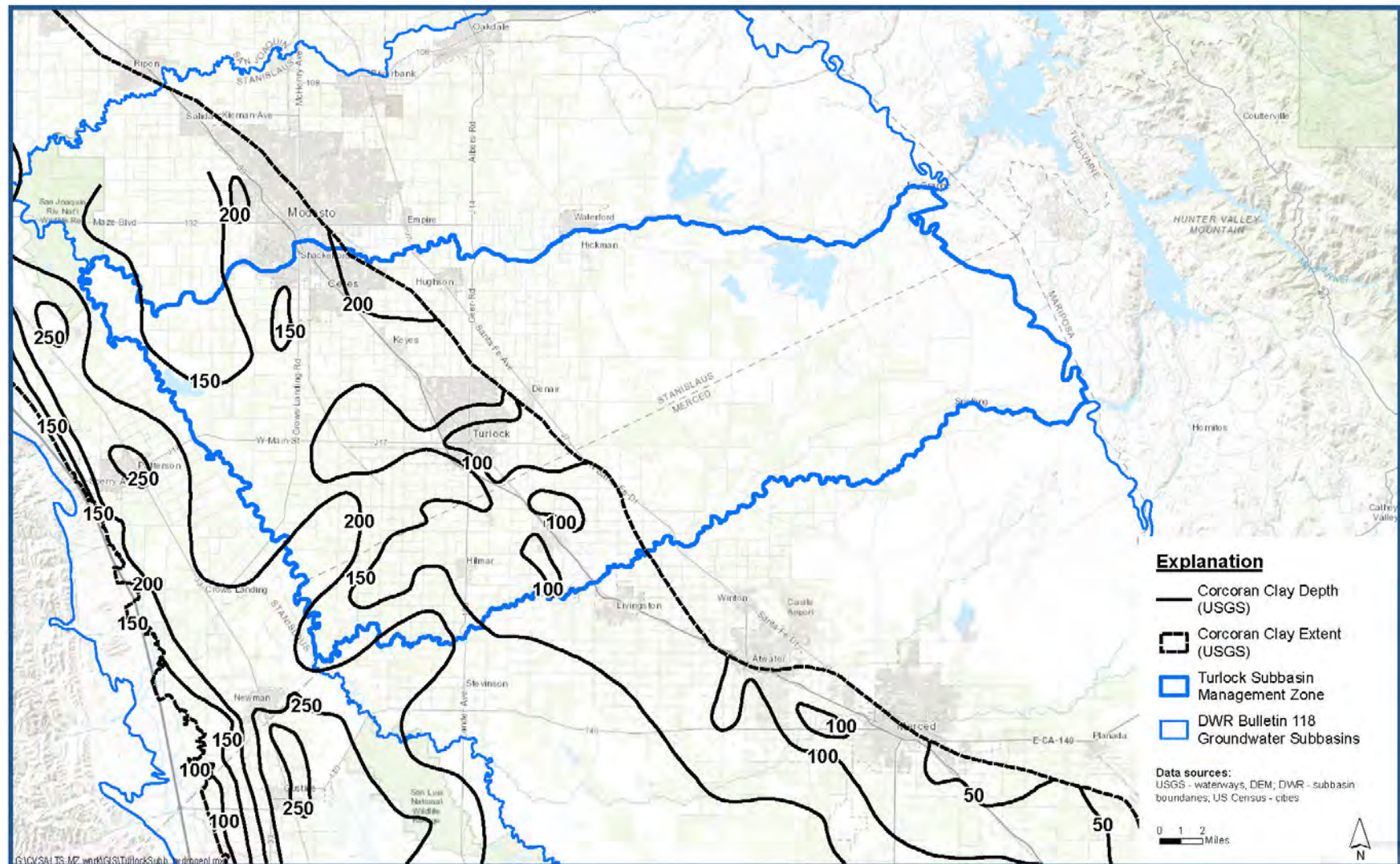


Figure 3-2. Location and Depth of the Corcoran Clay within the Turlock Groundwater Subbasin

Naturally-occurring concentrations of nitrate in groundwater are typically very low; therefore, observations of nitrate in the groundwater are considered to be primarily a function of contributing land uses at the surface and subsequent processes that transport nitrate through the subsurface into the groundwater. This makes nitrate a more useful indicator of influence from irrigated agriculture or other land uses than some other commonly available groundwater quality measures such as TDS or electrical conductivity and was therefore used for the vulnerability assessment. The 2014 GAR also provided a prioritization of the high vulnerability areas in the area covering the Turlock Subbasin based on several factors such as existing water quality, existing surface practices, etc. Areas were designated as high, moderate, or low priority to inform groundwater monitoring and management efforts (Figure 3-3).

## **3.2 Groundwater Elevations and Flow**

Regional groundwater flows generally from the Sierra Nevada foothills to the southwest, following the regional dip of basement rock and sedimentary units. However, contours of equal groundwater elevation for Spring 2018 (Figure 3-4) show lower groundwater elevations northeast of the City of Turlock, which draw groundwater toward this area from outside the Turlock Subbasin in the north and south. In the western portion of the subbasin, groundwater levels are highest in the south, indicating groundwater movement within the western portion of the subbasin to the northwest. The Turlock GSAs are in the process of developing their own description of groundwater levels and conditions in the Turlock Subbasin. The development of these data may be used to supplement this Preliminary Management Zone Proposal in the future.

## **3.3 Upper Zone Delineation**

The Upper Zone refers to the upper portion of the groundwater aquifer system used for determining ambient nitrate conditions in the Management Zone. The depth of the Upper Zone includes the depth from the bottom of the vadose zone to the top of the Lower Zone. The depth of the Upper Zone is based on well construction information, (where available), and other comparable information that provide the best available indication of well depth. The determination of the Upper Zone depth gives the highest weight to domestic well depths (Table 3-2). Where the Corcoran Clay (or E-Clay) is present, the Upper Zone does not extend below the Corcoran Clay.

**Table 3-2. Basis for Determining Depth of the Upper Zone**

| <b>Date Layer</b>                   | <b>Weights for Establishing Bottom of Upper Zone</b> |
|-------------------------------------|--|
| Domestic Wells Bottom Perforations  | 40%  |
| Farm Virtual Wells Top Perforations | 10%  |
| Urban PWS Top Perforations          | 20%  |
| Rural PWS Top Perforations          | 20%  |
| DDW Systems Top Perforations        | 10%  |
| <b>Total</b>                        | <b>100%</b>  |



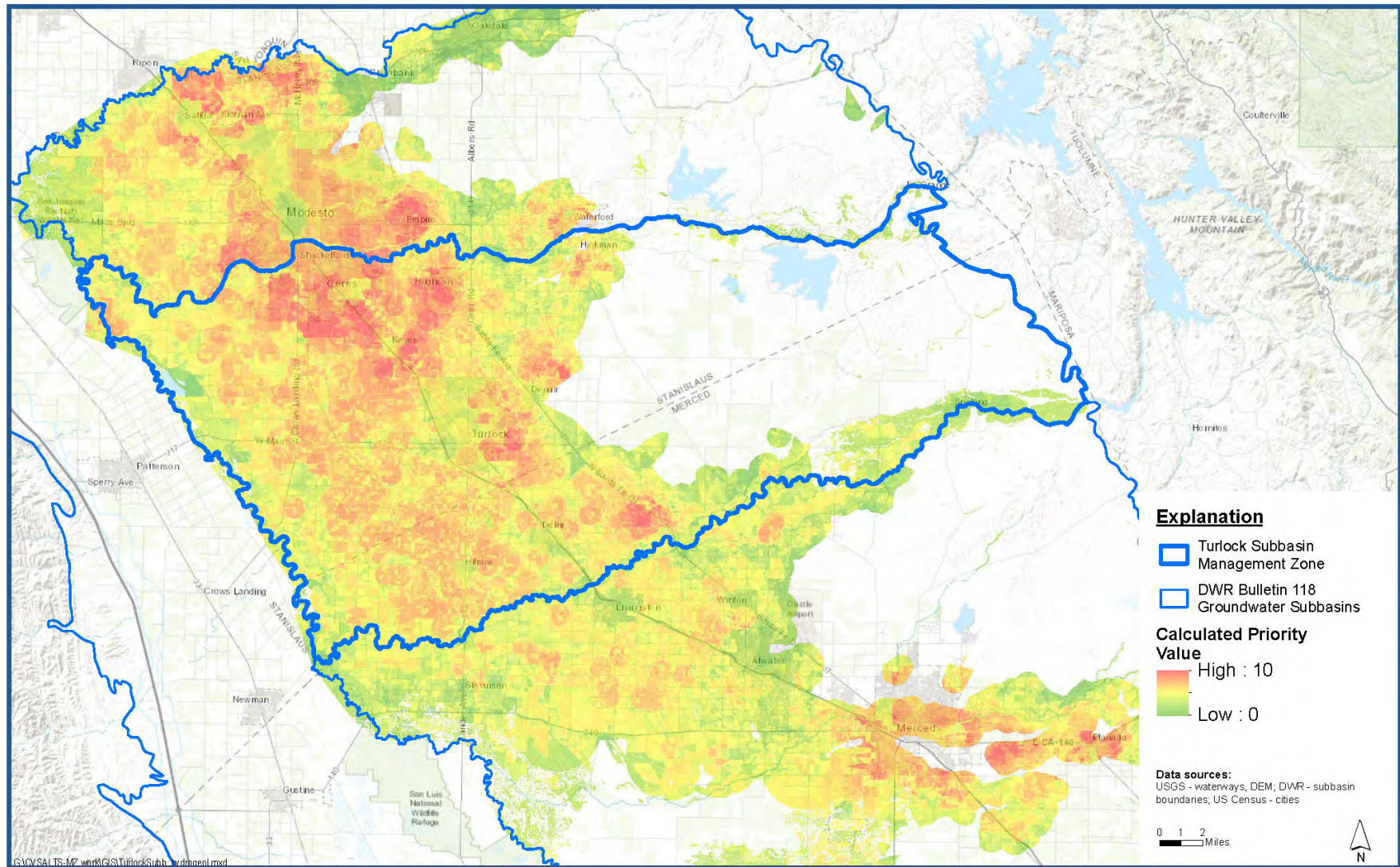


Figure 3-3. Nitrate High Vulnerability Map for the Turlock Groundwater Subbasin and Adjacent Areas (ESJWQC 2014).



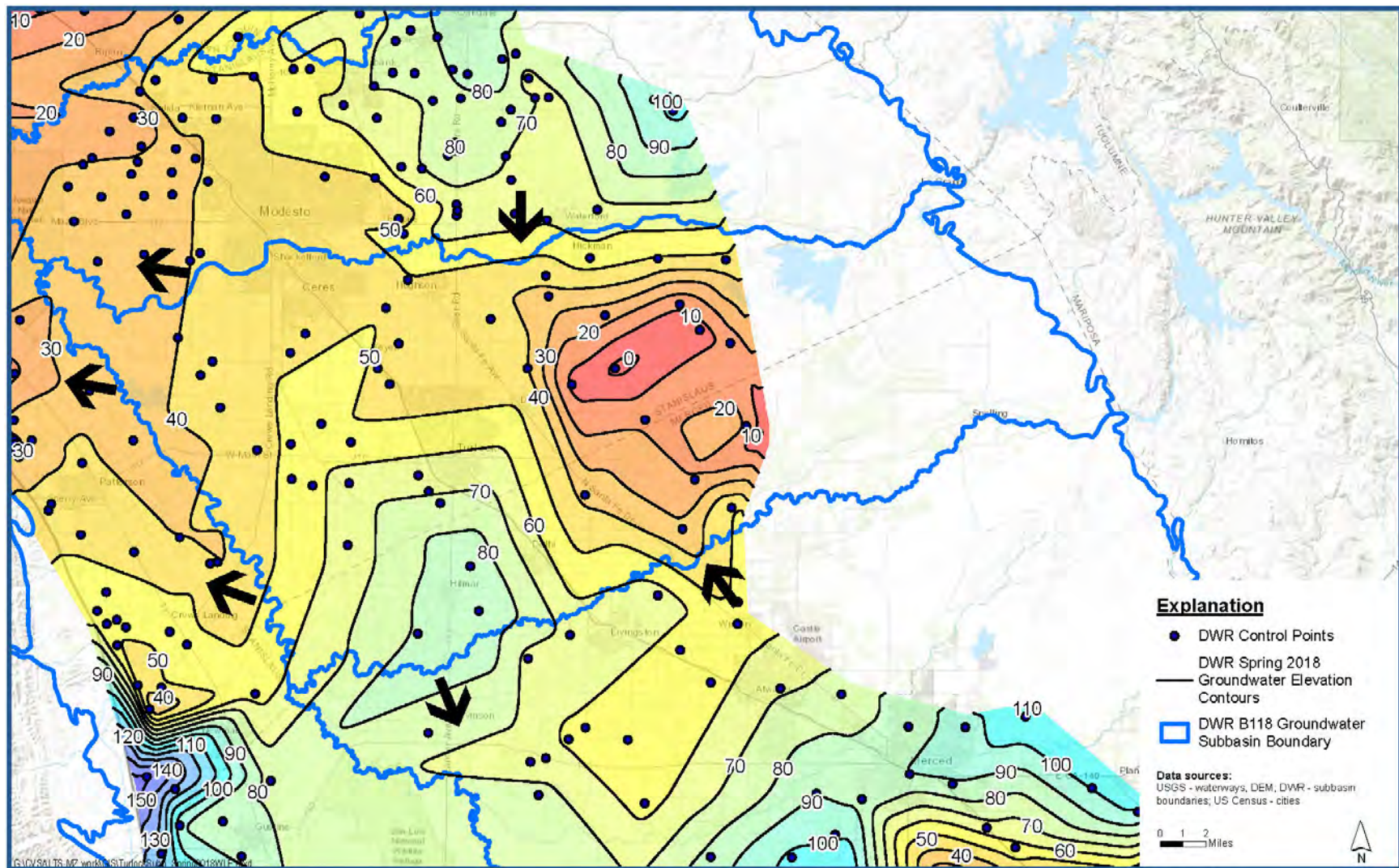


Figure 3-4. Spring 2018 Groundwater Elevation Contours for the for Turlock Groundwater Subbasin and Adjacent Areas



CV-SALTS (2016b) determined the boundaries of the Upper and Lower Zones throughout the Central Valley Floor through high resolution nitrate and TDS mapping using GIS spatial analyses of several layers of data. Well construction data were used in combination with depth to water contours and characteristics of the Corcoran Clay, including the extent, depth, and thickness of this significant clay member. Data for the development of the Upper and Lower Zones originated from:

- DWR depth to groundwater contours;
- Depth to groundwater from Groundwater Quality Assessment Reports;
- State Water Board's DDW database of location and construction information for public water systems
- US Geological Survey (USGS) California Central Valley Hydrologic Model 2.0 (CVHM2; in progress):
  - Modeled virtual farm well construction for agricultural pumping
  - Actual rural public well water system well construction information
  - Actual urban public well water system well construction information
  - Texture database of driller's logs, including domestic well construction information
  - Corcoran Clay depth, thickness, and extent

The above data were used to create interpolated layers over the Central Valley Floor of different well types and their perforation depths. The well construction layers were then combined in a weighting process to estimate where pumping occurs for the predominant well types. The weights provided in Table 3-2 were then used for calculating the depth to the bottom of the Upper Zone.

**Figure 3-5** shows the depth to the bottom of the Upper Zone in the proposed Management Zone, as previously delineated to support CV-SALTS analyses (e.g., CV-SALTS 2016b). Generally, the depth to the bottom of the Upper Zone is between 100 and 250 feet below ground surface in the Management Zone. The depth to the bottom of the Upper Zone is deepest to the east of the extent of the Corcoran Clay and shallower towards the eastern margin and southwestern area of the Management Zone.

### **3.4 Nitrate Water Quality**

**Table 3-3** summarizes the groundwater quality data that were readily available for use to develop this Preliminary Management Zone Proposal. These datasets include data previously developed for CV-SALTS and additional data obtained in 2019.

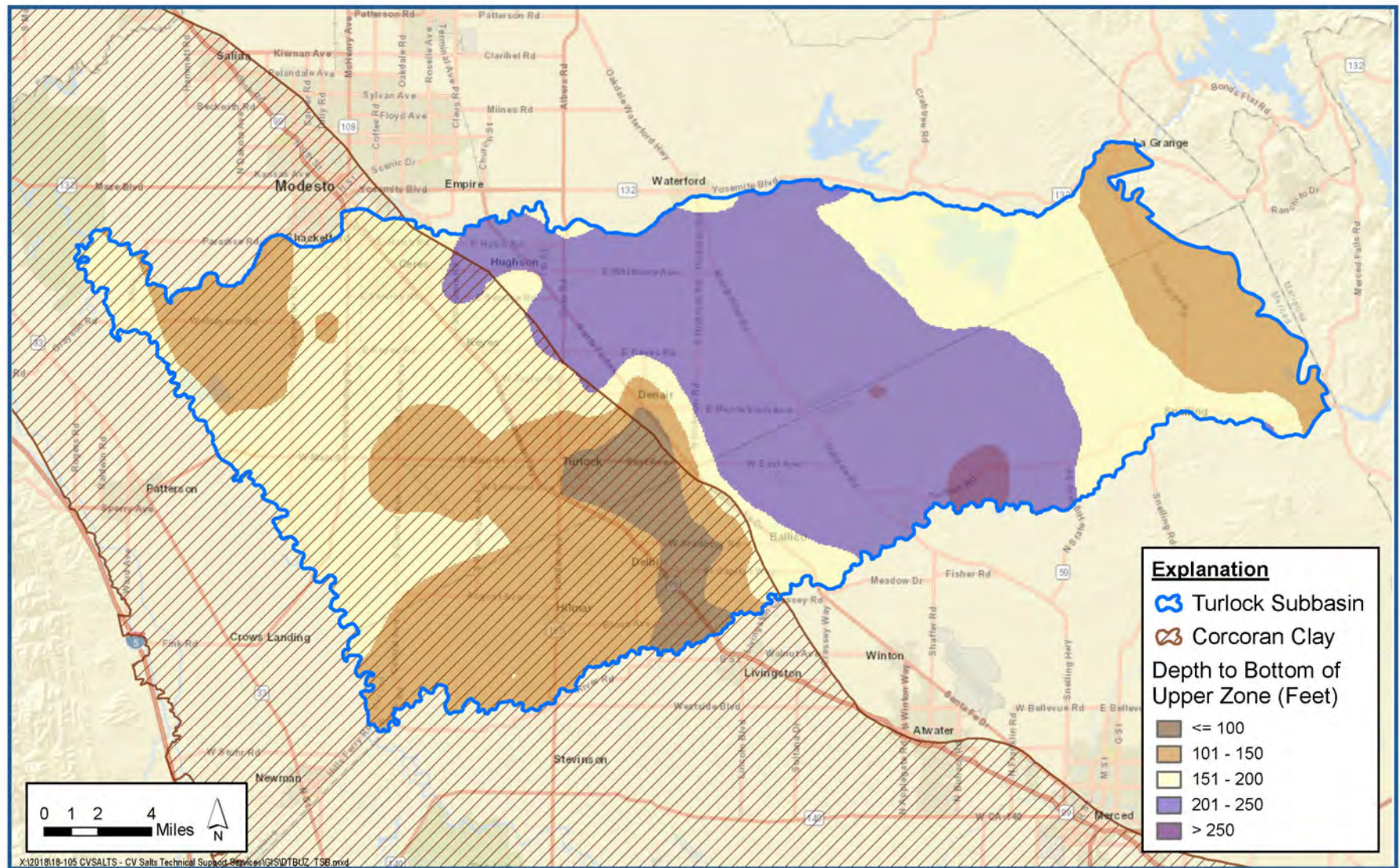


Figure 3-5. Depth to the Bottom of the Upper Zone of the Groundwater Underlying the Proposed Management Zone

**Table 3-3. Groundwater Quality Data Sources**

| Data Category   | Data Sources   |
|---|--|
| The Phase II CV-SALTS Conceptual Model nitrate groundwater database developed for the High Resolution Mapping project (CVSALTS 2016b) | <ul style="list-style-type: none"> <li>• Former California Department of Public Health (CDPH), now DDW</li> <li>• DWR</li> <li>• Central Valley Water Board Waste Discharge Requirements (WDR) data per the Dairy General Order</li> <li>• Central Valley Water Board Regulated Sites</li> <li>• State Water Board/USGS Groundwater Ambient Monitoring and Assessment Program (GAMA)</li> <li>• USGS</li> </ul>          |
| Geotracker GAMA <sup>3</sup> (Note: Not all entities had nitrate data from within the proposed Management Zone)                       | <ul style="list-style-type: none"> <li>• Department of Pesticide Regulation</li> <li>• DWR</li> <li>• GAMA – Domestic Wells; Special Studies, and Priority Basin Projects</li> <li>• Local Groundwater Projects</li> <li>• Monitoring Wells (Central Valley Water Board Regulated Sites)</li> <li>• DDW Public Water System Wells (Actual Locations)</li> <li>• USGS National Water Information System (NWIS)</li> </ul> |
| State Small Water Systems   | Merced and Stanislaus Counties   |
| Domestic Well Permit Sample Data  | Merced and Stanislaus Counties   |

Nitrate measurements and well data were compiled for the proposed Management Zone from the data sources listed in Table 3-3. Nitrate data were summarized by data source, depth, and recent nitrate exceedances.

**Table 3-4** provides a summary of wells with nitrate measurements in the Management Zone by well source. A total of 1,839 wells have nitrate data in the Management Zone, most of them (1,588 wells, or about 86%) have nitrate measurements since January 2000, and slightly less than half of those wells with recent (post-2000) nitrate measurements have nitrate concentrations that exceed the MCL of 10 mg/L as N.

Wells were categorized into an appropriate depth category (Upper Zone, Lower Zone, Upper/Lower, Below Lower, and Unknown).<sup>4</sup> CV-SALTS (2016b) produced GIS coverages of the depths to the bottom of the Upper and Lower Zones (e.g., see Figure 3-5). Depth information (well depth or top of screen depth and screen length) from the new dataset was used to categorize individual wells into their appropriate depth category. Wells without construction or depth information were categorized based on their well type:

<sup>3</sup> <https://geotracker.waterboards.ca.gov/gama/gamamap/public/>, accessed in February 2019)

<sup>4</sup> See text and CV-SALTS 2016a and 2016b for a description of the development and assignment of Upper Zone delineations.



**Table 3-4. Summary of Wells with Nitrate Data by Source (All Well Depths)**

| Source  | All Well Depth Categories |                                   |   |
|---|---------------------------|-----------------------------------|---|
|   | Wells with Nitrate Data   | Wells with Post-2000 Nitrate Data | Wells with Post-2000 Nitrate MCL Exceedance |
| DDW   | 336                       | 299                               | 78  |
| Dairy   | 920                       | 920                               | 527   |
| DWR   | 130                       | 0                                 | 0   |
| GeoTracker Regulated Facilities                 | 69                        | 69                                | 37  |
| Merced County Domestic/Local Small Water System | 201                       | 186                               | 38  |
| USGS  | 183                       | 114                               | 50  |
| <b>Total</b>                                    | <b>1,839</b>              | <b>1,588</b>                      | <b>730</b>                                  |

- Municipal wells were categorized using the DWR GIS coverage of well completion report statistics, which identifies the mean total depth of municipal wells in each township/range-section. The mean municipal well depth was assigned to the municipal well with no depth information posted in Geotracker GAMA and compared to the CV-SALTS depth to the bottom of the Upper and Lower Zones in order to estimate its depth category.
- Domestic wells were placed in the Upper Zone;
- State Water Board Regulated Site monitoring wells were placed in the Upper Zone; and
- Wells listed as an Unknown well type were placed in the “Unknown” depth category.

Of the entire dataset of 1,839 wells in the proposed Management Zone with a nitrate measurement, most of the wells (1,234 wells, or about 67%) are completed in the Upper Zone (**Figure 3-6**). There is a high concentration of Upper Zone wells in the western portion of the Management Zone, and deeper wells prevalent along the Highway 99 corridor and the cities of southern Modesto, Turlock, and Delhi. There were fewer wells with nitrate data available in the eastern and northeastern portions of the Management Zone.

**Table 3-5** identifies the number of wells in each depth category with nitrate data, wells with recent (post-2000) data, and wells with recent nitrate concentrations that exceed the nitrate MCL of 10 mg/L as N. Of the wells categorized into the Upper Zone almost all (95%) have post-2000 nitrate measurements, and slightly less than half (49%) have measured nitrate above the MCL.

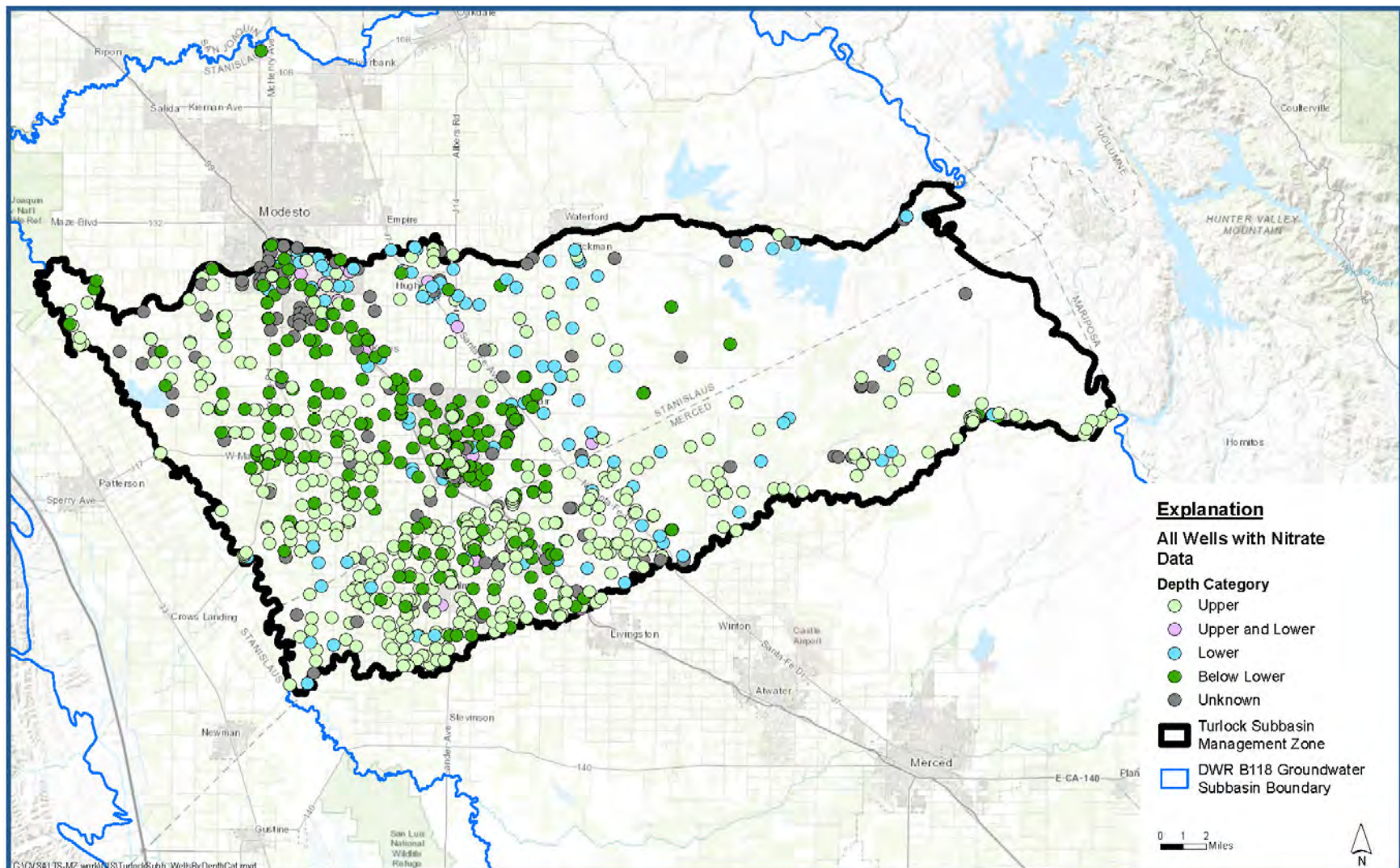


Figure 3-6. Wells with Nitrate Data within the Proposed Management Zone by Depth Category

**Table 3-5. Wells with Nitrate Measurements by Depth Category**

| Depth Category  | All Wells with Nitrate Data | Wells with Post-2000 Nitrate Data | Wells with Post-2000 Nitrate $\geq 10$ mg/L as N | Percent of Wells with Post-2000 Nitrate Data $\geq$ MCL |
|-----------------|-----------------------------|-----------------------------------|--|---|
| Upper           | 1,234 (67%)                 | 1170                              | 571  | 49%   |
| Lower           | 177 (10%)                   | 148                               | 45   | 30%   |
| Upper and Lower | 18 (1%)                     | 18                                | 8  | 44%   |
| Below Lower     | 273 (15%)                   | 226                               | 102  | 45%   |
| Unknown         | 137 (7%)                    | 26                                | 4  | 15%   |
| <b>Totals</b>   | <b>1,839 (100%)</b>         | <b>252</b>                        | <b>106</b>                                       | <b>--</b>   |

**Figure 3-7** shows Upper Zone wells with recent (post-2000) nitrate measurements divided into two categories: (1) wells with all post-2000 nitrate measurements at or below the MCL of 10 mg/L as N; and (2) wells with at least one nitrate measurement exceeding the MCL of 10 mg/L as N. Upper Zone wells with recent nitrate data are sparse in the eastern and northeastern areas of the Management Zone. Upper Zone wells with measured nitrate above the MCL are scattered throughout the Management Zone, with most located in the western portion of the Management Zone.

The high resolution CV-SALTS spatial analysis (CVSALTS 2016b) of nitrate in the Upper Zone was updated for this Preliminary Management Zone Proposal using the updated Upper Zone post-2000 nitrate dataset developed and described above. This update included the following steps:

- Temporal declustering: Annual average nitrate concentrations were calculated for each well for the years 2000-2018; those annual averages were then averaged to yield one average nitrate concentration representing recent conditions.
- Upper Zone wells outside the Management Zone and within a buffer zone of three miles around the Management Zone boundary were compiled and used in the updated high resolution analysis because nitrate occurrence does not cease at the border of the Management Zone.
- Geospatial interpolation of the well point data was performed (kriging) using a search radius of 1.5 miles.<sup>5</sup>
- Gap areas were shown to exist where post-2000 Upper Zone nitrate well data were insufficient to produce the spatial interpolation using the 1.5 mile search criterion.

<sup>5</sup> The 1.5 mile search radius was selected to refine the local ambient nitrate mapping for the proposed Management Zone and recognize the potential variability inherent in groundwater nitrate concentrations spatially. This search radius reduces the reliance on well data from farther away that may not represent local nitrate conditions.



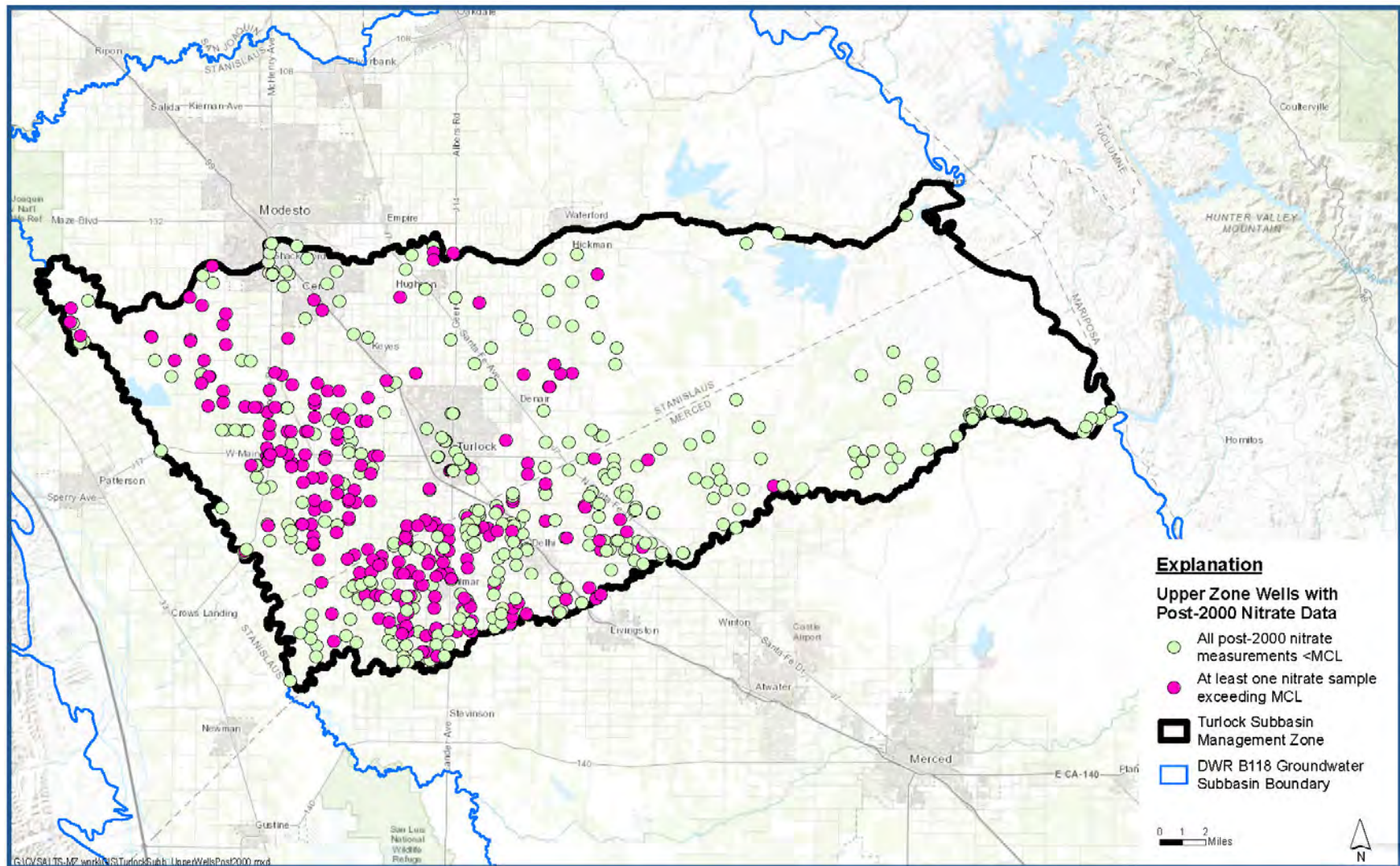


Figure 3-7. Upper Zone Wells with Nitrate Data and Nitrate MCL Exceedances

**Figure 3-8** illustrates the average post-2000 nitrate concentrations for all Upper Zone wells in the proposed Management Zone and control points in the 3-mile buffer. This figure also shows the interpolated ambient Upper Zone post-2000 nitrate as well as the gap areas where insufficient Upper Zone nitrate data exist. High nitrate concentrations exist throughout the Management Zone, particularly in the western half. Insufficient recent Upper Zone nitrate data are available in the eastern half of the Management Zone to fully assess the extent of potential nitrate contamination.



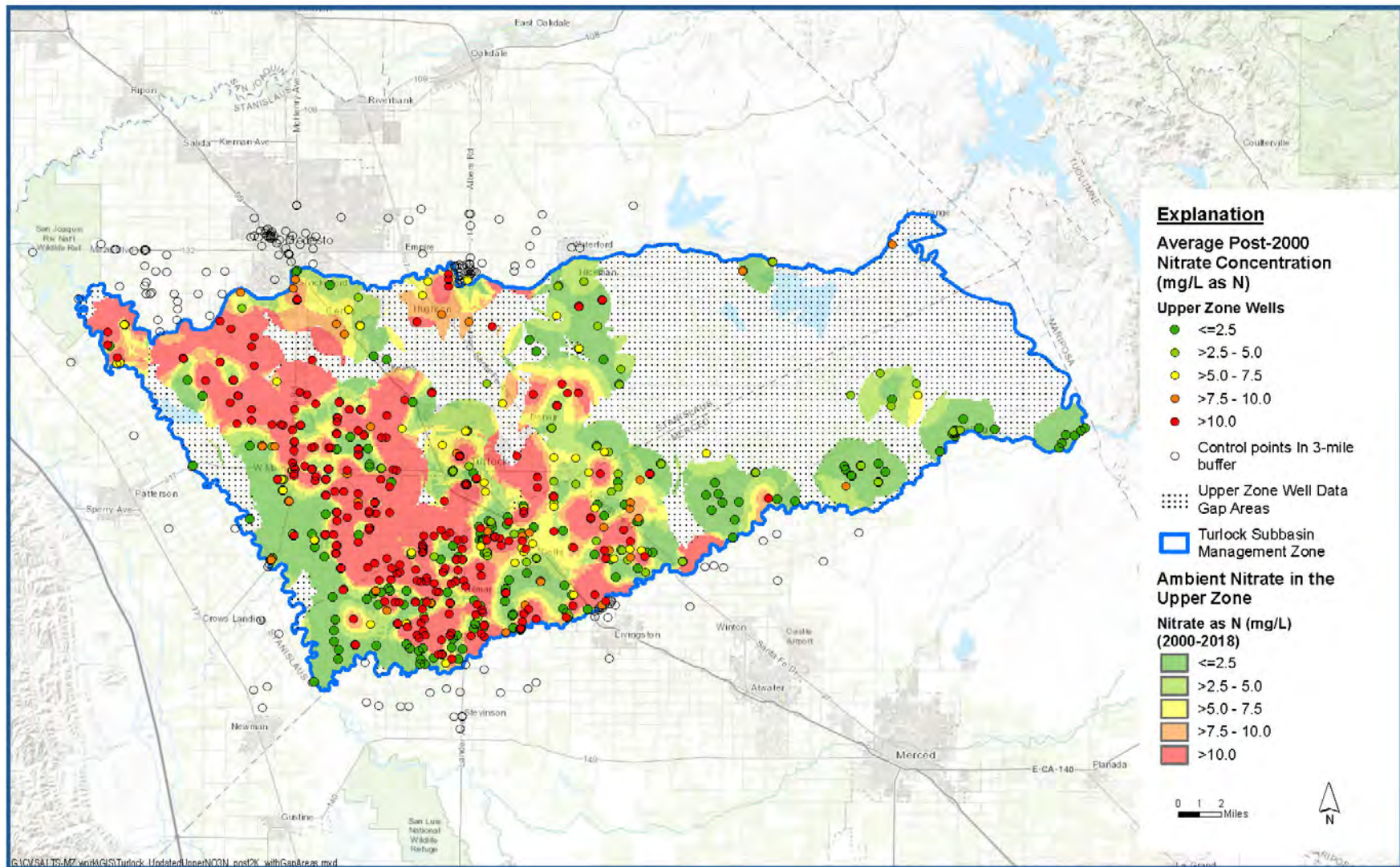


Figure 3-8. Ambient Post-2000 Nitrate Concentrations in the Upper Zone of Groundwater Underlying the Proposed Management Zone