Progress Report

to Support Development of

Total Maximum Daily Loads Addressing Nutrients and Algal Toxins *in* Waterbodies of the Pinto Lake Catchment

Pinto Lake
photo source: City of Watsonville
319h grant funds memorandum-Dec. 10, 2013
photo taken by: Tarmo Hanula-Register Pajaronian

Pinto Lake TMDL Progress Report

November 2015

This progress report builds upon an April 2015 TMDL Scoping Report, and thus incorporates narrative and information from the April 2015 Scoping Report – report sections herein containing new or updated information are highlighted in green.

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1. Preface

The purpose of this progress report is to present information to support development of total maximum daily loads (TMDLs) addressing nutrients and algal toxins in Pinto Lake. Practically speaking, TMDLs are water quality improvement plans, and thus a TMDL report is a type of planning document. The California Water Plan characterizes TMDLs as *"action plans…to improve water quality."* A TMDL allows stakeholders to determine how best to reach a TMDL's water quality improvement goals[1]. The State and Regional Water Boards help achieve those goals role by establishing scientifically-based numeric water quality targets, by providing oversight, support, and money for watershed improvement projects.

This progress report builds upon an April 2015 Pinto Lake TMDL scoping report. Therefore, this progress report incorporates most of the text and information from the April 2015 scoping report – report sections herein containing new or updated information are highlighted in green in both the table of contents, and in the body of the report. Data, information and narrative contained in this document are a draft work in progress, and thus are subject to revision and change during the course of TMDL development.

2. TMDL Project Location

The TMDL project includes Pinto Lake (see Figure 2-1) and surrounding areas which drain to the Lake. Based on GIS spatial analysis, Pinto Lake drains a 1,486 acre catchment of Santa Cruz County, north of the city of Watsonville (see Figure 2-2). The lake is a natural, perennial lake that has existed for at least 8,000 years as a result of a tectonically-driven local topographic depression (Plater et al., 2006).

Figure 2-1. Pinto Lake, August 2013.

[1] See State Water Resources Control Board videos webpage, http://www.waterboards.ca.gov/videos/ : What is a TMDL?

Figure 2-2. Location map, Pinto Lake catchment, Santa Cruz County, California.

Delineation of watershed drainage boundaries is a necessary part of TMDL development. Drainage boundaries of the conterminous United States are delineated based on the Watershed Boundary Dataset[2], which contain digital hydrologic unit boundary layers organized based on Hydrologic Unit Codes. Hydrologic Unit Codes (HUCs) were developed by the United States Geological Survey to identify all the drainage basins of the United States. Watersheds range in all sizes depending on how the drainage area of interest is spatially defined, if drainage areas are nested, and on the nature and focus of a particular hydrologic study. Watersheds can be characterized by a hierarchy as presented in Table 2-1.

[2] The Watershed Boundary Dataset (WBD) is developed by federal agencies and national associations. WBD contains watershed boundaries that define the areal extent of surface water drainage to a downstream outlet. WBD watershed boundaries are determined solely upon science-based principles, not favoring any administrative boundaries.

Table 2-1. Watershed hierarchy (basins, subbasins, watersheds, subwatersheds, catchments).

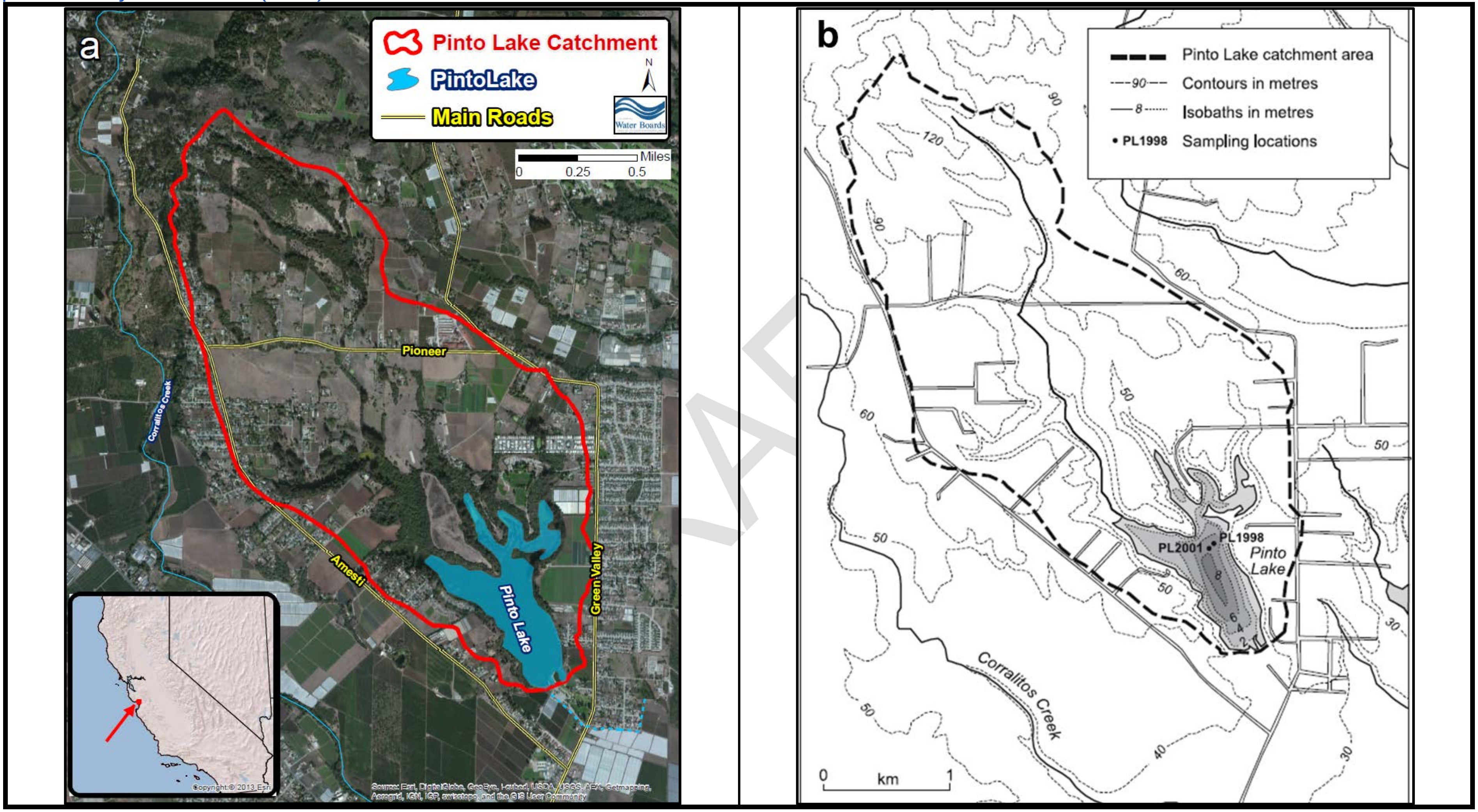
Hydrologic Unit	Approx. Drainage Area (square miles, unless otherwise noted)	Example(s)	Spatial Data Reference or Delineation Methodology
basin	≥ 1,000	Pajaro River basin	Watershed Boundary Dataset HUC-8 shapefiles
subbasin	> 250 to < 1,000	San Benito River subbasin	2 or 3 HUC-10s [B] *(spatial dissolve)*
watershed	~ 100 to ~ 250	Llagas Creek watershed Uvas Creek watershed	Watershed Boundary Dataset HUC-10 shapefiles
subwatershed	> 10 to < 100	Salsipuedes Creek subwatershed Corrilitos Creek subwatershed	Watershed Boundary Dataset HUC-12 shapefiles
catchment	~ 1 to < 10	Pinto Lake catchment	National Hydrography Dataset catchment shapefiles *in conjunction with* ArcMap® 10.1 spatial analyst hydrology tool
subcatchment	≤ 1,000 acres	Todos Santos Creek subcatchment Amesti Creek subcatchment	Delineation using ArcMap® 10.1 spatial analyst hydrology tool See Figure 4-5 on page 16

[A] Based on adaptation from Jonathan Brant, PhD, and Gerald J. Kauffman, MPA, PE (2011) Water Resources and Environmental Depth Reference Manual for the Civil Professional Engineer Exam.
[B] This is approximately equivalent to "Hydrologic Area" in the CalWater 2.2 watershed convention,

The Pinto Lake catchment was delineated by staff of the Central Coast Regional Water Quality Control Board (Central Coast Water Board) based on a digital elevation model used in conjunction with the Esri® ArcMap™ 10.1 spatial analyst extension hydrology tool. Notable is that staff's digital lake catchment delineation comports quite well with a Pinto Lake catchment delineation independently developed and published by university researchers (Plater et al., 2006) – see Figure 2-3 – thus providing additional confidence in our catchment delineation.

Elevations in the Pinto Lake catchment range from 112 feet above mean sea level (MSL) at the City of Watsonville's Pinto Lake Park located at the southeastern margin of the lake, to 513 feet above MSL in the northwestern, upland reaches of the lake catchment. In addition, two subcatchment–scale drainages can be defined based on Pioneer Road. Pioneer Road is an east-west road which bisects the lake catchment into a southern subcatchment which includes land areas in closer proximity to the lake, and a northern subcatchment which includes upland areas relatively farther away from Pinto Lake (see Figure 4-1 in report Section 4.1 for a map view illustration of the location of the subcatchments). According to Plater et al. (2006), lake bathymetry is generally in the range of 2 to 6 meters; maximum depths range to 8 meters in the central part of the lake.

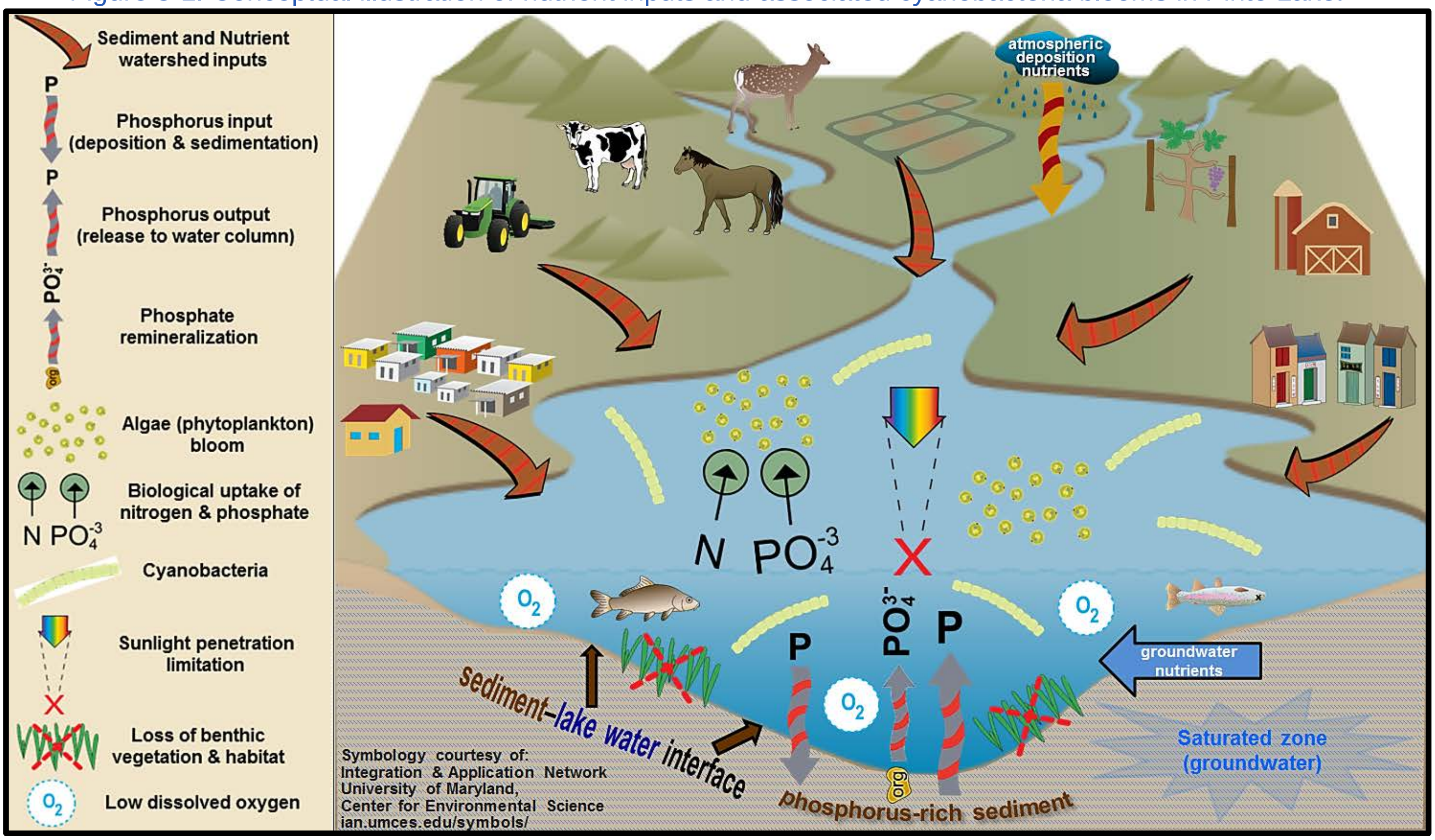
Figure 2-3. (a) Central Coast Water Board staff's digital delineation of the Pinto Lake catchment drainage area derived from application of the Esri® ArcMap™ 10.1 spatial analyst hydrology tool extension; and compare to: (b) a delineation of the Pinto Lake catchment drainage area published by Plater et al. (2006).



3. Description of the Water Quality Problem

Pinto Lake is listed on the Clean Water Act 303(d) list of impaired waterbodies due to impairments associated with harmful algal blooms. This type of water quality impairment is a biological response to excessive loading of nutrients to the lake. While nutrients - specifically nitrogen and phosphorus – are essential for plant growth and are naturally present and ubiquitous in the environment, they are considered pollutants when they occur at levels which have adverse impacts on water quality (see Figure 3-1). According to the 2010 Clean Water Act Section 303(d) report, the listed water quality impairments in Pinto Lake include unacceptable amounts of cyanobacteria microcystins (i.e., algal toxins), low dissolved oxygen, and scum/floating material. In the past, Pinto Lake was not subject to episodic and intense cyanobacteria algal blooms based on interviews with long-term lakeside residents, knowledgeable locals, or inferred from sediment core data (CSUMB and Resource Conservation District of Santa Cruz County, 2013).

Figure 3-1. Conceptual illustration of nutrient inputs and associated cyanobacteria blooms in Pinto Lake.



Episodic algal blooms in Pinto Lake, resulting from nutrient-driven biostimulation[3] constitute a potential health risk and public nuisance to humans, to their pets, and to wildlife. The majority of freshwater harmful algal blooms (HABs) reported in the United States and worldwide are due to one group of algae, cyanobacteria (CyanoHABs, or blue-green algae). University of California-Santa Cruz researchers report that Pinto Lake is one of the most toxic lakes ever recorded in the scientific literature based on episodic high levels of algal cyanotoxins[4]. An illustration of an algae bloom in Pinto Lake is presented in Figure 3-2, Figure 3-3, and Figure 3-4.

[3] As used herein, "biostimulation" refers to a state of excess growth of aquatic vegetation due to anthropogenic nutrient inputs into an aquatic system. Biostimulation is characterized by a number of other factors in addition to nitrogen and phosphorus inputs; for example, dissolved oxygen levels, chlorophyll *a*, sunlight availability, and pH.

[4] The National Wildlife Federation recently reported that Pinto Lake "contains some of the most toxic water in the nation."

Figure 3-2. Cyanobacteria bloom in Pinto Lake (photo submitted by City of Watsonville staff).

Figure 3-3. Cyanobacteria bloom at Pinto Lake boat dock, September 2015 (photo credit: Robert Ketley).

Figure 3-4. Cyanobacteria bloom at Pinto Lake fishing pier, October 2015 (photo credit: Robert Ketley).

A description of the water quality-related problems associated with Pinto Lake was recently articulated by the office of California Assembly Member Luis A. Alejo:

> *Freshwater blue green algae toxins caused the deaths of over 31 endangered southern sea otters in Monterey Bay. In 2012 a blue green algal bloom at Pinto Lake, just 4 miles from the Monterey Bay, resulted in the death of countless waterfowl. "The birds were convulsing on the ground and flying into buildings and cars all across town" states Robert Ketley, Water Quality Program Manager for Watsonville.*
>
> From: Press Release dated February 12, 2015 from California Assembly Member Luis A. Alejo

Possible health effects of exposure to blue-green algae blooms and their toxins can include rashes, skin and eye irritation, allergic reactions, gastrointestinal upset, and other effects. At high levels, exposure can result serious illness or death. These effects are not theoretical; worldwide animal poisonings and adverse human health effects have been reported by the World Health Organization (WHO, 1999). The California Department of Public Health and various County Health Departments have documented cases of dog die-offs throughout the state and the nation due to blue-green algae. Dogs can die when their owners allow them to swim or wade in waterbodies with algal blooms. Dogs are also attracted to fermenting mats of cyanobacteria near shorelines of waterbodies (Carmichael, 2011). Dogs reportedly die due to ingestion associated with licking algae and associated toxins from their coats.

Algal toxins originating from freshwater sources, such as coastal lakes and streams, have been implicated in the deaths of southern sea otters (Miller et al., 2010). Also noteworthy, City of Watsonville staff have reported anecdotal cases of people contracting skin rashes, upset stomach, or flu-like symptoms associated with contact with cyanotoxin blooms in Pinto Lake. Currently, there have been no confirmations of human deaths in the United States from exposure to algal toxins, however many people have become ill from exposure, and acute human poisoning is a distinct risk (Dr. Wayne Carmichael of the Wright State University-Department of Biological Sciences, as reported in NBC News, 2009).

4. Pinto Lake Catchment Setting

This section of the document presents brief and cursory highlights of the physical, climatic, and hydrologic setting of the Pinto Lake catchment. As appropriate, further information will be compiled during TMDL development.

4.1 Land Use & Land Cover (updated)

Land use and land cover in the Pinto Lake catchment was evaluated from digital data provided by the California Department of Conservation's Farmland Mapping & Monitoring Program. The Farmland Mapping and Monitoring Program maps are updated every two years with the use of aerial photographs, a computer mapping system, public review, and field reconnaissance. For this TMDL Project progress report, the 2012 Farmland Mapping and Monitoring Program data were used. Central Coast Water Board staff conducted a brief and cursory review of land use–land cover data for this progress report. Estimations of land use–land cover in the Pinto Creek catchment, and the northern and southern subcatchments are presented in Figure 4-1 and Figure 4-2. Land cover in the catchment is comprised largely of residential areas and cultivated cropland. Upland reaches on the northern subcatchment contain significant amounts of mixed woodland and grasslands.

Figure 4-1. Land use–land cover (year 2012) in the Pinto Lake catchment. Two subcatchments are also assessed: a northern subcatchment (drainage areas north of Pioneer Road) and a southern subcatchment (drainage areas south of Pioneer Road).

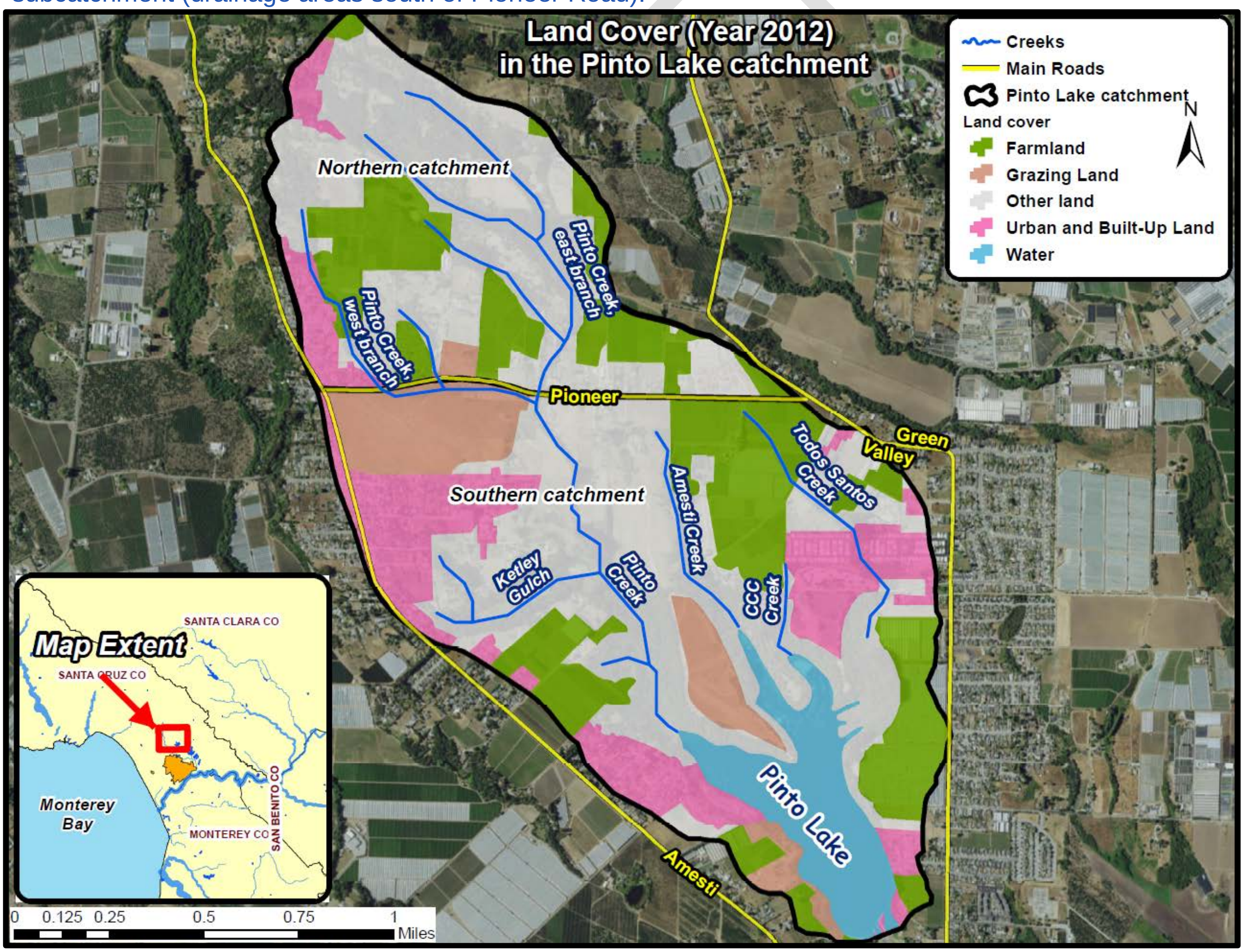
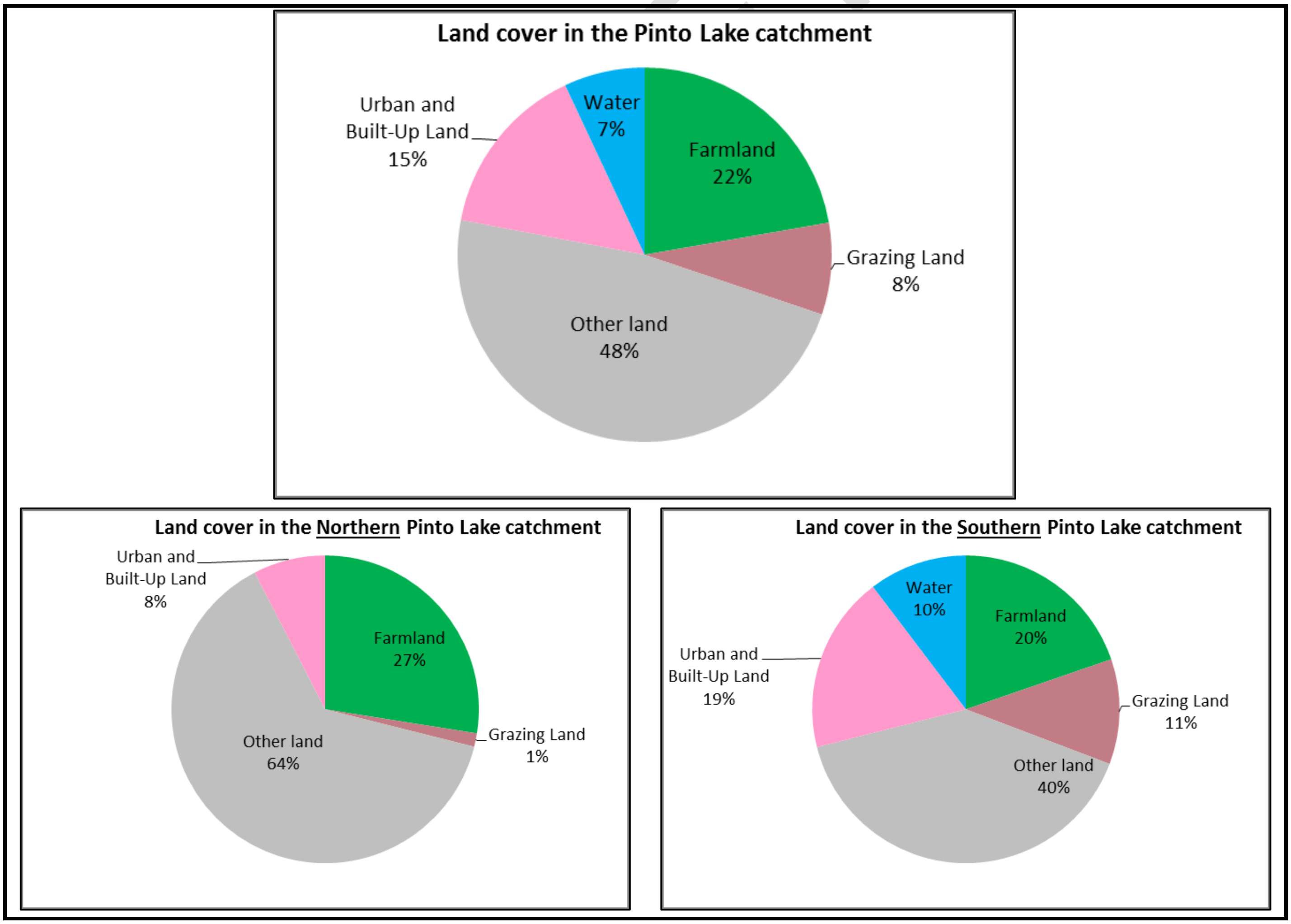


Table 4-1. Land use–land cover in the Pinto Lake catchment (year 2012), based on Farmland Mapping and Monitoring Program data. The table includes the total Pinto Lake catchment area and two subcatchment areas (the northern subcatchment and the southern subcatchment).

		Farmland *Acres & Percent of catchment*	Urban or Built Up *Acres & Percent of catchment*	Grazing land Grassland *Acres & Percent of catchment*	Undeveloped, Woodlands or Restricted *Acres & Percent of catchment*	Open Water *Acres & Percent of catchment*	Total
Pinto Creek catchment	**Total (all catchment)**	330.7 acres	223.5 acres	117.7 acres	710.7 acres	103.8 acres	1,486 acres
		22%	15%	8%	48%	7%	100%
	Northern subcatchment (north of Pioneer Rd.)	132.6 acres	36.6 acres	6.8 acres	306.3 acres	0	482
		27%	8%	1%	64%	0%	100%
	Southern subcatchment (south of Pioneer Rd.)	198.1acres	187.0 acres	110.9 acres	404.4 acres	103.8 acres	1,004 acres
		20%	19%	11%	40%	10%	100%

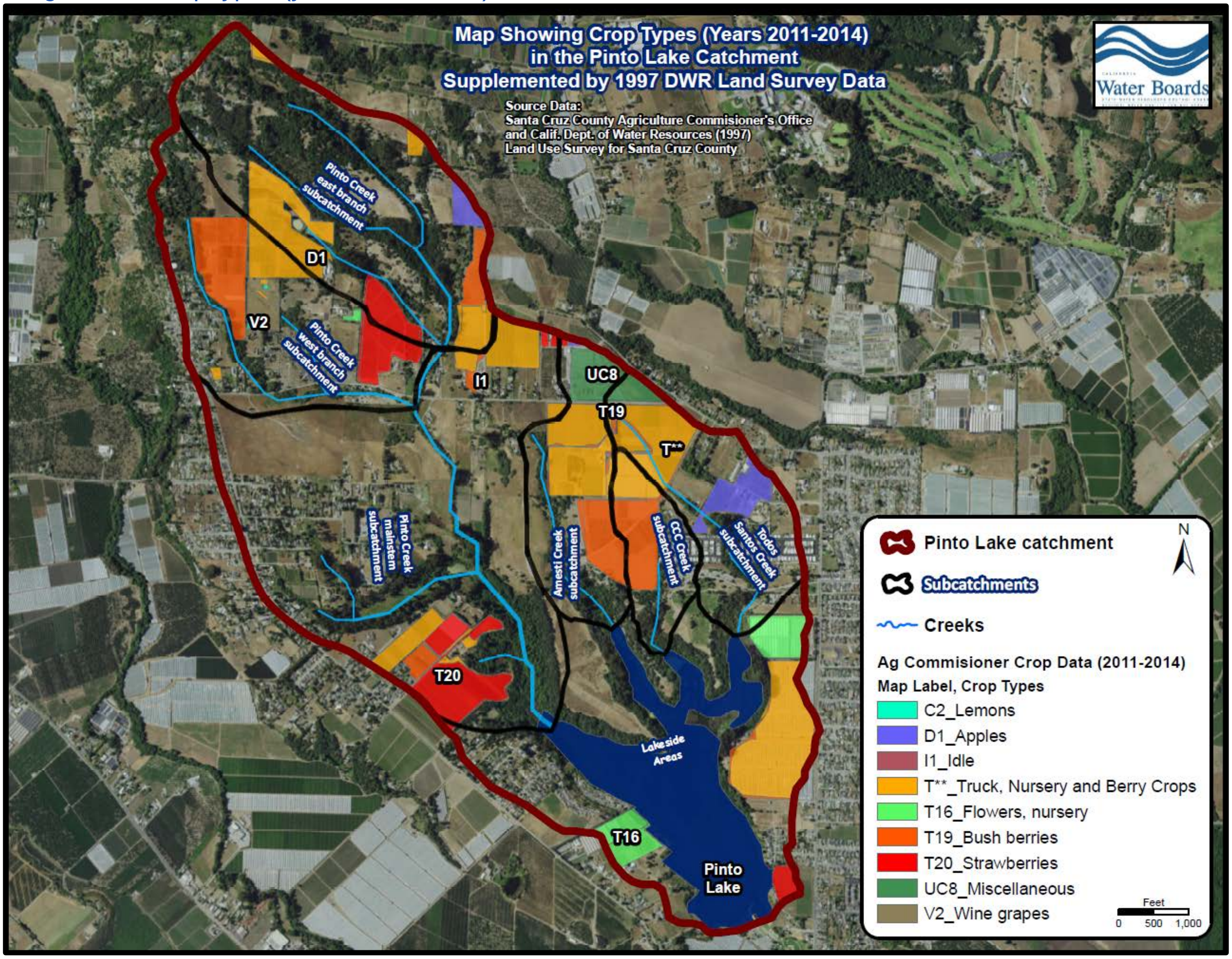
Data source: Department of Conservation, Farmland Mapping and Monitoring Program, 2012.

Figure 4-2. Pie charts of land use-land cover in the Pinto Lake catchment, and in two subcatchment areas.



Cultivated agriculture is an important land use activity in the Pinto Lake catchment. Figure 4-3 illustrates crop types grown during years 2011 to 2014 in the Pinto Lake catchment. Major crops included bush berries, strawberries, and truck and nursery crops.

Figure 4-3. Crop types (years 2011-2014) in the Pinto Creek catchment.



4.2 Hydrography (updated)

Assessing the hydrology of any given watershed or catchment is an important step in evaluating the magnitude and nature of pollutant transport and loading in waterbodies. Central Coast Water Board staff conducted a brief and cursory review of hydrologic data for this progress report. This section of the report outlines a cursory review and assessment of the hydrography of the Pinto Lake catchment. The entire drainage area of the Pinto Lake catchment encompasses over 1,400 acres with a network of creeks draining to Pinto Lake.

A generalized illustration of the hydrography of the Pinto Lake catchment is presented in Figure 4-4. The stream network shown in Figure 4-4 was delineated using the ArcMap™ 10.1 spatial analyst hydrology tool extension. The main lake tributary is called Pinto Creek, a third order stream on the basis of the Strahler stream classification convention. Pinto Creek drains the northern and western areas of the Pinto Lake catchment. A number of other informally named creeks[5] drain parts of the central and eastern margins of the lake catchment.

[5] The informal tributary creek names are used by local researchers and stakeholders working in the lake catchment and were provided to Central Coast Water Board staff by City of Watsonville staff.

Figure 4-4. Generalized hydrography of the Pinto Lake catchment.

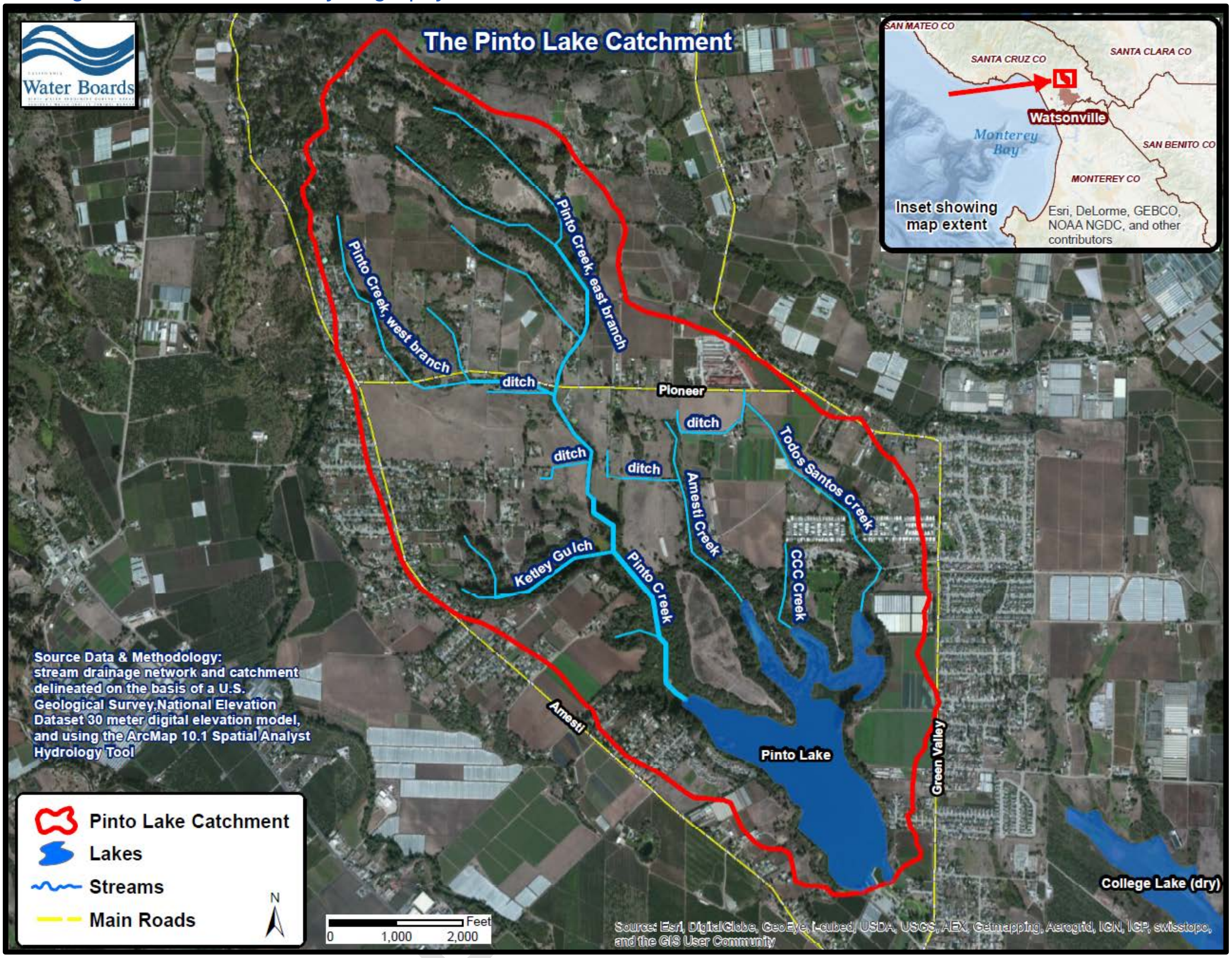


Table 4-2 presents an outline of known or presumed hydrologic conditions associated with the tributary creeks of Pinto Lake. More information on the hydrography of the Pinto Lake catchment will be compiled during TMDL development.

Table 4-2. Hydrologic conditions of tributary creeks of Pinto Lake.

Stream Reach	Strahler Stream Order	Mean Annual Flow (cubic ft./sec.)	Flow Regime
Pinto Creek	3rd order	unknown	Intermittent (source: NHDplus)
Pinto Creek, east branch	2nd order	unknown	Unknown, presumed intermittent
Pinto Creek, west branch	1st order	unknown	Unknown, presumed intermittent
Amesti Creek	1st order	unknown	Unknown, presumed intermittent
CCC Creek	1st order	unknown	Unknown, presumed intermittent
Todos Santos Creek	1st order	unknown	Unknown, presumed intermittent

The tributary creeks listed above in Table 4-2 each drain specific areas of land within the Pinto Lake catchment. Figure 4-5 illustrates these subcatchment–scale drainage areas. A *Lakeside Area* is also shown, indicating areas that drain directly to the lake – i.e., areas that do not drain to one of the identified tributary creeks. Table 4-3 presents a tabulation of the individual subcatchment drainage area sizes.

Figure 4-5. Subcatchment–scale drainage areas within the Pinto Lake catchment.

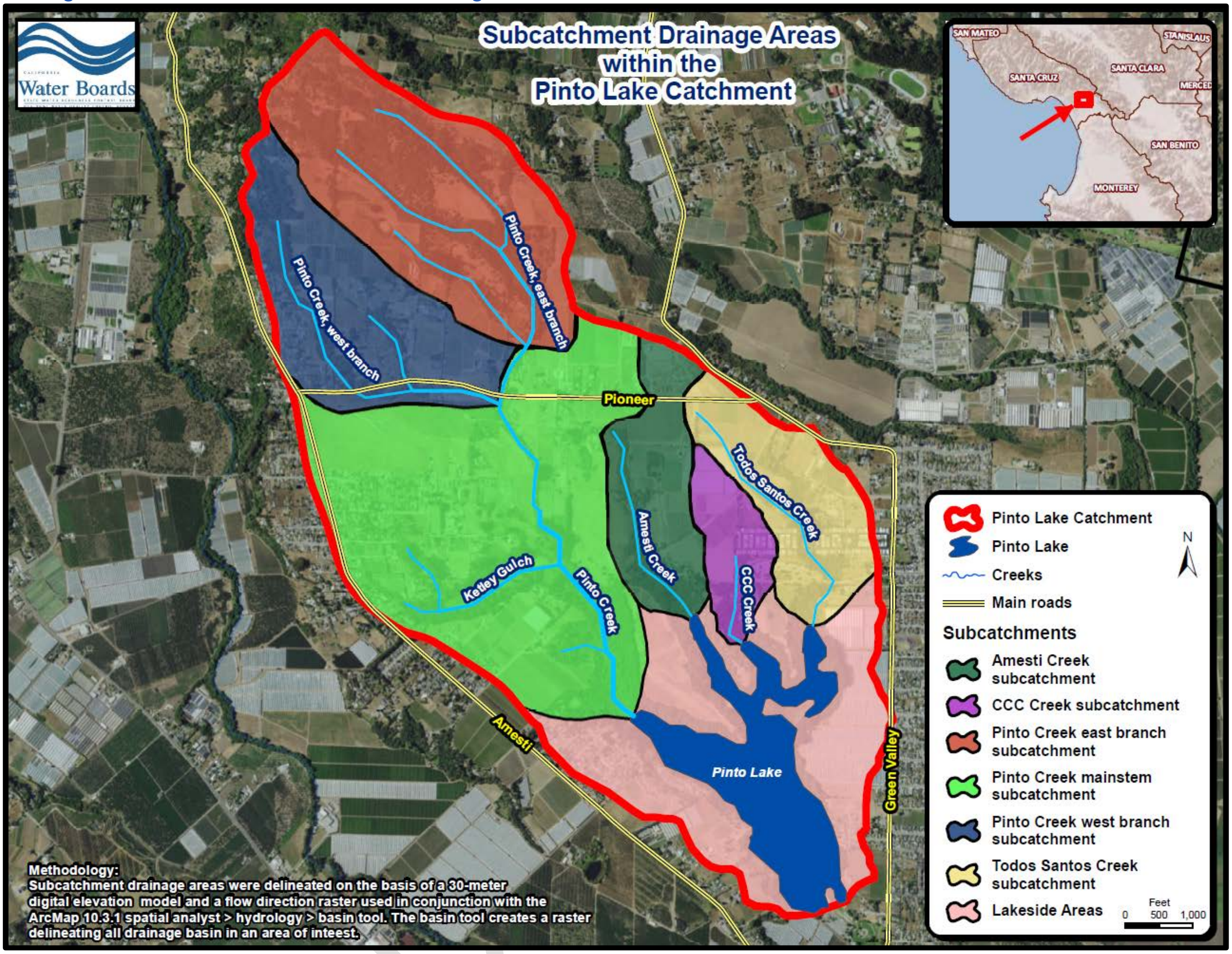


Table 4-3. Tabulation of subcatchment drainage areas sizes.

Subcatchment	Drainage Area[A] (acres)	Drainage Area[A] (square miles)
Pinto Creek, mainstem subcatchment	438	0.68
Pinto Creek, east branch subcatchment	253	0.40
Pinto Creek, west branch subcatchment	182	0.28
Amesti Creek subcatchment	100	0.16
CCC Creek subcatchment	50	0.08
Todos Santos Creek subcatchment	115	0.18
Lakeside Areas	348	0.55

[A] Methodology**:** 30-meter digital elevation model and a flow direction raster used in conjunction with the Esri® ArcMap 10.3.1™ spatial analyst tool.

4.3 Climate & Atmospheric Deposition (updated)

Central Coast Water Board staff conducted a brief and cursory review of climatic data for this progress report. Precipitation is often considered in the development of TMDLs. Precipitation is directly related to a number of watershed hydrologic functions, such as surface runoff, groundwater recharge, and water table elevations.

The Pinto Lake catchment, and California's central coast are characterized by a Mediterranean–type climate, with the vast majority of precipitation falling between November and April (see Table 4-4).

Table 4-4. Precipitation records in the vicinity of Pinto Lake.

Station	Elevation (ft.)	Climatic Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Watsonville Waterworks[A] **(1938-2013)**	95	Average Precipitation (inches)	4.52	3.89	3.02	1.52	0.49	0.14	0.04	0.05	0.30	0.99	2.39	4.18	**21.52**
Corralitos (COR)[B]	450	Average Precipitation (inches)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	**27.05**
Burrell Station (BRL)[B, C]	1,850	Average Precipitation (inches)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	**42.60**

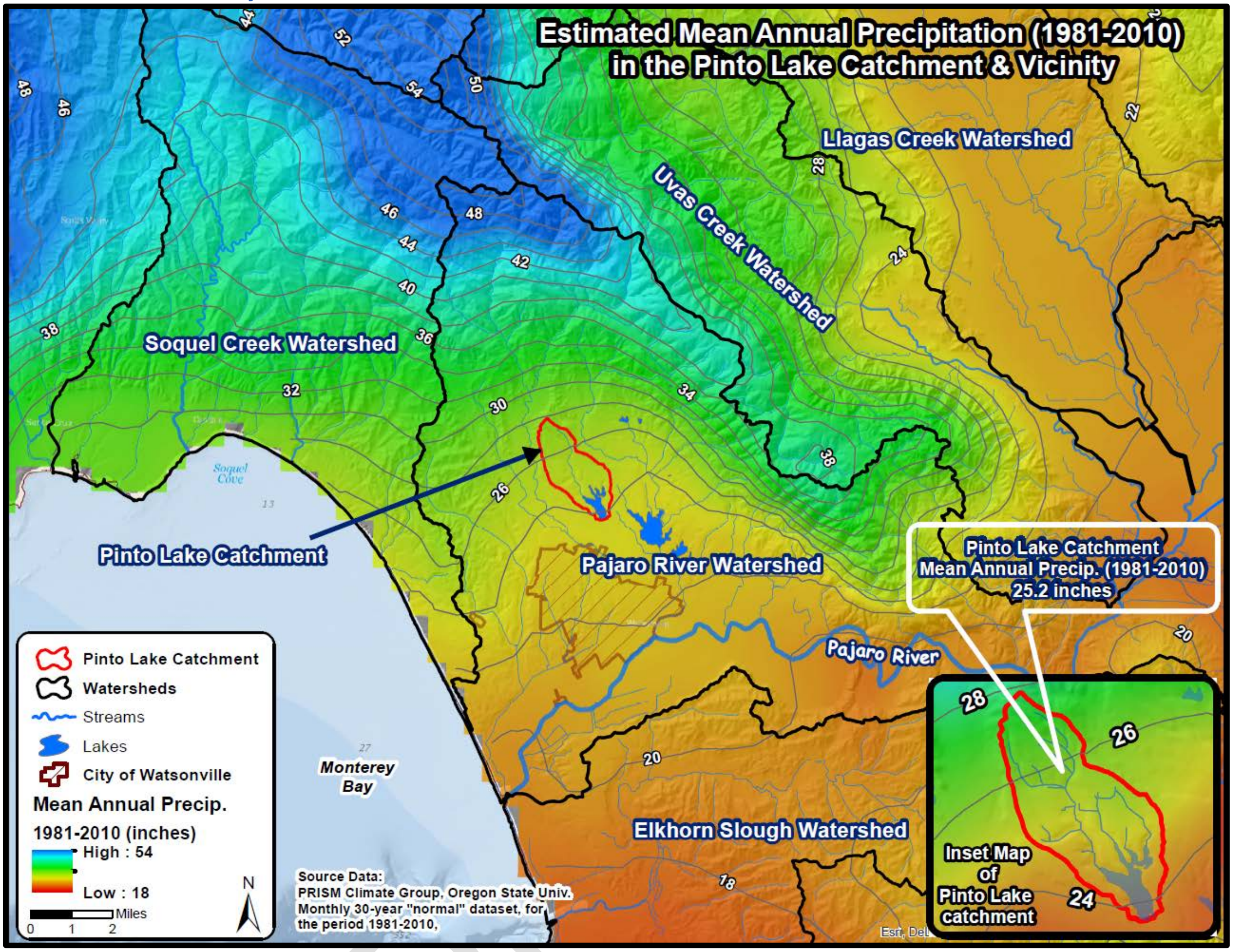
A: Western U.S. COOP weather station (Source: NOAA Western Regional Climate Center).
B: Calif. Dept. of Forestry weather station – data published in the California Natural Resources Agency CERES database.
C: Located in Soquel Creek watershed of Santa Cruz mountains, northwest of the Pinto Lake catchment.
NR = not reported

Mean annual precipitation estimates for the Pinto Lake catchment may be assessed using the Parameter-elevation Regressions on Independent Slopes Model (PRISM)[6]. PRISM is a climate mapping system that accounts for orographic climatic effects and is widely used in watershed studies and TMDL projects to make projections of precipitation into rural or mountainous areas where rain gage data is often absent, or sparse.

An isohyetal map for estimated mean annual precipitation (1981-2010) in the Pinto Lake catchment and vicinity is presented in Figure 4-6. Estimated mean annual precipitation within the Pinto Lake catchment is summarized in .Text Box 4-1.

[6] The PRISM dataset was developed by researchers at Oregon State University, and uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of climatic parameters. The dataset incorporates a digital elevation model, and expert knowledge of climatic variation, including rain shadows, coastal effects, and orographic effects.

Figure 4-6 . Estimated mean annual precipitation for the 30 year period of 1981-2010 in the Pinto Lake catchment and vicinity.



.Text Box 4-1. Estimated mean annual precipitation (1981-2010) in the Pinto Lake catchment.

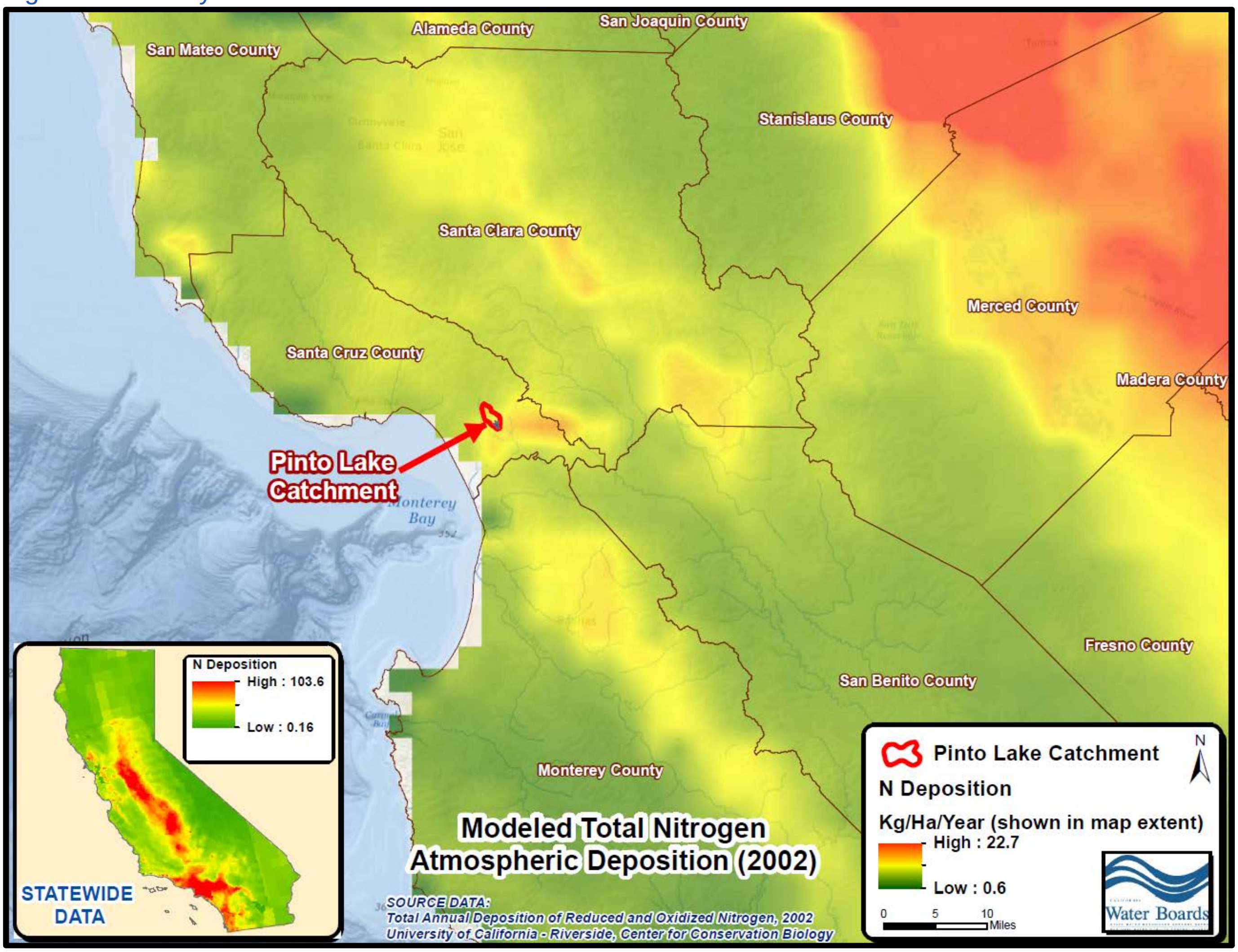
> Based on the PRISM data, estimated mean annual precipitation within the Pinto Lake catchment for the period 1981-2010 was **25.2 inches per year**.

It should be reiterated that the PRISM model represents average precipitation conditions over a 30 year period. As of summer 2015, California has been experiencing extreme drought conditions for several years. Consequently, solutions and timeframes for water quality improvements and monitoring aimed at achieving pollutant load reductions in Pinto Lake may need to consider assumptions about water quality conditions under extreme drought conditions.

Other climatic parameters may be considered during TMDL development. Atmospheric deposition of nitrogen and phosphorus is often considered in watershed assessments of nutrient pollution. Deposition of nutrients by rainfall can locally be a significant source of loading to surface waters in any given watershed. Because nitrogen can exist as a gaseous phase (while phosphorus cannot), nitrogen is more prone to atmospheric transport and deposition. Phosphorus associated with fine-grained airborne particulate matter can also exist in the atmosphere (USEPA, 1999). Additionally, atmospheric deposition of nitrogen compounds is generally most prevalent downwind of large urban areas, near point sources of combustion (like coal burning power plants), or in mixed urban/agricultural areas characterized by substantial vehicular combustion contributions to local air quality (Westbrook and Edinger-Marshall, 2014).

Figure 4-7 presents estimated total nitrogen atmospheric deposition for the year 2002 in the Monterey Bay region and vicinity based on a deposition model developed by the University of California-Riverside Center for Conservation Biology[7]. Based on summary statistics of the California statewide nitrogen deposition raster data, the 25th percentile of data values is 2.5 kilogram (kg) of nitrogen per hectare (Ha)[8] and the median value is 3.7 kg/hectare. These values (2.5 to 3.7 kg/Ha) presumably could represent a plausible range for lightly-impacted or natural ambient atmospheric deposition conditions in California. The estimated atmospheric deposition of nitrogen at Pinto Lake is 9 kg/Ha, which is higher than the aforementioned ambient condition, suggesting a human contribution to nitrogen atmospheric deposition at the lake. However, note that atmospheric nitrogen deposition at Pinto Lake is lower than in highly developed areas of southern California such as the Los Angeles Basin and the Santa Ana Basin, which generally can range to above 20 kg/Ha of nitrogen annually based on the raster data.

Figure 4-7. Estimated atmospheric deposition of nitrogen as N (units=kg/Ha/year) in the Monterey Bay region and vicinity.



Based on the University of California-Riverside atmospheric deposition model, atmospheric deposition of total nitrogen on Pinto Lake and annual atmospheric nitrogen loading to the lake can be estimated as shown in Text Box 4-2.

[7] Tonnesen, G., Z. Wang, M. Omary, and C. J. Chien. 2007. University of California-Riverside. Assessment of Nitrogen Deposition: Modeling and Habitat Assessment. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2006-032.

[8] One hectare is equal to 2.47 acres.

Text Box 4-2. Estimated annual atmospheric deposition of total nitrogen to Pinto Lake.

> The estimated average annual direct atmospheric deposition of total nitrogen on Pinto Lake is:
>
> **9.0 kilograms total nitrogen (N) per hectare per year**
>
> Based on spatial geometry calculation in Esri® ArcMap™ 10.3.1, the areal size of Pinto Lake is 46.7 hectares. Therefore, estimated average annual atmospheric nitrogen (N) load to the lake is:
>
> **420 kilograms (926 pounds) of N per year**

Atmospheric phosphorus can be found in organic and inorganic dust particles. A general atmospheric deposition rate for total phosphorus has been estimated as 0.6 kg of phosphorus/Ha/year (USEPA 1994, as reported in San Diego Regional Water Quality Control Board, 2006). Accordingly, atmospheric deposition of phosphorus at Pinto Lake, and annual atmospheric phosphorus loading at the lake can be estimated as shown in Text Box 4-3.

Text Box 4-3. Estimated annual atmospheric deposition of phosphorus to Pinto Lake.

> The estimated average annual direct atmospheric deposition of phosphorus on Pinto Lake is:
>
> **0.6 kilograms phosphorus (P) per hectare per year**
>
> Based on spatial geometry calculation in Esri® ArcMap™ 10.3.1, the areal size of Pinto Lake is 46.7 hectares. Therefore, estimated average annual atmospheric phosphorus (P) load to the lake is:
>
> **28 kilograms (62 pounds) of P per year**

4.4 Population & Housing (new)

In some watershed studies, census data on population and housing units[9] can be evaluated in efforts to estimate the number of septic systems in the watershed or catchment. Septic systems can potentially be a source of nutrients and/or pathogen discharges to local water resources. The County of Santa Cruz reportedly has a relatively active monitoring and response program for environmental issues associated with septic systems.

In order to estimate the number of housing units located within the Pinto Lake catchment, staff analyzed census blocks which geographically overlaid the Pinto Lake catchment using Esri® ArcMap™ 10.3.1 spatial analysis software. Figure 4-8 illustrates three main block groups geographically covering the Pinto Lake catchment. The block groups are labeled here as A, B, and C.

We estimate that the human population living within the Pinto Lake catchment is 2,025 people, with an average of 3.2 people per housing unit, according to 2010 Census Bureau data. The number of housing units in the catchment is approximately 630 (see Table 4-5).

Table 4-6 tabulates the narrative designations the U.S. Census Bureau gives these block group areas. le 4-5 presents population and housing estimates of the three block groups and details on how the estimates were derived in the associated footnotes.

Local stakeholders provided staff information on local household sewage disposal practices. Based on communication with Mr. John Ricker, County of Santa Cruz Water Resources Division Director, residential areas on the east side of Pinto Lake along Green Valley Road are sewered, while residential areas on the west side of Pinto Lake along Amesti Road use septic systems. Figure 4-8 illustrates that the majority of housing units in the Pinto Lake catchment are located on the west side of the lake and therefore presumably use septic systems as a means of their waste disposal. As TMDL development progresses, we anticipate further investigating septic systems as a nutrient source category in the Pinto Lake catchment.

[9] The U.S. Census Bureau defines a *housing unit* as "a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters."

Figure 4-8. Census blocks and associated reported number of housing units in the Pinto Lake catchment and the immediate vicinity (source data: U.S. Census Bureau, 2010).

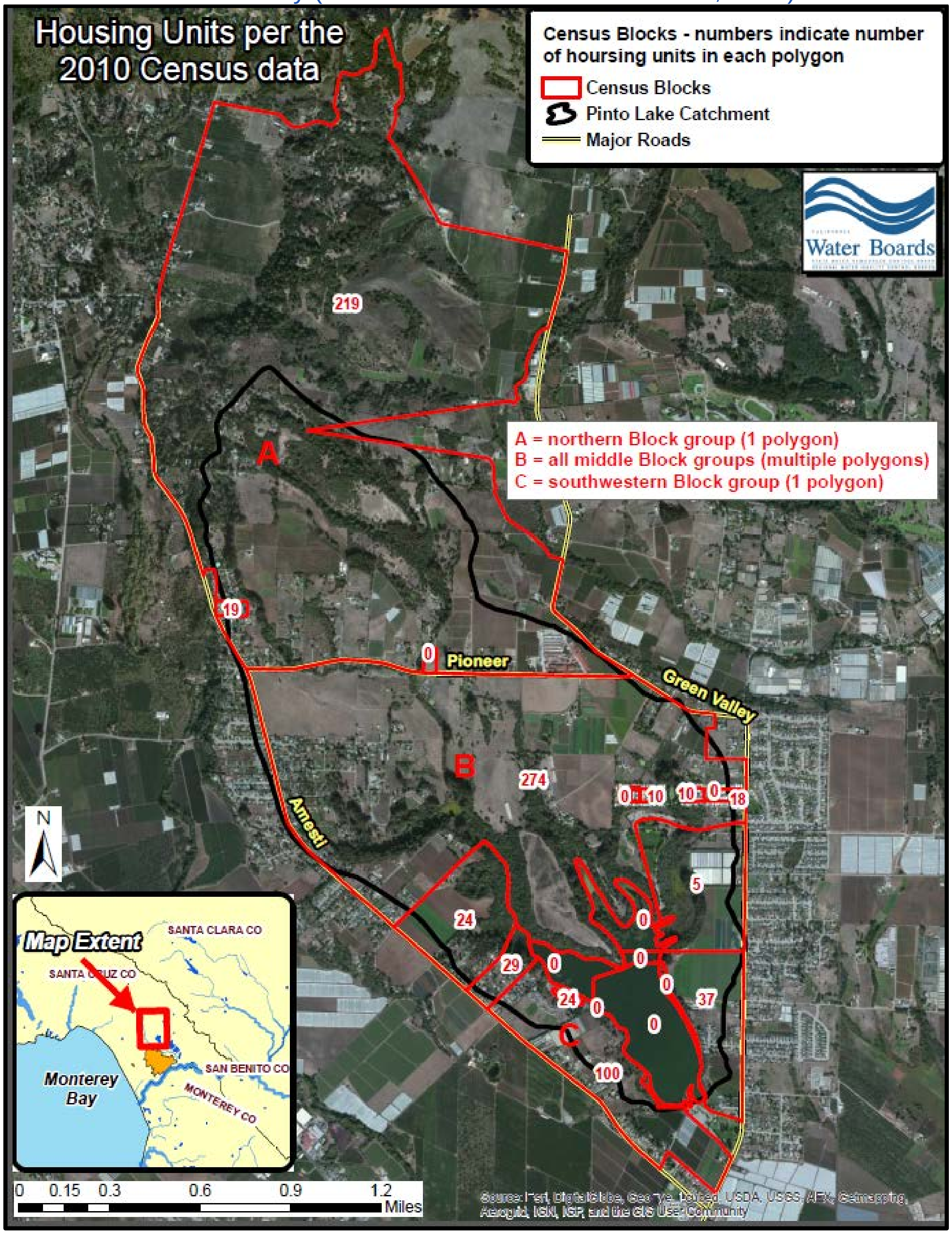


Table 4-5. Census block groups and associated estimates of number of housing units and total population within the Pinto Lake catchment.

Census Block Group[1]	Housing Units	Total Population
A[2] (northern block group)	110	320
B[3] (southern block group)	460	1,503
C[4] (southwestern block group)	60	202
Pinto Lake catchment total	630	2,025

[1] These letter values are arbitrary values associated with US Census Bureau Block groups (i.e., Block, Block Group, Census Tract, County, State). Please see Table 4-6 for the full text of the block groups.
[2] Half of census block “A” falls outside the catchment, and half the land classified as “residential” in the census block by the National Land Cover Dataset (2011) also falls outside the Pinto Lake catchment. Therefore, the census estimates for housing and population for this block group were reduced by half in this table (e.g. 219/2 = 110).
[3] –The majority of census block “B” is within the catchment, so the entire block group number is reported.
[4] Approximately 60% of this block group is within the catchment, therefore 60% of the total number of housing units and population is reported for this block group are shown in this table (e.g. 100*.6=60).

Table 4-6. U.S. Census Bureau blocks, block groups, census tracts, county andsState specified by the U.S. Census Bureau, 2010. For purposes of this analysis, staff arbitrarily assigned a letter to represent the Census Bureau narrative designations.

Census Block Letter for purposes of analysis (see Figure 4-8)	Specific Block groups
A	Block 1053, Block Group 1, Census Tract 1224, Santa Cruz County, California
B	Block 1054, Block Group 1, Census Tract 1224, Santa Cruz County, California
	Block 1016, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 1000, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 1014, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 2010, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2007, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2002, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2009, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2001, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 1015, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 1010, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 1001, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 1005, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 1002, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 1058, Block Group 1, Census Tract 1224, Santa Cruz County, California
	Block 2004, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2003, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 1004, Block Group 1, Census Tract 1231, Santa Cruz County, California
	Block 2008, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2011, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2005, Block Group 2, Census Tract 1231, Santa Cruz County, California
	Block 2006, Block Group 2, Census Tract 1231, Santa Cruz County, California
C	Block 1003, Block Group 1, Census Tract 1231, Santa Cruz County, California

4.5 Groundwater (updated)

Central Coast Water Board staff conducted a cursory review of groundwater data for this progress report. TMDLs do not directly address pollution of groundwater by controllable sources. However, shallow groundwater inflow to lakes and streams may be considered in the context of TMDL development. Groundwaters and surface waters are not closed systems that act independently from each other; it is well known that groundwater inflow to surface waters can be a source of nutrients or salts to any given surface waterbody. The physical interconnectedness of surface waters and groundwater is widely recognized by scientific agencies, researchers, and resource professionals, as highlighted below:

> *"Traditionally, management of water resources has focused on surface water or ground water as separate entities.…Nearly all surface-water features (streams, lakes reservoirs, wetlands, and estuaries) interact with groundwater. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water. Thus, effective land and water management requires a clear understanding of the linkages between ground water and surface water as it applies to any given hydrologic setting."*
>
> From: U.S. Geological Survey, 1998. Circular 1139: "Groundwater and Surface Water – A Single Resource."

> *"While ground water and surface water are often treated as separate systems, they are in reality highly interdependent components of the hydrologic cycle. Subsurface interactions with surface waters occur in a variety of ways. Therefore, the potential pollutant contributions from ground water to surface waters should be investigated when developing TMDLs."*
>
> From: U.S. Environmental Protection Agency, Guidance for Water Quality-Based Decisions: The TMDL Process – Appendix B. EPA 440/4-91-001.

"Although surface water and groundwater appear to be two distinct sources of water, they are not. Surface water and groundwater are basically one singular source of water connected physically in the hydrologic cycle...Effective management requires consideration of both water sources as one resource."

From: California Department of Water Resources: Relationship between Groundwater and Surface Water http://www.water.ca.gov/groundwater/groundwater_basics/gw_sw_interaction.cfm.

"The popular misconception in U.S. western culture appears to be that groundwater and surface water are 2 separate sources of water. This bimodal legal approach to managing what is one resource – water – has not resulted in rational water management in California…whether the water is above the land surface or below the land surface, it is the same water. Labeling it "groundwater" or "surface water" is a human construct that represents where the water is at that moment in time. They are not different sources."

From: Carl Hauge, retired Chief Hydrologist for the California Department of Water Resources, in Groundwater Resources Association of California, web seminar entitled *"No Surface Water = No Groundwater",* October 2015.

"Surface water and ground water are increasingly viewed as a single resource within linked reservoirs. The movement of water from streams to aquifers and from aquifers to streams influences both the quantity and quality of available water within both reservoirs"

From: C. Ruehl, A. Fisher, C. Hatch, M. Los Huertos, G. Stemler, and C. Shennan (2006), *Differential gauging and tracer tests resolve seepage fluxes in a strongly-losing stream.* Journal of Hydrology, volume 330, pp. 235-248.

"It's a myth that groundwater is separate from surface water and also a myth that it's difficult to legally integrate the two….California's groundwater and surface water are often closely interconnected and sometimes managed jointly."

From: Buzz Thompson, Professor of Natural Resources Law, Stanford University Law School, quoted in *Managing California's Groundwater*, by Gary Pitzer in Western Water January/February 2014, *and* from Public Policy Institute of California, *California Water Myths*, www.ppic.org.

Also worth noting, a clear and concise description about the nature of hydrologic interactions between lakes and groundwater was published by the U.S. Geological Survey, as shown below:

"Lakes interact with groundwater in three basic ways: some receive groundwater inflow throughout their entire bed; some have seepage loss to ground water throughout their entire bed; but perhaps most lakes receive groundwater inflow through part of their bed and have seepage loss to ground water through other parts."

From: U.S. Geological Survey, 1998. Circular 1139: "Groundwater and Surface Water – A Single Resource."

The range of information discussed above is illustrated conceptually in Figure 4-9.

Figure 4-9. Lakes are intimately connected to the groundwater system.

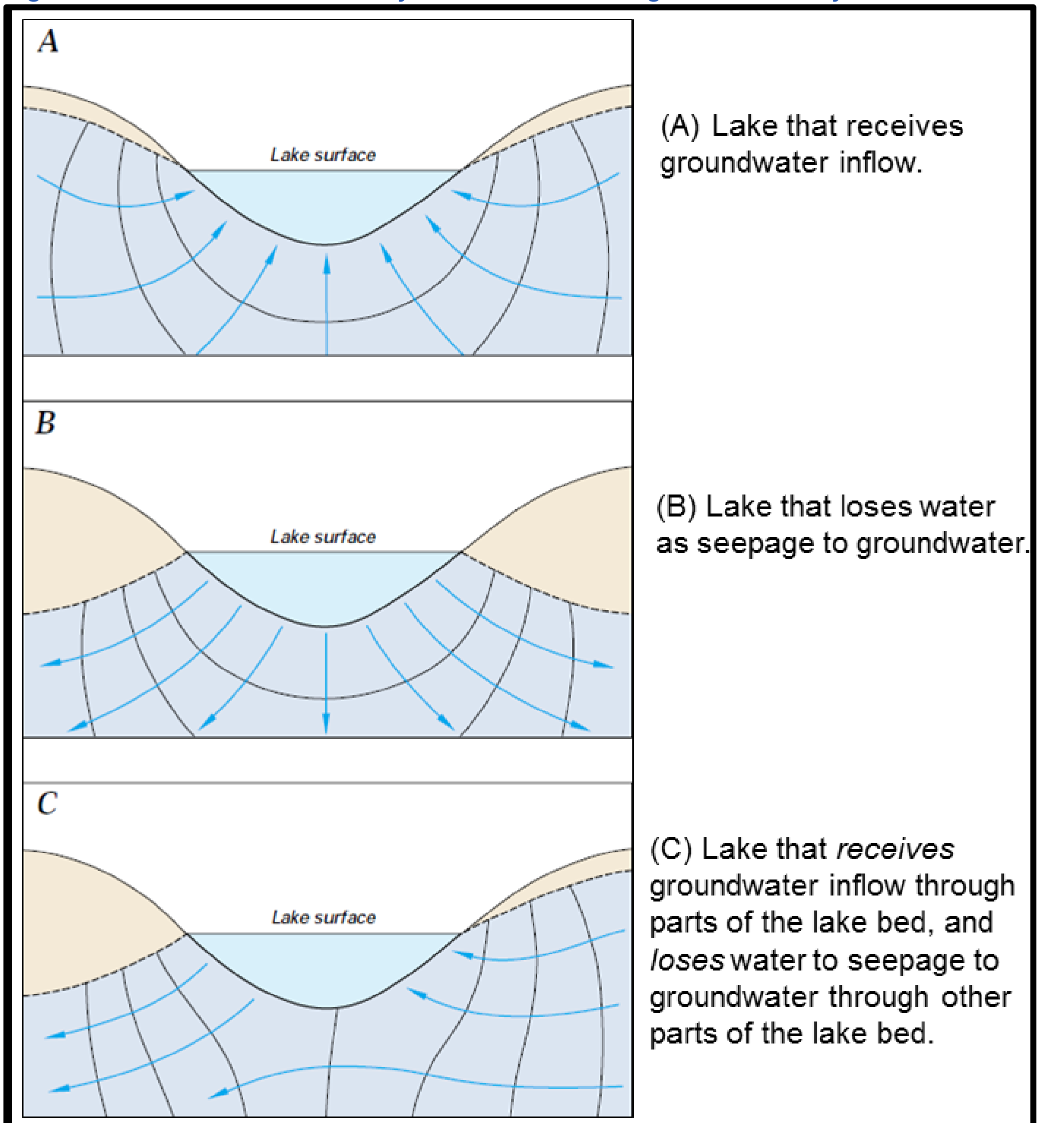
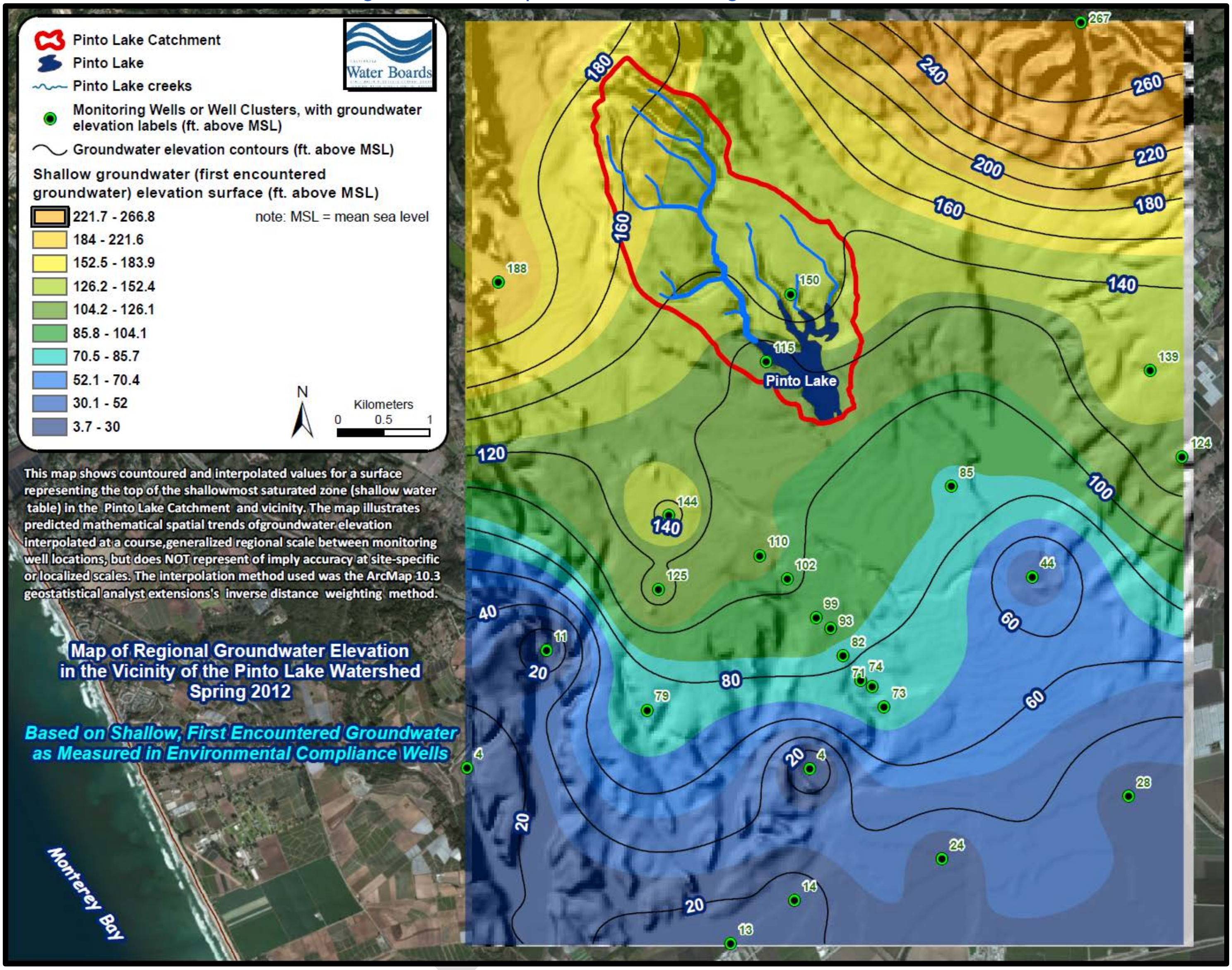


Figure credits: U.S. Geological Survey Circular 1139 (1998)

Groundwater has been recognized by local researchers as a potential and perhaps important source of nutrient loading to Pinto Lake (Ketley, Rettinger, and Los Huertos, 2013). The potential interaction between Pinto Lake and shallow groundwater can be deduced and estimated by examining groundwater elevations from wells which tap shallow groundwater. One of the most reliable sources of information on shallow groundwater is available from environmental compliance well information found in the State Water Resource Control Board's (State Water Board) GeoTracker database. Environmental compliance wells are generally constructed to monitor conditions in first-encountered groundwater, rather than in deeper drinking water supply and irrigation supply aquifers. Therefore, these environmental compliance wells can provide insight into groundwater elevation and hydraulic gradient in the water table of the shallow saturated zone. In addition, limited amounts of shallow groundwater elevation data in areas immediately surrounding Pinto Lake were made available to us by California State University researchers Scott Blanco and Erin Stanfield.

All groundwater flows along a hydraulic gradient, which is to say groundwater flows from areas of high hydraulic head (e.g., higher water level elevation) to areas of low head (e.g., low groundwater elevations). Using well construction details and water depth information available from GeoTracker and California State University researchers, we constructed a shallow groundwater elevation map (Spring 2012) for the Pinto Lake catchment and vicinity (see Figure 4-10) and shallow groundwater flow direction (see Figure 4-11).

Figure 4-10. Map of groundwater elevation Spring 2012, Pinto Lake catchment and vicinity, on the basis of shallow, first-encountered groundwater reported in monitoring well data.

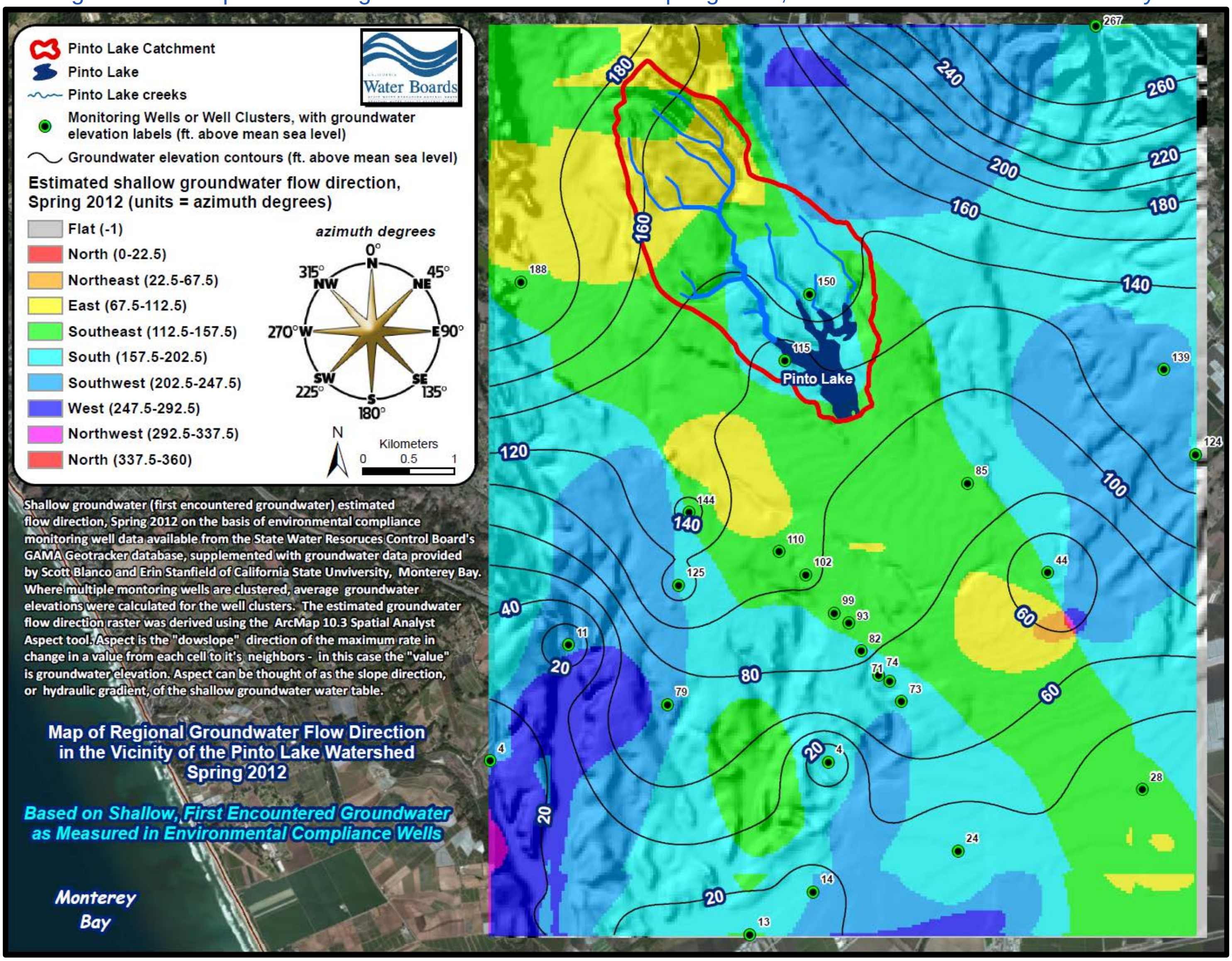


In Spring 2012, shallow groundwater underlying the Pinto Lake catchment and vicinity generally appears to flow in a southeast to south azimuthal direction (see Figure 4-11). Cursory review of groundwater data from previous years suggested a similar, long-term trend of a southeast to south shallow groundwater flow trend in the Pinto Lake catchment. These observations suggest that shallow groundwater flows towards – and potentially into – Pinto Lake generally from the north and northwest. At the south end of Pinto Lake, groundwater appears to be flowing away from the lake towards the southeast (i.e., towards the central axis of the Pajaro Valley groundwater basin). This type of shallow groundwater–lake interactions is a common hydrogeologic setting from many lakes, according to the U.S. Geological Survey (for example, refer back to Figure 4-9, type "C" groundwater– lake interaction on page 24).

It is worth nothing that a composite groundwater map for groundwater elevation observations from the fall of 2010, published by the Pacific Institute, also indicates a hydraulic gradient (groundwater flow) towards the southeast and south in the vicinity of Pinto Lake (Pacific Institute, undated report). Hydraulic gradients shown on composite groundwater maps are not necessarily directly comparable to our estimates of hydraulic gradient of first-encountered, shallow groundwater – however, the Pacific Institute reporting does add some measure of confidence to our estimate of groundwater hydraulic gradient in the Pinto Lake catchment.

It should be emphasized that our estimates of hydraulic gradients (flow direction) for shallow groundwater discussed above are only an approximation of subsurface, shallow groundwater conditions. The hydraulic gradient illustrated in Figure 4-10 and Figure 4-11 represents a mathematical spatial trend of groundwater elevations interpolated at a coarse, regional scale between observations from a limited number of monitoring sites, but does not represent or imply accuracy at localized, site-specific scales. Site-specific groundwater hydraulic gradients (flow directions) may vary due to factors such as groundwater pumping, artificial recharge, and local hydrogeologic conditions.

Figure 4-11. Map of shallow groundwater flow direction Spring 2012, Pinto Lake catchment and vicinity.



Estimated nitrate as N concentrations in shallow, recently-recharged groundwater are available from the U.S. Geological Survey. Figure 4-12 illustrates estimated nitrate as nitrogen concentration in project area shallow, recently-recharged groundwater in the Pajaro Valley and vicinity (data source: U.S. Geological Survey GWAVA model[10]). Shallow, recently recharged groundwater is defined by the U.S. Geological Survey in the GWAVA dataset as groundwaters less than 5 meters below ground surface. Table 4-7 presents numerical summaries of the predicted nitrate concentrations in shallow groundwater hydraulically upgradient of Pinto Lake. These shallow groundwaters are predicted to have relatively low average nitrate as N concentrations (3.65 mg/L mean and 1.36 mg/L median), with a range of predicted nitrate as N concentrations of 0.05 to 13.47 mg/L.

[10] The GWAVA dataset represents predicted nitrate concentration in shallow, recently recharged groundwater in the conterminous United States, and was generated by a national nonlinear regression model based on 14 input parameters.

Figure 4-12. Map illustrating estimated nitrate as N concentrations in shallow groundwater of the Pajaro Valley groundwater basin, and shallow groundwater hydraulically upgradient from Pinto Lake.

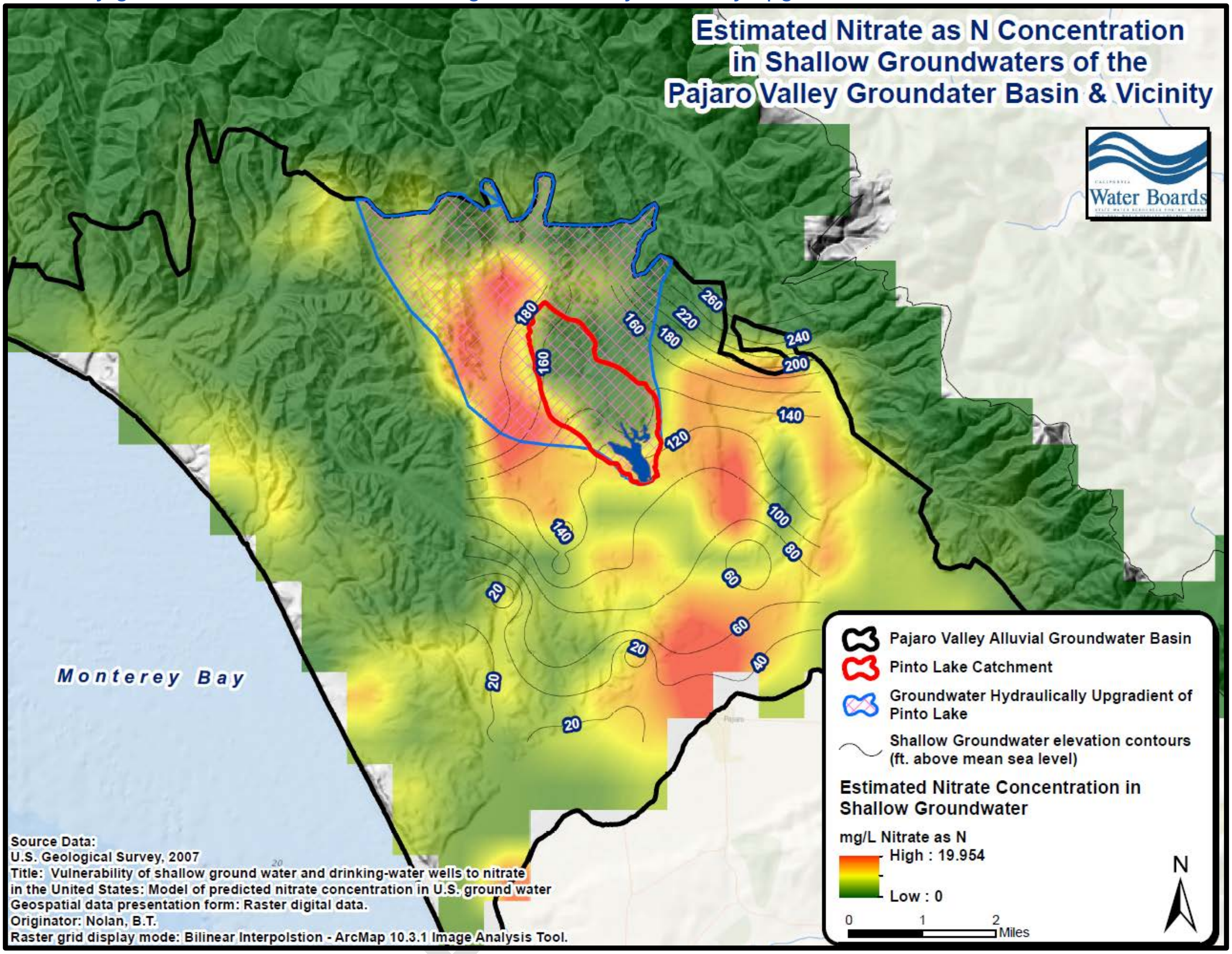


Table 4-7. Summary statistics for predicted nitrate concentrations (mg/L as N) in shallow, recently-recharged groundwater upgradient of Pinto Lake (refer back to Figure 4-12 for illustration of upgradient groundwater area).

Groundwater Model	Groundwater Body	Arithmetic Mean	Minimum	50% (median)	Maximum	Standard Deviation
GWAVA-S U.S. Geological Survey, 2007 Vulnerability of shallow ground water and drinking-water wells to nitrate in the United States: Model of predicted nitrate concentration in shallow, recently recharged ground water [A]	Shallow groundwater upgradient of Pinto Lake	3.65	0.05	1.36	13.47	4.07

[A] The GWAVA-S model predicts nitrate concentrations of shallow (typically less than five meters below ground surface), recently recharged groundwater, based on the work of Nolan and Hitt (2006).

4.6 Soils (updated)

Soils have physical and hydrologic characteristics which may have a significant influence on the transport and fate of nutrients. Watershed researchers and TMDL projects often assess soil characteristics in conjunction with other physical watershed parameters to estimate the risk and magnitude of nutrient loading to waterbodies (Mitsova-Boneva and Wang, 2008; McMahon and Roessler, 2002; Kellog et al., 2006). The relationship between nutrient export (loads) and soil texture is illustrated in Figure 4-13 and Figure 4-14. Generally, fine-textured soils with lower capacity for infiltration of precipitation/water are more prone to runoff and are consequently typically associated with a higher risk of nutrient loads to surface waters.

Figure 4-13. Median annual Total N and Total P export for various soil textures.

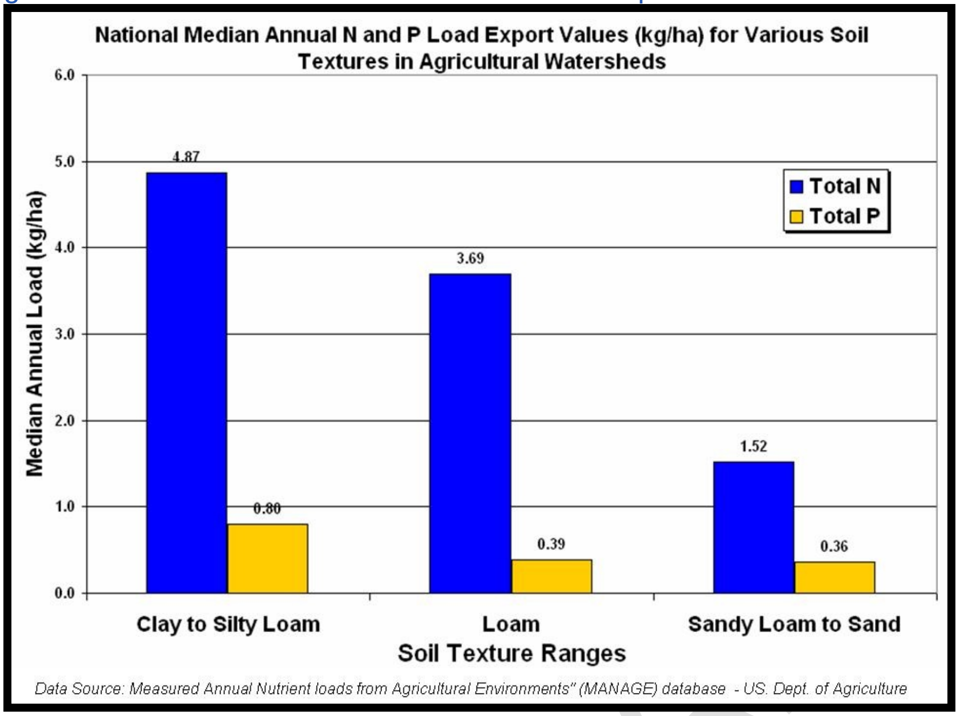
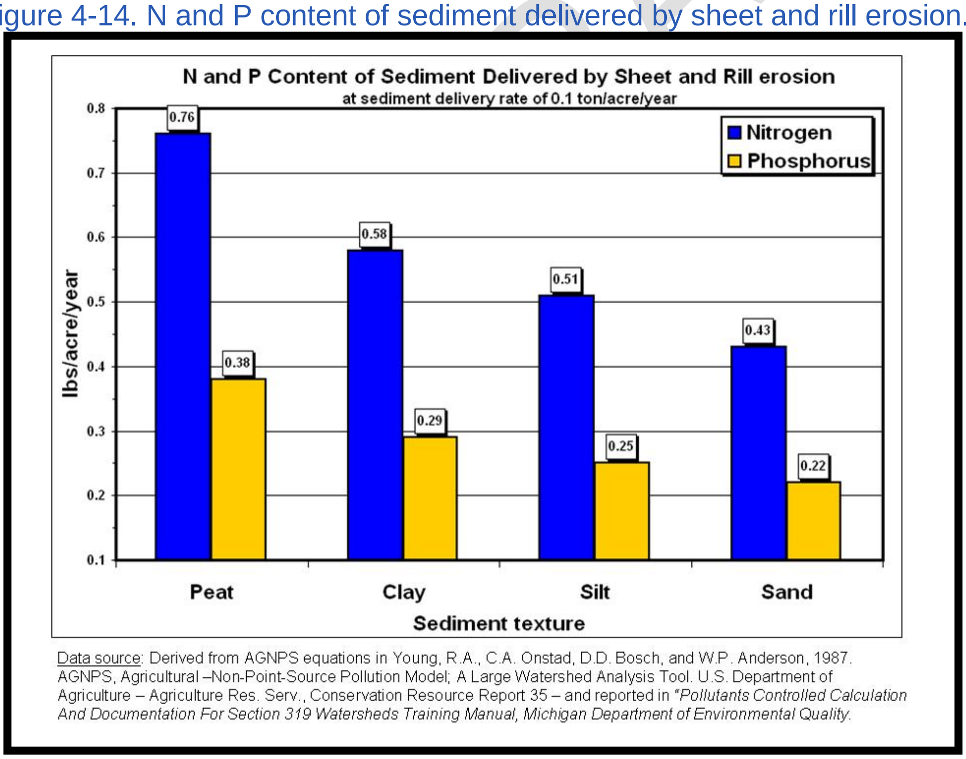


Figure 4-14. N and P content of sediment delivered by sheet and rill erosion.



Sediments and soils of the Pinto Lake catchment are generally expected to have relatively high phosphorus content compared to most ambient background soil conditions in California, and also higher in phosphorus relative to most soils sampled within the conterminous United States. Table 4-8 presents statistical summaries of phosphorus concentrations in soils in the United States.

Table 4-8. Statistical summaries of phosphorus concentrations soils in the conterminous United States; in the Oak and Chaparral Ecoregion of central California; and in the Pinto Lake catchment. Units = mg/kg.

Soil Dataset	Mean	Min.	10th %	25th %	50th % (median)	75th %	90th %	Max.	Number of Samples
Natural background concentrations of phosphorus in California soils (Kearney Soil Dataset) [A]									
Composite of all California Samples	412	13	73	199	360	555	776	1,210	50
Composite of California Oak & Chaparral Ecoregion Samples	421	82	195	309	378	487	602	1,210	17
U.S. Geological Survey National Soil Dataset –phosphorus concentrations in soil horizon A [B]									
Composite of All United States Samples (0-50cm)	626	trace	170	330	550	800	1,140	7,650	4857
Composite of All California Oak & Chaparral Ecoregion Samples (0-40cm)	664	170	240	340	530	910	1,090	2,210	41
Pinto Lake Sediment Core Data –phosphorus concentrations [C]									
Composite of all samples	1,278	491	600	711	1237	1,792	2,010	2,346	16
Pinto Creek (0-20cm)	633	491	504	523	600	710	789	842	4
Pinto Lake Abyss (0-20cm)	1,785	1,641	1,671	1,717	1,755	1,823	1,924	1,991	4
Pinto Lake Point (0-20cm)	1,968	1,631	1,702	1,809	1,948	2,108	2,251	2,346	4
Todos Santos (0-20cm)	725	708	709	711	717	731	748	759	4

[A] Kearney Foundation of Soil Science, Division of Agriculture and Natural Resources, University of California, 1996. Special Report: Background Concentrations of Trace and Major Elements in California Soil.
[B] U.S. Geological Survey, 2013. Data Series 801: Geochemical and Mineralogical Data for Soils of the Conterminous United States.
[C] City of Watsonville, Pinto Lake sediment core samples – unpublished data October 2014.

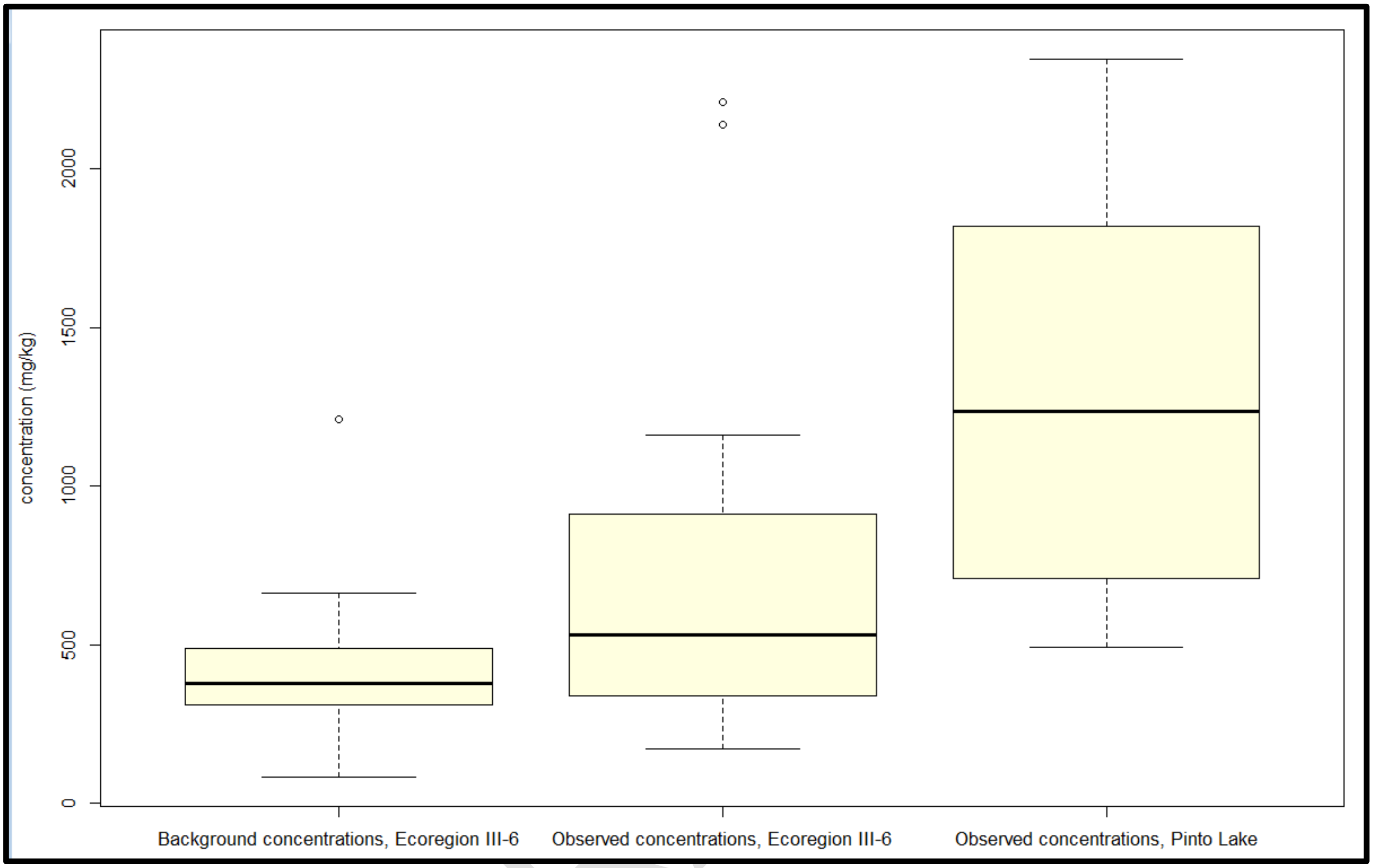
Figure 4-15 illustrates a box and whisker plot[11] of phosphorus concentrations in soils. Box and whisker plots are a graphical way of representing data dispersion. In this box plot, soils are grouped into three categories: 1) soil samples representing ambient, natural background conditions in California Ecoregion III-6[12]; 2) soils samples representing all observed soil conditions in sampling conducted by the U.S. Geological Survey in California Ecoregion III-6; and 3) sediment samples collected in the Pinto Lake catchment. In general, the box plot illustrates that phosphorus concentrations in sampled Pinto Lake catchment sediments are higher than phosphorus concentrations found more generally in samples from around California Ecoregion III-6.

The data suggests that the Pinto Lake catchment locally has soils and sediment that are relatively high in phosphorus.

[11] Statistical distributions can be represented as box plots. For more information on the nature and utility of box plots please refer to: http://en.wikipedia.org/wiki/Box_plot.

[12] Ecoregions are geographic areas with ecosystems that are generally similar physically, biologically, and climatologically. Ecoregion III-6 is a USEPA designation that refers to chaparral and oak woodland ecosystems of southern and central California, including much of the central coast region as well as chaparral and oak woodland ecosystems of the Sierra Nevada foothills. In this case, staff also included the Santa Cruz mountains geographically in our analysis; these mountains are technically in a different ecoregion, but were included here due to their proximity with the Pinto Lake catchment.

Figure 4-15. Box plot illustrating phosphorus concentration variation in soils of USEPA Ecoregion III-6 (central California oak and chaparral ecoregion) as compared to phosphorus concentrations in the Pinto Lake catchment sediments. Summary statistics for information in this boxplot were previously presented in Table 4-8.



Soil data for the Pinto Lake catchment are available from the U.S. Department of Agriculture National Resources Conservation Service's Soil Survey Geographic (SSURGO) Database. Soils attributes available in the SSURGO database include many soil attributes that can be important in farming, resource management, erosion, land management, and water quality. It should be noted that many SSURGO soil attributes are based on county-level and regional soil survey mapping, and thus site-specific and localized soil variation can be expected.

Various soil attributes that might be assessed in the context of TMDL development, or in the context of resource protection, land management, and water quality are presented in Figure 4-16 through Figure 4-21. In general, the SSURGO data indicate that large parts of the Pinto Lake catchment have soils with slow infiltration rates and which are relatively susceptible to erosion. If merited, a closer evaluation of soil attributes could occur as TMDL development progresses.

Also worth noting, some areas in and around the Pinto Lake catchment are characterized shallow (~two feet below ground surface) clay hardpan layers (see Figure 4-22), and thus these subsurface conditions can cause perched groundwater horizons and horizontal flow of shallow perched groundwater (personal communication Richard Casale, District Conservationist, U.S. Dept. of Agriculture Natural Resources Conservation Service, July 22, 2014). This type of shallow groundwater lateral flow therefore has the potential to result in hydraulic communication locally with surface waterbodies.

Figure 4-16. Map of soil units in the Pinto Lake catchment.

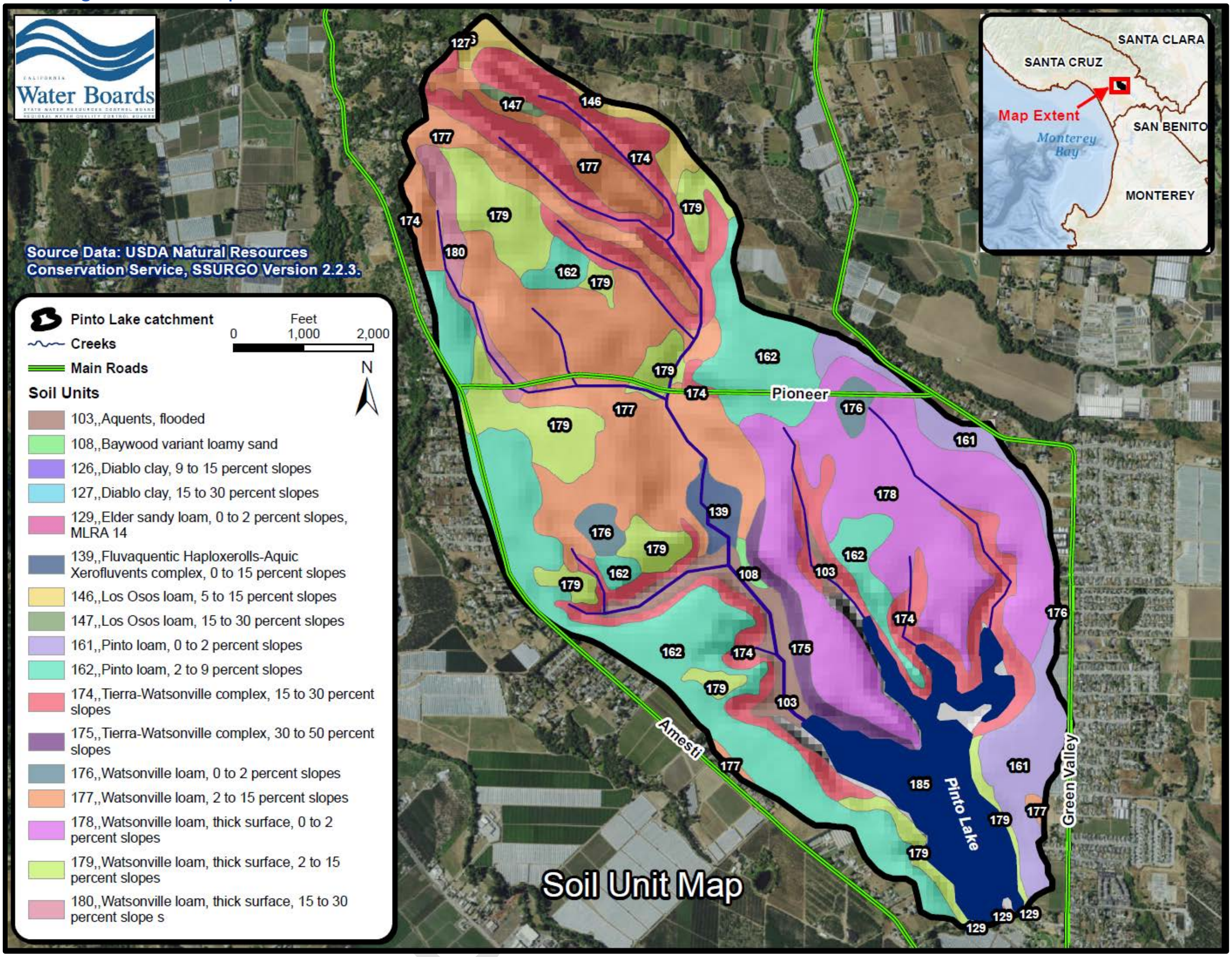


Figure 4-17. Soil textures in the Pinto Lake catchment and vicinity.

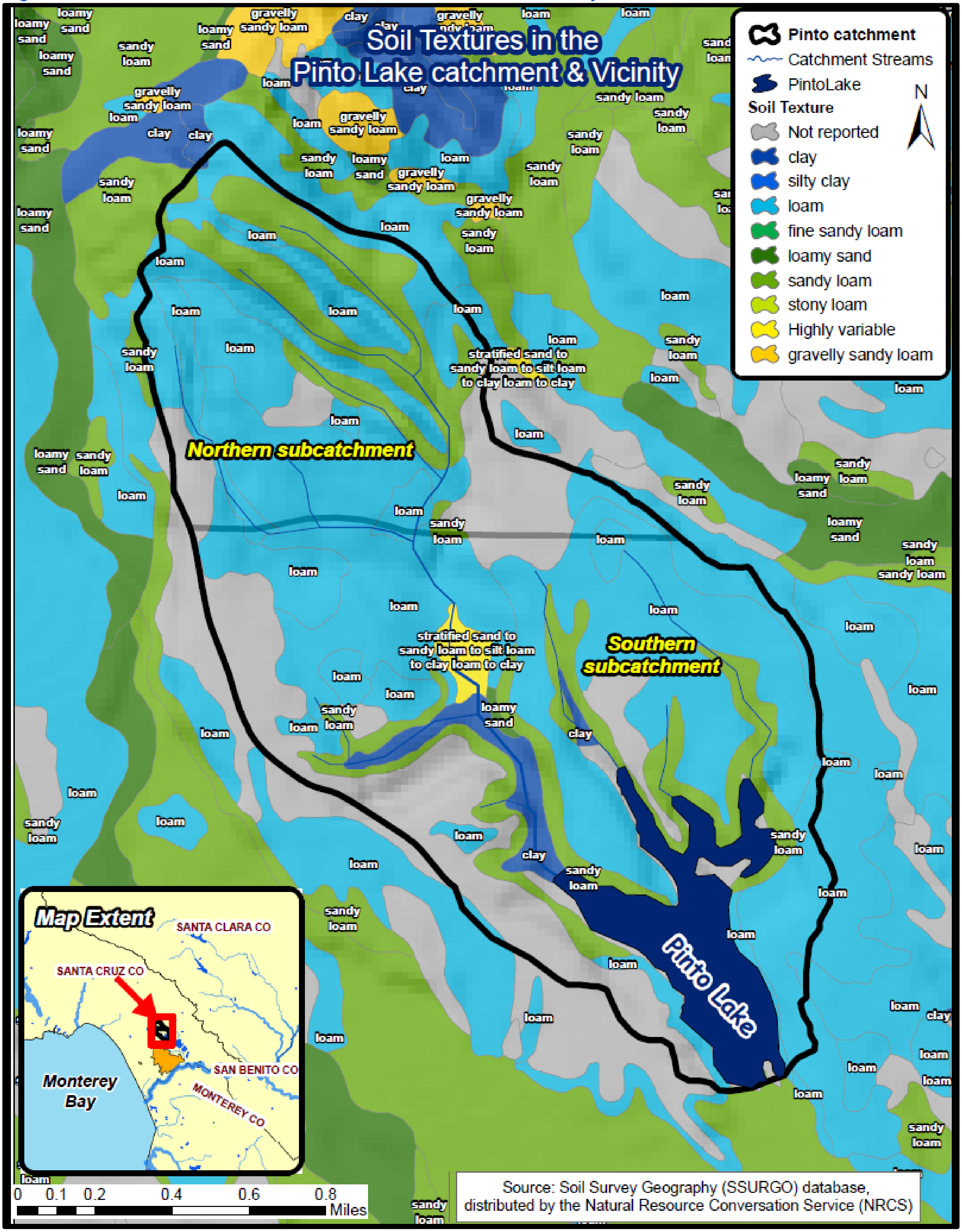
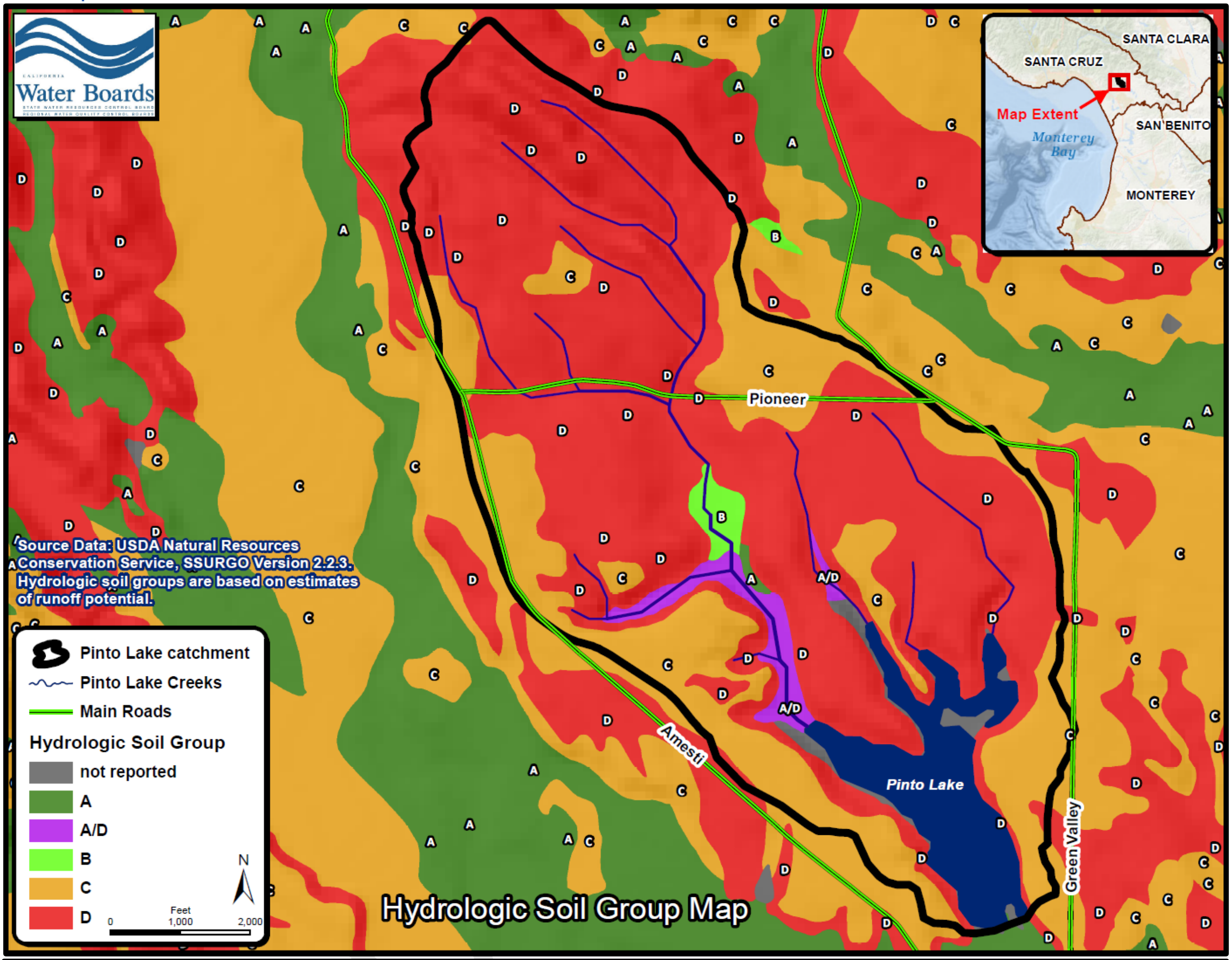


Figure 4-18. Hydrologic soils groups (HSGs) in Pinto Lake catchment and vicinity, with tabular description of HSGs.



Hydrologic Soil Group Descriptions	
A	Well drained to excessively drained sands or gravelly sands.
B	Moderately well drained or well drained soils having moderately fine to moderately course texture.
C	Soils having a slow infiltration rate when thoroughly wet; moderately fine or fine texture.
D	Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays, soils which have a high water table, soils that have a claypan or clay layer near the surface, and soils that overlie a shallow, nearly impervious surface.
A/D	If a soil is assigned a dual hydrologic group, the first letter is for drained areas and the second is for undrained areas.

Figure 4-19. Map showing soil taxonomic classifications in the Pinto Lake catchment.

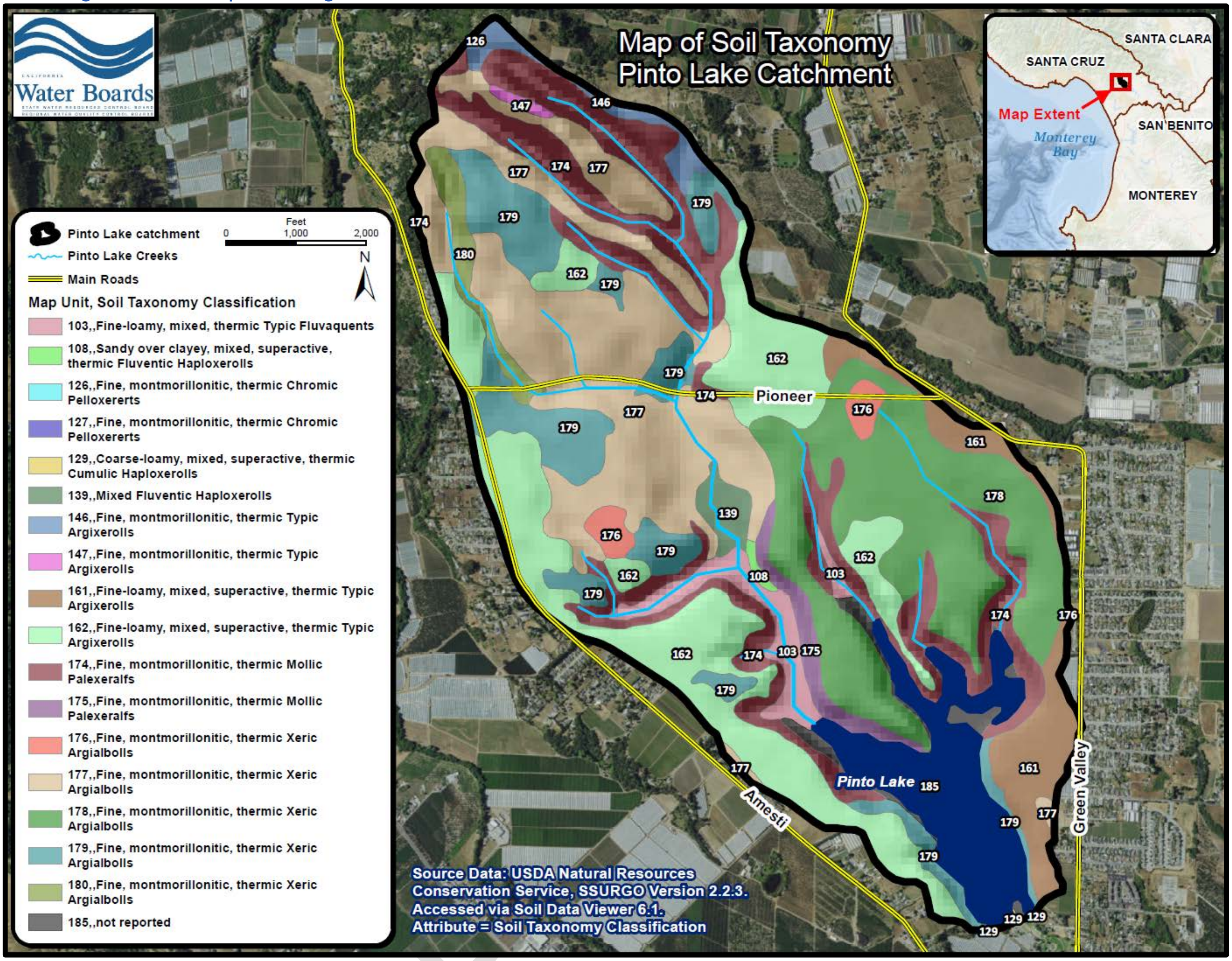


Figure 4-20. Map of soil erodibility (K factor) in the Pinto Lake catchment and vicinity.

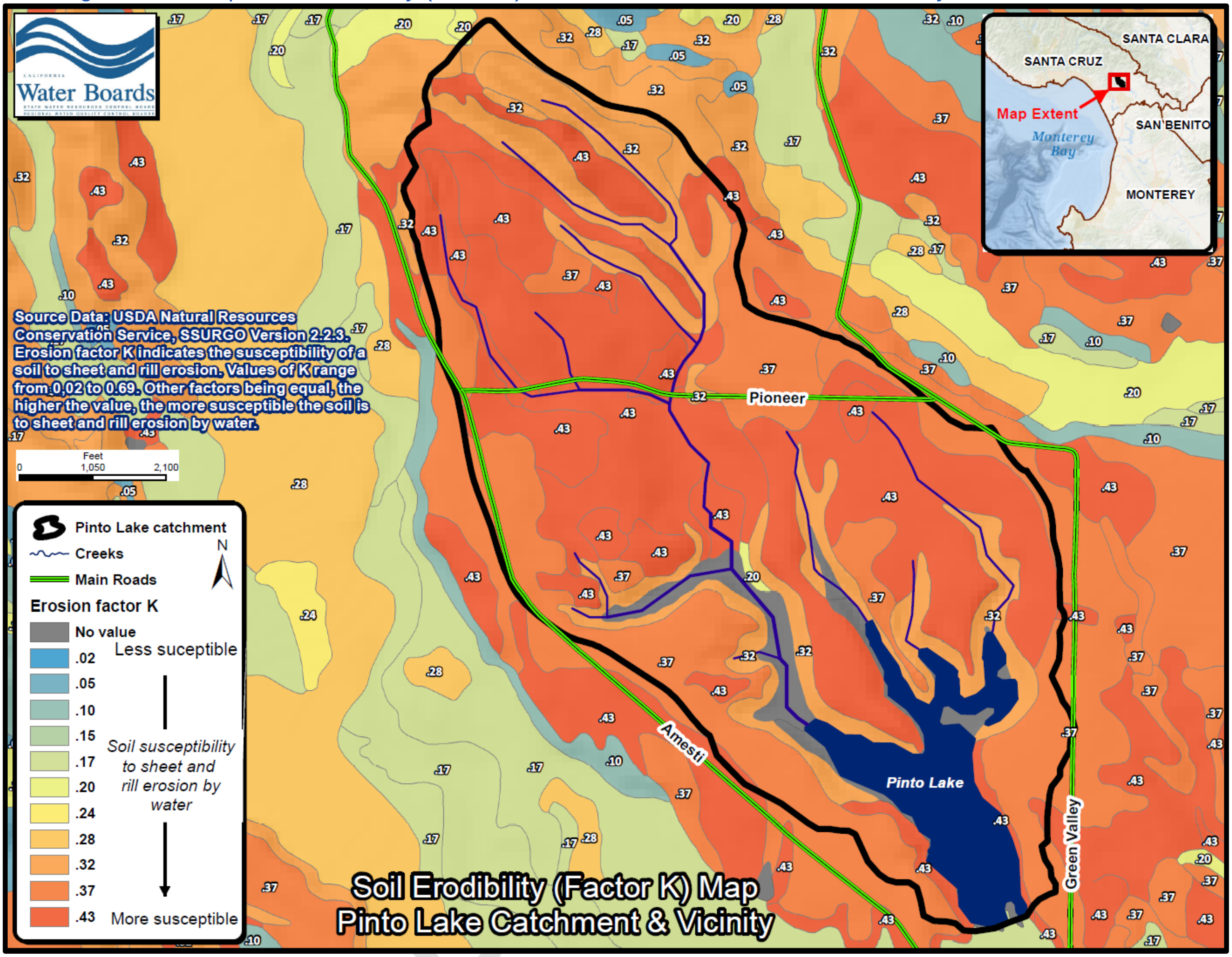


Figure 4-21. Map of soil cation exchange capacity, Pinto Lake catchment and vicinity.

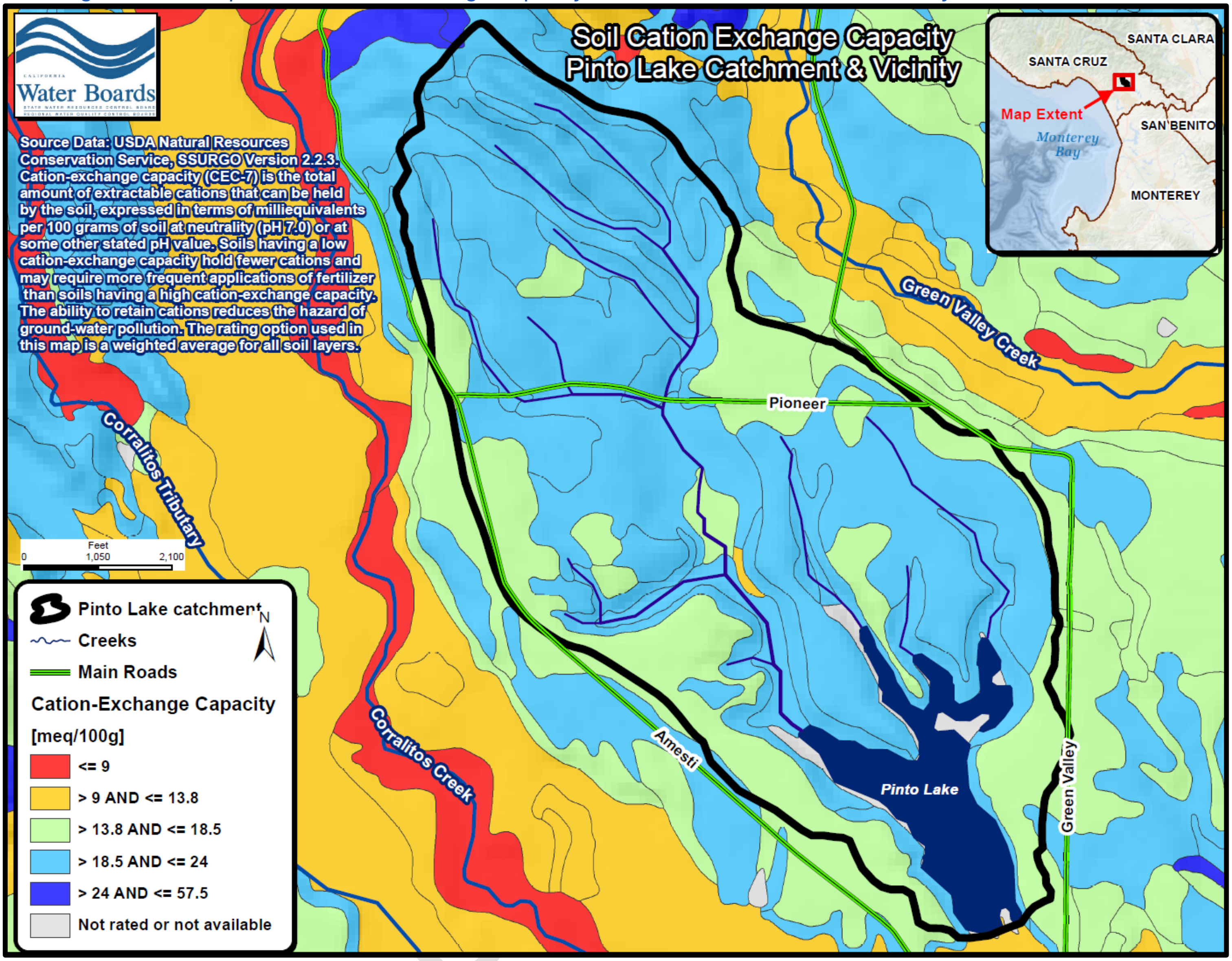
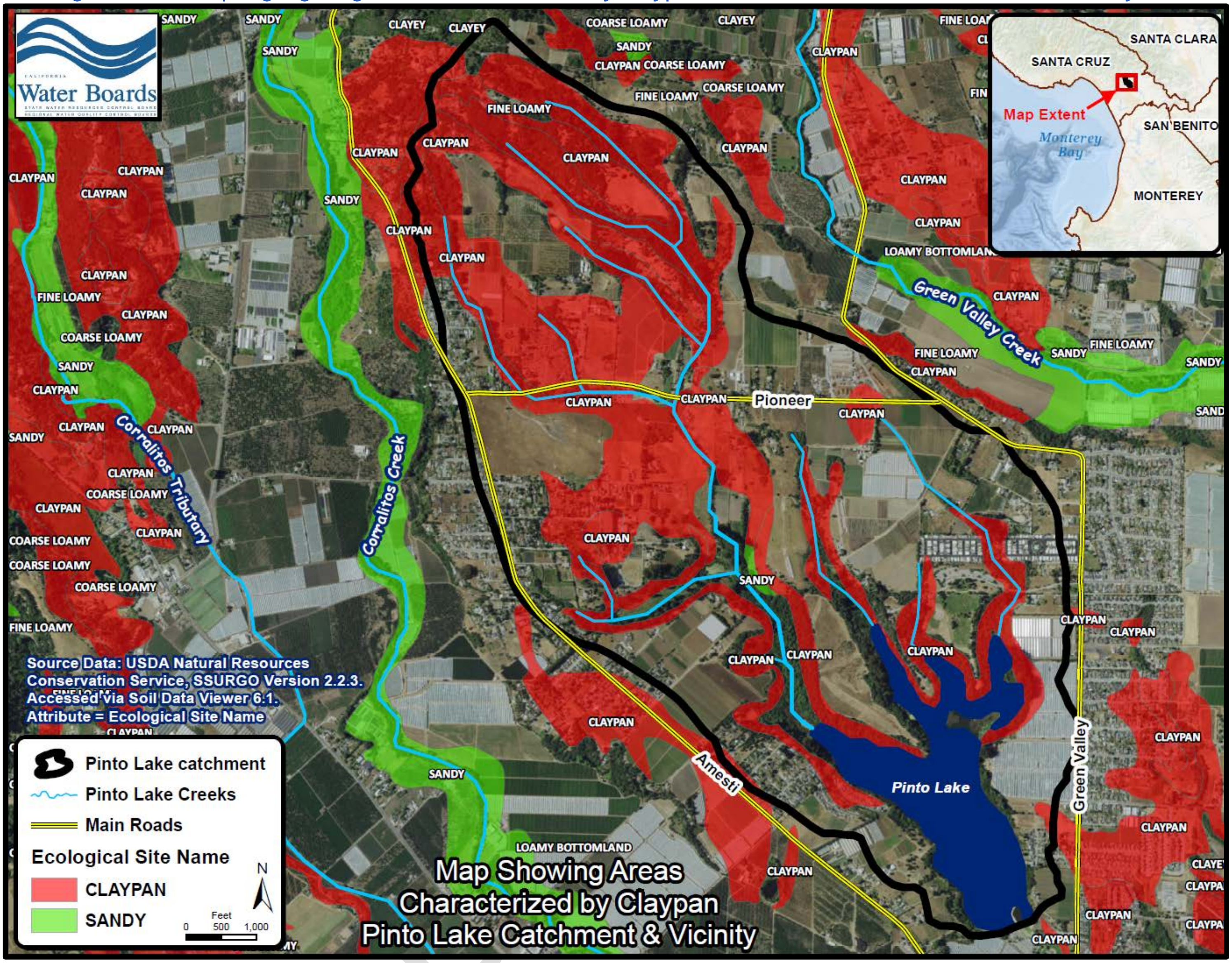


Figure 4-22. Map highlighting areas characterized by claypan in the Pinto Lake catchment and vicinity.



4.7 Geology

Geology can have a significant influence on natural, background concentrations of nutrients and other inorganic constituents in stream waters. The linkage between geologic conditions and stream water chemistry has long been recognized (for example, U.S. Geological Survey, 1910 and U.S. Geological Survey, 1985). Stein and Kyonga-Yoon (2007) reported that catchment geology was the most influential environmental factor on water quality variability from undeveloped stream reaches in lightly-disturbed, natural areas located in Ventura, Los Angeles, and Orange counties, California. Stein and Kyonga-Yoon (2007) concluded that catchments underlain by sedimentary rock had higher stream flow concentrations of metals, nutrients, and total suspended solids, as compared to areas underlain by igneous rock.

Additionally, the Utah Geological Survey hypothesized that organic-rich marine sedimentary rocks in the Cedar Valley of southern Utah may locally contribute to elevated nitrate observed in groundwater (Utah Geological Survey, 2001). Nitrogen found in the organic material of these rock strata are presumed by the Utah Geological Survey researchers to be capable of oxidizing to nitrate and may subsequently leach to groundwater.

Further, the Las Virgenes Municipal Water District (LVMWD, 2012) recently reported that high background levels of biostimulatory substances (nitrogen and phosphate) in the Malibu Creek Watershed appear to be associated with exposures of the Monterey/Modelo Formation. Also worth noting, Domagalski (2013) states that knowledge about natural and geologic sources of phosphorus in watersheds are important for developing nutrient management strategies.

Consequently, in evaluating the effect of anthropogenic activities on nutrient loading to waterbodies in a TMDL project, it may also be relevant to consider the potential impact on nutrient water quality which might result from local geology.

Central Coast Water Board staff conducted a brief and cursory review of geologic data for this progress report. Figure 4-23 presents an illustration of the geology of the Pinto Lake catchment and vicinity. Figure 4-23 is supplemented by a detailed geologic legend which is shown in Figure 4-24. Riparian creek corridors in the lake catchment are characterized by fine-grained Holocene[13] alluvium[14], while surficial geologic materials located outside the riparian corridors and in the uplands of the lake catchment are characterized by older, late Pleistocene[15] alluvium. A map of surficial geologic materials is presented in Figure 4-25.

Phosphorus-prone geologic materials may be associated with Upper Tertiary (Miocene) mudstones of the Santa Cruz mountains (geologic unit number 500, as illustrated on Figure 4-23). Whether or not detrital materials from these Miocene mudstones were ever deposited in the Pinto Lake catchment is uncertain. There is currently no direct surface water hydrologic connection between the lake catchment and Miocene strata of the Santa Cruz mountains. There may have been historical hydrologic connectivity between the lake catchment and the Miocene strata of the Santa Cruz mountains during flood stages, or due to migrations and changes in depositional patterns and stream networks in the recent geologic past.

If warranted, further review of geologic information may occur as TMDL development progresses.

[13] The Holocene is a geologic epoch which began 11,700 years ago at the end of the Pleistocene epoch and includes the present day. Thus, Holocene geologic materials include sediments and detrital matter that are currently being deposited on the land surface by air and water, as well as materials that have been deposited in the very recent geologic past.

[14] Sedimentary material deposited by rivers and streams is commonly referred to as alluvium, or alluvial deposits.

[15] The Pleistocene epoch is a relatively young geologic era which lasted from about 2.6 million years ago to 11,700 years ago.

Figure 4-23. Detailed map of geologic units and geologic materials (with associated numeric identifiers) in the Pinto Lake catchment and vicinity. A legend for the geologic units and their associated numeric identifiers shown on this map is presented in Figure 4-24.

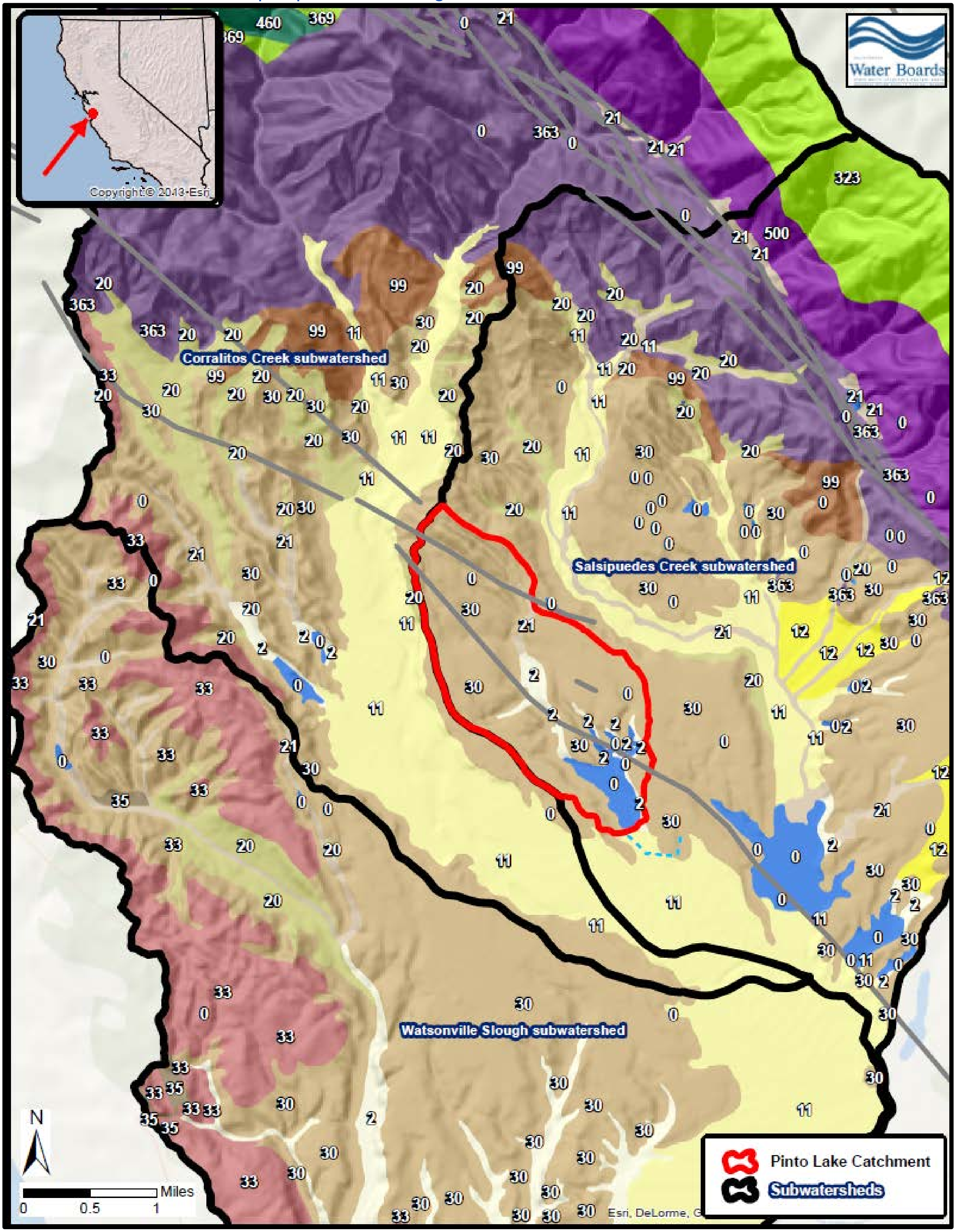


Figure 4-24. Legend for the geologic map previously shown in Figure 4-23.

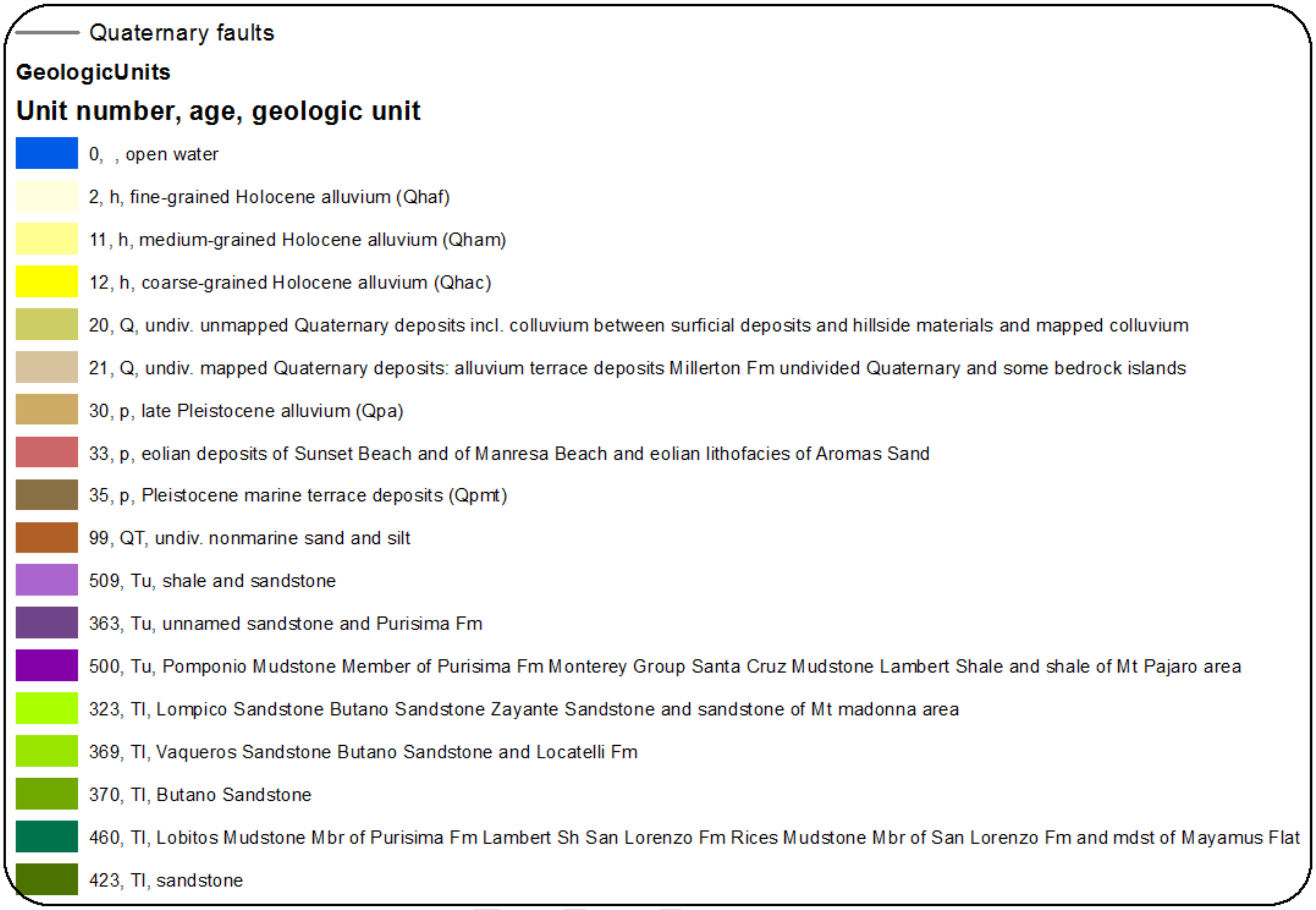
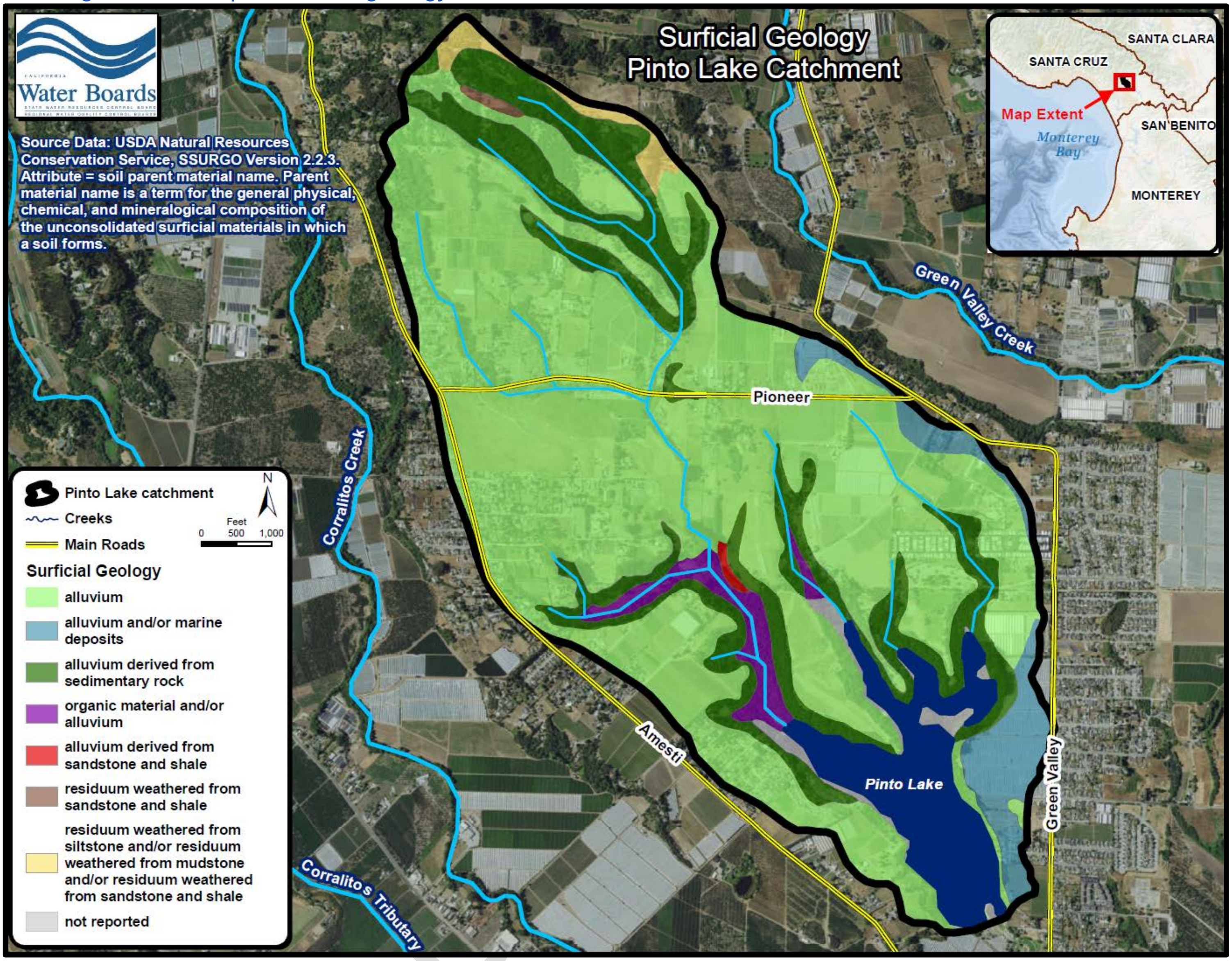


Figure 4-25. Map of surficial geology in the Pinto Lake catchment.



5. Water Quality Standards (new)

TMDLs are requirements pursuant to the federal Clean Water Act. The broad objective of the federal Clean Water Act is to "restore and maintain the chemical, physical and biological integrity of the Nation's waters[16]." Water quality standards are provisions of state and federal law intended to implement the federal Clean Water Act. In accordance with state and federal law, California's water quality standards consist of:

- Beneficial uses, which refer to legally-designated uses of waters of the state that may be protected against water quality degradation (e.g., drinking water supply, recreation, aquatic habitat, agricultural supply, etc.)
- Water quality objectives, which refer to limits or levels (numeric or narrative) of water quality constituents or characteristics that provide for the reasonable protection of beneficial uses of waters of the state.
- Anti-degradation policies, which are implemented to maintain and protect existing water quality, and high quality waters.

[16] Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.) Title 1, Section 101(a)

Therefore, beneficial uses, water quality objectives, and anti-degradation policies collectively constitute water quality standards[17]. Beneficial uses, relevant water quality objectives, and anti-degradation requirements that pertain to this TMDL are presented below in Section 5.1 Section 5.2 , and Section 5.3, respectively.

5.1 Beneficial Uses

California's water quality standards designate beneficial uses for each waterbody (e.g., drinking water supply, aquatic life support, recreation, etc.) and the scientific criteria to support that use. The Central Coast Water Board is required under both State and Federal Law to protect and regulate beneficial uses of waters of the state.

The Water Quality Control Plan for the Central Coastal Basin (Basin Plan) identifies beneficial uses for waterbodies of California's central coast region. Beneficial uses for surface waters in the Pajaro River basin are presented in Table 5-1. The Basin Plan also states that surface water bodies within the region that do not have beneficial uses specifically designated for them are assigned the beneficial uses of "municipal and domestic water supply" and "protection of both recreation and aquatic life." The Central Coast Water Board has interpreted this general statement of beneficial uses to encompass the beneficial uses of REC-1, REC-2, and MUN, along with all beneficial uses associated with aquatic life. The finding comports with the Clean Water Act's national interim goal of water quality [CWA Section 101(a)(2)] which provides for the protection and propagation of fish, shellfish, and wildlife.

Table 5-1. Central Coastal Basin Plan (June 2011 edition) designated beneficial uses for Pinto Lake.

Waterbody	MUN	AGR	GWR	REC1	REC2	WILD	SPWN	COMM
Pinto Lake	X	X	X	X	X	X	X	X

MUN: Municipal and domestic water supply	WILD: Wildlife habitat
AGR: Agricultural supply	WARM: Warm fresh water habitat
GWR: Ground water recharge	SPWN: Spawning, reproduction, and/or early development of fish
REC1: Water contact recreation	COMM: Commercial and sport fishing development
REC2: Non-Contact water recreation	

A narrative description of the designated beneficial uses Pinto Lake which are most likely to be at risk of impairment by water column nutrients and cyanobacteria are presented below.

5.1.1 Municipal & Domestic Water Supply (MUN)

Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply. According to State Board Resolution No. 88- 63, "Sources of Drinking Water Policy" all surface waters are considered suitable, or potentially suitable, for municipal or domestic water supply except under certain conditions (see Basin Plan, Chapter 2, Section II.)

The nitrate numeric water quality objective protective of the MUN beneficial use is legally established as 10 mg/L[18] nitrate as nitrogen (see Basin Plan, Table 3-2). This level is established to protect public health.

5.1.2 Ground Water Recharge (GWR)

*Uses of water for natural or artificial recharge of ground water for purposes of future extraction, **maintenance of water quality**, or halting of saltwater intrusion into freshwater aquifers. Ground water recharge includes recharge of surface water underflow (emphasis added) - (see Basin Plan, Chapter 2, Section II).*

The groundwater recharge (GWR) beneficial use is recognition by the state of the fundamental nature of the hydrologic cycle, and that surface waters and ground water are not closed systems that act

[17] See 40 CFR Ch. 1 §131

[18] This value is equivalent to, and may be expressed as, 45 mg/L nitrate as NO3.

independently from each other. Underlying groundwaters are, in effect, receiving waters for stream waters that infiltrate and recharge the subsurface water resource. Most surface waters and ground waters of the central coast region are both designated with the MUN (drinking water) and AGR (agricultural supply) beneficial uses. The MUN nitrate water quality objective (10 mg/L) therefore applies to *both* the surface waters, and to the underlying groundwater. This numeric water quality objective and the MUN and AGR designations of underlying groundwater are relevant to the extent that portions of Pajaro River basin streams recharge the underlying groundwater resource.

5.1.3 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 (see Basin Plan, Chapter 2, Section II).

In accordance with the Basin Plan, interpretation of the amount of nitrate which adversely effects the agricultural supply beneficial uses of waters of the state shall be derived from the University of California Agricultural Extension Service guidelines, which are found in Basin Plan Table 3-3. Accordingly, severe problems for sensitive crops could occur for irrigation water exceeding 30 mg/L[19]. It should be noted that the University of California Agricultural Extension Service guideline values are flexible, and may not necessarily be appropriate due to local conditions or special conditions of crop, soil, and method of irrigation.

Further, the Basin Plan provides water quality objectives for nitrate which are protective of the AGR beneficial uses for livestock watering. While nitrate (NO_3) itself is relatively non-toxic to livestock, ingested nitrate is broken down to nitrite (NO_2); subsequently nitrite enters the bloodstream where it converts blood hemoglobin to methemoglobin. This greatly reduces the oxygen-carrying capacity of the blood, and the animal suffers from oxygen starvation of the tissues[20]. Death can occur when blood hemoglobin has fallen to one-third normal levels. Resource professionals[21] report that nitrate can reach dangerous levels for livestock in streams, ponds, or shallow wells that collect drainage from highly fertilized fields. Accordingly, the Basin Plan identifies the safe threshold of nitrate as N for purposes of livestock watering at 100 mg/L[22].

5.1.4 Aquatic Habitat (WARM, WILD, SPWN)

WARM: Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

SPWN: Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

WILD: Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

The Basin Plan water quality objectives protective of aquatic habitat beneficial uses and which are most relevant to nutrient pollution[23] are the biostimulatory substances objective and dissolved oxygen objectives for aquatic habitat. The biostimulatory substances objective is a narrative water quality

[19] The University of California Agricultural Extension Service guideline values are flexible, and may not necessarily be appropriate due to local conditions or special conditions of crop, soil, and method of irrigation. 30 mg/L nitrate as nitrogen is the recommended uppermost threshold concentration for nitrate in irrigation supply water as identified by the University of California Agricultural Extension Service which potentially cause severe problems for sensitive crops (see Table 3-3 in the Basin Plan). Selecting the least stringent threshold (30 mg/L) therefore conservatively identifies exceedances which could detrimentally impact the AGR beneficial uses for irrigation water.

[20] New Mexico State University, Cooperative Extension Service. Nitrate Poisoning of Livestock. Guide B-807.

[21] University of Arkansas, Division of Agriculture - Cooperative Extension. "Nitrate Poisoning in Cattle". Publication FSA3024.

[22] 100 mg/L nitrate as nitrogen is the Basin Plan's water quality objective protective of livestock watering, and is based on National Academy of Sciences-National Academy of Engineering guidelines (see Table 3-3 in the Basin Plan).

[23] Nutrients, such as nitrate, do not by themselves necessarily directly impair aquatic habitat beneficial uses. Rather, they cause indirect impacts by promoting algal growth and low dissolved oxygen that impair aquatic habitat uses.

objective that states "*Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses*."

The Basin Plan also requires that in waterbodies designated for WARM habitat dissolved oxygen concentrations shall not be depressed below 5 mg/L and that in waterbodies designated for COLD and SPWN dissolved oxygen shall not be depressed below 7 mg/L. Further, since unionized ammonia is highly toxic to aquatic species, the Basin Plan requires that the discharge of waste shall not cause concentrations of unionized ammonia (NH3) to exceed 0.025 mg/L (as N) in receiving waters.

5.1.5 Water Contact Recreation (REC-1)

REC-1: Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs. (see Basin Plan, Chapter 2, Section II).

The Basin Plan water quality objective protective of water contact recreation beneficial uses and which is most relevant to nutrient pollution is the general toxicity objective for all inland surface water, enclosed bays, and estuaries (Basin Plan Chapter 3, section II.A.2.a). The general toxicity objective is a narrative water quality objective that states:

"All waters shall be maintained free of toxic substances in concentrations which are toxic to, or which produce detrimental physiological responses in, human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, toxicity bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board."

Because illnesses are considered detrimental physiological responses in humans, the narrative toxicity objective applies to algal toxins. Possible health effects of exposure to blue-green algae blooms and their toxins can include rashes, skin and eye irritation, allergic reactions, gastrointestinal upset, and other effects including poisoning. Note that microcystins are toxins produced by cyanobacteria (blue-green algae) and are associated with algal blooms, elevated nutrients, and biostimulation in surface waterbodies. The State of California Office of Environmental Health Hazard Assessment (OEHHA) has published peer-reviewed public health action-level guidelines for algal cyanotoxins (microcystins) in recreational water uses; this public health action-level for microcystins is 0.8 µg/L[24] (OEHHA, 2012). This public health action level can therefore be used to assess attainment or non-attainment of the Basin Plan's general toxicity objective and to ensure that REC-1 designated beneficial uses are being protected and supported.

5.2 Water Quality Objectives and Criteria

The Basin Plan contains specific water quality objectives that apply to nutrients and nutrient-related parameters. In addition, the Central Coast Water Board uses established, scientifically-defensible numeric criteria to implement narrative water quality objectives, and for use in Clean Water Act Section 303(d) Listing assessments. These water quality objectives and numeric criteria are established to protect beneficial uses and are compiled in Table 5-2.

[24] Includes microcystins LR, RR, YR, and LA.

Table 5-2. Compilation of Basin Plan water quality objectives and numeric criteria for nutrients and nutrient-related parameters.

Constituent Parameter	Source of Water Quality Objective/Criteria	Numeric Target	Primary Use Protected
Unionized Ammonia as N	Basin Plan numeric objective	0.025 mg/L	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries *(toxicity objective)*
Nitrate as N	Basin Plan numeric objective	10 mg/L	MUN, GWR (Municipal/Domestic Supply; Groundwater Recharge)
Nitrate as N	Basin Plan numeric criteria (Table 3-3 in Basin Plan)	5 – 30 mg/L *California Agricultural Extension Service guidelines*	AGR (Agricultural Supply – irrigation water) *"Severe" problems for sensitive crops at greater than 30 mg/L* *"Increasing problems" for sensitive crops at 5 to 30 mg/L*
Nitrate (NO3-N) plus Nitrite (NO2-N)	Basin Plan numeric objective (Table 3-4 in Basin Plan)	100 mg/L *National Academy of Sciences-National Academy of Engineers guidelines*	AGR (Agricultural Supply - livestock watering)
Nitrite (NO2–N)	Basin Plan numeric objective (Table 3-4 in Basin Plan)	10 mg/L *National Academy of Sciences-National Academy of Engineers guidelines*	AGR (Agricultural Supply - livestock watering)
Dissolved Oxygen	General Inland Surface Waters numeric objectives	For waters not mentioned by a specific beneficial use, dissolved oxygen shall not be depressed below 5.0 mg/L Median values should not fall below 85% saturation.	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries.
	Basin Plan numeric objective WARM, COLD, SPWN	Dissolved Oxygen shall not be depressed below 5.0 mg/L (WARM) Dissolved Oxygen shall not be depressed below 7.0 mg/L (COLD, SPWN)	Cold Freshwater Habitat, Warm Freshwater Habitat, Fish Spawning
	Basin Plan numeric objective AGR	Dissolved Oxygen shall not be depressed below 2.0 mg/L	AGR (Agricultural Supply)
pH	General Inland Surface Waters numeric objective	pH value shall not be depressed below 7.0 or raised above 8.5.	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries.
	Basin Plan numeric objective MUN, AGR, REC1, REC-2	The pH value shall neither be depressed below 6.5 nor raised above 8.3.	Municipal/Domestic Supply, Agricultural Supply, Water Recreation
	Basin Plan numeric objective WARM, COLD	pH value shall not be depressed below 7.0 or raised above 8.5	Cold Freshwater Habitat, Warm freshwater habitat
Biostimulatory Substances	Basin Plan narrative objective[A]	pending	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries *(biostimulatory substances objective)* -- (e.g., WARM, COLD, REC, WILD, EST)
Chlorophyll *a*	Basin Plan narrative objective[A]	40 µg/L *Source: North Carolina Administrative Code, Title 151, Subchapter 2B, Rule 0211*	Numeric listing criteria to implement the Basin Plan biostimulatory substances objective for purposes of Clean Water Act Section 303(d) Listing assessments.
Microcystins *(includes Microcystins LA, LR, RR, and YR)*	Basin Plan narrative objective[B]	0.8 µg/L *California Office of Environmental Health Hazard Assessment Suggested Public Health Action Level*	REC-1 (water contact recreation)

[A] *The Basin Plan biostimulatory substances narrative objective states: "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses." (Biostimulatory Substances Objective, Basin Plan, Chapter 3)*

[B] *The Basin Plan toxicity narrative objective states: "All waters shall be maintained free of toxic substances in concentrations which are toxic to, or which produce detrimental physiological responses in, human, plant, animal, or aquatic life." (Toxicity Objective, Basin Plan, Chapter 3)*

5.3 Anti-degradation Policy

In accordance with section II.A of the Basin Plan, wherever the existing quality of water is better than the quality of water established in the Basin Plan as objectives, **such existing quality shall be maintained** unless otherwise provided by provisions of the state anti-degradation policy. Practically speaking, this means that where water quality is *better* than necessary to support designated beneficial uses, such existing high water quality shall be maintained, and further lowering of water quality is not allowed except under conditions provided for in the anti-degradation policy.

The U.S. Environmental Protection Agency (USEPA) has also issued detailed guidelines for implementation of federal anti-degradation regulations for surface waters (40 CFR 131.12). The State Water Resources Control Board (State Water Board) has interpreted Resolution No. 68-16 (i.e., the state anti-degradation policy) to incorporate the federal anti-degradation policy to ensure consistency. It is important to note that federal policy only applies to surface waters, while state policy applies to both surface and ground waters.

For purposes of the anti-degradation policy, "high quality waters" are defined on a constituent-by-constituent basis. From the water quality management perspective, it is simply not enough to improve impaired waters – protection of existing high quality waters and prevention of any further water quality degradation should be identified as a high priority goal[25]. Simply put, TMDL implementation efforts are justified in considering improved protection of high quality waters and addressing anti-degradation concerns, as well as focusing on improving impaired waterbodies.

Indeed, the U.S. Environmental Protection Agency recognizes the validity of using TMDLs as a tool for implementing anti-degradation goals:

> *Identifying opportunities to protect waters that are not yet impaired: TMDLs are typically written for restoring impaired waters; however, states can prepare TMDLs geared towards maintaining a "better than water quality standard" condition for a given waterbody-pollutant combination, and they can be a useful tool for high quality waters.*
>
> From: USEPA, 2014a. Opportunities to Protect Drinking Water Sources and Advance Watershed Goals Through the Clean Water Act: A Toolkit for State, Interstate, Tribal and Federal Water Program Managers. November 2014.

6. Clean Water Act Section 303(d) Impairments (new)

Listing a water body as impaired under federal law in California is governed by the Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) Listing Policy. The State and Regional Water Boards assess water quality data for California's waters every few years to determine if they contain pollutants at levels that exceed protective water quality criteria and standards. This biennial assessment is required under Section 303(d) of the federal Clean Water Act. The last Section 303(d) assessment in the central coast region was approved by USEPA in 2010. The impairments identified in Pinto Lake in the 2010 assessment are shown in Table 6-1.

Table 6-1. Clean Water Act Section 303(d) impairments in Pinto Lake (year 2010).

Water Body Name	Waterbody Identifier	USGS Watershed Cataloging Unit*	Pollutant	Pollutant Category	Final Listing Decision
Pinto Lake	CAL3051003020020124122807	18060002	Chlorophyll-a	Nutrients	List on 303(d) list (TMDL required list)

[25] The Central Coast Water Board considers *preventing* impairment of waterbodies to be as important a priority as *correcting* impairments of waterbodies (see the staff report for agenda item 3, July 11, 2012 Central Coast Water Board meeting).

Water Body Name	Waterbody Identifier	USGS Watershed Cataloging Unit*	Pollutant	Pollutant Category	Final Listing Decision
Pinto Lake	CAL3051003020020124122807	18060002	Cyanobacteria hepatotoxic microcystins	Miscellaneous	List on 303(d) list (TMDL required list)
Pinto Lake	CAL3051003020020124122807	18060002	Low Dissolved Oxygen	Nutrients	List on 303(d) list (TMDL required list)
Pinto Lake	CAL3051003020020124122807	18060002	Scum/Foam-unnatural	Nuisance	List on 303(d) list (TMDL required list)
Pinto Lake	CAL3051003020020124122807	18060002	pH	Miscellaneous	List on 303(d) list (TMDL required list)

7. Water Quality Data (new)

Surface water quality data (i.e., data from the lake, from tributary creeks, and from diches) used in this report were kindly made available to Central Coast Water Board staff from the following sources:

1. City of Watsonville water quality data.
2. County of Santa Cruz water quality data.
3. Water quality data collected by researchers from University of California, Santa Cruz.
4. Water quality data collected by researchers from California State University, Monterey Bay.

Key stakeholders that assisted in contributing surface water quality data included Dr. Raphael Kudela and his team of researchers from the University of California–Santa Cruz; Mr. John Ricker of the County of Santa Cruz; Mr. Robert Ketley and Ms. Jackie McCloud of the City of Watsonville; Mr. Scott Blanco and Ms. Erin Stanfield affiliated with California State University–Monterey Bay.

Groundwater quality data (i.e., data from shallow groundwater[26] and springs) used in this report were obtained from the following sources:

1. U.S. Geological Survey's National Water Information System (NWIS).
2. State Water Board's GeoTracker database.
3. U.S. Geological Survey's National Uranium Resource Evaluation (NURE) Hydrogeochemical Reconnaissance dataset.

Where appropriate, Central Coast Water Board staff conducted additional data quality control and data filtering on the water quality data. This quality control included: 1) filtering the data to extract only grab samples and field measurements (thus excluding field blanks and duplicates); 2) converting nutrient data reported in compound molecular reporting conventions to the elemental reporting convention (e.g., converting nitrate molecular (NO_3) concentration values to nitrate as elemental nitrogen (N) values); 3)

[26] In an attempt to report groundwater data that reasonably could be expected to be representative of shallow groundwater, we filtered groundwater data on the basis of well construction information. If and where well construction information was available, we included in our final dataset only private domestic drinking water wells, or wells that were constructed to a depth less than 200 feet below ground surface. These well were presumed to be representative or influenced by shallower groundwaters. Wells identified as irrigation or municipal supply wells or wells constructed to a depth of greater than 200 feet below ground surface were excluded from our final dataset, as these types of wells would generally be expected to be influenced or representative of deeper groundwater aquifers (i.e., groundwaters that have not recently been in hydraulic communication with surface waters such as lakes, creeks, or ditches).

quantifying censored data[27] by substituting imputed values[28,29]; and 4) combining water quality data from monitoring sites which were in close proximity to each other (<200 meters), in the same surface waterbody, and when there was no compelling reason to treat them, for TMDL purposes, as individual, discrete monitoring sites[30]; consistent with guidance published in the *California Listing Policy* (State Water Board, 2004).

7.1 Nitrogen and Phosphorus Reporting Conventions (new)

Water quality data using different analytical reporting conventions can result in confusion, and even scientists and regulators have to practice diligence to avoid mixing-up and conflating nitrate concentrations which are reported in different conventions. Mixing up and conflating analytical nitrate reporting conventions can result in apples-to-oranges comparisons.

Nitrate concentration values are commonly reported as either molecular nitrate (NO3), or as nitrate as elemental nitrogen (i.e., NO3-N or nitrate as N). Note that the maximum contaminant level (MCL) in drinking water as molecular nitrate (NO3) is 45 mg/L, whereas this MCL when reported as elemental nitrogen (NO3-N) is 10 mg/L. While these two nitrate numeric values would appear to represent different concentrations, these concentration values are in fact actually equivalent to each other − the only difference being whether or not the molecular weight of the oxygen atoms in the nitrate molecule is included in the analytical reporting. Table 7-1 illustrates the difference between the two analytical reporting conventions.

National and USEPA water quality standards, water quality modeling tools, most scientific literature, and most TMDLs use the elemental nitrogen reporting convention (i.e., written as either nitrate as nitrogen; NO3-N; or nitrate as N). Likewise, this TMDL Report uses the elemental nitrogen convention (i.e., nitrate as N).

It should be noted that effective January 1, 2016 the State Water Board will require nitrate laboratory results to be expressed as nitrate as nitrogen. As a result, the maximum contaminant level for nitrate in drinking water is now expressed as “10 mg/L (as nitrogen)” instead of “45 mg/L (as nitrate)”; and thus the convention to report nitrate as molecular NO_3 (i.e., nitrate as NO3) is no longer appropriate.

[27] Censored data are non-quantified measurements of constituents that are reported as less than a detection limit or reporting limit, because the sample constituent exists in a concentration lower than can reliably be detected and reported by the laboratory.

[28] An imputed value is the implicit or estimated value of an item for which an actual or “true” value is not available or not known.

[29] Many substitution methods exist to account for censored data. In many water quality studies, censored data is often simply substituted with zero or with one-half the detection limit. These simple substitution schemes can introduce bias into resulting statistics of the dataset. In this report, we substituted imputed values for the censored data using a *Regression on Order Statistics* (ROS) technique for analyzing and censored data. The ROS technique for analyzing censored data is available via the State Water Board’s RP calculator tool. According to the State Water Board’s RP calculator user’s guide, the ROS technique for analyzing censored data is a robust and unbiased method for imputing censored data.

[30] The California Listing Policy section 6.1.5.2 states: *“Samples collected within 200 meters of each other should be considered samples from the same station or location.”* It should be recognized that TMDLs are watershed studies which endeavor to identify waterbody impairments at the stream reach scale. Typically, a monitoring program consisting of high-resolution, fine-scale monitoring – such as discrete monitoring locations upgradient and downgradient of a pipe or culvert – is more appropriate for field-scale or implementation studies.

Table 7-1. Illustration of equivalent nitrate concentrations in two different analytical reporting conventions.

Nitrate reporting convention used by most California Public Water Supply Districts & Agencies	multiply nitrate as NO_3 by: $\left(\frac{14 \text{ gram/mole N}}{62 \text{ gram/mole } NO_3}\right)$ to convert to nitrate as N	Nitrate reporting convention used by U.S. Environmental Protection Agency, U.S. Geological Survey, in most scientific literature, and in this TMDL report
Nitrate as NO_3 (mg/L)	**Reporting Equivalent as nitrogen (N) >>>>**	**Nitrate as N (mg/L)**
44.3*	☞	10
22.1	☞	5
11.1	☞	2.5
4.4	☞	1
2.2	☞	0.5

* In California, the drinking water standard for nitrate as NO_3 is established to two significant figures, and is 45 mg/l

Similarly, in this progress report ammonia is reported as elemental nitrogen (e.g., un-ionized ammonia as nitrogen – NH_3-N), and phosphate is reported as elemental phosphorus (e.g., orthophosphate as phosphorus – PO_4-P).

Also worth noting, is that most nitrogen analytical measurements include and report nitrate (NO_3) plus nitrite (NO_2), but because concentrations of nitrite (NO_2) are typically insignificant relative to nitrate, this mixture is simply called "nitrate" in this TMDL report, and in most regulatory contexts.

7.2 Surface Water Quality Data Summary (new)

The intent of this section of the progress report is to present numerical summaries of surface water quality data compiled for this TMDL project. This progress report does not attempt to assess water quality impairments in accordance with federal Clean Water Act Section 303(d) and the California Section 303(d) Listing Policy. Thus at this time, data and statistical summaries presented herein are for informational purposes only.

The locations of the sampling sites used in the numerical summaries are shown in Figure 7-1.

Statistical summaries of surface waters (lake water, creeks, ditches) in the Pinto Lake catchment are presented in Table 7-2 through Table 7-10. Selected constituents are presented spatially in Figure 7-2 and Figure 7-3.

Figure 7-1. Surface water monitoring locations in the Pinto Lake catchment and vicinity.

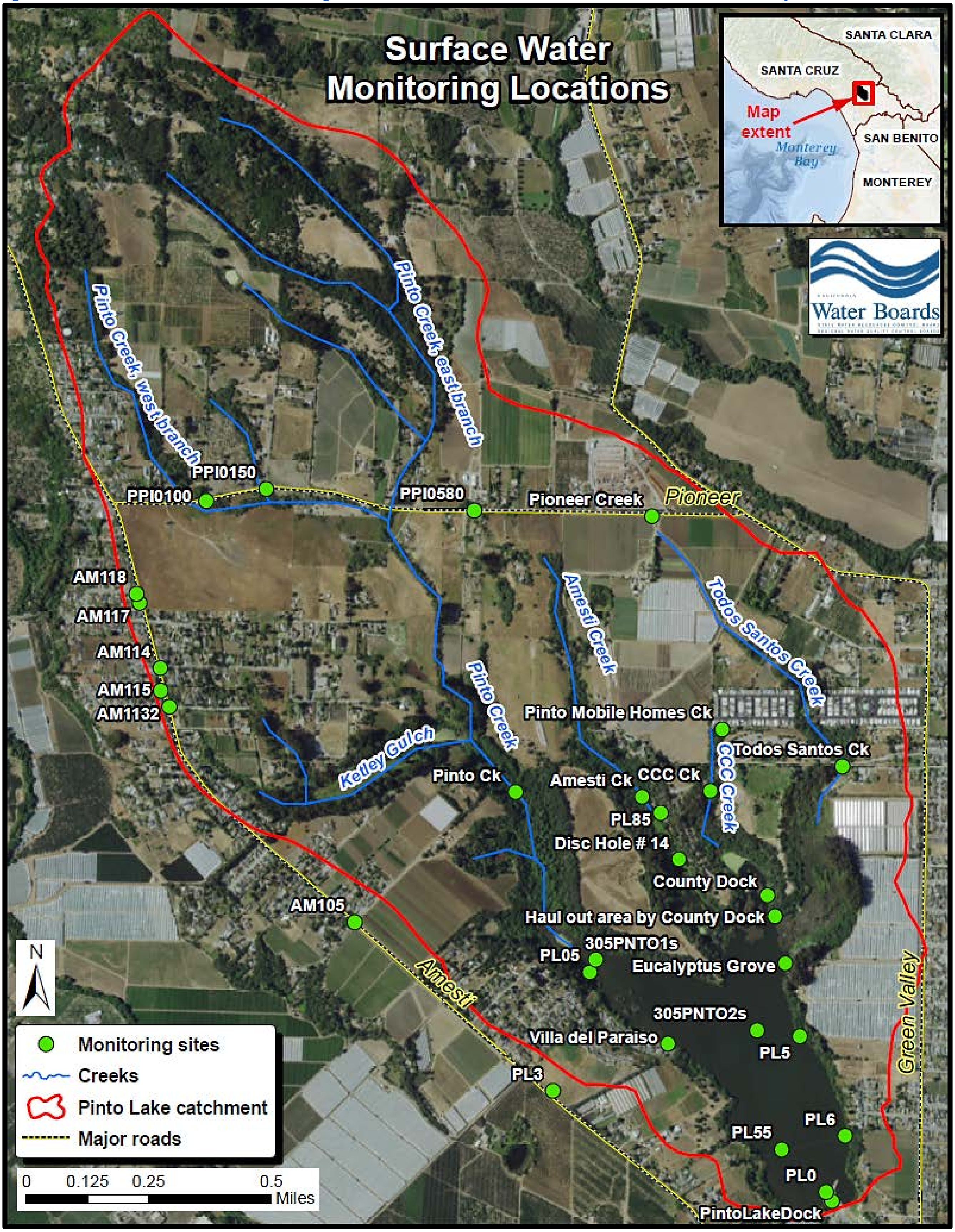


Table 7-2. Summary statistics for nitrate as N (units=mg/L) and exceedances of the drinking water standard in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 10mg/L (MUN Standard)	% Exceeding 10 mg/L
Pinto Lake	**All sites**	517	10/5/2000	4/26/2015	0.22	0.00	0.02	0.07	0.43	1.48	0	0%
	305PNTO1b	12	6/10/2005	5/22/2006	0.19	0.0021	0.005	0.02	0.47	0.65	0	0%
	305PNTO1m	12	6/10/2005	5/22/2006	0.20	0.0003	0.007	0.02	0.47	0.65	0	0%
	305PNTO1s	12	6/10/2005	5/22/2006	0.20	0.0015	0.007	0.02	0.47	0.69	0	0%
	305PNTO2b	12	6/10/2005	5/22/2006	0.17	0.0009	0.008	0.01	0.39	0.60	0	0%
	305PNTO2m	12	6/10/2005	5/22/2006	0.20	0.0002	0.011	0.02	0.44	0.69	0	0%
	305PNTO2s	12	6/10/2005	5/22/2006	0.20	0.0016	0.004	0.02	0.47	0.69	0	0%
	305PNTO3b	12	6/10/2005	5/22/2006	0.19	0.0012	0.007	0.02	0.45	0.70	0	0%
	305PNTO3m	12	6/10/2005	5/22/2006	0.20	0.0032	0.008	0.02	0.47	0.69	0	0%
	County Dock	10	8/1/2013	3/19/2015	0.17	0.0009	0.018	0.14	0.32	0.42	0	0%
	Disc Hole # 14	3	8/1/2013	3/19/2015	0.13	0.0023	0.083	0.16	0.19	0.22	0	0%
	Haul out area by County Dock	7	12/16/2013	7/1/2014	0.21	0.0038	0.100	0.25	0.32	0.35	0	0%
	PintoLakeDock	358	6/10/2005	4/26/2015	0.22	0.0000	0.030	0.08	0.43	1.12	0	0%
	PL0	23	5/7/1992	4/20/2005	0.30	0.0027	0.045	0.16	0.42	1.48	0	0%
	PL05	2	10/5/2000	4/20/2005	0.22	0.0500	0.133	0.22	0.30	0.38	0	0%
	PL3	3	12/6/2000	4/20/2005	0.25	0.1400	0.160	0.18	0.31	0.43	0	0%
	PL5	1	4/20/2005	4/20/2005	0.28	0.2800	0.280	0.28	0.28	0.28	0	0%
	PL55	1	4/20/2005	4/20/2005	0.42	0.4200	0.420	0.42	0.42	0.42	0	0%
	PL6	1	4/20/2005	4/20/2005	0.41	0.4100	0.410	0.41	0.41	0.41	0	0%
	PL8	1	10/5/2000	10/5/2000	0.05	0.0500	0.050	0.05	0.05	0.05	0	0%
	Villa del Paraiso	11	12/16/2013	3/19/2015	0.28	0.0018	0.021	0.24	0.43	0.78	0	0%
Amesti Creek	Amesti Creek	17	12/16/2012	4/1/2014	0.77	0.0200	0.038	0.12	1.37	4.97	0	0%
CCC Creek	CCC Creek	41	2/11/2013	4/1/2014	7.32	0.0770	3.760	4.28	5.07	26.05	7	17%
Pinto Creek	Pinto Creek	6	2/1/2012	4/1/2014	0.53	0.0328	0.079	0.25	0.99	1.39	0	0%
Pinto Mobile Homes Creek	Pinto Mobile Homes Creek	3	2/8/2013	4/1/2014	2.91	0.3195	1.885	3.45	4.20	4.96	0	0%
Pioneer Creek	Pioneer Creek	1	2/8/2013	2/8/2013	0.82	0.8200	0.820	0.82	0.82	0.82	0	0%
Todos Santos Creek	Todos Santos Creek	25	12/24/2012	4/1/2014	1.53	0.0953	0.224	0.85	1.96	5.49	0	0%
Ditch	**All sites**	21	5/6/1993	12/23/2014	3.48	0.01	0.96	2.53	4.54	14.51	1	5%
	AM105	3	3/3/2009	3/21/2012	1.04	0.6440	0.801	0.96	1.24	1.53	0	0%
	AM1132	8	5/6/1993	3/21/2012	2.16	0.0050	0.343	0.80	2.19	9.17	0	0%
	AM114	2	3/21/2012	12/23/2014	9.16	3.8120	6.487	9.16	11.84	14.51	1	50%
	AM115	2	3/3/2009	3/21/2012	4.88	4.2300	4.554	4.88	5.20	5.53	0	0%
	AM117	1	3/21/2012	3/21/2012	8.87	8.8660	8.866	8.87	8.87	8.87	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 10mg/L (MUN Standard)	% Exceeding 10 mg/L
	PL85	1	12/23/2014	12/23/2014	2.53	2.5300	2.530	2.53	2.53	2.53	0	0%
	PPI0100	1	12/23/2014	12/23/2014	4.77	4.7700	4.770	4.77	4.77	4.77	0	0%
	PPI0150	1	12/23/2014	12/23/2014	2.20	2.2000	2.200	2.20	2.20	2.20	0	0%
	PPI0580	1	12/23/2014	12/23/2014	3.31	3.3100	3.310	3.31	3.31	3.31	0	0%
	PPIO100	1	3/21/2012	3/21/2012	3.00	2.9950	2.995	3.00	3.00	3.00	0	0%

Table 7-3. Summary statistics for total nitrogen (units=mg/L) and exceedances of a generic lake criteria in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceed 1 mg/L[1]	% Exceed 1 mg/L
Pinto Lake	PintoLakeDock	223	4/18/2010	5/31/2014	1.9	0.7	1.1	1.6	2.3	12.9	177	79%
Amesti Creek	Amesti Ck	11	12/16/2012	3/11/2013	1.4	0.0	0.6	0.9	1.5	6.1	4	36%
CCC Creek	CCC Creek	30	2/11/2013	2/19/2014	6.6	0.1	3.3	4.0	5.1	28.9	29	97%
Pinto Creek	Pinto Ck	2	3/19/2012	12/16/2012	0.4	0.1	0.2	0.4	0.6	0.7	0	0%
Pinto Mobile Homes Creek	Pinto Mobile Homes Ck	1	2/8/2013	2/8/2013	4.3	4.3	4.3	4.3	4.3	4.3	1	100%
Pioneer Creek	Pioneer Creek	1	2/8/2013	2/8/2013	1.3	1.3	1.3	1.3	1.3	1.3	1	100%
Todos Santos Creek	Todos Santos Ck	16	12/24/2012	2/19/2014	2.5	0.3	0.6	2.1	4.0	6.4	9	56%

1 - A concentration of 1 mg/L phosphate represents the 75% percentile of all total nitrogen lake water quality criteria reported by states to the U.S. Environmental Protection Agency. As of July 2015, there were 63 different lake total nitrogen water quality criteria reported for lakes in various states. The 75^{th} percentile is a statistical threshold which represents that 75% of all reported lake criteria values were *lower* than 1 mg/L, and 25% of reported lake criteria were *higher* than 1 mg/L. This value is a screening threshold for informational purposes but should not be considered a TMDL numeric target.

Table 7-4. Summary statistics for unionized ammonia as N (units=mg/L) and exceedances of Basin Plan standard in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.025mg/L (Basin Plan Standard)	% Exceeding 0.025 mg/L
Pinto Lake	**All sites**	223	6/10/2005	3/19/2015	0.685	0.001	0.018	0.140	0.870	12.766	152	68%
	305PNTO1b	12	6/10/2005	5/22/2006	0.554	0.030	0.148	0.330	0.968	1.570	12	100%
	305PNTO1m	12	6/10/2005	5/22/2006	0.529	0.030	0.089	0.220	0.913	1.780	12	100%
	305PNTO1s	12	6/10/2005	5/22/2006	0.510	0.009	0.080	0.245	0.824	1.840	9	75%
	305PNTO2b	12	6/10/2005	5/22/2006	3.112	0.360	0.968	1.605	4.580	9.570	12	100%
	305PNTO2m	12	6/10/2005	5/22/2006	0.611	0.200	0.308	0.360	0.861	1.860	12	100%
	305PNTO2s	12	6/10/2005	5/22/2006	0.477	0.007	0.066	0.240	0.790	1.580	9	75%
	305PNTO3b	12	6/10/2005	5/22/2006	0.542	0.020	0.112	0.300	0.918	1.810	10	83%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.025mg/L (Basin Plan Standard)	% Exceeding 0.025 mg/L
	305PNTO3m	12	6/10/2005	5/22/2006	0.486	0.012	0.075	0.210	0.716	1.850	10	83%
	County Dock	10	8/1/2013	3/19/2015	0.822	0.006	0.015	0.040	0.861	4.977	5	50%
	Disc Hole # 14	2	8/1/2013	3/19/2015	0.012	0.003	0.007	0.012	0.016	0.021	0	0%
	Haul out area by County Dock	7	12/16/2013	7/1/2014	2.057	0.001	0.050	0.768	1.588	10.355	5	71%
	PintoLakeDock	98	6/10/2005	3/19/2015	0.323	0.001	0.011	0.028	0.288	4.482	50	51%
	Villa del Paraiso	10	12/16/2013	3/19/2015	1.661	0.004	0.019	0.152	0.955	12.766	6	60%
Amesti Creek	Amesti Creek	17	12/16/2012	4/1/2014	0.050	0.017	0.028	0.040	0.060	0.125	14	82%
CCC Creek	CCC Creek	41	2/11/2013	4/1/2014	0.046	0.005	0.020	0.030	0.049	0.406	26	63%
Pinto Creek	Pinto Ck	6	2/1/2012	4/1/2014	0.089	0.057	0.062	0.076	0.104	0.154	6	100%
Pinto Mobile Homes Creek	Pinto Mobile Homes Ck Creek	3	2/8/2013	4/1/2014	0.127	0.032	0.053	0.073	0.174	0.275	3	100%
Pioneer Creek	Pioneer Creek	1	2/8/2013	2/8/2013	0.040	0.040	0.040	0.040	0.040	0.040	1	100%
Todos Santos Creek	Todos Santos Creek	25	12/24/2012	4/1/2014	0.192	0.001	0.039	0.060	0.109	2.009	23	92%
Ditch	**All sites**	5	12/23/2014	12/23/2014	0.035	0.006	0.015	0.028	0.047	0.077	4	80%
	AM114	1	12/23/2014	12/23/2014	0.077	0.077	0.077	0.077	0.077	0.077	1	100%
	PL85	1	12/23/2014	12/23/2014	0.028	0.028	0.028	0.028	0.028	0.028	1	100%
	PPI0100	1	12/23/2014	12/23/2014	0.015	0.015	0.015	0.015	0.015	0.015	1	0%
	PPI0150	1	12/23/2014	12/23/2014	0.047	0.047	0.047	0.047	0.047	0.047	0	100%
	PPI0580	1	12/23/2014	12/23/2014	0.006	0.006	0.006	0.006	0.006	0.006	1	0%

Table 7-5. Summary statistics for dissolved oxygen (units=mg/L) and exceedances of Basin Plan standard in waterbodies in Pinto Lake.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. below 5.0 mg/L	% below 5.0 mg/L	No. below 7.0 mg/L	% below 7.0 mg/L
Pinto Lake	**All sites**	278	6/10/2005	7/19/2014	8.1	0.0	22.9	70	25%	120	43%
	305PNTO1b	12	6/10/2005	5/22/2006	4.4	1.9	8.3	9	75%	11	92%
	305PNTO1m	12	6/10/2005	5/22/2006	6.3	2.6	13.5	6	50%	9	75%
	305PNTO1s	12	6/10/2005	5/22/2006	6.7	3.3	14.0	4	33%	9	75%
	305PNTO2b	12	6/10/2005	5/22/2006	1.2	0.0	4.9	12	100%	12	100%
	305PNTO2m	12	6/10/2005	5/22/2006	3.0	0.2	6.6	10	83%	12	100%
	305PNTO2s	12	6/10/2005	5/22/2006	7.9	3.1	19.2	4	33%	7	58%
	305PNTO3b	12	6/10/2005	5/22/2006	5.4	0.7	9.6	6	50%	9	75%
	305PNTO3m	12	6/10/2005	5/22/2006	7.2	3.3	15.3	2	17%	7	58%
	PintoLakeDock	96	6/10/2005	6/25/2014	8.9	2.7	20.5	10	10%	31	32%
	PL5	86	1/18/2012	7/19/2014	10.3	0.7	22.9	7	8%	13	15%

Table 7-6. Summary statistics for dissolved oxygen saturation (units=%) in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Median Saturation (%)	Max
Pinto Lake	**All sites**	145	5/15/2009	7/19/2014	6.4	100.0	270.6
	PintoLakeDock	59	5/15/2009	4/1/2014	44.0	99.0	211.0
	PL5	86	1/18/2012	7/19/2014	6.4	101.85	270.6

Table 7-7. Summary statistics for phosphate as P (units=mg/L) and exceedances of a generic lake criteria for phosphate water quality criteria in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.2 mg/L[1]	% Exceeding 0.2 mg/L
Pinto Lake	**All sites**	314	4/18/2010	4/26/2015	0.14	0.00	0.03	0.11	0.20	1.12	73	23%
	County Dock	10	8/1/2013	3/19/2015	0.04	0.01	0.02	0.02	0.03	0.15	0	0%
	Disc Hole # 14	3	8/1/2013	3/19/2015	0.26	0.03	0.12	0.21	0.38	0.55	2	67%
	Haul out area by County Dock	7	12/16/2013	7/1/2014	0.04	0.01	0.01	0.03	0.05	0.13	0	0%
	PintoLakeDock	283	4/18/2010	4/26/2015	0.15	0.00	0.04	0.12	0.20	1.12	69	24%
	Villa del Paraiso	11	12/16/2013	3/19/2015	0.07	0.01	0.02	0.02	0.06	0.28	2	18%
Amesti Creek	Amesti Creek	18	2/11/2012	4/8/2013	0.49	0.39	0.41	0.43	0.49	0.76	18	100%
CCC Creek	CCC Creek	32	2/11/2013	1/2/2014	0.40	0.07	0.13	0.17	0.23	7.05	12	38%
Pinto Creek	Pinto Creek	5	2/1/2012	12/16/2012	0.14	0.07	0.07	0.07	0.07	0.07	1	20%
Pinto Mobile Homes Creek	Pinto Mobile Homes Creek	1	2/8/2013	2/8/2013	0.07	0.11	0.11	0.11	0.11	0.11	0	0%
Pioneer Creek	Pioneer Creek	1	2/8/2013	2/8/2013	0.11	0.06	0.07	0.10	0.19	1.02	0	0%
Todos Santos Creek	Todos Santos Creek	21	12/24/2012	1/2/2014	0.21	0.07	0.07	0.07	0.07	0.07	4	19%
Ditch	**All sites**	14	3/3/2009	12/23/2014	0.11	0.01	0.03	0.09	0.12	0.63	1	7%
	AM105	2	3/3/2009	3/21/2012	0.10	0.09	0.10	0.10	0.10	0.10	0	0%
	AM1132	2	3/21/2012	3/21/2012	0.02	0.01	0.01	0.02	0.02	0.03	0	0%
	AM114	1	12/23/2014	12/23/2014	0.08	0.08	0.08	0.08	0.08	0.08	0	0%
	AM115	3	3/3/2009	3/21/2012	0.06	0.02	0.02	0.03	0.09	0.15	0	0%
	AM117	1	3/21/2012	3/21/2012	0.02	0.02	0.02	0.02	0.02	0.02	0	0%
	PL85	1	12/23/2014	12/23/2014	0.63	0.63	0.63	0.63	0.63	0.63	1	100%
	PPI0100	1	12/23/2014	12/23/2014	0.12	0.12	0.12	0.12	0.12	0.12	0	0%
	PPI0150	1	12/23/2014	12/23/2014	0.13	0.13	0.13	0.13	0.13	0.13	0	0%
	PPI0580	1	12/23/2014	12/23/2014	0.12	0.12	0.12	0.12	0.12	0.12	0	0%
	PPIO100	1	3/21/2012	3/21/2012	0.03	0.03	0.03	0.03	0.03	0.03	0	0%

1 - A concentration of 0.2 mg/L phosphate represents the 75% percentile of all phosphate lake water quality criteria reported by states to the U.S. Environmental Protection Agency. As of July 2015, there were 19 different lake phosphate water quality criteria reported for lakes in various states. The 75th percentile is a statistical threshold which represents that 75% of all reported lake criteria values were *lower* than 0.2 mg/L, and 25% of reported lake criteria were *higher* than 0.2 mg/L. This value is a screening threshold for informational purposes but should not be considered a TMDL numeric target.

Table 7-8. Summary statistics for orthophosphate as P (units=mg/L) and exceedances of a generic lake criteria for orthophosphate water quality criteria in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.06 mg/L[1]	% Exceeding 0.06 mg/L
Pinto Lake	**All sites**	198	6/10/2005	12/9/2014	0.153	0.008	0.070	0.110	0.160	1.400	149	75%
	305PNTO1b	12	6/10/2005	5/22/2006	0.109	0.022	0.075	0.114	0.147	0.190	9	75%
	305PNTO1m	12	6/10/2005	5/22/2006	0.116	0.021	0.078	0.118	0.145	0.212	10	83%
	305PNTO1s	12	6/10/2005	5/22/2006	0.123	0.026	0.060	0.120	0.153	0.305	8	67%
	305PNTO2b	12	6/10/2005	5/22/2006	0.488	0.040	0.120	0.325	0.858	1.335	11	92%
	305PNTO2m	12	6/10/2005	5/22/2006	0.133	0.030	0.103	0.129	0.143	0.290	10	83%
	305PNTO2s	12	6/10/2005	5/22/2006	0.108	0.015	0.073	0.115	0.140	0.200	9	75%
	305PNTO3b	12	6/10/2005	5/22/2006	0.108	0.012	0.078	0.105	0.148	0.190	10	83%
	305PNTO3m	12	6/10/2005	5/22/2006	0.107	0.020	0.070	0.130	0.131	0.200	10	83%
	PintoLakeDock	102	6/10/2005	12/9/2014	0.145	0.008	0.060	0.110	0.168	1.400	72	71%
Amesti Creek	Amesti Creek	17	12/16/2012	4/1/2014	0.388	0.320	0.351	0.368	0.412	0.516	17	100%
CCC Creek	CCC Creek	34	2/11/2013	4/1/2014	0.094	0.020	0.059	0.074	0.095	0.569	24	71%
Pinto Creek	Pinto Creek	6	2/1/2012	4/1/2014	0.124	0.010	0.026	0.052	0.165	0.410	3	50%
Pinto Mobile Homes Creek	Pinto Mobile Homes Creek	3	2/8/2013	4/1/2014	0.314	0.021	0.121	0.221	0.461	0.701	2	67%
Pioneer Creek	Pioneer Creek	1	2/8/2013	2/8/2013	0.024	0.024	0.024	0.024	0.024	0.024	0	0%
Todos Santos Creek	Todos Santos Creek	25	12/24/2012	4/1/2014	0.121	0.010	0.022	0.063	0.143	0.494	13	52%

1 - A concentration of 0.06 mg/L orthophosphate represents the 75% percentile of all orthophosphate lake water quality criteria reported by states to the U.S. Environmental Protection Agency. As of July 2015, there were 8 different lake orthophosphate water quality criteria reported for lakes in various states. The 75th percentile is a statistical threshold which represents that 75% of all reported lake criteria values were *lower* than 0.06 mg/L, and 25% of reported lake criteria were *higher* than 0.06 mg/L. This value is a screening threshold for informational purposes but should not be considered a TMDL numeric target.

Table 7-9. Summary statistics for chlorophyll *a* (units=µg/L) and exceedances of 15 µg/L and of a generic lake criterion (35 µg/L) in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceed 15 µg/L[1]	% Exceed 15 µg/L	No. Exceed 35 µg/L[2]	% Exceed 35 µg/L
Pinto Lake	**All sites**	306	6/10/2005	6/19/2015	242.3	0.5	11.0	26.9	75.0	15,183.0	210	69%	133	43%
	305PNTO1s	12	6/10/2005	5/22/2006	65.9	2.0	13.5	23.5	39.3	490.0	8	67%	4	33%
	305PNTO2s	12	6/10/2005	5/22/2006	83.3	2.0	7.5	44.5	69.3	604.0	8	67%	7	58%
	PintoLakeDock	282	6/10/2005	6/19/2015	256.5	0.5	11.3	26.6	77.0	15,183.0	194	69%	122	43%
Amesti Creek	Amesti Creek	11	1/20/2013	4/8/2013	1.4	0.0	0.2	1.0	2.4	3.4	0	0%	0	0%
CCC Creek	CCC Creek	34	2/11/2013	1/8/2014	1.6	0.0	0.1	0.1	0.3	34.9	1	3%	1	0%
Pinto Creek	Pinto Creek	2	2/1/2012	2/11/2012	1.9	1.7	1.8	1.9	2.0	2.1	0	0%	0	0%
Pinto Mobile Homes Creek	Pinto Mobile Homes Creek	1	2/8/2013	2/8/2013	0.9	0.9	0.9	0.9	0.9	0.9	0	0%	0	0%
Pioneer Creek	Pioneer Creek	1	2/8/2013	2/8/2013	1.0	1.0	1.0	1.0	1.0	1.0	0	0%	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceed 15 µg/L[1]	% Exceed 15 µg/L	No. Exceed 35 µg/L[2]	% Exceed 35 µg/L
Todos Santos Creek	Todos Santos Creek	20	1/20/2013	2/7/2014	10.5	0.0	0.1	0.7	7.3	66.4	5	25%	2	10%

1 - Fifteen µg/L chlorophyll *a* represents a condition for which the Central Coast Water Board will designate water bodies as impaired for aquatic life use, Worcester, K, et al., 2010.

2 - A concentration of 35 µg/L chlorophyll *a* represents the 75th percentile of all chlorophyll *a* lake water quality criteria reported by states to the U.S. Environmental Protection Agency. As of July 2015, there were 281 different lake phosphate water quality criteria reported for lakes in various states. The 75th percentile is a statistical threshold which represents that 75% of all reported lake criteria values were *lower* than 35 µg/L and 25% of reported lake criteria were *higher* than 35 µg/L. This value is a screening threshold for informational purposes but should not be considered a TMDL numeric target.

Table 7-10. Summary statistics for microcystin (units=µg/L or ppb) and exceedances of 0.8 µg/L criteria in waterbodies in the Pinto Lake catchment.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.8µg/L[1]	% Exceeding 0.8 µg/L
Pinto Lake	**All sites**	493	4/3/2013	5/30/2015	6.8	ND	ND	0.01	0.25	1013.37	80	16%
	County Dock	34	5/6/2013	3/19/2015	0.03	ND	ND	ND	ND	ND	0	0%
	Disc Hole # 14	22	5/6/2013	3/19/2015	0.04	ND	ND	ND	ND	ND	0	0%
	Eucalyptus Grove	25	4/3/2013	9/24/2013	0.71	ND	ND	ND	0.57	10.00	6	24%
	Haul out area by County Dock	19	9/10/2013	11/6/2014	0.07	ND	ND	ND	ND	ND	0	0%
	PintoLakeDock	351	9/28/2006	5/30/2015	9.40	ND	ND	0.02	0.37	1013.37	68	19%
	Villa del Paraiso	42	4/3/2013	5/30/2015	0.64	ND	ND	ND	ND	12.00	6	14%

1 – The State of California Office of Environmental Health Hazard Assessment (OEHHA) has a published peer-reviewed public health action-level guideline for microcystins in recreational waters of 0.8 µg/L (2012).

Figure 7-2 presents information on the spatial distribution of the median total phosphate as P concentrations in surface waters based on available data. Figure 7-3 presents information on the spatial distribution of median total nitrogen as N concentrations in surface waters based on available data. Additional data analysis of surface water quality data is anticipated to be conducted as TMDL development progresses.

Figure 7-2. Total phosphate concentrations in the Pinto Lake catchment.

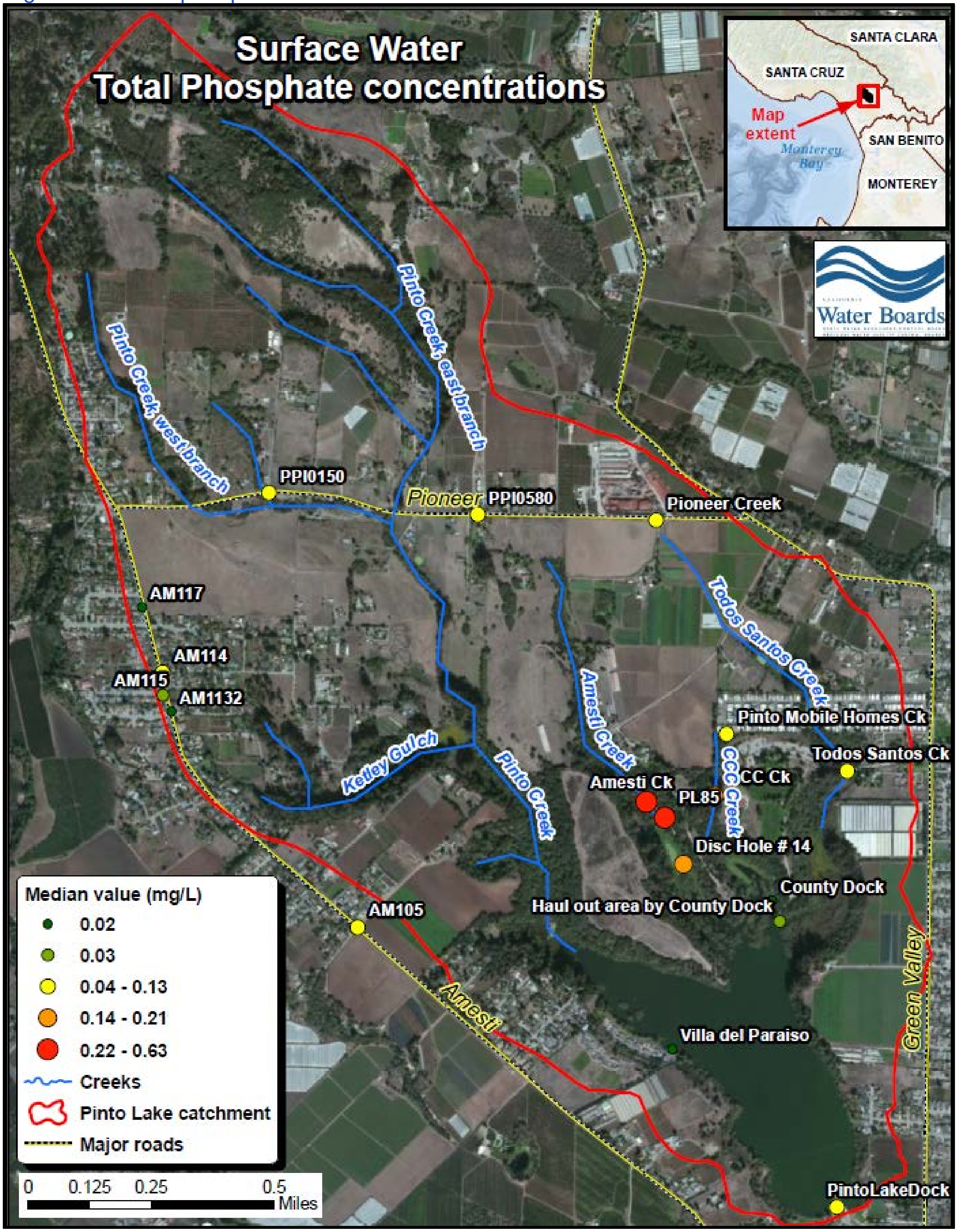
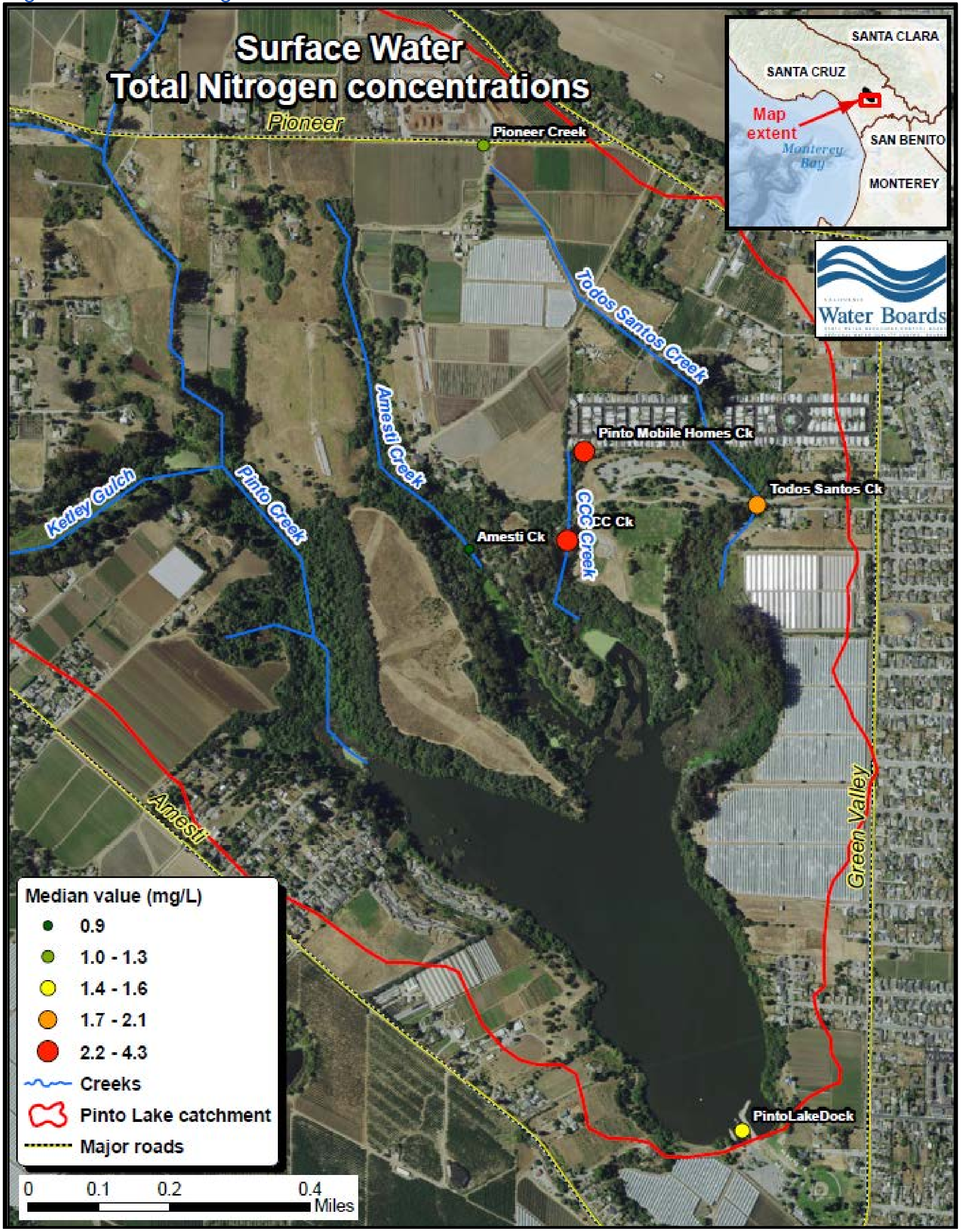


Figure 7-3.Total nitrogen concentrations in the Pinto Lake catchment.

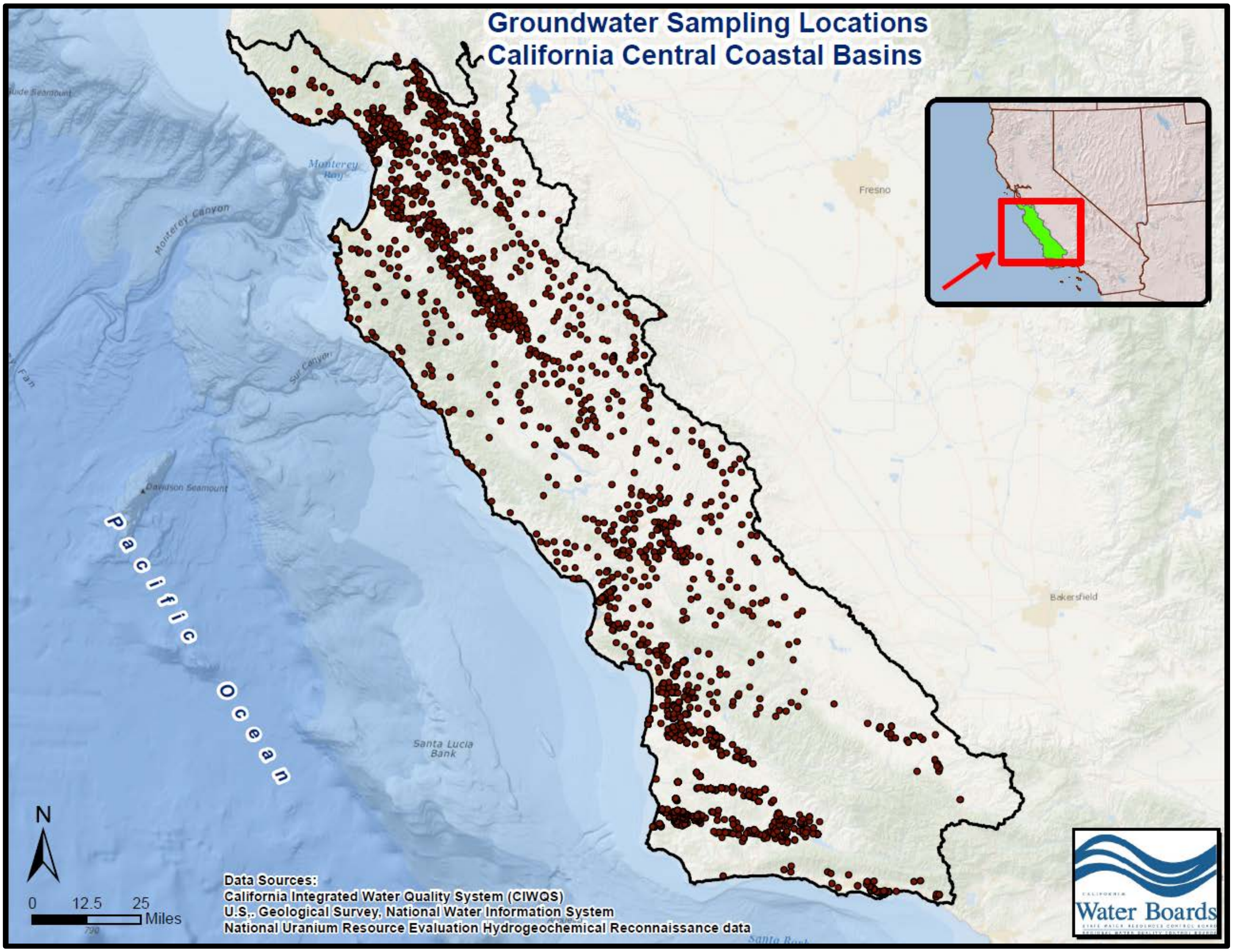


7.3 Groundwater Quality Data Summary (new)

The intent of this section of the progress report is to present numerical summaries of shallow groundwater quality data compiled for this TMDL project. This progress report does not attempt to assess water quality impairments in accordance with federal Clean Water Act Section 303(d) and the California Section 303(d) Listing Policy. Thus at this time, data and statistical summaries presented herein are for informational purposes only.

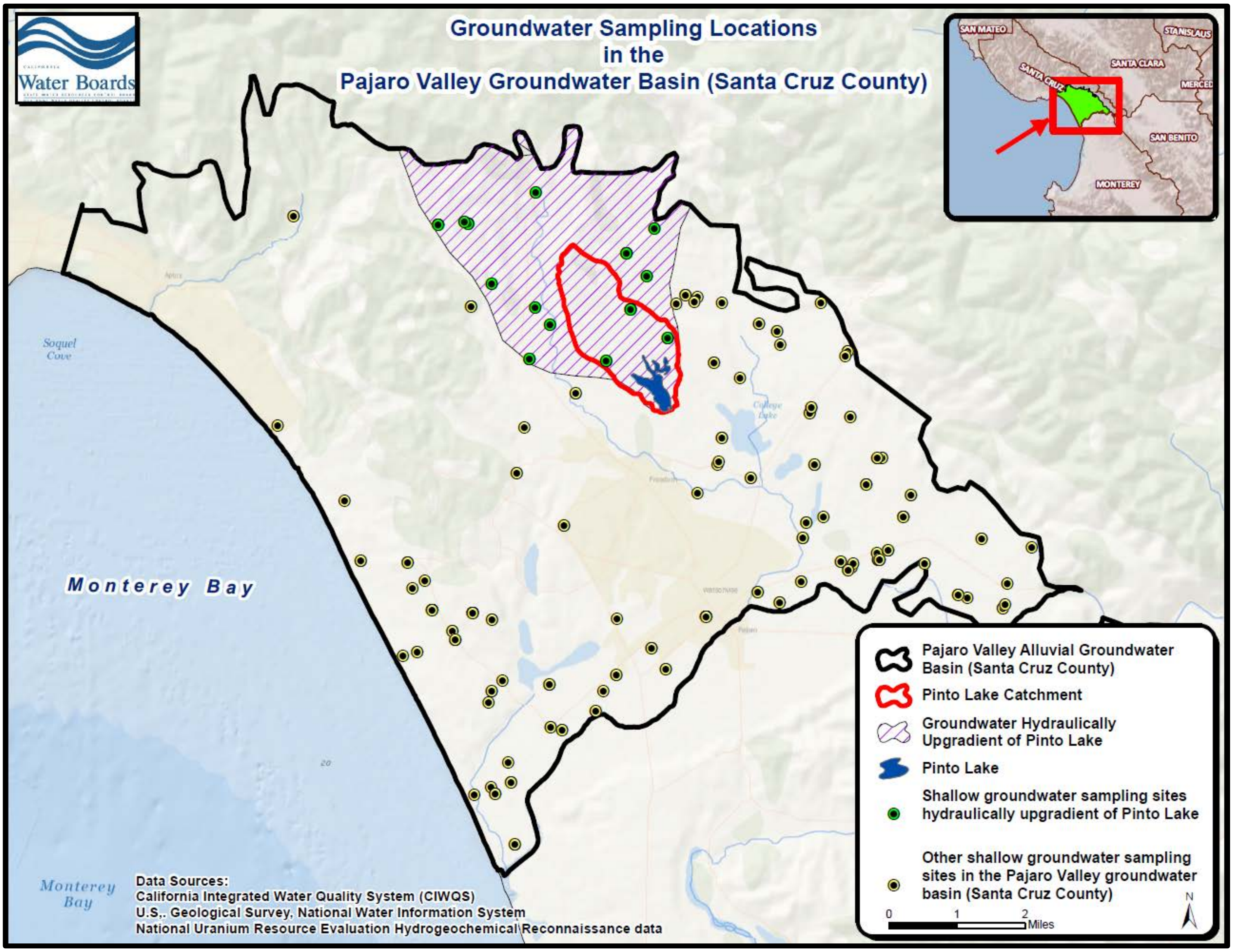
Groundwater data was compiled on a regional basis, to allow comparison of regional groundwater data to groundwater data in the Pajaro Valley groundwater basin and with shallow groundwater located hydraulically upgradient of Pinto Lake (refer back to Figure 4-11 on page 26 for a summary of groundwater elevation and estimated shallow groundwater flow directions). Figure 7-4 illustrates the location of groundwater sampling sites in[31] the California central coast region used in data compilation for this progress report. Figure 7-5 illustrates a higher-resolution map view of groundwater sampling sites in the Pajaro Valley groundwater basin (Santa Cruz County) and in the vicinity of Pinto Lake.

Figure 7-4. Regional map view of sampling sites in California central coastal basins used for statistical summaries of nutrient water quality in groundwaters. Statistical summaries are presented in Table 7-11 and Table 7-12.



[31] Refer back to footnote 26 on page 40 for a description of our attempt to isolate data representative of shallow, recently recharged groundwater.

Figure 7-5. Higher resolution map view of sampling sites in the Pajaro Valley groundwater basin used for statistical summaries of nutrient water quality in groundwaters. Statistical summaries are presented in Table 7-11 and Table 7-12.



Statistical summaries of regional groundwater bodies, groundwater in the Pajaro Valley groundwater basin; and groundwater upgradient of Pinto Lake which is thus presumed to flow towards and into the lake, are presented in Table 7-11 and Table 7-12.

Table 7-11. Summary statistics for available groundwater nitrate data (reporting units= nitrate as N, mg/L) and exceedances of California drinking water standard at three different scales: 1) in groundwater bodies of the Central Coast Region; 2) in the Pajaro Valley groundwater basin; 3) and in shallow groundwater hydraulically upgradient of Pinto Lake.

Groundwater Body (or Bodies)	No. of Samples	Temporal Representation		Arithmetic Mean	Min	10%	25%	50% (median)	75%	90%	Max	No. of Samples Exceeding 10 mg/L (MUN Standard)	% of Samples Exceeding 10 mg/L
Shallow groundwaters in California Central Coastal Basin aquifers (refer back to Figure 7-4)	1,586	Aug. 2012	Aug. 2015	12	0.002	0.1	0.4	3.4	13.9	36.0	188	474	30%
Shallow groundwater of the Pajaro Valley Groundwater Basin in Santa Cruz County (refer back to Figure 7-5)	85	June 2013	June 2015	7.43	0.059	0.10	0.20	1.2	9.0	25.5	48.2	19	22%
Shallow groundwater hydraulically upgradient of Pinto Lake (refer back to Figure 7-5)	12	June 2013	July 2014	1.58	0.10	0.38	1.18	1.3	1.75	2.8	4.3	0	0%

Table 7-12. Summary statistics for available groundwater phosphate data (reporting units= phosphate as P, mg/L) and exceedances of a generic lake criteria for phosphorus water quality criteria at three different scales: 1) in groundwater bodies of the Central Coast Region; 2) in the Pajaro Valley groundwater basin; 3) and in shallow groundwater hydraulically upgradient of Pinto Lake. Comparisons to the generic lake criteria for phosphorus are for informational purposes only as this criteria is not a regulatory standard in California.

Groundwater Body (or Bodies)	No. of Samples	Temporal Representation		Arithmetic Mean	Min	10%	25%	50% (median)	75%	90%	Max	No. of Samples Exceeding 0.2 mg/L (generic lake criteria)[1]	% of Samples Exceeding 0.2 mg/L
Shallow groundwaters in California Central Coastal Basin aquifers (refer back to Figure 7-4)	1,976	Sept. 1978	Aug. 2015	0.16	0	0.01	0.023	0.068	0.16	0.33	7.84	366	18%
Shallow groundwater of the Pajaro Valley Groundwater Basin in Santa Cruz County (refer back to Figure 7-5)	152	Aug 1981	Sept. 2005	0.087	0.0001	0.02	0.04	0.07	0.09	0.14	1.2	5	3%
Shallow groundwater hydraulically upgradient of Pinto Lake (refer back to Figure 7-5)	12	Jan. 1980	Aug. 1983	0.059	0.0002	0.0013	0.025	0.05	0.01	0.12	0.16	0	0%

[1] A concentration of 0.2 mg/L phosphate represents the 75% percentile of all phosphate lake water quality criteria reported by states to the U.S. Environmental Protection Agency. As of July 2015, there were 19 different lake phosphate water quality criteria reported for lakes in various states. The 75th percentile is a statistical threshold which represents that 75% of all reported lake criteria values were *lower* than 0.2 mg/L, and 25% of reported lake criteria were *higher* than 0.2 mg/L. This value is a screening threshold for informational purposes but should not be considered a TMDL numeric target.

Figure 7-6 presents information on the spatial distribution of average (arithmetic mean) nitrate as N concentrations in shallow groundwaters based on available data. Noteworthy is that shallow groundwaters located hydraulically upgradient of Pinto Lake on average tend to be relatively low in nitrate as N (generally less than 2 mg/L, refer back to Table 7-11 on page 61.

Figure 7-6. Bubble map illustrating mean nitrate as N concentrations in shallow groundwaters in the Monterey Bay region and vicinity. Note the relatively low mean nitrate concentrations in shallow groundwater hydraulically upgradient of Pinto Lake.

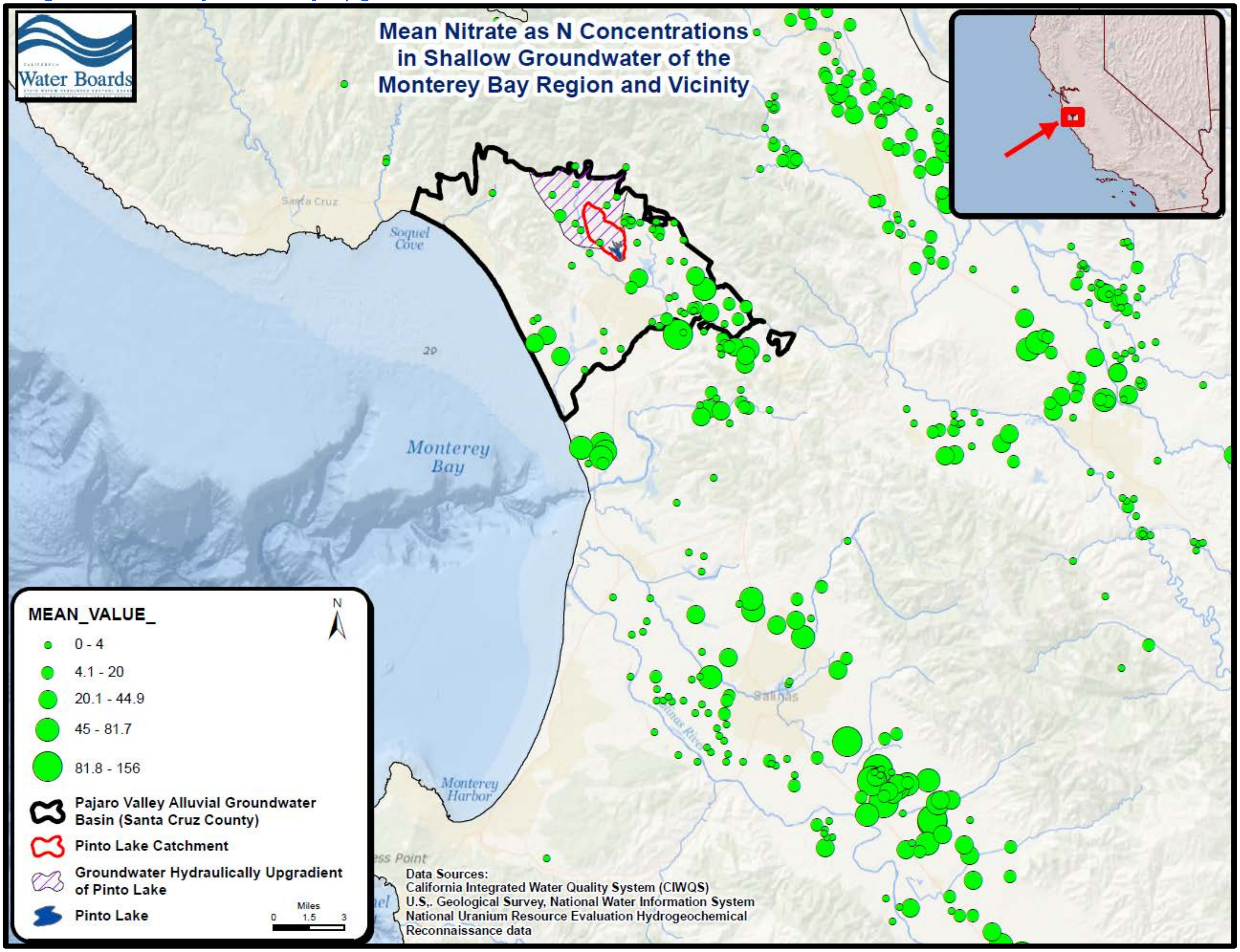
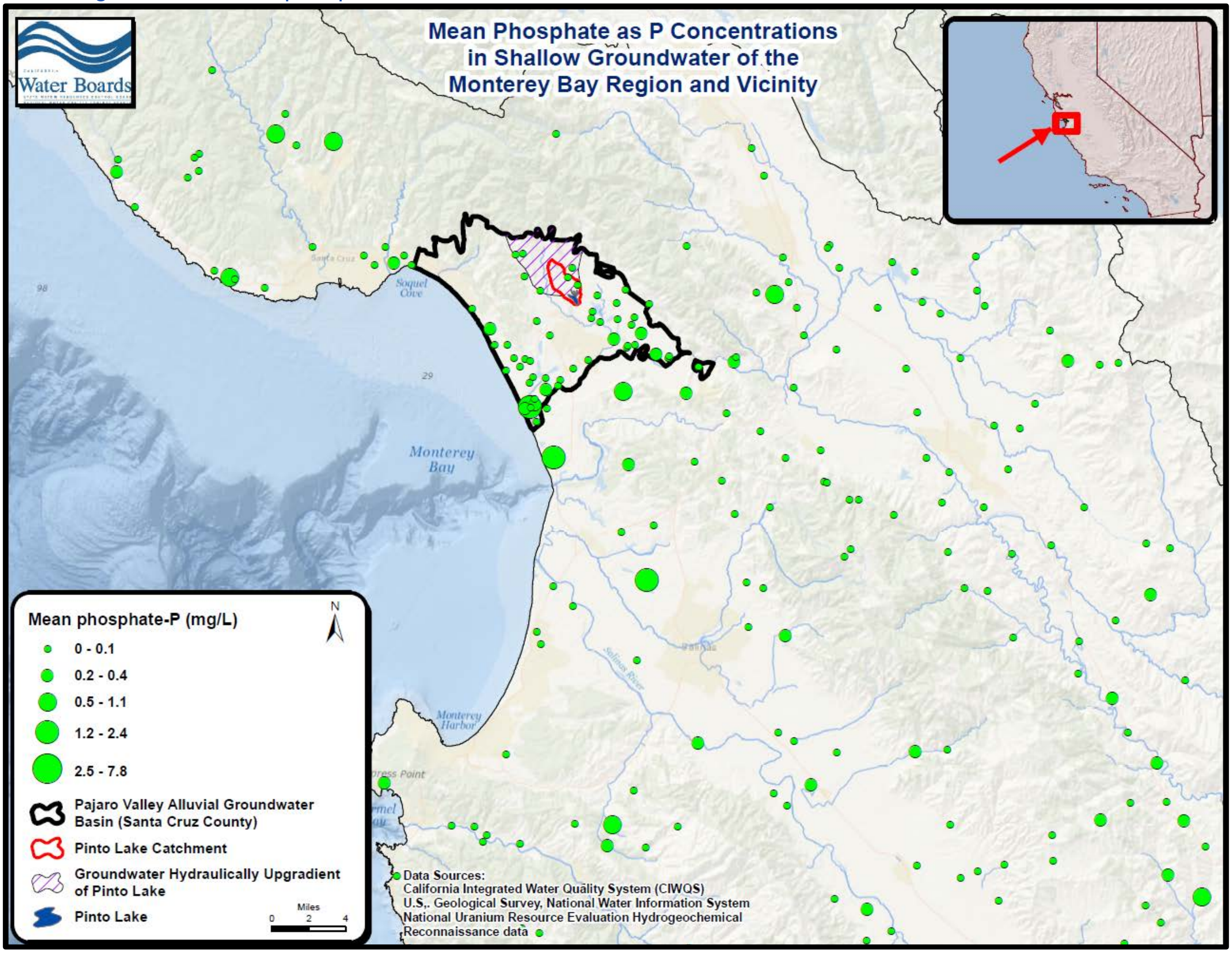


Figure 7-7 presents information on the spatial distribution of average (arithmetic mean) total phosphate as P concentrations in shallow groundwaters based on available data. Noteworthy is that shallow groundwaters located hydraulically upgradient of Pinto Lake on average tend to be relatively low in total phosphate as P (generally less than 0.06 mg/L, refer back to Table 7-12 on page 61.

Figure 7-7. Bubble map illustrating mean phosphate as P concentrations in shallow groundwaters in the Monterey Bay region and vicinity. Note the relatively low mean phosphate concentrations in shallow groundwater hydraulically upgradient of Pinto Lake, which appear to be close to natural, ambient background levels for phosphate.



8. Published Nutrient Water Quality Criteria for Lakes (new)

Numeric nutrient criteria are a critical tool for protecting and restoring waters at risk of nutrient pollution. USEPA has published current numeric criteria for lakes and reservoirs developed by various states for nitrogen, phosphorus, and other parameters. Nutrient numeric criteria are developed by states to represent thresholds of nutrient levels in lakes and reservoirs which are presumed to be reasonably protective of water quality and the designated uses of lake waters. Numeric criteria are often developed for a specific lake or reservoir, as the risks of nutrient pollution vary regionally and even vary from lake to lake. These water quality criteria were reported by USEPA as of July 2015 and are summarized in Table 8-1. The information in this table is for informational value only. It should be noted that this reporting is a "snapshot" of the current state of nutrient criteria nationwide as states continue to make progress towards developing and refining nutrient criteria.

Table 8-1. Summary statistics of nutrient and nutrient-related numeric water quality criteria for lakes and reservoirs as developed by various states and reported by USEPA (July 2015).

	mean	0%	10%	25%	50%	75%	90%	100%	Number of waterbodies
Chlorophyll-a (µg/L)	24.6	0.6	5	10	18	35	35	60	281
Orthophosphate as P (mg/L)	0.9	0.001	0.002	0.0065	0.017	0.062	2.17	7	8
Phosphate as P (mg/L)	4.2	0.01	0.01	0.03	0.09	0.2	0.215	6.6	16
Total Nitrogen (mg/L)	0.9	0.087	0.204	0.253	0.413	1	2.76	4	63
Total Phosphorus (mg/L)	0.09	0.005	0.013	0.015	0.040	0.04	0.1	5.5	347
Turbidity (NTU)	28.3	10	10	13.75	25	43.75	50	50	6

Source data: USEPA, State Development of Numeric Criteria for Nitrogen and Phosphorus http://cfpub.epa.gov/wqsits/nnc-development/
State criteria are reported for the following states and territories: American Samoa, Arizona, California, Colorado, Florida, Georgia, Illinois, Maryland, Massachusetts, Minnesota, Missouri, Nebraska , Nevada, New Jersey, New Mexico, North Carolina, Oklahoma, Oregon, Puerto Rico, Rhode Island, South Carolina, Texas, Vermont, Virginia, West Virginia, Wisconsin..

9. Potential Pollutant Sources (updated)

Elevated nutrients in a waterbody can contribute to biostimulation, such as algal blooms. There are many possible nutrient sources within any given watershed; in general the following can potentially be significant sources of nutrient loads:

- Urban runoff
- Wastewater treatment plants
- Fertilizer applications
- Livestock
- Erosion (natural or induced by human activities)
- Septic systems
- Natural sources
- Atmospheric deposition
- Shallow groundwater inflow into streams and lakes

Table 9-1 and Text Box 9-1 outline inferred sources of nutrient loading to Pinto Lake based on recent research (Ketley, Rettinger, and Los Huertos, 2013 and CSUMB and Resource Conservation District of Santa Cruz County, 2013). As warranted, more information regarding nutrient sources to Pinto Lake will be compiled and assessed during TMDL implementation.

Table 9-1. Estimated nutrient loads to Pinto Lake (table from CSUMB and Resource Conservation District of Santa Cruz County, 2013).

Source	Estimated 2011 load lbs
Lake sediments	1100 – 2645 pounds (mean 1650 pounds)
Watershed	220-660 pounds (mean 286 pounds)
Ground Water	Unknown without further research

Text Box 9-1. Inferred sources of controllable nutrient pollution to Pinto Lake based on grant-funded watershed studies.

Based on recent research (Ketley, Rettinger, and Los Huertos, 2013) inferred sources of controllable nutrient sources to Pinto Lake include agricultural operations, residential septic systems, and increased erosion and discharge of phosphorus-rich sediment to the lake as a result of the removal of historic native vegetation.

Source analysis will be an important component of TMDL development moving forward. At this time, some supplementary information regarding potential nutrient sources in the Pinto Lake catchment can be summarized as follows.

Based on information developed previously in report Section 4.3, the estimated average annual atmospheric deposition of total nitrogen load to Pinto Lake is **420 kilograms (926 pounds) of N per year.**

Based on information developed previously in report Section 4.3, the estimated average annual atmospheric deposition of phosphorus load to Pinto Lake is **28 kilograms (62 pounds) of P per year.**

Stakeholders recently informed Central Coast Water Board staff that there appears to be a high concentration of livestock, horses, and farm animals in the Pinto Creek mainstem subcatchment. Sometimes, livestock can impact the environment and nutrient water quality in a watershed by contributing to increased erosion and manure waste. Based on the information provided by local stakeholders, we initiated some public outreach efforts to property owners in areas of the Pinto Lake catchment thought to have high densities of livestock.

TMDL's often consider NPDES[32]-permitted facilities in a watershed. There is one NPDES-permitted facility in the Pinto Lake catchment. Information regarding this NPDES-permitted facility is summarized in Table 9-2

Table 9-2. Sun Land Garden Products, Inc. NPDES permit information.

Facility/Address	NPDES Permit Category	Latitude Longitude	Industrial Classification – Regulated Activity	Facility Size	Industrial Areas Exposed to Storm water Runoff	Receiving Water	Flow
Sun Land Garden Products Inc. 90 Pioneer Rd Watsonville California	General Permit to Discharge Storm Water Associated with Industrial Activity (WQ General Order No. 2014-0057-DWQ)	36.97214 -121.77654	Processing and distribution of potting soil mixes, compost and mulch.	21.7 acres	6.687 acres	Pinto Lake	Indirectly

Sources of information: State Water Board, Notice of Intent to Comply, dated June 22, 2015, submitted by Sun Land Garden Product, Inc. Storm Water Prevention Plan, prepared for Sun Land Garden Products Watsonville Facility, June 2015.

Reportedly, large quantities of redwood mulch have been observed in some recent sediment cores from the lake bottom of northern Pinto Lake, and in cores from the Todos Santa Creek drainage. One of these cores apparently had a layer of redwood mulch up to two feet thick. As needed, TMDL staff will engage with the Central Coast Water Board's NPDES staff to evaluate the cause and nature of these observed discharges.

Residential areas can be a source of nutrient discharges to lakes and streams, due to septic systems, car washing, lawn watering, and stormwater runoff. As part of our outreach efforts, staff have webposted a State Water Board informational video regarding addressing runoff from residential areas on our Pinto Lake TMDL webpage. Census data (see report Section 4.4) can provide insight on how many housing units and people are using septic systems in the vicinity of Pinto Lake.

Cultivated agriculture is often assessed as a potential source of nutrient pollution in a watershed. In recent years in the Pinto Lake catchment major crops included bush berries, strawberries, truck and nursery crops.

10. Public Outreach & Public Participation

Public outreach is a part of the TMDL development process. Leveraging knowledge about the Pinto Lake catchment from local residents, resource professionals, public agency staff, land owners, and land operators is very helpful to the Central Coast Water Board. Public outreach and public participation will

[32] NPDES = National Pollutant Discharge Elimination System

be an ongoing element of TMDL development activities. A Lyris email distribution list has been created for this TMDL project and is used to notify interested parties of public meeting and progress regarding this TMDL project. As of September 21, 2015, there are 149 email subscribers on the Pinto Lake Lyris email subscription database.

Central Coast Water Board staff held a TMDL "kick off" meeting in Watsonville in July 2014. At the meeting, staff met with and identified stakeholders who are interested in water quality issues associated with Pinto Lake, and those whom have knowledge about lake data, lake conditions, and lake history. Attendees of the meeting included growers, representatives of public agencies, interested local residents, resource professionals, representatives of environmental groups, and representatives of the agricultural industry. Central Coast Water Board staff often finds meetings like this to be quite useful from the perspective of information-sharing, which ultimately benefits TMDL development. An example of the usefulness of TMDL meetings like this was articulated by a meeting attendee:

> *"Your power point presentation was excellent and it was very nice of you to provide all of us with the power point slides for our information. The discussion after your presentation was excellent too. It was great that you opened up the meeting and encouraged everyone to add to the discussion. We had a lot of very valuable and interesting input from the people there."*
>
> From: email to Central Coast Water Board staff from a meeting participant at the July 2014 Pinto Lake TMDL meeting in Watsonville.

On June 2, 2015 Central Coast Water Board staff scheduled and facilitated a water quality update and CEQA[33] scoping meeting in Watsonville. At the meeting, stakeholders and staff discussed updated water quality information and watershed activities pertaining to the lake. Consistent with CEQA regulations, the discussions also focused on whether or not there might be any significant, adverse environmental impacts associated with foreseeable implementation actions intended to improve lake water quality[34].

11. Existing Plans to Improve Water Quality

In 2013, resource professionals from the California State University, Monterey Bay and the Resource Conservation District of Santa Cruz County prepared the Implementation Strategies for Restoring Water Quality in Pinto Lake. This report outlined the causes of algal cyanobacteria blooms in Pinto Lake and identified management practices and measures which could be taken to reduce nitrogen and phosphorus loading to lake waters, and to eliminate or substantially reduce these algal blooms and their toxins. The management measures identified can generally be outlined as follows:

- In- lake treatments to limit release of phosphorus from lake sediments.
- Erosion control/sediment capture practices to reduce nutrient loadings from agricultural and/or urban properties in the watershed.
- Irrigation and nutrient management programs for agricultural, commercial and residential properties in the watershed.
- Public education regarding management of on-site wastewater systems, gray water disposal and landscaping practices.
- Investigating options for sewer system extensions.

12. Anticipated Next Steps

As stated previously, Pinto Lake currently has unacceptable levels of cyanobacteria microcystins (e.g., algal toxins), low dissolved oxygen, unacceptable pH levels, and scum/floating material. In the past, Pinto Lake was not subject to episodic and intense cyanobacteria algal blooms based on historical data and interviews with long term lake-side residents, thus indicating that controllable conditions are causing or contributing to these water quality problems in recent years.

[33] CEQA is the acronym for the California Environmental Quality Act.

[34] CEQA implementation regulations §3775.5 require early public consultation to discuss the range of potentially significant environmental impacts which could be associated with TMDL implementation.

Consequently, Central Coast Water Board staff anticipates developing a total maximum daily loads report, and associated implementation strategy with the goal of improving water quality and attaining applicable water quality standards in Pinto Lake. Consistent with guidance from the State Water Board's Water Quality Control Policy for Addressing Impaired Waters, staff anticipates that a Pinto Lake TMDL project will need to be adopted through a basin plan amendment process in which the Water Quality Control Plan for the Central Coastal Basin would be amended to include any adopted TMDLs for the lake. The basin plan amendment process requires TMDLs to be approved by the Central Coast Water Board, as well as to receive approvals from the State Water Board and the California Office of Administrative Law.

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