Section 3: Salt & Nutrient Characterization

3.1 Salts and Nutrients – What are they and where do they come from?

The purpose of the SNMP is to address the management of salts and nutrients from various sources within the basin. This section explains how the appropriate constituents were selected to be addressed in this SNMP. Identification of existing and future sources of salts and nutrients is necessary for assessing constituent loads and analyzing impacts on basin groundwater quality.

The stakeholders developed a list of relevant salts, nutrients, and other constituents. The list includes total dissolved solids, chloride, and nitrate as they are typically associated with recycled water use. Arsenic, boron, and fluoride were included because these constituents have been detected at elevated concentrations in parts of the region. Chromium was added to the list at the request of Regional Board staff because both trivalent and hexavalent forms of chromium are known to naturally exist in the groundwater of the Antelope Valley Basin, as well as other groundwater basins in the Lahontan region. Phosphorous, nitrogen, and potassium were considered since agriculture is important in the Antelope Valley and these nutrients are associated with fertilizers and livestock waste. However, only nitrogen, in the form of nitrate, is found in the local groundwater. Each constituent is discussed below.

3.1.1 Total Dissolved Solids

Salinity in groundwater is typically characterized by measuring the water's electrical conductivity or the total dissolved solids (TDS) level. TDS represents the overall mineral content and is considered the more accurate indicator of salinity in water. Most TDS sources are anthropogenic in nature and include, but are not limited to, agricultural runoff, point source water pollution, and industrial and sewage discharge. Inorganic sources include minerals commonly found in nature through the weathering and dissolution of rocks and organic material from decaying organisms, plants, and animals.

There are no known health effects associated with the ingestion of TDS in drinking water. In California, TDS has secondary maximum contaminant levels (SMCL) and are regulated under Title 22 of the California Code of Regulations, particularly Secondary Drinking Water Standards, which are intended to control the aesthetic qualities (taste, odor and color) of drinking water. The TDS SMCL is made up of a range of consumer acceptance levels and includes a 500 mg/L "recommended" level, a 1,000 mg/L "upper" level, and a 1,500 mg/L "short term" level. High TDS concentrations can negatively impact sensitive crops. Based on guidelines from the Food and Agriculture Organization of the United Nations (FAO), TDS concentrations below 450 mg/L should not restrict a water's use for irrigation (i.e. crop selection or the irrigation management program should not have to be altered to accommodate the salinity level), levels between 450 and below 2000 mg/L can be slightly to moderately restrictive on crop selection and/or irrigation practices, and levels greater than 2000 mg/L may severely restrict effective irrigation use to only high salinity tolerant crops.

Based on available data between 2001 and 2010, average TDS concentrations in the Antelope Valley groundwater basin ranges from 122 mg/L to 1380 mg/L. Of the 58 wells analyzed in the Lancaster sub-basin, seven exceeded the recommended SMCL and only one well exceeded the upper SMCL. SMCLs are not enforceable standards and, as previously stated, are not health-threatening and are only set to protect the aesthetics of water.

3.1.2 Chloride

Chloride is widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$). Chloride is essential for metabolism (the process of turning food into energy) and help keep the body's acid-base balance.

Chloride in groundwater is naturally occurring from weathering of rocks, atmospheric deposition, and human uses and resulting wastes. As with TDS, many sources of chloride are anthropogenic. Sources of chloride from human use include food condiment and preservative, potash fertilizers, animal feed additive, production of industrial chemicals, dissolution of deicing salts, and treatment of drinking water and wastewater. Release of brines from industrial processes, leaching from landfills and fertilized soils, discharge of treated water from wastewater treatment facilities, infiltration from septic tank systems and irrigation activities, and other consumptive uses affect chloride in groundwater.

One commonly discussed source of chloride to the environment is from self-generating water softeners that use rock salt or potassium chloride pellets to treat hard water. These types of water softeners discharge a brine consisting of concentrated chloride levels. This briny waste may be discharged into the sewer system and then treated by a process that does not remove the chloride. Therefore, the salty waste may be released into the treatment plant's discharge location. Although the imported water to the Antelope Valley is considered only moderately hard (between 60 and 120 mg/L as CaO_3), it is possible that the use of self-generating water softeners exists in the region. Between 2009 and 2013, average chloride levels in imported water and the Lancaster Water Reclamation Plant (WRP) was 74 and 97 mg/L, respectively. The 23 mg/L increase in chloride concentration is within the 20 to 50 mg/L range expected for typical domestic water use. Based on these results, it is presumed that chloride-releasing water softeners are not widely used in the Antelope Valley at present.

As with TDS, there are no known health effects associated with the ingestion of chloride in drinking water. However, chloride concentrations in excess of 250 mg/L can affect taste. Chloride is regulated under the Secondary Drinking Water Standards and has SMCLs consisting of a 250 mg/L "recommended" level, a 500 mg/L "upper" level, and a 600 mg/L "short term" level. Elevated chloride concentrations can negatively impact sensitive crops. According to FAO guidelines, the most chloride sensitive crops are avocado, strawberries, and Indian Summer raspberries, which are not commercially grown in the Antelope Valley. The most chloride sensitive crops that are grown in the Antelope Valley are a variety of grapes, stone fruits, and citrus crops. These crops have a chloride tolerance up to 238 mg/L.

Based on available data, average chloride concentrations in the groundwater basin ranges from 3.17 mg/L to 180 mg/L. No wells exceeded the recommended SMCL standard.

3.1.3 Nitrate

Nitrate is a naturally occurring form of nitrogen. Nitrogen is essential to all life, including many crop plants which require large quantities to sustain high yields. Nitrate is found in groundwater and is a principal by-product of fertilizers. Other sources of nitrate include land use activities such as irrigation farming of crops, high density animal operations, wastewater treatment, food processing facilities and septic tank systems.

Nitrate is regulated under the Primary Drinking Water Standards and has a maximum contaminant level (MCL) of 10 mg/L as nitrogen (N). Nitrate in drinking water at levels above the MCL is a health risk for infants of less than six months of age. Such nitrate levels can interfere with the capacity of the infant's blood to carry oxygen, resulting in a serious illness; symptoms include shortness of breath and blueness of the skin (methemoglobin or "blue baby syndrome"). High nitrate levels may also affect the ability of the blood to carry oxygen in other individuals, such as pregnant women and those with certain specific enzyme deficiencies.

Based on available data, average nitrate concentrations in the groundwater basin ranges from non-detect (ND) to 3.69 mg/L as N. ND levels for nitrate are concentrations below the nitrate DLR (Detection Limit for purposes of Reporting) of 0.4 mg/L as N. About half of the wells analyzed had nitrate concentrations below the DLR. No wells exceeded the MCL standard.

3.1.4 Arsenic

Arsenic is an odorless and tasteless semi-metal element. It enters drinking water supplies from natural deposits in the earth or from agricultural and industrial practices. Higher levels of arsenic tend to be found more in groundwater sources than in surface water sources (i.e., lakes and rivers) of drinking water. The demand on ground water from municipal systems and private drinking water wells may cause water levels to drop and release arsenic from rock formations.

Arsenic has an MCL of 10 µg/L and is known to cause cancer in humans at high concentrations and is linked to other health effects such as skin damage and circulatory problems. The arsenic drinking water standard balances the current understanding of arsenic's possible health effects against the costs of removing arsenic from drinking water. Arsenic has the potential to reduce agricultural productivity. The FAO guidelines recommend a maximum concentration of 100 µg/L in irrigation water.

Based on available data, average arsenic concentrations in the groundwater basin ranges from ND (less than 2 µg/L) to 78 µg/L. Nineteen of the 55 wells within the Lancaster sub-basin exceed the arsenic MCL. Twelve of these high arsenic wells, including the 78 µg/L arsenic concentration, are located outside the more populated urbanized areas in the Antelope Valley.

Elevated arsenic levels are localized and are not a widespread problem in the region. Most drinking water wells with arsenic concentrations above 10 µg/L have been shut down and/or abandoned. Other options for high arsenic wells also include wellhead treatment for removing arsenic and implementing blending plans with lower arsenic concentration sources to decrease the arsenic level to below eighty percent of the MCL or 8 µg/L.

3.1.5 Chromium

Chromium is an odorless and tasteless metallic element. Chromium is found naturally in rocks, plants, soil and volcanic dust, and animals. The most common forms of chromium that occur in natural waters in the environment are trivalent chromium (chromium-3) and hexavalent chromium (chromium-6).

Chromium-3 is an essential human dietary element and is found in many vegetables, fruits, meats, grains and yeast. Chromium-6 occurs naturally in the environment from the erosion of natural chromium deposits, and it can also be produced by industrial processes (e.g., electroplating and metal finishing operations). There are demonstrated instances of chromium being released to the environment by leakage, poor storage or inadequate industrial waste disposal practices.

Chromium-6 has been known to cause cancer when inhaled and has also been linked to cancer when ingested. Chromium-6 is regulated under the State Primary Drinking Water Standard for total chromium, which has a State MCL of 50 µg/L. The State standard is more health protective than the National standard of 100 µg/L. The State total chromium MCL was established in 1977 to address the non-cancer toxic effects of chromium-6, and also includes the chromium-3 form. On July 1, 2014, the California Department of Public Health (CDPH) adopted a specific chromium-6 drinking water standard of 10 µg/L. . The chromium-6 MCL is one-fifth the level of the current total chromium MCL and is expected to reduce the theoretical cancer risk statewide from exposure to chromium-6.

Based on available data, average total chromium concentrations in the groundwater basin ranges from ND (less than 10 µg/L) to 13 µg/L. No wells exceeded the MCL standard for total chromium.

3.1.6 Fluoride

Fluoride compounds are salts that form when the element, fluorine, combines with minerals in soil or rocks. Some fluoride compounds, such as sodium fluoride and fluorosilicates, dissolve easily into groundwater as it moves through gaps and pore spaces between rocks. Most water supplies contain some naturally occurring fluoride. Fluoride also enters drinking water in discharge from fertilizer or aluminum factories. Also, many communities add fluoride to their drinking water to promote dental health.

Exposure to excessive consumption of fluoride over a lifetime may lead to increased likelihood of bone fractures in adults, and may result in effects on bone leading to pain and tenderness. Children aged 8 years and younger exposed to excessive amounts of fluoride have an increased chance of developing pits in the tooth enamel, along with a range of cosmetic effects to teeth.

Based on available data, average fluoride concentrations in the groundwater basin ranges from 0.13 mg/L to 5.5 mg/L. Two wells exceeded the fluoride MCL of 2 mg/L.

The agricultural water goal for fluoride was established by the FAO and National Academy of Sciences to protect livestock from tooth mottling and bone problems. The upper limit guideline for fluoride is 2.0 mg/L. Low fluoride levels below 1 mg/L are beneficial to both animals and humans.

3.1.7 Boron

Boron is a naturally-occurring element found in rocks, soil, and water. Human causes of boron contamination include releases to air from power plants, chemical plants, and manufacturing facilities. Fertilizers, herbicides and industrial wastes are among the sources of soil contamination. Contamination of water can come directly from industrial wastewater and municipal sewage, as well as indirectly from air deposition and soil runoff. Boron compounds are used in the manufacture of glass, soaps and detergents and as flame retardants.

The general population obtains the greatest amount of boron through food intake, as it is naturally found in many edible plants. Boron is taken as health supplements to build strong bones, treat osteoarthritis, use as an aid for building muscles and increasing testosterone levels, and improve thinking skills and muscle coordination.

Boron has a State Notification Level (NL) of 1 mg/L. CDPH established these health-based advisory levels to provide information to public water systems and others about certain non-regulated chemicals in drinking water that lack MCLs. Based on available data, average boron concentrations in the groundwater basin ranges from ND (less than 0.1 mg/L) to 1.52 mg/L. Only one well exceeded the NL.

Boron can accumulate in a sensitive crop to concentrations high enough to cause crop damage and reduce yields. Damage results when boron is absorbed in significant amounts with the water taken up by the roots. Based on FAO guidelines, boron concentrations below 0.7 mg/L should not restrict a water's use for irrigation, slight to moderate restrictions may occur for levels below 3.0 mg/L, and severe restrictions may occur for levels above 3.0 mg/L.

3.2 Historical Salt and Nutrient Characterization of the Groundwater Basin

The salt and nutrient characterization is based on the historical water quality or baseline conditions of the Antelope Valley groundwater basin. The baseline condition is the average concentration of each constituent in groundwater during the ten year period between 2001 and 2010. At the recommendation of the Regional Board, the State Board's GeoTracker Groundwater Ambient Monitoring and Assessment[1] (GAMA) and the USGS National Water Information System[2] (NWIS) online databases were used to download the historical monitoring results to establish the baseline conditions. GAMA was used to obtain municipal water supply well data. NWIS was used to obtain USGS monitoring well data. Refer to Sections 3.2.1 and 3.2.2 for additional information about GAMA and NWIS.

Many private well owners were reluctant to share their groundwater well information. Many well owners have serious concerns regarding privacy issues, although assurances could be made that the well information would remain anonymous and used solely for the purpose of baseline water quality determinations. The stakeholder group determined that it would be more practical to use water quality information from the publicly available GAMA and NWIS databases.

The first draft of this SNMP, sent to stakeholders in June 2013, included two separate analyses for the baseline groundwater conditions. The first analyzed USGS monitoring well results from the NWIS database and the second, utilizing results from the GAMA database, considered both municipal water supply and USGS monitoring wells. During the draft SNMP review process, it was discovered that the GAMA database was missing some USGS monitoring data from the northerly (Gloster) and westerly (West Antelope) areas of the groundwater basin. This inconsistency was found to be due to a discrepancy between the Federal (USGS 1987) and State (DWR 2004) groundwater basin boundaries. The data from the two database sources was subsequently combined and the results are included in this report.

Table 3-1 provides a well count summary organized by constituent, sub-basin, and data source. This includes wells in areas of the region that are not considered part of the USGS established sub-basins. Much of these areas are located over bedrock and do not have separate sub-basin analysis. These areas, however, are within the SNMP study area and are included in the overall basin analysis. Seven of the sub-basins have less than three wells for some or all of the constituents. A significant portion of the region is sparsely or not populated and, therefore, has limited well data available on GAMA and NWIS. Per the Regional Board, three wells per sub-basin are preferred for statistical significance. The last two rows of the table are the number of GAMA and NWIS sourced wells for each constituent. For both sources, the well count differs for each constituent because each well was monitored for a different set of constituents.

As mentioned earlier, the constituents investigated in the SNMP include TDS, nitrate, chloride, arsenic, chromium, fluoride and boron. The average concentrations, or baseline conditions, of

[1] http://geotracker.waterboards.ca.gov/gama/
[2] http://waterdata.usgs.gov/nwis

each constituent were determined for each sub-basin and for the groundwater basin as a whole, see Table 3-2. No data from the 2001-2010 timeframe was available for the Chaffee, Finger Buttes, and Oak Creek sub-basins.

There are distinct water quality differences presented between sub-basins. Water quality for wells can also vary by depth. A discussion regarding vertical partitioning of water quality was requested by the Lahontan Regional Board. However, the data available from the GeoTracker GAMA or USGS NWIS databases is insufficient for water quality analysis by vertical partitioning.

Most of the water quality data for the investigated constituents were measured at levels that were well below the DLR, a parameter set by CDPH for most regulated analytes. The DLR parameters are not laboratory specific and are independent of the analytical methods used. Most State certified laboratories are capable of achieving a detection limit that is lower than or equal to the DLR. Chloride and TDS do not have a DLR.

Figures 3-1 through 3-14 illustrate the mean concentration of each constituent by well and by sub-basin. The well locations were mapped using approximate latitude and longitude coordinates downloaded from the GAMA and NWIS databases. Many coordinate locations represent a cluster of wells (multiple wells using the same coordinates).

The groundwater basin has generally good water quality. The overall basin concentration of each constituent meets the SNMP water quality management goals. Compared to the other sub-basins, North Muroc and Peerless generally have higher concentrations of TDS, chloride, chromium, fluoride, and boron. This is not a concern, however, as the concentrations for these constituents meet all drinking water regulations. As discussed in the previous section, these constituents are naturally occurring.

Arsenic is a concern in the Antelope Valley. The elevated arsenic concentrations in the Gloster, Neenach, North Muroc, Peerless, and Willow Springs sub-basins exceed the regulatory drinking water and SNMP water quality management goals. High arsenic in groundwater is naturally occurring, resulting from dissolution of rocks and minerals. Arsenic concentrations above the MCL of 10 µg/L are not used for potable applications. Wells with concentrations above the MCL are typically treated to remove arsenic, blended to dilute arsenic concentration, or shut down.

Table 3-1: Total Number of Wells Organized by Constituent, Sub-Basin, and Data Source

	Arsenic	Boron	Chloride	Fluoride	Nitrate as N	Total Chromium	TDS
Buttes	10	10	10	10	10	9	10
Chaffee	-	-	-	-	-	-	-
Gloster	2	2	2	2	-	-	2
Finger Buttes	-	-	-	-	-	-	-
Lancaster	223	178	218	220	184	171	220
Neenach	5	1	4	4	7	6	4
North Muroc	5	5	5	5	8	7	6
Oak Creek	-	-	-	-	-	-	-
Pearland	24	23	25	24	25	22	22
Peerless	2	2	2	2	2	2	2
West Antelope	1	1	1	1	1	-	1
Willow Springs	5	4	5	5	6	4	5
No Sub-Basin (a)	62	36	53	52	57	50	46
AV Groundwater Basin	339	262	325	325	300	271	318
GAMA (b)	262	195	255	256	283	253	249
NWIS (c)	77	67	70	69	17	18	69

(a) These wells are located in areas that are not considered part of the established sub-basins.
(b) GeoTracker Groundwater Ambient Monitoring and Assessment (GAMA) database
(c) USGS National Water Information System (NWIS) database

Table 3-2: Baseline Water Quality Concentrations in the Antelope Valley Groundwater Basin (2001 - 2010)

Sub-Basin	Arsenic (µg/L)	Boron (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate as N (mg/L)	Total Chromium (µg/L)	TDS (mg/L)
MCL	10	1 (a)	500 (b)	2	10	50	1000 (c)
DLR	2	0.1	N/A	0.1	0.4	10	N/A
Buttes	1.32	0.07	19.1	0.38	1.42	8.77	301
Chaffee	-	-	-	-	-	-	-
Gloster	50.65	0.20	12.2	0.51	-	-	404
Finger Buttes	-	-	-	-	-	-	-
Lancaster	8.88	0.14	35.2	0.43	1.53	6.10	325
Neenach	13.24	0.20	51.9	0.46	1.84	7.64	446
North Muroc	55.15	0.87	201.9	0.68	2.18	10.17	858
Oak Creek	-	-	-	-	-	-	-
Pearland	0.76	0.07	17.5	0.19	4.06	1.91	256
Peerless	27.46	0.87	68.8	1.48	2.72	4.17	547
West Antelope	8.93	0.77	19.7	0.35	3.69	-	403
Willow Springs	12.43	0.04	22.1	0.21	1.81	4.00	301
AV Groundwater Basin	**9.66**	**0.17**	**38.4**	**0.44**	**1.97**	**5.53**	**350**

(a) Boron NL is 1 mg/L. There is no drinking water standard (MCL) for Boron
(b) Chloride SMCL: Consists of a 250 mg/L recommended level, a 500 mg/L upper level, and a 600 mg/L short-term level.
(c) TDS SMCL: Consists of a 500 mg/L recommended level, a 1,000 mg/L upper level, and a 1,500 mg/L short-term level.

Figure 3-1: TDS Concentration Range by Well

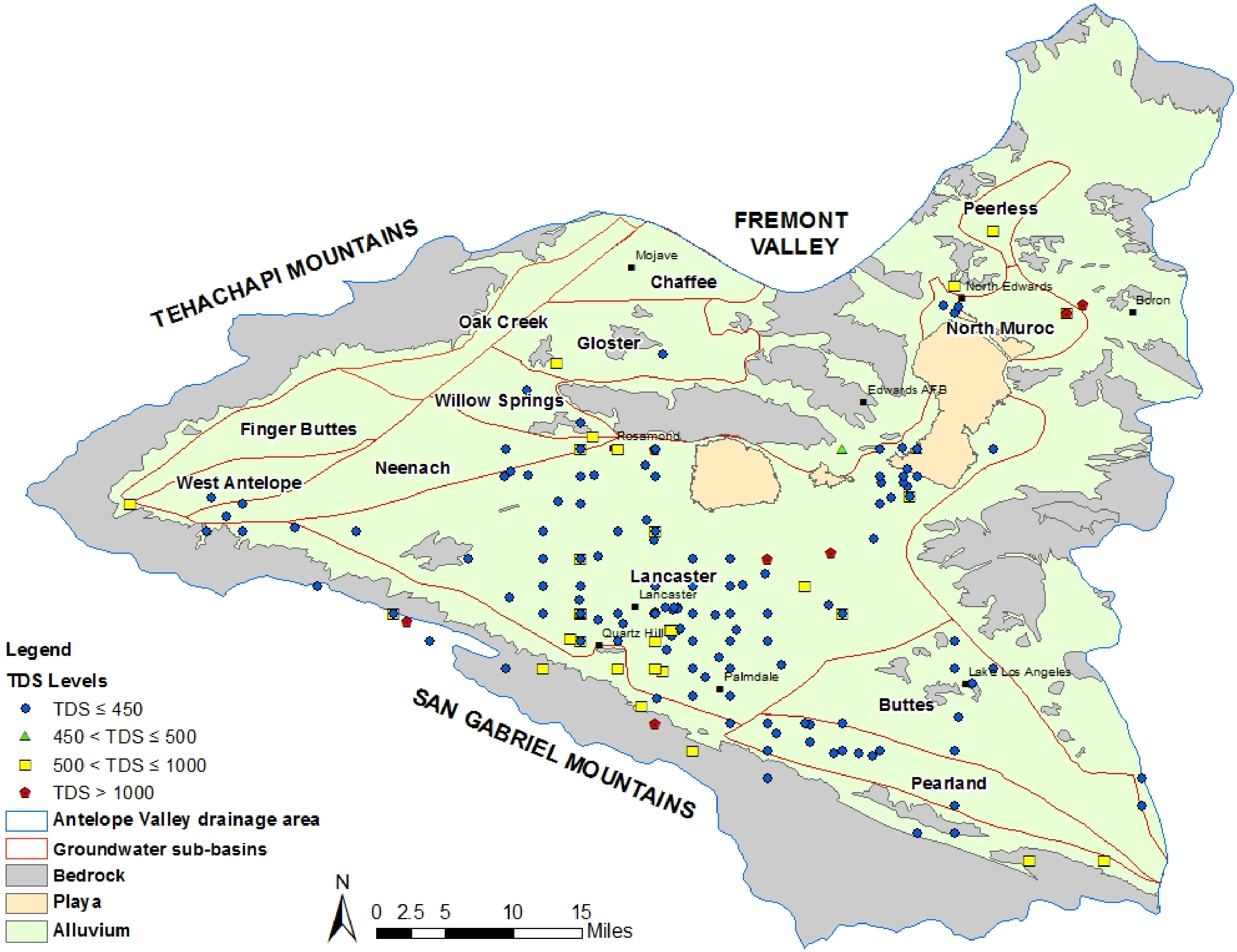


Figure 3-2: TDS Concentration Range by Sub-Basin

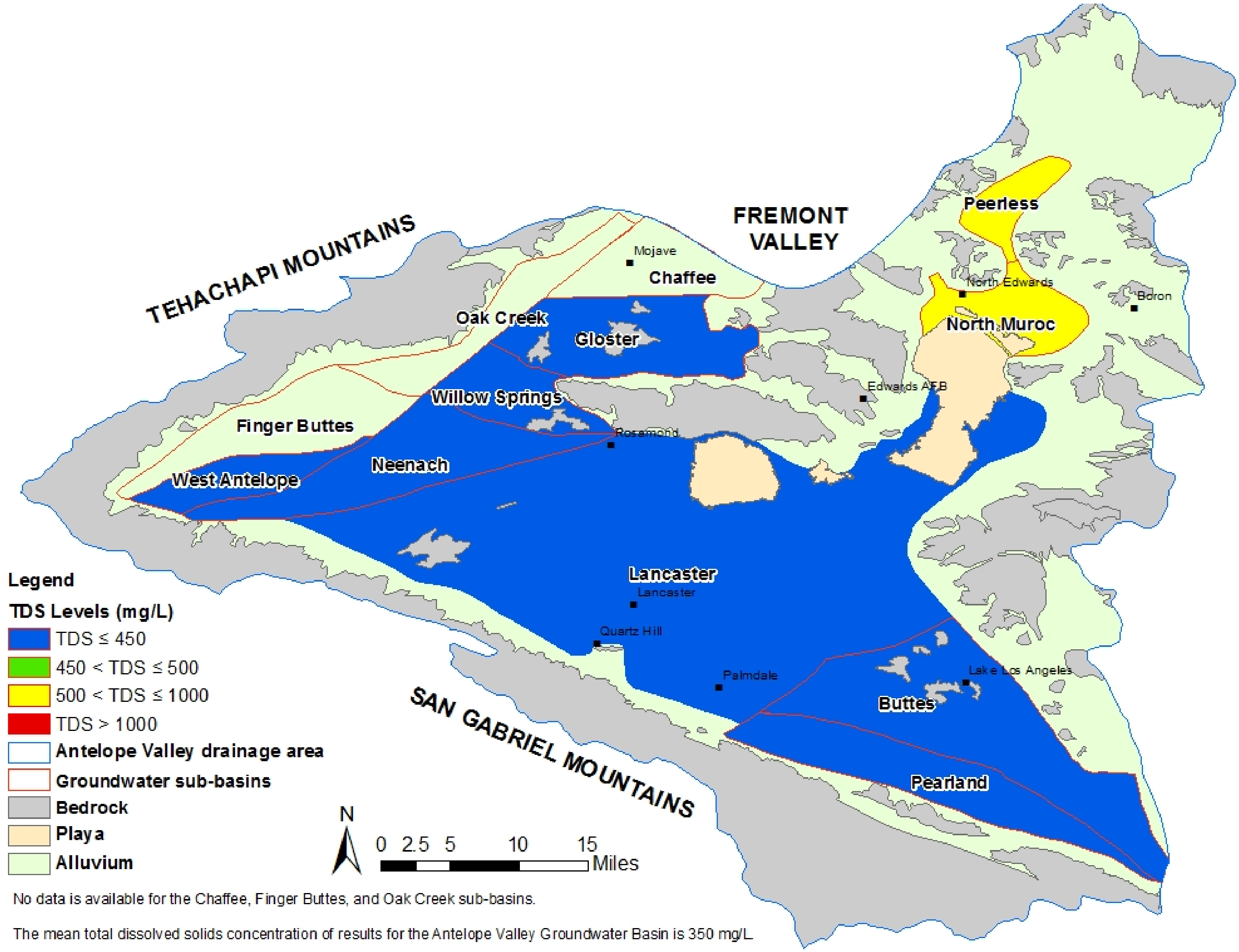


Figure 3-3: Chloride Concentration Range by Well

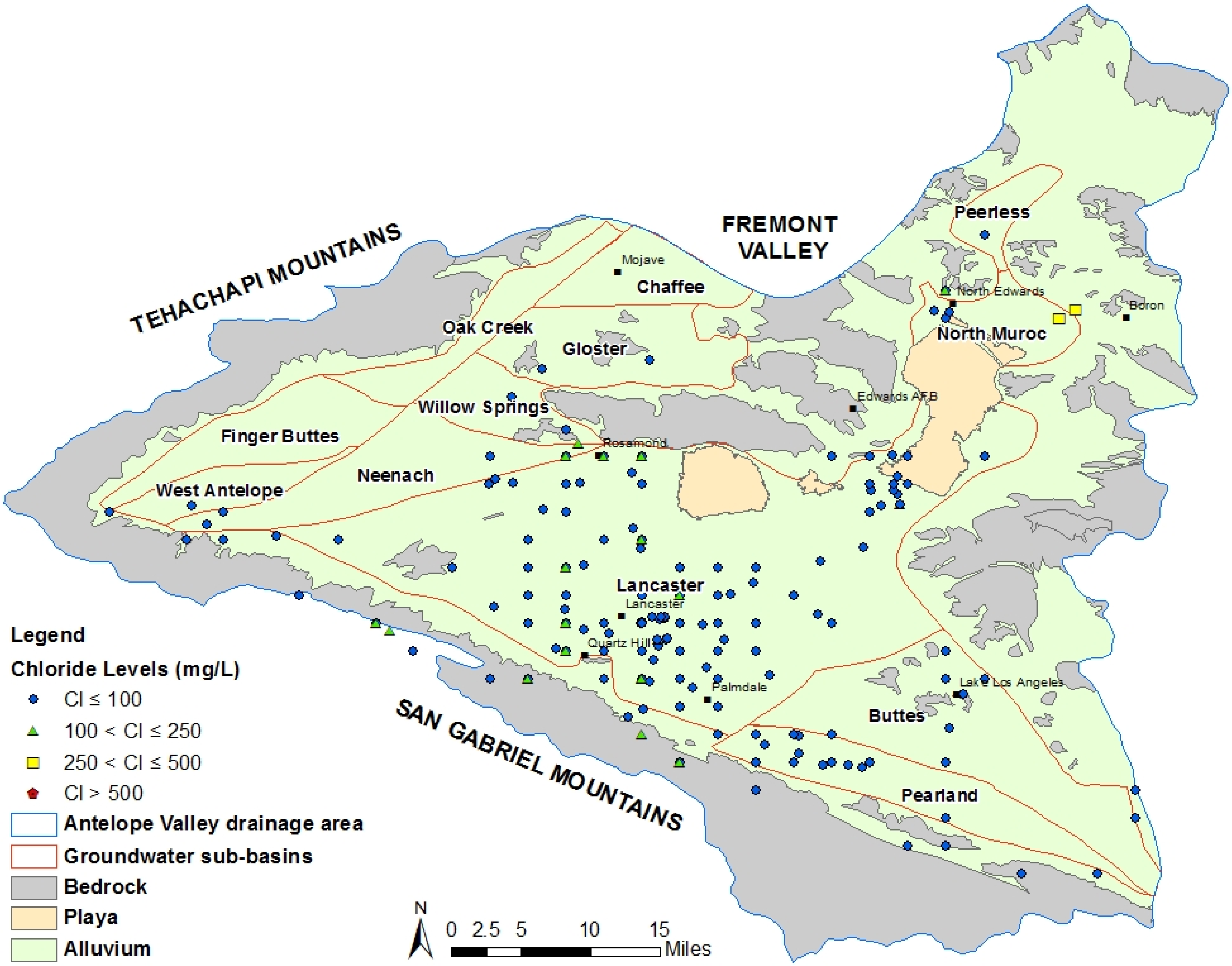
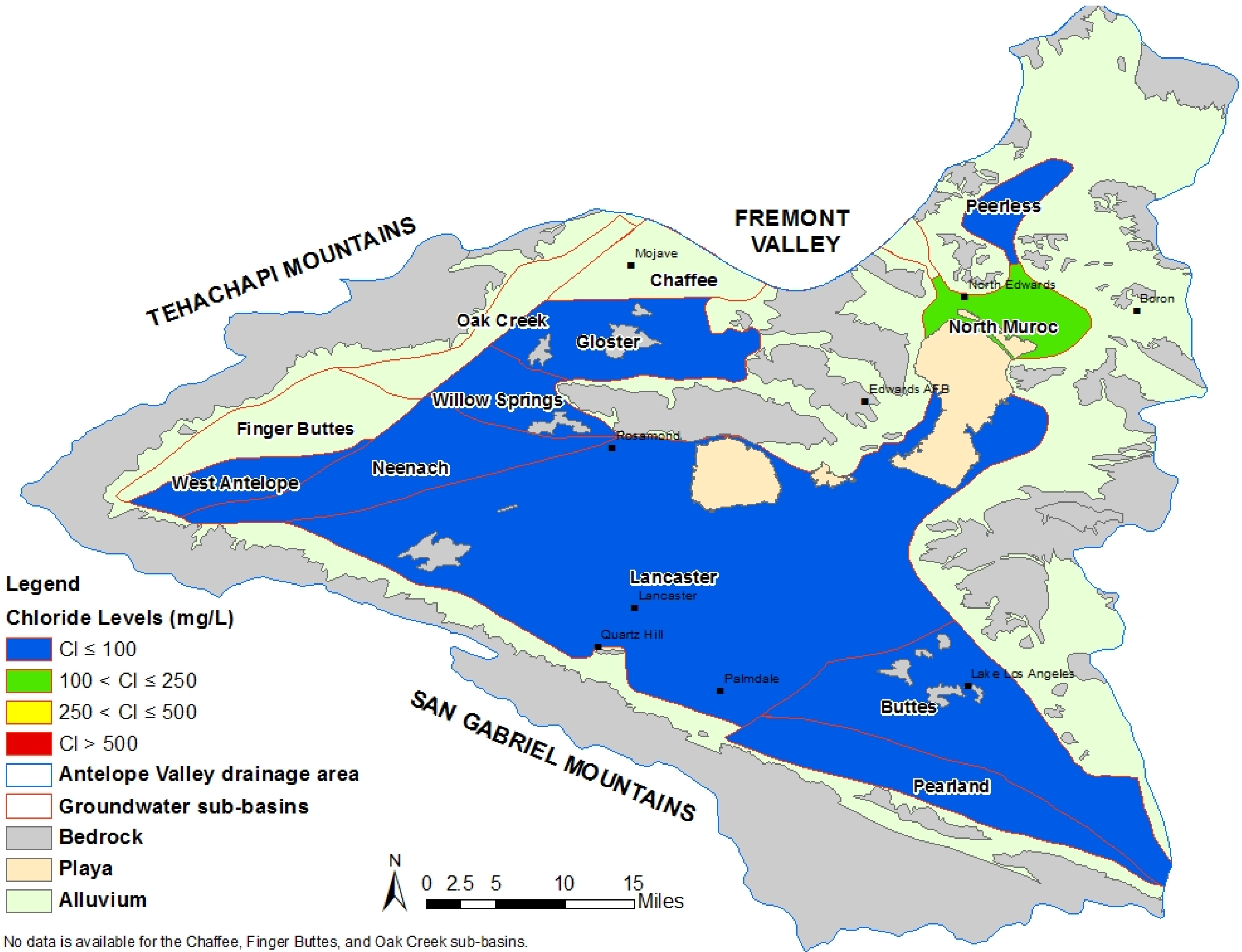


Figure 3-4: Chloride Concentration Range by Sub-Basin



No data is available for the Chaffee, Finger Buttes, and Oak Creek sub-basins.
The mean chloride concentration of results for the Antelope Valley Groundwater Basin is 38 mg/L.

Figure 3-5: Nitrate Concentration Range by Well

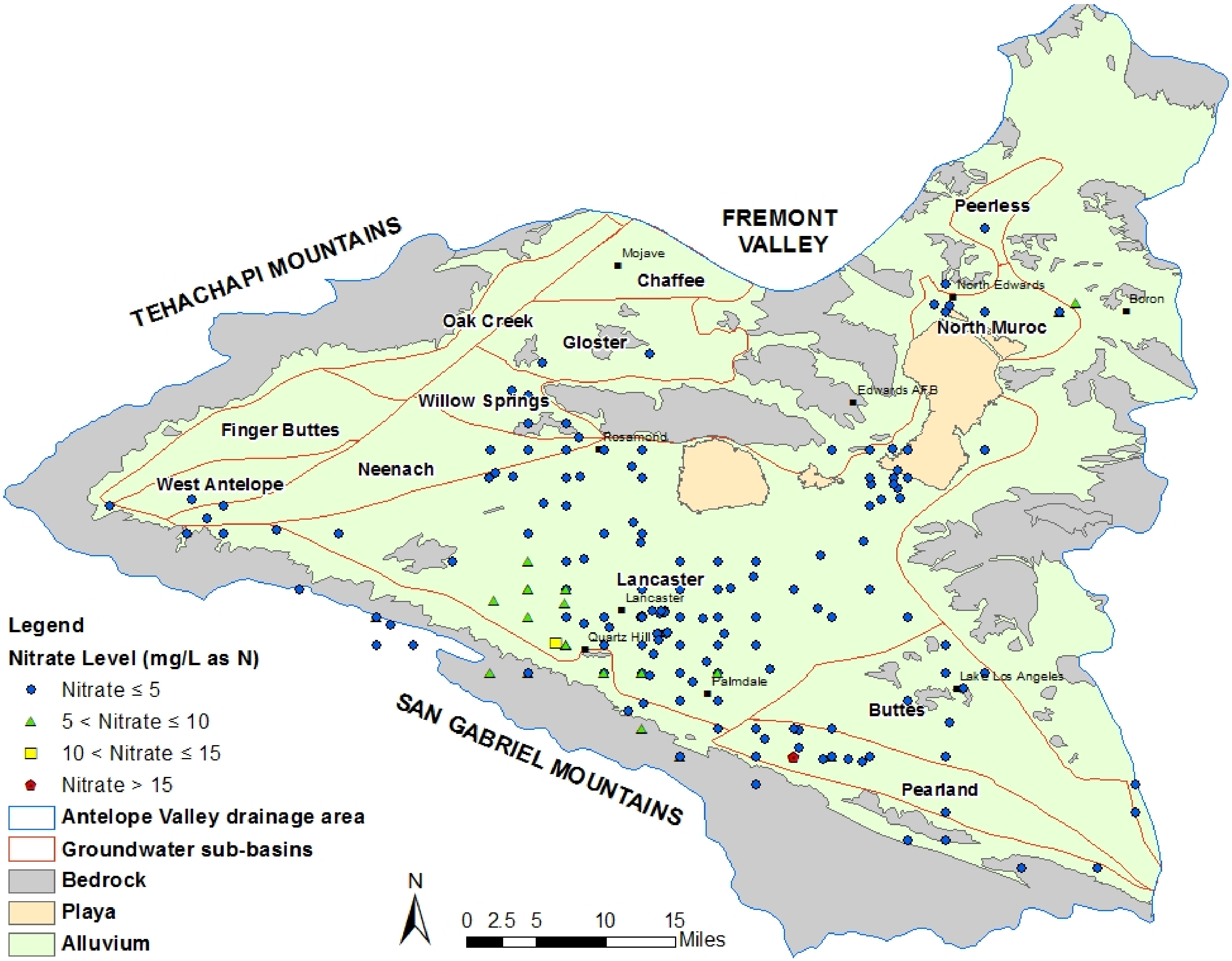
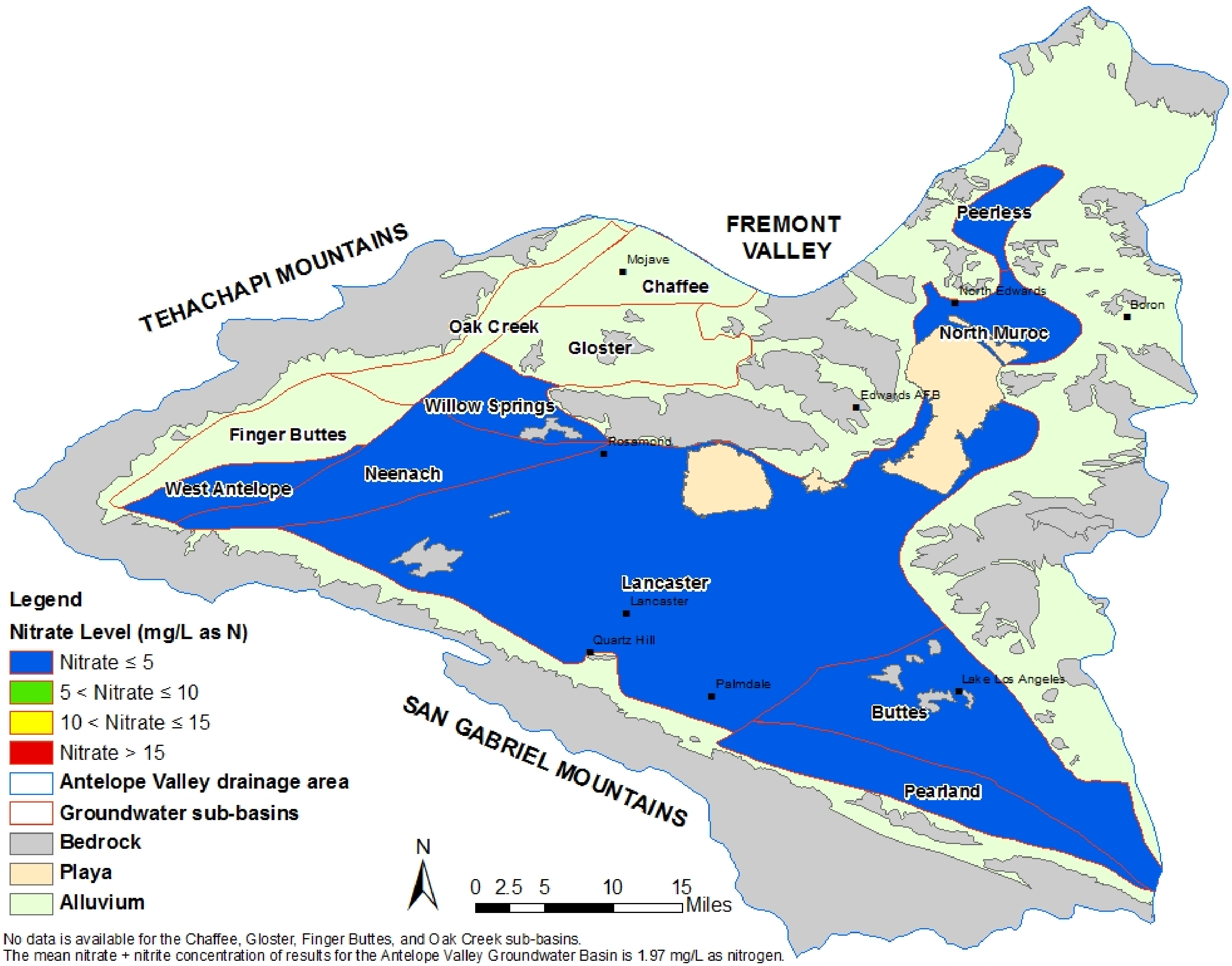


Figure 3-6: Nitrate Concentration Range by Sub-Basin



No data is available for the Chaffee, Gloster, Finger Buttes, and Oak Creek sub-basins.
The mean nitrate + nitrite concentration of results for the Antelope Valley Groundwater Basin is 1.97 mg/L as nitrogen.

Figure 3-7: Arsenic Concentration Range by Well

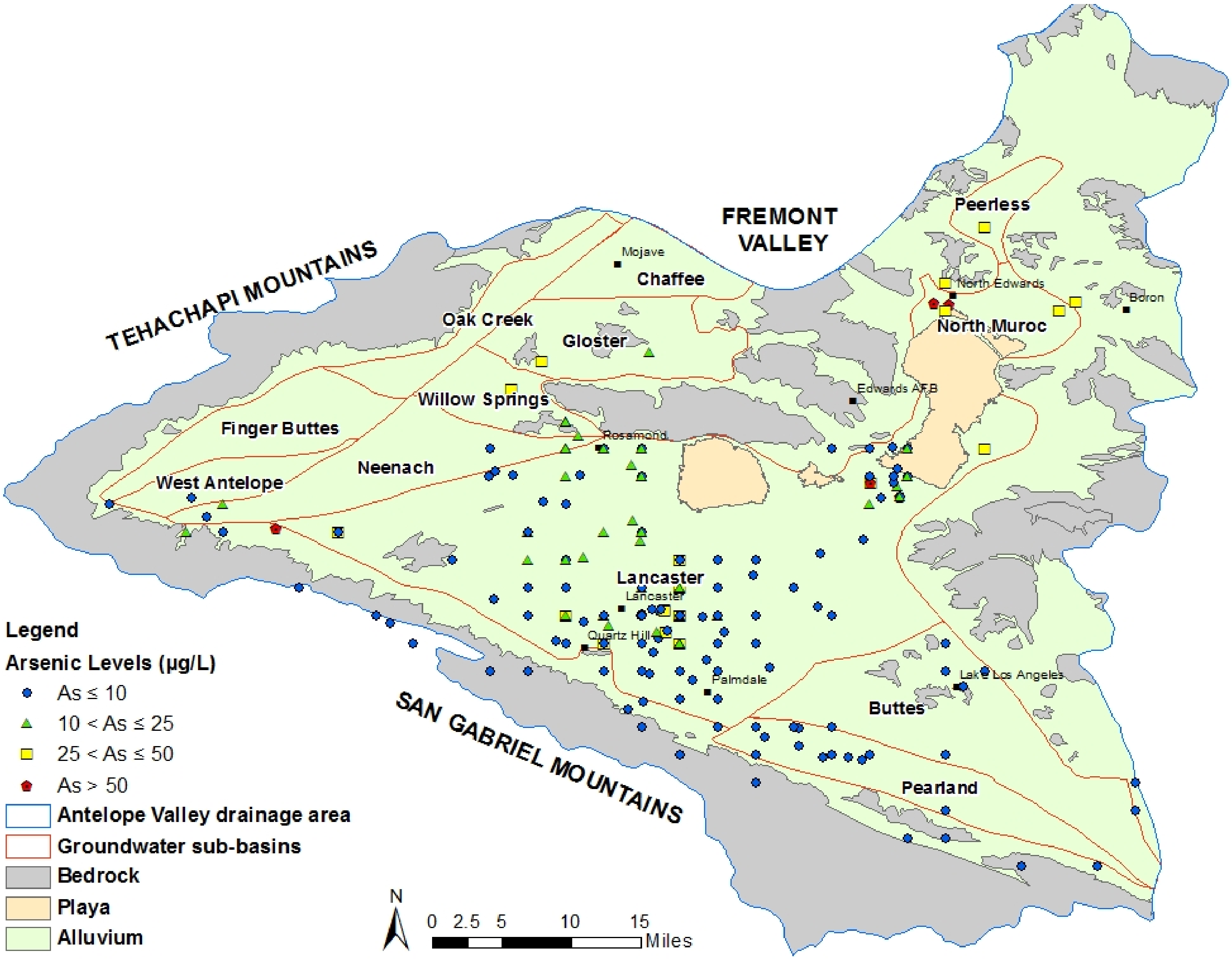
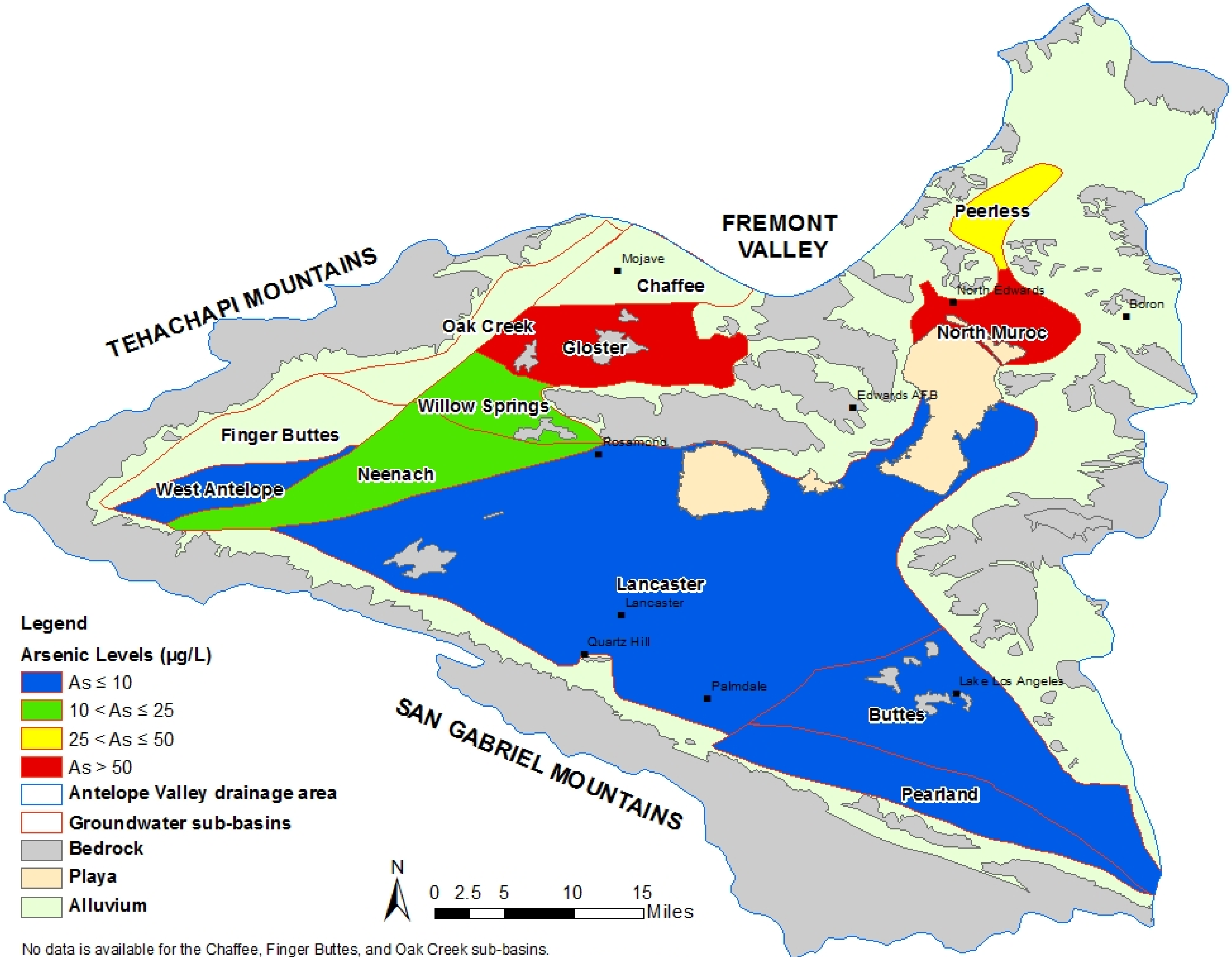


Figure 3-8: Arsenic Concentration Range by Sub-Basin



No data is available for the Chaffee, Finger Buttes, and Oak Creek sub-basins.
The mean arsenic concentration of results for the Antelope Valley Groundwater Basin is 9.66 μg/L.

Figure 3-9: Total Chromium Concentration Range by Well

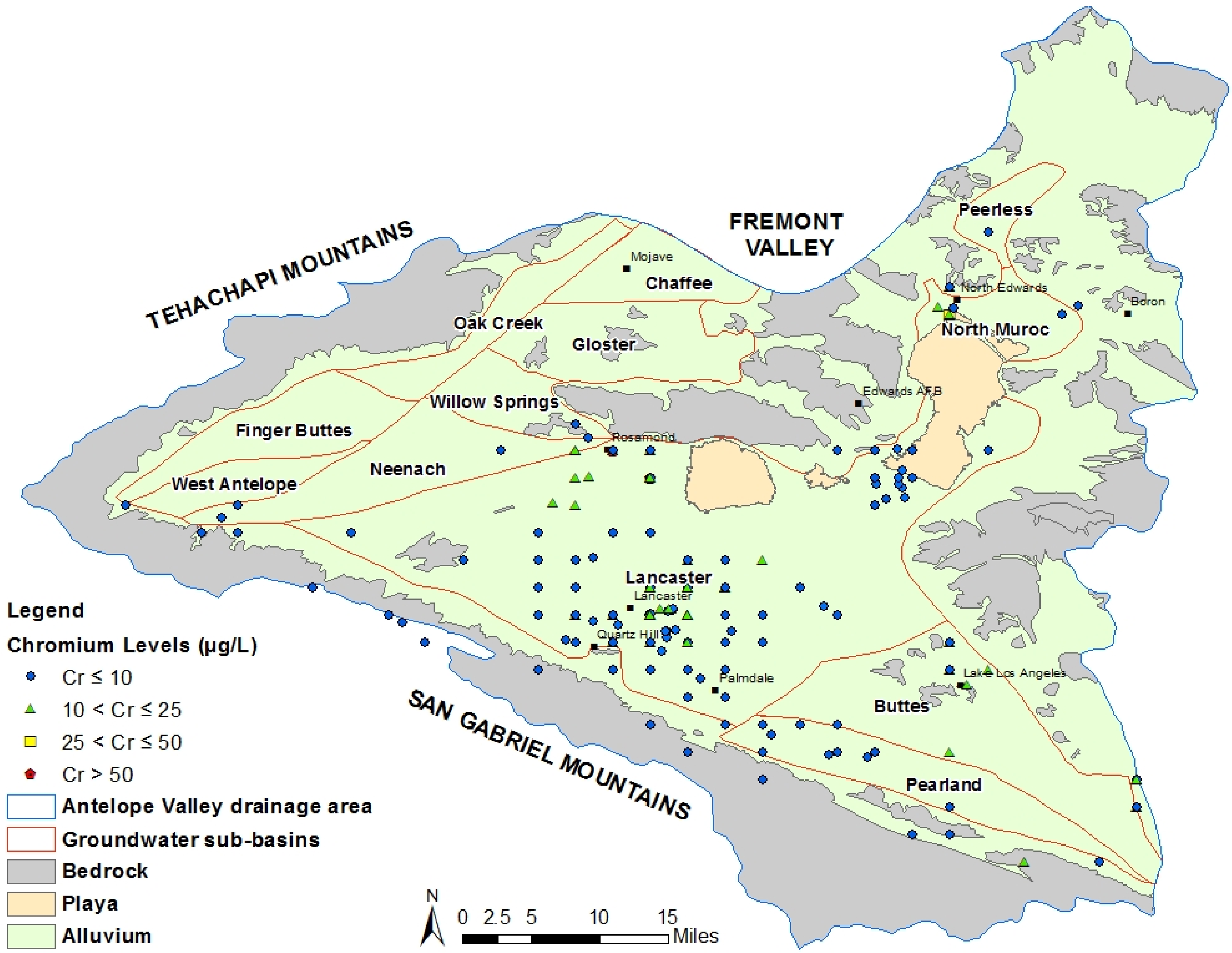


Figure 3-10: Total Chromium Concentration Range by Sub-Basin

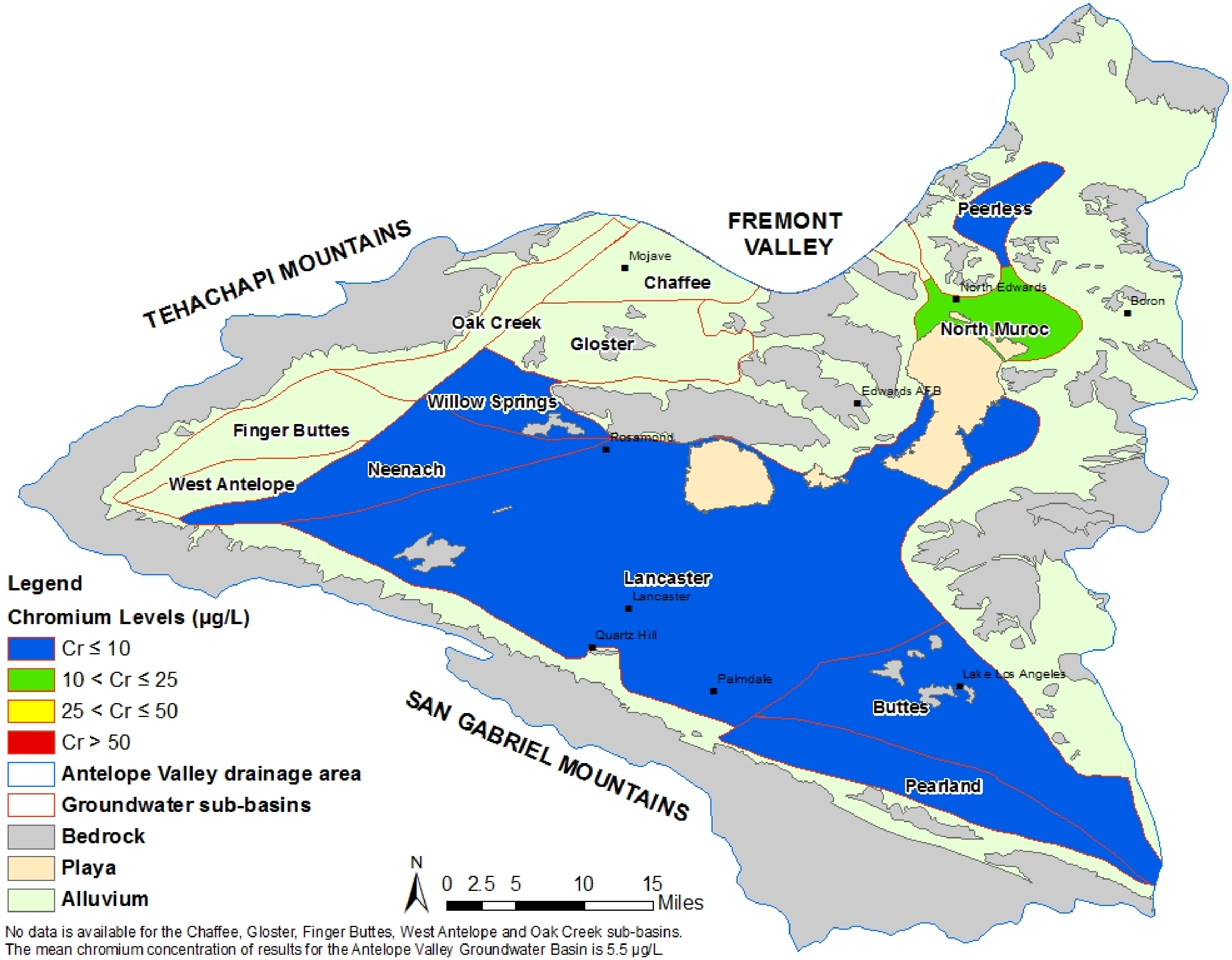


Figure 3-11: Fluoride Concentration Range by Well

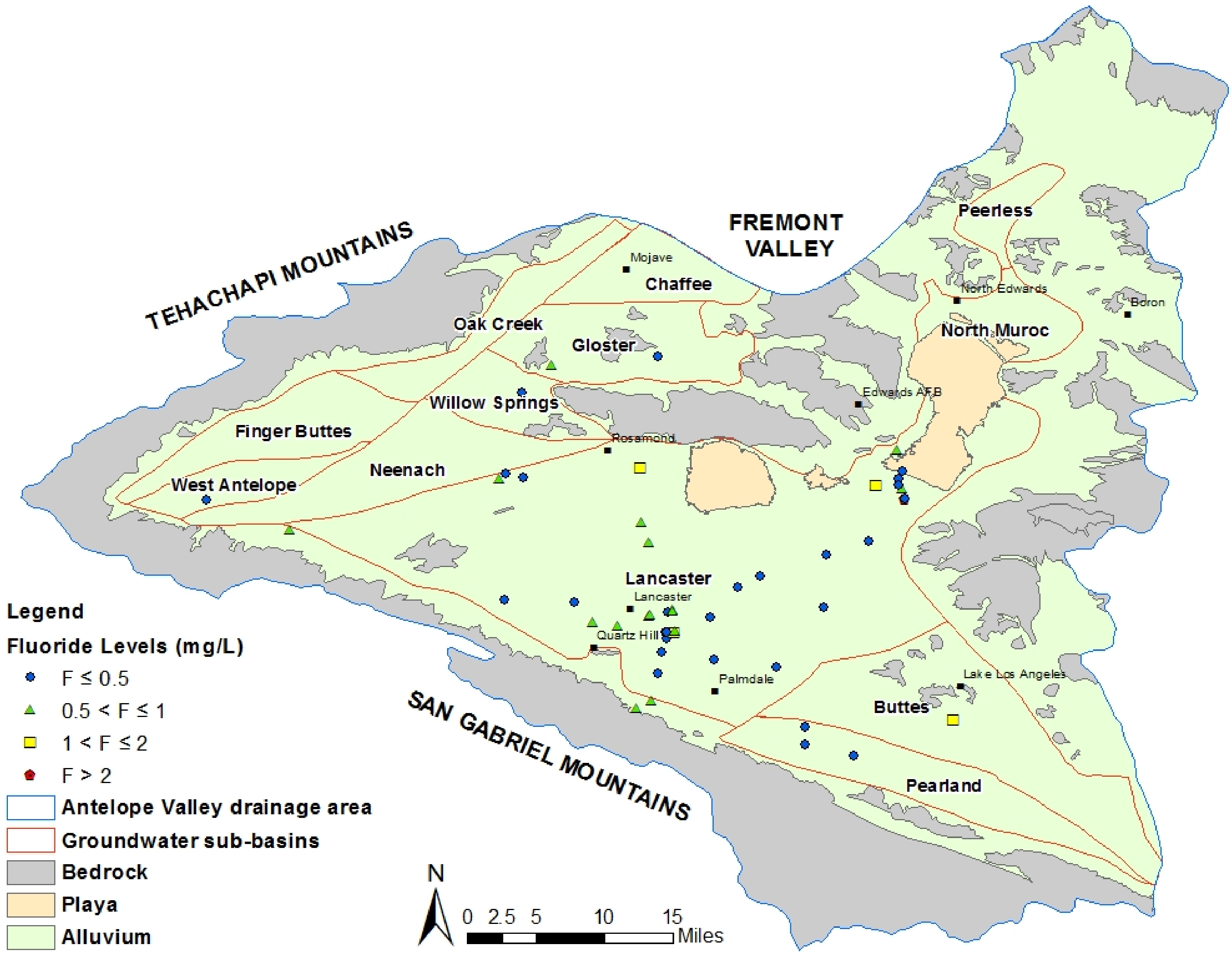
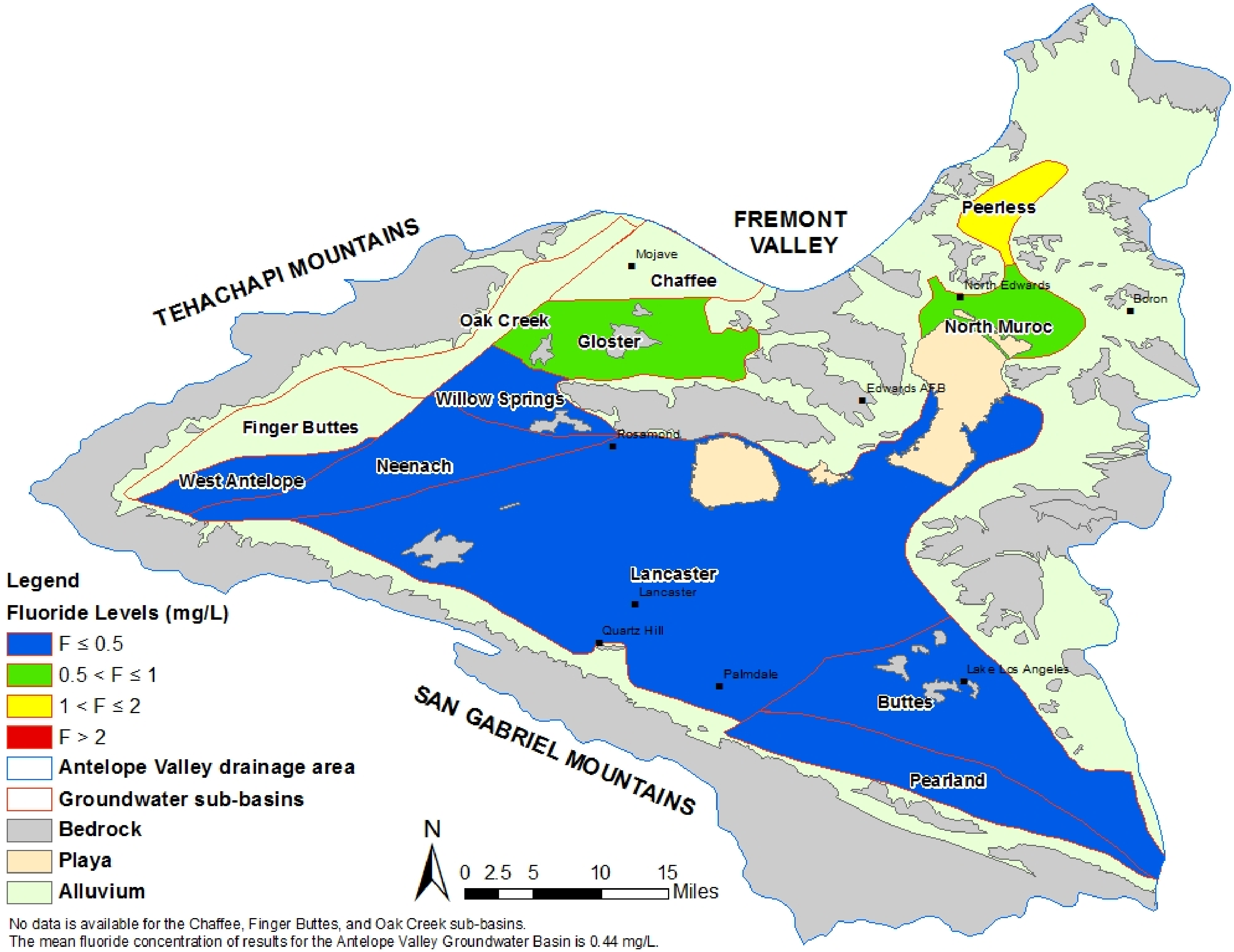


Figure 3-12: Fluoride Concentration Range by Sub-Basin



No data is available for the Chaffee, Finger Buttes, and Oak Creek sub-basins.
The mean fluoride concentration of results for the Antelope Valley Groundwater Basin is 0.44 mg/L.

Figure 3-13: Boron Concentration Range by Well

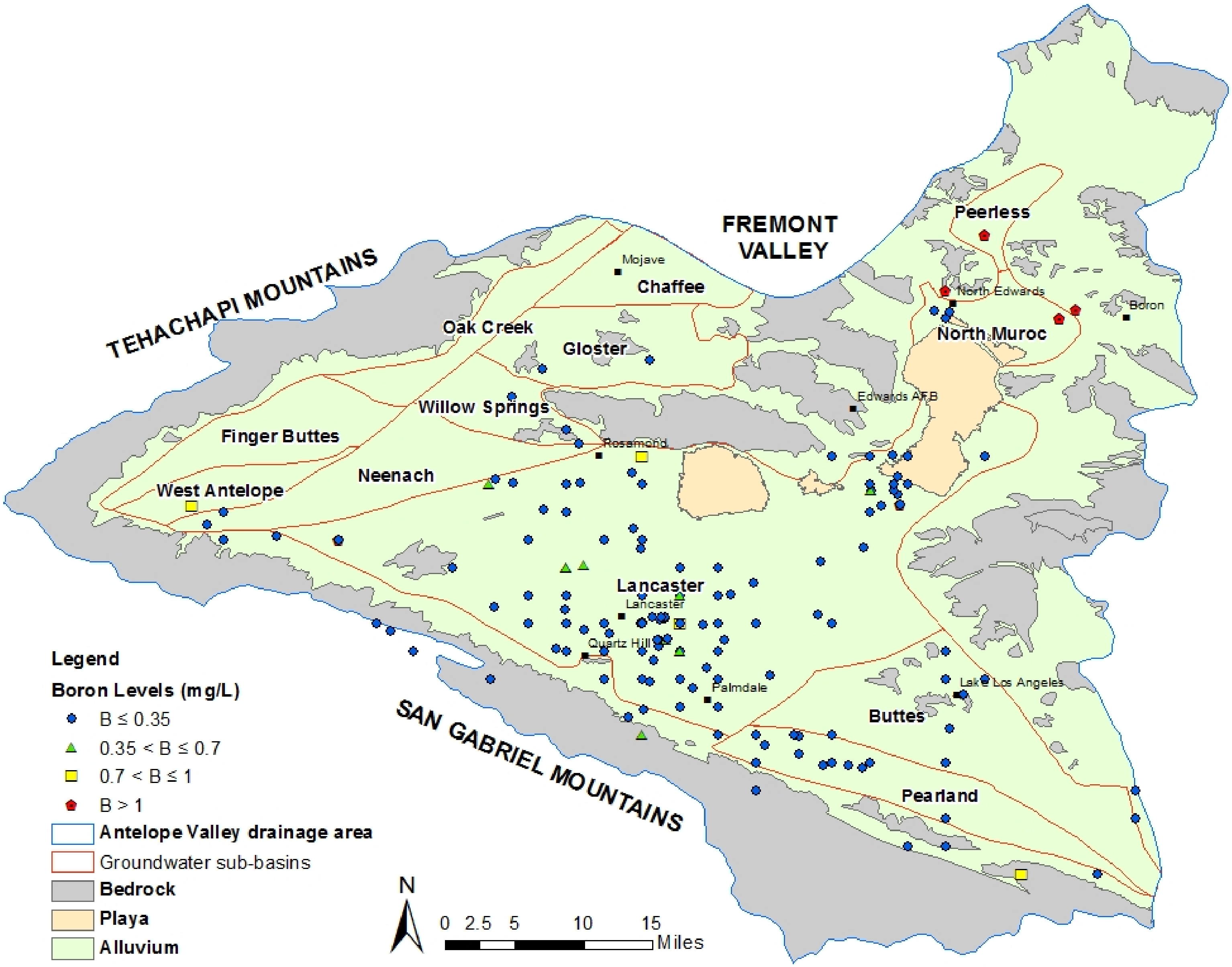
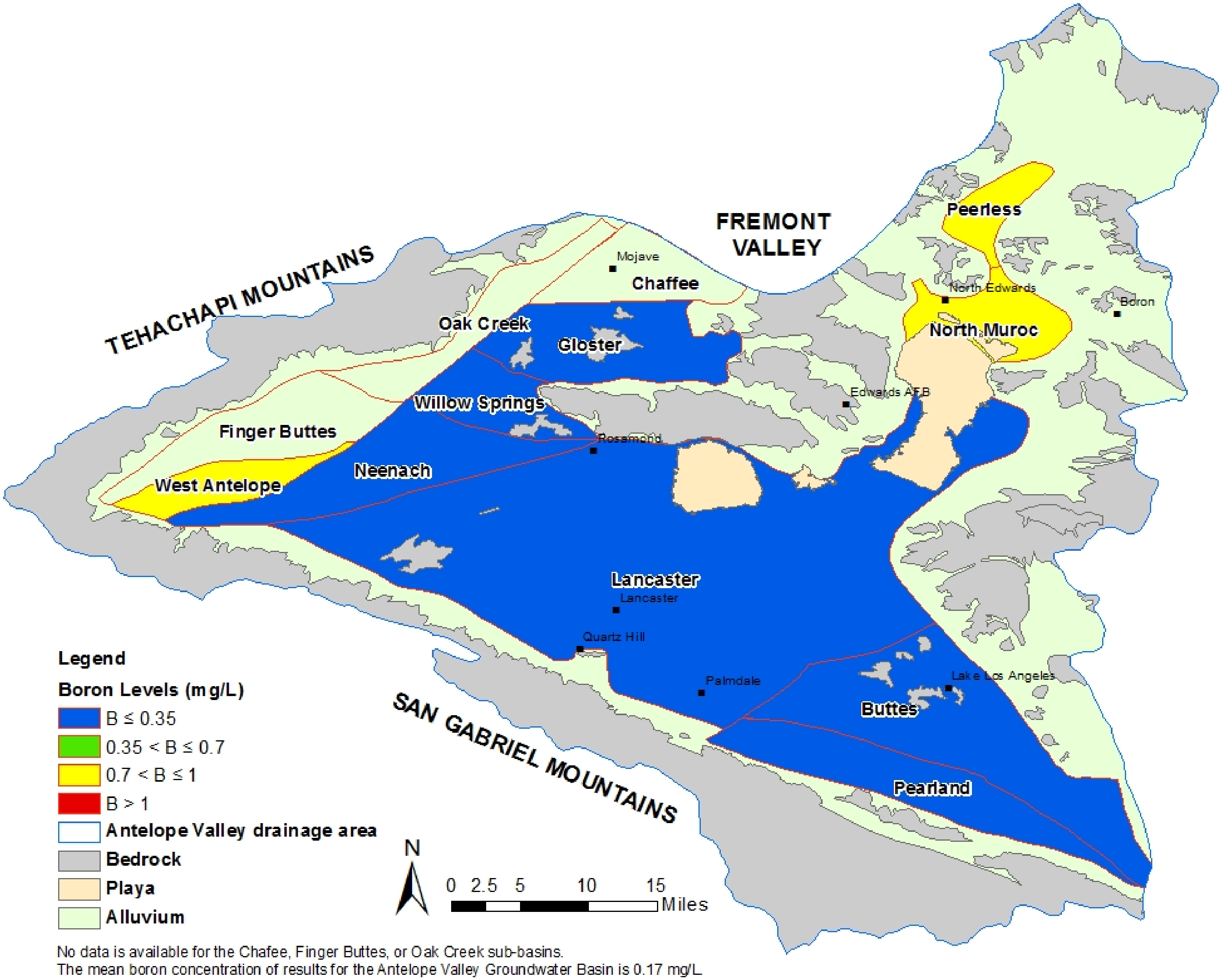


Figure 3-14: Boron Concentration Range by Sub-Basin



3.2.1 GeoTracker Groundwater Ambient Monitoring and Assessment Database

The State Board's GeoTracker GAMA database integrates data from State and Regional Boards, CDPH, Department of Pesticide Regulation (DPR), Department of Water Resources (DWR), USGS, and Lawrence Livermore National Laboratory (LLNL). The GAMA database was used to download historical water quality data for municipal water supply wells in the Antelope Valley.

The search parameters were selected based on the following criteria:

1. Datasets: Supply Wells – CDPH
2. GIS Layer: Groundwater Basins
3. Groundwater Basin: Antelope Valley (6-44)
4. Well Type: Wells With Results
5. Constituents: Arsenic (MCL=10 µg/L), Boron (NL=1 mg/L), Chloride (SMCL=500 mg/L), Chromium (MCL=50 µg/L), Fluoride (MCL=2 mg/L), Nitrate as NO_3 (MCL=45 mg/L) and Total Dissolved Solids (SMCL = 1000 mg/L)
6. Timeline: All Years

A data file for each constituent was exported separately. The data included the following fields: well ID, well name, approximate latitude, approximate longitude, chemical, qualifier, result, units, date, dataset category, dataset source, county, regional board, groundwater basin name, assembly district and senate district.

The approximate latitude and longitude coordinates of the CDPH supply wells are within one mile of the actual locations. Each set of well coordinates is a cluster of wells. The wells depicted in Figures 3-1 through 3-14 may represent multiple water supply wells. The location of each well in terms of sub-basin was determined by mapping the coordinates with ArcGIS software.

The downloaded data was then verified and filtered. The units for each sample entry were verified to ensure that they were consistent for the same chemical. Only samples tested within the 10-year baseline period of 2001-2010 were selected. Samples tested before and after the 10-year window were excluded. Future GAMA data should be reviewed to correct any errors in reported values due to incorrect units or values.

Nitrate as NO_3 data is available from GAMA. This data was converted to nitrate as nitrogen (N) by dividing each number by the molecular weight ratio of NO_3 to N (approximately 4.4).

3.2.2 USGS National Water Information System Database

As part of the USGS program for disseminating water data within USGS, to USGS cooperators, and to the general public, the USGS maintains a distributed network of computers and fileservers for the acquisition, processing, review, and long-term storage of water data. This distributed network of computers is called the NWIS. Many types of data are stored in NWIS, including comprehensive information for site characteristics, well-construction details, time-series data for gage height, streamflow, groundwater level, precipitation, and physical and chemical properties of water. Additionally, peak flows, chemical analyses for discrete samples of water, sediment, and biological media are accessible within NWIS.

USGS data is obtained on the basis of category, such as surface water, groundwater, or water quality, and by geographic area. Further refinement is possible by choosing specific site-selection criteria and by defining the output desired. The data originates from all 50 states, plus border and territorial sites, and include data from as early as 1899 to present. Of the over 1.5 million sites with NWIS data, the vast majority are for wells; however, there are thousands of sites with streamflow data, many sites with atmospheric data such as precipitation, and about 10,900 of the sites provide current condition data. The groundwater observations used in this plan were obtained for the Antelope-Fremont Valleys hydrologic unit, designated by the code 18090206 by USGS.

Individual well location coordinates were determined using the USGS site number for each well. The USGS well site-numbering system is based on the grid system of latitude and longitude and provides the geographic location of the well and a unique number for each site. The number consists of 15 digits: the first 6 digits denote the degrees, minutes, and seconds of latitude; the next 7 digits denote degrees, minutes, and seconds of longitude; and the last 2 digits are a sequential number for wells within a 1-second grid. In the event that the latitude-longitude coordinates for a well are the same, a sequential number such as “01,” “02,” and so forth, would be assigned as one would for wells.

The location of each well in terms of sub-basin was determined by using the well coordinates given by the site numbers and identifying the sub-basin location in a map created using ArcGIS software. Only data from the 2001 to 2010 baseline period were considered in the analysis.

3.3 Current Salt and Nutrient Characterization of the Groundwater Basin

For the initial analysis of this plan, the current water quality of the groundwater basin is assumed to be equivalent to the average water quality during the baseline period between 2001 and 2010 (see Table 3-2). In future analyses as part of the monitoring plan (see Section 5 regarding the SNMP monitoring plan), the current water quality will be determined by calculating the average water quality concentrations for the most recent 5-year period.

3.4 Salt and Nutrient Characterization of the Source Water

Imported and surface water used for potable supply may undergo treatment at one of the region’s four water treatment plants. Recycled water may originate from five different wastewater treatment plants in the Antelope Valley. Table 3-3 provides source water quality information for the constituents identified in Section 3.1. Along with water quantity projections, this information was used in determining the basin’s salt/nutrient loadings for the 25-year projection period.

The water imported to the Antelope Valley is of high quality and the average concentrations calculated for each of the SNMP constituents meet drinking water standards. Stormwater is considered a high quality water, because it contains low concentrations of most constituents, including salts and nutrients. Because of its high quality, it is desirable to maximize the use of stormwater for groundwater recharge to lower constituent concentrations in the basin. Thus, the Antelope Valley IRWMP stakeholders have identified projects that utilize stormwater to augment groundwater recharge. For the most part, the recycled water available in the Antelope Valley is also high quality and meets most drinking water standards. Recycled water produced by the Edwards Air Force Base tend to be higher in salt and nutrient concentration (e.g., TDS, nitrate, and chloride) which is probably due to source water coming from higher concentration supplies. The groundwater used in that area is typically pumped from the lower aquifer, which has a much higher mineral content than the middle and upper aquifers of the southern regions. Rosamond Community Services District treats wastewater to secondary standards and is undergoing treatment plant upgrades and expansion to produce tertiary treated recycled water. The first phase of the upgrades has been completed, but the reuse expansion is still underway.

Table 3-3: Source Water Quality

Constituent	Average Concentration (mg/L unless otherwise noted)										
	State Water Project (California Aqueduct)					WRP/WWTP (Recycled Water)					Stormwater
	Raw (a)	Treatment Plant (potable)									
		Acton (a)	Eastside (a)	Quartz Hill (a)	Rosamond (b)	Palmdale (c)	Lancaster (d)	Air Force Research Lab (e)	Main Base (f)	RCSD (g)	Littlerock Reservoir (h)
TDS	300	274	284	293	290	489	444	430	815	-	152
Chloride	85	83	83	86	84	158	128	50	330	-	3.7
Nitrate as N	0.90	0.90	0.97	0.91	0.92	3.07	6.31	3.3	16	6	0.08
Arsenic (µg/L)	3.8	1.4	1.2	1.2	1.2	ND	ND	7.2	2.3	-	ND
Chromium (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND
Fluoride	0.1	0.1	0.1	0.1	0.1	-	-	-	0.36	-	0.3
Boron	0.162	0.240	0.180	0.170	0.160	-	-	0.25	0.67	-	ND

Table Notes

(a) Antelope Valley-East Kern Water Agency Annual Water Quality Report (2001-2010) - Los Angeles County System. Boron was only tested in 2009.
(b) Antelope Valley-East Kern Water Agency Annual Water Quality Report (2001-2010) - Kern County System. Boron was only tested in 2009.
(c) Average 2013 water quality for tertiary treated effluent at LACSD 20 Palmdale WRP. The detection limit for arsenic is 1 µg/L.
(d) Average 2013 water quality for tertiary treated effluent at LACSD 14 Lancaster WRP.
(e) 2011 Annual Monitoring Report for EAFB Air Force Research Laboratory (AFRL) Treatment Plant.
(f) 2012 Annual Report for EAFB Main Base WWTP.
(g) Water quality in May 2013 for RCSD WWTP. Additional water quality testing after RCSD obtains permit from the Lahontan Regional Board.
(h) Water quality (2001-2010) provided by Palmdale Water District. Used as stormwater water quality.

3.5 Fate and Transport

Historically, groundwater in the basin generally flows north from the San Gabriel Mountains and south and east from the Tehachapi Mountains toward the Rosamond, Buckhorn, and Rogers dry lakes (DWR 2004). The general direction of groundwater flow is illustrated with groundwater level contours in Figure 3-15. In the Neenach sub-basin, groundwater flows to the northeast. In the Pearland sub-basin, groundwater generally moves from the southeast to northwest. In the Lancaster sub-basin, groundwater flows from areas of natural recharge to the low water altitude areas in the south-central part of the sub-basin.

Fate and transport refers to the way constituents move through the environment, from the source to how they arrive at their ultimate destinations.

The fate and transport of TDS and chloride in groundwater is influenced by groundwater flow which is governed by hydraulic gradients. Average TDS concentrations in the Antelope Valley Groundwater Basin are below the recommended SMCL. Chloride is soluble in water and moves freely with water through soil and rock. Chloride is not readily consumed by microorganisms, so it is more persistent than nitrate and likely to leach into groundwater (USGS 2004). Average chloride levels in the Antelope Valley Groundwater Basin are well below the recommended SMCL.

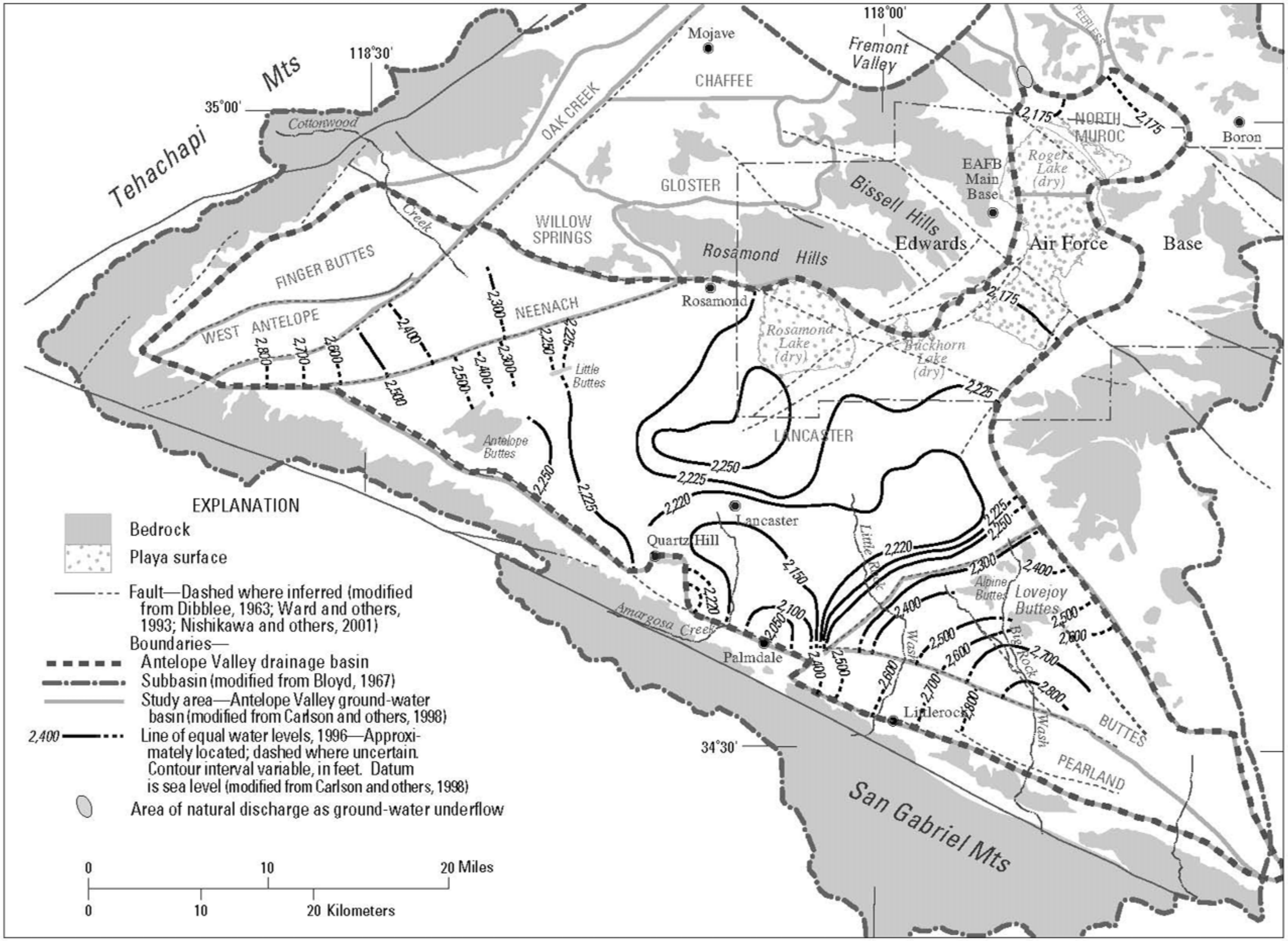
Elevated concentrations of nitrate are commonly found at shallow water-table depths. However, studies show that water and nitrate transport from the root zone to the water table follow preferential flow paths with potential to reach deeper portions of the soil vadose zone and the water table, with limited denitrification. Geologic and hydraulic parameters vary substantially causing high spatial variability of nitrate transport. But in general, nitrate is soluble and mobile at the concentrations typically found in soil and may leach into groundwater. Ammonium (NH_4^+) is strongly adsorbed by most soils and thus is not a concern.

Although movement of nitrate with percolating water through the unsaturated zone may take many years to reach groundwater, long-term increases are possible where aquifers are recharged by nitrate-rich water such as recycled water. In the saturated zone, groundwater movement is generally slow and there is little mixing. For that reason, nitrate contamination is generally localized and can possibly continue for decades after nitrate contaminant sources are eliminated because of the slow rate of movement and lack of dilution.

Fortunately, nitrate levels in the groundwater basin are well below the MCL.

Arsenic, boron, fluoride, and chromium in the region’s groundwater mainly originate from natural sources, such as rock and soil, as water moves through the ground and dissolves minerals and salts from the rock formations.

Figure 3-15: Antelope Valley Groundwater Levels (USGS 2004)



3.6 Current and Future Projects

To assess salt and nutrient impacts in the Antelope Valley, current and future projects having the potential to significantly contribute to salt and/or nutrient impacts to the Antelope Valley Groundwater Basin were identified. Details of these projects are described below. Initially, projects having the potential to impact the salt and nutrient content of Antelope Valley Groundwater Basin were identified from the projects listed in the 2007 AVIRWMP. The SNMP stakeholder group added and deleted projects to and from the project list, as necessary and as a result of meeting discussions. A project was deleted from the list if it was deemed irrelevant to this SNMP due to the project's implementation date occurring after the SNMP future planning period (2011-2035) or the project was not expected to impact the basin salt and/or nutrient levels. At the time of development of this SNMP, some projects were in the early stages of development, such as the concept phase, and were not included due to insufficient information to assess impacts. Inclusion of additional projects in future updates to the SNMP necessitates evaluation of project details for relevance, such as those listed in the SNMP "Project Identification Form". The blank and completed project identification forms are included in Appendix E.

Figure 3-16 is a map showing the locations of the identified SNMP projects within the Antelope Valley groundwater basin. Figure 3-17 shows the SNMP project locations within the Lancaster sub-basin.

3.6.1 Project Summary Descriptions

1. *Amargosa Creek Recharge Project*
   Proposed by the City of Palmdale, this project consists of multiple proposed improvements (overall project is the Upper Amargosa Creek Flood Control, Recharge, and Habitat Restoration Project), one of which includes expanding the size and capacity of spreading grounds to increase the natural recharge of the underlying aquifer. The recharge component includes eight basins to recharge groundwater using raw State Water Project water and stormwater runoff from the Amargosa Creek Watershed. Recharge volumes are dependent on available supply and annual precipitation, anticipated averages are listed below in Table 3-4.

2. *Antelope Valley Water Bank*
   The project is owned by the Valley Mutual Water Company, which operates the bank within the structure of the Semitropic-Rosamond Water Bank Authority (SRWBA). At full build-out, the water banking project will provide up to 500,000 acre-feet of storage and the ability to recharge and recover up to 100,000 AFY of water for later use when needed. The project recharges water from the State Water Project into storage using recharge basins and will use new and existing wells and regional conveyances to recover water for delivery. The project is being constructed in phases and currently has 320 acres of operational percolation pond capacity.

3. *Eastside Banking and Blending Project*
   Operational water recharge and recovery site providing a supplemental potable source of water for the AVEK Eastside Water Treatment Plant. The project will involve State Water Project water spread over local recharge basins, storing water for future recovery during dry or drought years. This alternative potable water supply will be used for periodic substitution or supplementation to the Eastside plant.

4. *Edwards Air Force Base Air Force Research Laboratory Treatment Plant*
   The Edwards Air Force Base (EAFB) Air Force Research Laboratory (AFRL) Treatment Plant produces secondary effluent. The effluent is discharged to onsite evaporation ponds.

5. *EAFB Main Base Wastewater Treatment Plant*
   The EAFB Main Base Wastewater Treatment Plant (WWTP) discharges treated domestic wastewater. The facility collects, treats and disposes of a design 24-hour daily average flow of 2.5 million gallons per day (MGD) and a design peak daily flow of 4.0 MGD from the housing, main base, north base and south base areas. The facility is designed to produce tertiary treated effluent and has the capacity to hold up to 3,000 gallons per day of seepage. For three months of the year during winter, the effluent is discharged to onsite evaporation ponds. The effluent is used to irrigate the golf course for the remainder of the year.

6. *EAFB Evaporation Ponds*
   The evaporation ponds receive effluent from the EAFB AFRL Treatment Plant and the EAFB Main Base WWTP.

7. *EAFB Golf Course Irrigation*
   The golf course is the largest user of recycled water at the EAFB. It receives the tertiary effluent from the EAFB Main Base WWTP as irrigation water during the warmer months of the year.

8. *Lancaster WRP Upgrade and Expansion*
   The upgrade and expansion project was completed in 2012. The major components were upgraded wastewater treatment facilities, recycled water management facilities, and municipal reuse. Wastewater treatment processes were upgraded to meet tertiary recycled water requirements prescribed in CDPH's Title 22.

9. *Lancaster WRP Eastern Agricultural Site*
   Existing agricultural site using recycled water produced by the Lancaster WRP. Per Regional Board requirements, recycled water is applied to the crops at agronomic rates, based on the needs of the crop plant, with respect to water and nitrogen, to minimize deep percolation from the root zone to the groundwater table of the applied recycled water.

10. *Lancaster WRP Environmental Maintenance Reuse*
    Disinfected tertiary recycled water produced by the Lancaster Water Reclamation Plant (WRP) is used for environmental maintenance at Apollo Community Regional Park (Apollo Park) and Piute Ponds. Since 1972, Apollo Park has been using recycled water to fill a series of lakes that are used for recreational fishing and boating. Piute Ponds are located on Edwards Air Force Base Property and uses recycled water to maintain marsh-type habitat. Flows below do not include water from Apollo Park lakes that is used for landscape irrigation within the park.

11. *Multi-use/Wildlife Habitat Restoration Project*
    Duck Hunting Club (Wagas Land Company) in both Kern and Los Angeles County, started in 1925. The Antelope Valley region is a flyaway zone for many migratory birds flying south and the Club has been preserving habitat. The Club is coordinating with Waterworks to replace their groundwater use with recycled water. The Club would also allow Waterworks to use a portion of the property for banking.

12. *North Los Angeles/Kern County Regional Recycled Water Project*
The recycled water project is the backbone for a regional recycled water distribution system in the Antelope Valley. The proposed system is sized to distribute recycled water for irrigation and other approved uses throughout the service area and also deliver recycled water for recharge areas. Construction is phased over time and portions are already complete. The first phase was implemented in 2009. The flow projection below is based on project components being complete and excludes flows to the Palmdale Hybrid Power Plant (3,400 AFY) and groundwater recharge.

13. *Palmdale Hybrid Power Plant Project*
Construction of a 570 Mega-Watt electricity generating facility. The power plant will be a hybrid design, utilizing natural gas combined cycle technology and solar thermal technology. The plant is projected to use approximately 3,400 AFY of recycled water and will employ “zero liquid discharge” design.

14. *Palmdale Recycled Water Authority Recycled Water Project*
The recycled water project is the recycled water distribution system for the Palmdale Recycled Water Authority (PRWA). Construction is phased over time and the first portion to serve McAdam Park was completed and implemented in 2012.

15. *Palmdale WRP Upgrade and Expansion*
The upgrade and expansion project was completed in 2011. The major components were upgraded wastewater treatment facilities, recycled water management facilities, and municipal reuse. Wastewater treatment processes were upgraded to meet tertiary recycled water requirements prescribed in CDPH’s Title 22.

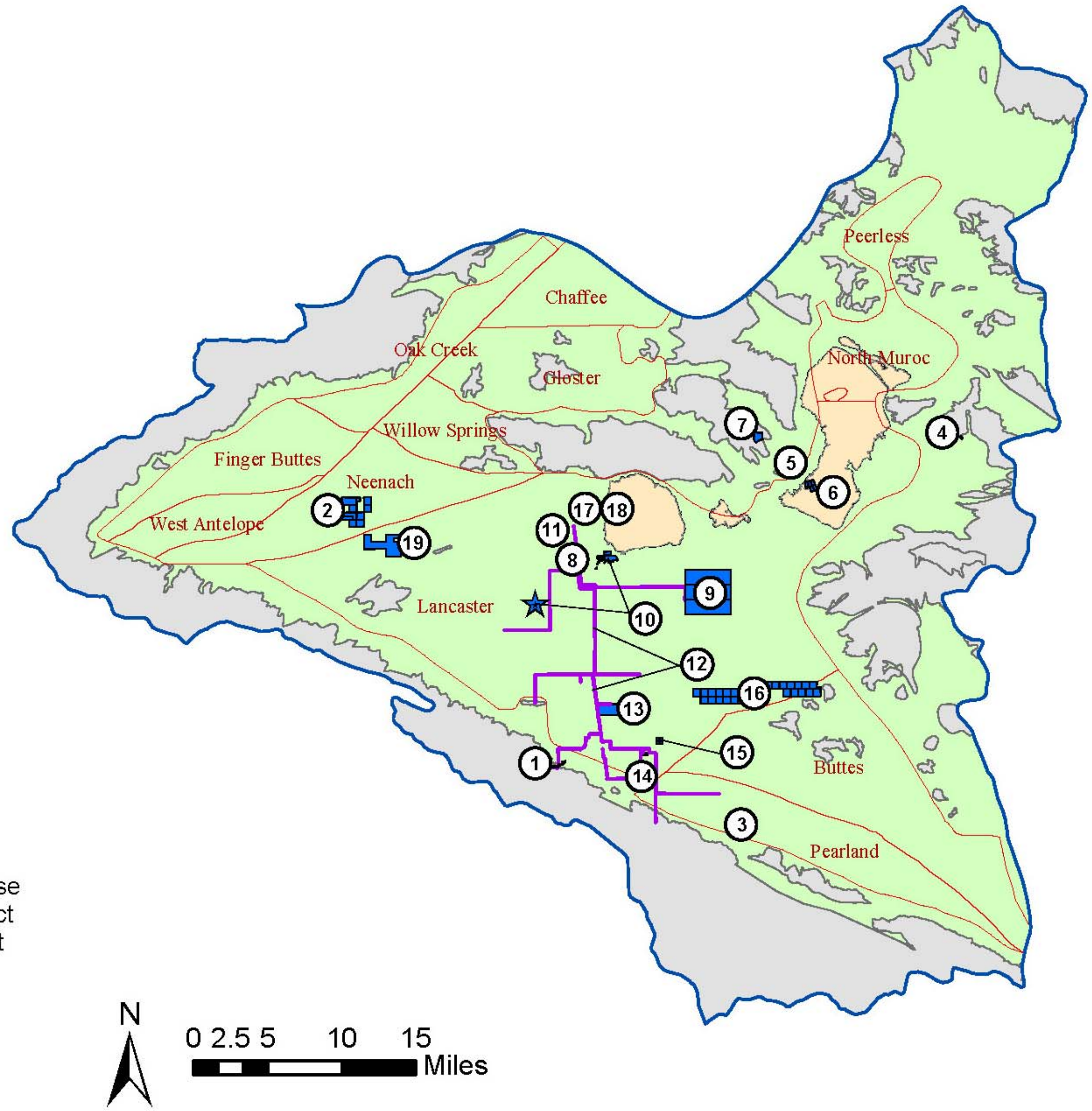
16. *Palmdale WRP Agricultural Site*
Existing agricultural site using recycled water produced by the Palmdale WRP. Per Regional Board requirements, recycled water is applied to the crops at agronomic rates, based on the needs of the crop plant, with respect to water and nitrogen, to minimize deep percolation of the applied recycled water from the root zone to the groundwater table. Additional land was acquired for future agricultural operations. Infrastructure is in place, but not is currently used.

17. *Rosamond Community Services District (RCSD) WWTP*
The plant, owned and operated by RCSD, produces both secondary and tertiary treated recycled water. The capacity of the secondary treatment is 1.3 MGD, while the tertiary capacity is 0.5 MGD. The design to upgrade the tertiary treatment capacity to 1.0 MGD is complete. However, the construction is on hold indefinitely due to lack of funding.

18. *RCSD WWTP Evaporation Ponds*
The evaporation ponds receive effluent from the RSCD WWTP.

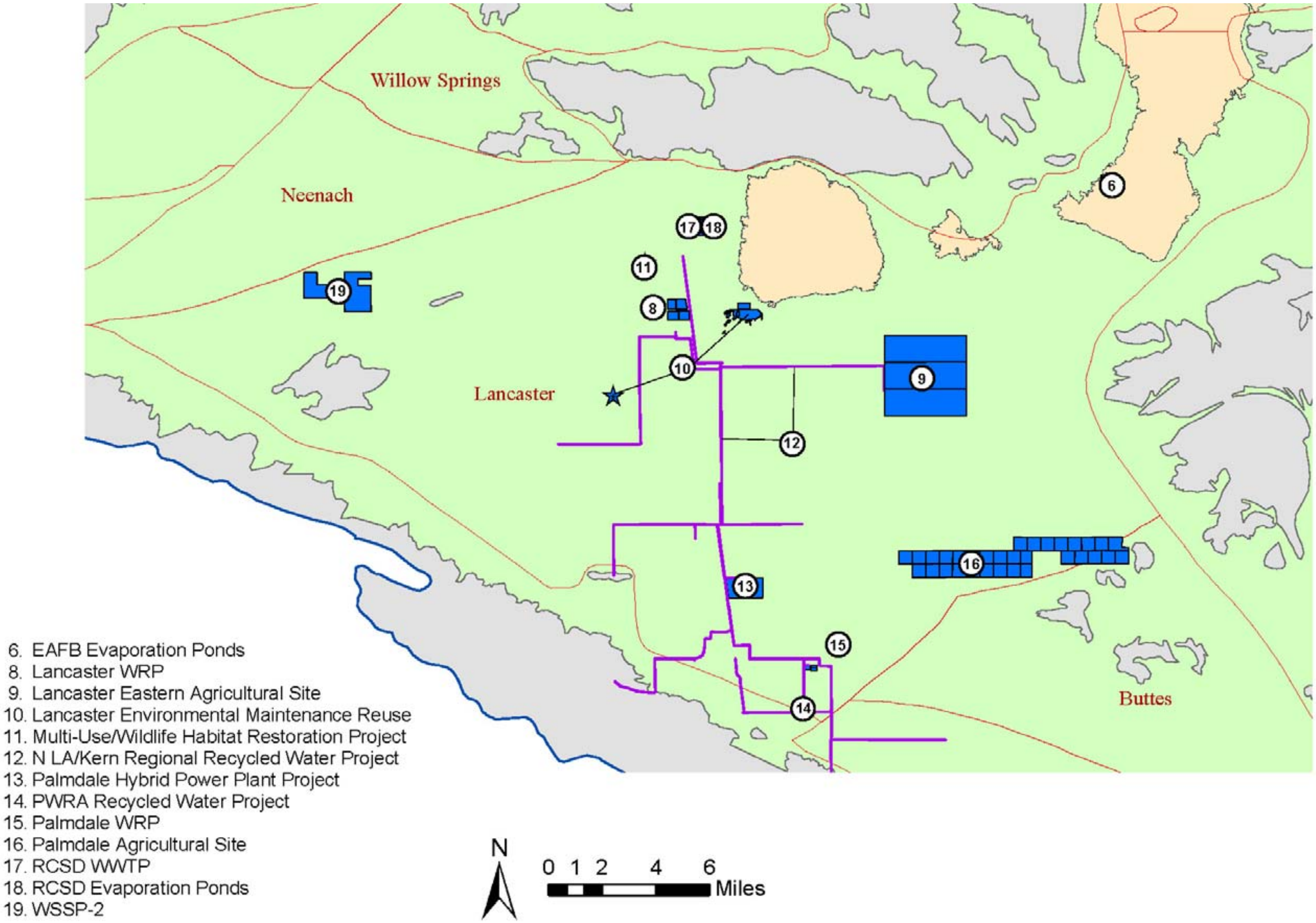
19. *Water Supply Stabilization Project (WSSP-2)*
Imported water stabilization program that utilizes State Water Project (SWP) water delivered to the Antelope Valley Region’s west side for groundwater recharge during wet years for supplemental supply during dry years and to meet peak summer demand. This project includes facilities necessary for the delivery of untreated water for indirect recharge (percolation basins) and wells and pipelines for raw water and treated water extraction and conveyance.

Figure 3-16: SNMP Projects in the Antelope Valley Basin



1. Amargosa Creek Recharge Project
2. Antelope Valley Water Bank
3. Eastside Banking and Blending Project
4. EAFB AFRL Treatment Plant
5. EAFB Main Base WWTP
6. EAFB Evaporation Ponds
7. EAFB Golf Course
8. Lancaster WRP
9. Lancaster Eastern Agricultural Site
10. Lancaster Environmental Maintenance Reuse
11. Multi-Use/Wildlife Habitat Restoration Project
12. N LA/Kern Regional Recycled Water Project
13. Palmdale Hybrid Power Plant Project
14. PWRA Recycled Water Project
15. Palmdale WRP
16. Palmdale Agricultural Site
17. RCSD WWTP
18. RCSD Evaporation Ponds
19. WSSP-2

Figure 3-17: SNMP Projects in the Lancaster Sub-Basin



Additional projects were considered, but had implementation dates after the 2035 SNMP planning horizon or had insufficient project details. The projects include:

- *Amargosa Water Banking and Stormwater Retention Project*
  This project would recharge a blend of recycled water from the Lancaster WRP with stormwater and/or treated imported water at a 100-acre stormwater basin in the City of Lancaster. The pilot project would allow extraction of 2,500 AFY. Ultimately, this recharge project would recharge 50,000 AFY of blend water, consisting of 40,000 AFY of imported water and 10,000 AFY of recycled water. The project would extract an average of 48,000 AFY of recharged water via a new well field and deliver the water to wholesaler/retailer distribution system(s) and private agricultural users.

- *Barrel Springs Detention Basin and Wetlands*
  Proposed by the City of Palmdale, this project will provide flood control for the City of Palmdale and provide for wetland enhancement and habitat protection. The project includes the construction of an 878 AF detention basin in the Barrel Springs area.

- *Hunt Canyon Groundwater Recharge & Flood Control Basin*
  Proposed by the Palmdale Water District, this project entails construction of a new 3,000 AF detention/recharge basin. The basin would be used to store raw aqueduct water to allow recharge into the aquifer and would act as a detention basin during severe storms.

- *Littlerock Creek Groundwater Recharge and Recovery Project*
  This project would involve groundwater recharge using a blend of recycled water, from the Palmdale Water Reclamation Plant, imported water and local stormwater. Completion of a feasibility study is expected in 2015.

3.6.2 Project Water Volume Projections

Table 3-4 shows the water volume projections, associated with current and future projects, for the 25-year planning period (2011-2035). This planning period parallels the planning horizon for the Antelope Valley IRWMP, 2013 Update, and the 2010 Integrated Regional Urban Water Management Plan for the Antelope Valley (LACWD, June 2011). These projections will allow the stakeholder group to analyze the salt and nutrient impacts the projects may have on the basin.

Table 3-4: Water Volume Projections for Current and Future Projects

Project Name	Source	Implementation Date	Water Quantity Projection (AFY)					
			2010	2015	2020	2025	2030	2035
Treatment Plants								
EAFB Air Force Research Laboratory Treatment Plant	Recylced	Implemented	46	46	46	46	46	46
EAFB Main Base WWTP	Recylced	Implemented	511	511	511	511	511	511
Lancaster WRP Expansion	Recylced	2012	-	17,000	18,500	20,000	21,500	23,000
Palmdale WRP Expansion	Recylced	2011	-	11,000	12,000	12,000	13,000	13,000
RCSD WWTP	Recylced	Implemented	560	560	560	560	560	560
Reuse								
EAFB Golf Course Irrigation	Recylced	Implemented	383	383	383	383	383	383
Lancaster WRP Eastern Agricultural Site	Recylced	Implemented	1,000	10,500	11,500	11,200	11,700	10,900
Landcaster WRP Environmental Maintenance Reuse	Recylced	Implemented	-	5,700	5,700	5,700	5,700	5,700
Multi-Use Wildlife Habitat Restoration Project	Recylced	2016	-	-	2,000	2,000	2,000	2,000
North LA/Kern County Regional Recycled Water Project	Recylced	2009	3	700	1,800	3,600	4,700	7,100
PRWA Recycled Water Project	Recylced	2012	-	80	1,000	1,000	2,300	3,500
Palmdale WRP Agricultural Site	Recylced	Implemented	7,600	10,200	6,400	7,400	4,100	800
Evaporation/Export								
EAFB Evaporation Ponds (Main Base & AFRL)	Recylced	Implemented	174	174	174	174	174	174
Palmdale Hybrid Power Plant Project	Recylced	2016	-	-	3,400	3,400	3,400	3,400
RCSD WWTP Evaporation Ponds	Recylced	Implemented	560	560	560	560	560	560
Groundwater Recharge/Banking								
Amargosa Creek Recharge Project	Imported	2015	-	24,300	24,300	24,300	24,300	24,300
	Stormwater		-	400	400	400	400	400
Antelope Valley Water Bank	Imported	2010	1,300	22,000	22,000	22,000	22,000	22,000
Eastside Banking and Blending Project	Imported	2015	-	5,000	10,000	10,000	10,000	10,000
Water Supply Stabilization Project (WSSP-2 Project)	Imported	Implemented	10,000	25,000	25,000	25,000	25,000	25,000