California Regional Water Quality Control Board
Central Coast Region

TOTAL MAXIMUM DAILY LOADS TECHNICAL REPORT
and
RECOMMENDATIONS FOR DEVELOPMENT OF SITE-SPECIFIC NUMERIC WATER QUALITY CRITERIA
FOR BORON
in
STREAMS OF THE ESTRELLA RIVER BASIN

San Luis Obispo and Monterey Counties, California

Final Project Report

October, 2013

This document is identified as a TMDL for streams of the Estrella River Basin (San Luis Obispo and Monterey counties, California) and is officially submitted to the U.S. Environmental Protection Agency to act upon and approve as a TMDL

Adopted by the
California Regional Water Quality Control Board
Central Coast Region
on ________________

and the
United States Environmental Protection Agency
on ________________

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http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/estrella_riv_boron/index.shtml

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1 CONCISE SUMMARY OF THE TMDL

A concise tabular summary of the proposed Estrella River Basin total maximum daily load (TMDL) for boron is presented below in Table 1-1.

Table 1-1. Tabular summary of Estrella River Basin TMDLs for boron.

ESTRELLA RIVER BASIN TMDLS FOR BORON – CONCISE SUMMARY **California Regional Water Quality Control Board, Central Coast Region**	
Waterbody Identification	Estrella River, Cholame Creek and their tributaries from confluence with Salinas River upstream to the headwaters. *303(d)-Listed Boron Impaired Waters:* • Estrella River WBID: CAR3170007119990225125807 • Cholame Creek WBID: CAR3170008120011127080727
Location	San Luis Obispo County, California Hydrologic Unit Code # 18060004 (Estrella River Basin)
TMDL Pollutant of Concern	Boron
Pollutant Sources	Natural background (major source) Irrigated agriculture (minor source)
Beneficial Uses Currently Supported *(on the basis of boron numeric water quality guidelines)*	*Estrella River:* Protected for aquatic habitat and wildlife protection (WARM, SPWN, WILD, RARE) Protected for livestock watering (AGR).
Beneficial Uses Impaired *(on the basis of boron numeric water quality objectives and guidelines)* See project report Table 4-6 for detailed information on impairments and stream reaches affected.	*Estrella River:* Impaired for use as irrigation supply (AGR) Impaired for drinking water supply (MUN)
	Cholame Creek Impaired for use as irrigation supply and stock watering (AGR) Impaired for drinking water supply (MUN) Impaired for protection of aquatic habitat and protection and wildlife (WARM, WILD, RARE)
Numeric Target	0.75 mg/L boron
Loading Capacity (TMDL)	Boron not to exceed 0.75 mg/L in receiving waters.
Implementation Strategy: **Proposed Actions to Correct 303(d)-Listed Impairments**	*Owners/operators of irrigated lands:* implement and comply with the Central Coast Water Board's Agricultural Order to minimize risk of boron loading from fertilizers and irrigation water. *Central Coast Water Board staff:* develop and implement revised water quality guidelines in the future if appropriate, based on additional data collection. This may include site-specific water quality objectives for boron based on the assessment that existing boron water quality criteria may be unachievable due to natural inputs.

2 INTRODUCTION

2.1 Clean Water Act Section 303(d) List

Section 303(d) of the federal Clean Water Act requires every state to evaluate its waterbodies, and maintain a list of waters that are considered "impaired" either because the water exceeds water quality standards or does not achieve its designated use. For each water on the Central Coast's "303(d) Impaired Waters List", the California Central Coast Water Board must develop and implement a plan to reduce pollutants so that the waterbody is no longer impaired and can be de-listed. Section 303(d) of the Clean Water Act states:

Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 1314(a)(2) of this title as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

The State complies with this requirement by periodically assessing the conditions of the rivers, lakes and bays and identifying them as “impaired” if they do not meet water quality standards. These waters, and the pollutant or condition causing the impairment, are placed on the 303(d) List of Impaired Waters. In addition to creating this list of waterbodies not meeting water quality standards, the Clean Water Act mandates each state to develop Total Maximum Daily Loads (TMDLs) for each waterbody listed. The Central Coast Regional Water Quality Control Board is the agency responsible for protecting water quality consistent with the Water Quality Control Plan for the Central Coastal Basin (Central Coast Basin Plan), including developing TMDLs for waterbodies identified as not meeting water quality objectives.

2.2 Boron and Water Quality Impacts

The constituent of concern addressed in this TMDL is boron. Streams within the Estrella River Basin are listed on California’s 2008-2010 Clean Water Act 303(d) List as impaired due to boron. In recent years, boron has been recognized as a risk to drinking water quality[1]. While boron is reported to be a probable essential trace element for humans[2], elevated levels of boron have detrimental health effects based on animal studies, prompting the State of California Department of Public Health to adopt non-regulatory action levels for boron in drinking water supplies. Additionally, while boron is a micronutrient essential in plant development, excessive amounts of boron can be toxic to cultivated crops. Elevated boron in stock drinking water supplies has adverse effects on livestock. Further, boron toxicity to aquatic species and wildlife has been demonstrated in the scientific literature, although concentrations of boron found in the environment are generally below levels identified as toxic to aquatic and terrestrial organisms. Because of these ranges of potential water quality impacts, many stakeholders, local residents, and local agencies have a stake in understanding the risks posed by high levels of boron in water resources. Also noteworthy is the fact that two of the Central Coast Water Board’s top priorities are correcting and *preventing* risks to human health and degradation of aquatic habitat[3]. This includes the prevention of any further lowering of water quality in surface waters which currently support some, or all of their designated beneficial uses[4].

Boron occurs both naturally and from anthropogenic sources. Boron is a naturally-occurring element that is found in the environment primarily due to leaching of rocks and sediment. High concentrations of naturally occurring boron are primarily found in arid and semiarid environments where drainage and/or leaching are restricted. Anthropogenic sources of boron to the environment include sewage effluents, detergents, industrial wastes, agrochemicals (such as fertilizers and insecticides), and the combustion of coal and petroleum in power plants. While the global biogeochemical boron cycle is largely attributable to natural fluxes, human inputs to the global boron cycle have locally contributed significantly to boron transport in rivers and streams (Park and Schleisinger, 2002).

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[1] U.S. Environmental Protection Agency, 2008. Drinking Water Health Advisory for Boron. Document Number 822-R-08-013, May 2008.

[2] Nielsen (1994) as reported in California Regional Water Quality Control Board Central Valley Region, *Boron: A Literature Summary for Developing Water Quality Objectives*. Draft, April 2000.

[3] see Staff Report, Agenda Item 3 for Central Coast Water Board Regular Meeting of July 11, 2012.

[4] “Beneficial uses” is a regulatory term which refers to the legally-protected current, potential, or future designated uses of the waterbody. The Water Board is required by law to protect all designated beneficial uses.

2.3 A Note on Spatial Datasets and Scientific Certainty

Staff endeavored to use the best available spatial datasets from reputable scientific and public agency sources to render and assess physical, hydrologic, and biologic conditions in the Estrella River Basin. Spatial data of these types are routinely used in TMDL development and watershed studies nationwide. Where appropriate, staff endeavored to clearly label spatial data and literature-derived values as estimates in this Project Report, and identify source data and any assumptions. It is important to recognize that the nature of public agency data and digital spatial data provide snapshots of conditions at the time the data was compiled, or are regionally-scaled and are not intended to always faithfully and accurately render all local, real-time, or site-specific conditions. When reviewing TMDLs, the U.S. Environmental Protection Agency will recognize these types of datasets as estimates, approximations, and scoping assessments.

Also noteworthy is that while science is one cornerstone of the TMDL program, a search for full scientific certainty and a resolution of all uncertainties is not contemplated or required in TMDLs adopted in accordance with the Clean Water Act, and pursuant to U.S. Environmental Agency (USEPA) guidance. Staff endeavored to identify uncertainties in the TMDL, and reduce uncertainties where possible on the basis of available data. It should be recognized that from the water quality risk management perspective, scientific certainty is balanced by decision makers against the necessities of addressing risk management[5]. Conceptually, this issue is highlighted by reporting from the U.S. National Research Council shown below:

> *"**Scientific uncertainty is a reality within all water quality programs, including the TMDL program that cannot be entirely eliminated.** The states and EPA should move forward with decision-making and implementation of the TMDL program in the face of this uncertainty while making substantial efforts to reduce uncertainty. Securing designated uses is limited not only by a focus on administrative rather than water quality outcomes in the TMDL process, but also by unreasonable expectations for predictive certainty among regulators, affected sources, and stakeholders… Although science should be one cornerstone of the program, an unwarranted search for scientific certainty is detrimental to the water quality management needs of the nation. Recognition of uncertainty and creative ways to make decisions under such uncertainty should be built into water quality management policy."*
>
> *From: National Academy of Sciences – National Research Council (2001)*
>
> *Report issued pursuant to a request from the U.S. Congress to assess the scientific basis of the TMDL program: National Research Council, 2001. "Assessing the TMDL Approach to Water Quality Management – Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction, Water Science and Technology Board"*
>
> *(Emphasis not added – emphasis as published in the original National Research Council report)*

3 PHYSICAL SETTING & WATERSHED DESCRIPTION

3.1 TMDL Project Area & Watershed Delineation

The geographic scope of this TMDL project[6] encompasses approximately 950 square miles of the Estrella River Basin located in eastern San Luis Obispo County and southeastern Monterey County (see Figure 3-1). The Estrella River is a tributary of the Salinas River. The Estrella River is formed by the confluence of San Juan and Cholame creeks near Shandon, California. From there, the Estrella River flows 28 miles northwestward uniting with the Salinas River at San Miguel.

ESRI™ ArcMap® 10.1 was used to create watershed layers for the TMDL project area. Drainage

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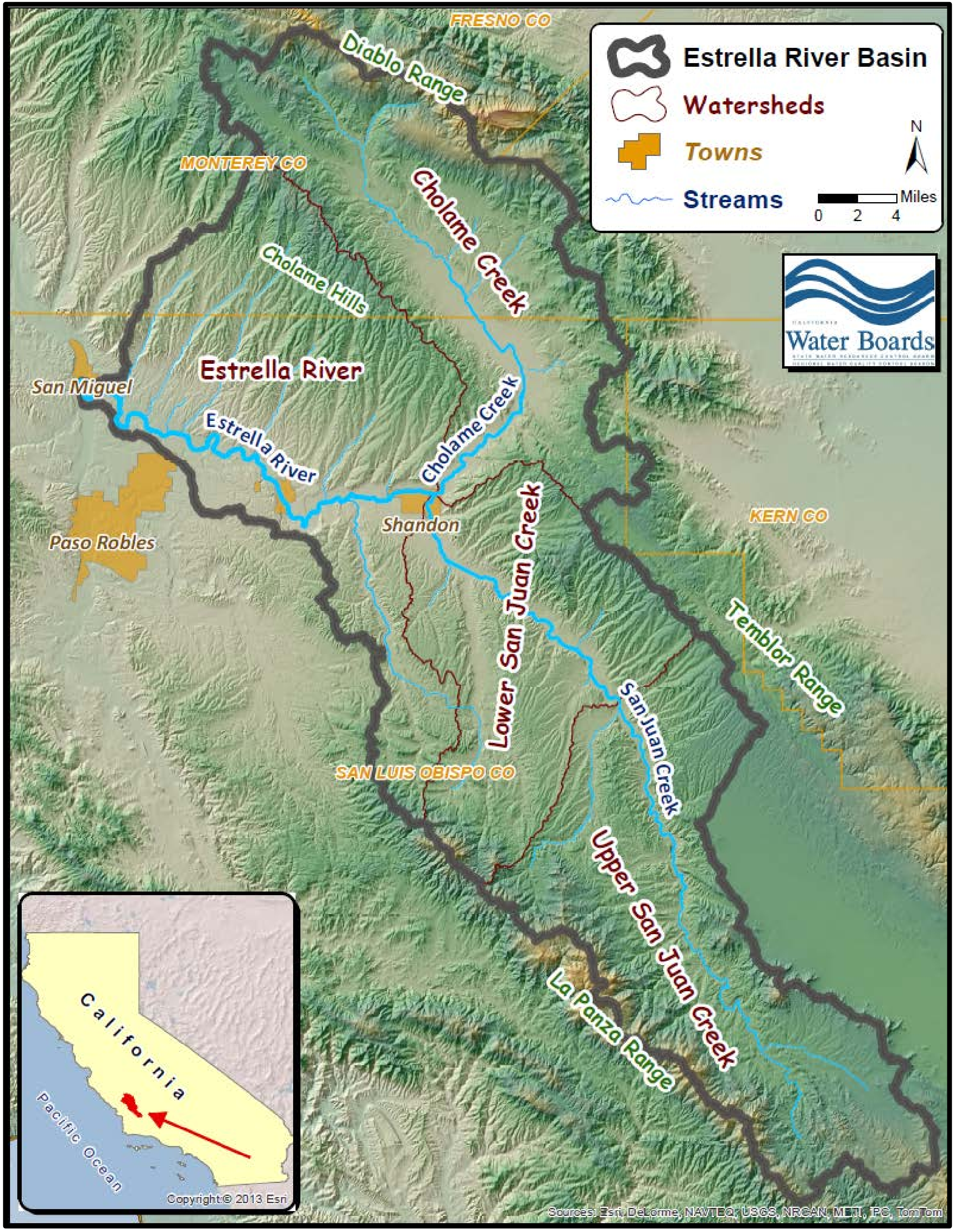
[5] U.S. National Research Council − National Academies of Science, 2001. *Assessing the TMDL Approach to Water Quality Management − Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction,* Water Science and Technology Board

[6] In the context of this report, the terms "TMDL project area" and "Estrella River Basin" are used interchangeably and refer to the same geographic area.

boundaries of the TMDL project area were delineated on the basis of the Watershed Boundary Dataset[7], which contain digital hydrologic unit boundary layers organized on the basis of Hydrologic Unit Codes (HUCs). Figure 3-1 illustrates watershed delineations in the Estrella River Basin.

Figure 3-1. TMDL Project Area – the Estrella River Basin and watersheds located within the basin.



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[7] 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.

The Estrella River Basin is delineated at the HUC-8 hydrologic unit scale. Individual watersheds (HUC-10 hydrologic unit scale) nested within the Estrella River Basin were delineated by clipping HUC-10 watershed shapefiles using the Estrella River Basin shapefile (HUC-8 # 18060004) as a mask. Based on HUC-10 delineations, there are four distinct watersheds nested within the Estrella River Basin: the 1) Estrella River Watershed (HUC-10 # 1806000404); the 2) Cholame Creek Watershed (HUC-10 # 1806000402); the 3) Lower San Juan Creek Watershed (HUC-10 # 1806000403); and the 4) Upper San Juan Creek Watershed (HUC-10 # 1806000401). A summary of the basin's watershed hierarchy is presented in Table 3-1.

Table 3-1. TMDL project area watershed hierarchy.

Name	Hydrologic Scale	Data Source	Drainage Area (square miles)
Estrella River Basin	**Basin**	WBD 8-digit Hydrologic Unit Code *Hydrologic Unit Code # 18060004*	949.7
Estrella River Watershed	**Watershed** *within the Estrella River Basin*	WBD 10-digit Hydrologic Unit Code *Hydrologic Unit Code # 1806000404*	277.5
Cholame Creek Watershed	**Watershed** *within the Estrella River Basin*	WBD 10-digit Hydrologic Unit Code *Hydrologic Unit Code # 1806000402*	237
Lower San Juan Creek Watershed	**Watershed** *within the Estrella River Basin*	WBD 10-digit Hydrologic Unit Code *Hydrologic Unit Code # 1806000403*	178.6
Upper San Juan Creek Watershed	**Watershed** *within the Estrella River Basin*	WBD 10-digit Hydrologic Unit Code *Hydrologic Unit Code # 1806000401*	256.5

3.2 Land Use & Land Cover

Figure 3-2 illustrates land use and land cover in the TMDL project area, based on the 2006 National Land Cover Dataset. NLCD is available from the Multi-Resolution Land Characterization consortium – a group of federal agencies who coordinate and generate consistent and relevant land cover information at the national scale for a wide variety of environmental, land management, and modeling applications. Table 3-2 tabulates the distribution of land use in the Estrella River Basin, while Table 3-3 presents the distribution of land cover in the individual watersheds which are nested within and comprise the Estrella River Basin.

The Estrella River Basin can be generally characterized as a rural, sparsely-populated river basin. Agriculture is the current dominant human land use activity in the river basin, including cultivated cropland and cattle grazing. Grassland, shrubland and forest also comprise substantial parts of upland reaches of the watershed within an ecosystem characterized by chamise-redshank chaparral, sage brush, and blue oak and coastal oak woodlands (source: National Land Cover Dataset, 2006; Calif. Dept. of Forestry and Fire Protection, 1977).

Figure 3-2. Estella River Basin land use - land cover (year 2006, NLCD).

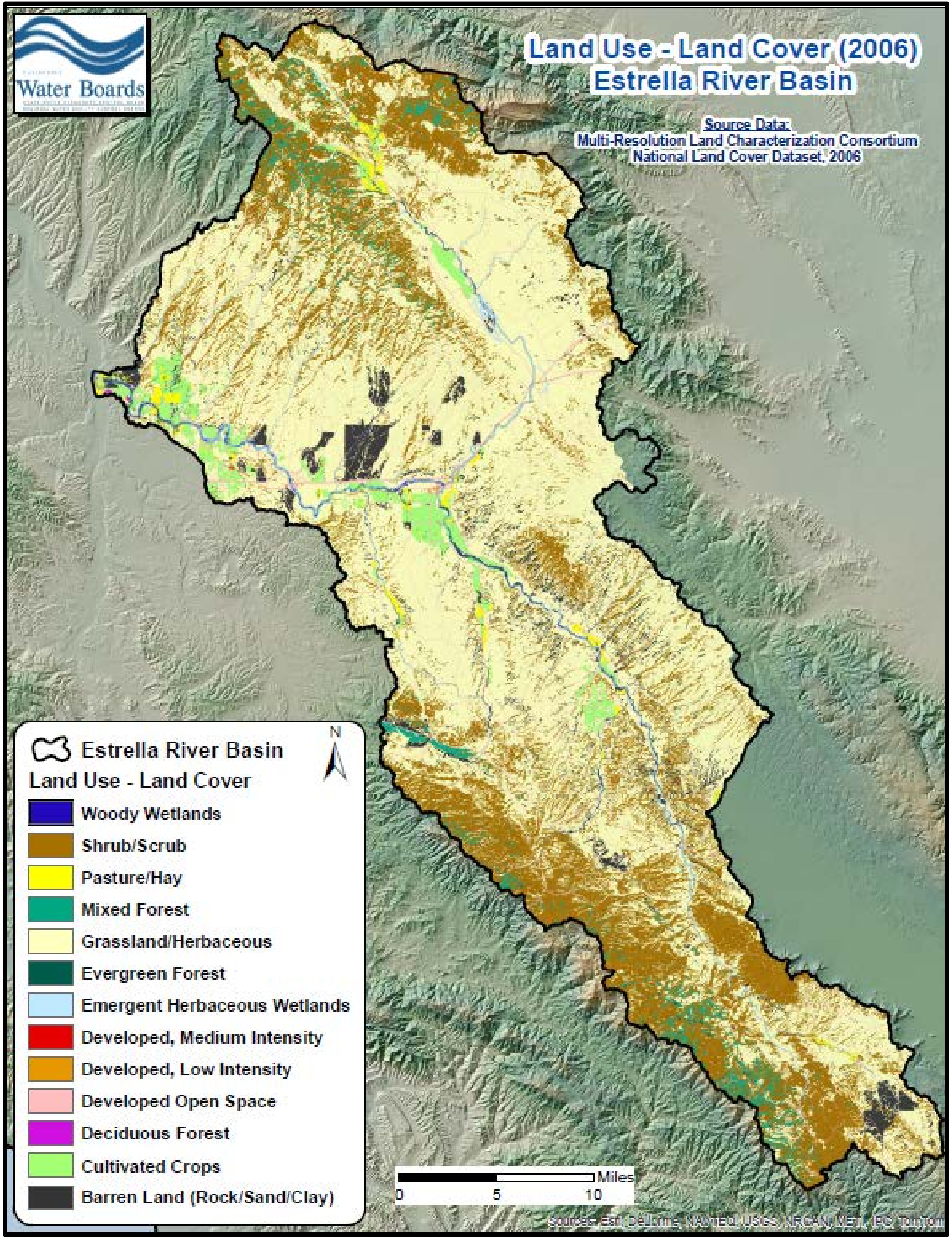


Table 3-2. Basin-scale land cover: tabulation of land use/land cover in the Estrella River Basin (year 2006).

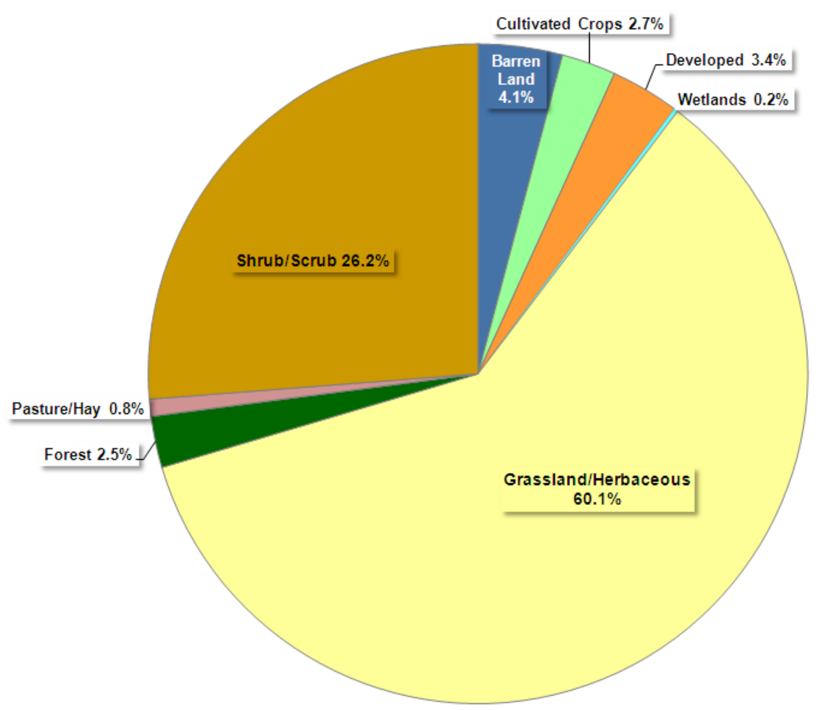
Estrella River Basin Land Cover	Acres	Estrella River Basin Land Cover Shown as Pie Chart
Barren Land (Rock/Sand/Clay)	25,083	
Cultivated Crops	16,208	
Deciduous Forest	110	
Developed Open Space	20,178	
Developed, Low Intensity	255	
Developed, Medium Intensity	18	
Emergent Herbaceous Wetlands	780	
Evergreen Forest	374	
Grassland/Herbaceous	365,055	
Mixed Forest	14,956	
Open Water	36	
Pasture/Hay	5,015	
Shrub/Scrub	159,395	
Woody Wetlands	379	
Total	607,842	

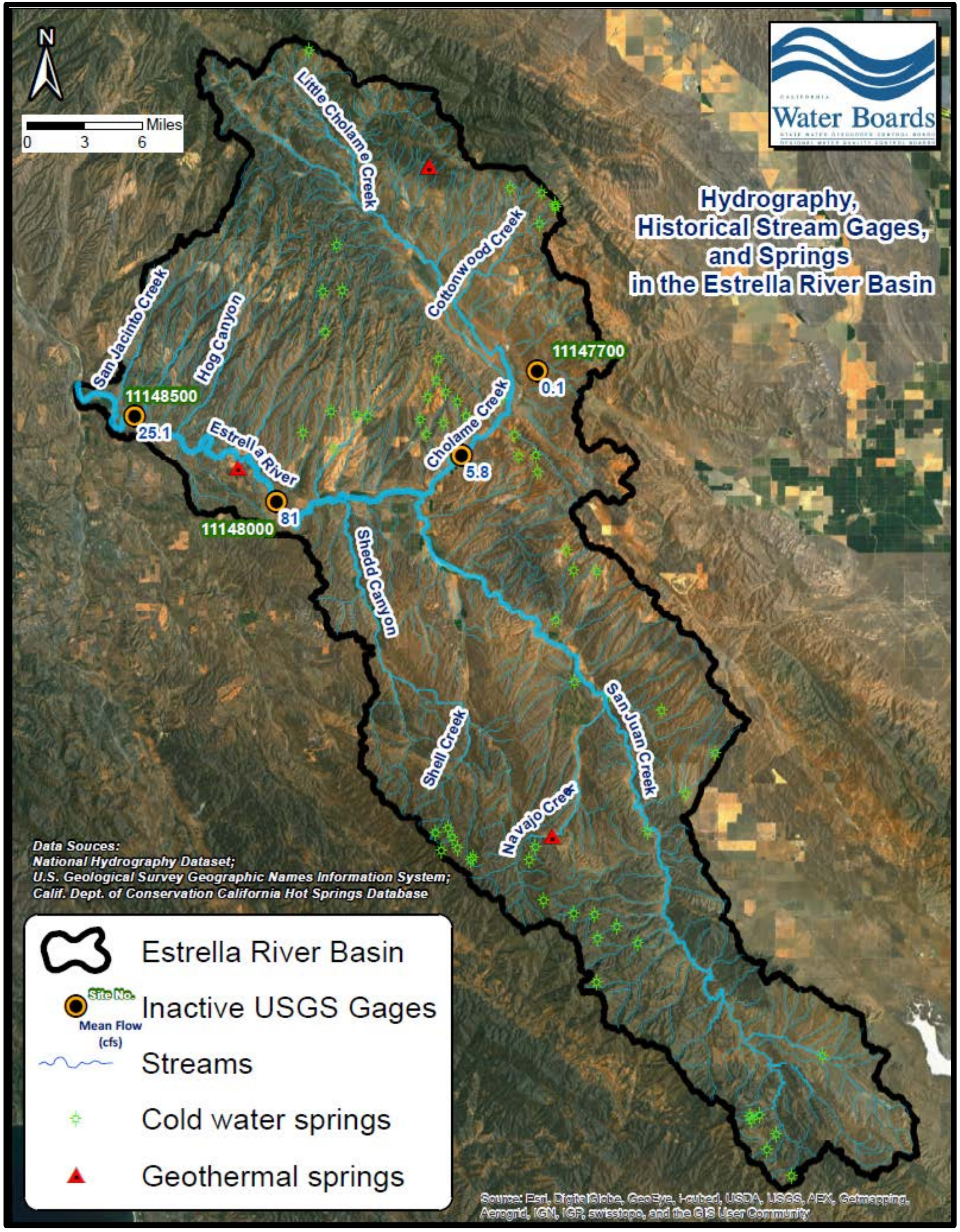
Table 3-3. Watershed-scale land cover: tabulation of land use/land cover of the watersheds located within the Estrella River Basin (year 2006).

	Estrella River Watershed		Cholame Creek Watershed		Lower and Upper San Juan Creek Watersheds	
Land Cover	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Barren Land (Rock/Sand/Clay)	10,360	5.832%	1,470	0.969%	13,145	4.720%
Cultivated Crops	9,368	5.274%	2,095	1.381%	4,727	1.697%
Deciduous Forest	86	0.048%	3	0.002%	21	0.008%
Developed Open Space	7,076	3.984%	4,562	3.008%	8,532	3.063%
Developed, Low Intensity	151	0.085%	93	0.061%	13	0.005%
Developed, Medium Intensity	15	0.009%	1	0.001%	1	0.000%
Emergent Herbaceous Wetlands	120	0.067%	659	0.434%	11	0.004%
Evergreen Forest	7	0.004%	64	0.042%	302	0.109%
Grassland/Herbaceous	116,536	65.608%	95,064	62.667%	153,526	55.122%
Mixed Forest	2,641	1.487%	5,566	3.669%	6,788	2.437%
Open Water	15	0.008%	5	0.004%	16	0.006%
Pasture/Hay	2,102	1.184%	1,451	0.957%	1,454	0.522%
Shrub/Scrub	28,883	16.261%	40,632	26.785%	89,901	32.278%
Woody Wetlands	265	0.149%	32	0.021%	79	0.029%
Total	177,626	100%	151,697	100%	278,519	100%

3.3 Hydrology

Assessing the hydrology of a watershed is an important step in evaluating the magnitude and nature of pollutant transport and loading in waterbodies. Hydrography of the Estrella River Basin is shown in Figure 3-3. The entire drainage area contributing to flow in the river basin encompasses 950 square miles.

Figure 3-3, Hydrography of the Estrella River Basin.



Data Souces:
National Hydrography Dataset;
U.S. Geological Survey Geographic Names Information System;
Calif. Dept. of Conservation California Hot Springs Database

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Table 3-4 presents legacy flow statistics for select stream reaches in the Estrella River Basin on the basis of inactive U.S. Geological Survey stream gages. Historically, the Estrella River is classified[8] as having near-perennial or sustained flows in the lower reaches of the river from near the confluence with the Salinas River upstream to approximately Estrella river mile 13 near Keyes Canyon. Due to local climatic and hydrologic conditions, most other stream reaches in the river basin have intermittent to ephemeral

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[8] The source of these hydrologic classification attributes is from the USGS's high resolution National Hydrography Dataset (NHD).

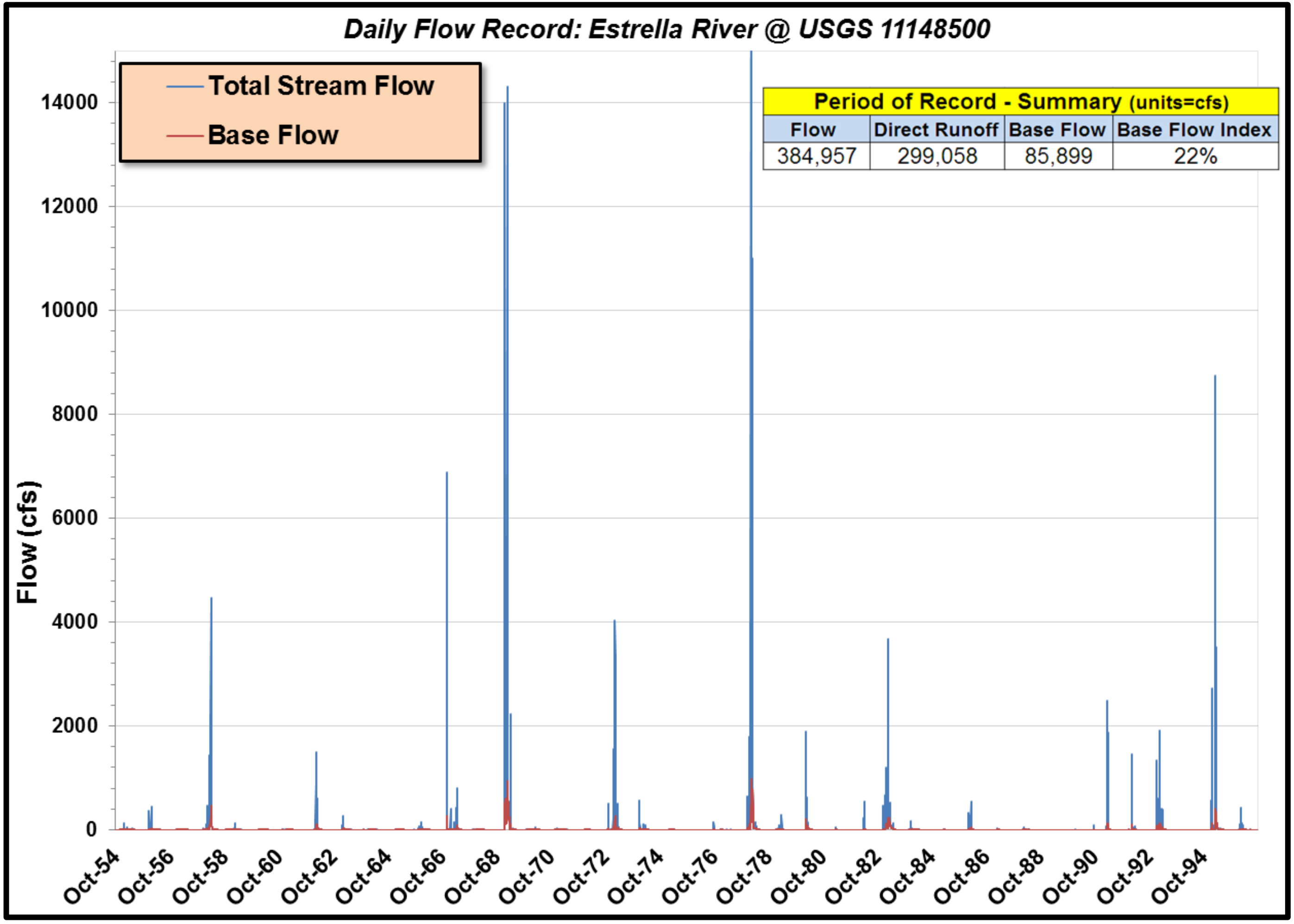
flows. However, locally some stream reaches may have sustained shallow groundwater inputs resulting in sustained or seasonal flows (for examples some reaches of lower Cholame Creek exhibit sustained flows).

Table 3-4. Flow statistics from historical USGS gages in the Estrella River Basin (units = cubic feet sec^{-1})

Site Number	Site Name	BFI_Ave.	Period of Record		MIN FLOW	P1	P10	P25	P50	P75	P90	P95	P99	MAX FLOW	AVE. FLOW
11148000	ESTRELLA R NR PASO ROBLES CA	0.299	Oct. 1939	Sept. 1941	0.70	0.80	1.40	3.30	6.00	11.00	129.00	373.60	2042.8	5,930	81.0
11147800	CHOLAME C NR SHANDON CA	0.010	Oct. 1958	Sept. 1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	64.5	3,320	5.8
11148500	ESTRELLA R NR ESTRELLA CA	0.227	Oct. 1954	Sept. 1996	0.00	0.00	0.00	0.00	0.00	1.00	6.90	25.00	430.7	18,500	25.1
11147700	CHOLAME C TRIB NR CHOLAME CA	0.392	Oct. 1958	Sept. 1965	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.94	14	0.1

Staff also considered the importance of groundwater contributions to stream flow. Consequently, flow separation analysis[9] (Figure 3-4) on Estrella River historical USGS gage 11148500 indicates a baseflow index[10] of 22% (see Figure 3-3 for location of this USGS gage). This baseflow index is substantially less than baseflow indices typically found in perennial streams in temperate climates or in coastal areas; however this data does illustrate that, locally, baseflow originating from groundwater inputs can be a contributor to hydrologic processes and surface flows in the Estrella River Basin.

Figure 3-4. Total stream flow, baseflow, and baseflow index for Estrella River at USGS 11148500.



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[9] Flow separation was accomplished using the Web-based Hydrograph Analysis Tool (W.H.A.T.) developed by the Purdue University engineering department.

[10] Baseflow is the component of stream flow over the period of record that is attributable to groundwater discharge into the stream.

3.4 Climate

In arid ecosystems characterized by low rainfall, soluble boron compounds may accumulate in soils in sufficient quantities to cause injury to plants. Note that arid regions are characterized by limited rainfall and leaching which can result in elevated levels of boron in the soil, Boron may be concentrated in arid soils by the evaporation of natural drainage waters – additionally, in cultivated areas irrigation water may add boron to soils (Whetstone et al, 1942, Peryea and Binham, 1986 Yermiyahu and Ben-Gal, 2006). In contrast, in sub humid climates rainfall is often sufficient to leach out any accumulated boron and other salts (U.S. Department of Agriculture, 1954). Indeed, it has been well documented since at least the 1940s that highly leached soils in the Pacific Northwest and along parts of the Atlantic seaboard may have problems with soil boron micronutrient deficiency (Whetstone et al., 1942).

Consequently, it is relevant to assess available data on regional climatic conditions for this TMDL report. Additionally, estimates of mean average surface temperature in the Estrella River Basin are necessary to calculate a geothermal gradient (geothermal gradient is discussed and developed in Section 3.7).

Precipitation rain gage data in the Estrella River Basin is available from the National Oceanographic and Atmospheric Administration - Western Regional Climate Center (http://www.wrcc.dri.edu). The Estrella River Basin has a Mediterranean climate, with the vast majority of precipitation falling between November and April (see Table 3-5).

Table 3-5. Parkfield rain gage precipitation records.

Station	Climatic Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Parkfield, CA COOP station 046703 Period of record 1943-1975	Average Precipitation (inches)	0.90	2.68	2.10	1.29	0.35	0.02	0.03	0.00	0.15	0.46	1.79	2.73	**14.51**

It is important to recognize that rainfall gauging stations have limited spatial distribution, and that gauging stations tend to be located in lower elevations where people live. Consequently, these locations can bias estimates of regional rainfall towards climatic conditions at lower elevations. The topography of the California central coast region however, can result in significant orographic enhancement of rainfall (e.g., enhancement of rainfall due to mountainous terrain and topographic relief).

Therefore, because of climatic spatial variability mean annual precipitation estimates for the Estrella River Basin may be assessed using the Parameter-elevation Regressions on Independent Slopes Model (PRISM)[11]. 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. PRISM is also the U.S. Department of Agriculture's official climatological dataset and PRSIM is used by the U.S. National Weather Service to spatially interpolate rainfall frequency estimates.

An isohyetal map for estimated mean annual precipitation in the Estrella River Basin is presented in Figure 3-5(A). Estimated mean annual temperature in the Estrella River Basin is presented in Figure 3-5(B).

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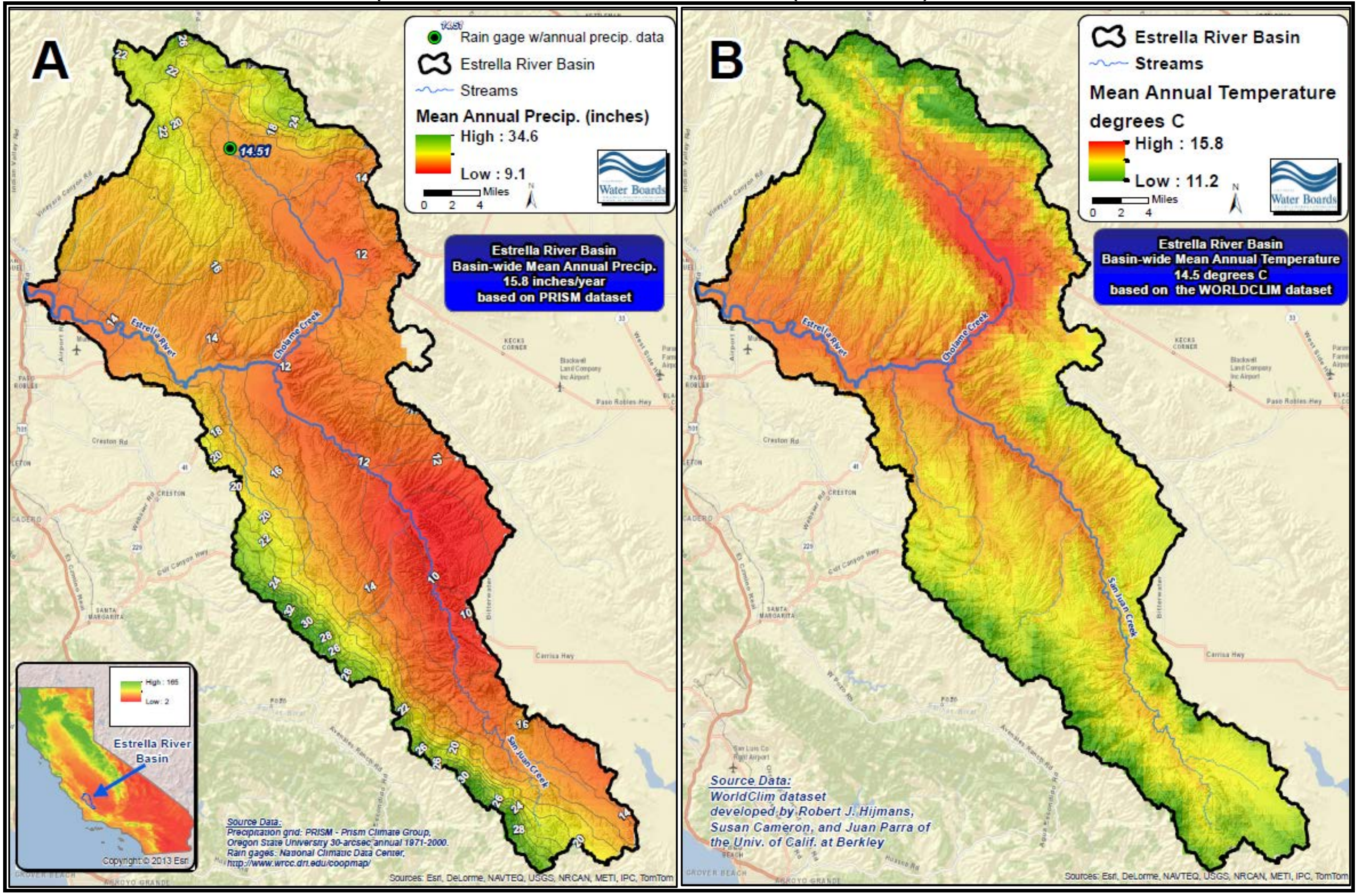
[11] The PRISM dataset was developed by researchers at Oregon State University, and uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of climatic parameters. The dataset incorporates a digital elevation model, and expert knowledge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

Figure 3-5. (A) Estimated mean annual precipitation (1971-2000) in the Estrella River Basin; and (B) Estimated mean annual temperature in the Estrella River Basin (1950-2000).



Source Data:
Precipitation grid: PRISM - Prism Climate Group, Oregon State University 30-arcsec annual 1971-2000.
Rain gages: National Climatic Data Center, http://www.wrcc.dri.edu/coopmap/

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, IPC, TomTom

Source Data:
WorldClim dataset developed by Robert J. Hijmans, Susan Cameron, and Juan Parra of the Univ. of Calif. at Berkley

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, IPC, TomTom

Additionally, staff considered climatic parameters which measure the degree of aridity. As highlighted previously in this section, soils associated with arid ecosystems often have relatively higher natural levels of boron. Note that Figure 3-6 illustrates estimated mean annual potential evapotranspiration rates[12] (PET) and aridity indices[13] (AI) for the Estrella River Basin. PET and AI are climatic parameters used to characterize degree of aridity or humidity at regional scales. Potential evapotranspiration (PET) rates in the Estrella basin range up to 1,590 millimeters per year and PET is particularly high in the lower-elevation valley floor stream reaches. Estrella Basin aridity indices range down to 1.91 – a value consistent with an arid region. Practically speaking, the data show that whereas the California central coast region is broadly characterized by a dry, semi-arid Mediterranean climate, the Estrella River Basin itself is in fact even *more* arid on average than the central coast region as a whole. Note that these observations are visually illustrated by the color gradients and climatic statistics presented in the maps of Figure 3-6.

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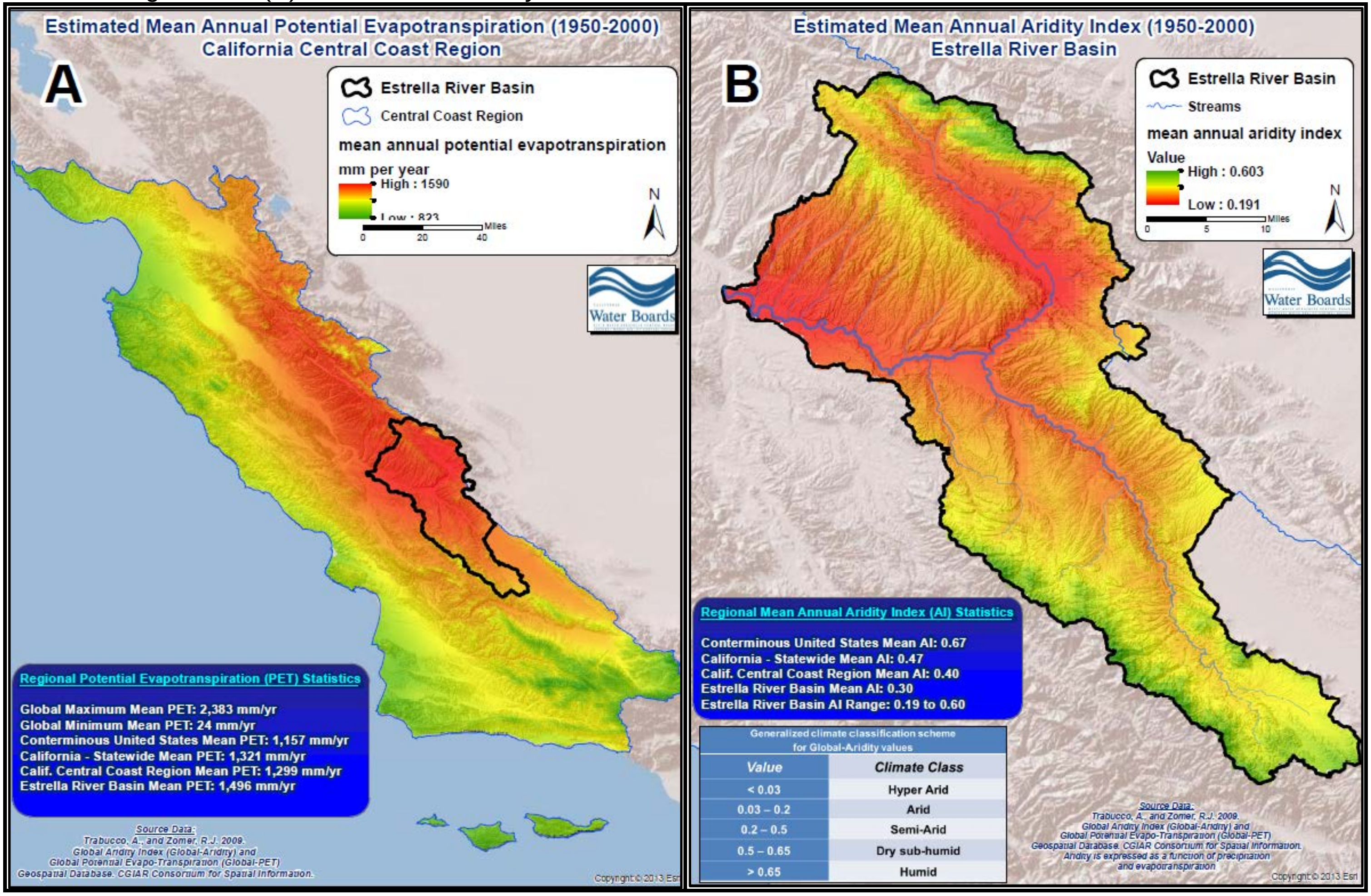
[12] Potential evapotranspiration is the amount of water that would be removed from the surface if the amount of water present were not a limiting factor. In other words, the potential evapotranspiration over the Sahara desert is very large because the amount of evaporation that *could* take place there is huge. However, because there isn't any water there to be evaporated the evapotranspiration that actually takes place is quite small.

[13] Aridity is expressed as a generalized function of precipitation and potential evapotranspiration. Lower aridity index (AI) values indicate increasingly arid conditions; by convention AI values from 0 to 0.5 indicate hyper-arid, to arid, to semi-arid conditions, whereas AI values greater than 0.5 indicate sub-humid to humid climatic conditions.

Figure 3-6. Climatic parameters: (A) mean annual potential evapotranspiration in the California central coast region; and (B) mean annual aridity index in the Estrella River Basin.



Regional Potential Evapotranspiration (PET) Statistics

Global Maximum Mean PET: 2,383 mm/yr
Global Minimum Mean PET: 24 mm/yr
Conterminous United States Mean PET: 1,157 mm/yr
California - Statewide Mean PET: 1,321 mm/yr
Calif. Central Coast Region Mean PET: 1,299 mm/yr
Estrella River Basin Mean PET: 1,496 mm/yr

Source Data:
Trabucco, A., and Zomer, R.J. 2009.
Global Aridity Index (Global-Aridity) and
Global Potential Evapo-Transpiration (Global-PET)
Geospatial Database. CGIAR Consortium for Spatial Information.

Regional Mean Aridity Index (AI) Statistics

Conterminous United States Mean AI: 0.67
California - Statewide Mean AI: 0.47
Calif. Central Coast Region Mean AI: 0.40
Estrella River Basin Mean AI: 0.30
Estrella River Basin AI Range: 0.19 to 0.60

Generalized climate classification scheme for Global-Aridity values

Value	Climate Class
< 0.03	Hyper Arid
0.03 – 0.2	Arid
0.2 – 0.5	Semi-Arid
0.5 – 0.65	Dry sub-humid
> 0.65	Humid

Source Data:
Trabucco, A., and Zomer, R.J. 2009.
Global Aridity Index (Global-Aridity) and
Global Potential Evapo-Transpiration (Global-PET)
Geospatial Database. CGIAR Consortium for Spatial Information.
Aridity is expressed as a function of precipitation
and evapotranspiration

Indeed, the Estrella River Basin and parts of the upper Salinas River Basin are among the few places in the central coast region that are characterized by truly arid conditions on the basis of aridity indices values (aridity index values ranging to less than 0.2). In contrast, the Santa Cruz and Santa Lucia mountains of coastal Monterey and San Luis Obispo counties would be climatically classified as dry sub-humid to humid while the Santa Maria Valley of Santa Barbara County would be classified as semi-arid on the basis of aridity index values.

Lastly, based on the statistical summaries calculated by ArcMap® 10.1 for digital climate grids presented in this section of the report, the Estrella River Basin is an arid to semi-arid ecosystem and with average climatic parameters of the basin that can be summarized as follows:

MEAN ANNUAL PRECIPITATION ESTIMATE:

Estimated mean annual precipitation within the Estrella River Basin, accounting for orographic effects:
15.8 inches per year (period of record 1971-2000)

MEAN ANNUAL TEMPERATURE ESTIMATE:

Estimated mean annual temperature within the Estrella River Basin:
14.5 degrees centigrade (period of record 1950-2000)

MEAN ANNUAL POTENTIAL EVAPOTRANSPIRATION (PET) ESTIMATE:

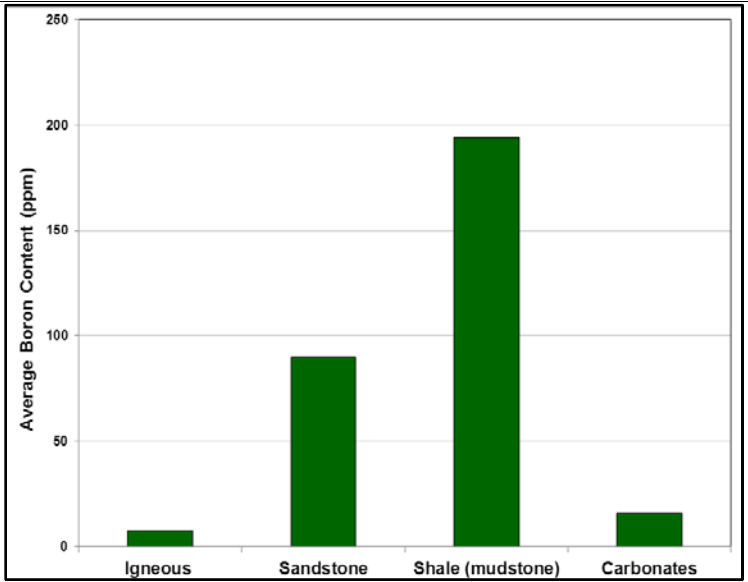
Estimated mean annual PET within the Estrella River Basin:
1,496 millimeters/year (period of record 1950-2000)

3.5 Geology

Given certain geologic and hydrogeological conditions, geology and groundwater can locally have a significant influence on inorganic constituents (such as boron) in streams (Reimann et al., 2009; Clow et al., 1996). Boron is an important constituent in some types of sediments and sedimentary rocks (Williams et al., 2000). As such, it is relevant to assess geologic conditions associated with the TMDL project area.

Boron is an important constituent of clastic sedimentary assemblages because it is preferentially concentrated in clay minerals causing rocks like shale or mudstone to contain one or two orders of magnitude more boron than quartz and feldspar-dominated silicates such as granitic rocks (Williams et al., 2001). Table 1-1 presents global averages and ranges of the boron composition of select rock types. The nexus of elevated boron content and sedimentary rock types is further illustrated in Figure 3-7.

Table 3-6. Global average boron concentrations (ppm) of select rock types.

Rock Type	Boron Composition [A] (ppm)	Average Boron Composition (ppm) of Select Rock Types shown as Bar Chart
Igneous	**7.5** (average)	
Sandstone	**90** (average) *3.5 – 400 (range)*	
Shale *(mudstone)*	**194** (average) *25 – 2,500 (range)*	
Carbonates	**16** (average) *1 – 240 (range)*	
Evaporites *(anhydrite-gypsum)*	**70** (average) *1 – 500 (range)*	
Serpentinite	*150 - 300 (range)*	

[A] sources: U.S. Geological Survey, 1985. *Study and Interpretation of the Chemical Characteristics of Natural Water.* USGS Water-Supply Paper 2254; and Christ, C. L.; Harder, H. In *Handbook of Geochemistry*; Wedepohl, K. H., Ed.; Springer-Verlag: Heidelberg, Germany, 1978; Chapter 5 - Boron.

Evidence of a correlation of boron with the weathering and leaching of rocks can be statistically tested. Note that dissolved calcium levels in surface water can be an indicator of weathering and leaching of silicate rocks and sediments (Neal, 1997). Accordingly, staff performed a Kendall's tau nonparametric correlation test using R[14] on the paired boron-calcium water quality samples[15] shown in Figure 3-8. Kendall's tau is a statistical measure of the monotonic association between two variables.

The correlation test indicates that boron and calcium are moderately well correlated (tau = 0.71). Further, the correlation is in fact highly statistically significant (p-value < 2.2 e-16), indicating a very small chance of observing this correlation by chance alone. By convention, Kendall's tau correlation coefficients are considered to be statistically significant when probabilities (p-values) are less than 0.05. Practically speaking, this means that there is a significant positive correlation or association between calcium (a rock-leaching indicator) and boron concentrations in these surface water samples.

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[14] Citation: R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

[15] Paired water quality samples in this context refer to calcium and boron samples that were collected at the same date/time and at the same sampling location.

Figure 3-7. Box and whiskers plot illustrating variations in boron concentrations in sampled rock type categories from California, and map showing locations of sampled sites.

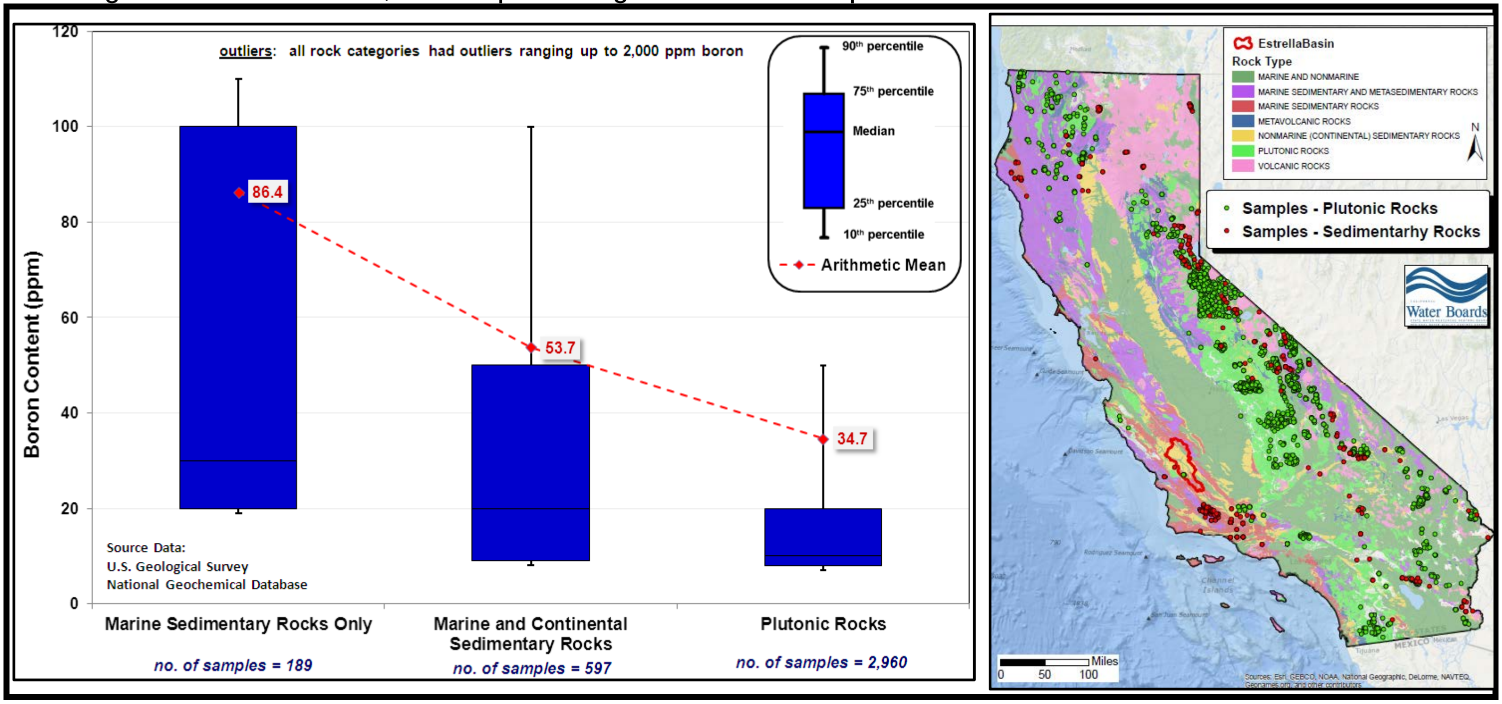

Figure 3-8. Statistical association of paired boron-calcium stream samples, California central coast.

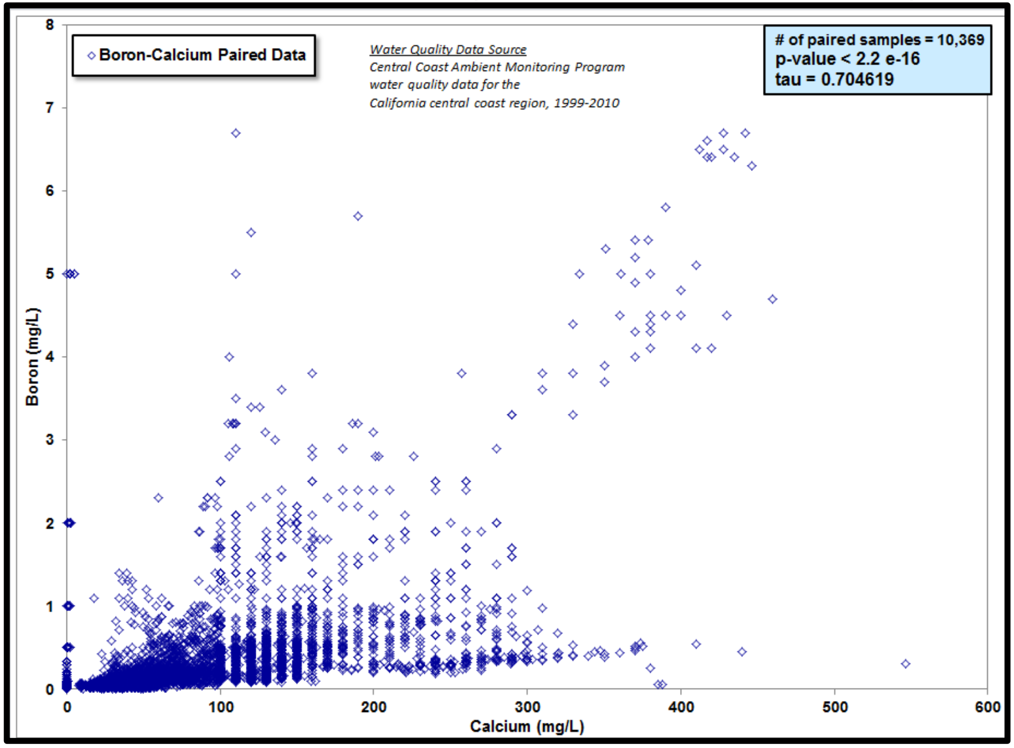

Figure 3-9 illustrates the geology of the Estrella River Basin. The river basin is located within the eastern side of the Central Coastal geologic province of central California[16]. The Central Coastal geologic province is characterized by a series of ranges and intermontane valleys exhibiting northwest-oriented topographic and geologic structural trends typical of this part of California.

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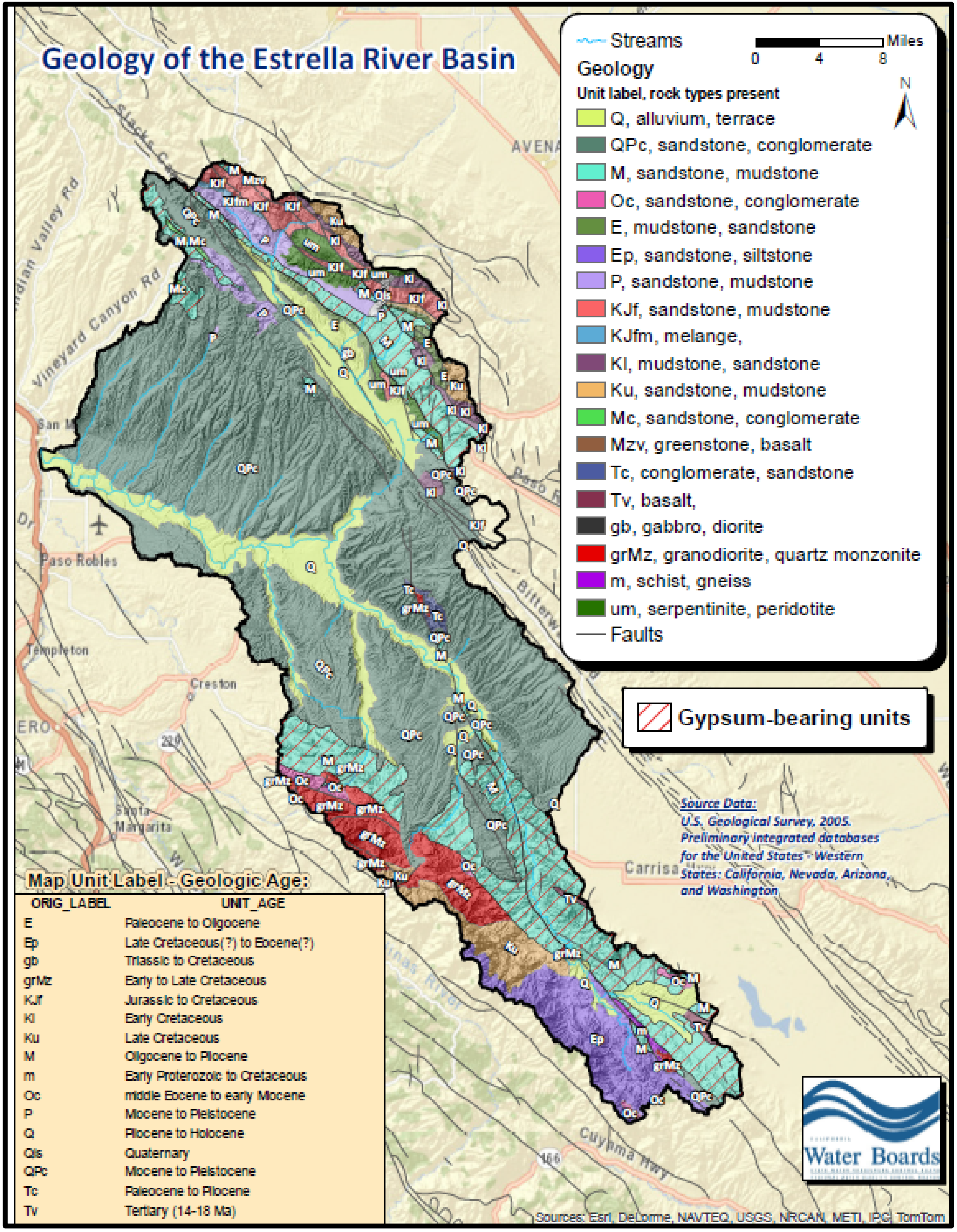
[16] The convention for geologic provinces used here is based on digital data from U.S. Geological Survey, 2000 – USGS Digital Data Series DDS-60: *Geologic Provinces of the World, 2000 World Petroleum Assessment, all defined provinces.*

Figure 3-9. Estrella River Basin generalized geologic map.



ORIG_LABEL	UNIT_AGE
E	Paleocene to Oligocene
Ep	Late Cretaceous(?) to Eocene(?)
gb	Triassic to Cretaceous
grMz	Early to Late Cretaceous
KJf	Jurassic to Cretaceous
Kl	Early Cretaceous
Ku	Late Cretaceous
M	Oligocene to Pliocene
m	Early Proterozoic to Cretaceous
Oc	middle Eocene to early Miocene
P	Miocene to Pleistocene
Q	Pliocene to Holocene
Qls	Quaternary
QPc	Miocene to Pleistocene
Tc	Paleocene to Pliocene
Tv	Tertiary (14-18 Ma)

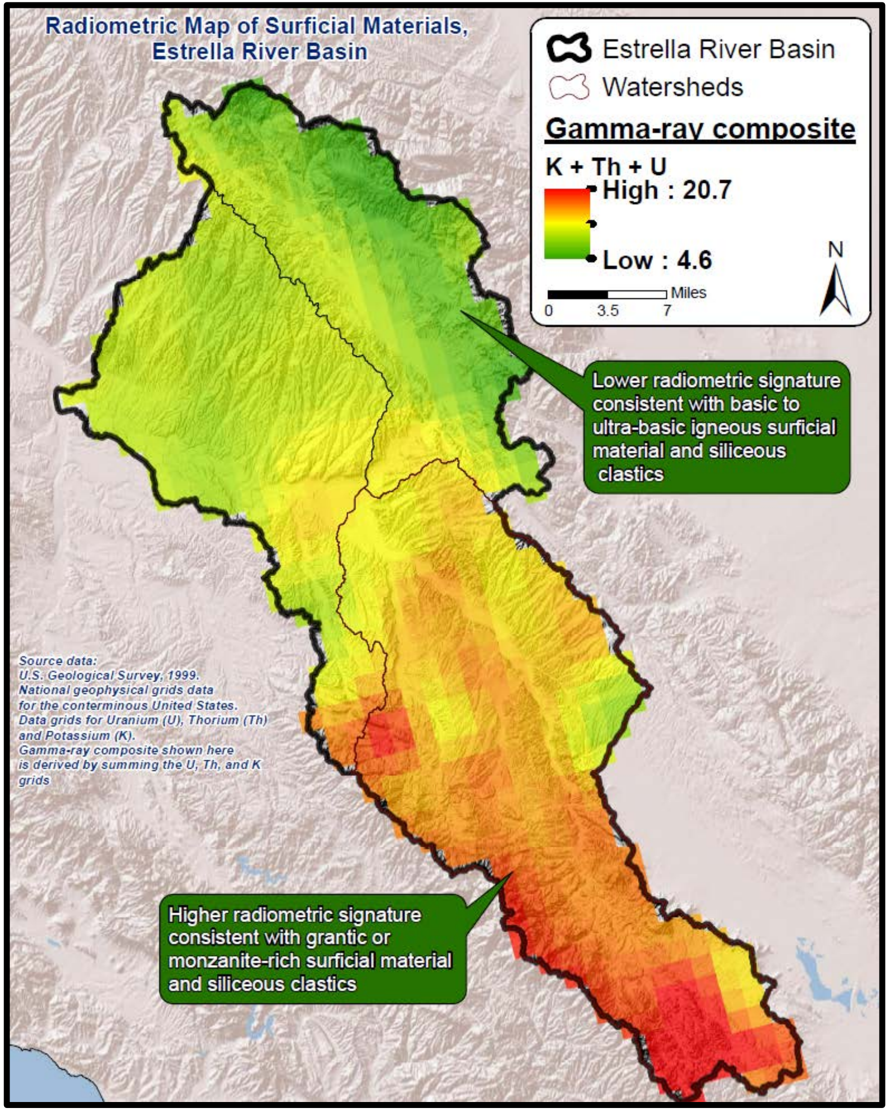
Source Data: U.S. Geological Survey, 2005. Preliminary integrated databases for the United States - Western States: California, Nevada, Arizona, and Washington

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

The Estrella River and its tributary Cholame Creek drain parts of the Diablo Range and the Cholame Hills in the northern and northeastern parts of the river basin (refer back to Figure 3-1 for visual representation of drainage areas and associated mountain ranges). The Cholame Hills are considered a northern extension of the Temblor Range. In the southern and southwestern part of the river basin, the Estrella River's tributary San Juan Creek receives drainage from parts of the La Panza Range as well as from the Temblor Range (refer back to Figure 3-1 for visual representation).

Geology in the Estrella River Basin include unconsolidated Quaternary deposits along stream reaches of lowland areas of the river basin; Tertiary sedimentary rocks in upland areas of the basin; and Mesozoic sedimentary assemblages Mesozoic granitic rocks, basalts, and some ultramafic rocks (serpentinite) in upland reaches in the Diablo Range (Cholame Creek Watershed) and La Panza Range (Upper San Juan Creek Watershed). As noted previously, marine sedimentary rocks (particularly marine shales and mudstones) are prone to having relatively high boron content. In addition, high concentrations of boron related to ultramafic rocks and serpentinization have been reported in the literature (Christ and Harder, 1969). Indeed, it should be reiterated that all of these geologic materials are present locally in areas of the Estrella River Basin. Geologic variation within the river basin is also illustrated by aerial measurements of natural background radioactivity in surficial geologic materials[17] (see Figure 3-10). The northern part of the river basin is characterized by relatively lower levels of natural radioactivity, suggestive of boron-prone mafic and ultra-mafic rocks as well as siliceous Tertiary sediments. The San Juan Creek watershed in the southern part of the river basin tends to be characterized by higher natural radioactivity in surficial materials, consistent with the presence of relatively boron-depleted igneous rocks such as granodiorites and quartz monzonites or sedimentary sandstones.

Figure 3-10. Gamma-ray radiometric map of the Estrella River Basin.



Lower radiometric signature consistent with basic to ultra-basic igneous surficial material and siliceous clastics

Higher radiometric signature consistent with grantic or monzanite-rich surficial material and siliceous clastics

Source data: U.S. Geological Survey, 1999. National geophysical grids data for the conterminous United States. Data grids for Uranium (U), Thorium (Th) and Potassium (K). Gamma-ray composite shown here is derived by summing the U, Th, and K grids

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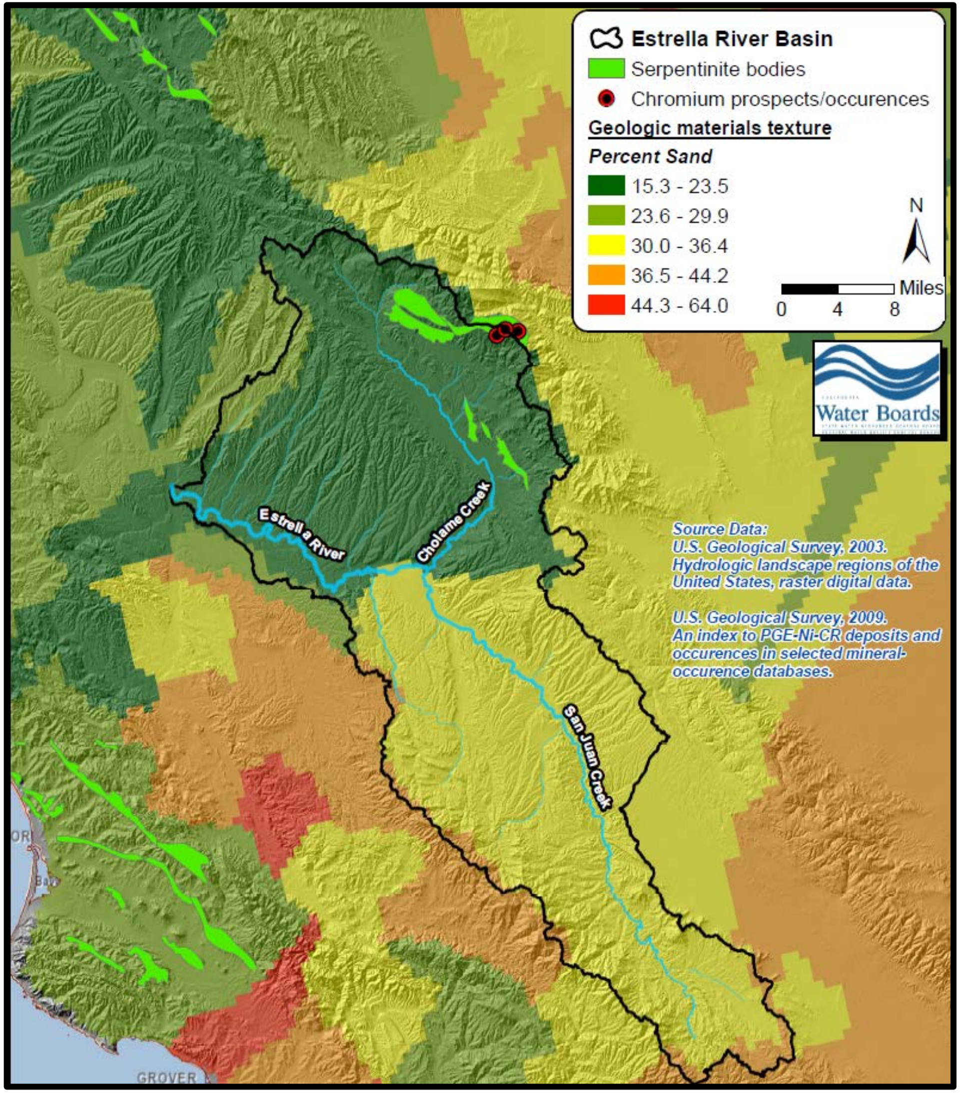
[17] Low levels of naturally-occurring radioactive elements occur in all rock material. Aerial gamma-ray surveys measure the gamma-ray flux produced by the radioactive decay of the naturally occurring elements K-40, U-238, and Th-232 in the top few centimeters of rock or soil.

Surficial geologic materials in the river basin include thick deposits (>100 feet) of alluvial sediments in lowland reaches and stream valleys of the river basin, and discontinuous or patchy distributions of residual clastic materials derived from erosion of igneous, metamorphic and sedimentary rocks in upland reaches of the river basin. Noteworthy is that surficial material of the Cholame Creek Watershed tend to be more clay-rich or fine-grained, whereas surficial materials in the San Juan Creek Watershed tend to be comprised of sand-rich or coarser-grained clastic materials[18]. Figure 3-11 illustrates that the northern reaches of the river basin (Cholame Creek Watershed, and reaches along the Estrella River) are low in average sand content (indicating the presence of fines or clay-rich geologic materials), additionally ultra-mafic serpentinite geologic bedrock is present in the Cholame Creek watershed. The ultramafic nature of these materials is also illustrated by the presence of mapped chromium occurrences and prospects in the northeastern reaches of the Cholame Creek watershed (refer again to Figure 3-11). Note additionally that Cholame Creek waters tend to have high levels of magnesium (refer to Section 4.7.2 and piper diagrams in Figure 4-2) – elevated magnesium would indeed be an expected geochemical signature of waters draining mafic or ultramafic geologic materials[19].

Figure 3-11. Illustration of percent sand in geologic materials, and distribution of ultra-mafic rock geology on the basis of serpentinite bedrock and chromium occurrences.



Source Data:
U.S. Geological Survey, 2003. Hydrologic landscape regions of the United States, raster digital data.

U.S. Geological Survey, 2009. An index to PGE-Ni-CR deposits and occurences in selected mineral-occurence databases.

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[18] This information is available from Soller, D.R., Reheis, M.C., Garrity, C.P., and Van Sistine, D.R., 2009, *Map Database for Surficial Materials in the Conterminous United States*: U.S. Geological Survey, Data Series 425

[19] Ultramafic geologic materials, such as serpentinite, are high in magnesium and iron, whereas intermediate and acidic silicate rocks are high in calcium and sodium.

In summary, marine sedimentary rocks, clay-rich geologic materials, and bodies of ultramafic rocks are present in the Estrella River Basin and are generally associated with the northern parts of the river basin – these types of materials are known to be prone to being enriched in boron based on the body of global scientific research and literature. As such, it would be expected that these types of geologic materials could locally contribute boron to groundwaters, springs, and surface waters of the Estrella River Basin.

Furthermore, within the Estrella River Basin evidence of active tectonic activity and mineral-rich saline subsurface waters are indicated by the presence of low-temperature geothermal mineral springs, seismic activity and faulting, as illustrated previously on Figure 3-3 and Figure 3-9. The significance of these geologic conditions is that older marine rock strata which potentially have salty connate pore fluids are tectonically uplifted close to the surface of the land, allowing older subsurface connate[20] pore fluids to potentially interact and/or mix with shallow meteoric groundwaters, surficial materials, springs, and surface waters. In some marine sedimentary rocks, these older, connate fluids tend to be saline (paleo-seawater), and can have geochemical signatures indicating they have remained in place within the subsurface rock reservoirs for a significant period of geologic time, possibly since deposition (Unruh et al., 1995 and Davisson et al., 1994). Indeed, connate groundwaters of non-meteoric origin are not uncommon in the California Coast Ranges (White et al, 1973 as reported in Vengosh et al., 2002)

It should be noted that the potential for tectonic uplift of sediments containing saline connate pore waters and the subsequent hydrologic interaction with shallow groundwaters and surface waters, is not simply theoretical or speculative. It has been well-established in the scientific literature that regions undergoing tectonic activity can result in regional over-pressure (exceeding hydrostatic pressure) of subsurface connate pore fluids. This over-pressure may cause the connate fluids to migrate upward along hydraulic conduits and be expelled via springs at the land surface, or to mix with shallow meteoric fresh waters. For example, isotopic studies of perennial springs found along ridge tops in the Rumsey Hills of Yolo County, California indicate these saline spring waters originate from deep, basinal connate waters, and that regional overpressure of subsurface fluids locally extends to the surface. This results in discharge of connate fluids originating from depth at the land surface (McPherson and Garven, 1999). Furthermore, the isotopic data from the Rumsey Hills study is consistent with mixing and hydraulic communication between shallow, meteoric groundwaters and saline connate waters originating from depth (Davisson et al., 1994).

In fact, reporting for the Paso Robles groundwater basin indicates that geologic faults in the basin allow connate waters trapped in older subsurface strata to migrate upward to the surface as geothermal or connate waters (Paso Robles Basin Draft Groundwater Management Plan Documents, 2010). Likewise, U.S. Geological Survey scientists report that boron and sodium-chloride rich connate waters underlying the Estrella River Basin migrate from depth to the to the surface and shallow subsurface (see Figure 3-12).

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[20] Connate fluids are liquids – for example, ancient sea water - that were trapped in the pores of marine or continental sedimentary rocks as they were deposited and buried. In general, buried marine sediments often contain connate saline waters reflecting a paleo-seawater origin, whereas buried continental sediments will contain connate waters of freshwater meteoric origin.

Figure 3-12. USGS interpretation of boron-rich connate waters underlying the Estrella River Basin, migrating to the surface and shallow subsurface.

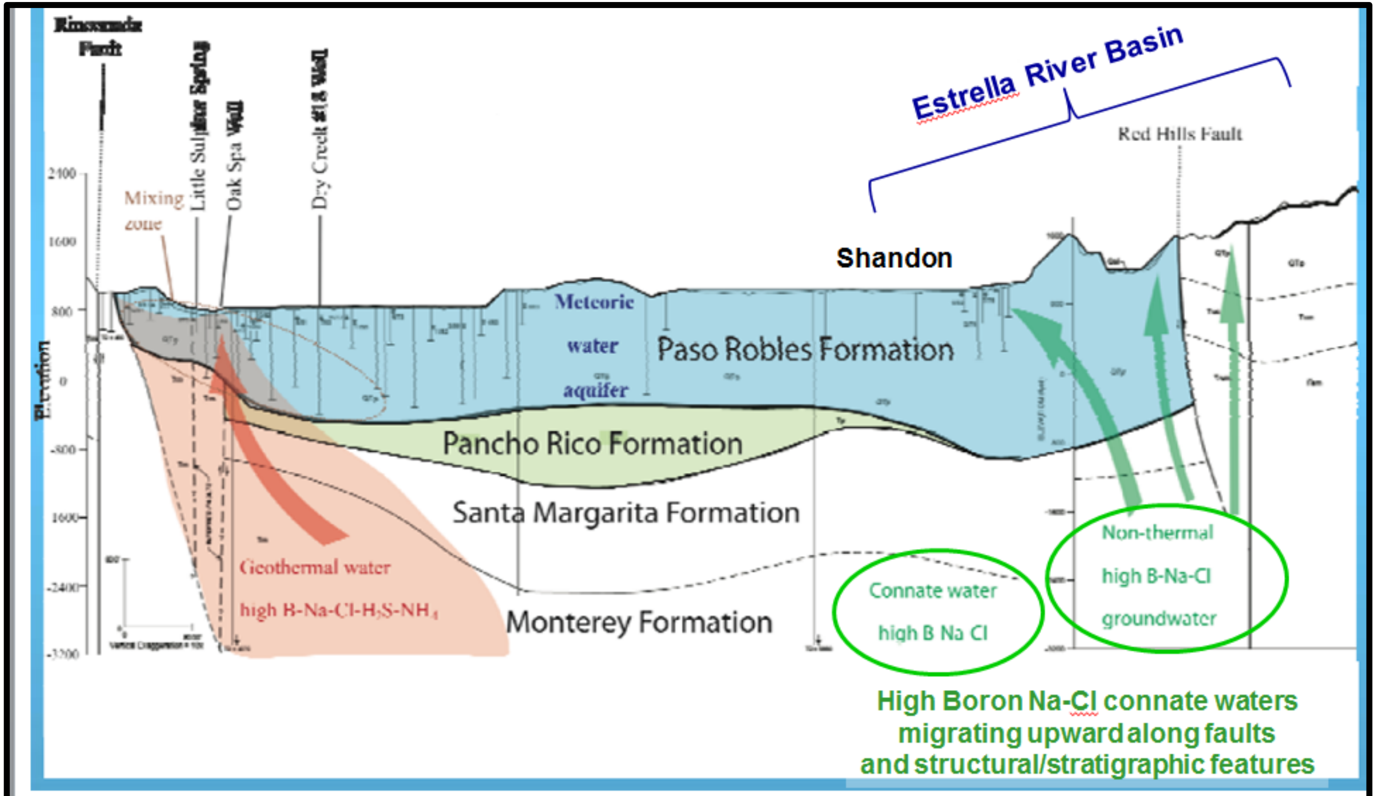
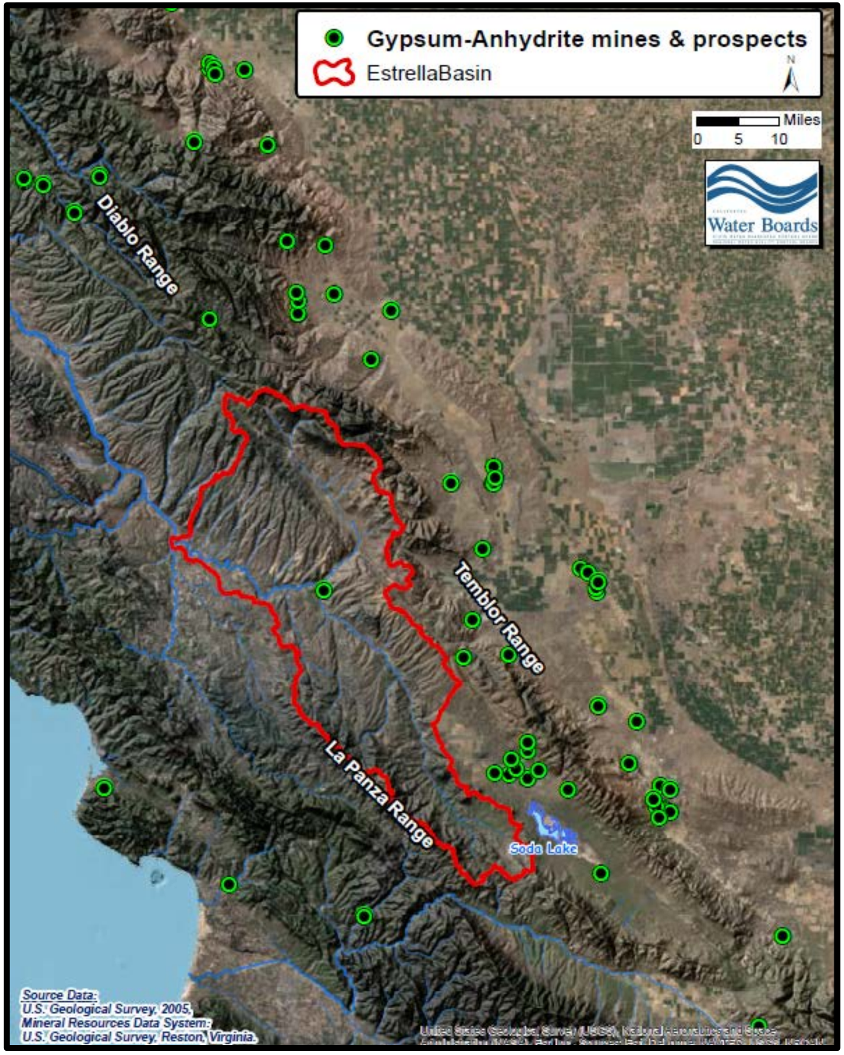


Figure from Rytuba and Goldstein
U.S. Geological Survey, Menlo Park, CA
www.slocountywater.org/site/Water%20Resources/Advisory%20Committee/Submittals/pdf/130206%20USGS%20Geothermal%20Presentation%20Submittal.pdf

Also noteworthy is the presence of evaporative sulfate-bearing minerals such as gypsum and anhydrite in Tertiary sedimentary rocks of the Estrella River Basin (refer back to Figure 3-9); these minerals attest to the marine origins of these rocks and evaporation of paleoseawaters once associated with these sediments. Indeed, the Estrella River Basin and the Temblor and Diablo ranges in the vicinity of the basin contain identified gypsum and anhydrite mining prospects (see Figure 3-13). Note that it has been reported in the literature that elevated boron concentrations in waters can be associated with dissolution of evaporative sediments (aka, anhydrite, gypsum) and geothermal processes (Sanchez-Martos and Pulido-Bosch, 1999). As discussed above, evaporative sediments and low temperature geothermal springs are indeed a characteristic of the Estrella River Basin.

Figure 3-13. Gypsum and anhydrite prospects and mines in and around the Estrella River Basin.



Source Data:
U.S. Geological Survey, 2005,
Mineral Resources Data System:
U.S. Geological Survey, Reston, Virginia.

To conclude, multiple lines of evidence – including geologic materials, inferred subsurface connate water-rock interactions, and rock types – indicate an environment that could result in leaching of higher amounts of boron relative to many other river basins. The northern parts of the Estrella River Basin (for example the Cholame Creek Watershed) in particular, appear to have the most favorable geologic conditions that could result in leaching of elevated amounts of boron.

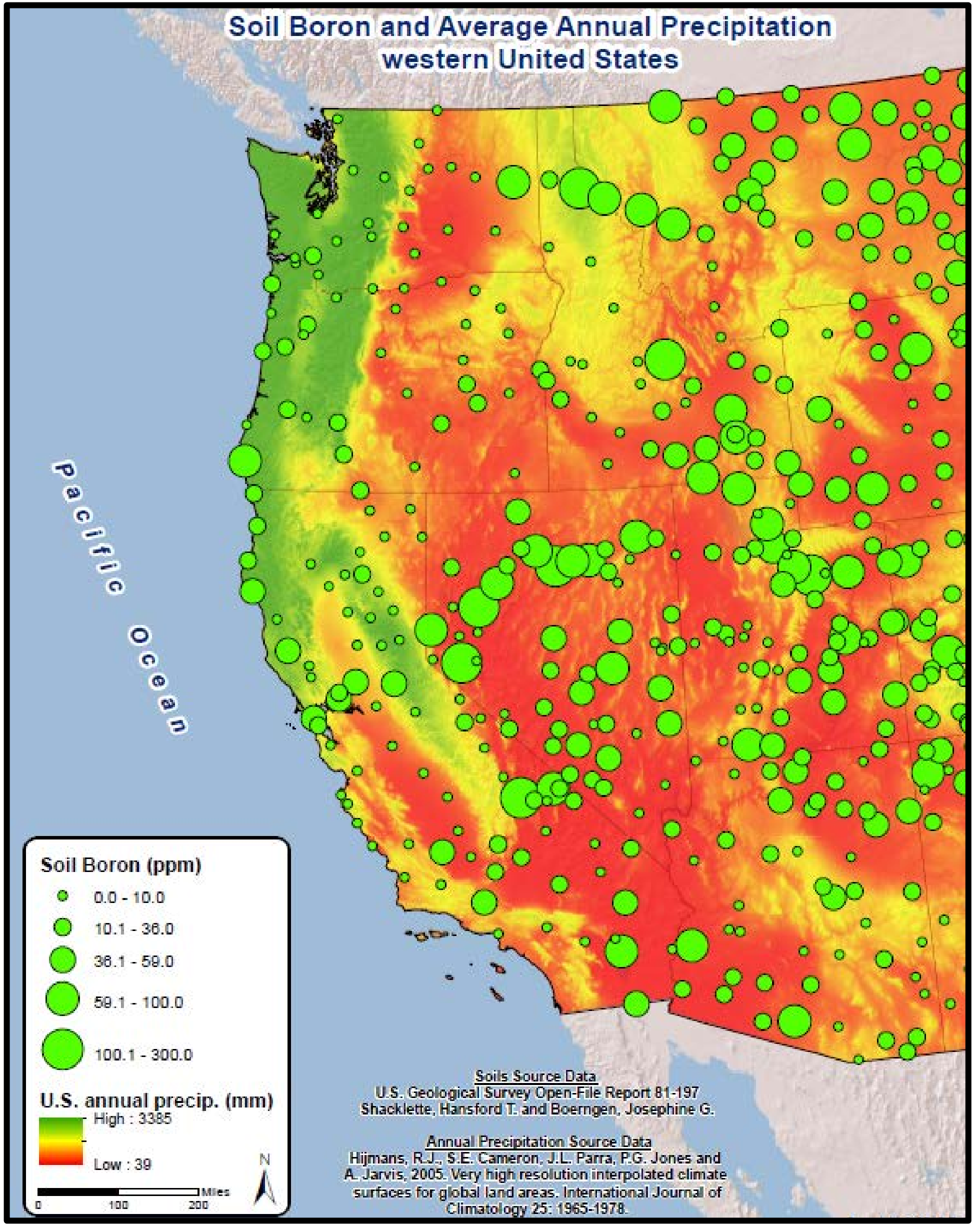
With regard to the aforementioned information on the nexus between geology, tectonics, and the hydrologic communication of subsurface waters, note that Section 3.7 of this project report develops and presents information and additional supporting lines of evidence on the nexus of hydrology, hydrochemistry, and subsurface waters.

3.6 Soils, Surficial Sediments & Stream Substrates

Soils and surficial sediments may be important to consider in TMDL development for several reasons. All soils and sediment contain some boron, which can thus be a source load of boron to surface waterbodies. Further, the sedimentary composition of stream substrates may play a substantial role in the magnitude and rate of groundwater recharge to the underlying groundwater resource. Many streams in the central coast region are designated for groundwater recharge beneficial use. In many basins, infiltration from stream flows is a major source of recharge to underlying aquifers. Consequently where appropriate, water quality in streams should be considered from the perspective of protecting water quality in the underlying groundwater resource (refer to Section 4.2.2 of this report).

Section 3.4 of this report documented that the Estrella River Basin locally is relatively very arid, even in comparison to the dry Mediterranean climatic conditions prevalent throughout the California central coast region. Further, as noted previously in Section 3.4 arid regions are characterized by limited rainfall and leaching which may result in elevated soil boron (Whetstone et al, 1942, Peryea and Binham, 1986 Yermiyahu and Ben-Gal, 2006). In contrast, in sub humid climates rainfall is often sufficient to leach out any accumulated boron and other salts (U.S. Department of Agriculture, 1954). For example, it has been well documented since at least the 1940s that highly leached soils in the Pacific Northwest and along parts of the Atlantic seaboard may have problems with soil boron micronutrient deficiency (Whetstone et al., 1942). These scientific observations are graphically documented and illustrated in Figure 3-14.

Figure 3-14. Bubble map of soil boron concentrations overlaid on mean annual precipitation (1950-2000) grid for the western United States. Note that the Pacific Northwest, and the Cascadia, and northern Sierra Nevada regions tend to have boron-deficient soils or lower boron-concentration soils.



Soil Boron and Average Annual Precipitation
western United States

Soils Source Data
U.S. Geological Survey Open-File Report 81-197
Shacklette, Hansford T. and Boerngen, Josephine G.

Annual Precipitation Source Data
Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978.

Figure 3-15 illustrates available geochemical data for surficial sediments indicating that, in general, parts of the Estrella River Basin include sediments with relatively high boron content. These observations would be consistent with the geologic and climatic conditions of the basin previously outlined in this project report.

Figure 3-15. Observed surficial sediment boron concentrations (ppm) at select sites (denoted by bubbles) in the Estrella River Basin and vicinity, and smoothed mathematical trend grid of the observed sediment boron concentrations (denoted by color gradient). The trend grid illustrates smoothed mathematical spatial trends of boron concentrations between sampled sediment sites at a generalized, coarse regional scale, but does not represent or imply accuracy at site-specific, local scales which will vary substantially.

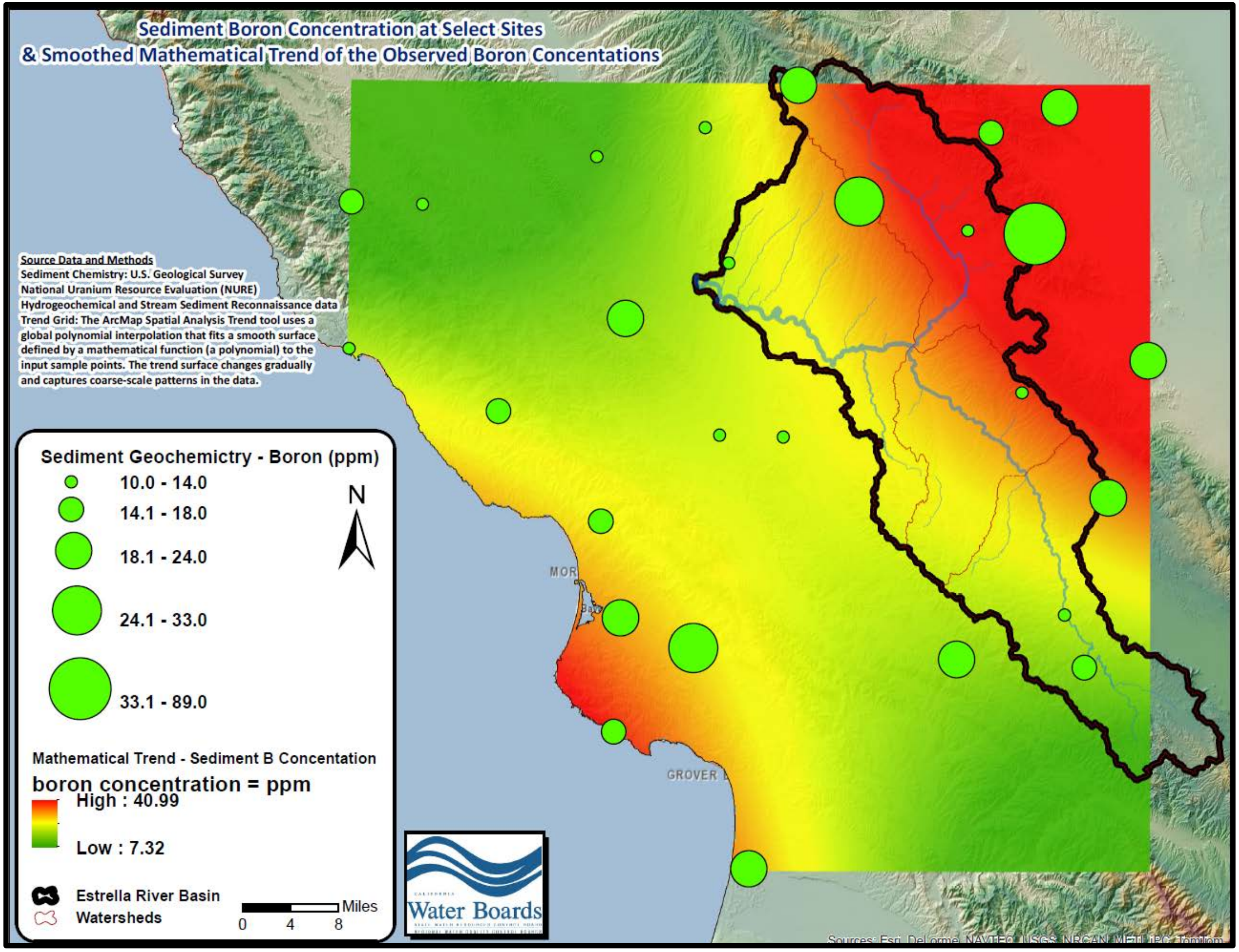
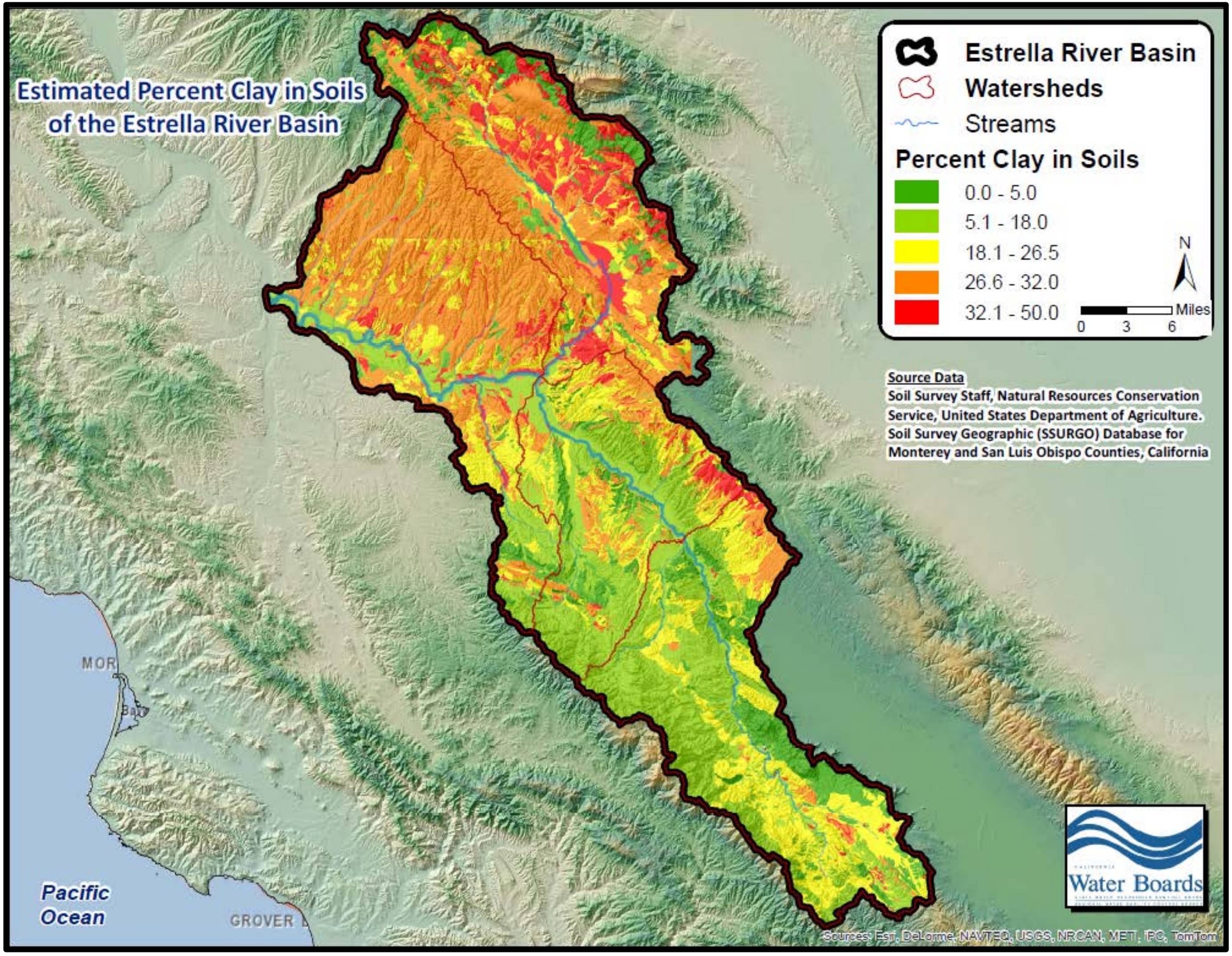


Figure 3-16 illustrates that soils in the Estrella River Watershed and the Cholame Creek Watershed of the Estrella River Basin generally have clay-rich soils. Note that monitoring data show that the Cholame Creek and Estrella River have elevated boron contents in surface waters. As noted previously in this project report (see Section 3.5), clastic clay geologic materials derived from the erosion of marine sedimentary rocks can be prone to having high boron content, depending on local geologic and climatic conditions.

Figure 3-16. Proportion (%) of clay in soils of the Estrella River Basin.



Source Data
Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database for Monterey and San Luis Obispo Counties, California

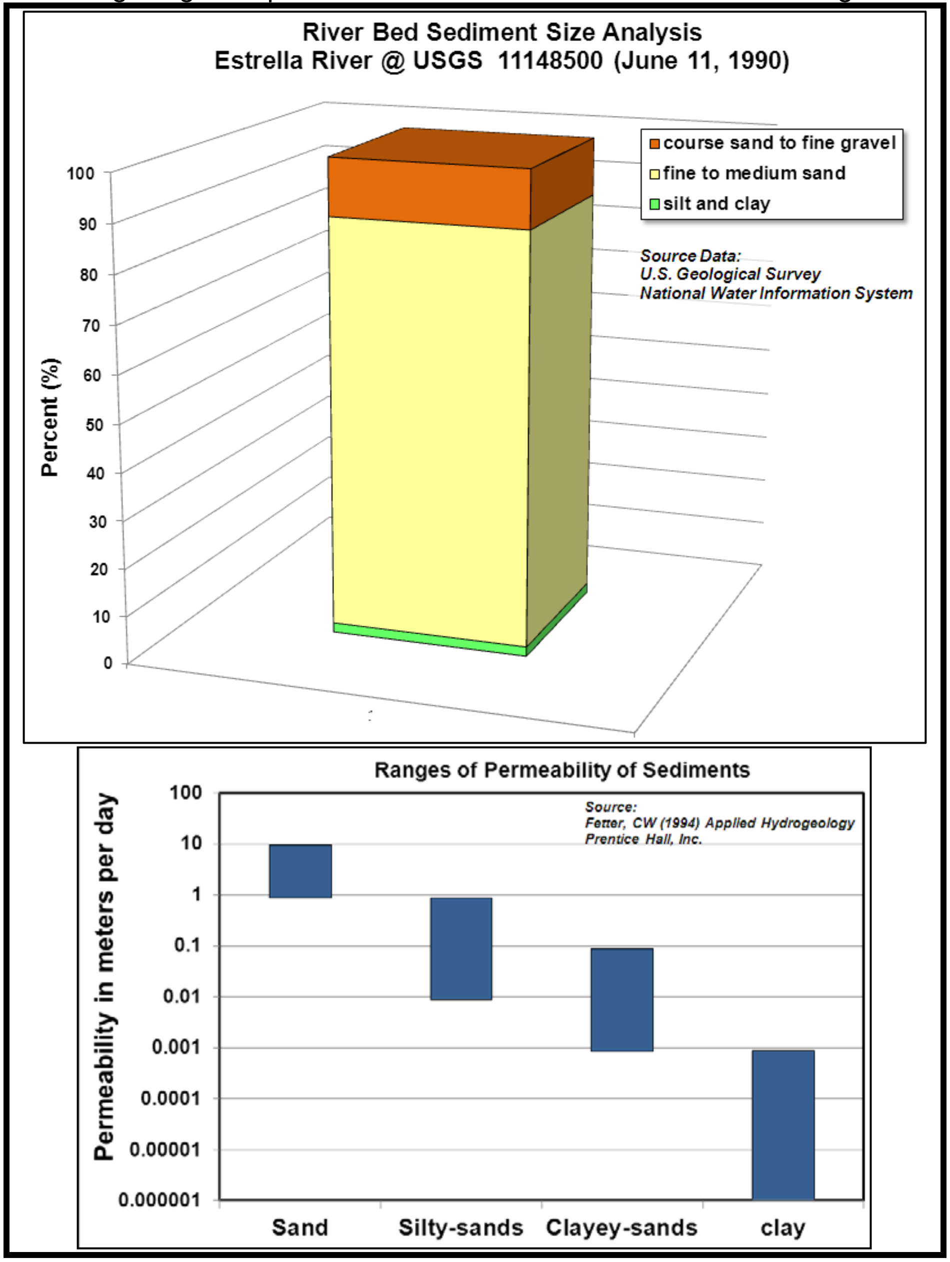
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

Staff also considered the sediment composition and permeability of stream substrates as it pertains to the nexus between surface waters and designated groundwater recharge beneficial uses. As noted previously, streams can be an important source for designated for groundwater recharge beneficial uses. Both the boron-impaired Estrella River and Cholame Creek are designated for groundwater recharge beneficial uses. Where appropriate, water quality in streams should be considered from the perspective of protecting water quality in the underlying groundwater resource.

As shown in Figure 3-17, streambed sediment analysis data indicate that the Estrella River is overwhelmingly composed of course-grained material such as sand and fine gravel. Therefore, the river bed represents a high-permeability, and efficient conduit for groundwater recharge. Permeability is a measure of a soil or rock’s ability to transmit fluid. The observation that there is frequently very little vertical separation between the creek bed and the underlying groundwater resource indicates there is presumably relatively little opportunity for distance attenuation of boron, or other pollutants, that may be present in creek waters as they percolate to the water table. Figure 3-17 illustrates creek bed sediment conditions and a graph comparing the permeability of various soil textures. Note that in sandy soils, water can be transmitted as rates as high as one to ten meters (3.3 feet to 33 feet) per day (see permeability bar chart shown in Figure 3-17). Based on the aforementioned information, transmission of boron-impaired surface waters in the river basin recharging to the shallow subsurface saturated zone of groundwater could locally happen quite rapidly, with little opportunity for attenuation or diffusion.

Finally, since many groundwater samples underlying and proximal to the Estrella River and Cholame Creek are currently exceeding water quality criteria for boron (refer to Section 3.7), these groundwaters therefore have no further assimilative capacity to absorb boron-impaired surface waters percolating to and recharging the groundwater resource. This observation highlights the relevance of considering designated groundwater recharge beneficial uses of streams in the river basin.

Figure 3-17. Graph illustrating stream bed sediment size distribution analysis for Estrella River, and graph showing ranges of permeabilites for various sediment size categories.



3.7 Groundwaters & Geothermal Waters

TMDLs do not directly address pollution of groundwater by controllable sources. However, shallow groundwater baseflow pollutant inputs to streams, and groundwater recharge designated beneficial uses of streams may be considered in the context of TMDL development. It is well known that groundwater discharge to surface waters can be a source of salts, boron, or other pollutants to any given surface waterbody. The physical connection between surface waters and groundwater is widely recognized by scientific agencies and resource professionals:

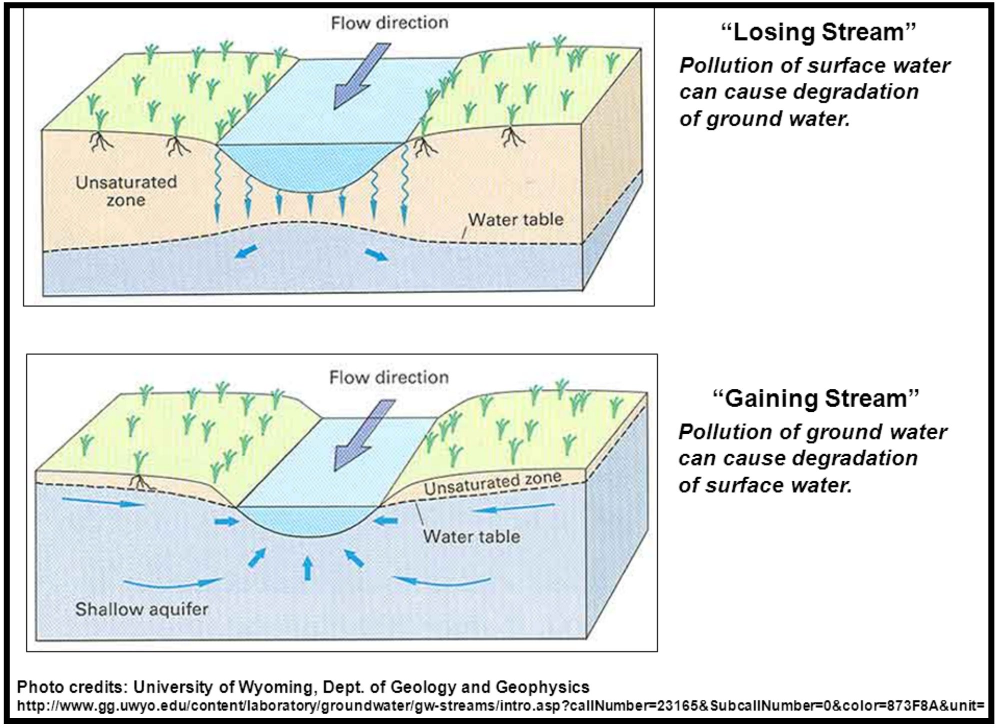
> *“Traditionally, management of water resources has focused on surface water or ground water as separate entities….Nearly all surface-water features (streams, lakes reservoirs, wetlands, and estuaries) interact with groundwater. Pollution of surface water can cause degradation of ground-water quality 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

As such, it is relevant to consider the nexus between groundwaters and surface water in this TMDL project – see Figure 3-18 which highlights this issue conceptually.

Figure 3-18. Streams are intimately connected to the ground water system.



“Losing Stream”
Pollution of surface water can cause degradation of ground water.

“Gaining Stream”
Pollution of ground water can cause degradation of surface water.

Photo credits: University of Wyoming, Dept. of Geology and Geophysics
http://www.gg.uwyo.edu/content/laboratory/groundwater/gw-streams/intro.asp?callNumber=23165&SubcallNumber=0&color=873F8A&unit=

Alluvial groundwater basins in and around the Estrella River Basin with isostatic residual gravity anomalies overlay[21] are illustrated in Figure 3-19. Two major groundwater units underlie the Estrella River Basin:

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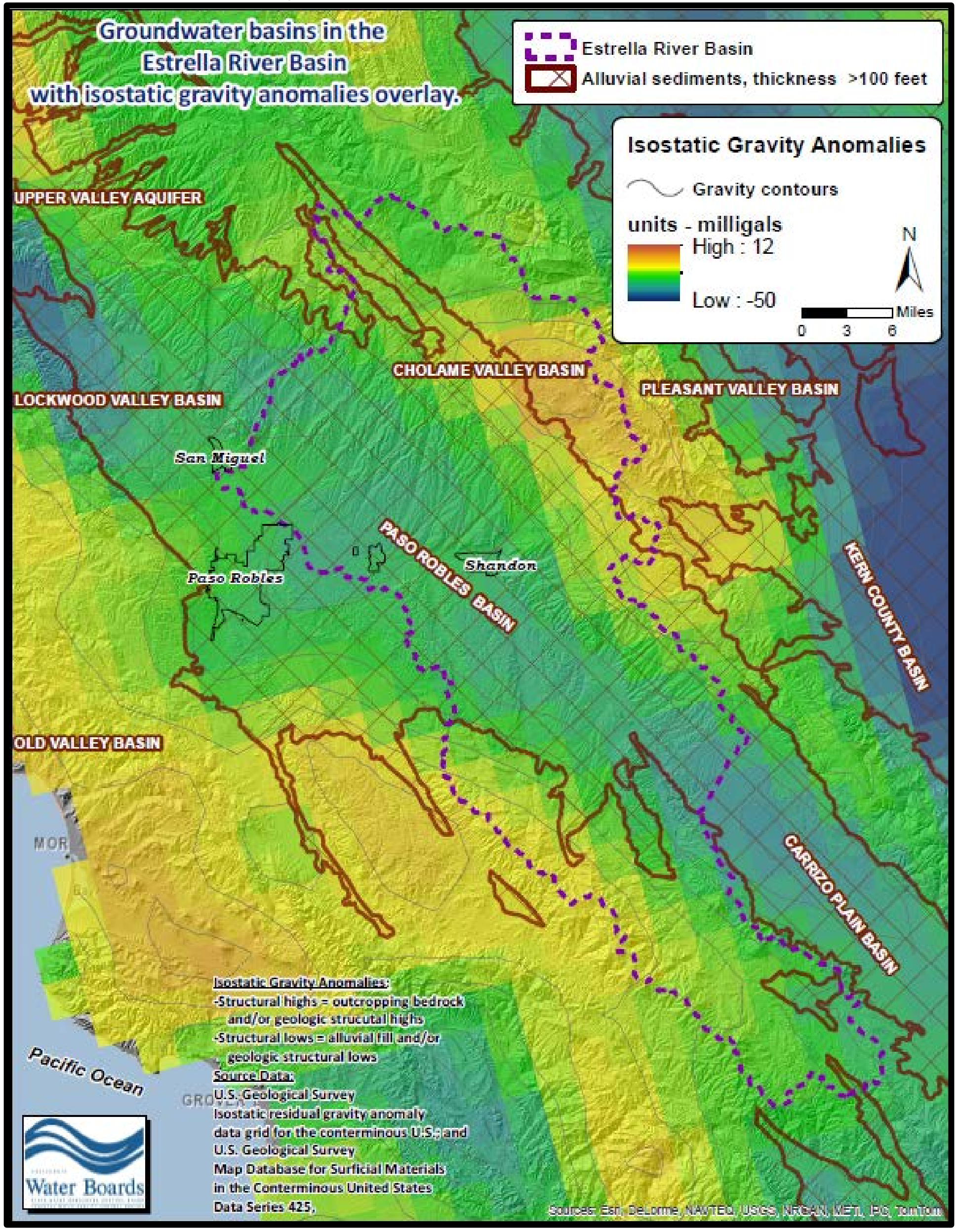
[21] Isostatic gravity anomaly data are a geophysical attribute that measures density contrasts, and can be used as a proxy to assess the presence and depth/thickness of alluvial fill. Caution and professional judgement must be used, because gravity anomalies can also be associated with subsurface geologic structure, fauts, and rapid changes in lithology. Data source: U.S. Geological Survey, *Isostatic residual gravity anomaly data grid for the conterminous U.S.*, 1999.

The Paso Robles Groundwater Basin, and the Cholame Valley Groundwater Basin. Hydrologic communication between these two basins are limited to an extent by faulting. Note that groundwater basins are three-dimensional in architecture, and gravity data can give insight into the shape and distribution of alluvial basins. As indicated by the gravity data, the depocenters of the deepest and thickest sections of sedimentary and alluvial fill are generally associated with more negative isostatic gravity anomaly values. Contour maps on the base of Paso Robles Formation indicate the depth of permeable sediments in the Paso Robles Groundwater Basin range from a few hundred feet in thickness to a 2,400 foot thick depocenter near the towns of Paso Robles and San Miguel (County of San Luis Obispo Pubic Works Department, 2002).

Figure 3-19. Groundwater basins (with isostatic gravity anomalies color gradient overlay) in the Estrella River Basin and vicinity.



Isostatic Gravity Anomalies:
-Structural highs = outcropping bedrock and/or geologic strucutal highs
-Structural lows = alluvial fill and/or geologic structural lows
Source Data:
U.S. Geological Survey
Isostatic residual gravity anomaly data grid for the conterminous U.S.; and
U.S. Geological Survey
Map Database for Surficial Materials in the Conterminous United States
Data Series 425,

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

Recall that groundwater baseflow can be a contributor to total stream flow in Estrella River Basin streams (refer back to Section 3.3 and Figure 3-4), and that groundwaters may therefore contribute boron and other inorganic constituents to surface waters. Available groundwater data presented below in this section of the report, in conjunction with hydrologic data previously outlined, suggest that elevated boron concentrations in groundwater may locally contribute to observed boron levels in Estrella River Basin streams.

Figure 3-20 illustrates historical groundwater data collected in the Estrella River Basin which often contains elevated levels of boron, in many cases exceeding water quality criteria. Note that Figure 3-20 indicates that some groundwater monitoring sites occur in minimally impacted areas (i.e., low human footprint areas), which generally preclude substantial human impacts to groundwater. Therefore, these samples can plausibly be considered to be representative of natural, ambient groundwater conditions, and it can be concluded that in some cases elevated boron in groundwaters of the river basin are due to natural conditions.

Figure 3-20. Historical boron concentrations (ppb) in groundwater, springs (Year 1979 – NURE HSSR program), and in low temperature geothermal waters in the Estrella River Basin, with human footprint color gradient overlay ("human footprint" is a measure of the degree of human disturbance to the landscape).

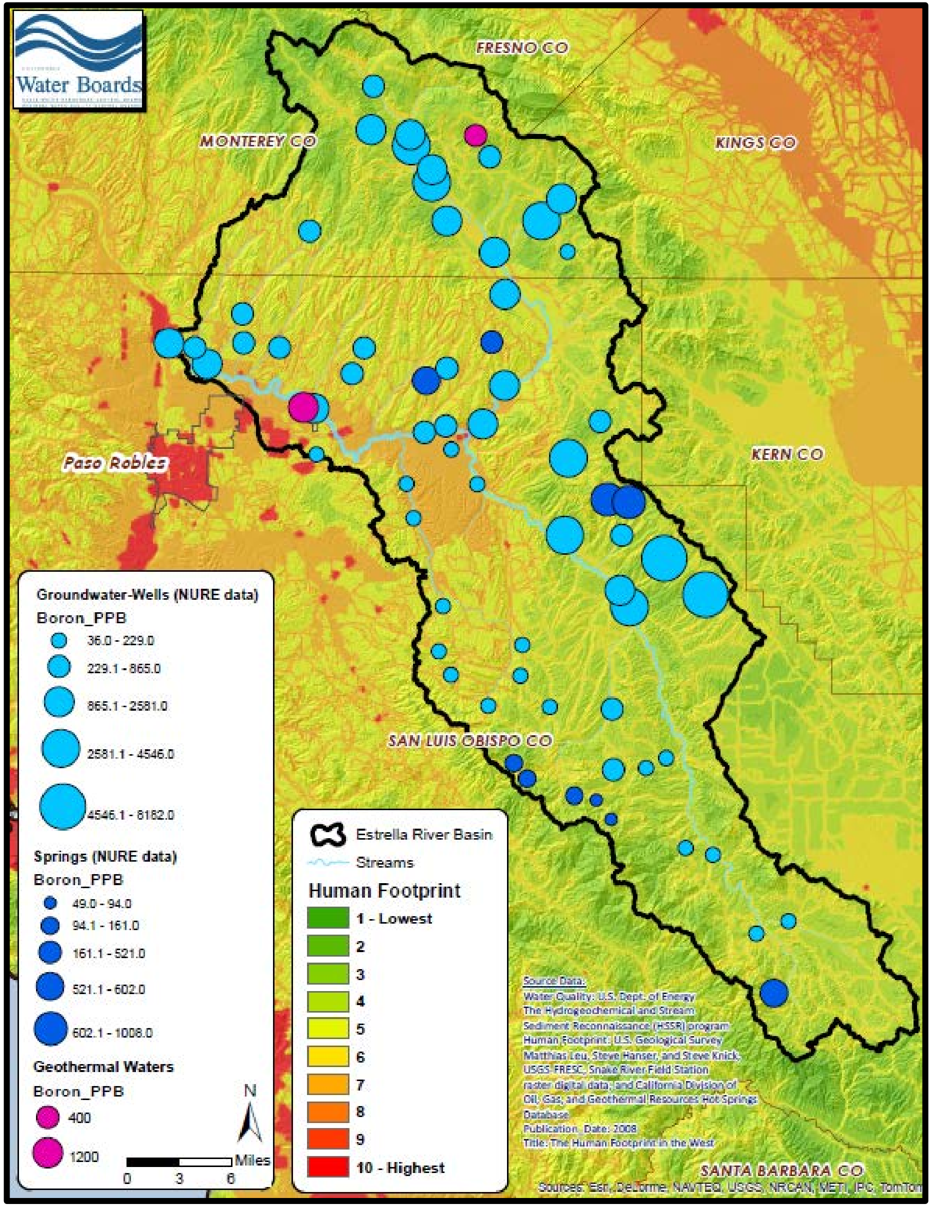


Figure 3-21 illustrates historical boron concentrations in groundwater and springs (Year 1979-80 – NURE HSSR program), with an interpolated mathematical grid of the observed boron concentrations. These data suggest that elevated boron concentrations in groundwater and springs are often closely associated with the marine sedimentary materials associated with the Diablo and Temblor Ranges within the river basin located in the eastern and northeastern parts of the Estrella River basin. In contrast, lower boron concentrations in groundwater and springs are often associated with the igneous and Mesozoic sedimentary strata of the La Panza Range drainages in the southern and southwestern margins of the river basin.

Figure 3-21. Historical boron concentrations (ppb) in groundwater and springs (Year 1979-80 – NURE HSSR program), with an interpolated mathematical grid of the observed boron concentrations (denoted by color gradient). The grid illustrates interpolated mathematical spatial trends of boron concentrations at a generalized, coarse regional scale between sampled well and spring sites but does not represent or imply accuracy at site-specific, local scales which will vary substantially.

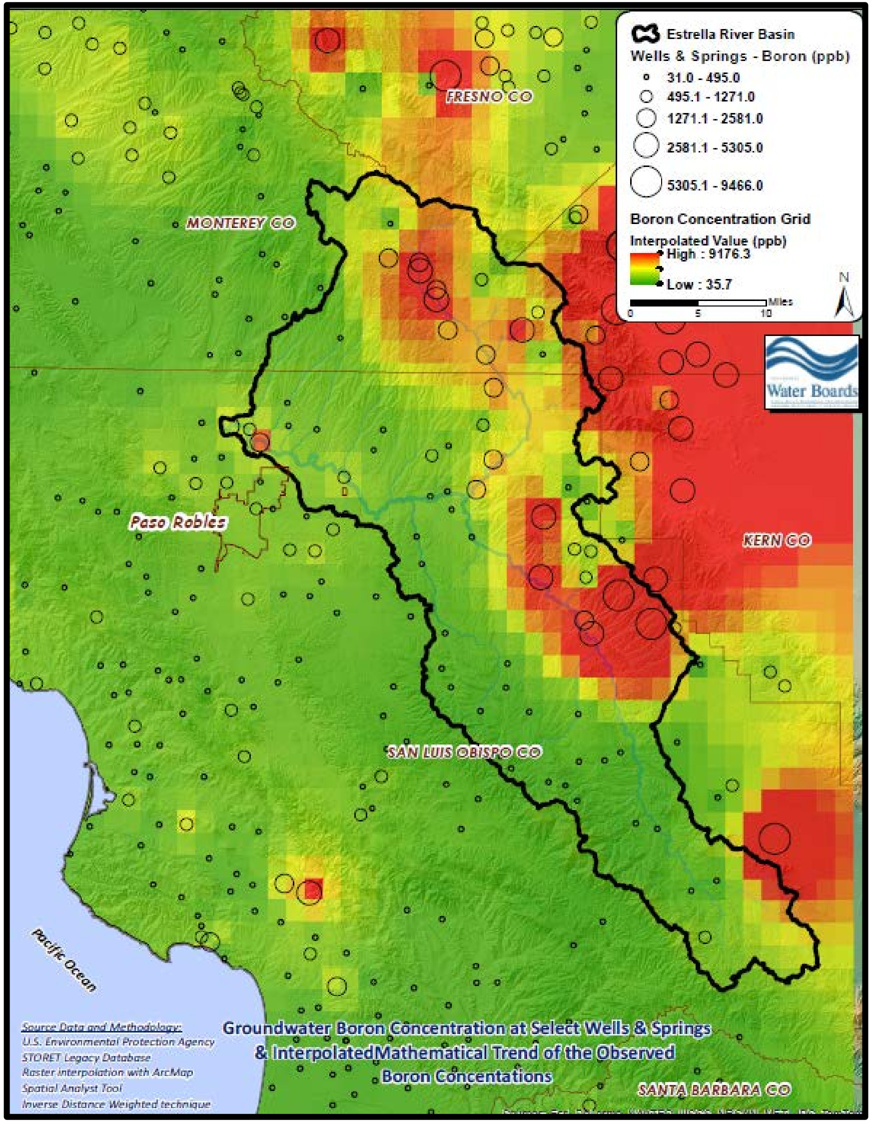


Figure 3-22 and Figure 3-23 provide a line of evidence illustrating that naturally elevated boron in California's water resources are not anomalous. These figures show that in California, it is not uncommon for elevated boron concenrations exceeding water quality criteria to be found in "pre-modern" groundwaters[22] (groundwaters that were recharged prior to 1952 on the basis of isotopic analyses). These "premodern" high-boron groundwaters therefore represent water resources which likely have not been significantly influenced by human activities or by anthopogenic boron discharges.

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[22] Tritium, a radioactive isotope of hydrogen, is measured and used to indicate differences in the relative age of groundwaters. Synthetic tritium was introduced into the atmosphere by nuclear testing between 1952 and 1980. Therefore groundwaters with relatively high levels of tritium indicate recharge by atmospheric meteoric waters since the 1950s. By convention, groundwaters with less than 0.8 TU represent groudnwaters which were recharged before 1952 (see USGS, 2007).

Figure 3-22. Sample locations of paired tritium-boron groundwater quality samples. Data from these locations are illustrated in Figure 3-23.

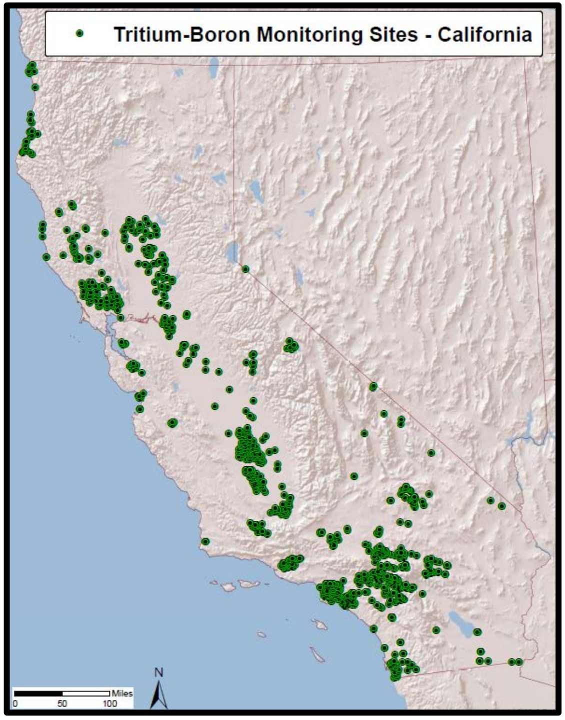
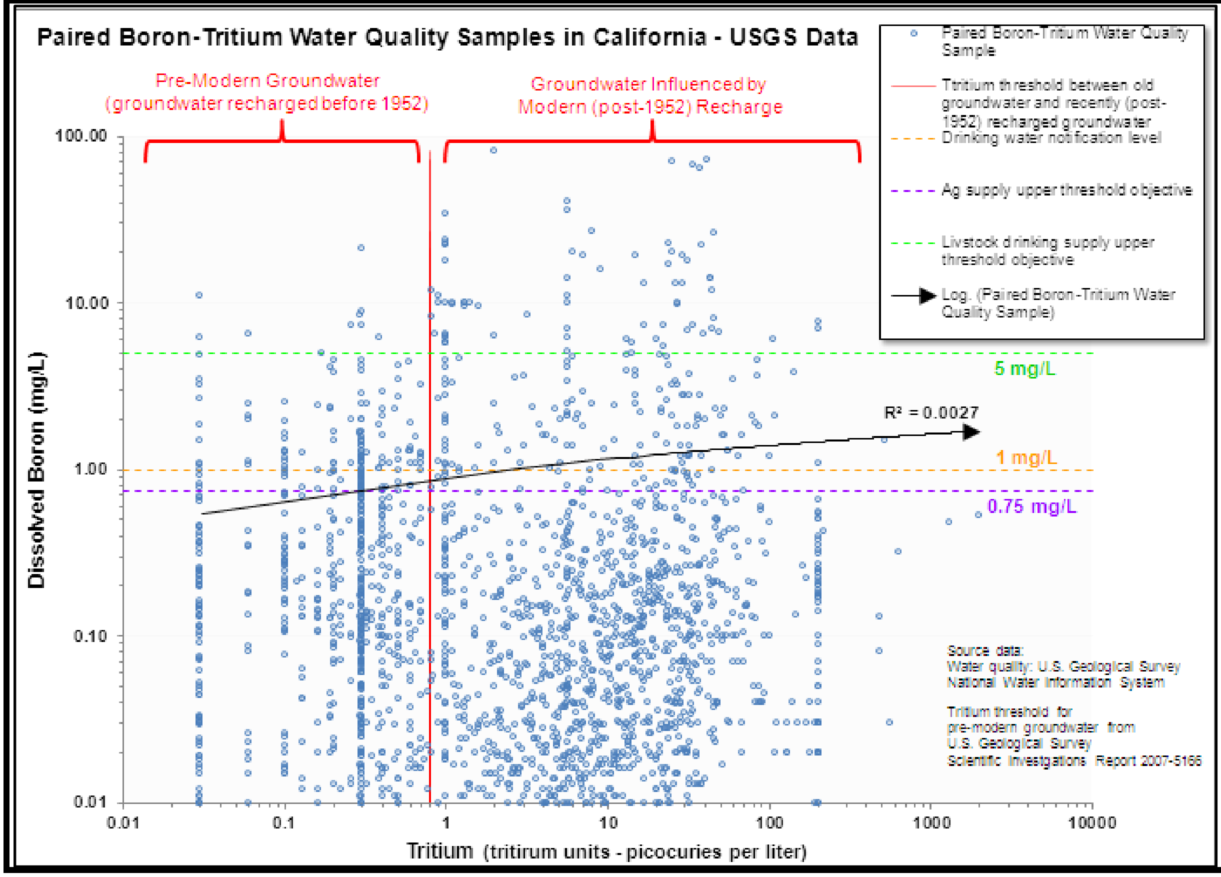


Figure 3-23. Scatter plot of paired tritium-boron groundwater samples with tabular summary statistics. The data illustrate that in “pre-modern groundwater” in California − which presumably are minimally influenced by human activities – it is not uncommon for boron concentrations to exceed water quality criteria.



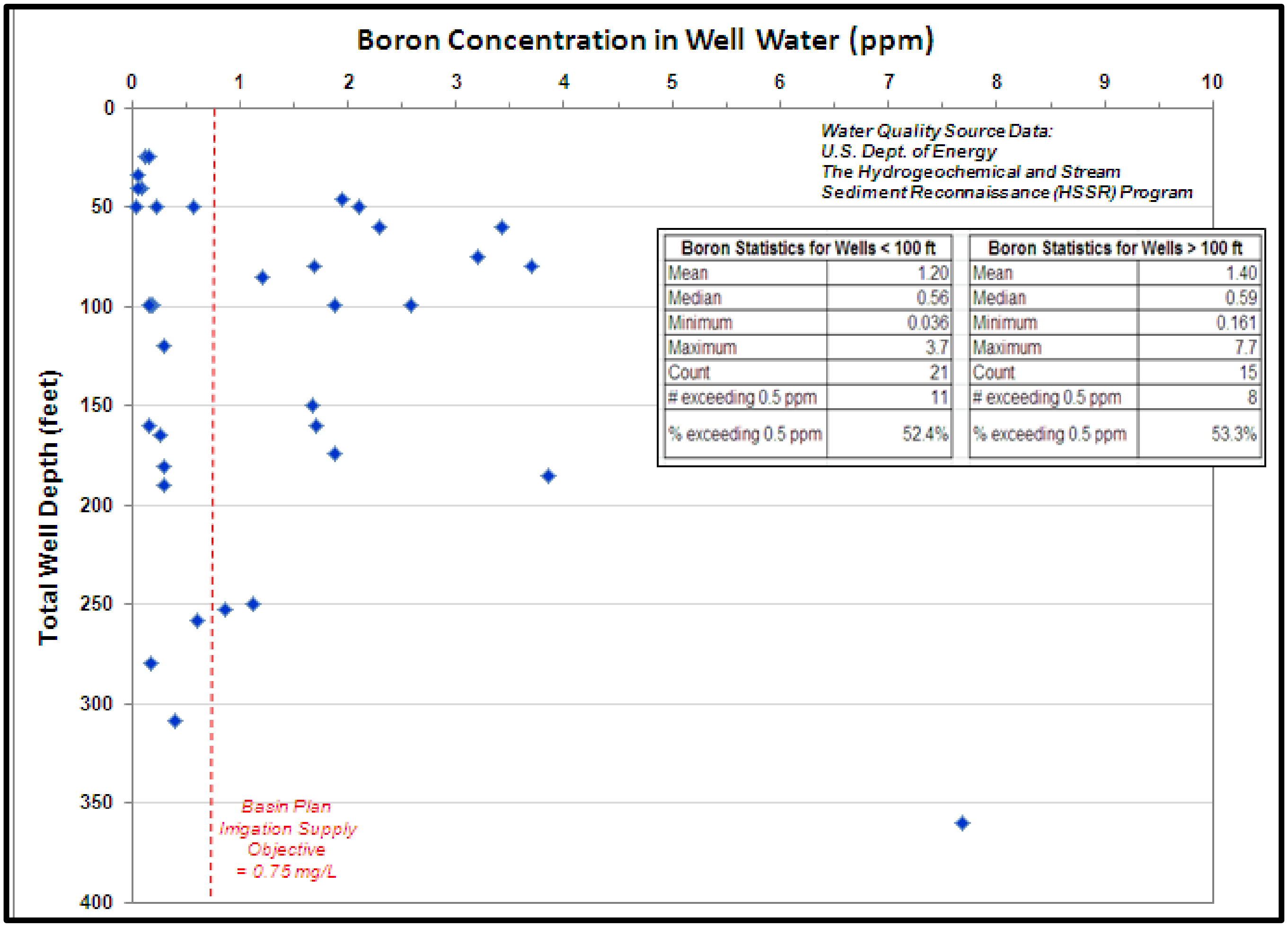
Source data:
Water quality: U.S. Geological Survey National Water Information System

Tritium threshold for pre-modern groundwater from U.S. Geological Survey Scientific Investigations Report 2007-5166

Boron Statistics in Pre-Modern California Groundwater ***(groundwater with < than 0.8 tritium units)***	
No. of samples	**520**
Mean of samples (mg/L)	**0.6**
Ag supply objective No. of Samples < 0.75 mg/L	**114**
Ag supply objective % of Samples >0.75 mg/L	**22%**
Drinking water notification level No. of Samples > 1 mg/L	**76**
Drinking water notification level % of Samples > 1 mg/L	**15%**
Livestock supply objective No. of Samples >5 mg/L	**8**
Livestock supply objective % of Samples > 5 mg/L	**1.5%**

Staff also considered whether elevated boron concentrations in groundwaters of the Estrella River Basin could be a result of long contact times in the subsurface. It might be expected that deeper groundwaters with longer residence times could result in more leaching of boron from subsurface geologic materials. However, available information on well depths and groundwater boron concentrations appear to indicate that even shallow groundwater (wells less than 100 feet deep) frequently have elevated boron concentrations in the river basin – see Figure 3-24. This suggests that a long residence time in the subsurface is not a controlling factor on elevated boron concentrations in water resources of the Estrella River Basin. Indeed, previous sections of this report documented that surficial materials, geology, and soils may play a role on locally elevated boron concentrations in water resources of the river basin.

Figure 3-24. Scatter plot: boron concentration in well water versus total well depth, for sampled wells within the Estrella River Basin.



Water Quality Source Data:
U.S. Dept. of Energy
The Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program

Boron Statistics for Wells < 100 ft	
Mean	1.20
Median	0.56
Minimum	0.036
Maximum	3.7
Count	21
# exceeding 0.5 ppm	11
% exceeding 0.5 ppm	52.4%

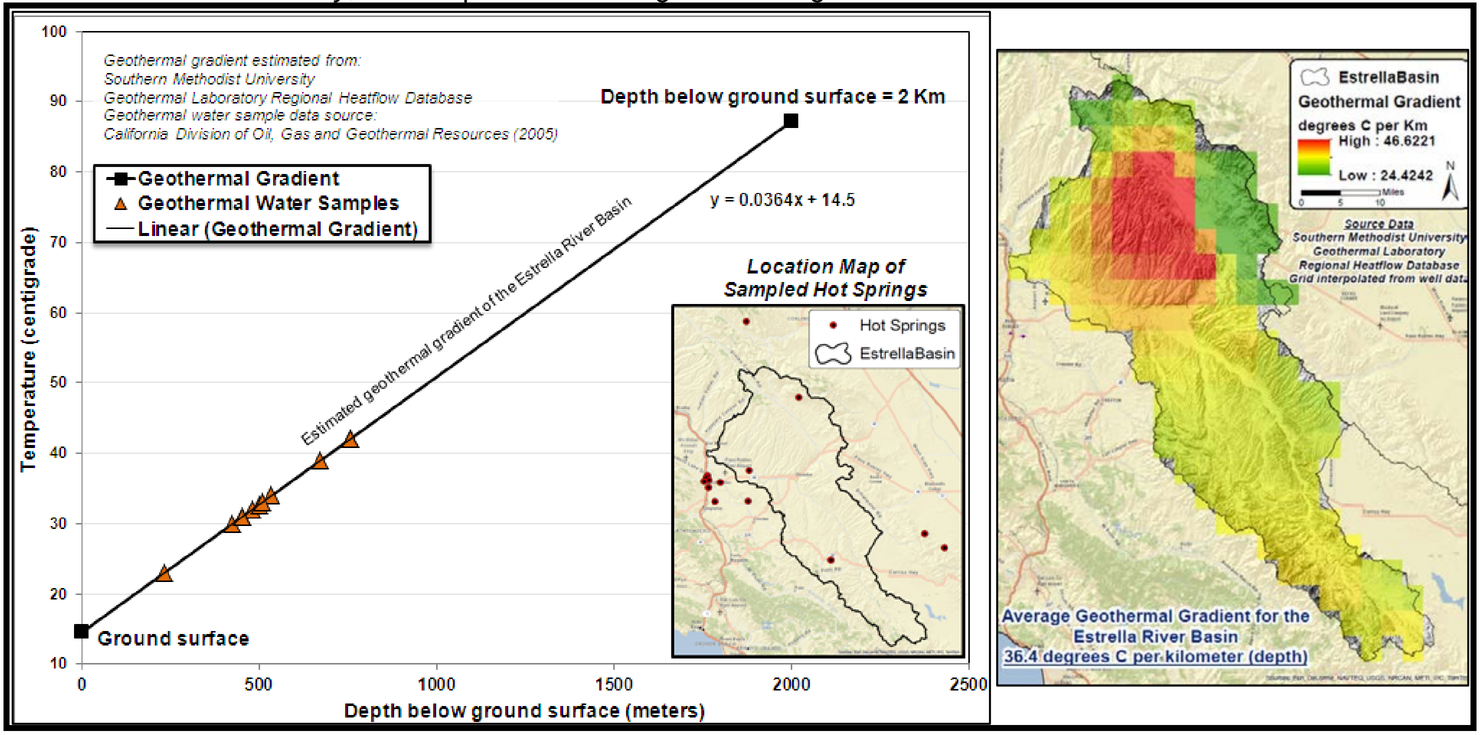
Boron Statistics for Wells > 100 ft	
Mean	1.40
Median	0.59
Minimum	0.161
Maximum	7.7
Count	15
# exceeding 0.5 ppm	8
% exceeding 0.5 ppm	53.3%

As previously noted in Section 3.5, the interaction of mineralized subsurface connate waters, shallow groundwaters, springs, surface waters, geology, and surficial materials may potentially contribute to elevated inorganic constituents, such as boron, in stream waters. Therefore, staff includes an additional line of evidence on the presence and character of mineralized connate geothermal fluids. Geothermal waters are fluids (either meteoric or connate) that circulate at depth, are typically saline or mineralized due to water—rock geochemical interactions, and may ultimately be discharged at the land surface via faults, fractures, stratigraphic bedding, or other favorable hydraulic conduits that allow the geothermal fluids to migrate upward from depth. The Estrella River Basin and vicinity are well-known to be areas of higher-than-average geothermal activity, and geothermal hot springs are present in and around the river basin (for example, refer back to Figure 3-3 which also shows locations of named hot springs in the Estrella River Basin). Note that water quality samples from hot springs in the Estrella River Basin and the immediate vicinity of the river basin reported elevated boron concentrations ranging from 0.4 mg/L to 9.2

mg/L (arithmetic mean = 3.3 mg/L) with total dissolved solids ranging from 946 mg/L to 3,060 mg/L (see water quality data in Appendix A).

Indeed, temperature data available for geothermal spring waters in the vicinity of the Estrella River Basin suggest that – at a *minimum* – these waters originate from depths of typically around 500 hundred meters to almost a kilometer below ground surface[23] (see Figure 3-25). These data constitute a line of evidence that mineralized, connate subsurface fluids which originate from depth can locally be in hydrologic communication with meteoric fluids associated with shallow groundwaters and surface waters of the Estrella River Basin. This mixing of locally deep, basinal saline waters with shallow meteoric groundwaters, surface waters, and surficial materials could indeed be expected to potentially increase boron concentrations in some streams of the Estrella River Basin. Note that boron is the 10th most abundant element is seawater[24], and would thus be expected to also be an important constituent of basinal saline connate waters (paleo-seawaters).

Figure 3-25. Graph of estimated minimum depth of origin for geothermal spring waters from the Estrella River Basin and vicinity, and map of estimated geothermal gradients for the Estrella River Basin.



Another line of evidence is available from electromagnetic imaging of the subsurface in the Cholame Valley illustrating a close association of low resistivity−mineralized fluids with fault zones (see Figure 3-26). This electromagnetic imaging suggests that, locally, fault zones in the Estrella River Basin can be hydraulic conduits that allow for connate mineralized fluids to migrate into shallow subsurface horizons and meteoric groundwaters of the river basin.

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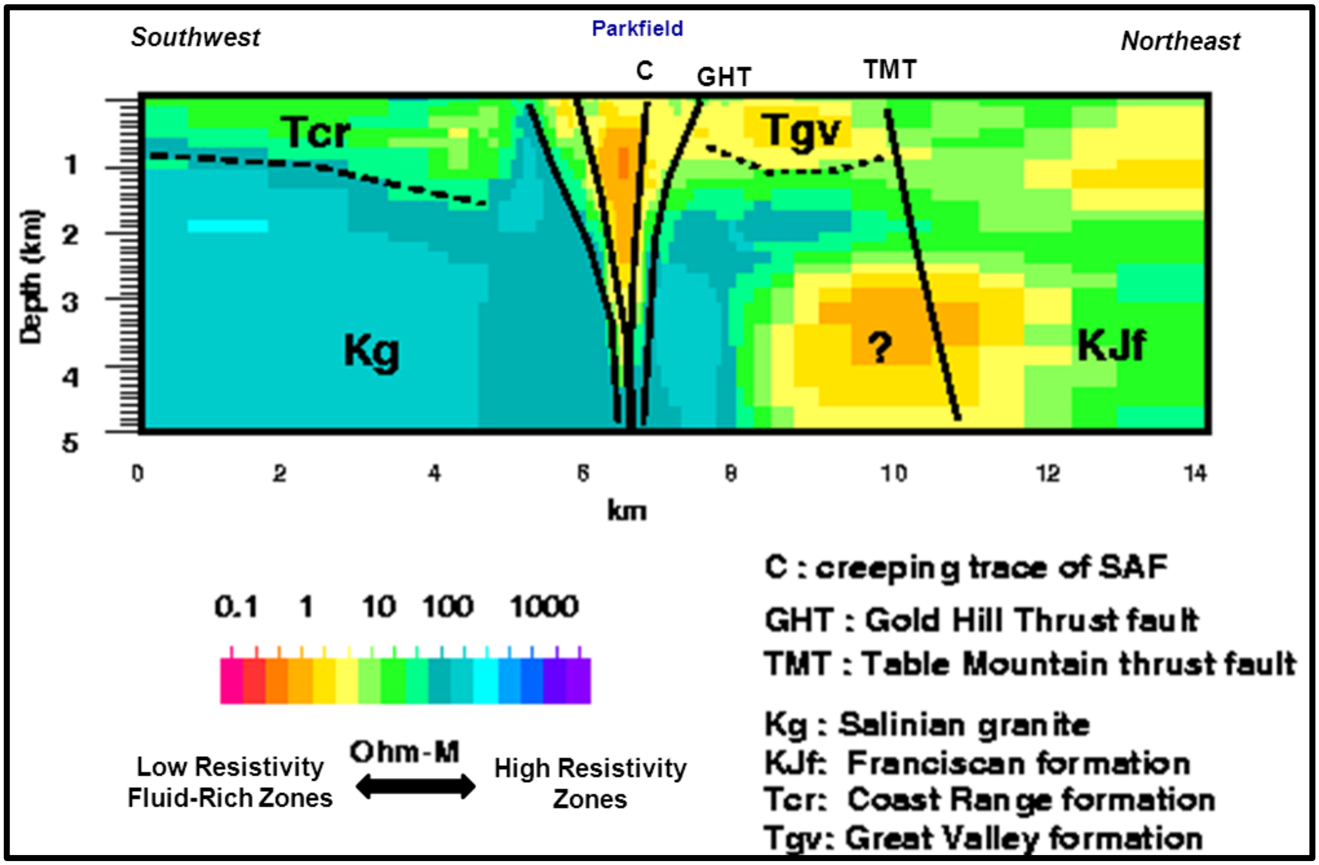
[23] Staff estimated the local geothermal gradient using an estimated local average surface temperatures developed in Section 3.4 and an estimated average geothermal gradient for the Estrella River Basin based on data files available from the Southern Methodist University Department of Earth Sciences - Geothermal Laboratory. The estimated depth of origin of the geothermal water samples developed here should be considered a minimum, since water temperature is measured at the surface and some cooling of the fluid could occur during its migration upward to the land surface.

[24] Source: Monterey Bay Aquarium Research Institute http://www.mbari.org/chemsensor/b/boron.html

Figure 3-26. Electromagnetic cross section image of subsurface at Parkfield in the Cholame Valley, illustrating the association of low resistivity–mineralized fluids and fault zones. Figure from Unsworth and Booker, 1998.



Lastly, an additional line of geochemical evidence can also be developed which likewise suggests hydrologic communication between surface waters, and subsurface waters, as well as and water–rock chemical interactions. Figure 3-27 illustrates that Cholame Creek water samples have elevated chloride concentrations, substantially exceeding mean chloride concentration in North American river waters. Note that the atmosphere and rainwater does contain very small amounts of chloride due to evaporation from ocean basins; however chloride is not an element found in silicate rock minerals[25]. Therefore, silicate rocks and precipitation would not be expected to be a plausible source of elevated chloride to surface waters and groundwaters. Further, chloride behaves conservatively in water; it does not interact with, or become sorbed onto minerals as it is transported within the waterbody. Consequently, elevated levels of chloride in surface water and groundwaters are most plausibly explained by inputs from anthropogenic sources; from saline connate subsurface water inputs; from evaporative processes; or a combination thereof. Connate waters (paleo-seawater) – sometimes referred to as “fossil waters” – are expected in areas of geologically young Tertiary marine sedimentary rocks that have not yet been entirely flushed by meteoric water circulation.

Additionally, Figure 3-27 shows several dilution trend lines between meteoric water and several types of other waters. A simple mixing of meteoric waters, with some inputs of chloride-rich connate seawater would plot along the seawater-meteoric dilution line. The deviation from this dilution line by water samples with the Estrella River Basin suggests there no such simple mixing process, and other processes affect the chloride-boron rations in water samples. A literature value for spring water which is composed of meteoric water with some fraction of chloride-rich connate water is also plotted on the graph. This spring water sample is representative of water that is a mixture of meteoric and some connate water, but that

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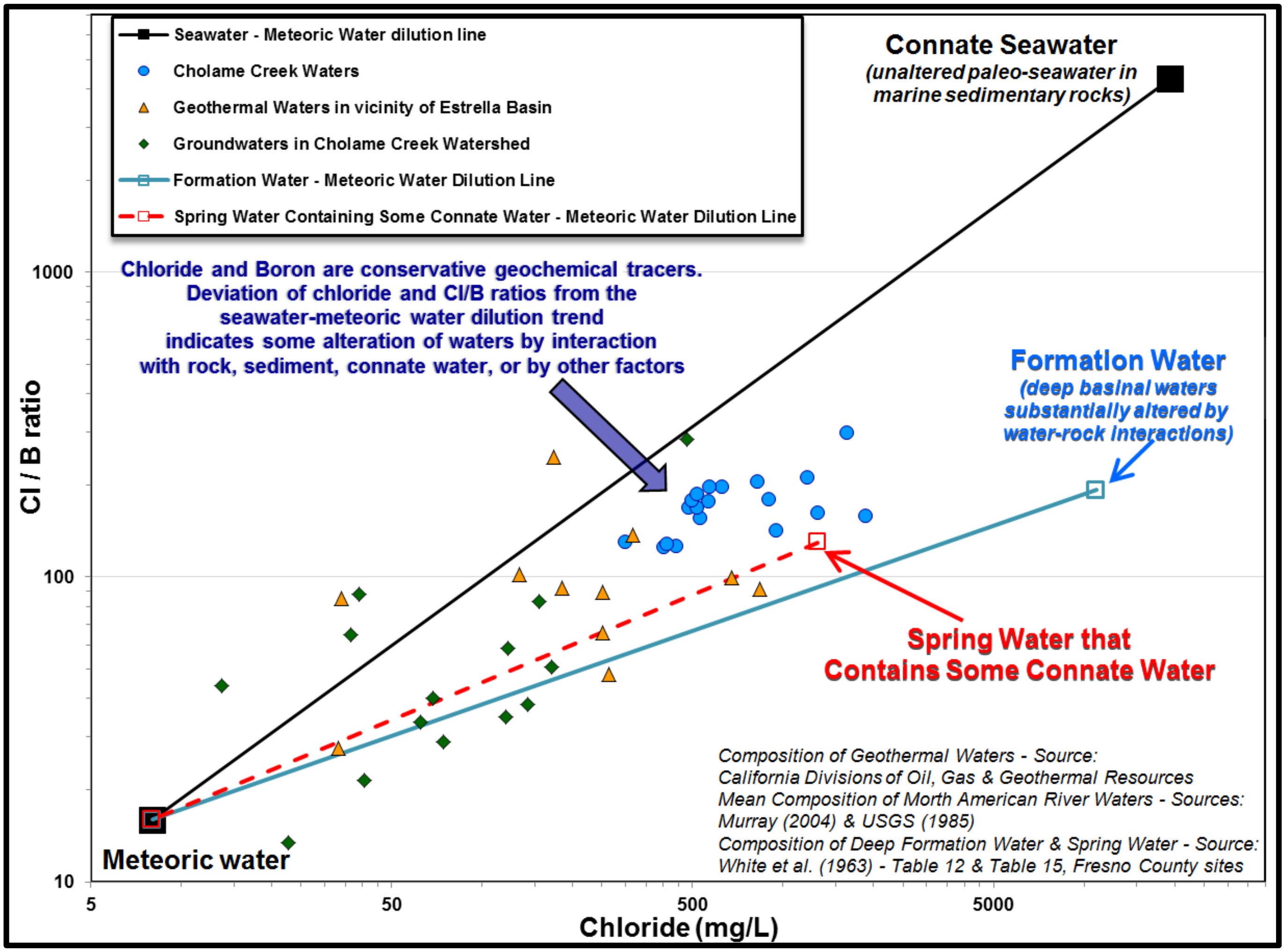
[25] While not found in silicate rocks, chloride is a major component in some evaporative chemical sedimentary deposits, however choride-rich evaporative sedimentary deposits are rare in California and are not found in the central coast region of California.

sample has also been altered by interaction with sediments and rock, resulting in a deviation from the seawater-meteoric water mixing line and boron-enrichment. The composition of this spring water sample comports relatively well with Cholame Creek waters, suggesting that chloride in Cholame Creek waters could have a connate origin. While Figure 3-27 does not in any way rule out anthropogenic inputs, it does suggest that water resources in the River Basin, including creek waters of the Cholame Creek Watershed, are mixtures of meteoric waters that may have some chloride-rich connate water inputs and which may have also been influenced by interactions between water, rocks, sediments, resulting in boron-enrichment.

Figure 3-27. Plot of chloride and chloride/boron ratios in Cholame Creek surface waters, groundwaters, and local geothermal waters relative to the dilution trend lines between global mean seawater (represented here as connate seawater) and meteoric water (North American mean river water); between deep basinal formation waters and meteoric water; and a dilution line between spring water that contains some connate water and meteoric water.



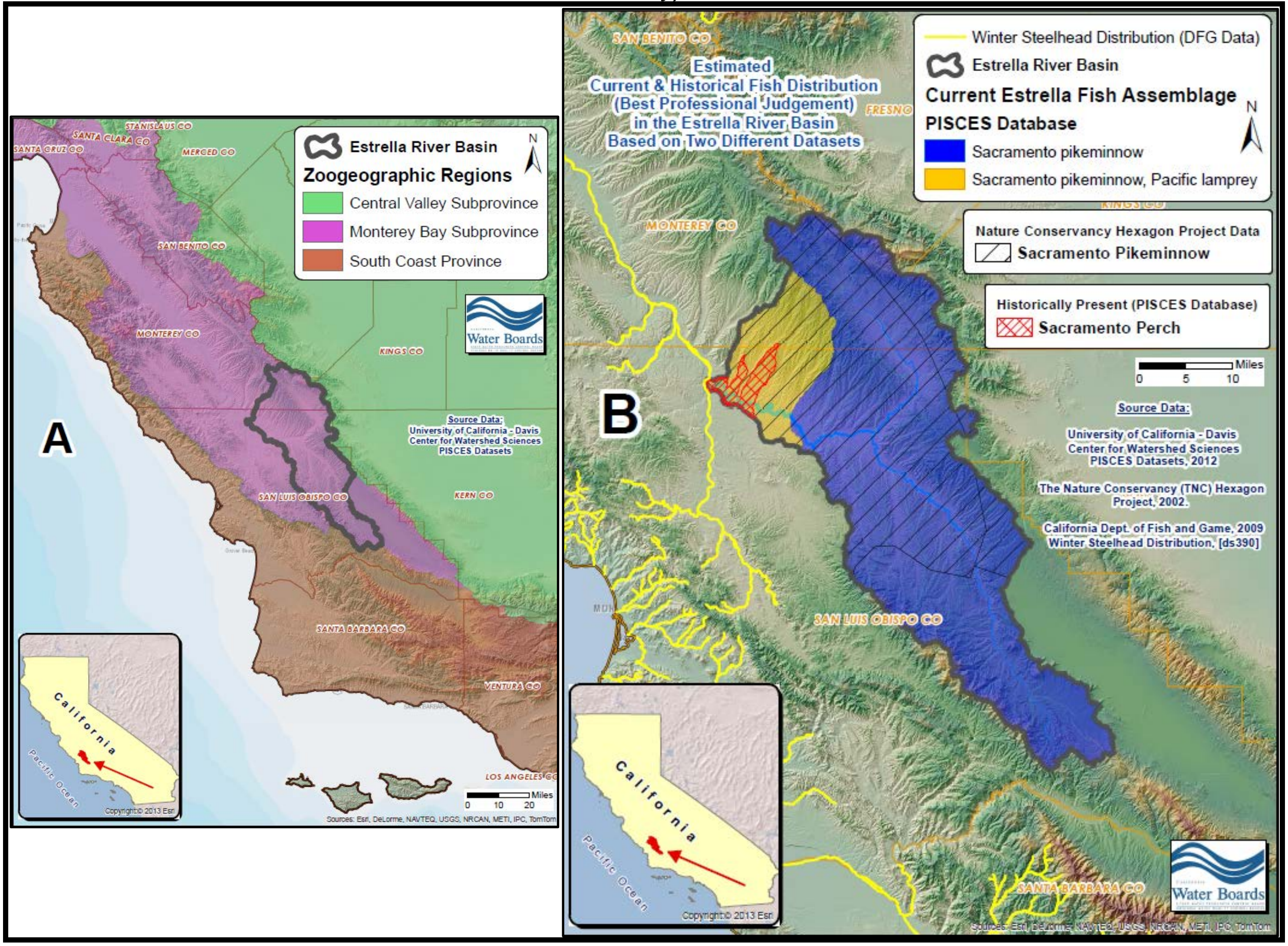
Chloride and Boron are conservative geochemical tracers. Deviation of chloride and Cl/B ratios from the seawater-meteoric water dilution trend indicates some alteration of waters by interaction with rock, sediment, connate water, or by other factors

Composition of Geothermal Waters - Source:
California Divisions of Oil, Gas & Geothermal Resources
Mean Composition of Morth American River Waters - Sources:
Murray (2004) & USGS (1985)
Composition of Deep Formation Water & Spring Water - Source:
White et al. (1963) - Table 12 & Table 15, Fresno County sites

3.7 Aquatic Habitat & Wildlife

Viable freshwater aquatic habitat is critical to numerous fish, bird, mammal, and invertebrate species, thus, water quality plays an important role in aquatic habitat. According to scientific literature, fish or wildlife could potentially be adversely affected by boron if elevated concentrations reach elevated numeric thresholds. Consequently, it is relevant to compile available information on aquatic habitat and fish resources in the TMDL project area. Figure 3-1 illustrates the historical and current presence of native California fish species in the Estrella River Basin and their presumed distributions. It should be noted that these estimates of native fish distributions are subject to uncertainties and some assumptions, and are based on the best professional judgment of fisheries biologists at the University of California-Davis[26]. Historically, at least three native fish species are estimated to have inhabited the Estrella River Basin − the Sacramento Perch, the Sacramento Pikeminnow, and the Pacific Lamprey. Currently, the Pikeminnow and the Pacific Lamprey are presumed to present in the river basin when stream flows or pooled water is present, whereas the Sacramento Perch is considered to be extirpated (locally extinct) from the basin. Also noteworthy, the Estrella River Basin does *not* contain winter migratory or spawning habitat for steelhead trout according to information from the U.S. National Marine Fisheries Service (refer to Figure 3-28(B)).

Figure 3-28. Aquatic habitat: (A) Zoogeographic provinces; and (B) Native fish currently and historically present in the Estrella River Basin and their presumed distributions when stream flow or pooled water is present based on best available scientific judgment from two sources (sources: Univ. of California Davis Center for Watershed Studies, and Nature Conservancy).



Furthermore, it is important to recognize that the Water Boards are required to protect, maintain, or restore aquatic habitat beneficial uses of waters of the State broadly for the full range of species dependent on aquatic habitats, for example: vegetation, fish or wildlife, including invertebrates (refer to Section 4.2.4). According to information from the California Department of Fish and Wildlife's California Natural Diversity Database, the Estrella River Basin contains 48 sensitive mammalian, bird, reptilian, and plant species. Of

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[26] University of California, Davis – Center for Watershed Sciences, PISCES species occurrence database. PISCES is a database that standardizes, maps, and analyzes the distribution of fish species in California based on watershed units.

these, there are several reptile and amphibian species that would be expected to be closely associated with, and particularly dependent on viable freshwater aquatic habitat including the California red-legged frog, and the southwestern pond turtle.

4 WATER QUALITY STANDARDS & WATER QUALITY DATA ANALYSIS

4.1 Water Quality Standards

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[27].” 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.

Therefore, beneficial uses, water quality objectives, and anti-degradation policies collectively constitute water quality standards. Beneficial uses, relevant water quality objectives, and anti-degradation requirements that pertain to this TMDL are presented below in Section 4.2, Section 4.3, and Section 4.4 respectively.

4.2 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 California Central Coast Water Board is required under both State and Federal law to protect and regulate beneficial uses of waters of the state. Table 4-1 presents the designated beneficial uses for streams of the Estrella River Basin as published in Table 2-1 of the Central Coast Central Coast Basin Plan.

Table 4-1. Central Coast Basin Plan designated beneficial uses for Estrella River Basin streams

Waterbody Names	MUN	AGR	PROC	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	COMM	SHELL
Estrella River	X	X			X	X	X	X		X		X				X	X	
Cholame Creek	X	X			X	X	X	X		X				X			X	
Little Cholame Creek	X	X			X	X	X	X		X				X			X	
San Juan Creek	X	X			X	X	X	X		X				X			X	

MUN: Municipal and domestic water supply.
AGR: Agricultural supply.
PRO: Industrial process supply.
IND: Industrial service supply
GWR: Ground water recharge.
REC1: Water contact recreation.
REC2: Non-Contact water recreation.
WILD: Wildlife habitat.
COLD: Cold fresh water habitat.
WARM: Warm fresh water habitat
MIGR: Migration of aquatic organisms.
SPWN: Spawning, reproduction, and/or early development.
BIOL: Preservation of biological habitats of special significance.
RARE: Rare, threatened, or endangered species
EST: Estuarine habitat
FRESH: Freshwater replenishment.
COMM: Commercial and sport fishing.
SHELL: Shellfish harvesting.

In accordance with the Central Coastal Central Coast Basin Plan, streams of the Estrella River Basin that are not listed above in Table 4-1 are assigned the following beneficial use designations: Municipal and Domestic Water Supply (MUN); and protection of both recreation and aquatic life.

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

A narrative description of the designated beneficial uses of project area surface waters which are most likely to be potentially at risk of impairment by water column boron are presented below.

4.2.1 Municipal and 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 Central Coast Basin Plan, Chapter 2, Section II.)*

The Central Coast Basin Plan water quality objective protective of municipal and domestic water supply beneficial uses and which is most relevant to boron pollution is toxicity general objective for all inland surface water, enclosed bays, and estuaries (Central Coast 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 excessive levels of boron have been observed to result in toxicity (prompting the California Department of Public Health to adopt numeric criterion for boron in drinking water supplies) and adverse health effects in humans and animals the Central Coast Basin Plan narrative toxicity objective applies to boron. The California Department of Public Health has established a drinking water health-based notification level for boron as 1 mg/L. Some men who drink water containing boron in excess of the notification level over many years may experience reproductive effects; this determination is based on animal studies[28]. This numeric water quality criterion is a non-regulatory water guideline; however this numeric criteria can be used to assess attainment or non-attainment of the Central Coast Basin Plan's narrative toxicity objective and to ensure that MUN designated beneficial uses are being protected and supported.

4.2.2 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 Central Coast Basin Plan, Chapter 2, Section II.)*

The groundwater recharge (GWR) beneficial use is recognition of the fundamental nature of the hydrologic cycle, and that surface waters and ground water are not closed systems that act independently from each other. Most surface waters and ground waters of the central coast region are both designated with the MUN beneficial use. The California Department of Public Health (CDPH) drinking water health-based notification level for boron therefore is applicable to *both* the creek waters, and to the underlying groundwater. The CDPH boron drinking water criterion and the MUN designation of underlying groundwater is relevant to the extent that portions of streams of the Estrella River Basin recharge the underlying groundwater resource. The Central Coast Basin Plan GWR beneficial use explicitly states that the designated groundwater recharge use of surface waters are to be protected to maintain groundwater quality. As such, if and where necessary, the GWR beneficial uses of the surface waters need to be protected so as to support and maintain the MUN beneficial use of the underlying ground water resource. The Central Coast Basin Plan does not specifically identify numeric water quality objectives to implement the GWR beneficial use, however a situation-specific weight of evidence approach can be used to assess if GWR is being supported, consistent with Section 3.11 of the California Listing Policy (SWRCB, 2004).

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[28] City of San Diego Water Department, 2005 Annual Drinking Water Quality Report.

4.2.3 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 Central Coast Basin Plan, Chapter 2, Section II.).*

While boron is an essential micronutrient in plants, elevated boron in irrigation water may cause toxic effects in cultivated crops. Typical toxicity symptoms are plant injury such leaf yellowing, spotting, or drying. On seriously affected trees, a gum or exudate on limbs or trunks is often noticeable[29]. The Central Coast Central Coast Basin Plan specifics a boron water quality objective for the protection of the irrigation supply beneficial use of waters, as follows:

Waters shall not contain concentrations of chemical constituents in amounts which adversely affect the agricultural beneficial use. In addition, waters used for irrigation and livestock watering shall not exceed concentrations for those chemicals listed in Table 3.4 (see Central Coast Basin Plan, Chapter 2, Section II.).

Table 3-4 (*Water Quality Control Plan, Central Coast Basin, Chapter III, page III-9*) lists the maximum concentration for boron for irrigation supply as 0.75 mg/L. Further, Table 3-4 of the Central Coast Basin Plan specifies a water quality objective for the protection of livestock watering supply beneficial uses of waters. Table 3-4 lists the maximum concentration for boron for livestock watering supply as 5.0 mg/L. Boron toxicity to cattle can result in slower growth rate, weight loss, and inflammation and edema in the legs of cattle[30].

4.2.4 Aquatic Habitat (WARM, SPWN, WILD, RARE)

> *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.*
>
> *RARE: Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species, established under state or federal law as rare, threatened, or endangered.*

The Central Coast Basin Plan water quality objectives protective of aquatic habitat beneficial uses and which is most relevant to water column boron is the general objective for toxicity for all inland surface waters, enclosed bays, and estuaries (Central Coast Basin Plan Section II.A.2.). 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 excessive levels of boron can cause toxicity to fresh water aquatic life, as demonstrated in the scientific literature, the narrative toxicity objective applies to boron. The Basin Plan does not include numeric water quality objectives or criteria for boron. Staff considered a range of published numeric criteria. According to USEPA (1988), the State of New York specifies 10 mg/L as a boron water quality criteria for class AA and A waters designated for aquatic use; the State of Missouri specifies 2 mg/L boron as an effluent limitation for subsurface waters that recharge surface waters designated for aquatic life

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[29] United Nations Food and Agriculture Organization (1985), Water Quality for Agriculture. ISBN 92-5-102263-1

[30] New Mexico State University-Cooperative Extension Service, Water Quality for Livestock and Poultry, Guide M-112, July 2009.

protection; the Canadian Water Quality Guidelines for boron for the protection of aquatic life specifies a long-term exposure threshold of 1.5 mg/L[31]; and the United States Mariana Islands Commonwealth specifies 5 mg/L as a boron water quality criteria for freshwater aquatic life. Additionally, according to scientific literature reviews available from RWQCBCVR (2000) and BCMWLAP (2003), adverse effects from boron on freshwater aquatic organisms range from 1.02 mg/L for rainbow trout embryo/larvae; to 4 mg/L for aquatic plants; to between 8-12 mg/L for ducks; to 13.6 for the freshwater flea *Dapnia magna*; to 47.0 mg/L for leopard frog embryo; and up to 1,376 mg/L for benthic invertebrate midge. Since data are unavailable for boron effects on terrestrial mammalian wildlife, Eisler (1990, as reported in BCMWLAP, 2003) concluded it was reasonable to apply the livestock boron criteria (5 mg/L) to the protection of mammalian wildlife until more data is available.

The Estrella River Basin does not support steelhead or other coldwater fisheries (refer back to Section 3.7 and Figure 3-28), as such staff concludes it is not appropriate to apply the more stringent boron numeric criteria identified above for cold water species. Also, the literature indicates that boron thresholds for amphibians and mammals are somewhat higher than boron thresholds for cold water fisheries and sensitive fish species. Therefore, staff proposes boron water quality criteria protective of freshwater aquatic habitat of 5 mg/L for the Estrella River Basin in order to implement the aforementioned Basin Plan narrative toxicity objective. Note that a 5 mg/L threshold comports with several numeric criteria identified in the administrative and literature sources shown above, and staff maintains that this threshold is reasonably neither over-protective nor under-protective given conditions in this river basin. It should be emphasized that this proposed TMDL aquatic habitat numeric criteria is not an enforceable regulatory water quality standard, but it can be used to assess attainment or non-attainment of the Central Coast Basin Plan's narrative toxicity objective and to evaluate if aquatic habitat designated beneficial uses are being protected and supported.

4.3 Water Quality Objectives, Criteria and Recommended Levels

The Central Coast Region's Water Quality Control Plan (Central Coast Basin Plan) contains specific water quality objectives that apply to chloride and sodium. In addition, the Central Coast Water Board is required to use established, scientifically-defensible numeric criteria to implement narrative water quality objectives, and for use in Clean Water Act Section 303(d) Listing assessments. Relevant water quality objectives and scientifically-based numeric criteria to protect beneficial uses are compiled in Table 4-2.

Table 4-2. Compilation of water quality objectives and numeric criteria for boron.

Parameter	Source of Water Quality Objective / Criteria	Numeric Targets	Primary Use Protected
Boron	Central Coast Basin Plan narrative objective for toxicity[A]	1 mg/L *California Department of Public Health Health-Based Notification Level* 10mg/L *California Department of Public Health Response Level*	MUN –GWR drinking water and groundwater recharge
Boron	Central Coast Basin Plan numeric water quality objective	0.75 mg/L *Central Coast Basin Plan Water Quality Objective*	AGR irrigation water supply
Boron	Central Coast Basin Plan numeric water quality objective	5 mg/L *Central Coast Basin Plan Water Quality Objective*	AGR Livestock watering
Boron	Central Coast Basin Plan narrative objective for toxicity[A]	5 mg/L *as reported in USEPA (1988) and by the British Columbia Ministry of Water, Land and Air Protection (2003)*	WARM.SPWN, RARE, WILD Aquatic Habitat and Wildlife

[A] The Central Coast Basin Plans General Objective for Toxicity 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."*

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[31] Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, 2009. Canadian Water Quality Protection Guidelines for the Protection of Aquatic Life.

4.4 Anti-degradation Policy

In accordance with Section II.A. of the Central Coast Basin Plan, wherever the existing quality of water is better than the quality of water established in the Central Coast 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 water quality shall be maintained and further lowering of water quality is not allowed except under conditions provided for in the anti-degradation policy.

4.5 California Clean Water Act Section 303(d) Listing Policy

In 2004, the State Water Board adopted the *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List* (State Water Board Resolution No. 2004-0063), hereafter referred to as the *California 303(d) Listing Policy.* The *California 303(d) Listing Policy* describes the process by which the State Water Board and the Regional Water Quality Control Boards will comply with the listing requirements of the federal Clean Water Act (CWA). The objective of the *California 303(d) Listing Policy* is to establish a standardized approach for developing California's CWA section 303(d) list and to provide guidance for interpreting data and information to make decisions regarding water quality standards attainment. The *California 303(d) Listing Policy* defines the minimum number of measured exceedances needed to place a water segment on the 303(d) list for conventional or other pollutants. The minimum number of measured exceedances for conventional pollutants, such as boron, is presented in Table 4-3.

Table 4-3. Minimum number of measured exceedances needed to place a water segment on the 303(d) list for conventional and other pollutants.

Sample Size	Number of Exceedances needed to assert impairment
5-30	5
31-36	6
37-42	7
43-48	8
49-54	9
55-60	10
61-66	11
67-72	12
73-78	13
79-84	14
85-91	15
92-97	16
98-103	17
104-109	18
110-115	19
116-121	20

4.6 Clean Water Act Section 303(d) Listings

The final 2010 Update to the 303(d) List and 303(d)/305(b) Integrated Report for the Central Coast contains boron listing decisions for Estrella River Basin streams as shown in Table 4-4.

Table 4-4. 303(d) listed waterbodies.

WATER BODY NAME	WBID	POLLUTANT NAME	LIST STATUS
Estrella River	CAR3170007119990225125807	Boron	TMDL Required
Cholame Creek	CAR3170008120011127080727	Boron	TMDL Required

4.7 Water Quality Data Analysis

4.7.1 Water Quality Data Sources & Monitoring Sites

The water quality data used for this TMDL project for the Estrella River Basin included data from several sources, as outlined below:

1. Recent (1999-2012) surface water quality data available from the Central Coast Ambient Monitoring Program (CCAMP)[32].
2. Recent surface water quality data available from the County of San Luis Obispo Public Works Department (County of San Luis Obispo Pubic Works Department, 2002).
3. Legacy surface water quality data (pre-1990) from the U.S. Environmental Protection Agency, Storage and Retrieval Data Warehouse (STORET) – legacy data center.[33]
4. Legacy surface water quality data (pre-1990) available from the California Regional Water Quality Control Board Central Valley Region (RWQCBCVR, 1990).
5. Legacy groundwater and springs water quality data published by the U.S. Geological Survey (USGS Open File Report 97-492) based on data collected by the National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance program.
6. Hot springs and geothermal waters chemical data available from the California Department of Conservation, Division of Oil, Gas and Geothermal Resources. This database includes the names and locations of hot springs in California, and the results of chemical analyses.

Appendix A contains a tabulation of monitoring sites for the TMDL project area. Figure 4-1 illustrates the surface water quality monitoring sites for which boron data is available in the Estrella River Basin. The locations of groundwater sampling sites, springs, and geothermal hot springs were previously shown in Figure 3-3 on page 27.

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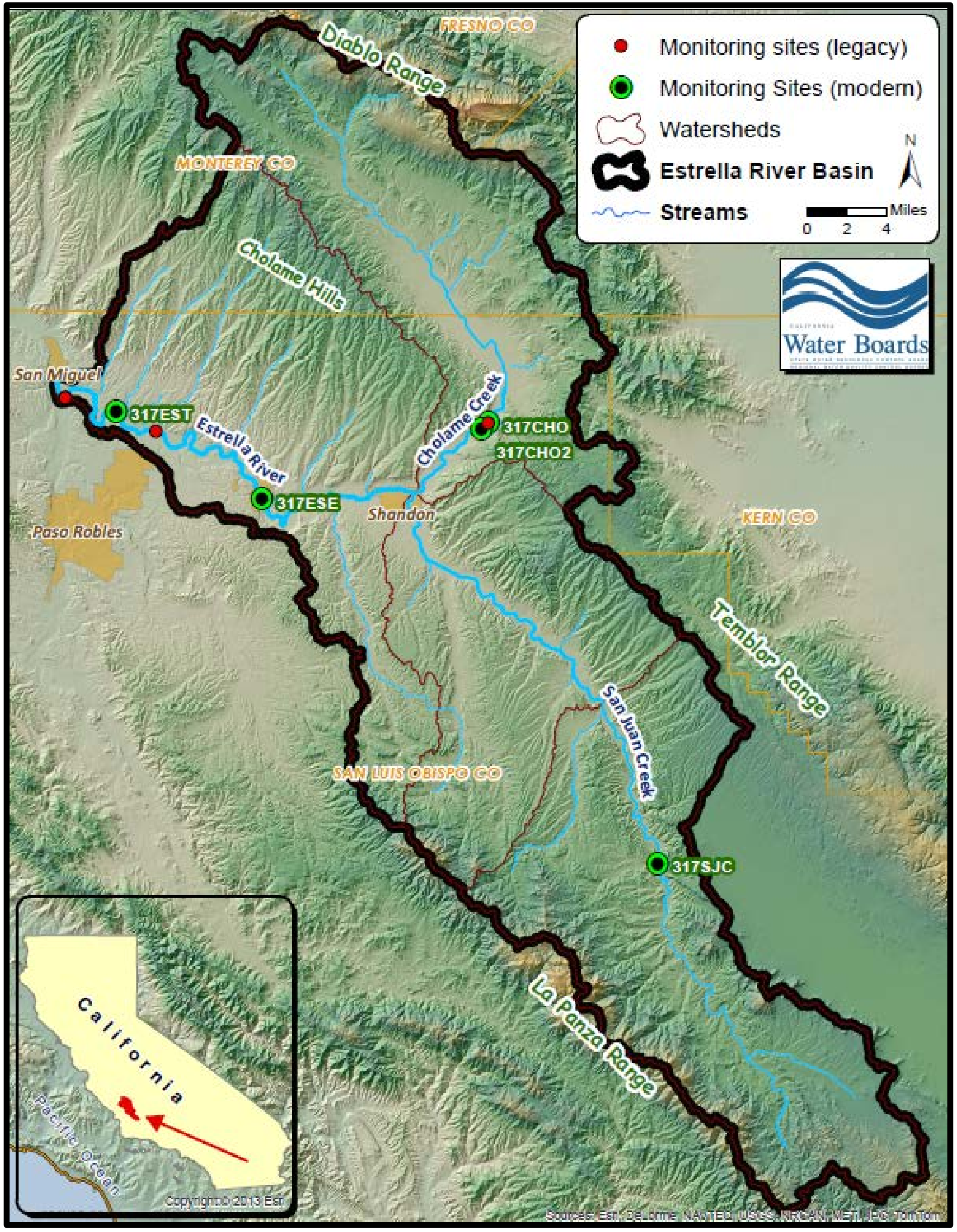
[32] CCAMP is the Central Coast Water Board's regionally-scaled water quality monitoring and assessment program. The Water Board's CCAMP data is collected by the Board's in-house staff consisting of trained field scientists and technicians who adhere to the sampling and reporting protocols consistent with the State's Surface Water Ambient Monitoring Program (SWAMP). SWAMP is a state framework for coordinating consistent and scientifically defensible methods and strategies for water quality monitoring, assessment, and reporting.

[33] Online linkage: http://www.epa.gov/storet/

Figure 4-1. Stream water quality monitoring sites which have boron data.



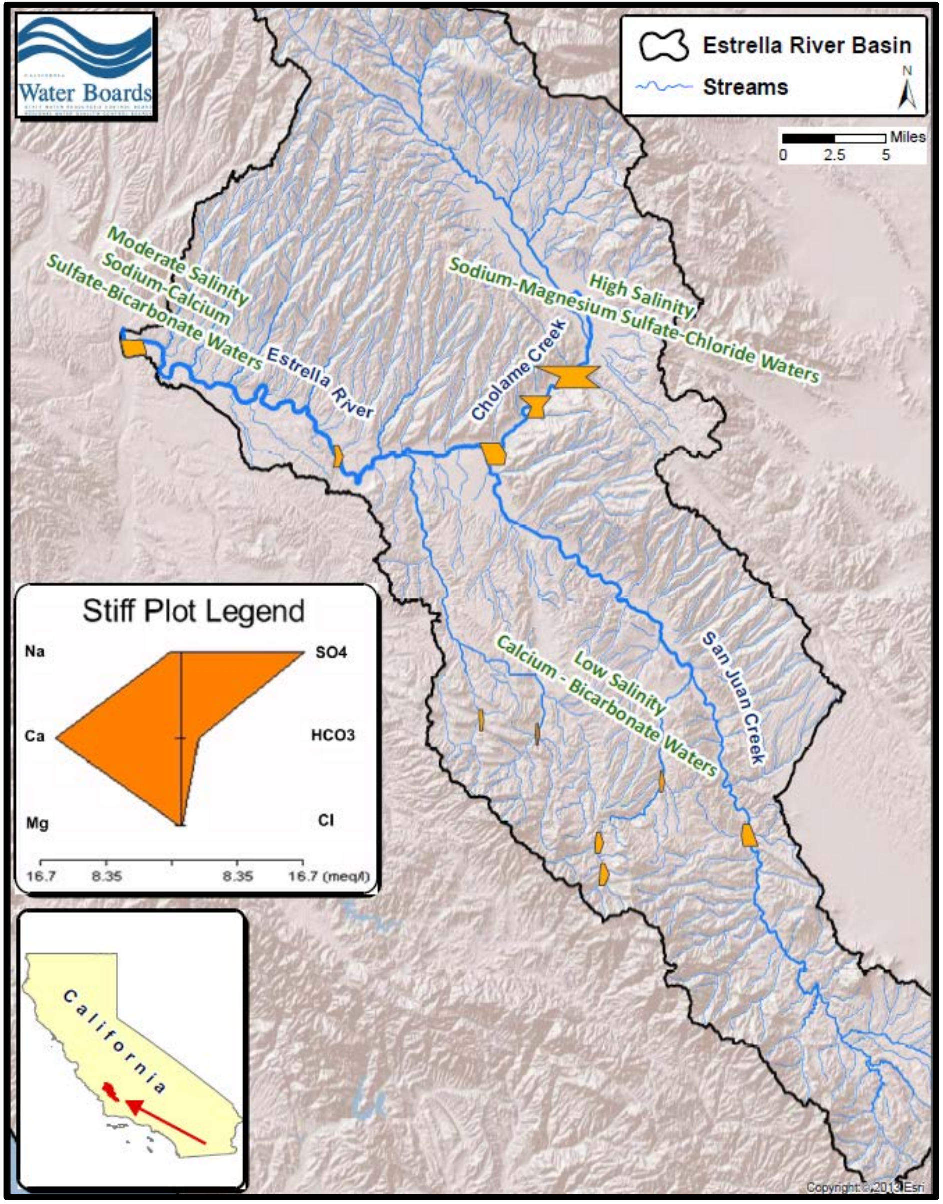
4.7.2 *General Water Quality Types*

Figure 4-2 illustrates generalized water quality types in streams of the Estrella River Basin on the basis of Stiff diagrams. Much of the data represented here are from pre-1990 sampling events, so these should be considered historical, or baseline conditions in the river basin. Surface water quality in the upper San Juan Creek watershed can be characterized as low salinity, calcium-bicarbonate waters (Ca-HCO_3). Surface water quality in the Cholame Creek watershed can be characterized as higher salinity, sodium-magnesium sulfate-chloride waters (Na-Mg Cl-SO_4). The Estrella River can be characterized generally as moderate salinity Na-Ca SO4-HCO_3 waters somewhat intermediate between observed water quality in the San Juan Creek and Cholame Creek watersheds – perhaps, in part, representing the influence of drainage from both of these watersheds into the Estrella River.

Undoubtedly, these differences in water quality types reflect, to some degree, differences in geology, surficial materials, and soils within the Estrella River Basin (refer back to report Section 3.5 which summarizes the geology of the Estrella River Basin) The higher salinity, sulfate-rich waters of the

Cholame Creek Watershed would an expected water quality signature due—in part—to drainage from areas containing Tertiary marine clastic sedimentary rock geologic assemblages of the central coast ranges. In contrast, the low salinity, calcium-bicarbonate waters of the upper San Juan Creek watershed likely represent a water quality signature that would be expected from areas draining granitic rocks and Mesozoic clastic sedimentary rock assemblages of the central coast ranges. Indeed, it has been reported in the literature that in central coast streams that drain areas dominated by Mesozoic clastic sedimentary assemblages, bicarbonate generally predominates over sulfate in stream waters; whereas where drainage is dominated by Tertiary-aged marine and continental sediments, sulfate predominates over bicarbonate (Davis, 1961). Unsurprisingly, high observed boron concentrations are associated with the higher salinity, sulfate and chloride-rich waters associated with drainage from Tertiary marine rock material in the Estrella River Basin.

Figure 4-2. General water quality types in the Estrella River Basin streams, on the basis of Stiff diagram analysis.

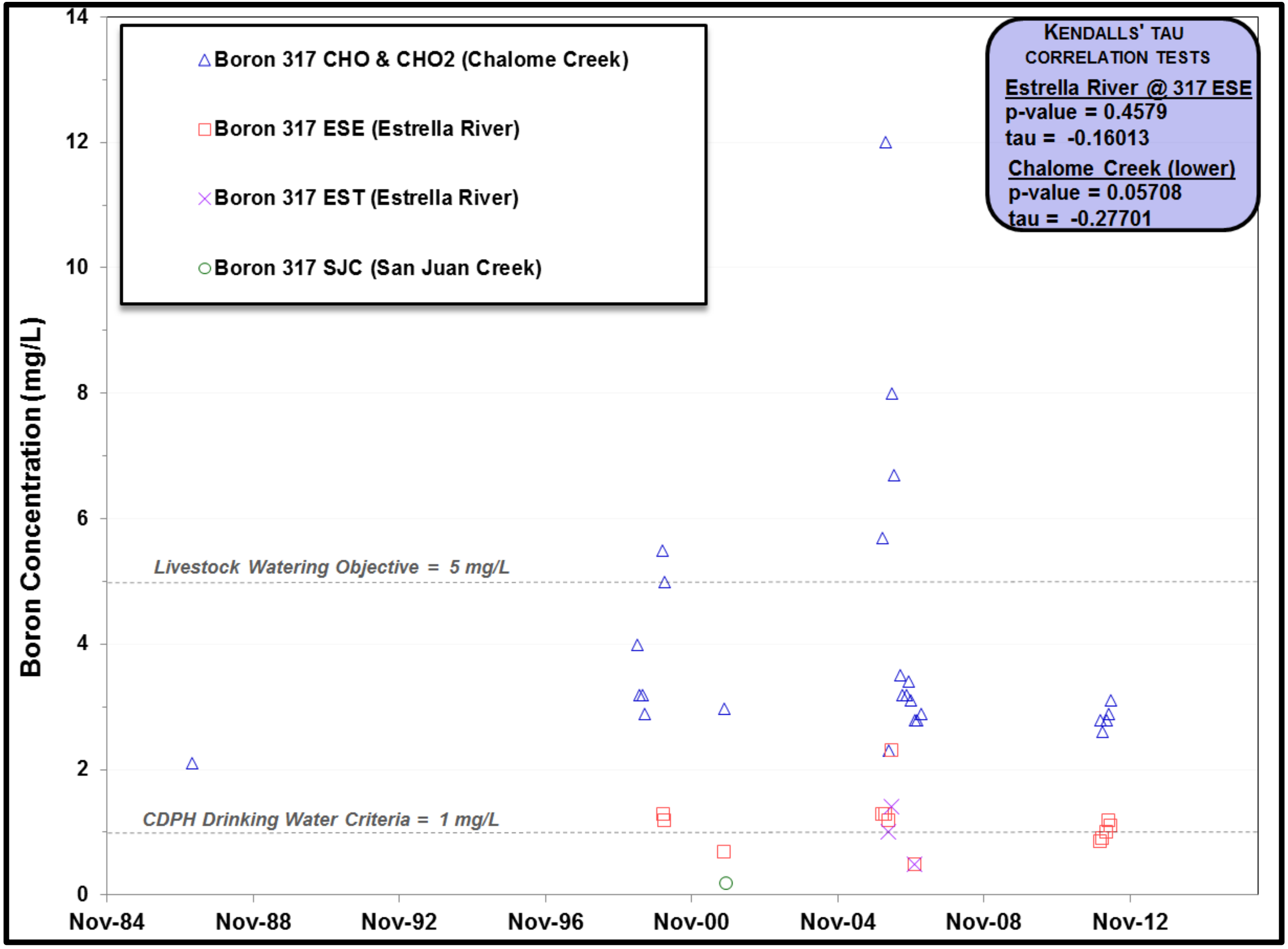


4.7.3 Water Quality Temporal Trends

Time-series temporal plots of boron water quality from stream monitoring sites within the Estrella River Basin (see Figure 4-3) do not appear to show any statistically significant or substantial temporal variation.

Staff performed a Kendall's tau nonparametric correlation tests using R[34] on the time series datasets for Cholame Creek (317CHO & CHO2) and the Estrella River (site 317ESE) shown in Figure 4-3. The correlation test indicates that boron concentrations at Cholame Creek and the Estrella River are weakly correlated with respect to time over the period of record (Cholame Creek /Tau = -0.277; Estrella River / Tau = -0.160). Further, the weak correlation between boron and time is *not* statistically significant (Cholame Creek p-value = 0.05708[35]; Estrella River p-value = 0.4579). Practically speaking, this means that there is *no* significant positive or negative (increasing or decreasing) correlation or association between boron concentrations and the temporal period of record in these surface water samples from the lower Cholame Creek and the Estrella River. In short, boron concentrations have not significantly increased nor decreased over this 12-year period of record for these stream water quality samples.

Figure 4-3. Time series of boron water quality monitoring data.



4.7.4 Water Quality Flow-based Trends

Analysis of flow-based trends can provide insight into potential seasonal and flow-related variation in boron concentrations in streams. Staff performed a Kendall's tau nonparametric correlation test using R on the paired boron-flow events[36] shown in Figure 4-4. The correlation test indicates that boron and flow

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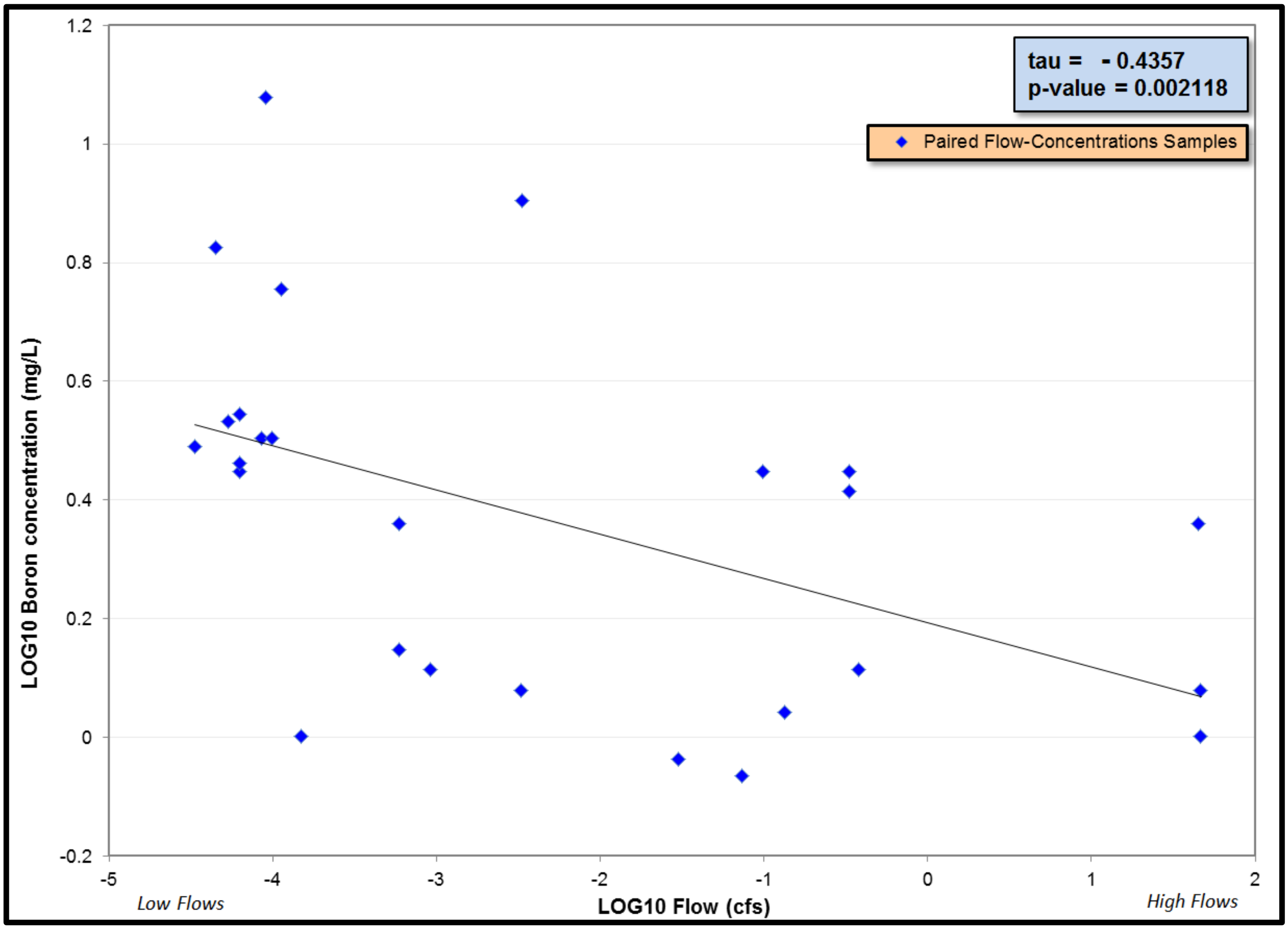
[34] Citation: R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

[35] By convention, Kendall's tau correlation coefficients are considered to be statistically significant when probabilities (p-values) are *less* than 0.05.

[36] Paired water quality samples in this context refer to boron and flow measurements that were collected at the same date/time and at the same sampling location.

are weakly to moderately correlated (tau = – 0.4357). Further, the correlation is in fact statistically significant (p-value = 0.002118), indicating a very small chance of observing this correlation by chance alone. Practically speaking, this means that there is a significant negative correlation or association between boron concentrations and flow (i.e., decreasing boron concentrations with increasing flow) in these surface water samples. Based on the available data, staff determines that there are patterns of flow-based variation in boron water quality in the Estrella River and Cholame Creek. This is almost undoubtedly because high flow conditions represent a hydrologic regime when low-salinity meteoric, fresh waters associated with runoff and precipitation make up a much larger contribution to stream flow compared to the relatively more saline water column conditions attributable to natural and geologic conditions which likely prevail at lower flow regimes.

Figure 4-4. Scatter plot of paired boron and stream flow sampling events in the Estrella River and Cholame Creek.



4.7.5 Summary Water Quality Statistics

Table 4-5 presents summary statistics for the suite of 1999-2012 water quality data for streams reaches of the Estrella River Basin. These water quality data represent the suite of samples that are used in this TMDL to assess water quality status and impairment, in accordance with the California 303(d) Listing Policy and the Water Quality Control Plan for the Central Coast Region.

Table 4-5. Streams of the Estrella River Basin summary boron water quality statistics (1999-2012). Units = mg/L.

									AGR Water Quality Criteria		**MUN Drinking Water Quality Criteria**		**Freshwater Aquatic Habitat protection criteria**
									Irrigation Supply	**Livestock Watering**			
Waterbody-Monitoring Site	**Constituent**	**No. of Samples**	**Temporal Representation**		**Min**	**Median**	**Mean**	**Max**	**No. and (%) Exceeding 0.75 mg/L**	**No. and (%) Exceeding 5 mg/L**	**No. exceeding 1 mg/L**	**% exceeding 1mg/L**	**No. and (%) exceeding 5 mg/L**
Cholame Creek @ 317CHO	Boron	20	5/13/1999	2/15/2007	2.3	3.2	4.3	12.0	20 (100%)	5 (25%)	20	100%	5 (25%)
Cholame Creek @ 317CHO2	Boron	5	1/9/2012	5/1/2012	2.6	2.8	2.8	3.1	5 (100%)	0 (0%)	5	100%	0 (0%)
Estrella River @ 317ESE	Boron	13	2/1/2000	5/1/2012	0.5	1.2	1.1	2.3	11 (85%)	0 (0%)	8	62%	0 (0%)
Estrella River @ 317EST	Boron	3	3/30/2006	12/13/2006	0.5	1.0	1.0	1.4	2 (67%)	0 (0%)	1	33%	0 (0%)
San Juan Creek @ 317SJC	Boron	1	10/17/2001		-	-	-	0.2	0 (0%)	0 (0%)	0	0%	0 (0%)

4.8 Impairment Assessment Findings

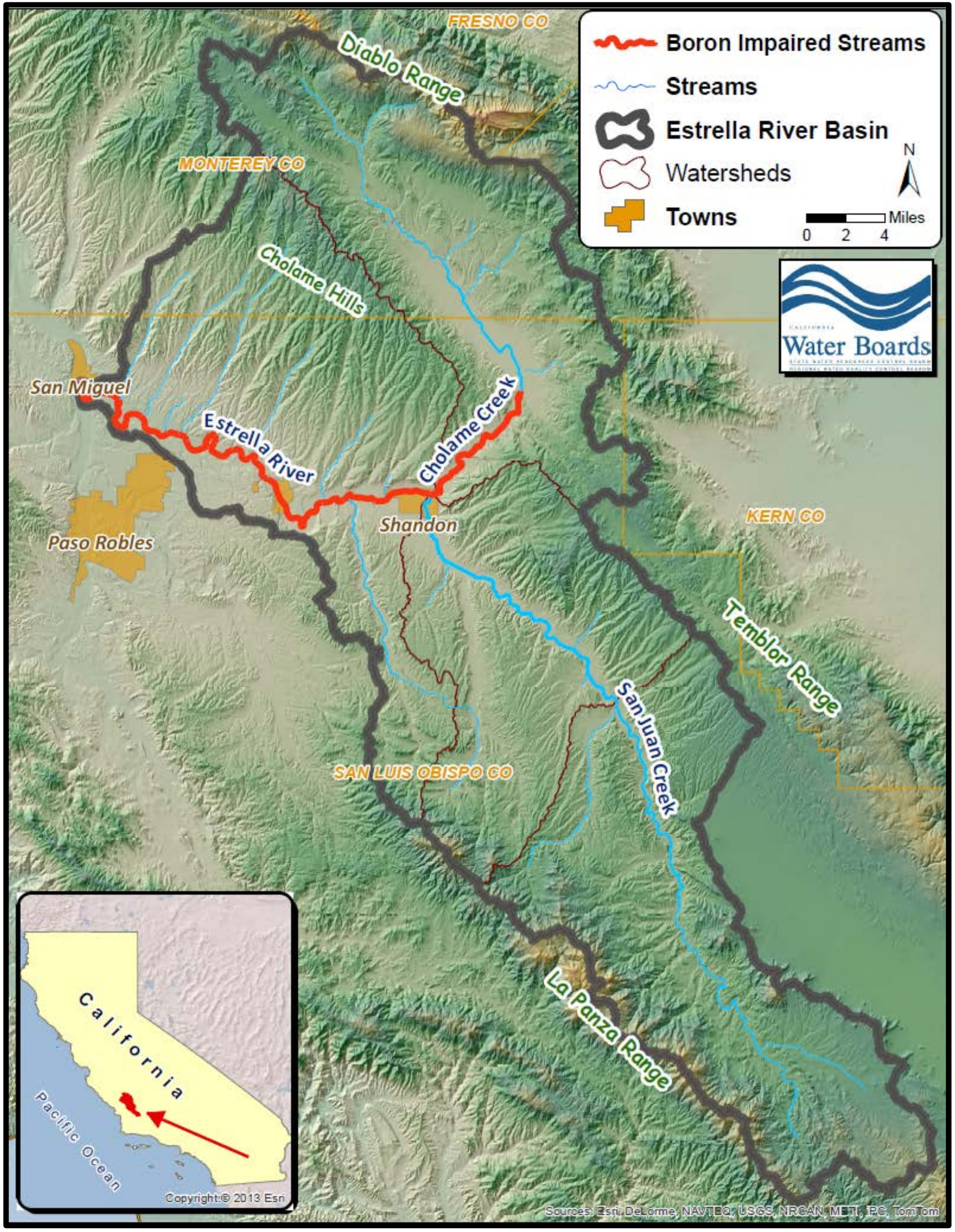
High levels of boron are currently impairing designated beneficial uses of the Estrella River and Cholame Creek. The standards and water quality objectives used to assess boron water quality conditions in streams of the Estrella River Basin were previously presented in Table 4-2. Summary statistics of water quality parameters and exceedance frequencies as compared to numeric water quality objectives were previously presented in Section 4.7.5. Consequently, these exceedance frequencies are compared to the methodologies promulgated in the California Listing Policy (refer back to Section 4.5) to determine attainment or non-attainment of water quality standards. Table 4-6 presents a status summary of potential impairments of designated beneficial uses of surface waters in the TMDL project area. Figure 4-5 graphically illustrates the identified boron-impaired stream reaches in the river basin.

Table 4-6. Status summary of designated beneficial uses of Estrella River Basin streams that could potentially be impacted by boron.

Stream	Designated Beneficial Use	Boron Water Quality Objective, or Recommended Numeric Level ^{A} (refer to Table 4-2)	Exceeding Water Quality Criteria or Non-regulatory Recommended Level?	Is Beneficial Use Being Supported?	Reach Impaired
Estrella River *(currently on CWA 303d List)*	MUN & GWR *(drinking water supply & groundwater recharge)*	*Basin Plan Toxicity Narrative Objective* 1.0 mg/L	Yes	No	Estrella River all reaches
	AGR *(irrigation supply)*	0.75 mg/L	Yes	No	Estrella River all reaches
	AGR *(livestock watering)*	5 mg/L	No	Yes	none
	WARM, SPWN,WILD, RARE *(aquatic habitat)*	*Basin Plan Toxicity Narrative Objective* 5 mg/L	No	Yes	none
Cholame Creek *(currently on CWA 303d List)*	MUN & GWR *(drinking water supply & groundwater recharge)*	*Basin Plan Toxicity Narrative Objective* 1.0 mg/L	Yes	No	Cholame Creek all reaches
	AGR *(irrigation supply)*	0.75 mg/L	Yes	No	Cholame Creek all reaches
	AGR *(livestock watering)*	5 mg/L	Yes	No	Cholame Creek upstream of Bitterwater Rd.
	WARM, ,WILD, RARE *(aquatic habitat)*	*Basin Plan Toxicity Narrative Objective* 5 mg/L	Yes	No	Cholame Creek upstream of Bitterwater Rd.
Upper San Juan Creek (upstream of Hwy. 58) *(NOT on current CWA 303d List)*	MUN & GWR *(drinking water supply & groundwater recharge)*	*Basin Plan Toxicity Narrative Objective* 1.0 mg/L	No	Yes ^{A} *For Upper San Juan Creek upstream of Hwy. 58; no boron data for lower San Juan Creek*	None identified on the basis of limited available data
	AGR *(irrigation supply)*	0.75 mg/L	No	Yes ^{A} *For Upper San Juan Creek upstream of Hwy. 58; no boron data for lower San Juan Creek*	None identified on the basis of limited available data
	AGR *(livestock watering)*	5 mg/L	No	Yes ^{A} *For Upper San Juan Creek upstream of Hwy. 58; no boron data for lower San Juan Creek*	None identified on the basis of limited available data
	WARM, ,WILD, RARE *(aquatic habitat)*	*Basin Plan Toxicity Narrative Objective* 5 mg/L	No	Yes ^{A} *For Upper San Juan Creek upstream of Hwy. 58; no boron data for lower San Juan Creek*	None identified on the basis of limited available data

[A] This determination was made on the basis of one water quality sample collected from San Juan Creek at Highway 58. It should be noted that the California 303(d) Listing Policy specifies that there be a minimum of five samples with exceedances of water quality criteria before a waterbody can be listed on the CWA 303(d) list. . At this time, staff finds that San Juan Creek upstream of Highway 58 is meeting all boron water quality criteria on the basis of one water quality sample.

Figure 4-5. Identified boron-impaired streams of the Estella River Basin

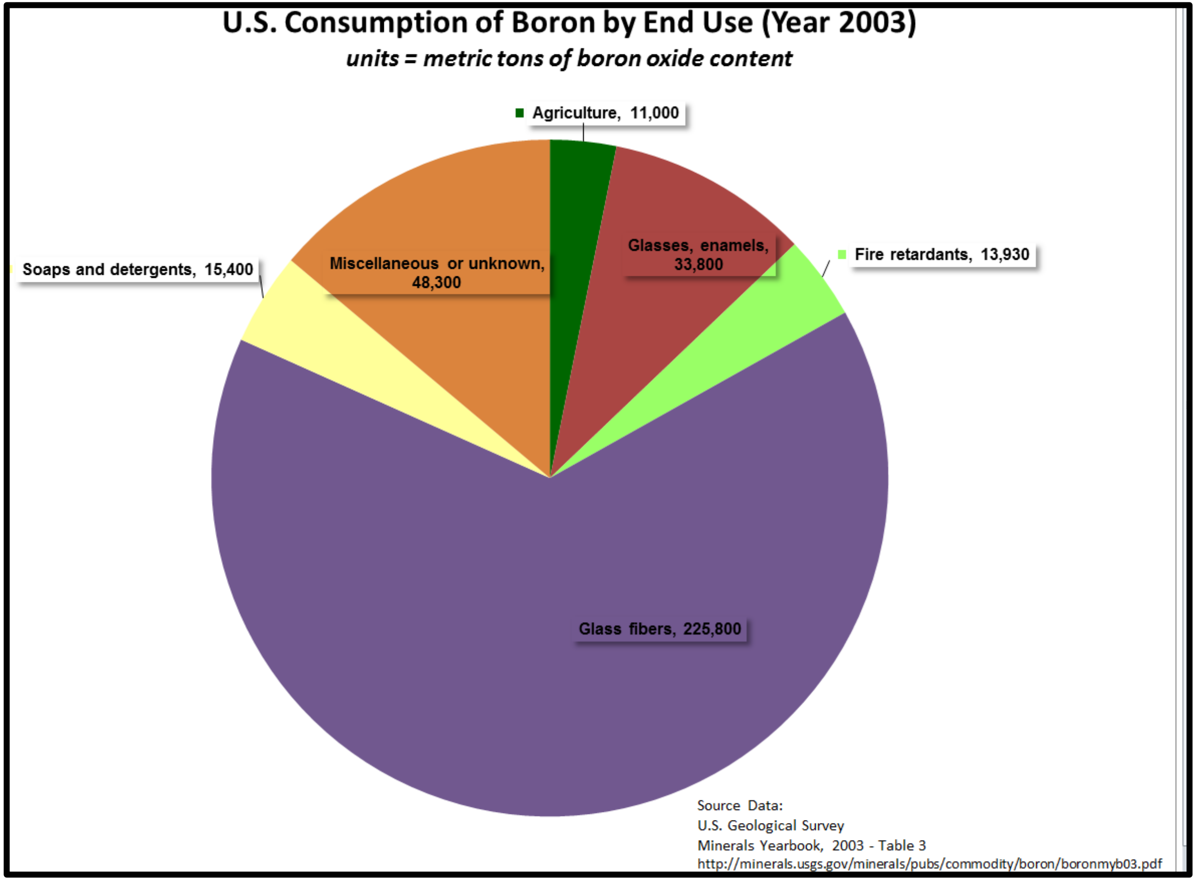


5 SOURCE ANALYSIS

Boron occurs both naturally and from anthropogenic sources. Boron is a ubiquitous and naturally-occurring element that is found in the environment due to leaching of rocks and sediment, the infiltration of meteoric salts, and from mixing of groundwaters. High concentrations of naturally occurring boron are primarily found in arid and semiarid environments where drainage and/or leaching are restricted. Anthropogenic sources of boron to the environment include sewage effluents, detergents, industrial wastes, agrochemicals (such as fertilizers and insecticides), and the combustion of coal and petroleum in power plants. The highest natural concentrations of boron are found in sediments and sedimentary rock, particularly clay-rich marine sediments. High boron concentrations found in seawater, which average around 4.5 mg/L, ensures that clays of marine origin are enriched in boron relative to other rock types (World Health Organization, 1998). Usually, boron is released into the environment from natural landscapes very slowly and at low concentrations by natural weathering (Butterwick et al, 1989 as reported in British Columbia Ministry of Water, Land and Air Protection, 2003).

Anthropogenic sources of boron in the environment include wastewater and effluents; coal and petroleum product combustion (which may result in atmospheric deposition to surface waters and the landscape); agrochemicals (fertilizers and pesticides); produced waters from oil, gas, or geothermal production; and cleaning compounds (BCMWLAP, 2003). Figure 5-1 illustrated U.S. consumption of boron by end use. It should be noted that *glass products do not release boron to water resources or to the environment*, because boron is tightly bound chemically to the glass crystalline structure. An estimated 32,000 tons of boron annually enter the North American environment from anthropogenic sources, primarily laundry products, fertilizers and other agricultural chemicals, coal combustion, and mining and processing (Eisler 1990, as reported in U.S. Department of the Interior, 1998). While the global biogeochemical boron cycle is largely attributable to natural fluxes, human inputs to the global boron cycle have locally contributed significantly to boron transport in rivers and streams (Park, Schleisinger, 2002).

Figure 5-1. U.S. consumption of boron minerals and compounds by end use, year 2003.



Source Data:
U.S. Geological Survey
Minerals Yearbook, 2003 - Table 3
http://minerals.usgs.gov/minerals/pubs/commodity/boron/boronmyb03.pdf

Therefore, in any given watershed, plausible sources that could cause or contribute to elevated concentrations of boron in surface waters can potentially include the following:

- Wastewater effluent from urban areas, industrial facilities, and wastewater treatment plants.
- Agricultural chemicals, stormwater runoff and irrigation discharges
- Septic systems
- Produced water from oil, gas or geothermal wells
- Atmospheric deposition of boron associated with anthropogenic combustion of coal and oil.
- Natural and non-controllable sources, such as rocks, soils, springs, groundwaters.

As a matter of practicing due diligence, staff compiled and assessed available data for each potential source category shown above in order to confirm or refute these sources as probable causes/contributors to elevated boron in streams of the Estrella River Basin.

5.1 Point Sources

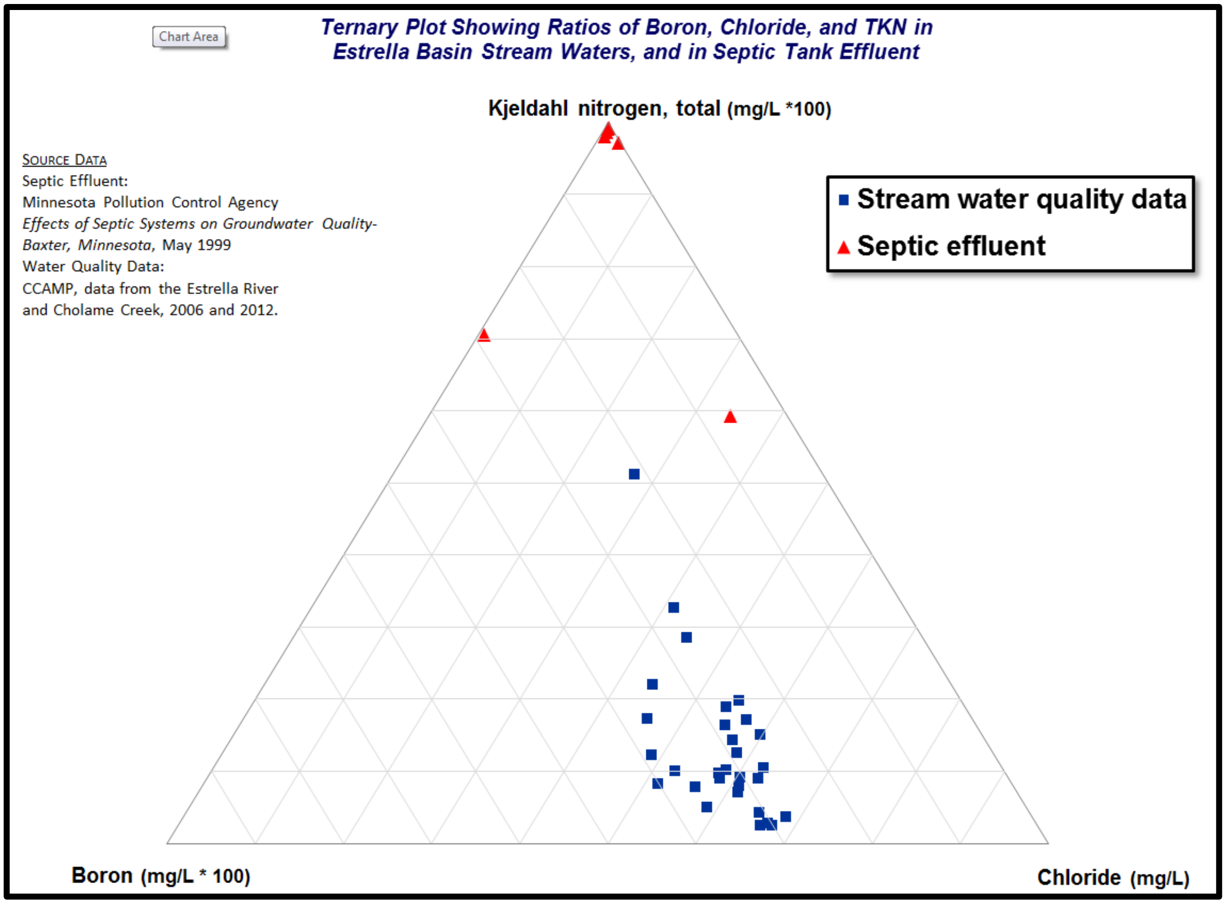
The TMDL project area is a sparsely populated, rural river basin. According to the California Integrated Water Quality System (CIWQS) database, there are no NPDES point source discharges in the Estrella River Basin, nor are there any census-designated urban areas which would be subject to NPDES municipal separate stormwater sewer system permit requirements. Therefore, boron waste load allocations for NPDES point sources are set at zero.

5.2 Nonpoint Sources

5.2.1 Septic Systems

The highest observed boron concentrations in streams of the Estrella River Basin are at the monitoring sites at Cholame Creek. These monitoring sites are well upstream of the community of Shandon. There are no septic systems upstream of monitoring sites 317CHO or 317CHO2 that could plausibly cause or contribute to elevated boron in these creek waters. The Estrella River Basin is sparsely populated with an estimated basin-wide total population of 615 people, and an average population density of 0.16 persons per square kilometer[37]. Furthermore, stream waters of the Estrella River Basin are distinctly different from typical chemical characteristics and signatures of septic tank effluent (see Figure 5-2). It is implausible that this source category significantly contributes to, or causes, boron impairments in stream waters of the Estrella River Basin (this does not rule out impact to groundwaters from septics). Therefore, a load allocation for this source category to surface receiving waters is not warranted.

Figure 5-2. Ternary plot showing chemical ratios of select constituents in literature-reported septic effluent, and in stream waters of the Estrella River Basin.



Ternary Plot Showing Ratios of Boron, Chloride, and TKN in Estrella Basin Stream Waters, and in Septic Tank Effluent

SOURCE DATA
Septic Effluent:
Minnesota Pollution Control Agency
Effects of Septic Systems on Groundwater Quality- Baxter, Minnesota, May 1999
Water Quality Data:
CCAMP, data from the Estrella River and Cholame Creek, 2006 and 2012.

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[37] Source data: U.S. Geological Survey - Attributes for NHDplus Catchments (Version 1.1) for the Conterminous Unites States: Population Density, 2000.

5.2.2 Irrigated Cropland

There are currently 116 farming and ranching operations in the Estrella River Basin enrolled in the Central Coast Water Board's Agricultural Regulatory Program (Order R3-2012-0011). The overwhelming majority of these are located in lower reaches of the river basin, including along the Estrella River.

According to current information available to the Central Coast Water Board the primary cultivated crop in the Estrella River Basin is vineyards (grapes). Row crops (carrot, lettuce, etc.) and orchards (olive, walnut) are also cultivated in the basin. Boron discharges to waterbodies from agricultural operations can result from pesticide application, fertilizer application, and application and discharge of irrigation or storm waters.

Based on information available from the California Department of Pesticide Regulation the boron-enriched pesticides boric acid, borax, and disodium octaborate have not been applied in the Estrella River Basin over the years 1999-2011 (see Figure 5-3). Therefore, pesticides do not appear to be a source of boron loading to streams of this river basin on the basis of available information.

Applications of fertilizers, and application of irrigation water containing elevated levels of boron are potential source categories that could contribute increased levels of boron to soils, surficial sediments, and surface waters within the Estrella River Basin. Boron in soils constitutes a possible source of boron runoff and discharge to surface waters (Alabama State Water Program website, accessed August 2013). Indeed, it is recognized in the technical literature that sometimes irrigation waters and other nonpoint sources can contribute significant amounts of boron to soils (Whetstone et al, 1942, Peryea and Binham, 1986 Yermiyahu and Ben-Gal, 2006, Uygan and Cetin, 2012, and Muntean, undated).

It should be noted that available information indicates that many growers in the Estrella River Basin currently use micro-irrigation, and many do not have tailwater, which presumably should limit the amount of boron added or discharged to streams, surficial sediments, and soils. However, recent increases in vineyard cultivation in the river basin is reportedly resulting in an increase in the number of agricultural wells drilled into deeper and lower water quality aquifers, with the water being stored in surface reservoirs used for frost protection (PRO Water Equity, Inc., 2013). Some of these lower quality agricultural waters are also reportedly used in irrigation management (PRO Water Equity, Inc., 2013). While these types of practices could potentially add boron to soils and surficial sediments of the river basin, their impact on stream water quality is currently uncertain. Noteworthy is the observation the boron concentrations in samples of surface waters from the Estrella River and the lower Cholame Creek have not significantly increased, nor decreased over the past 12 years (refer back to Section 4.7.3 and Figure 4-3).

Because fertilizing material and application of irrigation water can potentially result in loading of boron to surface waters, this source category will be given a load allocation. However, based on available information on current irrigation practices, and the fact that nitrogen and phosphorus levels[38] in the Estrella River occur at relatively low levels, staff concludes this source category is minor relative to the stream loading of boron from natural and geologic sources (see Section 5.2.5).

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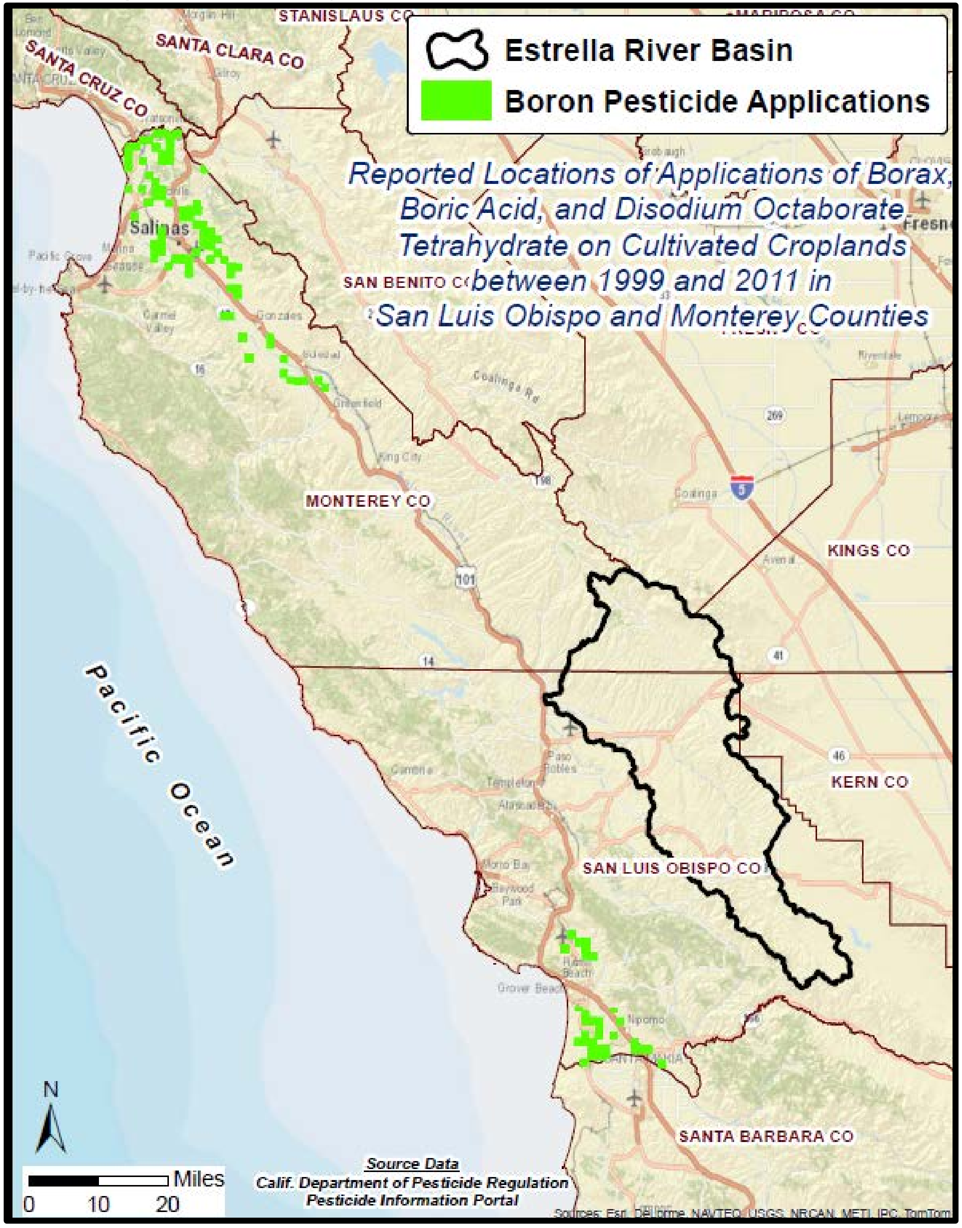
[38] Elevated nitrogen and phosphorus in surface could be an indicator of runoff and discharge of fertilizing materials.

Figure 5-3. Reported locations of boron pesticide applications on cultivated cropland from 1999-2011, San Luis Obispo and Monterey Counties.



Reported Locations of Applications of Borax, Boric Acid, and Disodium Octaborate Tetrahydrate on Cultivated Croplands between 1999 and 2011 in San Luis Obispo and Monterey Counties

Source Data
Calif. Department of Pesticide Regulation
Pesticide Information Portal

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

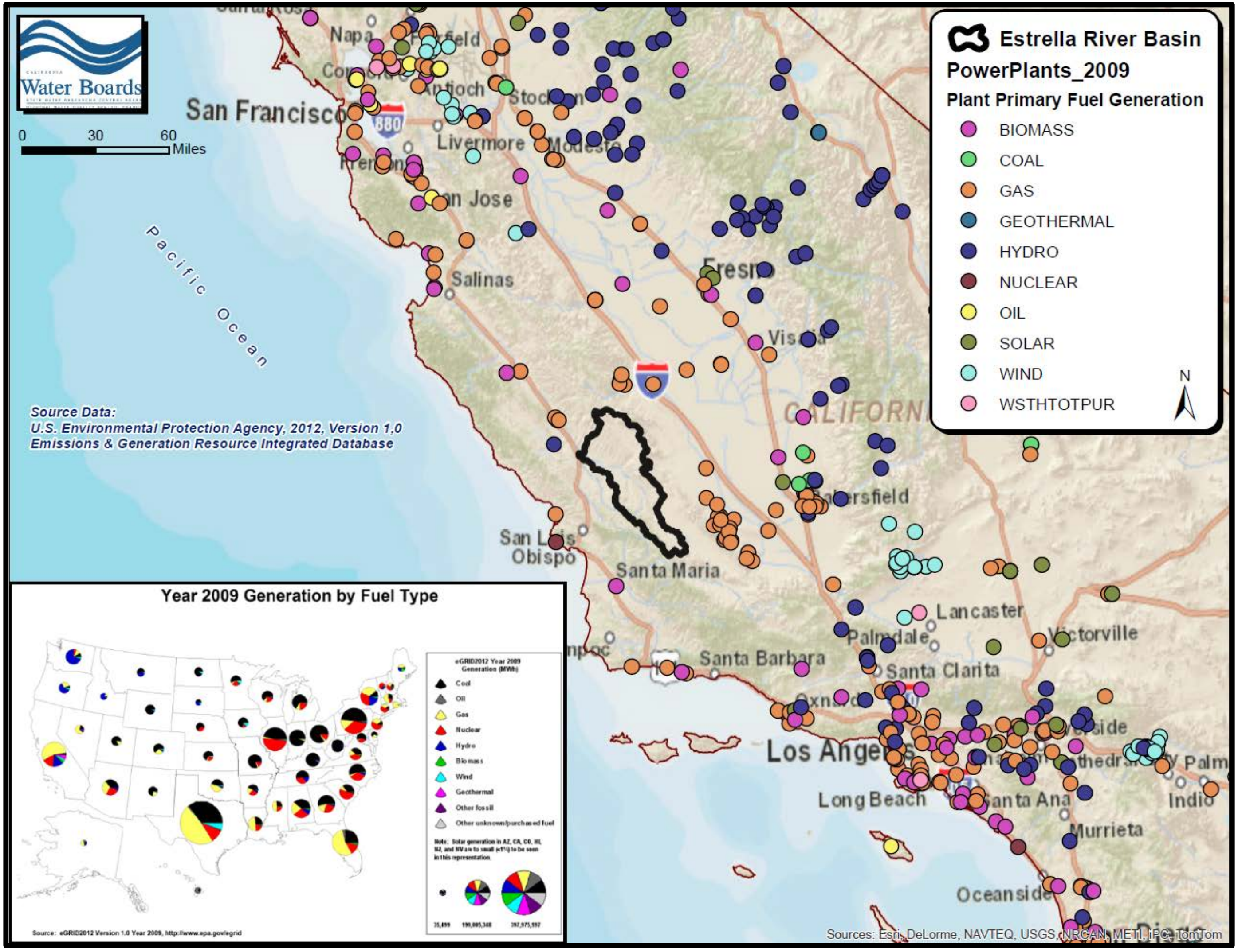
5.2.3 Oil, Gas and Geothermal Production

In any given watershed, improperly-managed produced water from oil, gas, and geothermal wells can potentially contribute to elevated inorganics, salts, or boron in surface waters and groundwaters. This is because these produced waters come from hydrocarbon or geothermal subsurface reservoirs typically containing brackish or saline connate pore water fluids. However, there are no oil or gas fields in the Estrella River Basin. According to public well records from the California Division of Oil, Gas and Geothermal Resources (DOGGR), historically, petroleum wells have been drilled within the Estrella River Basin. These wells evidently were either exploratory boreholes or outpost wells, and available data indicate they never resulted in oil or gas field production. With regard to geothermal production, according to spatial information available from DOGGR there are no geothermal production fields anywhere in San Luis Obispo or Monterey counties. Based on the aforementioned information, it is implausible that the oil, gas, and geothermal production source category causes or contributes to elevated boron in Estrella River Basin stream waters, therefore, an allocation for this source category is not warranted.

5.2.4 Atmospheric Deposition

Combustion of coal and petroleum are recognized in the literature as a source of anthropogenic boron releases to the environment. It should be noted that in contrast too much of the eastern and Midwestern United States, power plant fuel generation in California relies overwhelmingly on natural gas, hydroelectric and nuclear. There are very few coal and oil power plants in California, and none anywhere in the central coast region or in the vicinity of the Estrella River Basin. It is implausible that coal and oil power generation source category causes or significantly contributes to boron in Estrella River Basin stream waters, therefore an allocation for this source category is not warranted.

Figure 5-4. Power plants and primary fuel generation category.



Source Data:
U.S. Environmental Protection Agency, 2012, Version 1.0
Emissions & Generation Resource Integrated Database

Note: Solar generation in AZ, CA, CO, HI, NJ, and NV are to small to be seen in this representation.

Source: eGRID2012 Version 1.0 Year 2009, http://www.epa.gov/egrid

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

5.2.5 Natural Sources

Natural sources contribute to elevated boron concentrations in some streams of the Estrella River Basin, and natural sources may be the major source of boron loading to these streams. Information developed regarding watershed conditions in this project report in Section 3.5, Section 3.6, and Section 3.7 constitute multiple lines of evidence that natural conditions such as geology, tectonics, climatic conditions, springs and groundwater chemistry, geothermal activity, and evidence of hydrologic communication between meteoric waters, and saline connate fluids would be expected to cause or contribute to elevated boron levels observed locally in streams of the Estrella River Basin. Rock types, soils and surficial sediments in the river basin are of a type that would be prone to higher levels of boron; very arid climatic conditions found in the river basin would be expected to be prone to having higher levels of boron in water resources; and water resources even in minimally human-impacted areas of the river basin often have relatively high levels of boron. In addition, statewide isotopic data suggest that it is not uncommon for some of California's water resources to have highly elevated boron in waters not impacted by humans, sometimes even exceeding boron water quality numeric criteria (see Section 3.7 and Figure 3-23). The isotope data are not specific to the Estrella River basin, but do provide for a supporting circumstantial line of evidence and an illustration that highly elevated boron concentrations occasionally occur naturally in some California waters.

5.3 Summary of Sources

It should be noted that it is difficult to determine the exact amount of boron which enters waterbodies from various nonpoint sources, as there is not currently a robust body of scientific literature or models pertaining to boron watershed loading and boron transport and fate mechanisms to streams. Indeed it is recognized in the regulatory literature that limited data are available to quantify the anthropogenic releases of boron to the environment (see USEPA, 2008). As such, staff provides qualitative assessments of potential boron sources to surface waterbodies of the Estrella River Basin.

Multiple lines of evidence are developed in this report demonstrating that non-controllable natural sources contribute to or cause elevated levels of boron in streams of the Estrella River Basin. The only controllable source that could plausibly contribute to elevated boron in waterbodies is irrigated agricultural operations. Based on the weight of evidence presented in this report, natural non-controllable sources are the major source of boron to surface receiving waterbodies. Application of irrigation water and fertilizers could plausibly be a minor contributor of boron to waterbodies. However current regulation of agriculture operations and ongoing implementation practices required by existing regulation are anticipated to minimize the risk of controllable boron loading and mitigate anthropogenic boron loading to streams to the extent feasible (see Implementation Plan, Section 8.2).

6 NUMERIC TARGETS

According to USEPA (1999), the "primary goals of target analysis are (1) to clarify whether the ultimate goal of the TMDL is to comply with a numeric water quality criterion, comply with an interpretation of a narrative water quality criterion, or attain a desired condition that supports meeting a specified designated use; (2) to identify the waterbody's critical conditions; (3) to identify appropriate ways to measure (track) progress toward achieving stated goals; and (4) to tie the measures to pollutant loading."

6.1 Boron Criteria for Protection of MUN and GWR

The purpose of this target is to implement the Central Coast Basin narrative toxicity general water quality objective and to ensure support of designated for drinking water supply beneficial uses in the Estrella River Basin. Based on information previously provided in Section 4.2.1, the numeric target for boron which demonstrates whether or not MUN and GWR designated beneficial uses are being supported is as follows:

- *The controllable discharge of wastes shall not cause concentrations of chloride to exceed 1 mg/L in receiving waters.*

6.2 Boron Criteria for Protection AGR

The purpose of this target is to implement the Central Coast Basin Plan's water quality objective for irrigation water supply. The Central Coast Basin Plan contains two water quality objectives for boron protective of agricultural supply uses: 0.75 mg/L boron for irrigation supply and 5 mg/L for livestock watering. The water quality objective for irrigation supply is more stringent than the boron water quality objective for livestock watering, therefore the irrigation supply criteria is fully protective for all AGR beneficial uses. Based on information previously provided in Section 4.2.3, the numeric target for boron which demonstrates whether or not AGR designated beneficial uses are being supported is as follows:

- *The controllable discharge of wastes shall not cause concentrations of boron to exceed 0.75 mg/L in receiving waters.*

It is worth noting that based on available water quality data, boron concentrations in the Estrella River are easily achieving the numeric target protective of the livestock watering AGR beneficial use (5 mg/L) under all flow and seasonal conditions and therefore livestock watering designated beneficial uses of the river are being supported[39]. Note that State and Federal anti-degradation policies require that existing boron water quality which is currently supporting livestock watering **be maintained**, and that future lowering of existing water quality is not allowed unless consistent with provisions of the State and Federal anti-degradation policies[40,41].

6.3 Boron Criteria for Protection of Aquatic Habitat (WARM, SPWN, WILD, RARE)

The purpose of this target is to implement the Central Coast Basin Plan's narrative toxicity general water quality objective and to ensure support of designated for aquatic habitat beneficial uses in the Estrella River Basin. Based on information previously provided in Section 4.2.4, the numeric target for boron which demonstrates whether or not aquatic habitat designated beneficial uses are being supported is as follows:

- *The controllable discharge of wastes shall not cause concentrations of boron to exceed 5 mg/L in receiving waters.*

Based on available water quality data, boron concentrations in the Estrella River are easily achieving this numeric target under all flow and seasonal conditions and therefore aquatic habitat designated beneficial uses of the river are being supported[42]. It should be noted that State and Federal anti-degradation policies require that existing boron water quality which is currently supporting aquatic habitat **be maintained**, and that future lowering of existing water quality is not allowed unless consistent with provisions of the State and Federal anti-degradation policies[43,44].

7 LOADING CAPACITIES & ALLOCATIONS

7.1 Introduction

The TMDL represents the loading capacity of a waterbody—the amount of a pollutant that the waterbody can assimilate and still support beneficial uses. TMDLs are composed of a wasteload allocation (point sources) a load allocation (for nonpoint sources and natural background) and a margin of safety. Boron loads in Estrella River Basin are estimated to be mostly attributable to natural background conditions, with some potential contribution from irrigated agriculture. Designated MUN, aquatic habitat, and AGR beneficial uses are locally not being supported in the river basin (refer back to Table 4-6).

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[39] Note that Cholame Creek upstream of Bitterwater Road exceeds boron water quality criteria for livestock watering on the basis of available data.

[40] The State Water Resources Control Board and appellate court decisions indicate that water can be considered high quality for purposes of the anti-degradation policy on a constituent by constituent basis. Therefore, water can be of high quality under the anti-degradation policy for some constituents or beneficial uses, but not for others (see Court of Appeal of the State of California, Third Appellate District, Appeal Case C066410, Acociacion de Gente Unida, etc. et al. v. Central Valley Regional Water Quality Control Board).

[41] Refer to Section 4.4

[42] Note that Cholame Creek upstream of Bitterwater Road exceeds boron water quality criteria for aquatic habitat on the basis of available data.

[43] The State Water Resources Control Board and appellate court decisions indicate that water can be considered high quality for purposes of the anti-degradation policy on a constituent by constituent basis. Therefore, water can be of high quality under the anti-degradation policy for some constituents or beneficial uses, but not for others (see Court of Appeal of the State of California, Third Appellate District, Appeal Case C066410, Acociacion de Gente Unida, etc. et al. v. Central Valley Regional Water Quality Control Board).

[44] Refer to Section 4.4

7.2 Existing Loading

There are no current flow gages in the Estrella River Basin, and daily flow data is unavailable to credibly estimate stream boron loads. A limited number of sampling events which collected instantaneous flow data are available, and are used to provide a rough, gross approximation of stream boron loads based on the sampling events in the years 2006 and 2012 – see Table 7-1 . Because of the limited nature of the flow data, there is substantial uncertainty with these approximations, and they are insufficient to resolve long term temporal or seasonal trends.

Table 7-1. Estimated stream boron loads based on limited available flow data for the years 2006 and 2012.

Waterbody	Mean Observed Instantaneous Flow (cfs)	Number of Flow Observations	Mean Boron Concentration (mg/L)	Number of Boron Samples	Gross Estimate of Mean Annual Load (pounds)
Estrella River @ 317ESE	6.7	14	1.17	10	15,435
Cholame Creeek @ 317CHO	3.895	23	4.58	13	35,125

7.3 Loading Capacity (TMDL)

The loading capacity (TMDL) for waterbody segments in the TMDL project area is the amount of boron that can be assimilated without exceeding the water quality objectives. The TMDL is the sum of allocations for nonpoint and point sources and any allocations for a margin of safety. TMDLs are often expressed as a mass load of the pollutant but can also be expressed as a unit of concentration (40 CFR 130.2(i)). The TMDL allocations, which include background levels, are also equal to the numeric targets.

The Basin Plan contains water quality objectives for boron. The most stringent relevant water quality objective for boron (and therefore the one that is fully protective of the entire range of all boron-impaired designated beneficial uses) is the numeric Basin Plan objective for boron in irrigation supply water (see Table 4-2). Thus the loading capacities for the TMDL project area waterbodies are:

The following Total Maximum Daily Load is applicable to the Estrella River, Cholame Creek, and their tributaries and is applicable to each day of all seasons:

Waters shall not contain concentrations of boron in excess of 0.75 mg/L

7.4 Allocations

7.4.1 Waste Load Allocations

The waste load allocation for boron component is set at zero, because there are no point sources of boron in the Estrella River Basin.

7.4.2 Load Allocations

On the basis of source analysis (refer back to Section 5), the load allocations for boron are assigned to natural sources, and to irrigated agriculture. The load allocations are set equal to the numeric target protective of irrigation supply (0.75 mg/L), and thus this allocation is protective of all designated beneficial uses of stream waters (e.g., AGR, MUN, GWR, WILD, WARM, RARE, SPWN).

7.4.3 Tabular Summaries of Allocations

Table 7-2 presents tabular summaries of the boron TMDL allocations.

Table 7-2. Boron allocations.

BORON WASTE LOAD ALLOCATIONS [A]			
Waterbody	**WBID**	**Party Responsible (Source)**	**Receiving Water Allocation for Boron (mg/L)**
Estrella River Cholame Creek and their tributaries	Estrella River CAR3170007119990225125807 Cholame Creek CAR3170008120011127080727	NONE	0
BORON LOAD ALLOCATIONS [A]			
Waterbody	**WBID**	**Responsible Party (Source)**	**Receiving Water Allocation for Boron**
Estrella River Cholame Creek and their tributaries	Estrella River CAR3170007119990225125807 Cholame Creek CAR3170008120011127080727	Natural Sources (no responsible parties - not subject to regulation)	0.75 mg/L
Estrella River Cholame Creek and their tributaries	Estrella River CAR3170007119990225125807 Cholame Creek CAR3170008120011127080727	Owners/operators of irrigated cropland (fertilizer application and irrigation water)	0.75 mg/L

[A] federal and state anti-degradation requirements apply to all waste load and load allocations.

7.5 Margin of Safety

The Clean Water Act and federal regulations require that TMDLs provide a margin of safety to account for uncertainty concerning the relationship between pollution controls and water quality responses (see 40 CFR 130.7(c)(1)). The margin of safety for this TMDL is implicitly included through the use of the most stringent boron water quality objective (i.e., irrigation supply numeric objective) as the TMDL. The water quality was established using conservative assumptions, translating to an implicit margin of safety.

7.6 Critical Conditions and Seasonal Variation

Staff determined that there flow-based variation in boron concentrations in boron impaired streams of the Estrella River Basin. Based on staff's analyses, boron concentrations are generally lower during high flow conditions, likely due to increase inputs of fresh, meteoric water from runoff and precipitation. Seasonal or flow-based variability is accounted for and addressed by use of the allocations equal to the water quality objectives and concentration-based allocations; this assures the loading capacity of the water body be met under all flow and seasonal conditions.

7.7 Linkage Analysis

The goal of the linkage analysis is to establish a link between pollutant loads and desired water quality. This, in turn, ensures that the loading capacity specified in the TMDLs will result in attaining the desired water quality. For these TMDLs, this link is established because the load allocations are equal to the numeric targets, which are the same as the TMDLs. The numeric targets are used directly to calculate the loading capacity (TMDLs). Requiring the responsible parties for boron loading to reduce boron discharges to the numeric water quality objectives and targets will establish a direct link between the TMDL target and sources.

8 IMPLEMENTATION STRATEGY: PROPOSED ACTIONS TO ADDRESS 303(d)-LISTED IMPAIRMENTS

8.1 Introduction

The purpose of a TMDL implementation strategy is to describe the steps necessary to correct or address a water quality impairment and to provide a strategy to attain water quality standards or to correct the identified CWA 303(d)-listed impairment. The TMDL implementation strategy provides a series of actions and schedules that will correct the identified 303(d)-listed boron water quality impairments.

8.2 Irrigated Agriculture

Irrigated agriculture is estimated to be a potential minor source of boron loads to surface waters in the Estella River Basin. To continue to protect existing water quality and minimize the risk of further degradation of boron water quality, it is necessary to control and manage the risk of anthropogenic sources of boron loading from irrigated cropland. Achievement of load allocations for this source category will be demonstrated by owners and operators of irrigated lands implementing and complying with the Conditional Waiver of Waste Discharge Requirements for Irrigated Lands (Order R3-2012-0011) and the Monitoring and Reporting Programs in accordance with Orders R3-2012-0011-01, R3-2012-0011-02, and R3-2012-0011-03, or its renewals or replacements**.** These regulatory measures are hereafter are collectively referred to as the “Agricultural Order.” Owners and operators of irrigated agricultural lands must perform monitoring and reporting in accordance with Monitoring and Reporting Program Orders R3-2012-0011-01, R3-2012-0011-02, and R3-2012-0011-03, as applicable to the operation.

The Agricultural Order requires that discharges comply with applicable water quality standards and with applicable provisions of the Water Quality Control Plan for the Central Coast Basin (Basin Plan). The Agricultural Order requires that dischargers must develop and implement a farm water quality management plan, or update the farm plan as necessary to achieve compliance with the agricultural order. Farm plans should incorporate measures designed to achieve the boron load allocations identified in this TDML, and to prevent any further lowering of boron surface water quality, consistent with anti-degradation requirements promulgated in the Basin Plan. Staff has concluded that the current Agricultural Order provides the requirements necessary to implement and achieve load allocations for irrigated lands in this TMDL. **At this time no further regulatory measures are deemed necessary to achieve the load allocations for irrigated lands.**

8.2.1 Determination of Progress Towards & Attainment of Load Allocations

In terms of ultimately assessing TMDL achievement and supporting de-listing decisions to remove waterbodies from the Clean Water Act Section 303(d) list[45], it is necessary to identify metrics to assess progress towards and attainment of water quality standards and load allocations. Irrigated agriculture is the only plausible controllable boron source identified in this TMDL. To allow for flexibility, Central Coast Water Board staff will assess progress towards and attainment of load allocations for irrigated lands using one or a combination of the following:

1. Attaining the load allocations in receiving waters.
    a. *Note: Natural conditions may render existing boron water quality criteria in stream waters locally unattainable in some reaches of the Estrella River and Cholame Creek even with control of anthropogenic sources. As such, site specific water quality objectives may be promulgated in the future for specific stream reaches based on additional data collection. Is this case, attainment of boron load allocations for irrigated lands will be assessed on the basis of bullets 2. and 3. shown below, in conjunction with compliance with anti-degradation requirements as outlined in Section 8.6.*

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[45] The de-listing criteria, methodologies, and de-listing policy guidance are identified in Section 4 of the State Water Resources Control Board’s Water Quality Control Policy for Developing California’s Clean Water Act Section 303(d) list.

2. Implementing management practices that are capable of achieving load allocations identified in this TMDL.
3. Owners and operators of irrigated lands may provide sufficient evidence to demonstrate that they are and will continue to attain the irrigated lands load allocations; such evidence could include documentation submitted by the owner or operator to the Executive Officer that the owner or operator is not causing waste to be discharged to impaired waterbodies resulting or contributing to exceedances of the irrigated lands load allocations.

8.3 Recommendation to Develop Site-Specific Water Quality Criteria

Site specific water quality objectives (SSOs) or refinements in the water quality objective are often considered when a numeric objective is in question and not the use itself. In the case of the Estrella River and Cholame Creek, natural conditions such as geologic materials, soils, and the interaction of subsurface waters and surface waters **may render the TMDL and the identified boron water quality objectives unattainable on the basis of non-controllable, local natural conditions which likely exceed the load allocation for natural sources.** Pending the acquisition of additional water quality data and pending verification that owners and operators of irrigated lands are implementing and complying with requirments specified in the agricultural order, staff may recommend that a modification of the boron numeric water quality objectives applicable to the Estrella River and Cholame Creek. This may include development of site specific objectives (SSOs).

8.4 Evaluation of TMDL Implementation

Water Board staff will endeavor to review data and evaluate implementation efforts every three years. Water Board staff will utilize information submitted pursuant to the Agricultural Order to evaluate efforts on croplands. When and as appropriate, Water Board staff will rely on information generated by the County Farm Bureaus, University of California Cooperative Extension, and/or Natural Resources Conservation Service as part of existing and future projects (i.e. Clean Water Act Section 319(h) grants) to determine that existing rangeland efforts continue to protect water quality.

When the Central Coast Water Board has sufficient information to determine that the risk of anthropogenic boron loading to streams of the river basin is being managed to the extent practicable, the Water Board may determine that development of site specific boron water quality criteria are necessary on the basis on natural background loading to streams. Alternatively if during future review cycles, allocations and numeric targets are being met, Water Board staff will recommend the waterbody be removed from the 303(d) list.

8.5 Additional Monitoring Data

Additional data collected in the future by CCAMP and by other entities should be evaluated and used for the potential development of revised boron numeric water quality guidelines or site specific objectives. Current monitoring sites were shown previously in Figure 4-1. It should be noted that site 317CHO is a site where water sometimes pools during dry conditions, and thus evaporative process may concentrate dissolved inorganics such as salts and boron. As such, this site may not be representative of Cholame Creek more broadly. Currently, CCAMP staff is collecting water quality data on Cholame Creek at alternate site 317CHO2, which may be more representative of baseline conditions in the creek. Limited surface water quality data are available for the San Juan Creek watershed. One water quality sample on upper San Juan Creek at Highway 58 indicated excellent water quality, with a boron concentration far below all identified water quality criteria. Staff recommends that, resources permitting, supplemental water quality data be collected by CCAMP or other Water Board staff on lower San Juan Creek to confirm or refute that surface waters of San Juan Creek are meeting boron load allocations. Additionally, as resources permit, additional boron water quality data should be collected by Water Board staff outside the normal CCAMP sampling rotational cycle to provide for better temporal resolution of boron water quality.

Based on available data and staff's analysis it appears that local natural and geologic conditions may render current water quality objectives for irrigation supply and the load allocations for boron in reaches of the

Estrella River and Cholame Creek unachievable. It should be noted that there appears to be flow variation in boron concentrations (refer back to Section 4.7.4). Note that under high flow conditions, fresh meteoric waters and runoff dilute boron concentrations in stream waters. Currently, there is relatively limited water quality data for high flow regimes. Therefore, pending the acquisition of additional water quality data it may be possible to conclude that SSOs for boron are only necessary at low flow conditions.

8.6 Anti-degradation Requirements

Staff has developed this TMDL, in part, to be consistent with state anti-degradation policy. This policy requires, in part that when the existing quality of water is better than the quality of water established as objectives, such existing water quality shall be maintained unless otherwise provided for by the provisions of State Water Resources Control Board Resolution No. 68-16. High quality waters are determined on a “pollutant-by-pollutant”/”parameter-by-parameter” basis, by determining whether water quality is better than the criterion for each parameter using chemical or biological data[46].

The State Water Resourced Control Board has explained that high quality waters are determined based on specific properties or characteristics[47]. Therefore, waters can be of high quality for some constituents or beneficial uses, but not for others. In the Estrella River designated aquatic habitat (WARM, SPWN, WILD), and livestock watering (AGR) beneficial uses are being supported on the basis of boron data. Consequently, future lowering of existing boron water quality in the Estrella River is not allowed unless consistent with provisions of the state and federal anti-degradation policies. Non-compliance with anti-degradation requirements may be determined on the basis of trends in declining water quality consistent with the methodologies provided in Section 3.10 of the California 303(d) Listing Policy (SWRCB, 2004).

8.7 Timeline

There is currently insufficient data to refute the potential of anthropogenic contributions of boron to streams of the Estrella River Basin; likewise there is currently insufficient data to develop site specific boron water quality criteria on the basis of natural loading to streams. Staff anticipates that two more CCAMP monitoring cycles in the River Basin, in conjunction with the evaluation of data collected pursuant to the Agricultural Order, or available through other sources will be necessary prior to making a determination to develop site specific boron water quality criteria. Based on current CCAMP monitoring schedules, this amounts to a minimum of 12 years from the date of Water Board adoption of this TMDL. As such, staff anticipate that the 303(d) listed water quality impairment, which may include the potential development of site specific water quality criteria for boron, could be resolved by the year 2025.

Amending boron numeric water quality guidelines applicable the Estrella River will require development of a Central Coast Basin Plan amendment, with Central Coast Water Board, State Board, USEPA approvals, and considerable expenditure of staff resources. There is not an immediate urgency to develop site specific boron water quality criteria for this river basin. There are no permit effluent limitations for boron based on the existing water quality objectives regulating discharges in the Estrella River Basin, and there is no information that existing boron water quality is negatively impacting current beneficial uses of surface waters of the river basin. Indeed, stakeholders have reported that many crop types currently grown in the Estrella Basin are tolerant of relatively higher levels of boron[48], or that irrigation wells are drilled into high-quality water aquifers. Additionally, according to the 2012 Water Quality Report for the community of Shandon, the public water supply for the community comes from groundwater wells in the Paso Robles Basin and is normally very clean and of high quality (San Luis Obispo County Department of Public Works, 2013). However, consistent with the Central Coast Water Board’s identified priorities, is it prudent to ensure that controllable sources of boron are managed to prevent risks to human health and to aquatic habitat, and to ensure further lowering of water quality does not occur.

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[46] See: State Water Resources Control Board (2008), *Water Quality Standards Academy, Basic Course, Module 14*. Presented by U.S. Environmental Protection Agency, Region 9 – Office of Science and Technology (May 12, 2008).

[47] Court of Appeal of the State of California Third Appellate District, Asocacion De Gente Unida Por El Agua et al. v. Central Valley Regional Water Quality Control Board (Super. Ct. No. 34-2008-00003604CU-WM-GDS)

[48] This information was provided to staff by growers who attended an August 26, 2013 public workshop on TMDL development.

8.8 Cost Estimates & Funding Sources

Existing regulatory requirements are sufficient to implement and attain proposed load allocations for boron from controllable sources in the Estrella River Basin. Therefore, Water Board staff is not required to develop cost estimates associate with implementing this TMDL; implementation of the TMDL will be accomplished through an existing permitting tools[49]. Note that an approved TMDL can expand opportunities for available grant funding to implementing parties to improve nonpoint source pollution control. Central Coast Water Board grant staff is available to answer questions about the grant application and approval process, please contact Katie McNeill Central Coast Water Board environmental scientist at (805) 549-3336, or katie.mcneill@waterboards.ca.gov. For informational purposes, staff provides some examples of funding sources available to growers to implement improved farm water quality management practices, as shown below.

Environmental Quality Incentives Program (EQIP)
EQIP is a program designed to address significant natural resources needs and objectives including: soil erosion and water pollution prevention, farm and ranch land production, agricultural water conservation, and wildlife habitat preservation and development. EQIP offers financial and technical assistance to eligible participants for the installation of vegetated, structural and management practices on eligible agricultural land. EQIP typically cost-shares at 90 percent of the costs of eligible conservation practices. Incentive payments may be provided for up to three years to encourage producers to conduct management practices they would not otherwise do without the incentive. Limited resource producers and beginning farmers and ranchers may be eligible for cost-share up to 90 percent. More information is also available from the local NRCS office or from the Upper Salinas–Las Tablas Resource Conservation District website at http://us-ltrcd.org/

Clean Water Act 319(h) Grant Program
This program is a federally funded nonpoint source pollution control program that is focused on controlling activities that impair beneficial uses and on limiting pollutant effects caused by those activities. The 319(h) grant program offers funds to non-profit organizations, government agencies including special districts, and education institutions. Specific non-point source activities that are eligible for 319(h) funds may include, but are not limited to: the implementation of best management practices for agricultural drainage, physical habitat alteration, channel stabilization, sediment control, hydrologic modification, livestock grazing, irrigation water management, and confined animal facilities management. Other eligible activities include technology transfer, ground water protection, pollution prevention, technical assistance, facilitation of citizen monitoring and facilities of education elements of projects.

More information about the 319(h) Grant Program is available from the California State Water Resources Control Board site at http://www.waterboards.ca.gov/water_issues/programs/nps/solicitation_notice.shtml, or contact Mathew Freesel, State Board Division of Water Quality, 319(h) Grants Program at (916) 341-5485.

Other Sources of Funding for Growers and Landowners
The Upper Salinas–Las Tablas Resource Conservation District (USLTRCD) maintains strong partnerships with local, state and federal organizations and agencies that provide funding and/or resources to conservation projects. Depending on available grant sources, the USLTRCD may be able to provide free planning and other technical assistance for eligible agricultural conservation projects on agricultural lands, including engineering design and permitting assistance. The USLTRCD can provide access to cost-share assistance for eligible projects through the USDA NRCS and other partner programs. For certain projects the USLTRCD may also be able to apply for other grant funds on behalf of a cooperating farmer, rancher or landowner. More information is also available from the local NRCS office or from the Upper Salinas–Las Tablas Resource Conservation District website at
http://us-ltrcd.org/.

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[49] State Water Resources Control Board, Office of Chief Counsel Memo, dated Oct. 27, 1999. Subject: Economic Considerations in TMDL Development and Basin Planning.

9 PUBLIC PARTICIPATION

9.1 Public Meetings & Stakeholder Engagement

Staff conducted stakeholder outreach efforts during TMDL development. Staff conducted a public workshop in San Luis Obispo on August 26, 2013 and staff engaged with stakeholders during the development of the TMDL through informal contacts such as email. Individuals and entities staff engaged during the public workshop or contacted during TMDL development included individuals and representatives of the following:

- Owners and operators of irrigated cropland in the Estrella River Basin
- Agricultural consultants
- County of San Luis Obispo Department of Public Works
- Upper Salinas-Las Tablas Resource Conservation District
- San Luis Obispo County Farm Bureau
- California Department of Fish and Wildlife
- City of Paso Robles Department of Public Works
- PRO Water Equity, Inc.
- North County Watch
- University of California Cooperative Extension
- Central Coast Salmon Enhancement

The staff report, resolution, and technical project reports were made available for a 34-day public comment commencing on September 19, 2013. Water Board staff solicited public comment from a range of stakeholders including local land owners and land operators, agricultural representatives, representatives of environmental groups, resource professionals, and public agencies.

One public comment letter was received from:

1. Ms. Janet Parrish, TMDL Liaison, U.S. Environmental Protection Agency (USEPA), Region IX, San Francisco, in a letter dated October 21, 2013. Ms. Parrish states in the letter that USEPA supports and recommends adoption of this TMDL by the Central Coast Water Board.

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Appendix A – Water Quality Data

This appendix contains water quality data for the Estrella River Basin for streams, springs, geothermal waters, and groundwaters.

Stream Samples

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Boron,dissolved	4	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Boron,dissolved	3.2	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Boron,dissolved	3.2	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Boron,dissolved	2.9	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Boron,dissolved	5.5	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Boron,dissolved	5	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Boron,dissolved	5.7	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Boron,dissolved	12	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Boron,dissolved	2.3	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Boron,dissolved	8	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Boron,dissolved	6.7	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Boron,dissolved	3.5	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Boron,dissolved	3.2	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Boron,dissolved	3.2	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Boron,dissolved	3.4	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Boron,dissolved	3.1	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Boron,dissolved	2.8	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Boron,dissolved	2.8	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Boron,dissolved	2.9	mg/L
317CHO	SLOcounty	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836		Boron,dissolved	2.97	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Calcium	106	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Calcium	108	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Calcium	105	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Calcium	110	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Calcium	120	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Calcium	110	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Calcium	190	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Calcium	140	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Calcium	60	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Calcium	83	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Calcium	110	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Calcium	110	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Calcium	110	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Calcium	110	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Calcium	120	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Calcium	120	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Calcium	120	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Calcium	130	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Calcium	130	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/2/1999	Chloride	739	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/1999	Chloride	615	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/7/1999	Chloride	1100	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Chloride	825	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Chloride	631	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Chloride	566	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Chloride	489	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Chloride	1630	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Chloride	899	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Chloride	1200	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Chloride	1900	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Chloride	300	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Chloride	1300	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Chloride	950	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Chloride	440	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Chloride	400	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Chloride	410	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Chloride	530	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Chloride	520	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Chloride	500	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Chloride	520	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Chloride	570	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/2/1999	Dissolved Solids,Total	3320	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/1999	Dissolved Solids,Total	3070	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/7/1999	Dissolved Solids,Total	4400	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Dissolved Solids,Total	3580	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Dissolved Solids,Total	2990	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Dissolved Solids,Total	2840	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Dissolved Solids,Total	2520	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Dissolved Solids,Total	4900	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Dissolved Solids,Total	3560	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Dissolved Solids,Total	4400	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Dissolved Solids,Total	7400	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Dissolved Solids,Total	1400	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Dissolved Solids,Total	5100	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Dissolved Solids,Total	4300	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Dissolved Solids,Total	2300	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Dissolved Solids,Total	2100	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Dissolved Solids,Total	2000	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Dissolved Solids,Total	2400	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Dissolved Solids,Total	2300	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Dissolved Solids,Total	2100	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Dissolved Solids,Total	2300	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Dissolved Solids,Total	2500	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2006	Flow	0.000114375	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/1/2006	Flow	9.17E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/29/2006	Flow	44.78645833	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Flow	0.003325833	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Flow	4.52E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Flow	6.21E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Flow	8.54E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Flow	9.88E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Flow	5.33E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/8/2006	Flow	3.35E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/12/2006	Flow	0	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/9/2007	Flow	6.29E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Flow	0.000114375	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Flow	9.17E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Flow	44.78645833	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006 1:00	Flow	0.003325833	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006 1:00	Flow	4.52E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006 1:00	Flow	6.21E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006 1:00	Flow	8.54E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006 1:00	Flow	9.88E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006 1:00	Flow	5.33E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Flow	3.35E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Flow	0	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Flow	6.29E-05	cfs
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Hardness as CaCO3	1230	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Hardness as CaCO3	986	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Hardness as CaCO3	921	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Hardness as CaCO3	868	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Hardness as CaCO3	1700	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Hardness as CaCO3	1300	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Hardness as CaCO3	1800	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Hardness as CaCO3	2300	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Hardness as CaCO3	510	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Hardness as CaCO3	1600	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Hardness as CaCO3	1400	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Hardness as CaCO3	770	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Hardness as CaCO3	760	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Hardness as CaCO3	710	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Hardness as CaCO3	850	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Hardness as CaCO3	830	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Hardness as CaCO3	800	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Hardness as CaCO3	840	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Hardness as CaCO3	900	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Magnesium	235	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Magnesium	174	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Magnesium	160	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Magnesium	144	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Magnesium	340	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Magnesium	250	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Magnesium	320	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Magnesium	480	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Magnesium	88	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Magnesium	340	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Magnesium	260	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Magnesium	120	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Magnesium	120	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Magnesium	110	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Magnesium	130	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Magnesium	130	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Magnesium	120	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Magnesium	130	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Magnesium	140	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/2/1999	Nitrite as N	0.01	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/1999	Nitrite as N	0.021	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/7/1999	Nitrite as N	0.009	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Nitrite as N	0.009	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Nitrite as N	0.009	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Nitrite as N	0.009	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Nitrite as N	0.009	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Nitrite as N	0.009	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Nitrite as N	0.0198	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Nitrite as N	0.01	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Nitrite as N	0.01	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Nitrite as N	0.01	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Nitrite as N	0.022	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Nitrite as N	0.014	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Nitrite as N	0.012	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/2/1999	Nitrogen,Total Kjeldahl	1.4	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/1999	Nitrogen,Total Kjeldahl	1	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/7/1999	Nitrogen,Total Kjeldahl	1.4	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/13/1999	Nitrogen,Total Kjeldahl	1	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/2/1999	Nitrogen,Total Kjeldahl	0.85	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	6/30/1999	Nitrogen,Total Kjeldahl	0.82	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/29/1999	Nitrogen,Total Kjeldahl	1.1	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/25/2000	Nitrogen,Total Kjeldahl	2.2	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/8/2000	Nitrogen,Total Kjeldahl	2.3	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/26/2006	Nitrogen,Total Kjeldahl	1.9	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/2/2006	Nitrogen,Total Kjeldahl	2.1	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	3/30/2006	Nitrogen,Total Kjeldahl	1.5	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	4/27/2006	Nitrogen,Total Kjeldahl	1.1	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	5/24/2006	Nitrogen,Total Kjeldahl	1.8	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	7/20/2006	Nitrogen,Total Kjeldahl	1.1	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	8/16/2006	Nitrogen,Total Kjeldahl	1.5	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	9/21/2006	Nitrogen,Total Kjeldahl	0.66	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	10/19/2006	Nitrogen,Total Kjeldahl	0.73	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	11/9/2006	Nitrogen,Total Kjeldahl	3.3	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	12/13/2006	Nitrogen,Total Kjeldahl	0.77	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	1/10/2007	Nitrogen,Total Kjeldahl	0.91	mg/L
317CHO	CCAMP	Cholame Creek @ Bitterwater Rd.	35.70981498	-120.303836	2/15/2007	Nitrogen,Total Kjeldahl	0.73	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Boron,dissolved	2.8	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Boron,dissolved	2.6	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Boron,dissolved	2.9	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Boron,dissolved	2.8	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Boron,dissolved	3.1	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Calcium	110	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Calcium	100	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Calcium	120	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Calcium	110	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Calcium	120	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Chloride	590	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Chloride	640	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Chloride	640	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Chloride	630	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Chloride	660	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Dissolved Solids,Total	2600	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Dissolved Solids,Total	2700	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Dissolved Solids,Total	2600	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Dissolved Solids,Total	2700	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Dissolved Solids,Total	2700	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Flow	0.099	cfs
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Flow	0.3336	cfs
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Flow	-0.106375	cfs
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Flow	0	cfs
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Flow	-0.009125	cfs
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Hardness as CaCO3	840	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Hardness as CaCO3	780	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Hardness as CaCO3	930	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Hardness as CaCO3	860	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Hardness as CaCO3	930	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Magnesium	140	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Magnesium	130	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Magnesium	150	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Magnesium	140	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Magnesium	150	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Nitrite as N	0.004	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Nitrite as N	0.01	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Nitrite as N	0.01	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Nitrite as N	0.01	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Nitrite as N	0.01	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	1/9/2012	Nitrogen,Total Kjeldahl	0.22	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	2/7/2012	Nitrogen,Total Kjeldahl	0.34	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	4/3/2012 1:00	Nitrogen,Total Kjeldahl	0.26	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	3/6/2012	Nitrogen,Total Kjeldahl	0.23	mg/L
317CHO2	CCAMP	Cholame Creek dwnstrm of Bitterwater Rd.	36.7061	-1203099	5/1/2012 1:00	Nitrogen,Total Kjeldahl	0.43	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/1/2000	Boron,dissolved	1.3	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/8/2000	Boron,dissolved	1.2	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Boron,dissolved	1.3	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Boron,dissolved	1.3	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Boron,dissolved	1.2	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Boron,dissolved	2.3	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Boron,dissolved	0.49	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Boron,dissolved	0.86	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Boron,dissolved	0.92	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Boron,dissolved	1.2	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Boron,dissolved	1	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Boron,dissolved	1.1	mg/L
317ESE	SLOcounty	Estrella River @ River Rd.	35.65306	-120.5075		Boron,dissolved	0.68	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/1/2000	Calcium	100	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/8/2000	Calcium	93	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Calcium	100	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Calcium	86	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Calcium	52	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Calcium	130	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Calcium	58	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Calcium	78	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Calcium	72	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Calcium	100	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Calcium	82	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Calcium	85	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/1/2000	Chloride	252	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/8/2000	Chloride	263	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Chloride	290	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Chloride	260	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Chloride	190	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Chloride	410	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Chloride	95	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Chloride	190	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Chloride	220	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Chloride	240	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Chloride	230	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Chloride	220	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Dissolved Solids,Total	1600	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Dissolved Solids,Total	1400	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Dissolved Solids,Total	970	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Dissolved Solids,Total	2000	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Dissolved Solids,Total	590	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Dissolved Solids,Total	1200	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Dissolved Solids,Total	1300	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Dissolved Solids,Total	1500	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Dissolved Solids,Total	1600	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Dissolved Solids,Total	1400	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/25/2006	Flow	0.380891667	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/1/2006	Flow	0.000926042	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/29/2006	Flow	46.58567917	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Flow	0.000591667	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/12/2006	Flow	0	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Flow	0.380891667	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Flow	0.000926042	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Flow	46.58567917	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006 1:00	Flow	0.000591667	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Flow	0	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Flow	0.073125	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Flow	0.0303125	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Flow	0.00015	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Flow	0.00329	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Flow	0.1344375	cfs
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/1/2000	Hardness as CaCO3	645	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/8/2000	Hardness as CaCO3	611	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Hardness as CaCO3	640	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Hardness as CaCO3	580	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Hardness as CaCO3	350	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Hardness as CaCO3	830	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Hardness as CaCO3	320	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Hardness as CaCO3	480	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Hardness as CaCO3	470	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Hardness as CaCO3	620	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Hardness as CaCO3	540	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Hardness as CaCO3	540	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/1/2000	Magnesium	96	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/8/2000	Magnesium	92	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Magnesium	93	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Magnesium	88	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Magnesium	53	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Magnesium	120	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Magnesium	43	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Magnesium	71	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Magnesium	70	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Magnesium	89	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Magnesium	83	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Magnesium	81	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/1/2000	Nitrite as N	0.009	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/8/2000	Nitrite as N	0.0099	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Nitrite as N	0.01	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Nitrite as N	0.01	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Nitrite as N	0.01	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Nitrite as N	0.012	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Nitrite as N	0.012	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Nitrite as N	0.0041	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Nitrite as N	0.01	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Nitrite as N	0.01	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Nitrite as N	0.01	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Nitrite as N	0.01	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/1/2000	Nitrogen,Total Kjeldahl	0.75	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/8/2000	Nitrogen,Total Kjeldahl	0.94	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/26/2006	Nitrogen,Total Kjeldahl	0.86	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/2/2006	Nitrogen,Total Kjeldahl	0.91	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/30/2006	Nitrogen,Total Kjeldahl	1.5	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/27/2006	Nitrogen,Total Kjeldahl	0.69	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	12/13/2006	Nitrogen,Total	0.11	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
						Kjeldahl		
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	1/9/2012	Nitrogen,Total Kjeldahl	0.27	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	2/7/2012	Nitrogen,Total Kjeldahl	0.55	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	4/3/2012 1:00	Nitrogen,Total Kjeldahl	0.36	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	3/6/2012	Nitrogen,Total Kjeldahl	0.38	mg/L
317ESE	CCAMP	Estrella River @ River Rd.	35.65323998	-120.506435	5/1/2012 1:00	Nitrogen,Total Kjeldahl	0.55	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Boron,dissolved	1	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Boron,dissolved	1.4	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Boron,dissolved	0.49	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Calcium	43	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Calcium	100	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Calcium	58	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	2/2/1999	Chloride	545	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/2/1999	Chloride	410	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/7/1999	Chloride	455	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Chloride	130	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Chloride	280	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Chloride	95	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	2/2/1999	Dissolved Solids,Total	2730	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/2/1999	Dissolved Solids,Total	2110	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Dissolved Solids,Total	960	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Dissolved Solids,Total	1500	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Dissolved Solids,Total	590	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Hardness as CaCO3	280	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Hardness as CaCO3	620	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Hardness as CaCO3	320	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Magnesium	42	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Magnesium	88	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Magnesium	43	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	2/2/1999	Nitrite as N	0.01	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/2/1999	Nitrite as N	0.021	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/7/1999	Nitrite as N	0.009	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Nitrite as N	0.01	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Nitrite as N	0.012	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Nitrite as N	0.012	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	2/2/1999	Nitrogen,Total Kjeldahl	0.91	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/2/1999	Nitrogen,Total Kjeldahl	0.55	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/7/1999	Nitrogen,Total Kjeldahl	0.52	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	3/30/2006	Nitrogen,Total Kjeldahl	2.4	mg/L

SiteTag	Sampling Entity	Site Description	Latitude	Longitude	Date	AnalyteName	Result	Result Units
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	4/27/2006	Nitrogen,Total Kjeldahl	0.6	mg/L
317EST	CCAMP	Estrella River @ Airport Rd.	35.71725798	-120.639219	12/13/2006	Nitrogen,Total Kjeldahl	0.11	mg/L
317SJC	SLOcounty	San Juan Creek @ Hwy. 58	35.3874	-120.1507		Boron,dissolved	0.19	mg/L

Geothermal Spring Waters

Spring name	Latitude	Longitude	Analyte Name	Result	Result Units	Data Source
Table Mountain (Spring)	35.908300	-120.366700	Boron	0.4	mg/L	California Division of Oil, Gas, and Geothermal Resources Hot Springs Database (2008)
Well 26S/13E-11L1 M	35.679200	-120.543300	Boron	1.2	mg/L	California Division of Oil, Gas, and Geothermal Resources Hot Springs Database (2008)

Cold Water Spring Samples

Record Number	Latitude	Longitude	Analyte Name	Date	Resu;t	Result Units	Data Source
1115343	35.73480	-120.34850	Boron	1979/10/11	521	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115357	35.70200	-120.41560	Boron	1979/10/12	576	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115379	35.60060	-120.20660	Boron	1979/10/06	882	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115381	35.60290	-120.22840	Boron	1979/10/06	1008	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115473	35.36810	-120.31050	Boron	1979/10/02	157	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115479	35.35390	-120.26170	Boron	1979/10/04	161	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115481	35.38110	-120.32400	Boron	1979/10/04	161	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115503	35.33410	-120.22390	Boron	1979/10/04	94	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115505	35.35030	-120.23950	Boron	1979/10/04	49	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115655	35.18830	-120.05660	Boron	1979/10/05	602	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database

Groundwater Samples

(note: because sampled wells are on private property, for confidentiality reasons staff are not providing latitude-longitude location coordinates).

Record Number	Latitude	Longitude	Analyte Name	Date	Resu;t	Result Units	Data Source
1115155	—	—	Boron	1979/10/23	294	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115157	—	—	Boron	1979/10/23	271	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115161	—	—	Boron	1979/10/15	1209	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115163	—	—	Boron	1979/10/15	3429	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115165	—	—	Boron	1979/10/15	229	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115167	—	—	Boron	1979/10/15	1688	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115169	—	—	Boron	1979/10/15	2101	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115171	—	—	Boron	1979/10/16	1870	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115173	—	—	Boron	1979/10/16	3352	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115175	—	—	Boron	1979/10/17	3706	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115177	—	—	Boron	1979/10/17	1877	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115179	—	—	Boron	1979/10/17	2581	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115181	—	—	Boron	1979/10/17	1716	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115183	—	—	Boron	1979/10/18	444	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115187	—	—	Boron	1979/10/16	565	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115289	—	—	Boron	1979/10/19	2296	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database

Record Number	Latitude	Longitude	Analyte Name	Date	Resu;t	Result Units	Data Source
1115291	—	—	Boron	1979/10/19	595	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115293	—	—	Boron	1979/10/19	1373	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115313	—	—	Boron	1979/10/19	208	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115315	—	—	Boron	1979/10/19	1133	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115319	—	—	Boron	1979/10/20	402	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115321	—	—	Boron	1979/10/20	299	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115323	—	—	Boron	1979/10/06	175	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115325	—	—	Boron	1979/10/06	202	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115327	—	—	Boron	1979/10/06	134	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115333	—	—	Boron	1979/10/07	201	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115335	—	—	Boron	1979/10/10	1687	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115337	—	—	Boron	1979/10/11	184	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115339	—	—	Boron	1979/10/12	3194	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115341	—	—	Boron	1979/10/12	3850	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115345	—	—	Boron	1979/10/11	422	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115347	—	—	Boron	1979/10/11	294	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115349	—	—	Boron	1979/10/11	344	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database

Record Number	Latitude	Longitude	Analyte Name	Date	Resu;t	Result Units	Data Source
1115351	—	—	Boron	1979/10/11	281	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115353	—	—	Boron	1979/10/11	312	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115355	—	—	Boron	1979/10/12	1848	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115363	—	—	Boron	1979/10/06	311	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115371	—	—	Boron	1979/10/06	4546	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115373	—	—	Boron	1979/10/06	1939	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115375	—	—	Boron	1979/10/06	7683	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115377	—	—	Boron	1979/10/06	865	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115385	—	—	Boron	1979/10/10	8182	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115485	—	—	Boron	1979/10/02	161	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115487	—	—	Boron	1979/10/02	161	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115495	—	—	Boron	1979/10/03	86	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115497	—	—	Boron	1979/10/03	59	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115499	—	—	Boron	1979/10/04	87	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115501	—	—	Boron	1979/10/04	59	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115507	—	—	Boron	1979/10/05	90	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115513	—	—	Boron	1979/10/12	90	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database

Record Number	Latitude	Longitude	Analyte Name	Date	Resu;t	Result Units	Data Source
1115515	—	—	Boron	1979/10/12	61	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115517	—	—	Boron	1979/10/10	36	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115523	—	—	Boron	1979/10/11	344	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115525	—	—	Boron	1979/10/12	350	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115651	—	—	Boron	1979/10/05	133	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database
1115653	—	—	Boron	1979/10/05	164	ppb	U.S. Dept. of Energy Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program database