Tuolumne County Stream Team

Water Quality Monitoring Report 2008-09

Tuolumne County
Resource Conservation District

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Table 1: List of Abbreviated Terms & Symbols

cm	centimeters
CWRCB	California Water Resources Control Board
DO	Dissolved Oxygen
DWR	Department of Water Resources
SC	Specific Conductivity
µS/cm	Microsiemens/cm (unit of electrical conductivity)
mg/l	Micrograms per liter
mpn	Most probable number
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units (water cloudiness)
ppm	Parts per million
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SNC	Sierra Nevada Conservancy
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WRCB	Water Resources Control Board (see also CWRCB)

Table 2: Conversion Table – Centigrade (Celsius) to Fahrenheit. ^{0}Fahrenheit – 32 ÷ 1.8 = ^{0}Celsius or C= 5/9 F -17.777.

°C	°F	°C	°F
0	32	20	68
1	33.8	21	69.6
2	35.6	22	71.6
3	37.4	23	73.4
4	39.2	24	75.2
5	41	25	77
6	42.8	26	78.8
7	44.6	27	80.6
8	46.4	28	82.4
9	48.2	29	84.2
10	50	30	86
11	51.8	31	87.8
12	53.6	32	89.6
13	55.4	33	91.4
14	57.2	34	93.2
15	59	35	95
16	60.8	36	96.8
17	62.6	37	98.6
18	64.4	38	100.4
19	66.2	39	102.2

Table 3: Conversion Table – Centimeters to Inches. Cm X 0.39 = inches.

Cm	In	Cm	In
1	0.4	21	8.3
2	0.8	22	8.7
3	1.2	23	9.1
4	1.6	24	9.4
5	2.0	25	9.8
6	2.4	26	10.2
7	2.8	27	10.6
8	3.1	28	11.0
9	3.5	29	11.4
10	3.9	30	11.8
11	4.3	31	12.2
12	4.7	32	12.6
13	5.1	33	13.0
14	5.5	34	13.4
15	5.9	35	13.8
16	6.3	40	15.7
17	6.7	45	17.7
18	7.1	50	19.7
19	7.5	55	21.7
20	7.9	60	23.6

Chapter 1. Introduction

1.1. Project History & Purpose

The Tuolumne County Stream Team was formed in 2006 in conjunction with the publication of the Foothill Watershed Assessment and Tuolumne County Water Quality Plan. Both of these documents can be downloaded from the TCRCD website (www.tcrcd.org). These publications identified three primary threats to the county's water quality:

- Soil erosion and sediment delivery to waterways
- Total and fecal coliform bacteria, associated pathogens, and nutrients
- Urban contaminants (eg. trace metals, herbicides, hydrocarbons, solvents, etc.)

The *Tuolumne County Water Quality Plan* includes recommended programs to improve these and other water quality parameters through implementation of multiple programs (e.g., improved erosion control, public education and outreach). The Tuolumne County Stream Team was charged with collecting ongoing information on the health of surface waters countywide. In January, 2007, the Tuolumne County Stream Team was transferred from Tuolumne County to the Tuolumne County Resource Conservation District to ensure continued program oversight.

Members of the Tuolumne County Stream Team are volunteers from the community that have been trained in standardized water quality sampling methods. Collection and analysis of water samples by the Stream Team occurs in compliance with the protocols established pursuant to the Tuolumne County Water Quality Plan's Quality Assurance Project Plan (QAPP) reviewed and approved by the State Water Resources Control Board. These protocols have been summarized in a Water Quality Field Manual used by the members of the Stream Team. When applicable, Stream Team results have been compared to water quality objectives set by the USEPA and/or the Central Valley Regional Water Quality Control Board Basin Plan.

The Tuolumne County Stream Team meets a minimum of once yearly to discuss sampling protocols, problems encountered, and monitoring results with other members of the team. Special training sessions are added from time to time to expand the parameters measured by the members of the Stream Team. Communication with the Stream Team is facilitated through a subscription-based email list, available through the TCRCD website (www.tcrcd.org).

1.2. Monitoring Location and Dates.

Table 4: 2008-2009 Stream Team monitoring locations

Location Description	County Code	County Site #
Big Creek @ Ferretti Road	BC-01	21
Curtis Creek @ Lime Kiln Rd.	CRT-01	11
Curtis Creek @ Tuolumne Road	CRT-02	12
Curtis Creek tributary @ Standard Rd.	STD-01	13
Garrote Creek @ GCSD Driveway	GC-01	20
Mt. Eaton Ditch @ Buchanan Mine Rd.	MED-01	18
Peppermint Creek @ Pulpit Rock Road	PMT-01	3
Sonora Creek @ Southgate Drive	SRA-01	7
Sullivan Creek @ Creekside Dr. opposite Fern Lane	SV-03	27
Sullivan Creek @ Longeway Road	SV-01	24
Sullivan Creek @Bergel Road-SR 108	SV-06	30
Sullivan Creek @Buena Vista Avenida	SV-04	28
Sullivan Creek @Potato Ranch Road	SV-05	29
Sullivan Creek tributary across from Brentwood Lake	SV-07	*
Turnback Creek @ Old Buchanan Mine Rd	TBK-04	19
Turnback Creek @ Tuolumne Road	TBK-01	15
Turnback Creek @ Yosemite Road	TBK-03	17
Twain Harte Creek @ Crystal Falls Drive	TH-02	25
Twain Harte Creek @ Eproson Park	TH-01	23
Woods Creek @ Rawhide Road Bridge	WD-01	4
Woods Creek @ Rotary Park	WD-03	6
Woods Creek @ Sonora High School	WD-04	*

*new site as of 2008-2009 sample season

Table 5. 2008-2009 Stream Team monitoring dates.

Monitoring Dates
November 1, 2008
December 5-6, 2008
January 2-3, 2009
February 6-7, 2009
March 6-7, 2009
April 3-4, 2009
May 1-2, 2009
June 5-6, 2009

Monitoring was scheduled for the first weekend of each month during the rainy season (normally October/November through June). In order to accommodate volunteers' busy schedules and to share limited sampling equipment, during each Stream Team event sites were sampled by volunteers at some point between Friday morning and Saturday afternoon. This variability of sampling days and times affected the consistency of our data (eg. sites sampled in the afternoon had higher air and water temperatures than those sampled in the morning). However, this flexibility in sampling times allowed us to continue detecting patterns in water quality indicators, while encouraging broad-based community participation and using limited equipment.

1.3. Executive Summary of 2008/2009 Season

Twenty-two (22) sites were monitored by forty-five (45) volunteers in the 2008-2009 Tuolumne County Stream Team season. Highlights of monitoring results include:

- Water temperatures measured at each site were a function of time and weather conditions during each sample, as well as site-specific factors such as elevation, aspect, and surrounding vegetation. Woods Creek at Sonora High School had the highest average water temperature (mean across all sample dates) while Turnback Creek at Old Buchanan Mine Rd. had the lowest. This is likely because each month Woods Creek at SHS was sampled on Friday afternoons after school by Sonora High volunteers, while Turnback at Old Buchanan was sampled early Saturday mornings by Summerville High Ecology Club. Sonora High is also a relatively lower elevation site, while Turnback Creek at Buchanan Mine Rd. is at a higher elevation and is shaded by surrounding topography and vegetation (>50% canopy cover). As would be expected January had the lowest temperatures (mean across all sample sites), while November and June had the highest water temperatures. The overall lowest measured water temperature was 2.7°C at Mt. Eaton Ditch at Buchanan Mine Rd. in January, while the highest was 16.9°C in Peppermint Creek at Pulpit Rock Rd. in June.

- At most sites, pH samples were generally in the circumneutral range (6.5-8.5), indicating that pH levels in creeks throughout the county tend to be at healthy levels for most aquatic organisms. Overall pH measurements were often slightly alkaline, which could be related to equipment drift, as post-sample calibration indicated that Stream Team pH meters had a tendency to read slightly high. The highest average pH levels (mean across all dates) were found at Sonora Creek at South Gate Dr. and Woods Creek at Rawhide Rd., while the tributary to Sullivan Creek across Middlecamp Rd. from Brentwood tended to have the lowest pH (more acidic). The month of March had the highest average pH (mean across all sites) while November had the lowest. Highest observed pH was 9.3 in Woods Creek at Rawhide Rd. in June and the lowest was 6.2 in Turnback Creek at Old Buchanan Rd. in December.

- Specific Conductivity (SC) results varied greatly from month to month. The three sites in Woods Creek (at Sonora High, Rotary Park, and Rawhide Rd.) had the highest average SC readings (mean across all dates). The tributary to Curtis Creek at Standard Rd. site continued to have relatively elevated levels, as has been noted in previous years, likely related to current or historical land use practices in surrounding areas upstream from the site. Sullivan Creek at Potato Ranch Rd. had the lowest mean SC. November had the lowest average SC (mean across all sites), while June had the highest.

- Dissolved Oxygen (DO) measurements showed healthy levels throughout the county, the great majority of samples exceeding the RWQCB Basin Plan standard of 7.0 mg/L for cold water habitat. The highest average DO (mean across all dates) was in Groveland Creek at the GCSD driveway. The lowest average DO (mean across all dates) was found at Turnback Creek at Yosemite Rd. As would be expected, samples taken during cooler months (December-April) generally had higher DO levels than warm months (November and May-June).

- Turbidity measurements tended to be relatively low, indicating that water samples collected during Stream Team events had good clarity. Higher turbidity levels corresponded with samples collected during or directly following rain events. Because erosion and sedimentation processes take place very episodically during rain events, Stream Team samples likely did not capture the maximum turbidity levels that occurred in the county during the 2008-09 rainy season. The highest average turbidity (mean across all dates) was Sullivan Creek at Potato Ranch Rd. The lowest average turbidity (mean across all dates) was observed at Twain Harte Creek at Crystal Falls Dr. This site is directly below the dam at Lower Crystal Falls Lake, which may slow water and allow some suspended particles to settle out before reaching the sample site. May and November had the highest average turbidity levels, while April had the lowest. The highest overall turbidity level was 199 NTU measured in the tributary to Sullivan Creek across Middlecamp Rd. from Brentwood Lake in November.

- *E. coli* levels at Stream Team sites varied greatly across sites and months. The significant number of samples that had *E. coli* levels beyond EPA standards indicates that there is a potential human health risk associated with immersion in many county streams. The month of May had the greatest number of sites exceeding EPA guidelines, while December, February, and April tended to have lower levels. Variability was likely related to changes in precipitation, soil saturation, storm water runoff, and other factors. Big Creek at Ferretti Rd., Curtis Creek at Tuolumne Rd., Curtis Creek tributary at Standard Rd., and Sullivan Creek at Longeway Rd. were all below EPA standards each month. All other sites exceeded standards during at least one sample event. The highest overall *E. coli* levels were observed in Woods at Rawhide Rd. and Peppermint Creek at Pulpit Rock Rd. in May.

1.4. Training and Meetings

The Stream Team held its annual kick-off meeting October 24, 2008 at the TCRCD office to discuss consistency with various protocols and sampling plan for the 2008-09 season.

On November 8, 2008 a training session for new Stream Team volunteers was held at Sonora High School and over 20 new participants attended. After participating in training session, new volunteers accompanied experienced volunteers for 1-2 sample events before going into the field independently.

1.5. Equipment & Supplies - Needs

The Stream Team is continually in need of additional funding to pay for equipment maintenance and calibration supplies, reagents and sterile bottles for bacteria samples, as well as new equipment and supplies to expand the Stream Team's capacity.

Chapter 2. Water Quality Indicators

Much of the following is excerpted from the Tuolumne County Stream Team Monitoring Handbook (4th Edition, Terry Strange, Strange Aquatic Resources with information compiled from the US Environmental Protection Agency and California State Water Resources Control Board Clean Water Team).

The following parameters are measured by members of the Tuolumne County Stream Team. These indicators of stream health were recommended for ongoing monitoring by the Tuolumne County Water Quality Plan (2007) and Tuolumne County Foothill Watershed Assessment (2007). Both documents can be found online at www.tcrcd.org.

2.1. Temperature – Air

Air temperature affects water temperature. The importance of water temperature is described in Section 2.2.

2.2. Temperature – Water

Importance of Water Temperature

Temperature is one of the most important water quality parameters. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperature ranges vary among different organisms: some survive best in colder water, whereas others prefer warmer water. If water temperatures are outside this optimal range for a prolonged period of time, organisms can be stressed, fail to reproduce, and can die. Temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases.

Factors Affecting Water Temperatures

Natural Factors

- Sunlight energy such as seasonal and daily changes, effects of shade (cover), and air temperature
- Wind speed at water surface
- Stream flow
- Depth of water
- Inflow of groundwater which is usually colder than creek water
- Inflow of surface water including a drainage ditch or another creek
- Color and turbidity of water (suspended sediment absorbs heat)

Human Factors

- Removal of riparian vegetation

- Soil erosion, filling in deep pools that were once cold, dark refugia for fish
- Stormwater runoff from hot impervious surfaces
- Alterations to stream morphology, substrate and flow
- Cooling water discharges from power plants
- Water diversion or storage resulting in decreased flows
- Water originating from surface or bottom of reservoir

Acceptable Water Temperature Ranges

Acceptable temperature ranges depend on site-specific biotic community. For example, the table below demonstrates the acceptable temperature range for selected fish.

Table 6. Maximum weekly average temperature for growth and short-term maximum temperatures for selected fish*

Species	Growth	Maxima	Spawning**	Embryo Survival***
Bluegill	32°C (90°F)	35°C (95°F)	25°C (77°F)	34°C (93°F)
Carp		21°C (70°F)	33°C (91°F)	
Channel catfish	32°C (90°F)	35°C (95°F)	27°C (81°F)	29°C (84°F)
Largemouth bass	32°C (90°F)	34°C (93°F)	21°C (70°F)	27°C (81°F)
Rainbow trout	19°C (66°F)	24°C (75°F)	9°C (48°F)	13°C (55°F)
Sockeye salmon	18°C (64°F)	22°C (72°F)	10°C (50°F)	13°C (55°F)
Coho Salmon	16.5°C (62°F)	22°C (72°F)		
Steelhead	20.5°C (69°F)	24°C (75°F)		
Chinook		24°C (75°F)	6-13°C (43-55°F)	5-13°C (41-55°F)

* Adapted from EPA's *Draft Volunteer Stream Monitoring: A Method Manual. An Analysis of the Effects of Temperature on Salmonids of the Pacific Northwest with Implications for Selecting Temperature Criteria.* Sullivan, K., D.J. Martin, R.D. Cardwell, J.E. Toll, and S. Duke. 2000

** The optimum or mean of the range of spawning temperatures reported for the species.

*** The upper temperature for successful incubation and hatching reported for the species

2.3. pH

pH is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 0.0 to 14.0. As acidity increases the pH gets lower. The pH scale measures the logarithmic concentration of hydrogen (H+) and hydroxide (OH-) ions, which make up water (H+ **+** OH- = H2O). When both types of ions are in equal concentration, the pH is 7.0 or neutral. Below 7.0, the water is acidic (there are more hydrogen ions than hydroxide ions). When the pH is above 7.0, the water is alkaline, or basic (there are more hydroxide ions than hydrogen ions). Since the scale is logarithmic, a drop in the pH by 1.0 unit is equivalent to a 10-fold increase in acidity. So, a water sample with a pH of 5.0 is 10 times as acidic as one with a pH of 6.0, and a pH of 4.0 is 100 times as acidic as a pH of 6.0.

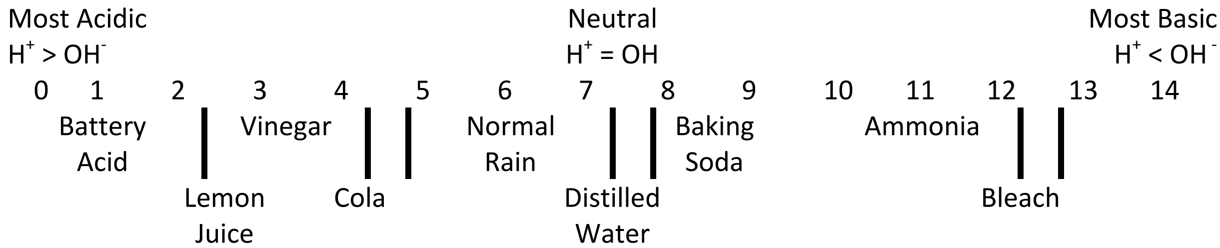


Figure 1. pH scale showing the value of some common substances (Source: U.S. Fish and Wildlife Service)

Importance of pH

pH affects many chemical and biological processes in the water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefers a range of 6.5-8.5. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and available for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species like rainbow trout. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, and certain wastewater discharges.

Input of basic or acidic substances (anthropogenic or natural)

pH can change because of external inputs. Variations in pH along a stream may due to:

- Changes in tree types surrounding the water, for example conifer needles are acidic and maple leaves are basic.
- Changes in adjacent soils or rock types and erosion events.
- Changes in the stream bottom material, for example the difference between gravel, silt, and bedrock.
- Large changes in temperature affecting the CO_2/O_2 (carbonic acid) cycle in the water.
- Changes in human activity affecting the stream.

Other Factors

- In fresh water, increasing temperature decreases pH.
- Waters with high algal growth can show a diurnal change in pH. When algae grow and reproduce they use carbon dioxide. This reduction causes the pH to increase. Therefore, if conditions are favorable for algal growth (sunlight, warm temperatures), the water will be more alkaline. Maximum pH usually occurs in late afternoon, pH will decline at night. Because algal growth is restricted to light penetrating zones, pH can vary with depth in lakes, estuaries, bays and ocean water.
- High levels of bacterial activity in sediments can cause associated water to become acidic.
- Human-made inputs that reduce pH include acid rain (from automobiles or industrial sources) and acid mine drainage. Nutrients can indirectly affect pH by stimulating algal growth.

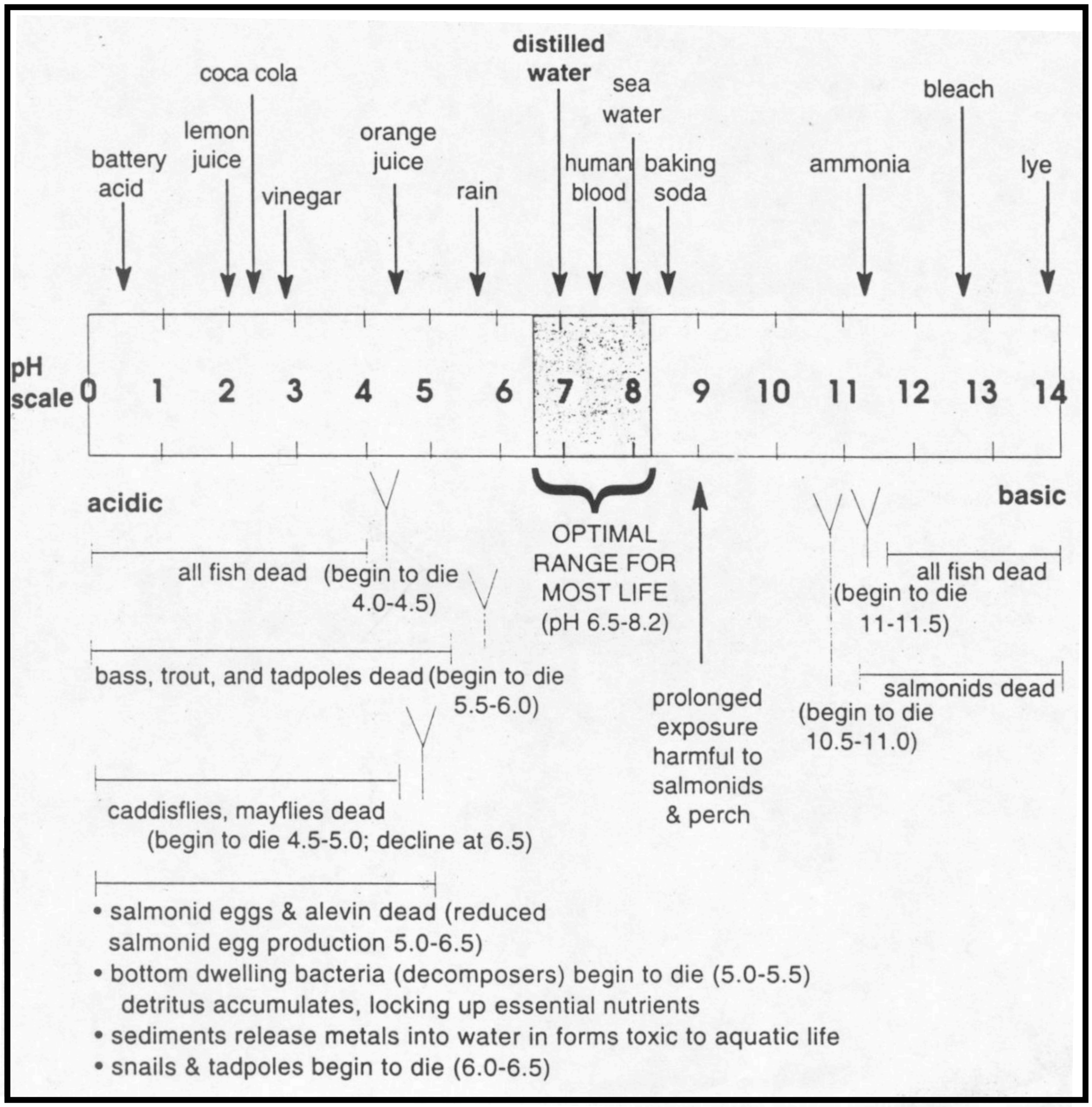


Figure 2. Lethal pH limits for selected aquatic organisms. From “The Stream keeper’s Field Guide” Watershed Inventory and Stream Monitoring Methods. Murdoch, Cheo, O'Laughlin, Adopt-A-Stream Foundation. SECOND EDITION, 1996.

2.4. Specific Conductivity

Conductivity is the ability of water to conduct an electrical current. Dissolved ions in the water are conductors. The major positively charged ions are sodium (Na^+) calcium (Ca^{2+}), potassium (K^+) and magnesium (Mg^{2+}). The major negatively charged ions are chloride (Cl^-), sulfate (SO_4-2), carbonate (CO_3-2), and bicarbonate (HCO_3-). Nitrates (NO_3-2) and phosphates (PO_4-3) are minor contributors to conductivity, although very important biologically.

Salinity is a measure of the amount of salts or ions in the water. Because dissolved ions increase salinity as well as conductivity, the two values are related. The salts in sea water are primarily sodium chloride (NaCl). However, other saline waters, such as Mono Lake, owe their high salinity to a combination of dissolved ions including sodium, chloride, carbonate and sulfate.

Specific conductivity, which is measured by the Stream Team, is the conductivity normalized to a temperature of 25°C.

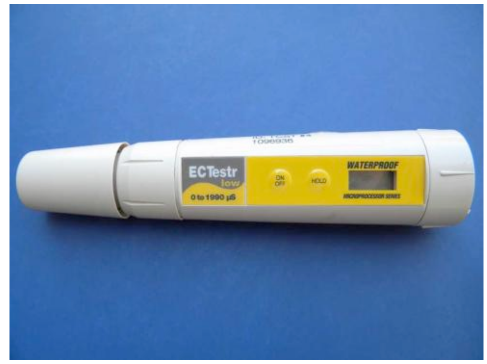


Figure 3: Stream Team Oakton Electrical Conductivity meter.

Importance of Conductivity

Conductivity can affect the quality of water used for irrigation or drinking. Most aquatic biota tolerate a range of conductivity. However, the ionic composition of the water can be critical. For example, cladocerans (water fleas) are far more sensitive to potassium chloride than sodium chloride at the same concentration.

Conductivity varies with water source such as ground water, water drained from agricultural fields, municipal wastewater, and rainfall. Therefore, conductivity measurements can be used identify groundwater seepage or a sewage leak.

What Affects Conductivity of Water

- Soil and rocks release ions into water that flows through or over them. The geology of a certain area will determine the amount and type of ions.
- Salinity and conductivity of coastal rivers are influenced by tides. Sea spray can carry salts into the air that then fall back into the rivers with rainfall.
- De-icing salt used on roads and driveways can easily end up in nearby streams and affect salinity until diluted by large volumes of low salinity water.
- Flow of rivers into estuaries can greatly affect salinity as well as the location of the estuarine mixing zone. This is very important to the survival of estuarine organisms.
- Fresh water lost by evaporation will increase the conductivity and salinity of the waterbody. Warm weather can increase ocean salinity.
- As temperature increases, conductivity increases. Salinity is the amount of salt actually present in the water; therefore, it is not dependent on temperature.

Acceptable Conductivity Ranges

Possible data ranges encountered in the field are shown in Table 7. Waters that might have higher conductivity than reported here are rivers or drainage ditches dominated by subsurface agricultural return flows; ephemeral streams or pools late in the season; tidally influenced coastal waters; and naturally saline lakes or ponds.

Table 7. Electrical conductivity ranges of various water types.

Water Type	Conductivity (μS/cm)
Distilled Water	0.5 - 3.0
Melted snow	2 - 42
Potable water in U.S.	30 - 1500
Irrigation Supply Water	< 750

2.5. Dissolved Oxygen

The amount of oxygen dissolved in water is measured in parts per million (ppm) or milligrams/liter (mg/L). While precise conversion between these units depends on water density, for the purposes of the Stream Team we consider 1 ppm=1 mg/L.

Importance of Dissolved Oxygen (DO)

The creek system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants as a result of photosynthesis. Running water, because of its churning, dissolves more oxygen than still water, such as that of a reservoir behind a dam. Most aquatic organisms need oxygen to survive and grow. Some species, such as trout and stoneflies require high levels of DO, while other species such as catfish, worms and dragonflies, are more tolerant of decreased levels.

A depletion of DO in water can potentially affect aquatic biotic communities by causing the death of adults and juvenile, a reduction in growth, failure of fish eggs/insect larvae to survive, a change in species present; and/or growth of toxic or smothering bacteria, fungi, or algae.

Factors Affecting Dissolved Oxygen Levels in Water

<u>Pollution</u>

If organic material (e.g. algae) or waste (e.g. septic leaks) is present in water, bacteria quickly move in to decay the material. As they respire and feed on the decaying material, they use up oxygen and generate CO_2 in the water. Large algae blooms (caused by events like people dumping lawn clippings or leaves, or fertilizer runoff) can create near-zero oxygen conditions in creeks.

<u>Temperature</u>

As temperature increases, less oxygen can be dissolved in water. When water holds all the DO it can at a given temperature, it is said to be 100 percent saturated with oxygen. Water can be supersaturated with oxygen under certain conditions (e.g. below large dams where discharging flows are very turbulent). The following table shows the concentration of dissolved oxygen that is equivalent to the 100 percent saturation for the noted temperature (and normal barometric pressure) in fresh water.

Dissolved Oxygen Saturation

Table 8. 100% Dissolved Oxygen saturation at sea level.

Temperature (degrees Celsius)	Dissolved Oxygen (mg/L)	Temperature (degrees Celsius)	Dissolved Oxygen (mg/L)
0	14.6	16	9.9
1	14.2	17	9.7
2	13.8	18	9.6
3	13.5	19	9.3
4	13.1	20	9.1
5	12.8	21	8.9
6	12.5	22	8.7
7	12.1	23	8.6
8	11.8	24	8.4
9	11.6	25	8.3
10	11.3	26	8.1
11	11.0	27	8.0
12	10.8	28	7.8
13	10.5	29	7.7
14	10.3	30	7.6
15	10.1	31	7.5

Figure 4: LaMotte Dissolved Oxygen Kit used by Stream Team.

Sources of Dissolved Oxygen (DO)

Oxygen is added to water by:

- <u>Re-aeration</u>: Oxygen from air is dissolved in water at its surface, mostly through turbulence. Examples of this include water tumbling over rocks (rapids, riffles, curves in the waterway) and wave action.
- <u>Photosynthesis:</u> Plants produce oxygen when they photosynthesize. DO is generally highest in the late afternoon, and lowest in the early morning hours before sunrise.

Consumption of Dissolved Oxygen (DO)

Dissolved oxygen is used in two major ways—both of which contribute to the Biological Oxygen Demand (BOD) of the creek system:

<u>Respiration</u>

- Aquatic organisms breathe and use oxygen.
- Large amounts of oxygen are consumed by algae and aquatic plants at night (when large masses of plants are present).
- Large amounts of oxygen are consumed by decomposing bacteria (when there are large amounts of dead material to be decomposed, there will be significant numbers of bacteria).

<u>Substances</u>

Examples of substances that breakdown and use oxygen in the process are generally biodegradable and include dead organic matter, algae, sewage/feed lot waste, yard clippings/yard waste, oil/grease, and fertilizer runoff.

Causes of Low Dissolved Oxygen (DO) Levels

- Increases in water temperature
- Algal blooms
- Human waste
- Animal waste (especially from feedlots/dairy farms)
- Depletion near the bottom of reservoirs by bacteria

Other Factors

- Altitude—water holds less oxygen at higher altitudes
- Salinity—dissolved oxygen decreases as salinity increases
- Mineral content—dissolved oxygen decreases as the mineral content/concentration of the water increases

Acceptable Dissolved Oxygen (DO) Ranges

The RWQCB Basin Plan standard for cold water habitat is 7.0 mg/L. The following table gives specific DO values required for the health of various species:

Table 9. Biologic effects of decreasing Dissolved Oxygen (DO) levels on salmonids, non-salmonids fish, and aquatic invertebrates

	DO (mg/mL) Instream	Intergravel
I Salmonid waters		
A. Embryo and larval stages		
No production impairment	11	8
Slight production impairment	9	6
Moderate production impairment	8	5
Severe production impairment	7	4
Limit to avoid acute mortality	6	3
B. Other life stages		
No production impairment	8	
Slight production impairment	6	
Moderate production impairment	5	
Severe production impairment	4	
Limit to avoid acute mortality	3	
II. Non-Salmonid waters		
A. Early Life stages		
No production impairment	6.5	
Slight production impairment	5.5	
Moderate production impairment	5	
Severe production impairment	4.5	
Limit to **avoid** acute mortality	4	
B. Other life stages		
No production impairment	6	
Slight production impairment	5	
Moderate production impairment	4	
Severe production impairment	3.5	
Limit to avoid acute mortality	3	
III. Invertebrates		
No production impairment	8	
Some production impairment	5	
Limit to avoid acute mortality	4	

2.6. Turbidity

Turbidity is a measure of water clarity and how much the material suspended in the water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. Turbidity can affect the color of the water. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing the resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates.

Figure 5. Hach Turbidimeter used by Stream Team.

Sources of Turbidity

- Soil erosion
- Waste discharge
- Urban runoff
- Eroding stream banks
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments
- Excessive algal growth (e.g. phytoplankton)

Why Measure for Turbidity

Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activity, discharges, and other sources. Turbidity often increases sharply during a rainfall, especially in developed watersheds, which typically have relatively high proportions of impervious surfaces. The flow of storm water runoff from impervious surfaces rapidly increases stream velocity, which increases the erosion rates of stream banks and channels. Turbidity can also rise sharply during dry weather if earth-disturbing activities are occurring in or near a creek without erosion control practices in place.

Regular monitoring of turbidity can help detect trends that might indicate increasing erosion in watersheds. However, turbidity is closely related to stream flow and velocity and should be correlated with these factors. Comparisons of the change in turbidity over time, therefore, should be made at the same point at the same flow.

Turbidity is not a measurement of the amount of suspended solids present or the rate of sedimentation of a stream since it measures only the amount of light that is scattered by suspended particles. Measurement of Total Suspended Solids (TSS) is a more direct measure of the amount of material suspended and dissolved in water.

2.7. Fecal Indicator Bacteria

Fecal bacteria are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. *E. coli* is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. Because total coliform bacteria are naturally found in the environment in soils, degrading leaves, and other sources, they are no longer commonly used as a water quality indicator.

Importance of Bacteria

Most strains of *E. coli* bacteria are generally not harmful by themselves, but in freshwater they are used as indicators of the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Elevated levels of these bacteria can cause health problems (including ear infections, upset stomachs, and urinary tract infections), cloudy water, unpleasant odors, and an increased biological oxygen demand (the amount of oxygen consumed by microorganisms in breaking down waste). The US EPA recommends *E. coli* as the best indicators of health risk from water contact in fresh-water.

Sources of Fecal Coliform

- Wastewater treatment plants
- On-site septic systems
- Domestic and wild animal manure
- Storm runoff

Acceptable Fecal Indicator Bacteria Ranges

The USEPA has developed contact recreation guidelines for *E. coli* in fresh water. Stream Team results were compared to the swimming level of contact at <235 MPN *E. coli*/100ml as the water quality threshold to indicate a potential concern.

Table 10. USEPA contact recreation guidelines for *E. coli.*

Level of Contact	**USEPA *E. coli* Guideline (MPN/100ml)**
Swimming	<235
Designated beach area	235-297
Moderate full body contact	298-408
Light full body contact	409-574
Infrequent full body contact	>574

2.8. General Stream Conditions

In addition to measuring general water quality indicators, Stream Team volunteers also observed and recorded general physical stream characteristics including: water murkiness (ranging from clear to cloudy to murky based on the depth in inches below the surface that is visible), percent canopy (percentage of tree cover), presence of algae or water plants, presence or absence of an oily sheen, presence or absence of foam or suds, and presence or absence of litter (generally defined as small scattered pieces of garbage) or trash (generally defined as larger and more concentrated garbage). Recording these general stream conditions assists in interpretation of monitoring results and provides a record of stream changes over time.

Stream Team members also recorded general weather conditions including cloud cover, precipitation, and wind because these conditions directly affect water and air temperatures, the volume of water in-stream, and may affect the volume of run-off from the surrounding watershed into streams.

Except for the most significant observations, which are noted in results section, most descriptions of general stream characteristics and weather conditions recorded at each site are not included in this report, but are used to interpret the quantitative data and will be saved in database.

Chapter 3. Results

3.1. Big Creek at Ferretti Rd.

Table 11. Monthly water quality indicators Big Creek at Ferretti Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Jan 09	6.7	4.2	7.3	200	>10.0	0.6	n/a
Feb 09	2.5	5.7	7.2	250	10.0	0.5	31
Mar 09	16.0	8.6	7.7	80	>10.0	5.4	31
Apr 09	17.0	12.0	7.6	110	>10.0	1.2	10
May 09	13.0	16.0	7.5	80	9.3	2.6	108
Jun 09	16.5	14.3	6.9	210	8.2	1.7	231

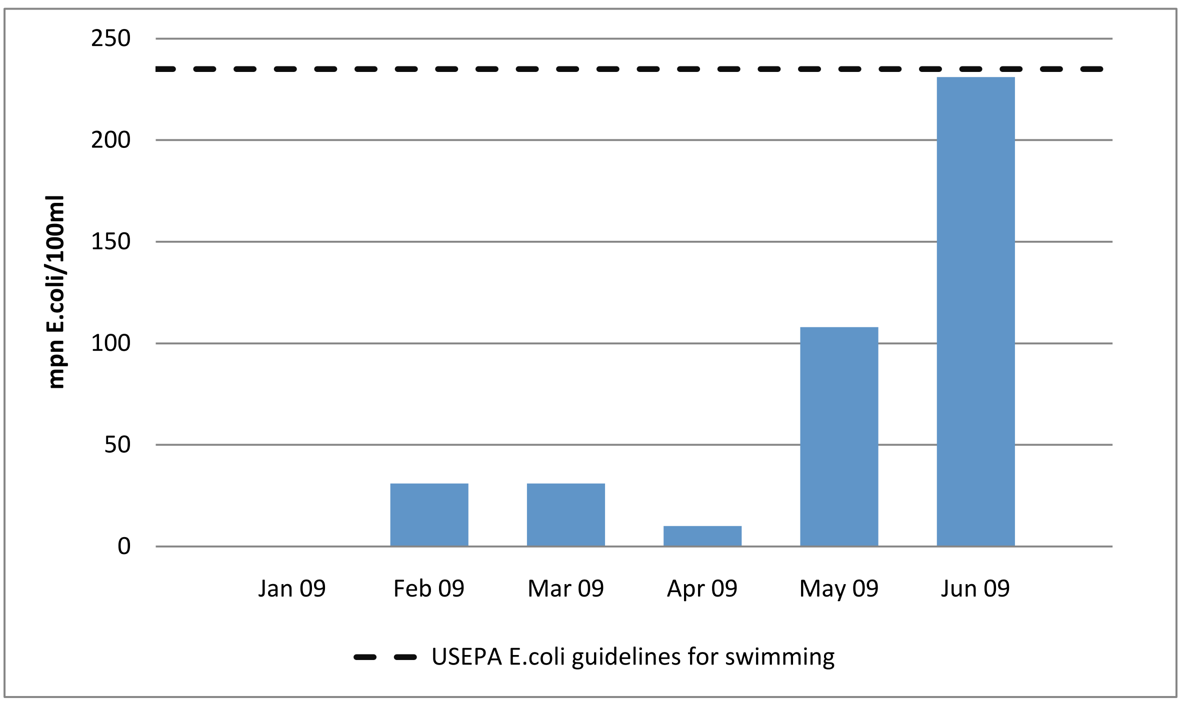
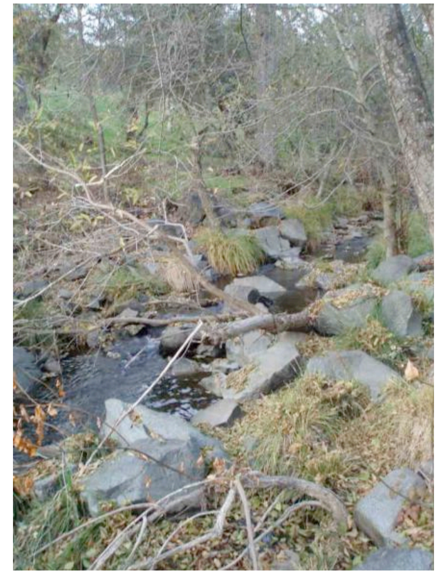


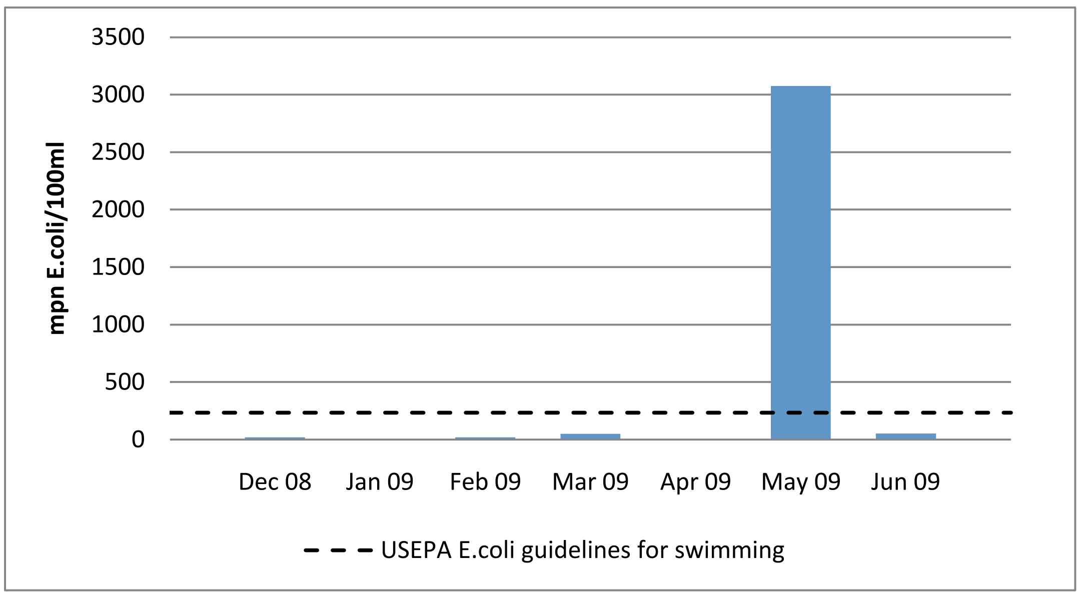
Figure 6. Monthly *E. coli* levels at Big Creek at Ferretti Rd.

3.2. Curtis Creek at Lime Kiln Rd.

Table 12. Monthly water quality indicators at Curtis Creek at Lime Kiln Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	11.3	9.3	8.0	260	9.3	0.5	20
Jan 09	6.8	5.7	8.3	213	9.6	2.4	n/a
Feb 09	7.8	7.5	8.3	260	9.7	2.0	20
Mar 09	10.5	5.8	8.0	180	>10.0	6.7	51
Apr 09	12.5	12.0	8.1	270	9.5	1.3	n/a
May 09	14.5	13.8	8.2	157	8.5	57.7	3076
Jun 09	16.3	16.6	7.8	200.0	8	1.7	52





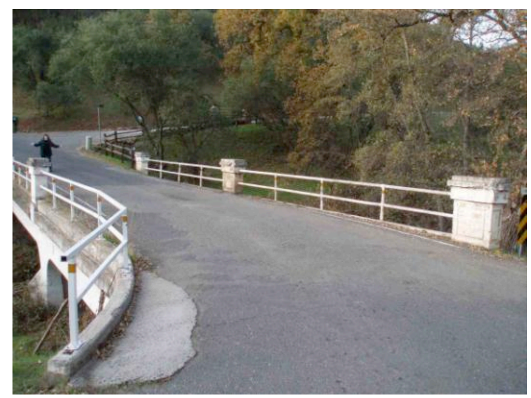
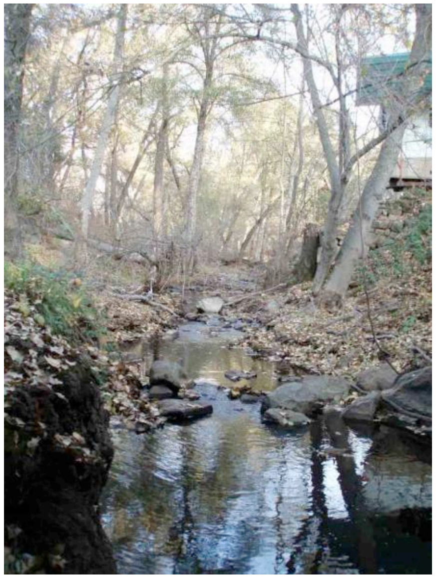


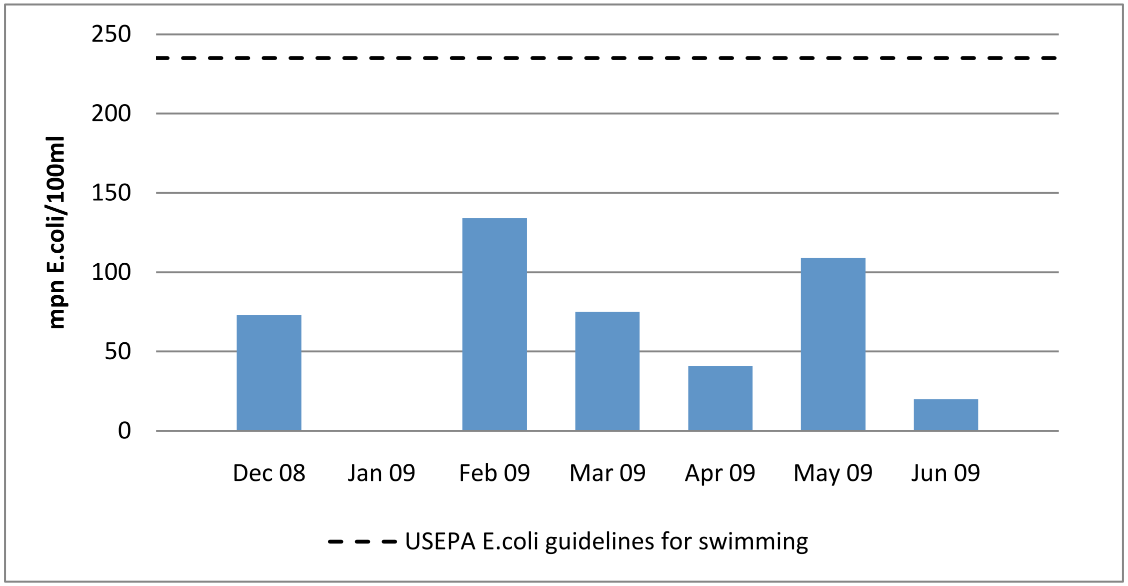
Figure 7. Monthly *E. coli* levels at Curtis Creek at Lime Kiln Rd.

3.3. Curtis Creek at Tuolumne Rd.

Table 13. Monthly water quality indicators at Curtis Creek at Tuolumne Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	11.8	8.9	7.6	210	8.9	2.1	73
Jan 09	7.0	6.2	8.0	180	9.3	180	n/a
Feb 09	11.5	9.0	7.5	253	9.2	18.7	134
Mar 09	10.8	10.0	7.7	163	8.0	10.0	75
Apr 09	14.5	12.9	8.2	260	9.4	2.1	41
May 09	16.0	13.5	7.5	220	7.8	2.1	109
Jun 09	17.3	15.4	8.5	127	4.7	3.1	20





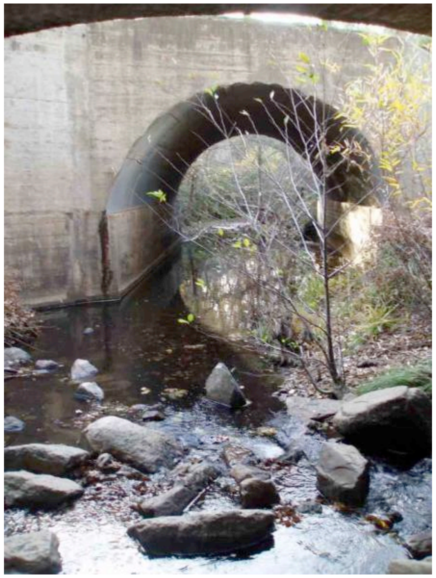


Figure 8. Monthly *E.coli* levels at Curtis Creek at Tuolumne Rd.

3.4. Curtis Creek tributary at Standard Rd.

Table 14. Monthly water quality indicators at Curtis Creek tributary at Standard Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	15.3	8.7	7.3	530	n/a	5.5	41
Jan 09	7.7	7.5	7.7	100	6.9	1.0	n/a
Feb 09	11.7	9.3	6.8	387	7.8	0.5	<10
Mar 09	11.2	11.2	7.9	230	8.1	4.9	41
Apr 09	14.0	16.1	7.7	330	4.5	0.6	31
May 09	18.7	14.8	7.5	357	6.2	0.8	52
Jun 09	14.0	15.9	7.4	413	9.0	0.8	63

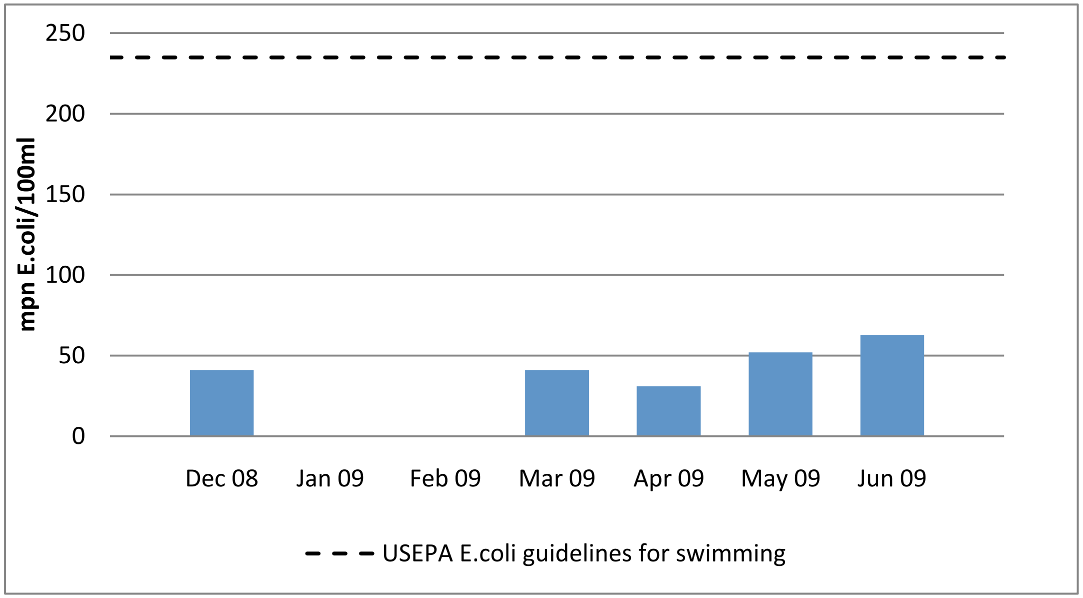


Figure 9. Monthly *E. coli* in Curtis Creek tributary at Standard Rd.

3.5. Garrotte Creek at GCSD Driveway

Table 15. Monthly water quality indicators at Garrotte Creek at GCSD.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Jan 09	3.5	4.5	7.5	250	>10.0	0.7	n/a
Feb 09	2.0	6.2	7.5	240	10.0	0.8	30
Mar 09	12.2	7.1	7.8	160	>10.0	11.2	20
Apr 09	13.0	8.0	7.7	220	>10.0	0.3	10
May 09	12.5	11.7	7.7	130	9.8	78.2	657
Jun 09	14.0	13.2	7.2	220	8.9	0.5	249

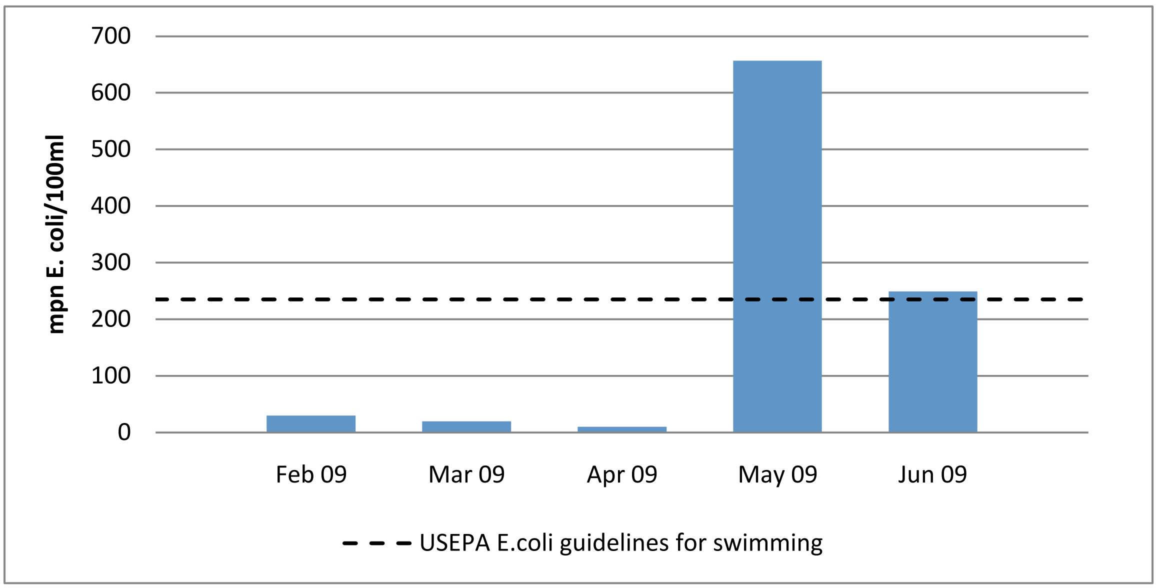
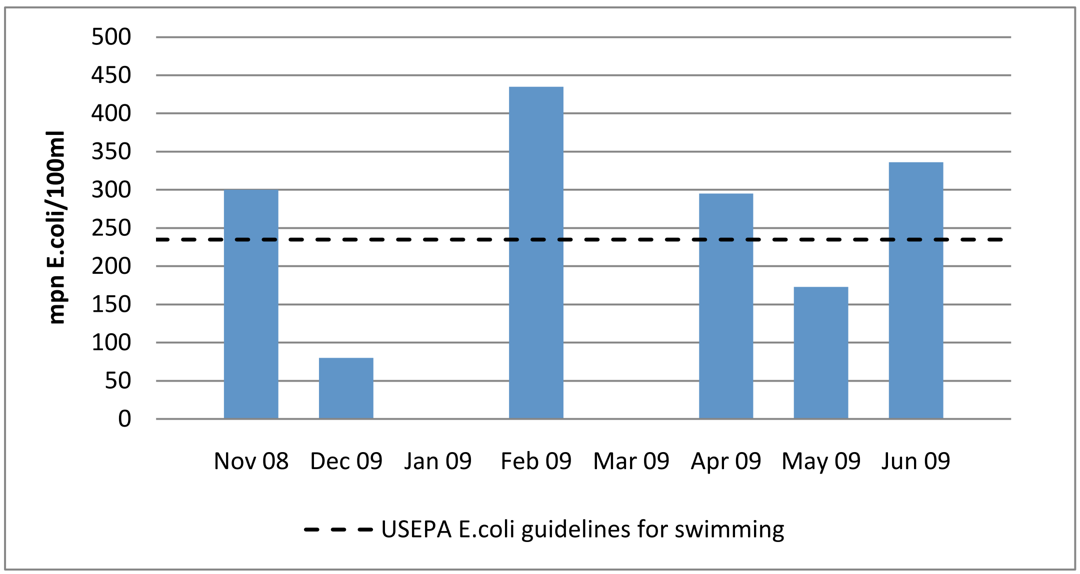


Figure 10. Monthly *E. coli* levels in Garrotte Creek at Groveland Community Service District Driveway.

3.6. Mt. Eaton Ditch at Buchanan Mine Rd.

Table 16. Monthly water quality indicators at Mt. Eaton Ditch at Buchanan Mine Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	14.2	11.9	7.1	23.3	7.9	18.1	300
Dec 09	14.2	6.7	6.2	20.0	8.3	2.6	80
Jan 09	5.3	2.7	n/a	30.0	9.0	4.6	n/a
Feb 09	5.7	5.2	8.1	30.0	8.1	4.5	435
Mar 09	7.2	5.0	n/a	73.3	5.1	9.3	n/a
Apr 09	10.0	5.0	7.6	40.0	8.2	3.9	295
May 09	11.0	10.7	7.5	40.0	5.3	40.2	173
Jun 09	12.7	11.1	7.5	10.0	7.0	11.6	336



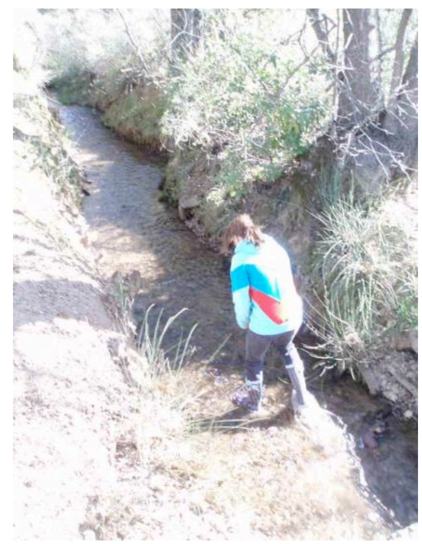


Figure 11. Monthly *E. coli* levels in Mt. Eaton Ditch at Buchanan Mine Rd.

3.7. Peppermint Creek at Pulpit Rock Rd.

Table 17. Monthly water quality indicators in Peppermint Creek at Pulpit Rock Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	5.5	7.0	7.7	360	8.9	0.6	197
Jan 09	7.2	5.7	8.0	343	8.9	0.4	n/a
Feb 09	18.7	10.3	8.2	337	9.4	1.0	52
Mar 09	12.0	7.1	8.1	240	9.8	1.5	86
Apr 09	10.8	9.6	8.6	367	7.0	0.7	30
May 09	16.0	13.3	8.7	240	8.5	19.2	1733
Jun 09	18.0	16.9	9.0	360	4.4	0.8	75

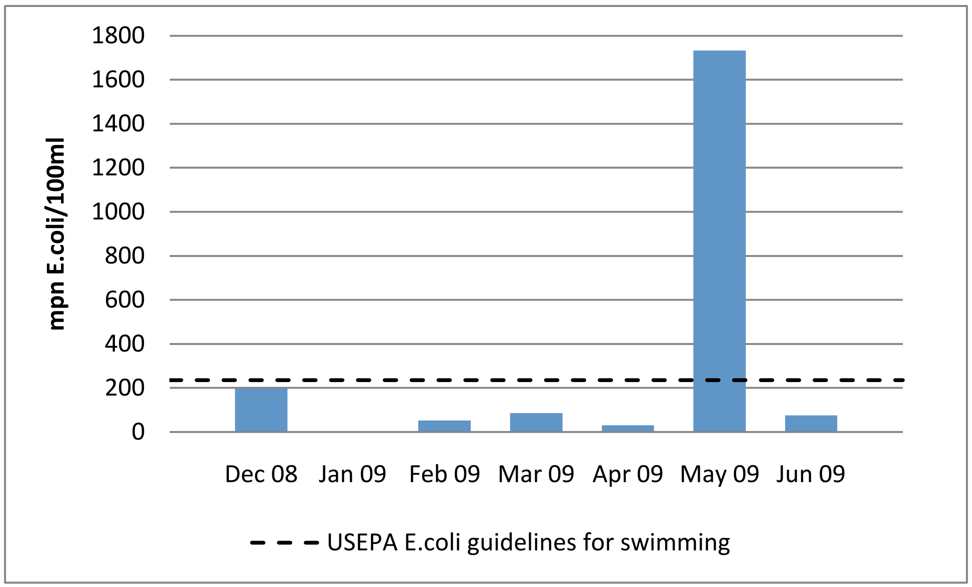


Figure 12. Monthly *E.coli* levels in Peppermint Creek at Pulpit Rock Rd.

3.8. Sonora Creek at Southgate Rd.

Table 18. Monthly water quality indicators in Sonora Creek at Southgate Dr.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	7.5	7.5	8.1	280	>10.0	0.7	345
Jan 09	3.7	6.0	8.5	260	9.2	1.9	n/a
Feb 09	9.5	9.0	8.6	310	8.1	1.5	259
Mar 09	7.5	7.2	8.4	280	>10.0	5.0	169
Apr 09	9.0	9.3	9.0	410	8.2	1.1	86
May 09	14.2	13.2	7.8	160	7.8	55.9	1291
Jun 09	21.0	16.4	9.0	270	6.0	2.6	1162

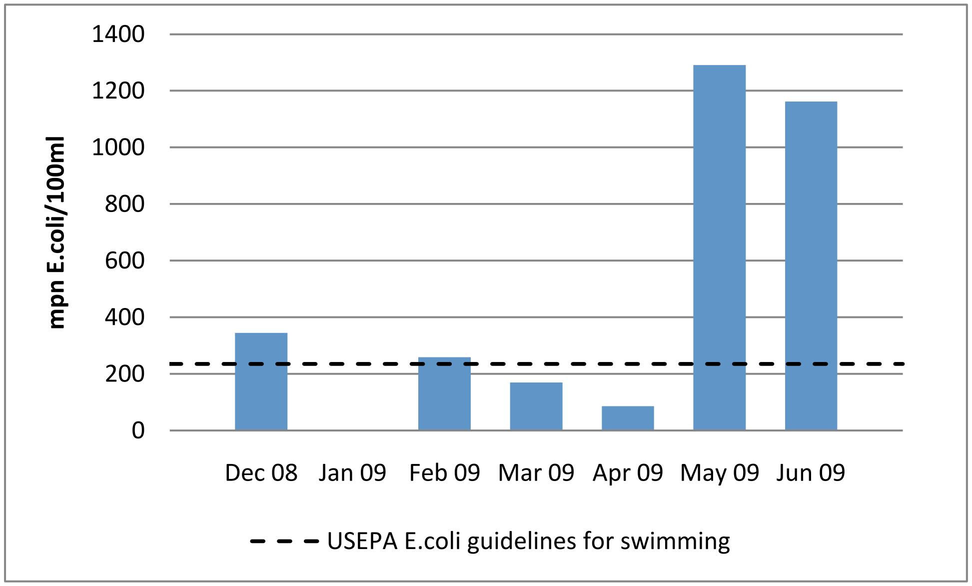
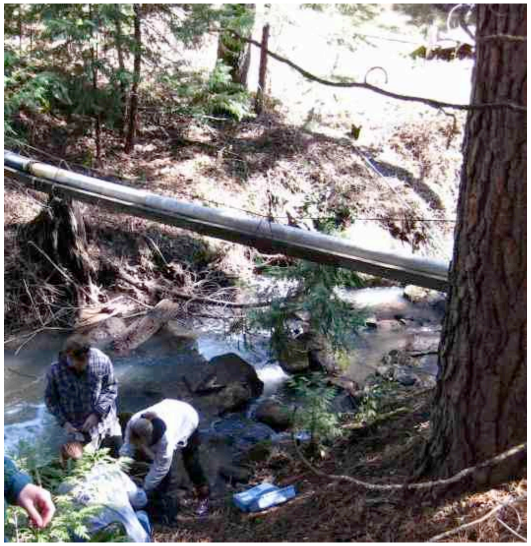


Figure 13. Monthly *E. coli* levels in Sonora Creek at Southgate Dr.

3.9. Sullivan Creek at Longeway Rd.

Table 19. Monthly water quality indicators in Sullivan Creek at Longeway Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 08	11.5	8.6	7.3	0	8.6	0.9	<10
Jan 08	3.0	4.5	7.7	35	9.0	4.6	n/a
Feb 09	9.3	6.8	7.6	44	>10.0	2.4	10
Mar 09	8.0	6.5	7.4	34	>10.0	13.7	10
Apr 09	11.3	10.4	7.5	57	9.6	2.4	<10
May 09	9.7	12.6	7.4	45	9.2	9.2	<10



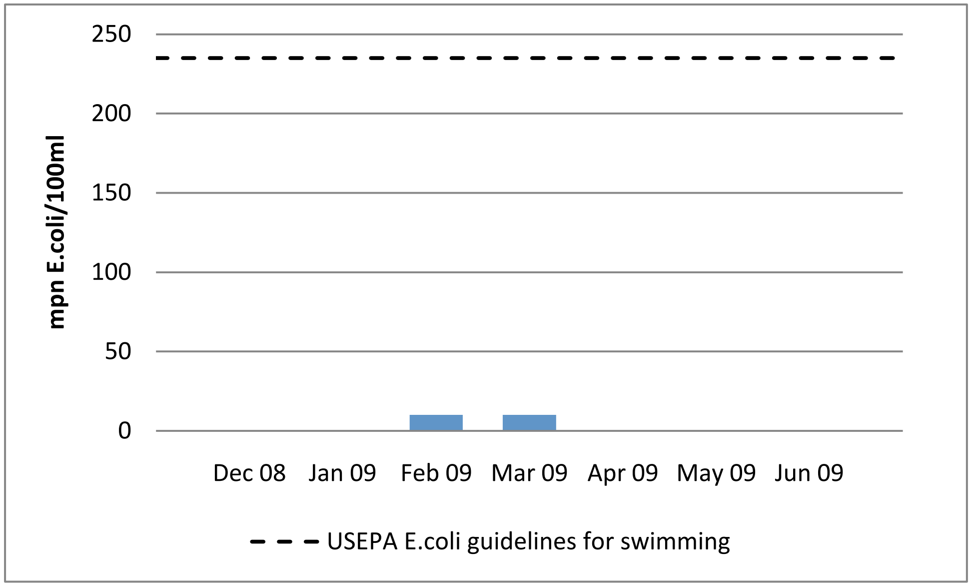


Figure 14. Monthly *E.coli* levels in Sullivan Creek at Longeway Rd.

3.10. Sullivan Creek at Creekside Dr. opposite Fern Lane

Table 20. Monthly water quality indicators in Sullivan Creek at Creekside Dr. opposite Fern Lane.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 08	12.5	12.4	6.8	118	4.6	5.9	2030
Dec 08	9.3	6.6	7.4	89	9.0	1.0	41
Jan 09	2.9	3.9	7.5	55	10.0	7.7	n/a
Feb 09	9.3	7.4	8.0	71	10.0	3.1	52
Mar 09	10.0	5.8	7.7	53	>10.0	25.2	63
Apr 09	9.7	9.0	7.8	115	n/a	1.7	52
May 09	12.0	12.5	7.5	69	8.8	34.6	455

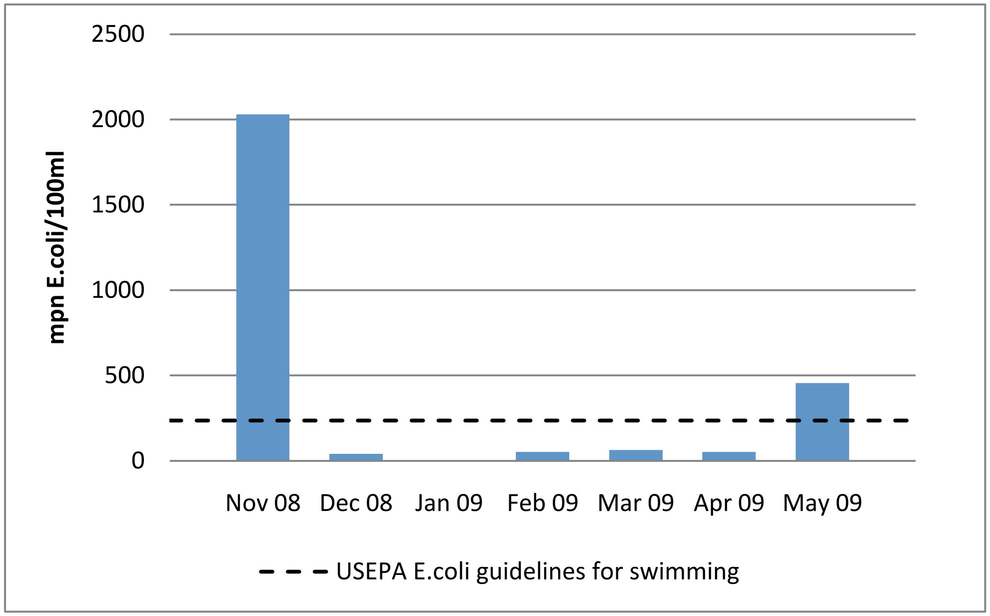
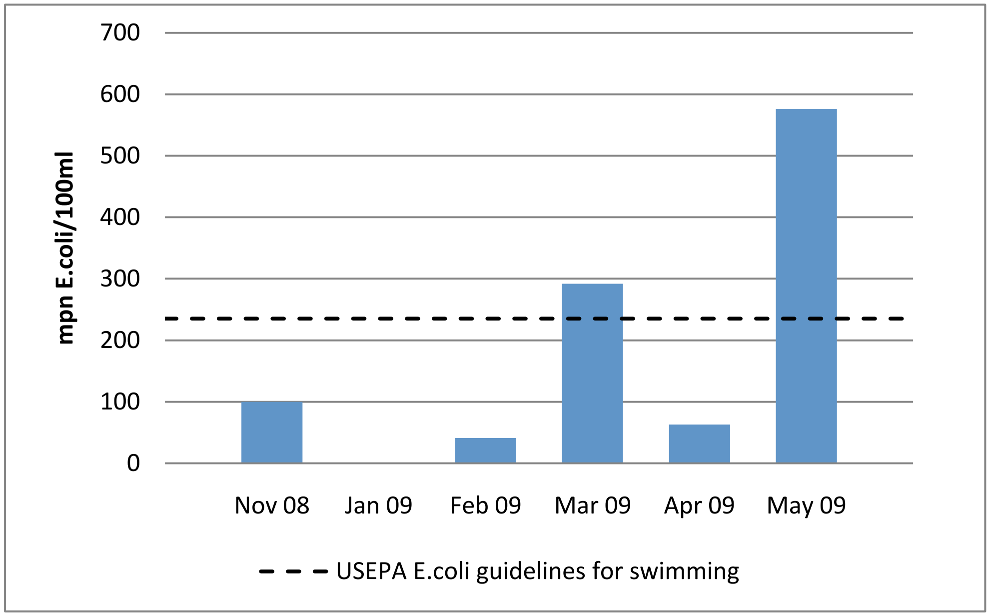


Figure 15. Monthly *E.coli* levels in Sullivan Creek at Creekside Dr. opposite Fern Lane.

3.11. Sullivan Creek at Buena Vista Avenida

Table 21. Monthly water quality indicators in Sullivan Creek at Buena Vista Avenida

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	13.9	13.9	6.9	11	7.8	14.2	100
Jan 09	5.0	5.2	7.6	223	9.6	2.3	n/a
Feb 09	9.9	8.0	8.0	264	>10.0	0.4	41
Mar 09	10.0	6.6	7.9	105	>10.0	4.6	292
Apr 09	12.7	9.4	8.0	304	>10.0	0.5	63
May 09	11.2	11.8	7.9	120	9.5	34.8	576



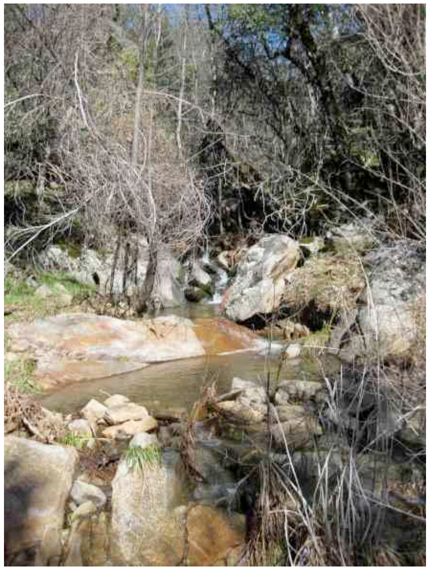


Figure 16.Monthly *E. coli* levels in Sullivan Creek at Buena Vista Avenida.

3.12. Sullivan Creek at Potato Ranch Rd.

Table 22. Monthly water quality indicators in Sullivan Creek at Potato Ranch Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	12.5	12.3	7.1	117	5.7	1.2	1100
Dec 09	5.8	4.8	7.4	86	10.0	0.6	20
Jan 09	2.2	3.6	7.4	57	9.4	4.5	75
Feb 09	9.0	6.8	7.8	73	>10.0	3.1	135
Mar 09	7.5	5.4	7.7	54	>10.0	24.9	122
Apr 09	10.5	8.1	7.6	130	>10.0	1.5	n/a
May 09	12.0	12.9	7.6	79	9.0	46.8	546

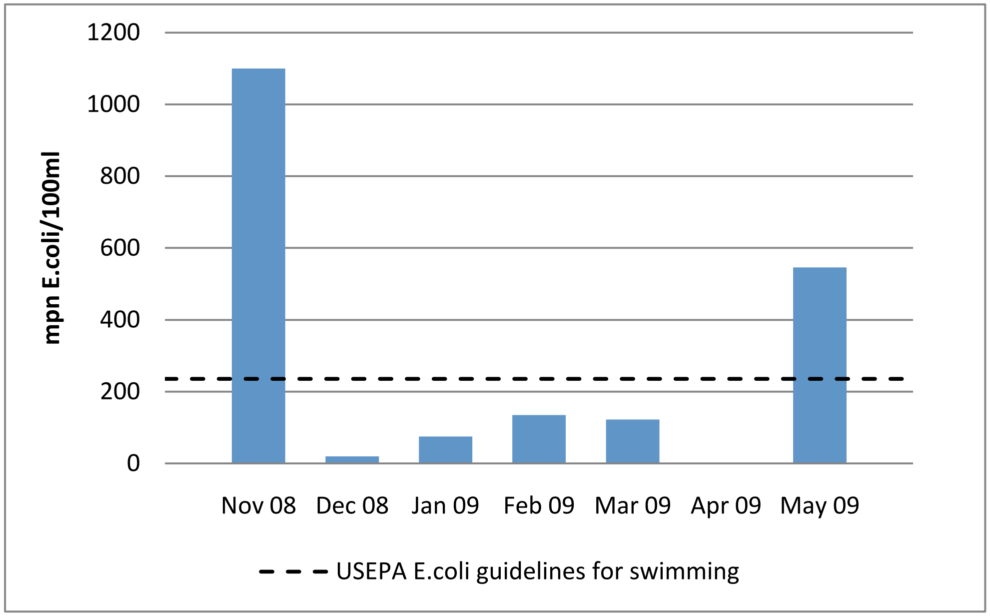


Figure 17. Monthly *E.coli* levels in Sullivan Creek at Potato Ranch Rd.

3.13. Sullivan Creek at Bergel Rd.-SR 108

Table 23. Monthly water quality indicators in Sullivan Creek at Bergel Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	13.0	13.4	7.1	15	9.1	6.0	750
Dec 09	7.2	6.5	6.7	71	10.0	0.9	359
Jan 09	2.7	4.4	6.8	42	9.8	4.6	n/a
Feb 09	7.8	6.9	7.6	80	>10.0	4.6	<10
Mar 09	6.8	5.6	7.7	49	>10.0	24.1	243
Apr 09	9.6	9.2	7.5	65	>10.0	2.7	31
May 09	12.8	13.0	7.7	57	9.0	105.7	2046
Jun 09	n/a	n/a	n/a	n/a	n/a	n/a	41

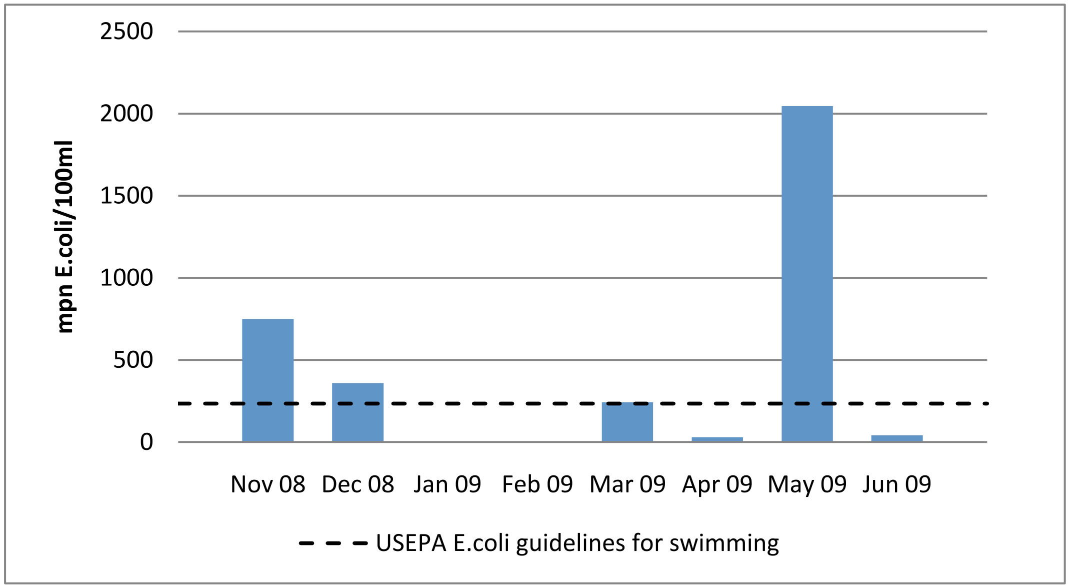


Figure 18. Monthly *E.coli* levels in Sullivan Creek at Bergel Rd.

3.14. Sullivan Creek tributary across from Brentwood

Table 24. Monthly water quality indicators in Sullivan Creek tributary across Middlecamp Rd. from Brentwood Lake.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Cond-uctivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	E.coli (mpn/ 100ml)
Nov 09	11.0	12.3	7.2	30	7.6	199.0	4960
Dec 09	15.3	8.7	7.2	22	8.3	16.4	1124
Jan 09	5.2	6.2	7.1	41	8.5	2.4	520
Feb 09	10.0	9.1	7.3	62	9.0	2.2	21
Mar 09	7.2	6.7	7.1	47	10.0	5.3	75
Apr 09	12.4	11.0	6.7	78	8.9	2.2	n/a
May 09	10.0	10.4	7.0	53	8.0	11.5	145

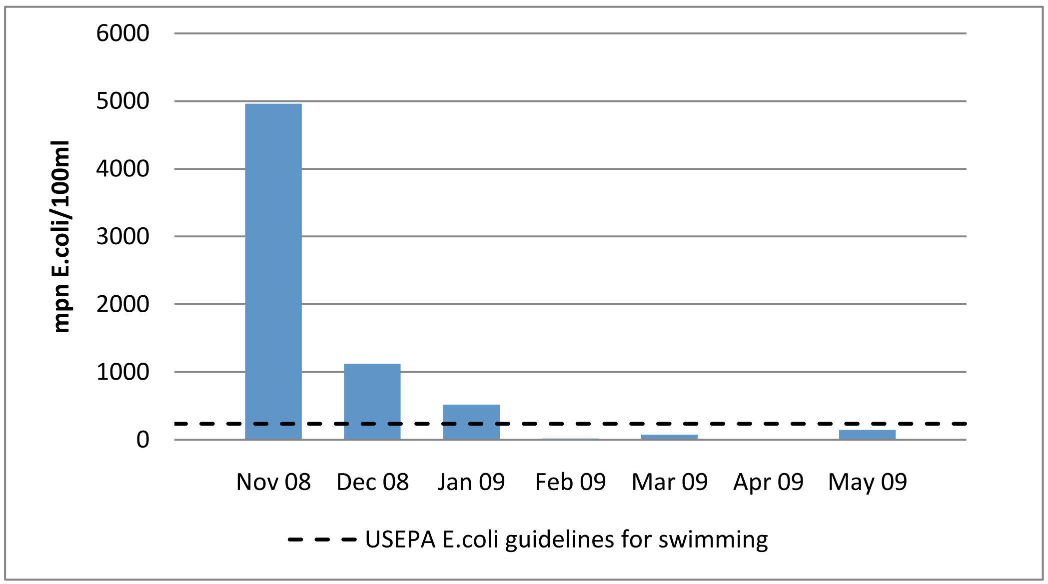


Figure 19. Monthly *E.coli* levels in Sullivan Creek tributary across Middlecamp Rd. from Brentwood Lake.

3.15. Turnback Creek at Old Buchanan Mine Rd.

Table 25. Monthly water quality indicators in Turnback Creek at Old Buchanan Mine Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Cond-uctivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	11.5	11.5	7.7	80	7.2	8.8	<10
Dec 09	3.0	3.9	6.2	110	6.8	1.5	10
Jan 09	n/a	3.0	n/a	100	7.2	5.9	n/a
Feb 09	3.3	4.5	n/a	100	6.7	n/a	41
Mar 09	1.4	4.5	n/a	70	7.5	4.0	n/a
Apr 09	3.7	4.5	7.9	90	9.0	1.4	121
May 09	10.5	10.1	7.4	70	4.6	33.2	439
Jun 09	11.0	10.0	7.8	100	6.1	1.7	84

*Note: Large deposits of trash were reported by volunteers at this site. Trash was removed during the Great Sierra River Clean-Up event in September 2009.

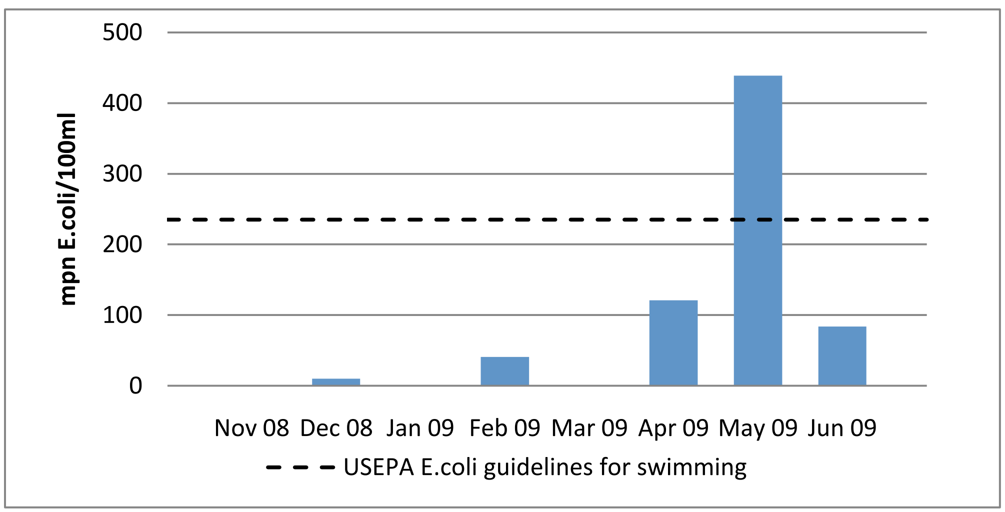
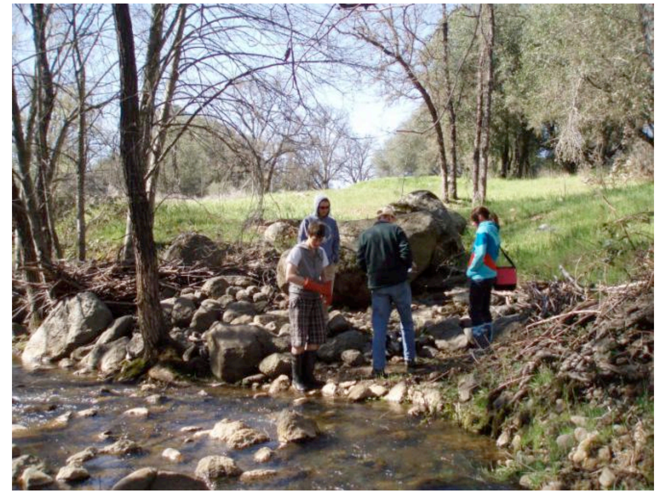


Figure 20. Monthly *E. coli* levels in Turnback Creek at Old Buchanan Mine Rd.

3.16. Turnback Creek at Yosemite Rd.

Table 26. Monthly water quality indicators in Turnback Creek at Yosemite Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	14.2	5.5	6.7	177	5.1	1.6	10
Jan 09	4.0	4.0	n/a	130	8.5	5.9	n/a
Feb 09	n/a	n/a	n/a	153	9.2	26.6	96
Mar 09	7.0	5.4	n/a	100	5.7	49.7	75
Apr 09	9.0	7.6	7.2	150	7.0	4.5	41
May 09	12.0	11.8	7.3	120	5.2	74.1	1187
Jun 09	13.0	12.1	7.6	120	6.8	4.8	269



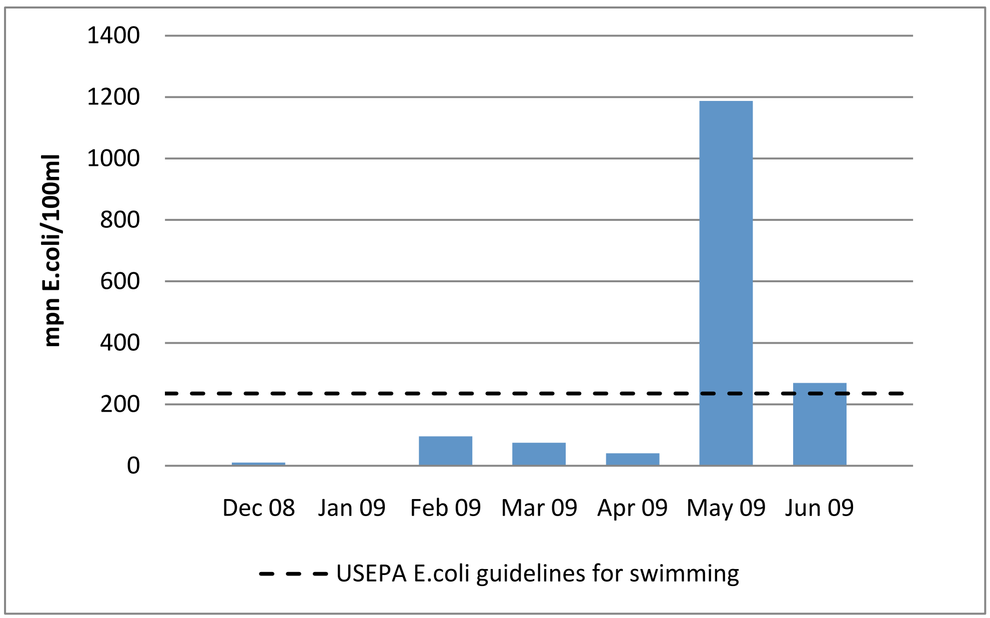
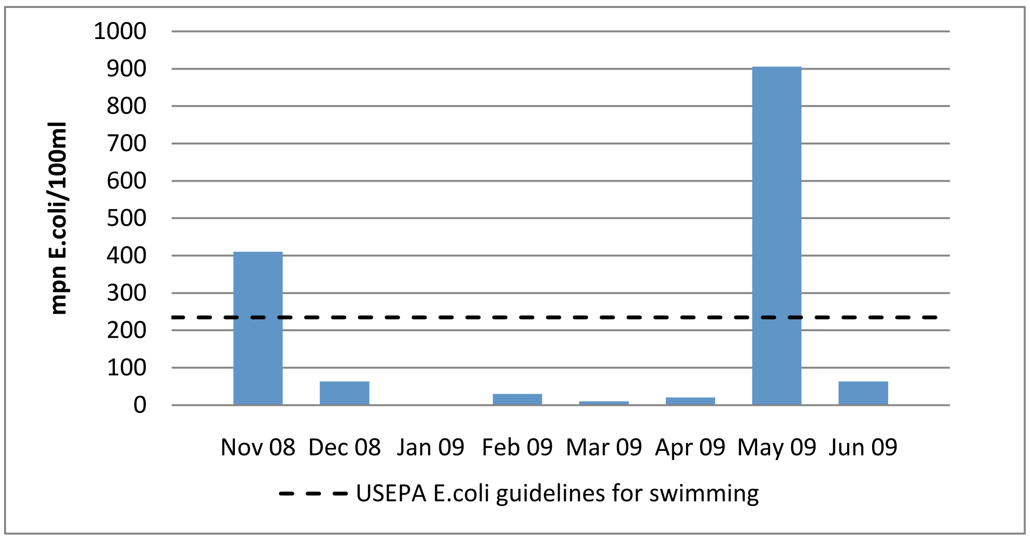


Figure 21. Monthly *E.coli* levels in Turnback Creek at Yosemite Rd.

3.17. Turnback Creek at Tuolumne Rd.

Table 27. Monthly water quality indicators in Turnback Creek at Tuolumne Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	13.5	12.1	6.5	190	5.4	1.2	410
Dec 09	15.3	6.5	6.5	130	6.6	0.5	63
Jan 09	5.2	3.1	n/a	110	9.2	6.7	n/a
Feb 09	6.3	n/a	n/a	120	7.3	1.0	30
Mar 09	7.0	5.2	n/a	77	8.9	5.2	10
Apr 09	10.0	6.4	8.0	110	6.8	1.2	20
May 09	12.0	11.3	7.7	107	6.0	39.6	906
Jun 09	14.0	11.7	7.4	120	8.1	1.2	63



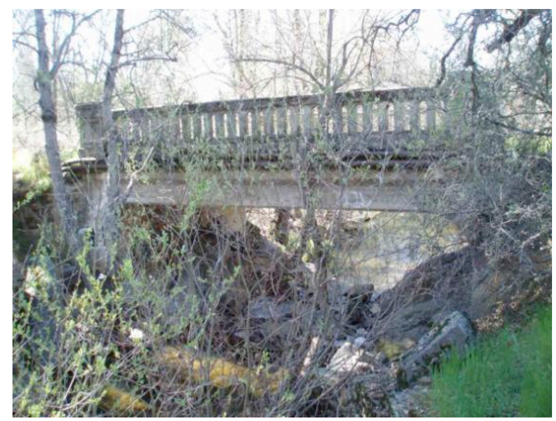


Figure 22. Monthly *E.coli* levels in Turnback Creek at Tuolumne Rd.

3.18. Twain Harte Creek at Eproson Park

Table 28. Monthly water quality indicators in Twain Harte Creek at Eproson Park.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	9.5	13.4	7.3	62	n/a	56.9	2260
Dec 09	14.0	11.8	7.0	134	8.0	6.7	<10
Jan 09	4.2	6.9	7.1	134	8.5	7.6	3448
Feb 09	8.2	8.9	7.3	155	9.0	4.9	66
Mar 09	7.0	6.9	7.2	100	9.2	7.2	96
Apr 09	12.0	10.0	7.1	171	9.2	6.7	10
May 09	9.0	12.2	7.0	94	8.8	29.0	373

*Note: Stream Team volunteers consistently report a petroleum and/or septic smell at this site.

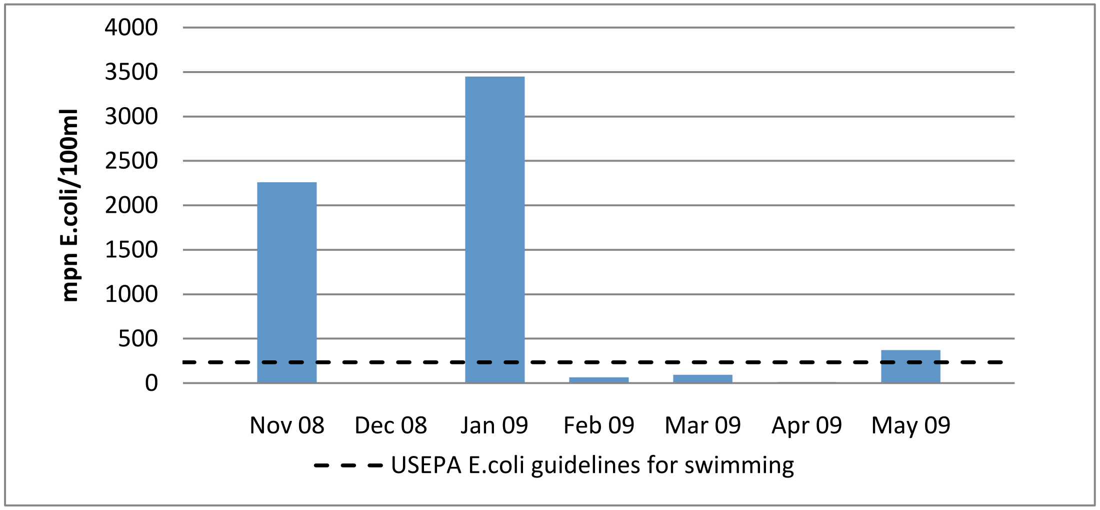


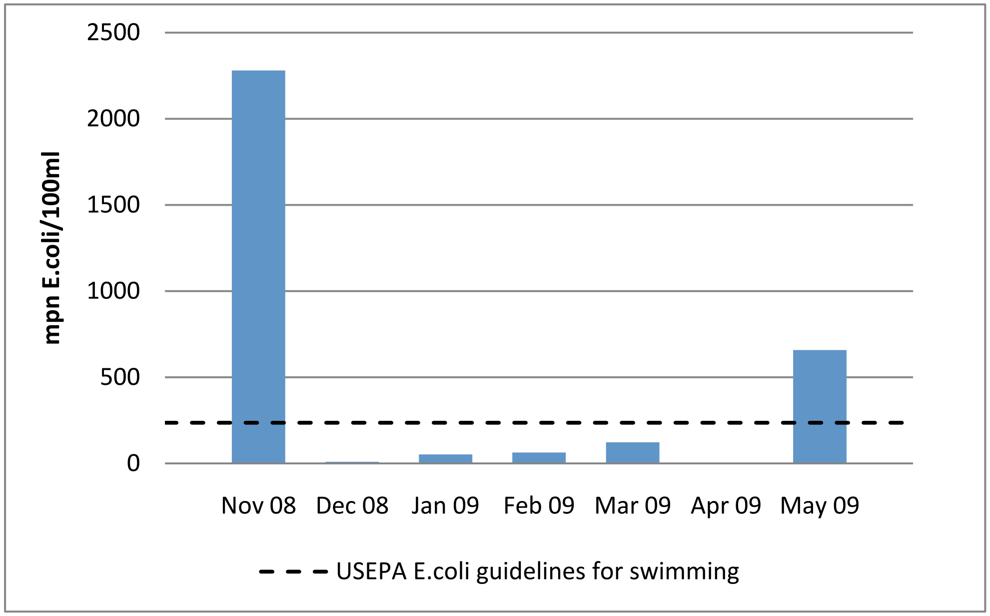
Figure 23. Monthly *E.coli* levels in Twain Harte Creek at Eproson Park.

3.19. Twain Harte Creek at Crystal Falls Dr.

Table 29. Monthly water quality indicators in Twain Harte Creek at Crystal Falls Dr.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	14.5	15.1	6.4	98	>10.0	10.2	2280
Dec 09	11.2	8.4	7.6	64	9.2	5.2	10
Jan 09	5.0	4.9	7.4	71	7.0	13.9	53
Feb 09	10.0	7.6	7.7	75	9.8	7.8	63
Mar 09	9.0	5.6	7.8	49	>10.0	30.1	122
Apr 09	12.5	12.5	7.6	117	9.4	4.9	<10
May 09	12.0	13.8	7.6	87	9.0	27.7	657

*Note: Stream Team volunteers report foam/suds, septic and/or sulfur smell, algae, trash, and graffiti at this site.



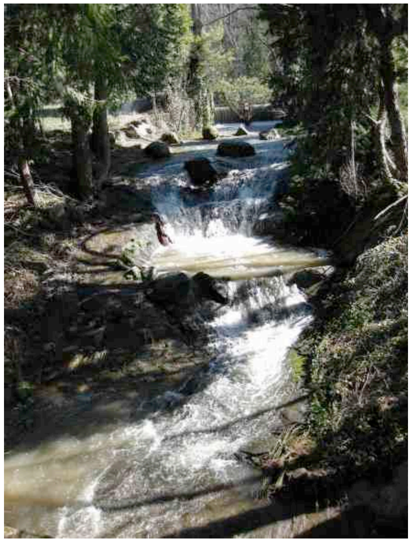


Figure 24. Monthly *E.coli* levels in Twain Harte Creek at Crystal Falls Dr.

3.20. Woods Creek at Rawhide Rd.

Table 30. Monthly water quality indicators in Woods Creek at Rawhide Rd.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Nov 09	6.0	14.1	8.0	350	7.5	2.1	980
Dec 09	5.5	5.9	8.2	430	>10.0	0.9	41
Jan 09	7.2	4.6	8.5	430	9.6	1.8	n/a
Feb 09	18.7	10.1	8.8	360	>10.0	2.9	281
Mar 09	12.0	6.9	8.6	420	8.7	6.0	241
Apr 09	13.0	9.7	9.3	523	5.0	2.4	134
May 09	16.0	13.5	8.9	210	8.2	109.7	8164
Jun 09	18.0	16.4	9.3	430	5.9	5.0	857

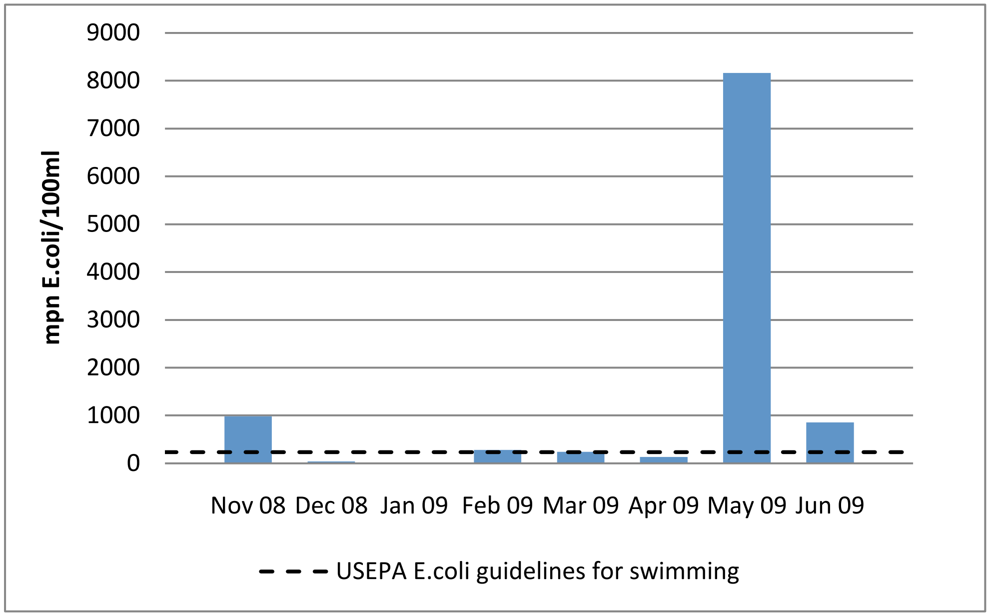
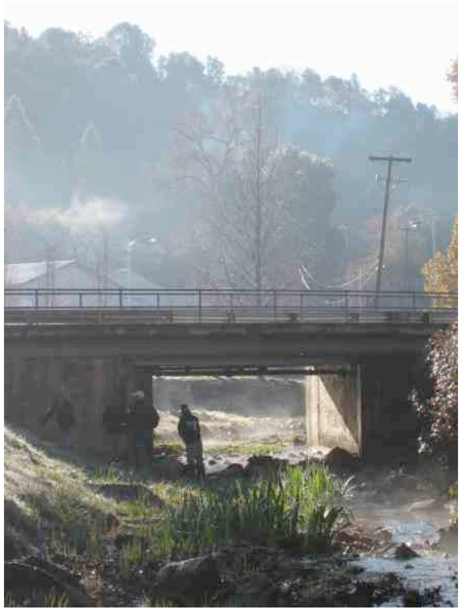


Figure 25. Monthly *E.coli* levels in Woods Creek at Rawhide Rd.

3.21. Woods Creek at Rotary Park

Table 31. Monthly water quality indicators in Woods Creek at Rotary Park.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	8.8	8.7	8.0	517	>10.0	0.5	97
Jan 09	4.3	7.3	8.4	540	6.0	0.6	n/a
Feb 09	12.7	9.7	8.5	527	7.6	0.4	121
Mar 09	9.2	8.5	8.4	430	>10.0	2.0	63
Apr 09	9.3	9.4	9.3	553	7.2	0.7	420
May 09	15.4	13.7	8.1	490	7.0	2.7	1071
Jun 09	18.8	16.1	8.9	480	10.0	2.7	1223



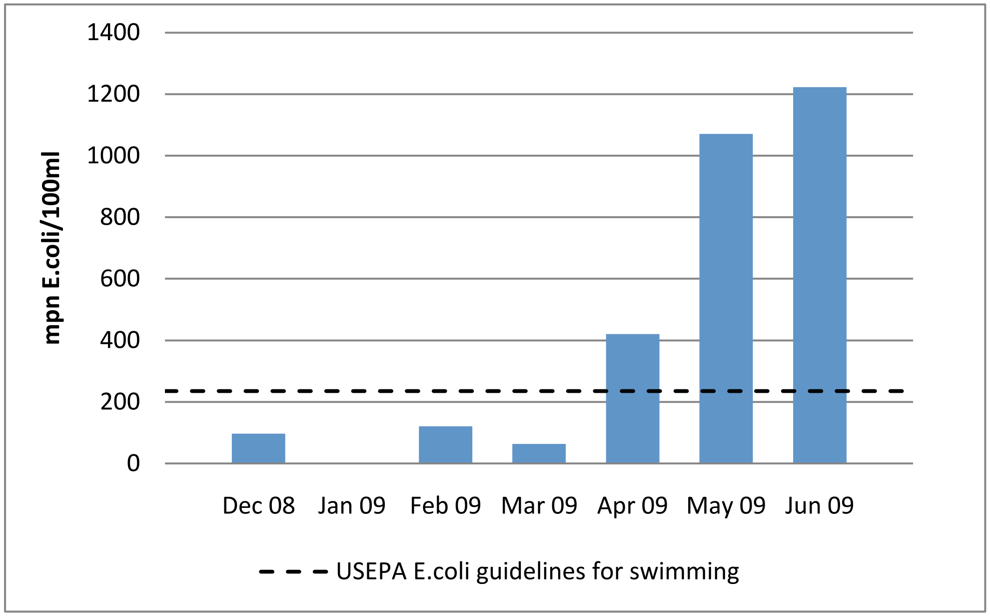
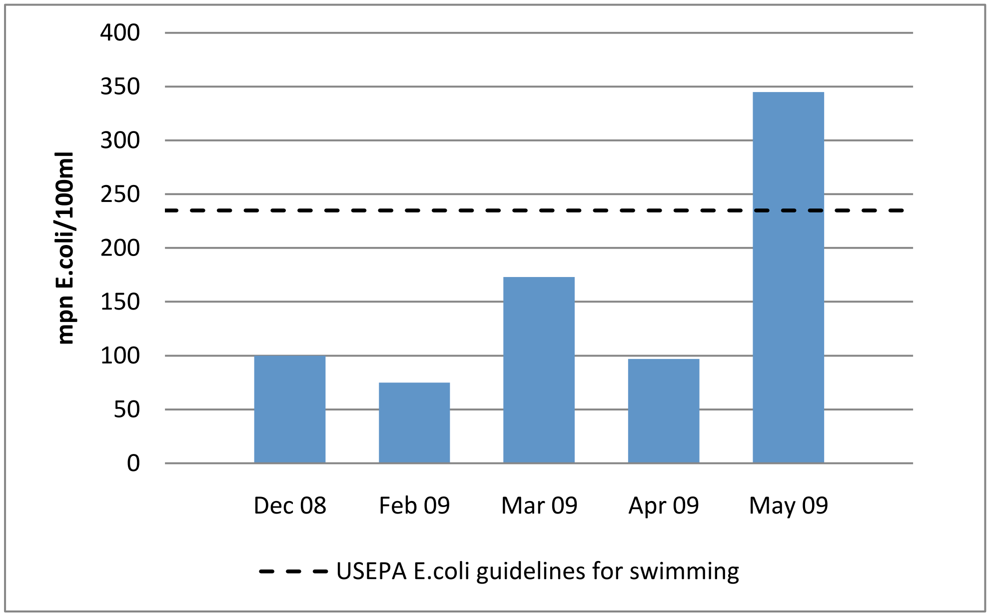


Figure 26. Monthly *E.coli* levels in Woods Creek at Rotary Park.

3.22. Woods Creek at Sonora High School

Table 32. Monthly water quality indicators in Woods Creek at Sonora High School.

Sample Date	Air Temp (°C)	Water Temp (°C)	pH	Con-ductivity (µS/cm)	Dissolved Oxygen (ppm)	Turbidity (NTU)	*E.coli* (mpn/ 100ml)
Dec 09	16.8	12.0	8.2	420	8.8	0.6	100
Jan 09	12.2	11.4	8.3	530	7.7	1.1	n/a
Feb 09	11.3	11.3	7.9	360	5.5	4.0	75
Mar 09	16.0	14.8	7.4	497	9.8	1.0	173
Apr 09	14.5	14.4	8.4	520	6.4	2.3	97
May 09	16.8	12.0	8.2	420	8.8	0.6	345



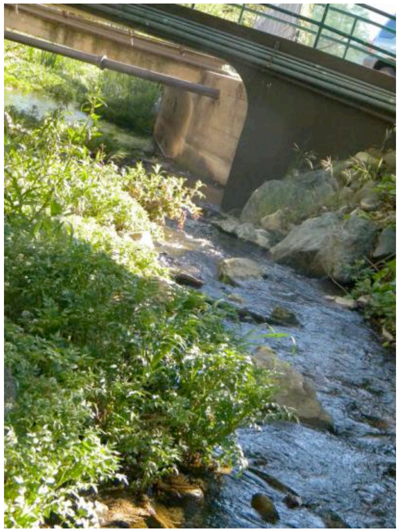


Figure 27. Monthly *E.coli* levels in Woods Creek at Sonora High.

3.23. Air Temperature

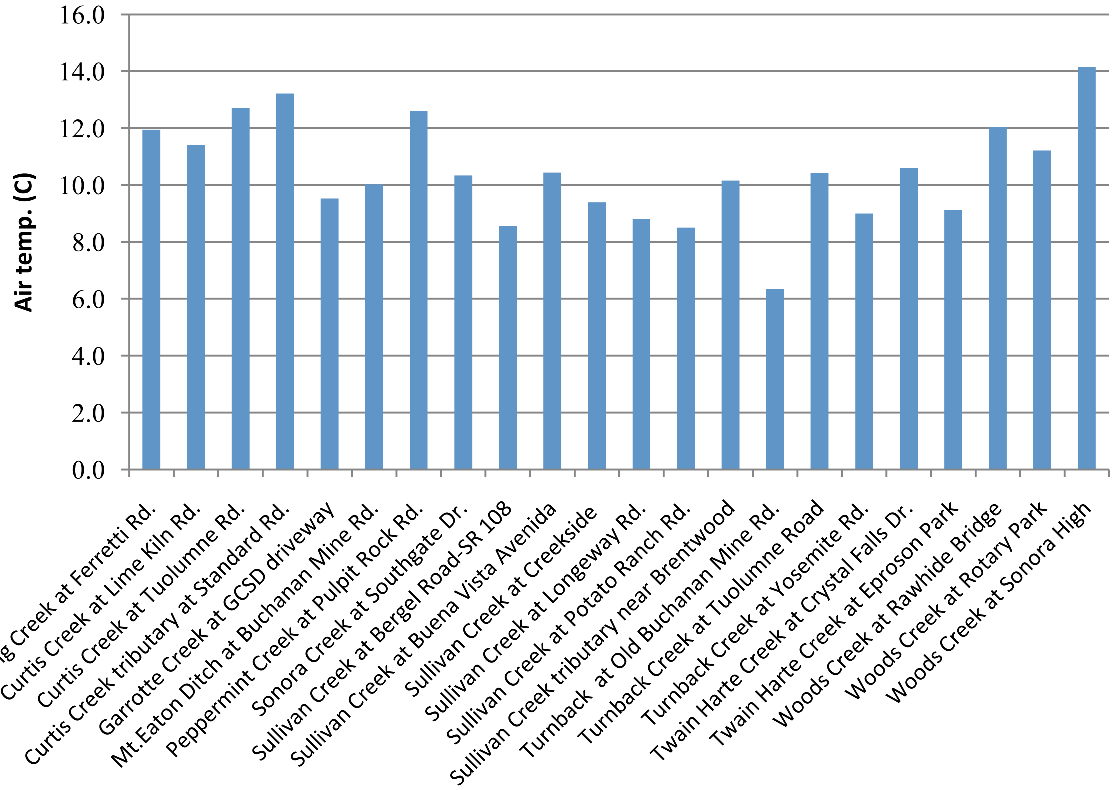


Figure 28. Average air temperature in each Stream Team site. Number indicates mean temperature across all sample dates.

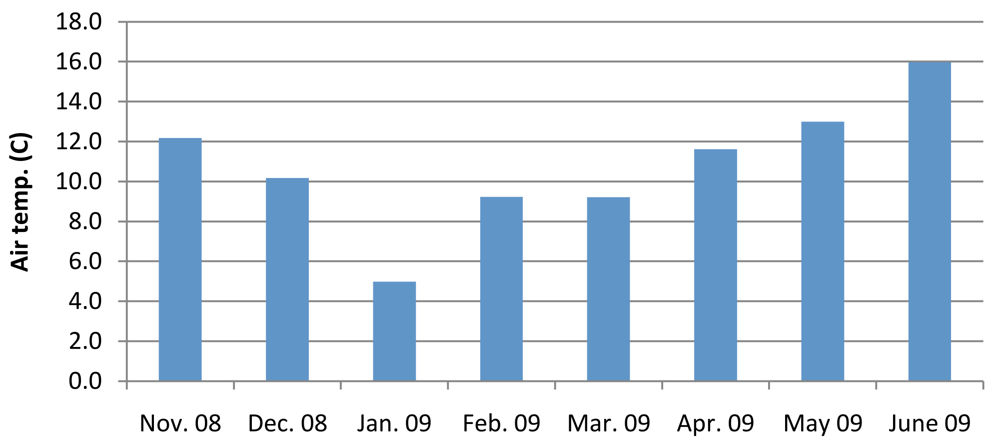


Figure 29. Average air temperature each month. Number indicates mean temperature across all sample sites.

3.24. Water Temperature

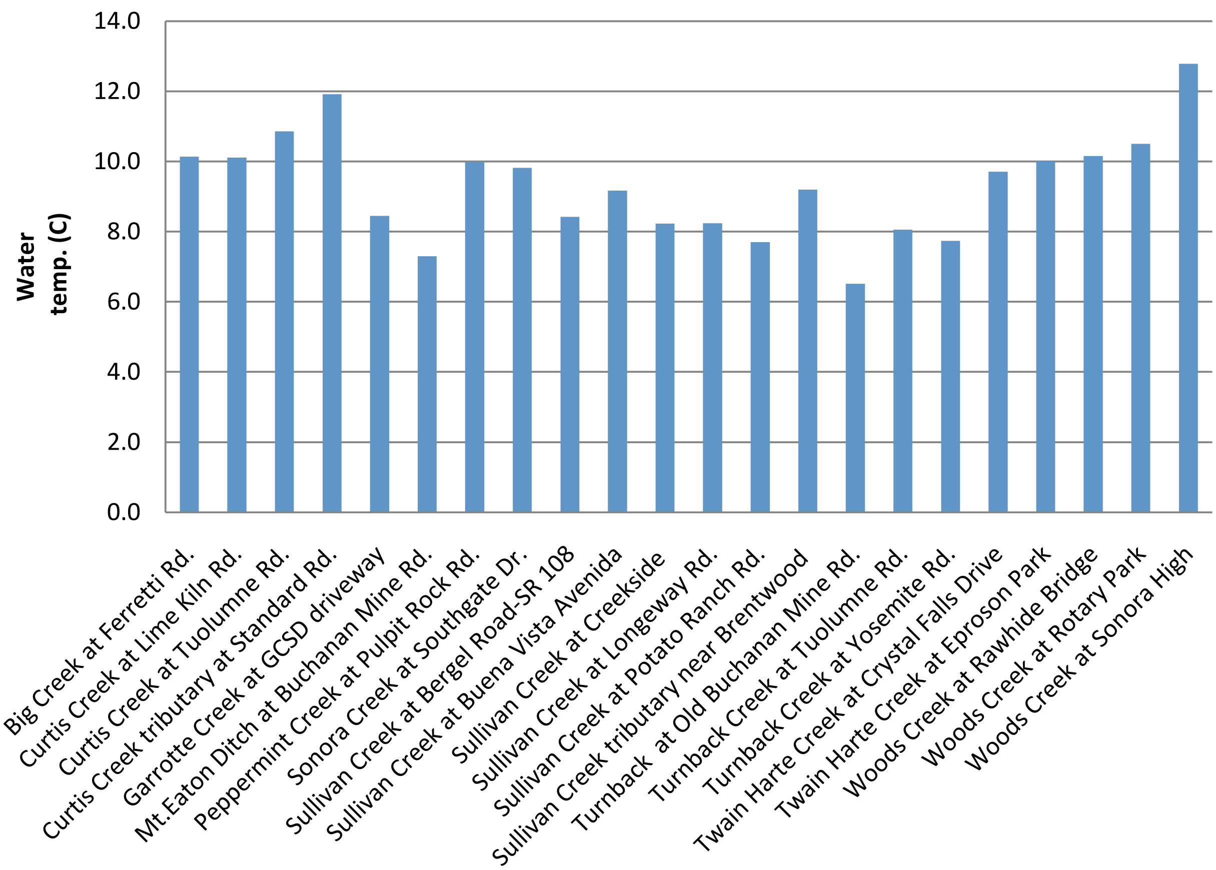


Figure 30. Average water temperature in each Stream Team site. Number indicates mean temperature across all sample dates.

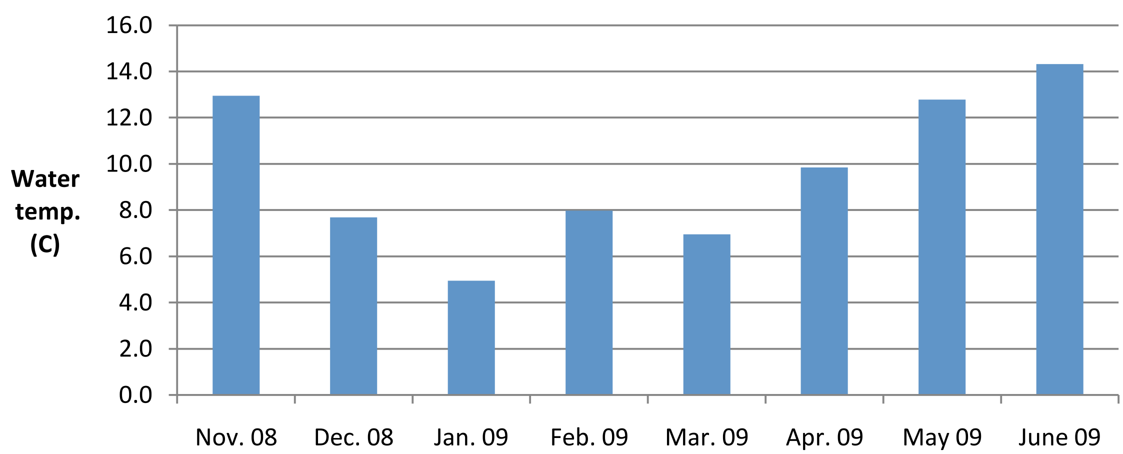


Figure 31. Average water temperature each month. Number indicates mean temperature across all sample sites.

3.25. pH

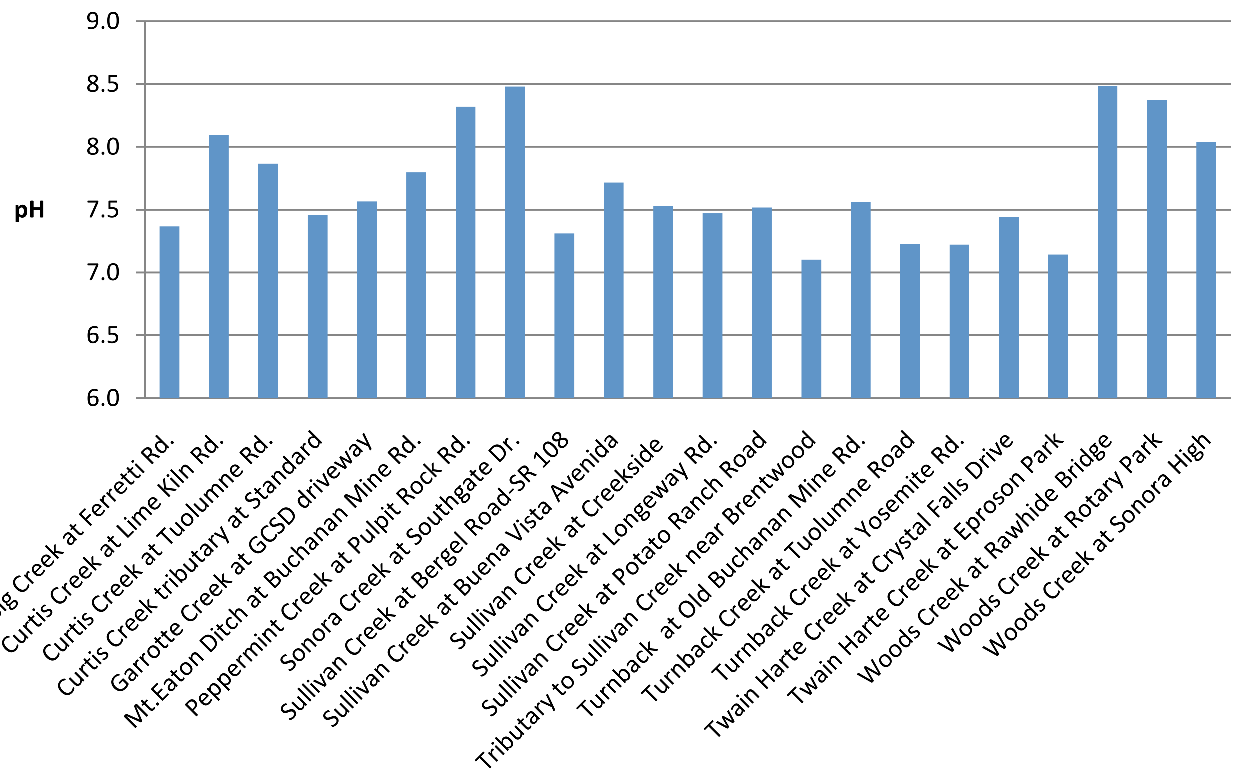


Figure 32. Average pH in each Stream Team site. Number indicates mean pH across all sample dates.

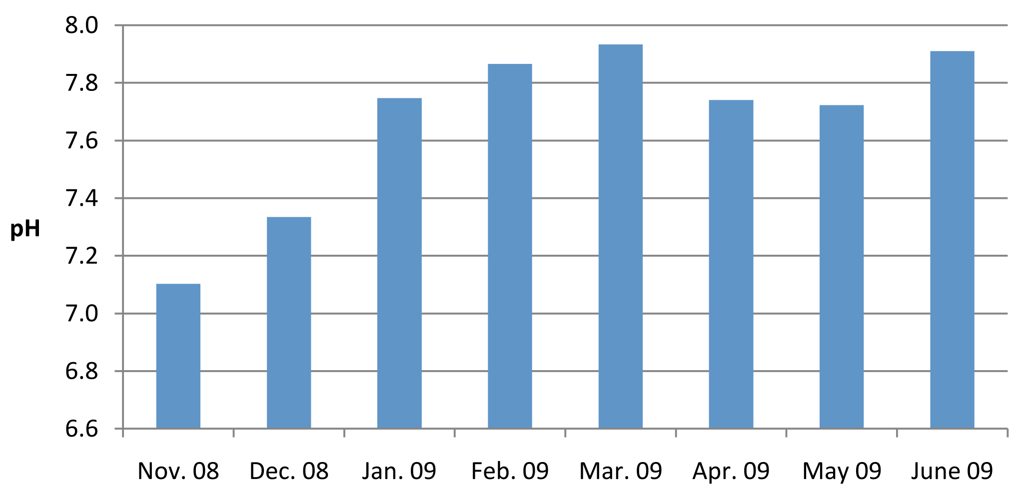


Figure 33. Average pH each month. Number indicates mean pH across all sample sites.

3.26. Specific Conductivity

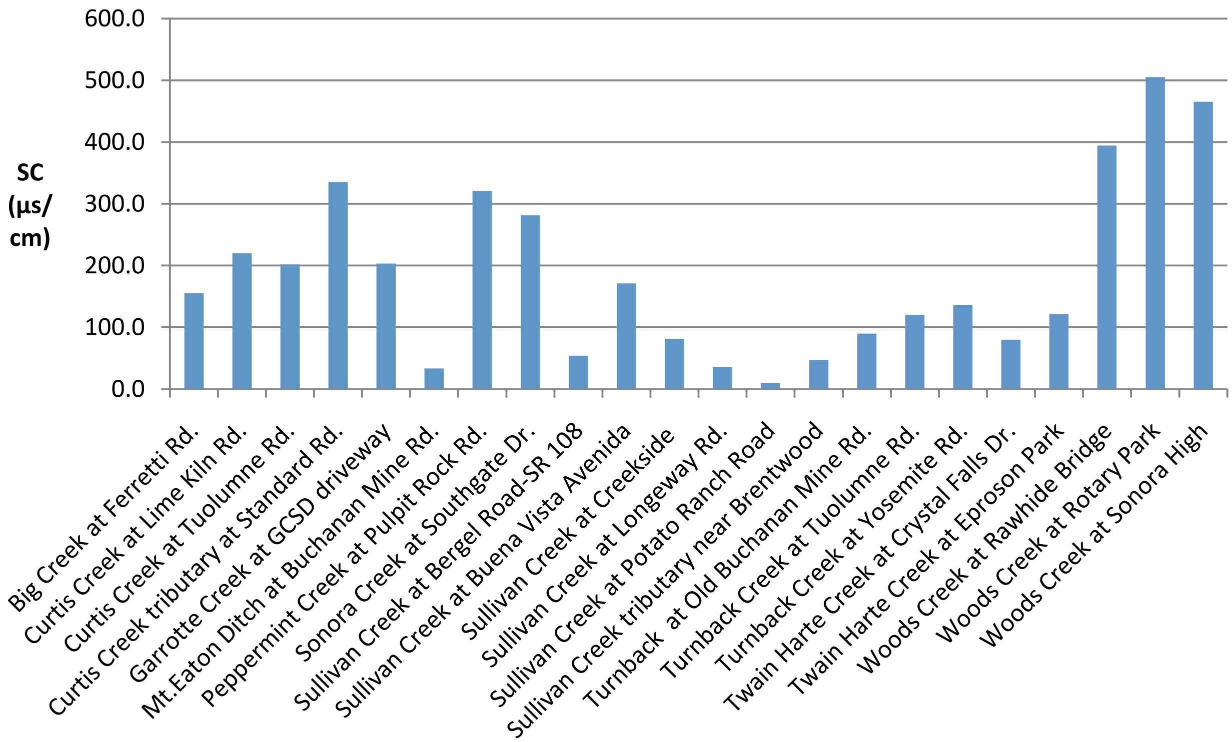


Figure 34. Average SC in each Stream Team site. Number indicates mean SC across all sample dates.

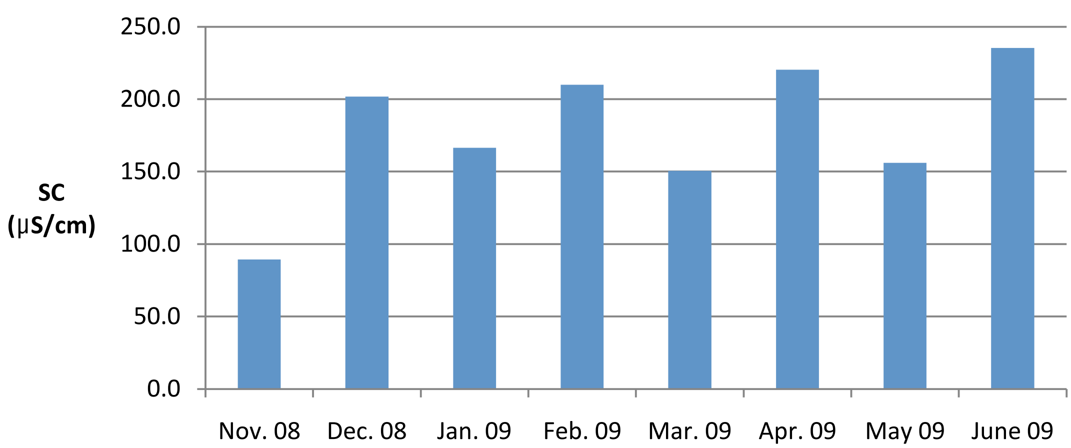


Figure 35. Average SC each month. Number indicates mean SC across all sample sites.

3.27. Dissolved Oxygen

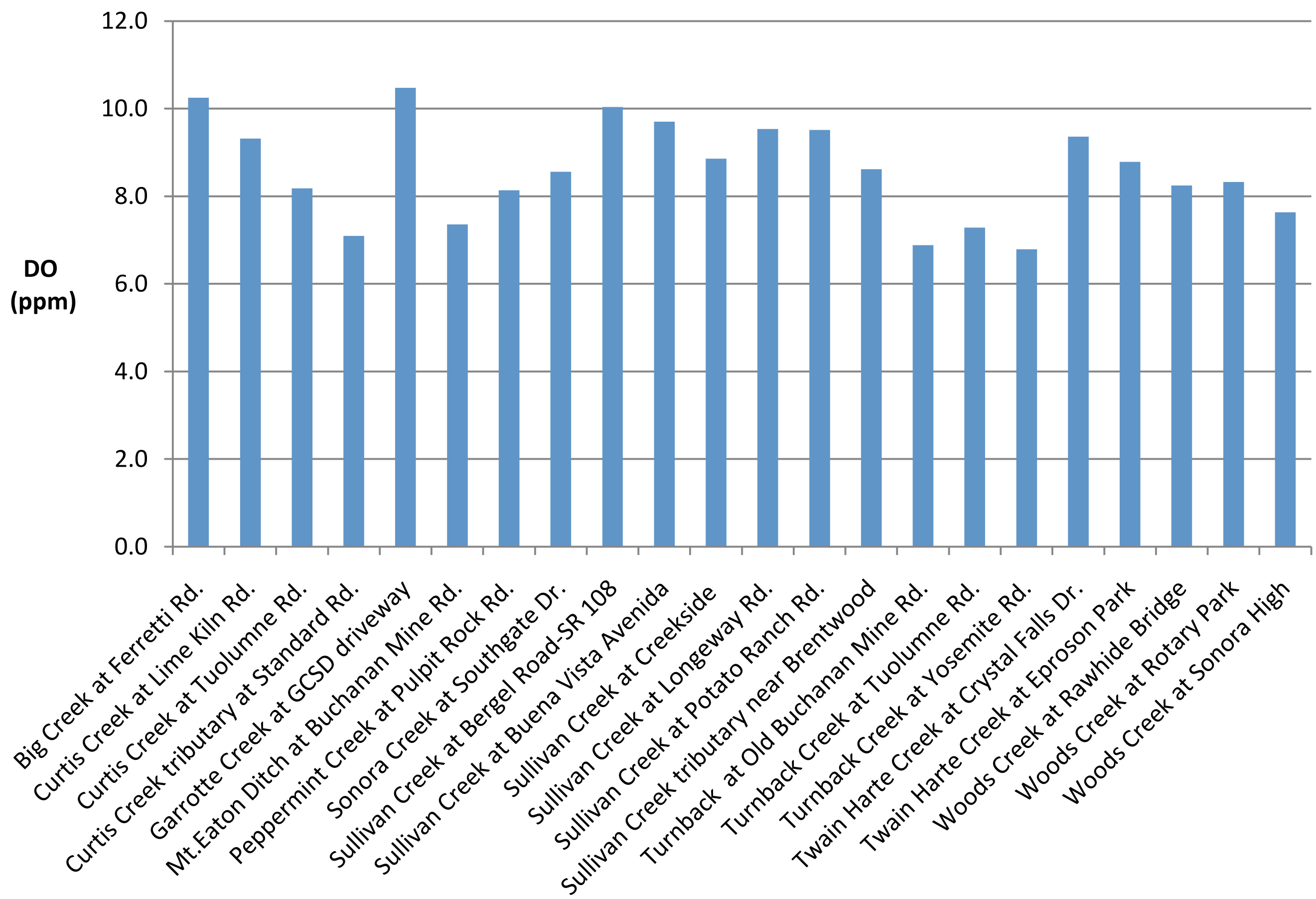


Figure 36. Average DO in each Stream Team site. Number indicates mean DO across all sample dates.

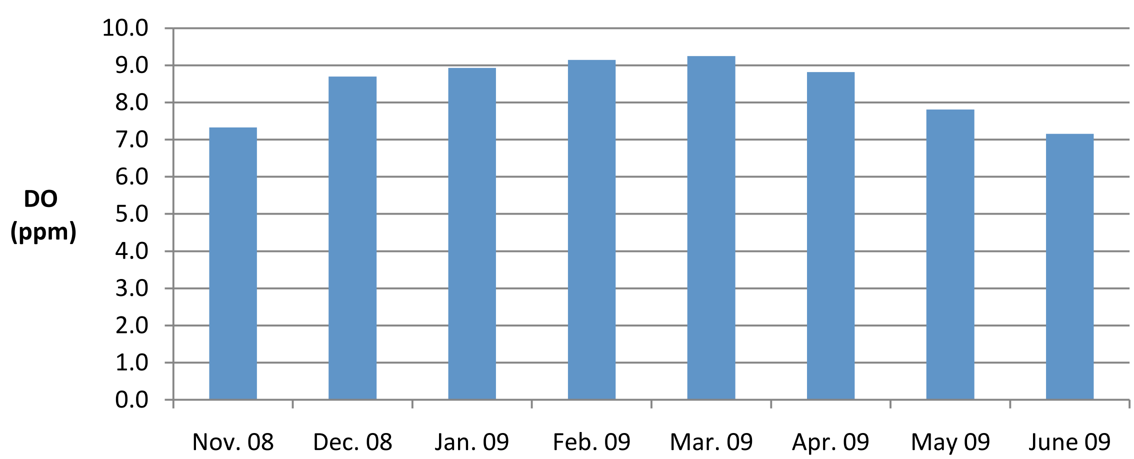


Figure 37. Average DO each month. Number indicates mean DO across all sample sites.

3.28. Turbidity

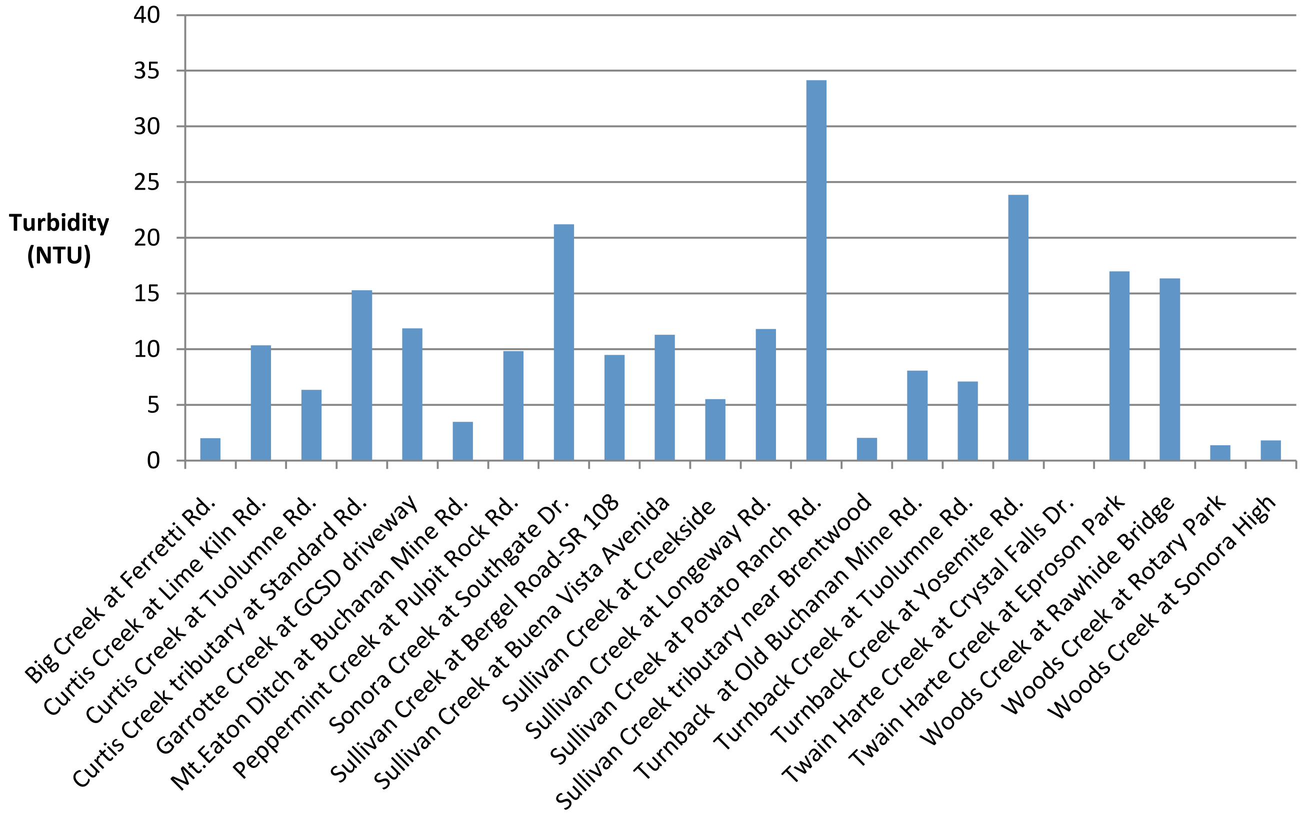


Figure 38. Average turbidity in each Stream Team site. Number indicates mean turbidity across all sample dates.

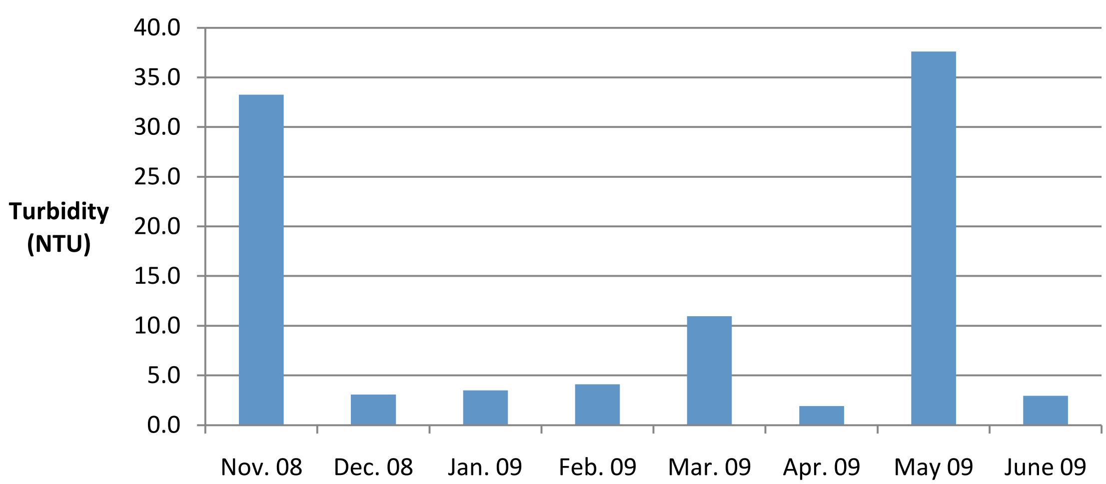


Figure 39. Average turbidity each month. Number indicates mean turbidity across all sample sites.

3.29. Precipitation

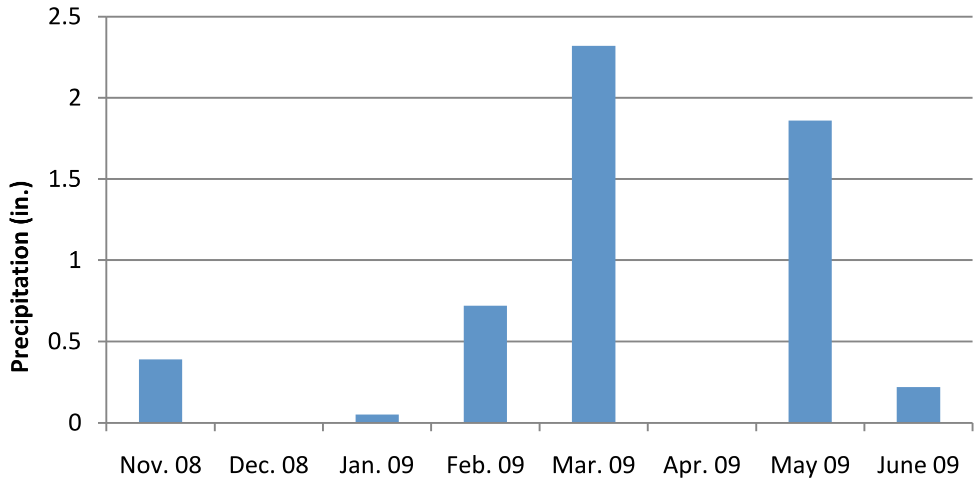


Figure 40. Cumulative precipitation in four days prior to each sample event. Data is from Sonora, California local daily precipitation data obtained from the DWR California Data Exchange Center (http://cdec.water.ca.gov/).

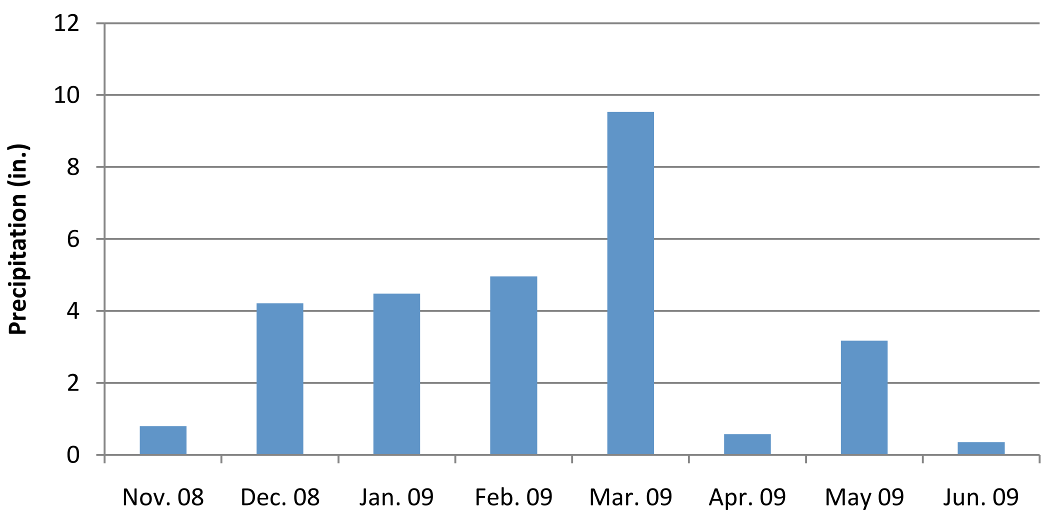


Figure 41. Total precipitation for month preceding each Stream Team monitoring event (http://cdec.water.ca.gov/).

3.30. Fecal Indicator Bacteria

Table 33. *E. coli* levels at each Stream Team site during the 08-09 season. *E. coli* levels in highlighted cells exceed EPA guidelines for recreational use.

MPN *E. coli*/100ml	Nov. 08	Dec. 08	Jan. 09	Feb. 09	Mar. 09	Apr. 09	May 09	Jun. 09
Big Creek at Ferretti Rd.	n/a	n/a	n/a	31	31	10	108	231
Curtis Creek at Lime Kiln Rd.	n/a	20	n/a	20	51	n/a	3076	52
Curtis Creek at Tuolumne Rd.	n/a	73	n/a	134	75	41	109	20
Curtis Creek tributary at Standard Rd.	n/a	41	n/a	<10	41	31	52	63
Garrotte Creek at GCSD driveway	n/a	n/a	n/a	30	20	10	657	249
Mt.Eaton Ditch at Buchanan Mine Rd.	300	80	n/a	435	n/a	295	173	336
Peppermint Creek at Pulpit Rock Rd.	n/a	197	n/a	52	86	30	1733	75
Sonora Creek at Southgate Dr.	n/a	345	n/a	259	169	86	1291	1162
Sullivan Creek at Bergel Road-SR 108	750	359	n/a	<10	243	31	2046	41
Sullivan Creek at Buena Vista Avenida	100	n/a	n/a	41	292	63	576	n/a
Sullivan Creek at Creekside	2030	41	n/a	52	63	52	455	n/a
Sullivan Creek at Longeway Rd.	n/a	<10	n/a	10	10	<10	<10	n/a
Sullivan Creek at Potato Ranch Rd.	1100	20	75	135	122	n/a	546	n/a
Sullivan Creek tributary near Brentwood	4960	1124	520	20.5	75	n/a	145	n/a
Turnback at Old Buchanan Mine Rd.	<10	10	n/a	41	n/a	121	439	84
Turnback Creek at Tuolumne Rd.	410	63	n/a	30	10	20	906	63
Turnback Creek at Yosemite Rd.	n/a	10	n/a	96	75	41	1187	269
Twain Harte Creek at Crystal Falls Dr.	2280	10	52.8	63	122	<10	657	n/a
Twain Harte Creek at Eproson Park	2260	<10	3448	65.5	96	10	373	n/a
Woods Creek at Rawhide Bridge	980	41	n/a	281	241	134	8164	857
Woods Creek at Rotary Park	n/a	97	n/a	121	63	420	1071	1223
Woods Creek at Sonora High	n/a	100	n/a	75	173	97	345	n/a

Level of Contact	**USEPA *E. coli* Guideline (MPN/100ml)**
Swimming	<235
Designated beach area	235-297
Moderate full body contact	298-408
Light full body contact	409-574
Infrequent full body contact	>574

3.31. Relationship between precipitation, turbidity, and *E. coli.*

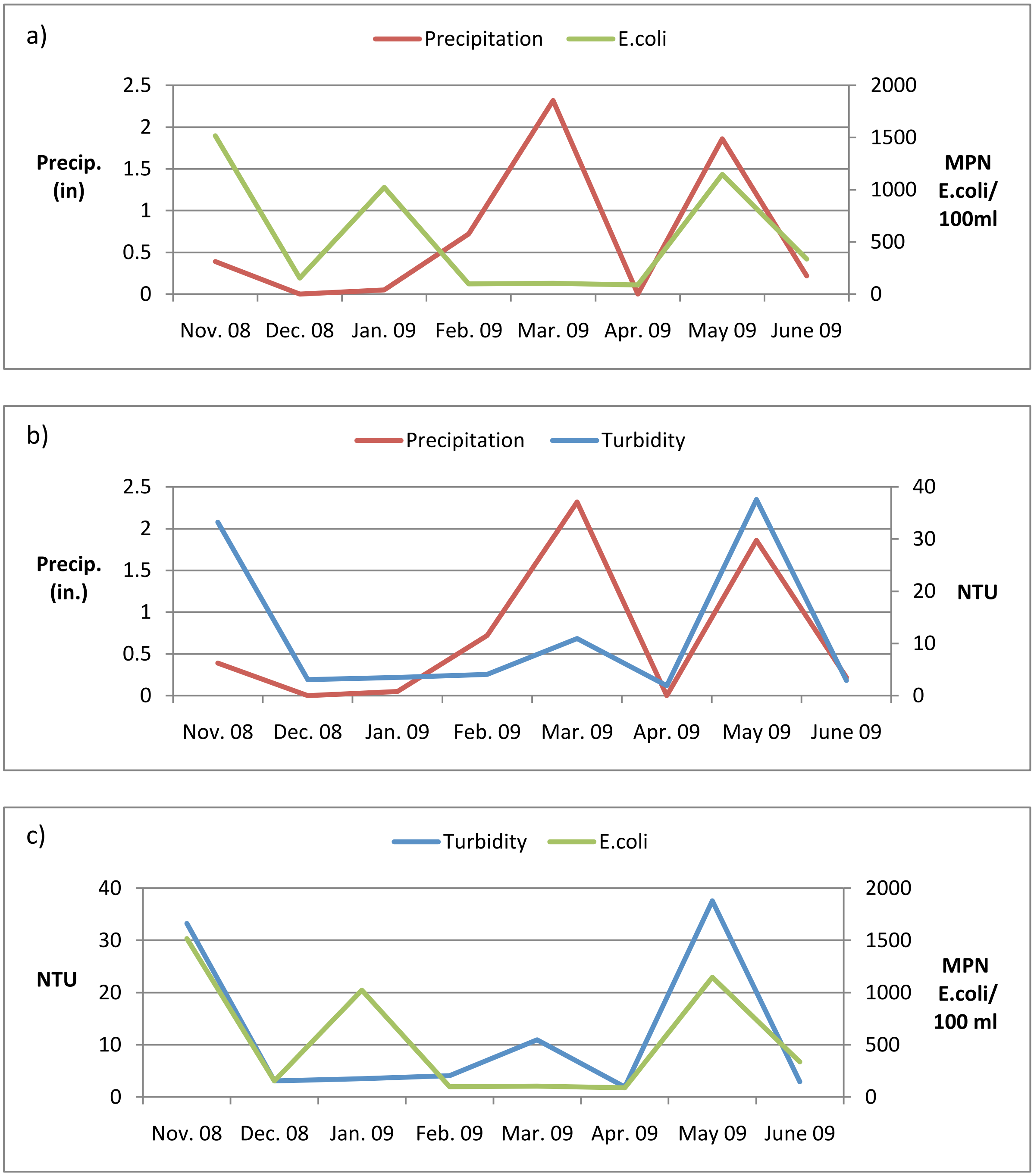


Figure 42 a) Four day cumulative precipitation prior to sample and average *E. coli* levels (mean across all sites), b) Four day cumulative precipitation prior to sample and average turbidity levels (mean across all sites) , and c) average *E. coli* levels and average turbidity levels (mean across all sites).

Chapter 4. Discussion and conclusions

4.1. How clean and healthy are our creeks?

In Tuolumne County we're lucky to live in the upper reaches of the Tuolumne River and Stanislaus River watersheds, which are relatively unimpaired by urban and agricultural development. Except for Don Pedro Reservoir, no water bodies within the Upper Tuolumne River and Upper Stanislaus Rivers are listed as impaired under the Federal Clean Water Act. Don Pedro Reservoir is listed on the 2002 California Section 303(d) list and TMDL Priority Schedule for mercury contamination associated with historic mines now inundated by the reservoir. Stream Team monitoring results demonstrate that Tuolumne County also has water quality problems related to current land use practices that should be addressed.

Monthly bacteria samples indicate that many creeks in Tuolumne County are unsafe for contact recreation due to fecal contamination. While Stream Team turbidity samples didn't show consistently cloudy water, excessive erosion and sedimentation continue to be a major issue for the county. For example, according to estimates in the Foothill Watershed Assessment, Phoenix Lake is accumulating sediment at 10-20 times the naturally occurring rate. While monthly Stream Team samples currently don't include measurements of urban contaminants, these also continue to be a potential threat to water quality in the county. These water quality issues carry with them environmental, economic and social consequences for current and future Tuolumne County residents.

4.2. Next Steps for the TCRCD and the Stream Team

- **Identify source(s) of fecal contamination**. Microbial Source Tracking will use genetic analysis of fecal indicator bacteria to determine the source(s) of contamination. This analysis will begin the spring of 2010 and will continue through 2011.

- **Begin collection of year-round water quality data**. While in the past Stream team has taken a vacation from data collection over the summer, we hope to continue collecting data in perennial streams through the summer of 2010. The next data report will reflect all data collected from October 2009-October 2010. We hope to publish this data report on the TCRCD website by December 2010.

- **Expand Stream Team monitoring parameters.** During the summer or fall of 2010 the TCRCD plans to host a training session for Stream Team volunteers focusing on additional biological and physical indicators of stream health. This will include a simple protocol for macro-invertebrate identification (insects, worms, clams, snails, and other invertebrates visible without a microscope), as well as documentation of invasive plant species present at each site. Analysis of biological communities at sample sites can provide a broader measure of overall stream health than physical and chemical analysis alone. Additional physical parameters will include simple descriptions of channel morphology and bank stability.

- **Expand community outreach and education about watershed Best Management Practices (BMPs).** The TCRCD will be creating and distributing a Watershed Owner's Manual and Property Self-Assessment Manual to help property owners evaluate and improve their effect on local water quality. We also plan to host workshops and events related to these publications and to post them on our website. In order to improve our outreach and educational materials, we plan to integrate Stream Team data into GIS (geographic information systems) and create watershed maps and brochures for the public. We also plan to continue seeking additional funding for implementation of erosion control BMPs, watershed restoration and invasive plant control projects, and other on-the-ground projects throughout the county.

4.3. Suggested steps for Tuolumne County residents

All Tuolumne County residents can contribute to improvements in water quality and ecosystem health in local watersheds. Below are some common problems in Tuolumne County and some suggested steps for addressing these problems.

Problem:
Excessive soil erosion can reduce water quality and degrade habitat in local creeks. This can also lead to increased sedimentation in lakes and reservoirs.
What you can do:
- Protect bare soil surfaces on your property and use vegetation to hold soil in place and allow water to soak into soil.
- Assess your roads for erosion and address road problems. Also assess erosion prone areas on your property and minimize disturbance in these areas.
- Use erosion and sediment control practices at construction and disturbed sites and in areas used by livestock, horses, and other animals.

Problem:
Old or faulty septic systems can leak nutrients and potential pathogens into local creeks.
What you can do:
- Properly maintain and care for your septic system.
- Have your septic tank inspected annually to determine when it needs to be pumped.

- For more information about septic system maintenance, please contact the Tuolumne County Department of Environmental Health or check out this interactive website: http://septicguy.com/home.php, for some helpful hints.

Problem:
Invasive non-native plants often crowd out native plants and reduce wildlife habitat benefits and, in some cases, cause bank de-stabilization.
What you can do:
- Help improve riparian vegetation and habitat by participating as a volunteer in a watershed restoration project hosted by the TCRCD or another organization.
- In your yard consider planting native plants that will not only provide habitat but will also reduce your water consumption.
- For information about the removal of non-natives on your property contact the Tuolumne County Agricultural Commissioner or the local UCCE office.

Problem:
Stormwater flowing from rooftops, over paved areas, and across the landscape often collects pet waste, fertilizer, pesticides, oil, grease, litter/trash, and other potential pollutants and delivers these into local creeks.

What you can do:
- Reduce the amount of contaminants that get into stormwater from your property by avoiding or minimizing the use of fertilizers and pesticides in your yard, washing your car at a car wash, rather than in your driveway, and by purchasing and using nontoxic, biodegradable, recycled, and recyclable products whenever possible.
- Help to educate the community. Make sure that others know that storm drains carry stormwater directly into local streams, rivers, lakes, and wetlands, **not** to a wastewater treatment plant.
- Promote good stewardship of our waterways by participating in the Great Sierra River Cleanup, an annual event each September held in conjunction with the California Coastal Cleanup Day.
- Dispose of hazardous waste products properly by bringing them to a free drop-off event sponsored by the Tuolumne County Solid Waste Department.