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Freshwater Quality Monitoring in the San Francisco Bay Area Network

2007 Annual Report

Natural Resource Technical Report NPS/SFAN/NRTR—2009/177

ON THE COVER
Monitoring site OLM 1 – John West Fork, tributary to Olema Creek, Point Reyes National Seashore
NPS Photo

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This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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NPS D-58, February 2009

Contents

Figures

Page

Figures (continued)

Figures (continued)

Tables

Page

Tables (continued)

Executive Summary

This report summarizes Water Year 2007 (10/1/2006 – 9/30/2007) water quality data for the San Francisco Bay Area Network (SFAN) Freshwater Quality Monitoring Program. The SFAN includes Eugene O'Neill (EUON), John Muir (JOMU), and Fort Point (FOPO) National Historic Sites, the Presidio of San Francisco (PRES), Muir Woods (MUWO) and Pinnacles National (PINN) Monuments, Point Reyes National Seashore (PORE), Golden Gate National Recreation (GOGA). The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Freshwater quality ranks among the most important vital signs being monitored by the SFAN. The SFAN has many unique aquatic resources that are significant in an ecological and economic context, supporting a variety of federally protected species. Furthermore, the National Park Service (NPS) has a legal obligation to ensure streams meet minimum water quality standards.

Monitoring methods followed the approved SFAN freshwater quality monitoring protocol (Cooprider and Carson 2006). Sampling includes collection of field and lab measured water quality parameters. Core parameters measured in the field include temperature (air and water), dissolved oxygen, pH, specific conductance, and discharge. Pathogen parameters include coliform bacteria (total coliform and *Escherichia coli (E. coli)*) as well as fecal coliform in Olema Creek. Measured nutrient parameters include nitrate, ammonia and total Kjeldahl nitrogen (TKN).

In Water Year 2007, a total of 255 visits were made to 25 monitoring stations throughout four national park units. Monitoring sites were visited monthly. In addition, on Olema Creek, staff conducted weekly sampling during an intensive five-week winter sampling season in cooperation with the San Francisco Regional Water Quality Control Board Tomales Bay Total Maximum Daily Load pathogen monitoring program.

Water year 2007 had recorded precipitation of 29.38 inches at the Bear Valley headquarters area in Point Reyes National Seashore; 79 percent of the 30-year moving average of 37.40 inches. Measured water quality results were commonly within the water quality objectives established by the San Francisco Regional Water Quality Control Board Basin Plan (California Regional Water Quality Control Board- San Francisco Bay Region 2006) and the U S Environmental Protection Agency (US EPA). The most common exceedences seen were pH below 6.5 in the San Francisco Bay region and below 7.0 in the Central Coast Region, dissolved oxygen below 7.0 mg/L, and bacteria levels above the standards established for contact recreation. Exceedences occurred most frequently in Pinnacles National Monument. Throughout the SFAN, 20 percent of the samples (41 of 201 samples) exceeded the *E. coli* contact recreation criteria.

Observed nutrient levels throughout the network were low compared to the US EPA Ecoregion III regional reference values (US EPA 2000). Only one percent of the ammonia (as N) samples had results above the 0.10 mg/L detection level, mean nitrate (as N) was 0.34 mg/L and mean TKN was 0.99 mg/L. Based on these observations, it is recommended that nutrient sampling be reduced to include only TKN and nitrate each month with ammonia sampled quarterly in October, January, April, and July, as well as during any storm sampling events.

In PORE, nine stations in the Olema Creek and Pine Gulch Creek watersheds were monitored. Throughout both watersheds 14 percent of the *E. coli* samples exceeded the established criteria for contact recreation. In the Olema Creek watershed nine percent of samples fell below the dissolved oxygen objective; there were no results below the criteria in Pine Gulch Creek. Seventeen percent of the pH results from both watersheds fell below the criteria for cold water habitat. 90 percent of the pH and dissolved oxygen results which fell below the criteria came from the two stations on Olema Creek with intermittent flow. In Olema Creek, mean TKN was 1.01 mg/L and mean nitrate (as N) was 0.26 mg/L. In Pine Gulch Creek, mean TKN was 1.34 mg/L and mean nitrate (as N) was 0.24 mg/L.

In GOGA, seven stations in the Rodeo Creek, Tennessee Valley Creek, Nyhan Creek, and Oakwood Creek watersheds were monitored. Throughout the watersheds, 32 percent of the pH measurements, 13 percent of the dissolved oxygen measurements, and 24 percent of the *E. coli* bacteria measurements failed to meet the objectives established in the Basin Plan. Additionally, two exceedences of the total coliform bacteria criteria were observed in Nyhan Creek, indicating a high level of bacteria loading into the stream. In Rodeo and Gerbode Creeks, mean TKN was 0.52 mg/L and mean nitrate (as N) was 0.25 mg/L. In Tennessee Valley Creek, mean TKN was 1.89 mg/L, the highest observed through the SFAN watersheds, and mean nitrate (as N) was 0.20 mg/L.

One station in Franklin Creek was monitored in JOMU. In Franklin Creek, there were no pH results outside of the recommended criteria; 30 percent of the dissolved oxygen measurements, 30 percent of the *E. coli* bacteria samples, and 20 percent of the total coliform bacteria samples fell outside the objectives established in the Basin Plan. The mean TKN was 1.70 mg/L and the mean nitrate (as N) was 1.28 mg/L, the highest observed in the SFAN.

At PINN eight stations in the Chalone Creek watershed were monitored. Stations were located in Chalone Creek as well as the tributaries Bear Gulch, McCabe Canyon and Sandy Creek. The Central Coast RWQCB Basin Plan establishes a criteria of >7 for pH. In the Chalone Creek watershed the pH fell below the criteria during 52 percent of the measurements**;** 31 percent of the dissolved oxygen results fell below the established criteria. Chalone Creek had the highest number of exceedences of the *E. coli* and total coliform bacteria contact recreation criteria with 28 percent of the *E. coli* criteria and eight percent of the total coliform samples exceeding the criteria. 45 percent of the *E. coli* exceedences in PINN were observed at the McCabe Canyon station as well as the highest total coliform level in the SFAN of 41,000 MPN/100mL. The only observed ammonia results above the detection level were seen in the Chalone Creek watershed, although the levels were well below the objectives established in the Basin Plan. The mean TKN in the watershed was 0.65 mg/L and mean nitrate (as N) was 0.13 mg/L, the lowest mean nutrient levels throughout the SFAN.

Acknowledgements

This monitoring would not be possible without the assistance of many people throughout the SFAN network and other organizations. Dean Tucker in the Water Resources Division provided a great deal of assistance with the NPStoret database including data handling and analysis. Much of the monitoring in Pinnacles National Monument was performed by Paul Johnson. Dale Roberts provided additional assistance with the NPStoret database and data reporting. Erin Brown and Sarah Carlisle at Point Reyes National Seashore assisted with monitoring and data entry. Brannon Ketcham provided project oversight and Marcus Koenen provided project support.

Introduction

Background

The San Francisco Bay Area Network (SFAN) is made up of eight national park units, Eugene O'Neill (EUON), John Muir (JOMU), and Fort Point (FOPO) National Historic Sites, the Presidio of San Francisco (PRES), Muir Woods National Monument (MUWO) and Point Reyes National Seashore (PORE), Golden Gate National Recreation (GOGA), and Pinnacles National Monument (PINN) (
Figure **1**). The SFAN identified freshwater quality as a high priority vital sign and has dedicated $120,000 annually to monitoring of the vital sign. Freshwater quality monitoring is conducted under the SFAN Freshwater Quality Protocol, version 2.11, approved in October 2006, which identifies stream monitoring stations and the parameters to be monitored at those stations, in five of the Network's national park units (Cooprider and Carson 2006).

The National Park Service's Management Policies (NPS 2006) states that parks will "use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals". The Inventory and Monitoring (I&M) program was established to help accomplish those policies. Freshwater quality ranks among the most important vital signs being monitored by the San Francisco Bay Area Network I&M Program. The SFAN has many unique aquatic resources that are significant in an ecological and economic context. Freshwater systems within the network support a variety of federally protected species including the California freshwater shrimp (*Syncharis pacifica*) [FE[1]], coho salmon (*Oncorhynchus kisutch*) [FE/SE[2]], steelhead trout (*Oncorhynchus mykiss*) [FT[3]], and the California red-legged frog (*Rana aurora draytonii*) [FT].

The National Park Service (NPS) has a legal obligation to ensure streams meet minimum water quality standards. The California Environmental Protection Agency regulates water quality through the State Water Resources Control Board which is divided into nine Regional Water Quality Control Boards (RWQCB). All SFAN park units with the exception of PINN fall under the regulation of the San Francisco Bay RWQCB. Pinnacles National Monument is within the Central Coast RWQCB area. Through the Basin Plans the Regional Water Quality Control Boards have set beneficial uses for water bodies and numerical and narrative objectives to meet the uses (California Regional Water Quality Control Board – San Francisco Bay Region 2006). There are specific numerical objectives for ammonia, pH, dissolved oxygen, and pathogenic indicator bacteria listed by each RWQCB. Neither the state of California nor the San Francisco Bay RWQCB has set objectives for nitrates or phosphates. Additionally, there are no national water quality criteria for temperature, specific conductance, turbidity or total suspended solids.

Beneficial uses of freshwater bodies within the SFAN include contact and non-contact recreation, fish spawning and migration, cold freshwater habitat, and wildlife habitat. Freshwater quality also has a direct impact on several other resources including: Marine water quality, federally protected stream species and fish assemblages, amphibians and reptiles, riparian habitat, wetlands, and aquatic macroinvertebrates.

[1] FE – federally endangered
[2] SE – state endangered
[3] FT – federally threatened

Figure 1. Map of the San Francisco Bay Area Inventory and Monitoring Network.

Objectives

Monitoring objectives as stated in the SFAN Freshwater Quality Protocol are:

- Determine variability and long term trends in water quality through monthly summaries of select parameters (water temperature, pH, conductivity, dissolved oxygen, total nitrogen, nitrate, ammonia, discharge, fecal and total coliform), at selected sites in priority freshwater streams within SFAN.

- Determine the existing ranges and diurnal variability of water temperature, pH, conductivity, and dissolved oxygen at selected sites in priority streams within SFAN.

- Determine the extent that selected sites in priority streams within SFAN meet federal and state water quality criteria for fecal indicator bacteria, un-ionized ammonia, dissolved oxygen, and pH through monthly sampling.

- Determine the annual, seasonal, and 30-day mean fecal coliform load to Tomales Bay (an impaired water body) from Olema Creek as required by the San Francisco Bay Regional Water Quality Control Board's Tomales Bay Pathogen Total Maximum Daily Load (TMDL) Program.

Several of the monitoring questions and program objectives set forth in the protocol rely on trend analysis based on long-term data sets. The objectives of this first-year report are to establish reporting format, and present findings from monitoring data collected at SFAN long-term water quality monitoring sites during the 2007 water year. The water year runs from October 1 to September 30 of each year. However, monitoring for the 2007 water year was not initiated until November 2006, following protocol approval.

Results presented in this report describe existing chemical and biological ranges at SFAN water-quality sites. Effort has been made to determine the extent to which first-year data show that monitored freshwater resources in SFAN parks meet federal and state water quality criteria for beneficial uses.

Overview of Aquatic Resources

Watershed conditions in the SFAN vary from coastal watersheds in wilderness areas to an urbanized watershed managed as a public water supply. Land uses within the more rural watersheds include agricultural and commercial (e.g., beef and dairy cattle ranching, oyster harvesting, and equestrian) operations as well as predominantly wilderness areas.

The Mediterranean climate of the San Francisco Bay Region is characterized by wet winters followed by dry summer months. The hydrologic systems are very flashy, with high runoff in the winter, and very low to intermittent flow dominating summer conditions. In response to flashy hydrologic conditions and the highly active geologic processes associated with the San Andreas Fault, stream channels are typically dynamic. Chalone Creek in PINN includes a highly mobile sand bed that is typically dry in the summer months. Watersheds within JOMU and the developed portions of GOGA are highly altered by development and urbanization. These systems are highly constrained, with natural processes engineered out of the stream system. Watersheds within the Marin and San Mateo County portions of GOGA, as well as PORE, are less constrained and functional, supporting anadromous steelhead. The larger PORE/GOGA watersheds including Olema Creek, Redwood Creek and Pine Gulch Creek are documented to support both coho salmon and steelhead. Stream systems in these areas have been impacted by historic or current agricultural activities as well as more dispersed development.

Several NPS efforts to improve water resources within SFAN are underway. The Redwood Creek watershed (MUWO/GOGA) is currently the focus of a variety of activities including watershed planning, transportation planning, water quality and water rights investigations, sensitive species monitoring, aquatic system and riparian restoration, invasive non-native plant removal and habitat restoration, and mapping of all watershed features. Similar activities are occurring throughout the network on a smaller scale. Several stream restoration projects are on-going at PORE including implementation of rangeland water quality Best Management Practices, as well as fish passage and habitat restoration projects. Restoration efforts for Chalone Creek (PINN) and its floodplain have also been initiated. Streambank restoration (including removal of invasive plants, erosion control, and bank stabilization) is proposed along Franklin Creek (JOMU), and a feasibility study for a wetland restoration is being conducted at EUON. Major tidal wetland restoration efforts are on-going at PORE, GOGA, and PRES. Wetlands inventories and functional assessments are being conducted at GOGA, as well as PORE. Restoration efforts have primarily focused on the protection and restoration of natural physical processes and habitat known to benefit federally protected aquatic species as well as water quality.

Study Area

Point Reyes National Seashore (PORE)

Olema Creek

Olema Creek is the largest undammed tributary of Lagunitas Creek. The 14.5 square mile watershed flows north through the Olema Valley, the landward expression of the San Andreas Fault Zone. Its confluence with Lagunitas Creek lies at the head of Tomales Bay. The watershed supports viable populations of coho salmon, steelhead trout, and California red-legged frogs. The California freshwater shrimp has been documented in the watershed intermittently. Because of its significance both as habitat for T&E species, and a source of pollutant loading to Tomales Bay, Olema Creek is the subject of extensive monitoring through both this water quality program and the SFAN fisheries monitoring program.

Hydrologic monitoring in Olema Creek began in 1996 with the installation of a hydrologic monitoring station at the Bear Valley Road Bridge. Water quality monitoring within the Olema Creek watershed has been conducted since 1999. Fisheries monitoring, focused on coho salmon, has been conducted in the Olema Creek watershed since 1994-95.

Currently, 35 percent of the Olema Creek watershed is managed for beef cattle grazing. Two horse concessions operations, Stewart Horse Stable and Five Brooks Horse Stable are located in the central portion of the watershed. Because they support anadromous species of fish, the drainages monitored within the Olema Creek watershed should all meet the cold freshwater habitat beneficial use objectives as defined by the San Francisco Bay RWQCB.

Within the Olema Creek watershed, perennial flow persists from Five Brooks north in the mainstem and all tributaries off of Inverness Ridge. Tributaries originating on Bolinas Ridge (to the east) are perennial to ephemeral. Several tributaries flow into Olema Creek including (from south to north): Randall Gulch, John West Fork, Giacomini Gulch, Davis-Bucher Creek, Quarry Gulch, and Vedanta Creek.

Six primary and two secondary sampling sites along the length of the watershed, including four mainstem sites, and four tributaries were selected as part of the SFAN Freshwater Quality Monitoring Program (Table 1). The secondary sites are monitored through the PORE Pastoral Water Quality Monitoring Program; core parameters and coliform bacteria samples are collected.

Table 1. Olema Creek watershed monitoring station locations (upstream to downstream) – See Figure 2.

Station	Type	Flow regime	Site Description
OLM 18	Primary	Intermittent	Olema Creek upstream of Randall Gulch
OLM 1	Primary	Intermittent	John West Fork (tributary) – just upstream of Highway 1
OLM 2	Secondary	Intermittent	Giacomini Gulch (tributary) - just upstream of Highway 1
OLM 14	Primary	Perennial	Olema Creek at Five Brooks bridge
OLM 6A	Primary	Perennial	Davis-Bucher Creek (tributary) - upstream of trail crossing (a "reference" stream which flows out of an area with minimal human impacts/alterations)
OLM 4	Secondary	Intermittent	Quarry Gulch (tributary) - near confluence with Olema Creek
OLM 11	Primary	Perennial	Olema Creek at Bear Valley Road bridge
OLM 10B	Primary	Perennial	Olema Creek adjacent to Olema Marsh

Figure 2. Olema Creek watershed and Pine Gulch Creek watershed water quality monitoring stations.

Pine Gulch Creek

The approximately 7.5 square mile watershed feeds Pine Gulch Creek which flows parallel to Olema Creek for approximately two miles at the southern end of the Olema Valley (Figure 2). The San Andreas Fault separates the two creeks, with Pine Gulch Creek flowing south into Bolinas Lagoon. Much of the downstream portion of the creek, including one of the monitoring sites (PNG 1), is located on private lands. Pine Gulch Creek supports a viable population of steelhead trout and an intermittent population of coho salmon, which are the subject of SFAN fisheries monitoring. No coho salmon were observed in Pine Gulch Creek in 2007 (Del Real et al. 2007). Because it supports anadromous species of fish, the Pine Gulch Creek watershed should meet the cold freshwater habitat criteria as defined by the San Francisco Bay Regional Water Quality Control Board (RWQCB). Three water quality monitoring stations are located throughout the watershed; all stations are located on the mainstem of Pine Gulch Creek (Table 2).

Table 2. Pine Gulch watershed monitoring station locations (upstream to downstream) – See Figure 2

Station	Site type	Flow regime	Site Description
PNG 3	Primary	Perennial	Pine Gulch Creek near Texiera Ranch at Olema Valley Trail crossing
PNG 2	Primary	Perennial	Pine Gulch Creek, downstream of Dogtown
PNG 1	Primary	Perennial	Pine Gulch Creek downstream of Olema-Bolinas Road, adjacent to Gospel Flats organic farm

Golden Gate National Recreation Area (GOGA)

Rodeo Creek

Rodeo Creek empties into Rodeo Lagoon at Rodeo Beach, Fort Cronkhite (GOGA). The approximately 4.4 square mile watershed is located in the southernmost portion of the Marin Headlands (Figure 3). The lagoon is infrequently connected with the ocean and is not commonly affected by tidal influence. The Rodeo Creek headwaters are located entirely within GOGA lands in the Marin Headlands. Rodeo Creek is perennial, includes a North Fork and South Fork, and is fed by Gerbode Creek and several small, unnamed tributaries. Developments in the area with potential affects on water quality include: park housing, a horse stable operation, and the offices and buildings of Ft. Cronkhite. Water quality monitoring has been conducted on Rodeo Creek as part of the GOGA stables monitoring since 1999.

Three sampling sites were selected in this watershed, two primary sites and a secondary site above the influence of park developments (Table 3).

Table 3. Rodeo Creek watershed monitoring station locations - see Figure 3.

Station		Flow regime	Site Description
RC 1	Primary	Perennial	Downstream of stables and approximately 420 meters upstream of the confluence with Gerbode Creek
GERB 1	Primary	Perennial	Upstream of the Miwok trail bridge, approximately 300 m upstream of the confluence with Rodeo Creek
RC 2	Secondary	Perennial	Upstream of the stable, approximately 1 mile upstream of RC1

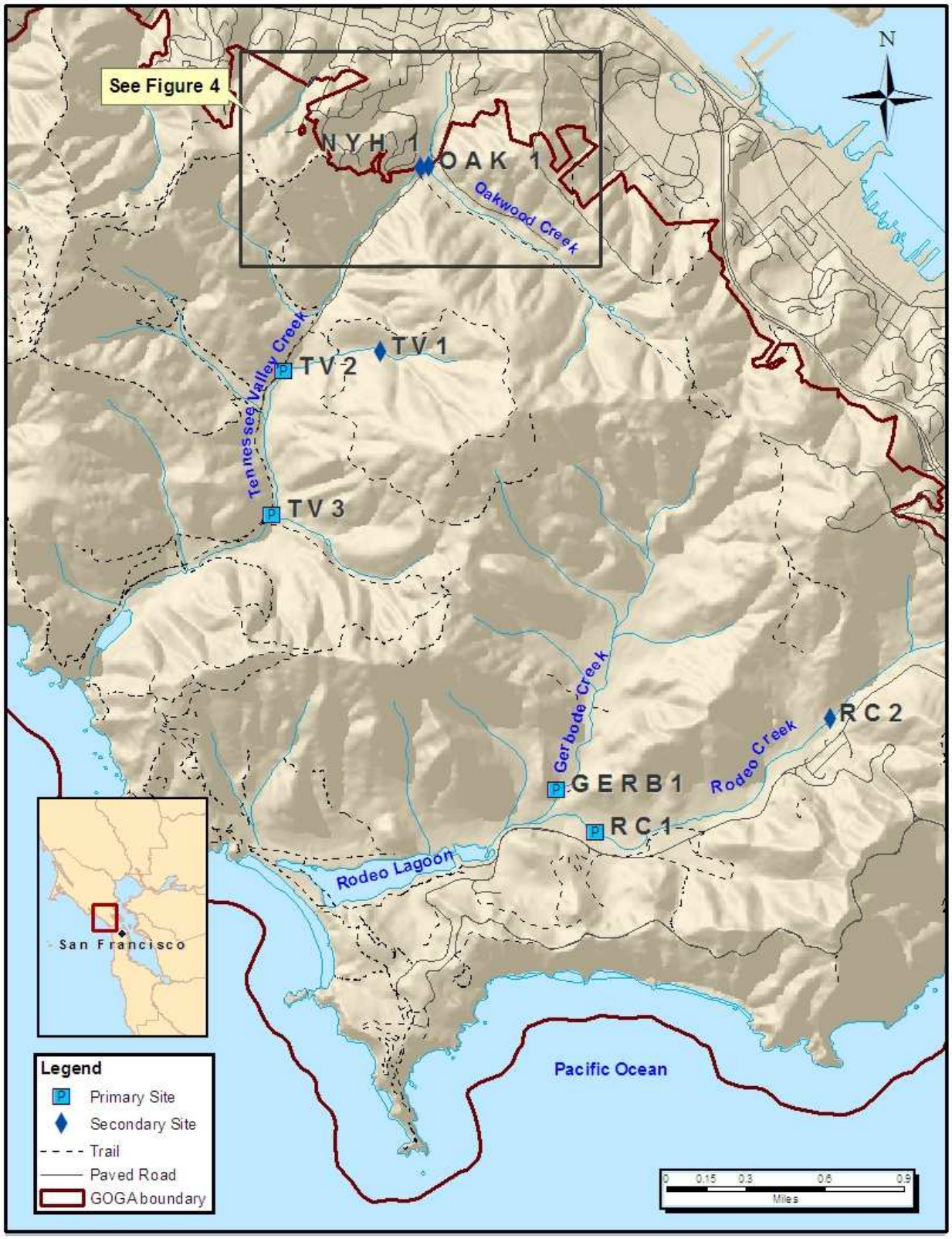

Figure 3. Rodeo Creek watershed and Tennessee Valley Creek watershed monitoring stations.

Tennessee Valley Creek

The Tennessee Valley Creek watershed, which is approximately 2.4 square miles, is located in the valley north of Rodeo Valley and south of Redwood Creek. Its headwaters are located entirely within GOGA lands. It flows northeast to southwest and empties into the Pacific Ocean at Tennessee Cove. Developments in the watershed include a day-use parking lot and a horse-stable operation at the headwaters of the watershed.

Three sampling sites are located in this watershed, two primary sites, TV2 and TV3, and a secondary site, TV 1 (Table 4).

Table 4. Tennessee Valley Creek watershed monitoring station locations (upstream to downstream) - see Figure 3.

Station		Flow regime	Site Description
TV 1	Secondary	Intermittent	Above Miwok horse stables - frequently dry
TV 2	Primary	Intermittent	Below Miwok horse stables and upstream of confluence with Haypress tributary
TV 3	Primary	Perennial	Slightly downstream of the confluence with the Backdoor tributary

Oakwood Valley and Nyhan Creeks

Oakwood Valley Creek flows near the eastern boundary of GOGA lands in a watershed adjacent to the Tennessee Valley Creek watershed (Figure 4). Nyhan Creek flows on the opposite side of the drainage divide from Tennessee Valley. Oakwood Valley Creek flows north and east on GOGA lands until it joins Nyhan Creek just outside the park boundary. Nyhan Creek (an approximately 2 square mile watershed) then flows east into Coyote Creek and then into Richardson Bay.

NYH 1 and OAK 1 are secondary sampling sites for GOGA (Table 5). Because of the proximity to the primary monitoring stations these sites were visited on days when Tennessee Valley and Rodeo Creek watersheds were monitored. These secondary sites represent park lands draining to Richardson Bay, where the RWQCB is completing a TMDL for pathogens. The sampling location for each creek is just upstream of their confluence, adjacent to Tennessee Valley Road. Both of these sites have intermittent flow and were monitored for core parameters (temperature, conductivity, dissolved oxygen and pH), discharge, and coliform bacteria (total coliform and *E. coli*) during monthly sampling visits. Because these are secondary sites, no nutrient samples were collected.

Table 5. Nyhan Creek and Oakwood Creek monitoring station locations - see Figure 4.

Station		Flow regime	Site Description
NYH 1	Secondary	Intermittent	Adjacent to Tennessee Valley Road. 50 m upstream of the confluence with Oakwood Creek
OAK 1	Secondary	Intermittent	Adjacent to Tennessee Valley Road. 50 m upstream of the confluence with Nyhan Creek

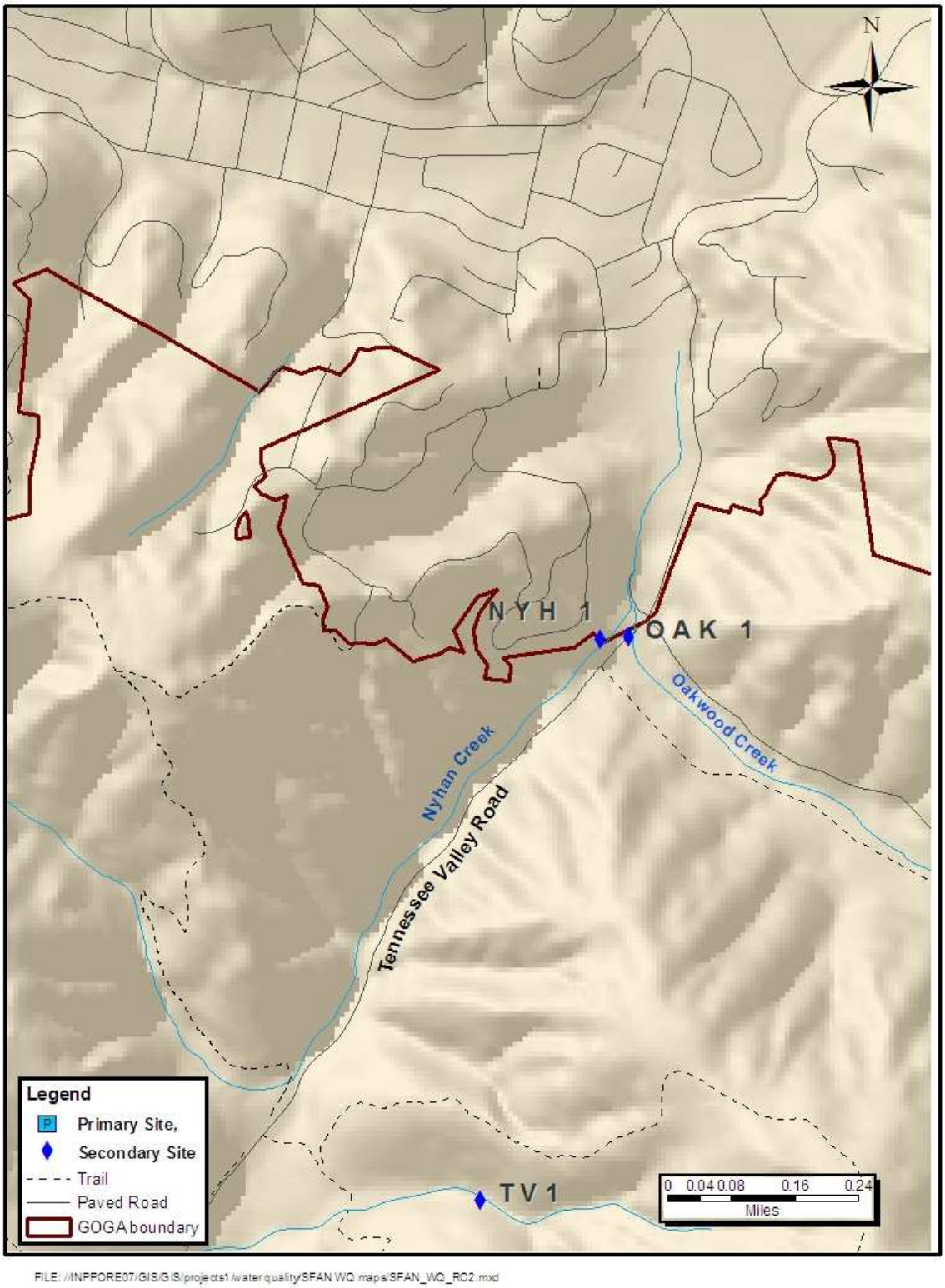

Figure 4. Oakwood Creek and Nyhan Creek water quality monitoring stations.

Pinnacles National Monument (PINN)

Chalone Creek

Ninety-five percent of Pinnacles National Monument is located within the Chalone Creek watershed. However, most of the Chalone Creek headwaters are located outside the park boundary. The drainage area of Chalone Creek as it leaves the park is approximately 70 square miles. The portion of the creek within the park is braided and intermittent, flowing for approximately five months out of the year. Eventually, the watershed drains into the Salinas River to the southwest of the monument.

Tributaries to Chalone Creek include the West Fork of Chalone Creek, Bear Gulch, McCabe Canyon, and Sandy Creek (Figure 5). These streams cut through the Pinnacles rock formations and played a role in the formation of a cave complex found in the monument. Sandy Creek drains from the east entrance of the park and flows along Hwy. 146 before its confluence with Chalone Creek near the Pinnacles campground.

Eight sampling sites were selected within the Chalone Creek watershed, including five primary sites, and three secondary sites (Table 6). All eight sites have intermittent flow.

Table 6. Chalone Creek watershed monitoring station locations – see Figure 5.

Station		Flow regime	Site Description
CHA 3	Secondary	Intermittent	Approx. 1 mile upstream of the Bear Gulch confluence
CHA 2	Primary	Intermittent	Above the Chalone Creek bridge and upstream of the Bear Gulch confluence
CHA 1	Primary	Intermittent	Chalone Creek, 0.4 miles downstream of the Sandy Creek confluence at the Monument boundary
BG 2	Primary	Intermittent	On Bear Gulch, downstream of the visitor center
SC 3	Secondary	Intermittent	Sandy Creek near the campground dumpstation
SC 2	Secondary	Intermittent	Unnamed tributary to Sandy Creek
SC 1	Primary	Intermittent	The furthest downstream site on Sandy Creek, 0.5 miles below the confluence with McCabe Canyon
MC 1	Primary	Intermittent	On McCabe Canyon, just upstream of the confluence with Sandy Creek

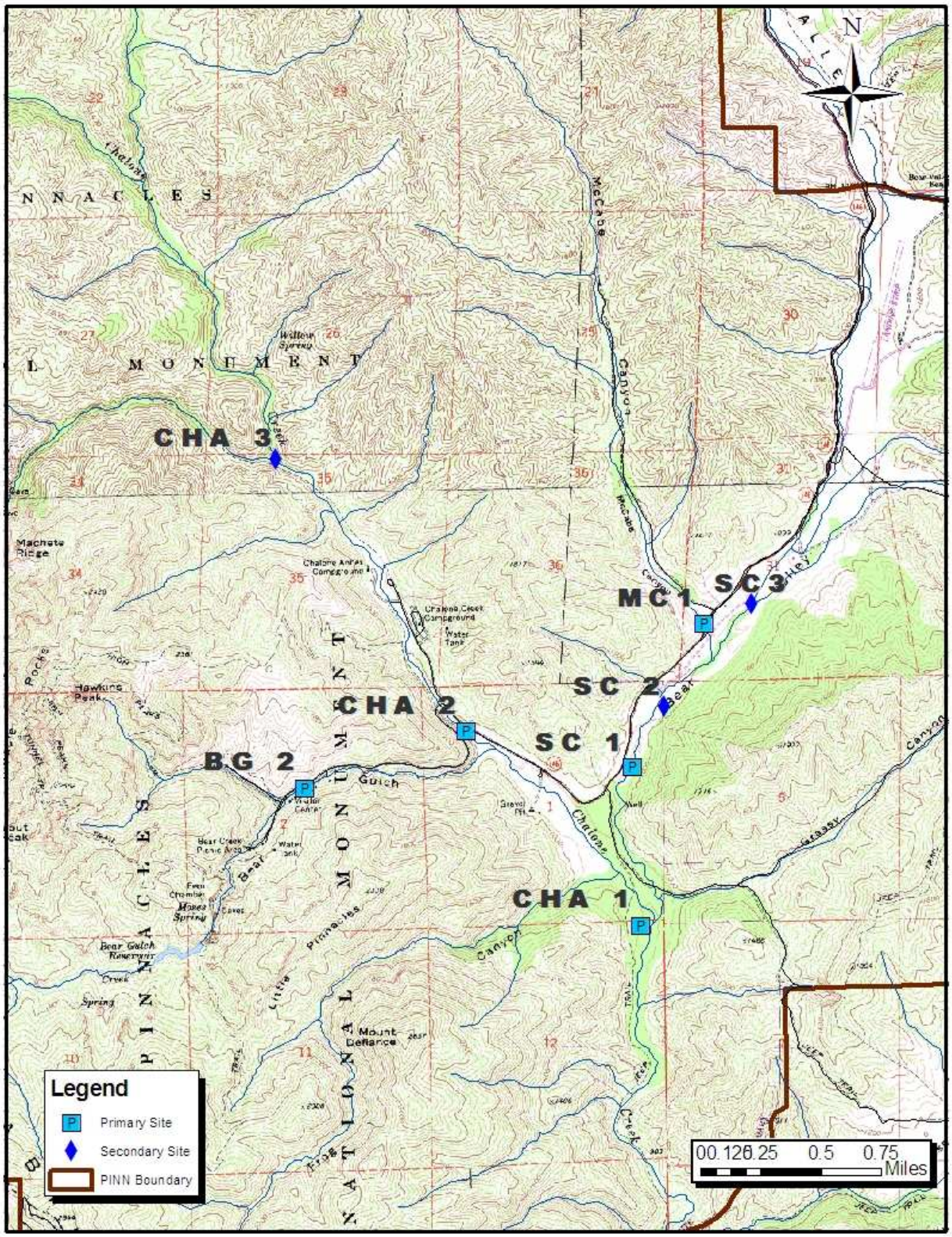

Figure 5. Chalone Creek watershed water quality monitoring stations.

John Muir National Historic Site (JOMU)

Franklin Creek

The five square mile Franklin Creek watershed supports an intermittent stream that flows through the site just west of the John Muir house (Figure 6). It flows generally eastward from the hills overlooking Martinez and joins Alhambra Creek (also referred to as Arroyo del Hambre) just downstream of the property. There was not water quality monitoring at this site before the 2004 pilot sampling to develop the SFAN Freshwater Quality Protocol. In August 2003 a staff plate and data-logging water level monitor were installed in Franklin Creek, just upstream of the creek's exit of the property. Water level data continues to be collected by NPS staff. Steelhead trout have been identified in Franklin Creek, although the reach of the creek through JOMU is not good habitat for salmonids.

Because only approximately 150 meters of Franklin Creek are on NPS property, a single water quality site is monitored for core parameters (temperature, conductivity, dissolved oxygen and pH), discharge, coliform bacteria (total coliform and *E. coli*), and nutrient parameters (nitrate, ammonia and total Kjeldahl nitrogen) (Table 7).

Table 7. Franklin Creek watershed monitoring station location – see Figure 6.

Station		Flow regime	Site Description
FRA 1	Primary	Intermittent	At the bridge within JOMU, approximately 300 feet downstream of the tunnel that runs under State Highway 4

Strentzel Creek

Approximately half of the Strentzel Creek watershed is located within JOMU property. An extensive geomorphology study took place in 2005 which identified significant erosion and sedimentation issues in the watershed; these issues are a management priority for JOMU (Moore et al. in draft 2008). Five secondary monitoring stations have been identified within the watershed which will be monitored for sediment and the core parameters during storm events when possible. It was not possible to sample at Strentzel Creek during the 2007 water year because very few storm events occurred.

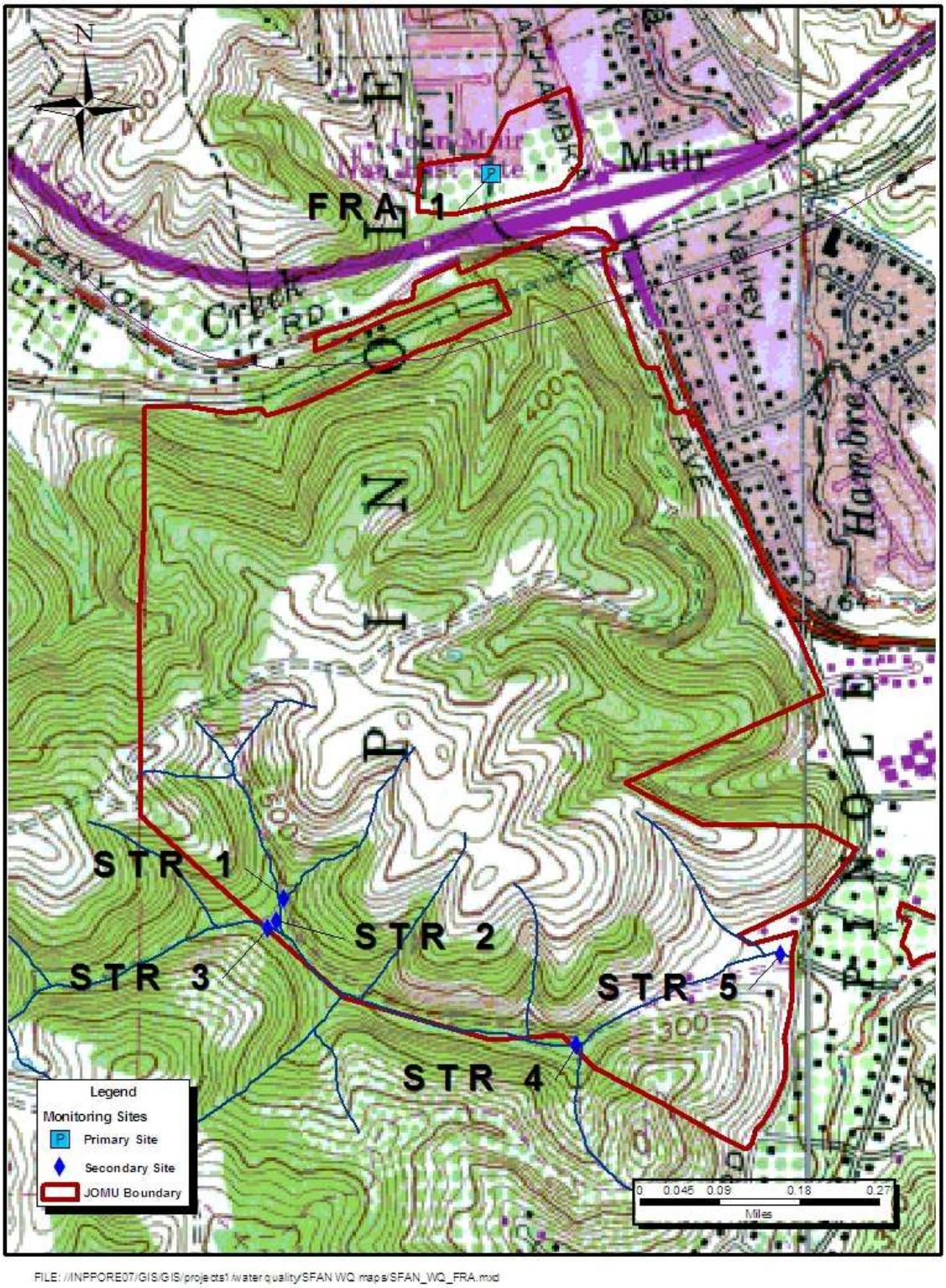

Figure 6. Franklin Creek and Strentzel Creek watershed water quality monitoring locations. Strentzel Creek not monitored in WY 2007.

Methods

Water Quality Criteria

The Clean Water Act mandates the establishment of water quality standards to preserve and protect surface water quality in the U.S. individual states while tribes establish criteria to protect designated beneficial uses. In California, through Basin Plans, the Regional Water Quality Control Boards (RWQCB) have set "numerical and narrative objectives for surface waters" (Tables 8, 9, 10, and 11) (California Regional Water Quality Control Board San Francisco Bay Region 2007, California Regional Water Quality Control Board Central Coast Region 1994). The RWQCB numeric objectives for bacteria are based on the national criteria established by the US Environmental Protection Agency (US EPA) (1986). The Basin Plans also outline the beneficial uses assigned to each stream that is a significant surface water feature. Many states or agencies commonly refer to established water quality "standards" or "criteria"; this report will refer to water quality "objectives" as stated in the Basin Plans. Although the San Francisco Bay RWQCB has identified some nutrients as impairments to Tomales Bay, the region has not established an objective for any nutrients except un-ionized ammonia.

Table 8. Numerical objectives for physical parameters in surface waters from the San Francisco Bay Region Basin Plan (2007).

Parameter	Water Quality Objective
Dissolved Oxygen (non-tidal waters)	Cold water habitat 7.0 mg/L minimum Warm water habitat 5.0 mg/L minimum
pH	Less than 8.5 and greater than 6.5
Un-ionized ammonia (as N)	Annual Median 0.025 mg/L Maximum Central Bay 0.16 mg/L Maximum Lower Bay 0.4 mg/L

Table 9. Numerical objectives for physical parameters for inland surface waters from the Central Coast Region Basin Plan (1994).

Parameter	Water Quality Objective
Dissolved Oxygen	Inland waters general objective - 5.0 mg/L minimum
pH	Waters not mentioned by a specific beneficial use - less than 8.5 and greater than 7.0
Un-ionized ammonia (as N)	Annual Median 0.025 mg/L as N

Table 10. General numeric objectives for bacteria parameters in surface waters from the San Francisco Bay Region Basin Plan (2007) and Central Coast Region Basin Plan (1994).

Beneficial Use	Fecal Coliform (MPN/100mL)	Total Coliform (MPN/100mL)
Contact recreation (REC1)	Log mean < 200 [a] 90th percentile < 400 [b]	Median < 240 No sample > 10,000
Non-contact recreation (REC2)	Mean < 2000 90th percentile < 4000	
Shellfish harvesting	Median < 14 [a] 90th percentile < 43 [b]	Median < 70 90th percentile < 230

[a] Based on a minimum of five consecutive samples equally spaced over a 30-day period.

[b] No more than 10 percent of total samples during any 30-day period may exceed this number.

Table 11. Additional Water Quality Criteria for bacteria for Contact Recreation (REC 1) from the San Francisco Bay Region Basin Plan (2007) and Central Coast Region Basin Plan (1994).

	Marine Water	Fresh Water
Total Coliform		
Single Day Sample	10,000	10,000
30 Day Average	1,000	1,000
E. coli		
Single Day Sample	235	235
30 Day Average	126	126
Enterococcus		
Single Day Sample	104	61
30 Day Average	35	33
Fecal coliform		
Single Day Average	400	400
30 Day Average	200	200

Clean Water Act Section 303d Listed Waters

Water bodies within and adjacent to NPS lands have been listed under Section 303(d) for not meeting defined beneficial uses. With the state as the lead in development of TMDLs, the NPS is participating as an active stakeholder, along with other stakeholders, to support development and implementation of water quality monitoring and enhancement efforts to address water quality pollution issues.

The San Francisco Bay RWQCB recently completed a Pathogens Total Maximum Daily Load (TMDL) project plan for the Tomales Bay Watershed (California Regional Water Quality Control Board 2007). Within the Tomales Bay watershed, the TMDL set forth water quality targets for the Bay and its tributaries, including:

- Zero discharge of human waste
- Tomales Bay Shellfish Harvest Closure <30 days per year
- Coliform Bacteria Levels (in MPN/100 ml)
    - Tomales Bay
        - Median < 14 and 90^{th} percentile < 43
    - Tomales Bay Tributaries (Walker Creek, Lagunitas Creek, Olema Creek)
        - Log mean < 200 and 90^{th} percentile < 400

As part of the TMDL development process, the NPS proposed a monitoring regime for Olema Creek that would be conducted in conjunction with other stakeholders and the RWQCB for compliance with the approved TMDL. This includes monthly monitoring as well as intensive weekly monitoring for five consecutive weeks during the winter rainy season.

Tomales Bay (PORE/GOGA) and its tributaries (Lagunitas Creek and Walker Creek) as are also 303(d) listed for sediment and nutrients (Table 12). In addition, Tomales Bay and Walker Creek are also 303(d) listed for mercury. The San Francisco Bay RWQCB is in the process of developing a TMDL for mercury within Walker Creek, and has yet to initiate TMDL development for sediment or nutrients in Tomales Bay/Lagunitas Creek/Walker Creek (Table 13). In anticipation of these pending TMDL projects, the NPS worked with the USGS-Water

Resources Division through the NPS competitive grant program to conduct a three-year investigation on sediment issues in Lagunitas and Walker Creek. This investigation (Curtis 2008) provides baseline sediment information for USGS monitored stations in these watersheds.

Table 12. Proposed 2006 CWA Section 303(d) list of water quality limited segments. (California Regional Water Quality Control Board – San Francisco Bay Region 2006)[4].

Waterbody (Watershed)	Park Unit	Pollutant
Coyote Creek (Richardson Bay)	GOGA	Diazinon
Lagunitas Creek (Tomales Bay)	PORE, GOGA	Sediment, Nutrients
Richardson Bay[5]	GOGA	High Coliform, Mercury, PCBs, Pesticides, Exotic Species
San Francisco Bay	GOGA, PRES	PCBs, Nickel, Pesticides, Exotic Species, Dioxin, Selenium
San Francisco Bay Urban Creeks	GOGA	Diazinon
San Francisquito Creek	GOGA	Diazinon, Sediment
San Pedro Creek (Pacific Ocean)	GOGA	High Coliform
Tomales Bay	PORE, GOGA	Sediment, Nutrients, Mercury

Table 13. Completed San Francisco Bay area TMDL projects (California Regional Water Quality Control Board – San Francisco Bay Region 2007)

Water body (Watershed)	Park Unit	Pollutant
San Francisco Bay	GOGA, PRES	Mercury
Tomales Bay	PORE, GOGA	Pathogens
Walker Creek[6]	GOGA	Mercury

[4] Main TMDL page - http://www.waterboards.ca.gov/sanfranciscobay/tmdlmain.shtml
[5] San Francisco Bay PCBs and Richardson Bay pathogens scheduled for completion June 2008
[6] January 23, 2007, the San Francisco Bay Regional Water Board adopted a Basin Plan amendment incorporating a TMDL for mercury in the Walker Creek and Soulajule Reservoir watersheds. The State Water Board will consider the amendment for approval at a later date.

Site Selection

SFAN watersheds were identified in the *San Francisco Bay Area Network Preliminary Water Quality Status Report* (Cooprider, 2004). Monitoring locations were selected based upon Water Resources Division recommended priority criteria for Category 1 and Category 2 watersheds, as well as review by park staff as outlined by the Freshwater Work Group Subcommittee (NPS 2002). Category 1 waters included Section 303d listed streams and significant water bodies (in the case of the SFAN, this would include Areas of Special Biological Significance (ASBS). Category 2 water bodies were those that 1) had established threats, 2) were subject to ecological impairment, 3) lacked baseline data or 4) were linked to another Vital Sign having water column measurement needs.

Co-locating water quality sites with past or current fish or macroinvertebrate monitoring sites helps ensure data linkages. Examples of how this may be employed include presence of a stream gauge or other permanent hydrologic monitoring equipment (linkage to freshwater dynamics vital sign), and linkage to other aquatic vital signs (e.g., stream fish assemblages or freshwater dynamics). Selected monitoring sites represent inputs from all areas of the watershed (i.e., all major tributaries), capture the most downstream site within NPS property, and are accessible.

When possible all sites within a given watershed were sampled on the same day and at the same time for each monthly sampling event in order to limit diurnal variation. Sampling began at the furthest upstream site and progressed downstream.

Sample Regime

The sampling design for the SFAN Freshwater Quality Monitoring Program involves a rotating basin approach in which each watershed is monitored for a two-year period. This approach allows the SFAN to collect sufficient samples for each site and watershed to perform statistical analyses, while allowing for sufficient funds to perform laboratory analyses and provide representative data for each site. There are two "sets" of basins in this design, meaning that every four years, each site, and watershed group will have a minimum two years monitoring data available for analysis. This design should allow the detection of both short- and long-term trends in the watersheds. Table 14 provides the water-quality monitoring schedule for SFAN freshwater resources. This schedule proved to be manageable for the first year of program implementation. Where annual monitoring is mandated by a state TMDL project (currently the Olema Creek watershed) monitoring will continue every year for the TMDL target parameter. Secondary sites in the Olema Creek watershed were not monitored during SFAN I & M sampling. However, they were visited monthly as part of a separate PORE water quality monitoring project. Occasionally, streams did not have enough water to collect water quality data or samples.

This report includes results from October 1, 2006 to Sept 30, 2007 (WY 2007), the first year of protocol implementation. The monitoring schedule calls for the monitoring of nine priority watersheds during the first two years of protocol implementation. Alternate watersheds will be monitored during the following two years, 2009-2010, with the exception of the Olema Creek watershed which will be monitored every year. Monthly site visits were made to each priority watershed with the exception of the Strentzel Creek watershed which was not monitored during the 2007 water year due to insufficient storm events. Although the monitoring schedule states

that monitoring will occur during one storm event in several of the watersheds, storm monitoring did not occur during the 2007 water year due to the lack of storm events.

Table 14. San Francisco Bay Area Network monitoring schedule.
M=monthly, S=during at least one storm event, W=5 consecutive weeks as required by RWQCB TMDL.

Stream	Park Unit	WY 2007 & 2008	WY 2009 & 2010	Number of Monitoring Sites
Olema Creek	PORE	M, S, W	M, S, W	6 Primary / 2 Alternate
Franklin Creek	JOMU	M		1 Primary
Pine Gulch	PORE	M		3 Primary
Strentzel Creek	JOMU	S		No Primary / 5 Alternate
Chalone Creek	PINN	M, S		5 Primary / 3 Alternate
Rodeo Creek	GOGA	M, S		2 Primary / 1 Alternate
Tennessee Creek	GOGA	M, S		2 Primary / 1 Alternate
Nyhan Creek	GOGA	M, S		No Primary / 1 Alternate
Oakwood Creek	GOGA	M, S		No Primary / 1 Alternate
West Union Creek	GOGA		M	2 Primary / 3 Alternate
Lagunitas Creek	PORE/GOGA		M	3 Primary
Lower Redwood	GOGA/MUWO		M, S	7 Primary / 3 Alternate
Upper Redwood Creek	GOGA/MUWO		M	2 Primary / 1 Alternate

Sample Parameters

The NPS Inventory and Monitoring Program calls for required monitoring of all basic "Level 1" Water Quality Parameters. Required "Level 1" parameters include: flow, pH, specific conductance, dissolved oxygen, and temperature (NPS 2002). Table 15 shows the parameters of interest for SFAN priority streams that were collected from all primary sites. Conductivity, the ability of a solution to pass an electric current, is an indicator of the presence of dissolved solids and can be influenced by the geology of an area as well as urban runoff. Ideally, streams should have conductivity between 150 to 500 µS/cm to support diverse aquatic life (Behar 1997). Conductivity varies across water temperatures; Specific conductance is conductivity adjusted to 25 C. Results are commonly reported as specific conductance in order to compare results across stations or sampling times with varied water temperatures.

Monthly site visits included the measurement of core parameters as well as the collection of a grab sample. Instantaneous measurements and grab samples were collected in the centroid of flow. Samples were analyzed for nutrients: nitrate, ammonia, and total kjeldahl nitrogen (TKN), and bacteria: total coliform and *E. coli* as well as fecal coliform in the Olema Creek watershed. TKN is a measure of organic nitrogen and ammonia. Nutrient samples were processed at a private laboratory, Analytical Sciences. Table 16 lists the processing methods used for all

parameters. Ammonia was analyzed using standard method 4500-NH3 with a detection limit of 0.20 mg/L; nitrate was analyzed using EPA method 300 with a detection limit of 0.10 mg/L; and TKN was analyzed using standard method 4500-Norg C with a detection limit of 0.25 mg/L. Ammonia results above the detection level, seen only in Chalone Creek, were converted to un-ionized ammonia to determine whether the results fell within the criteria established by the Regional Water Quality Control Boards.

Bacteria samples were processed using several methods. Total coliform and E.coli bacteria were processed by the private laboratory through April 2007. Through the SFAN program, equipment to operate the Idexx Quantitray system was installed at the Pacific Coast Science and Learning Center (PCSLC) in Point Reyes National Seashore in January 2007. The Idexx system operated by NPS staff at the PCSLC is the same system used by Analytical Sciences, but the cost is $8 per sample rather than $40. For quality assurance and control purposes, samples were processed by both Analytical Sciences and NPS staff during February, March, and April 2007. Fecal coliform samples, collected only for the Olema Creek watershed, were always processed at a private laboratory, Test America, using the EPA multi-tube method 9221-E. Table 17 shows the timing and methods used for the processing of bacteria samples. The acquisition of the Idexx system allowed for affordable analysis of bacteria samples from several of the secondary water quality sites, such as Nyhan and Oakwood creeks, in addition to the primary sites.

Table 15. SFAN water quality monitoring parameters.

Parameter Groups	Parameters Collected
Core	Water Temperature, Specific Conductance; Dissolved Oxygen, pH
Bacteria	Total Coliforms; *E. coli*
Sediment	Turbidity; Total Suspended Sediment (TSS); Suspended Sediment Conc. (SSC)
Nutrients	Total Kjeldahl Nitrogen; Nitrate; Ammonia
Discharge	Flow velocity and stream cross-sectional area

Table 16. Water quality parameter collection and laboratory methods.

Parameter	Method
Core parameters	Instantaneous reading taken with a YSI 85 and Oakton pH meter in the centroid of flow
Total coliform bacteria	Enzyme Substrate Coliform Test: 9223B Enzyme Substrate Test using colilert
E. coli bacteria	Enzyme substrate coliform test: 9223B enzyme substrate test using colilert
Fecal coliform bacteria	Total coliform by multiple tube fermentation: 9221B
Ammonia	SM 4500-NH3
Nitrate	EPA method 300
TKN	SM 4500-Norg C
Discharge	Following USGS Measurement of Stream Discharge by Wading (Rantz 1982) using Marsh-McBirney Flowmate or Swoffer or Pygmy propeller

Table 17. SFAN bacteria processing methods and schedule.

Parameter – location and method	Olema Creek watershed	All other watersheds
Fecal Coliform – Multi-tube	10/06 - 4/07	None
E. coli – Analytical Sciences by Idexx Quantitray	None	11/06 – 4/07
E. coli – NPS staff by Idexx Quantitray	1/07-9/07	2/07-9/07
Total coliform – Test America by multitube	3/07	
Total coliform – Analytical Sciences by Idexx Quantitray	none	11/06 - 4/07
Total coliform – NPS staff by Idexx Quantitray	1/07-9/07	2/07-9/07

All water quality sampling followed the methods laid out in the SFAN Freshwater Quality Protocol (Cooprider and Carson 2006). Core parameter measurements were taken using a YSI-85 multi-parameter instrument and Oakton pH meter. Discharge measurements were taken using a Marsh-McBirney Flowmate flowmeter, Swoffer current meter, or Pygmy current meter.

Data Handling and Analysis

All data was entered in NPStoret, the database created and provided by the National Park Service Water Resources Division. All analysis was performed and graphs were created using the utilities within NPStoret. Summary statistics are provided for all sites, but it should be noted that the minimum and maximum values for the nutrient parameters are the values observed for those results above the detection limit. The true minimum observed value for nutrients at most stations was <0.10 mg/L for ammonia and nitrate or <0.25 mg/L for TKN. Ammonia and nitrate data were reported from the laboratory as ammonia (as N) and nitrate (as N) for PINN and as NH_3 and NO_3 for all other watersheds. Results were converted to ammonia (as N) and nitrate (as N) for reporting consistency. Stations with fewer than five results, such as CHA 1 and CHA 2 from PINN were considered to have a data set too small for analysis and are not included in the graphs (US EPA 1998).

The Quantitray method of bacteria analysis requires that dilutions of the samples be used in order to obtain results above 2419 MPN/100 mL, the quantification limit for undiluted samples. Commonly, 10X or 100X dilutions will be used for samples which are known to have high levels of bacteria. However, as 2007 was the first year of sampling, the correct dilution was not always used for each sample. Occasionally, there were total coliform results which were above the maximum quantification limit (MQL) because the dilution was not high enough. In those instances, a value equal to the MQL, commonly 2,419, was utilized when computing the mean, median, and percentiles for all box and whiskers graphs. The bacteria results summary tables show the number of samples collected as well as the number of total coliform samples which were greater than the quantification limit. All *E.coli* results fell within the quantification limit.

Summary core parameter results are based on instantaneous measurements which do not reflect the diurnal variation seen in these watersheds. This is particularly true for water temperature which was most often measured during the early afternoon hours; therefore the summary tables presented do not reflect the true minimum and maximum temperatures that might occur throughout the day or evening.

Quality Control

Field equipment was calibrated daily before sampling. For pH meters, a three-point calibration was performed. Calibration of the YSI 85 dissolved oxygen probe was performed at each site by entering the approximate altitude of the site location while the probe was in the storage container, which is assumed to be at 100 percent saturation. Daily calibration of the YSI 85 specific conductance is not recommended by the manufacturer. The specific conductance was cross-checked against a reference calibration and calibrated when the measurements were more than 5 µS/cm outside the value of the reference solution. Calibration and cross-checks were documented.

In order to assess precision, duplicate measurements were made for field measurements and a duplicate grab sample was taken for nutrient and bacteria parameters. At least one duplicate or 10 percent of the day's samples was collected per sampling event. One field blank was collected and submitted for laboratory analysis during each sampling day in order to assess possible contamination. Laboratory quality control measures included matrix spikes, method blanks, and calibration standards. There were no personnel changes during the 2007 water year. Data was entered into NPStoret by one staff and verified by an alternate staff person.

Fecal coliform samples, collected only for the Olema Creek watershed, were always processed at the private laboratory. Table 17 shows the timing and methods used for the processing of bacteria samples. For quality assurance and control purposes, *E. coli* and total coliform samples were processed by both Analytical Sciences and NPS staff during February, March, and April 2007.

Precision

As stated in the SFAN freshwater quality monitoring protocol quality assurance project plan a minimum of one field sample per set of samples submitted to the laboratory was processed and analyzed in duplicate to determine precision. The measurement quality objective (MQO) for nitrate (as N), TKN, and ammonia (as N) is +/-30 percent relative percent difference (RPD). The precision MQO for total and fecal coliforms is +/-60 percent RPD. An MQO was not established for *E. coli*, but can be assumed to be the same as total coliforms.

Only one of 63 nitrate (as N) samples failed to meet the MQO. The nitrate (as N) samples had a mean precision of 5.34 percent (Table 18). The precision of the ammonia (as N) samples was not assessed as there were no duplicated ammonia samples above the laboratory detection limit. All the TKN samples met the MQO and had a mean precision of 15.21 percent.

As previously stated, the bacteria samples were processed at Analytical Sciences for a portion of the year, then processed with the Quantitray method by SFAN staff for the remainder of the year at the SFAN lab. Of the samples processed at Analytical Sciences, four of 27 *E. coli* samples failed to meet the MQO; the samples had a mean precision of 36 percent. All of the total coliform samples met the MQO and had a mean precision of 25 percent. The precision for the Quantitray samples handled at the SFAN lab was slightly worse, although the sample set was larger. At the SFAN lab, five of 33 *E. coli* samples failed to meet the MQO; the mean precision was 36 percent. Nine of 33 total coliform samples failed to meet the MQO; the mean precision was 39 percent.

Table 18. Precision of SFAN nutrient and bacteria samples.

	Nitrate (as N)	**TKN**	**Total Coliform (Analytical Sciences)**	**Total Coliform (SFAN lab)**	***E. Coli* (Analytical Sciences)**	***E. Coli* (SFAN Lab)**
# of Samples	39	51	27	33	27	33
Percent of samples failed to meet MQO	3	0	0	27	15	15
Mean Precision (Relative Percent Difference)	5.34	15.21	25	39	36	36

Results

Descriptive statistics for freshwater quality monitoring for WY 2007 are presented below. The data summarized in this report are available for download from the US EPA's STORET Data Warehouse (http://www.epa.gov/storet/dw_home.html). Results are organized by NPS unit and watershed. Box and whiskers plots show the first, second (median), and third quartiles and the 10^{th} and 90^{th} percentiles. Far outliers are any results greater than three times the interquartile range, and are also shown on the plots.

Point Reyes National Seashore (PORE)

Olema Creek

As part of the I&M monitoring efforts in WY 2007, primary monitoring stations were sampled in Olema Creek. A total of 15 visits were made to each site during the 2007 water year. The sites were visited monthly starting in November 2006. Additionally, as required by the San Francisco Bay RWQCB, the sites were visited once weekly for five consecutive weeks during the winter in order to determine the mean fecal coliform load to Tomales Bay. During those sampling events, core parameters were measured and samples were analyzed for fecal coliform bacteria. Nutrient samples were not collected.

Water year 2007 was drier than the 30-year moving average with 29.38 inches recorded at the Bear Valley headquarters area compared to a 30-year moving average of 37.24 inches (Figure 7).

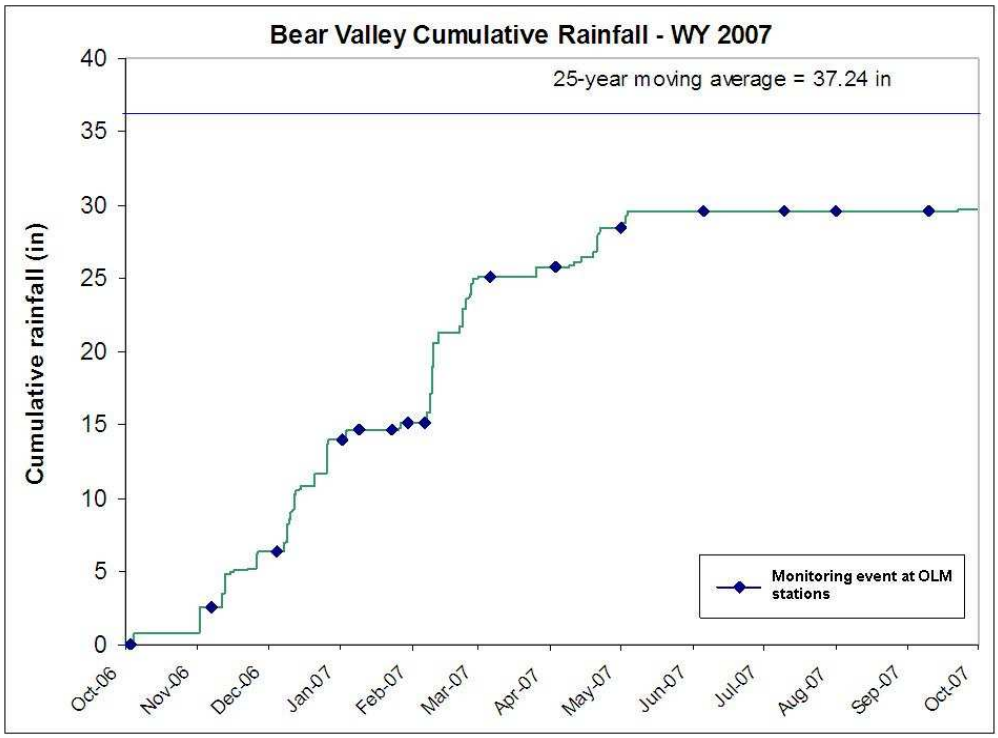

Figure 7. Cumulative rainfall at Bear Valley headquarters near monitoring station OLM 11.

Core parameters analysis: Olema Creek and its tributaries are highly responsive to storm events. The monitoring schedule did not overlap with many of these storm events. Instantaneous discharge measurements were taken during each monitoring site visit when there was measurable flow. The maximum discharge measured during a monitoring event, 20.81 cubic feet per second (cfs), was at OLM 10B, the furthest downstream monitoring site, on March 6, 2007. It should be noted that a discharge measurement of 687 cfs was collected at Bear Valley Road Bridge in February 2007; the peak discharge in Olema Creek during WY 2007 was likely higher than 687 cfs, but was not captured with a measurement.

Measurements for pH fell within the water quality objective of 6.5 to 8.5 established by the San Francisco Bay RWQCB at four of the six monitoring sites (Table 19). At OLM 18, the furthest upstream monitoring site, and OLM 1, below OLM 18, pH was consistently below the water quality objective (
Figure **8**). Both of these stations have intermittent flow, which likely influenced the pH results. The 2007 mean pH of 6.30 for OLM 18 was well below the 2001-2006 mean pH for this site of 7.00. Additionally, the 2007 mean pH of 6.51 for OLM 1 was below the 1997-2006 mean of 7.23. It should be noted that two other sites, OLM 11 and OLM 14, also had lower mean pH in 2007 than during 1999-2006, although the difference was not as large. Two other sites, OLM 6A and OLM 10B had higher mean pH in 2007 than during 2003-2006. Monitoring equipment for pH has changed throughout this time period and may have influenced the summary data.

Figure 9 shows a typical relationship for temperature and dissolved oxygen (at OLM 11). As flow decreases and temperature rises in the summer, dissolved oxygen decreases. Dissolved oxygen levels frequently fell below the water quality objective at OLM 18 and OLM 1 and fell below the objective on one occasion at OLM 10B (Figure 10). These sites, OLM 18 and OLM 1, have intermittent flow, whereas the other sites in the watershed have perennial flow. The low dissolved oxygen at these sites may be attributed to the low or intermittent flow conditions frequently seen at OLM 18 and OLM 1 as well as the one occasion, September 2007, at OLM 10B when the calculated discharge was 0.25 cfs. The lowest dissolved oxygen conditions at OLM 18 and OLM 1 occurred during October and November 2006 and September 2007. Water temperature results ranged from 5.2 ºC during the winter months to 18.1 ºC in the summer months. Figure 5 shows the general temperature trend which was observed at all sites. Low temperature results were often outside the ideal range for rearing of juvenile coho salmon (Figure 11). This was not a concern as low results were observed during the winter months which were not during the peak rearing season and are not thought to cause stress to salmonids; throughout the year water temperatures in Olema Creek most often support salmonids.

Specific conductance levels were between 87.8 and 317.7 µS/cm; levels were generally higher under low flow conditions and lower following a rainfall event (Figure 12). Salinity levels in the Olema watershed rarely fell outside the mean of 0.1 ppt.

Table 19. Core parameter results for the Olema Ceek watershed – WY 2007.

	# of Samples	Sp. Conductance (µS) Min	Max	Dissolved Oxygen (mg/l) Min	Max	pH Min	Max	H_20 Temp (°C) Min	Max
OLM 18	15	87.8	202.8	3.65	11.47	5.60	7.20	5.2	13.7
OLM 1	15	97.8	219.1	4.21	11.28	6.12	7.49	6.0	14.5
OLM 14	15	113.4	316.3	7.18	12.36	7.02	8.17	6.3	15.1
OLM 6A	15	170.1	312.8	9.64	12.76	7.37	8.3	6.7	13.8
OLM 11	15	113.0	317.7	8.02	14.37	6.69	7.84	5.8	18.1
OLM 10B	15	132.9	306.2	5.97	14.11	6.83	7.88	5.8	16.0

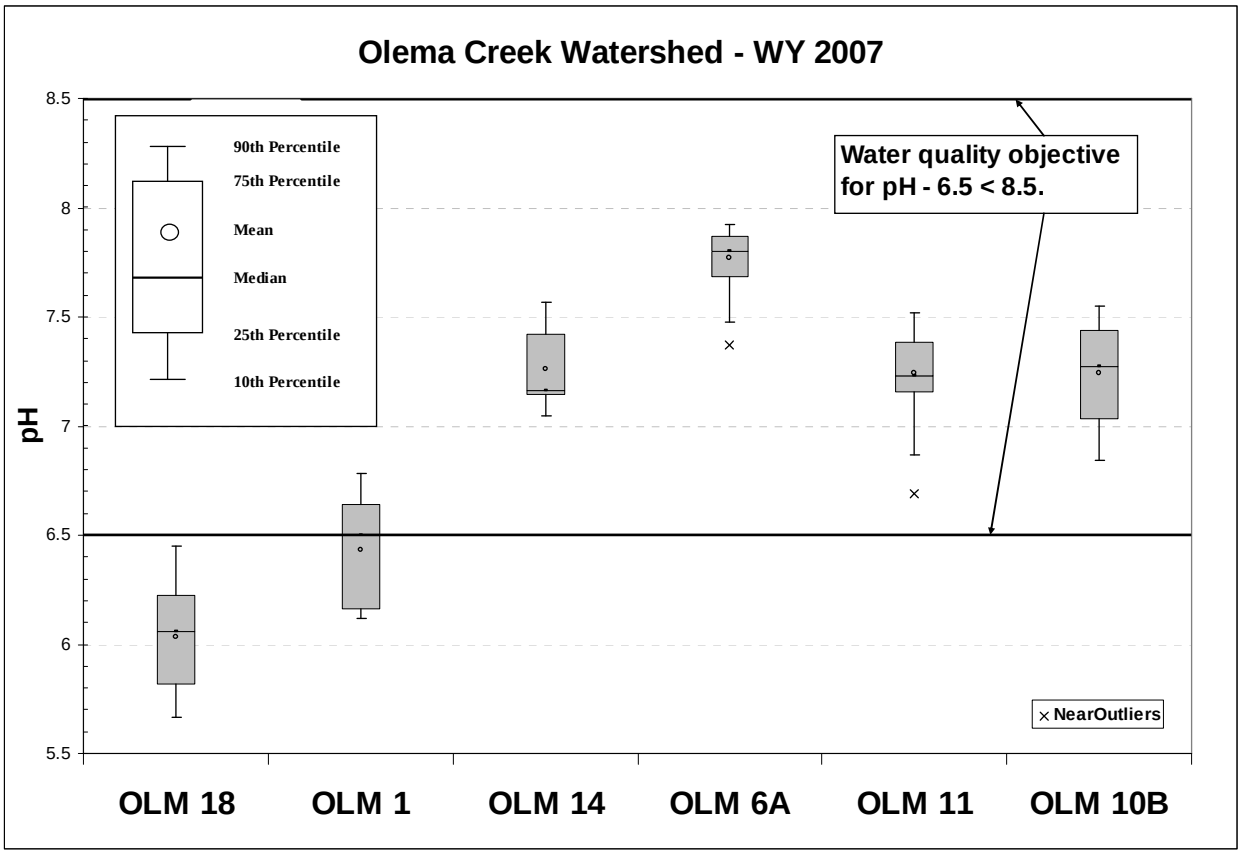

Figure 8. Olema Creek Watershed pH results.

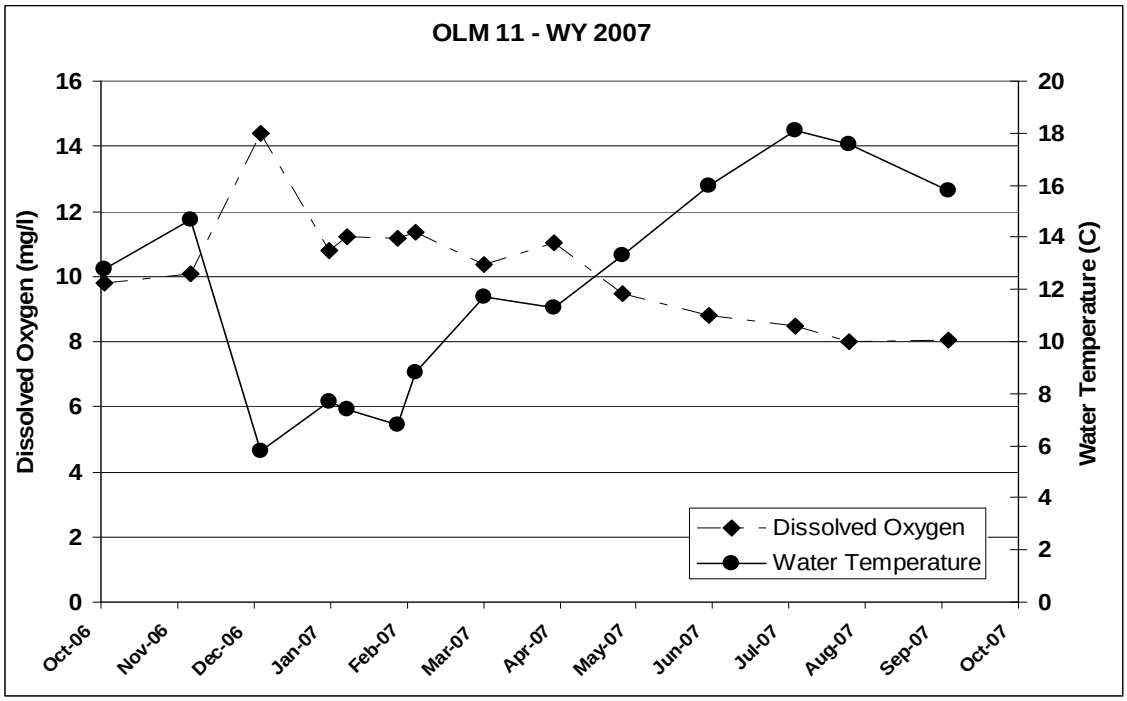

Figure 9. Dissolved oxygen and instantaneous water temperature at OLM 11 – WY 2007.

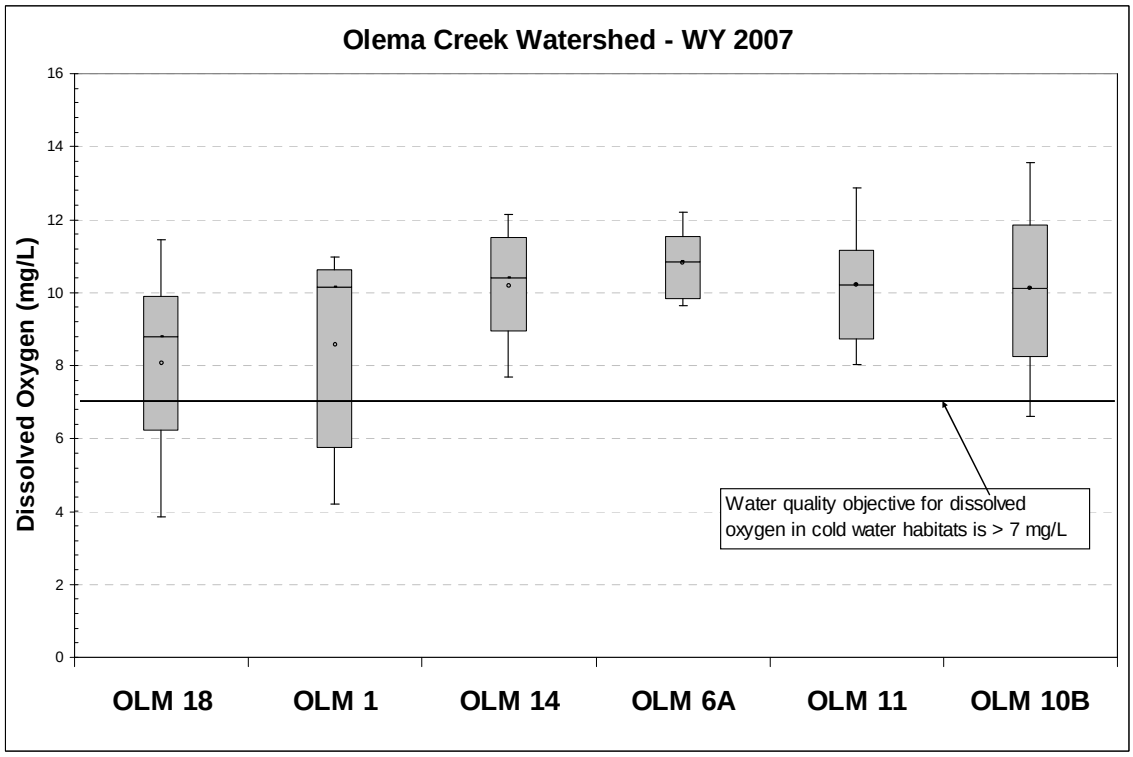

Figure 10. Olema Creek watershed dissolved oxygen results.

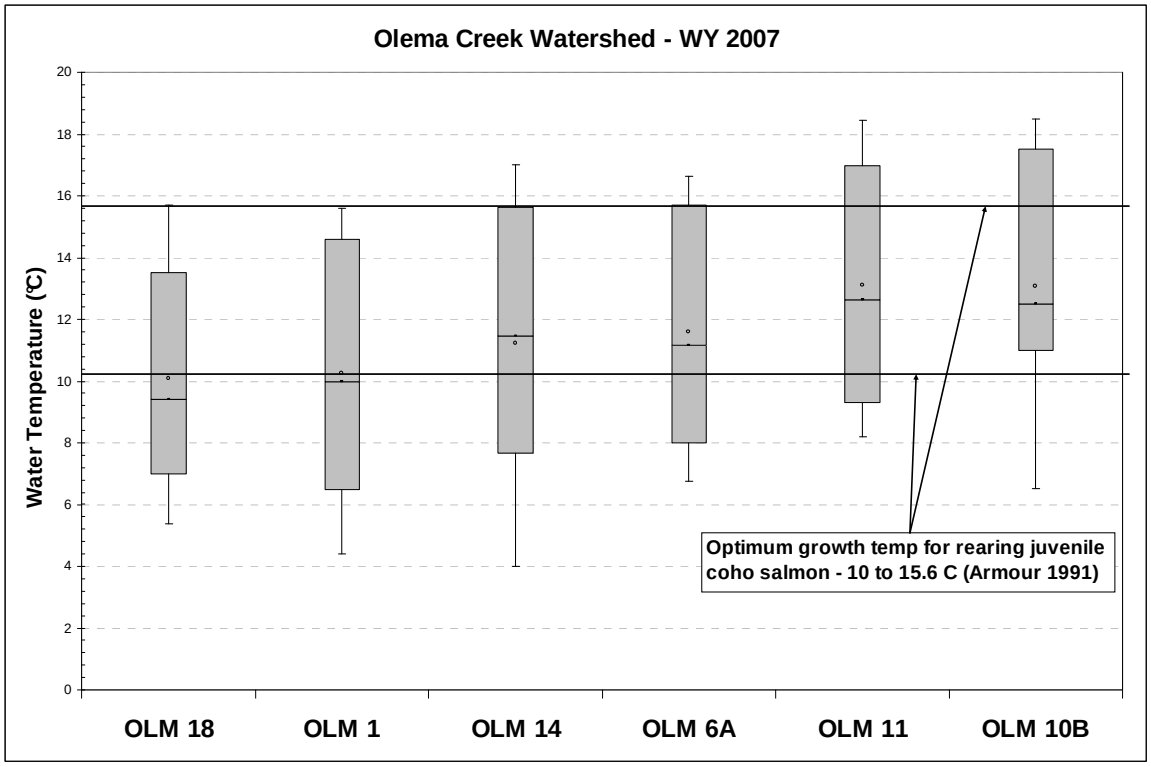

Figure 11. Olema Creek watershed instantaneous water temperature results.

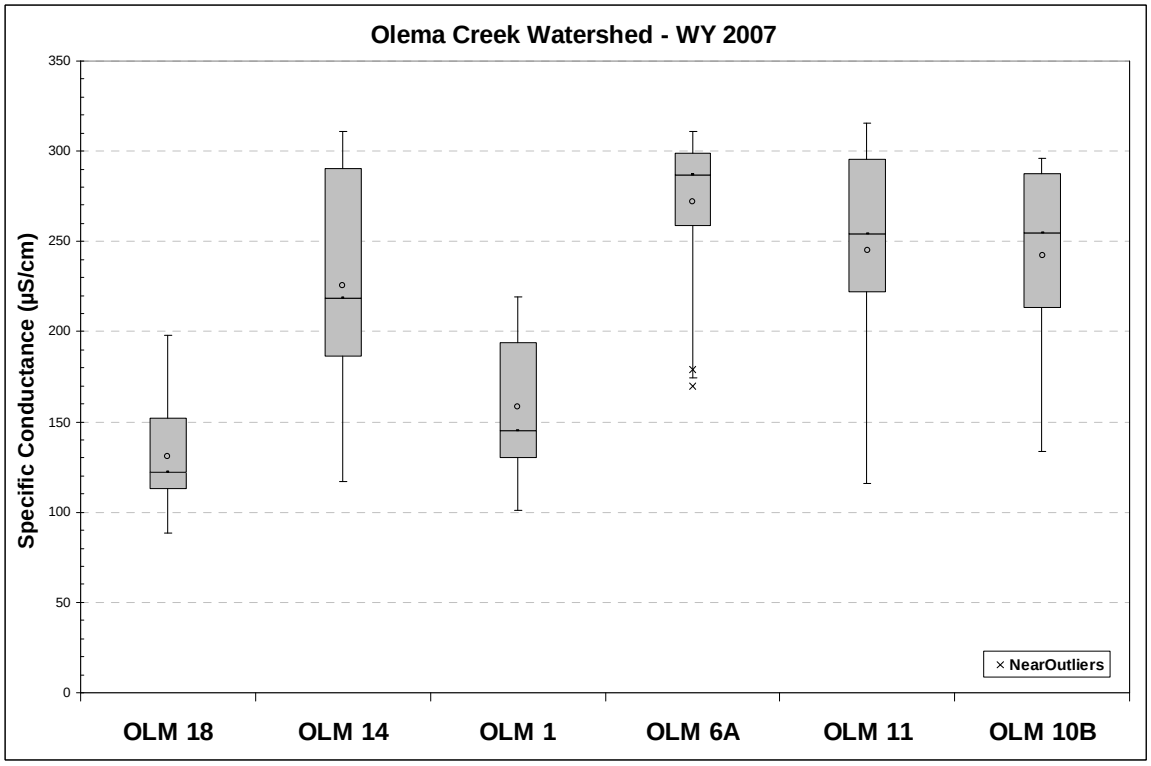

Figure 12. Olema Creek watershed specific conductance results.

Nutrient analysis: Ammonia levels did not exceed the detection limit at any of the Olema Creek watershed monitoring sites. TKN was above the detection limit for 24 percent of the samples; nitrate was detected in 79 percent of the samples. Mean nitrate and TKN levels were most often below 0.30 mg/L and 1.0 mg/L respectively with nitrate detected more frequently than TKN (Table 20). Figure 13 represents the temporal nature of nutrient loading in the Olema Creek watershed, with higher levels detected in January, the period of highest runoff, and lower levels through the summer. There were not any significant rainfall events which preceded the higher levels of nitrate seen at OLM 1 and OLM 14 during the Nov 7 and Dec 5, 2006 sampling events.

Table 20. Olema Creek watershed nutrient results – WY 2007

	# of Samples	Nitrate as N (mg/L) No. of Detects	Nitrate as N (mg/L) Min / Max	TKN (mg/L) No. of Detects	TKN (mg/L) Min / Max	Ammonia as N (mg/L)
OLM 18	11	5	0.07 / 0.29	3	0.33 / 6.70	No Detections
OLM 1	11	9	0.08 / 0.90	3	0.25 / 1.30	No Detections
OLM 14	11	9	0.14 / 0.50	2	0.26 / 1.70	No Detections
OLM 6A	11	11	0.17 / 0.36	1	0.44 / 0.44	No Detections
OLM 11	11	9	0.05 / 0.72	3	0.36 / 0.80	No Detections
OLM 10B	11	9	0.05 / 0.68	4	0.27 / 1.70	No Detections

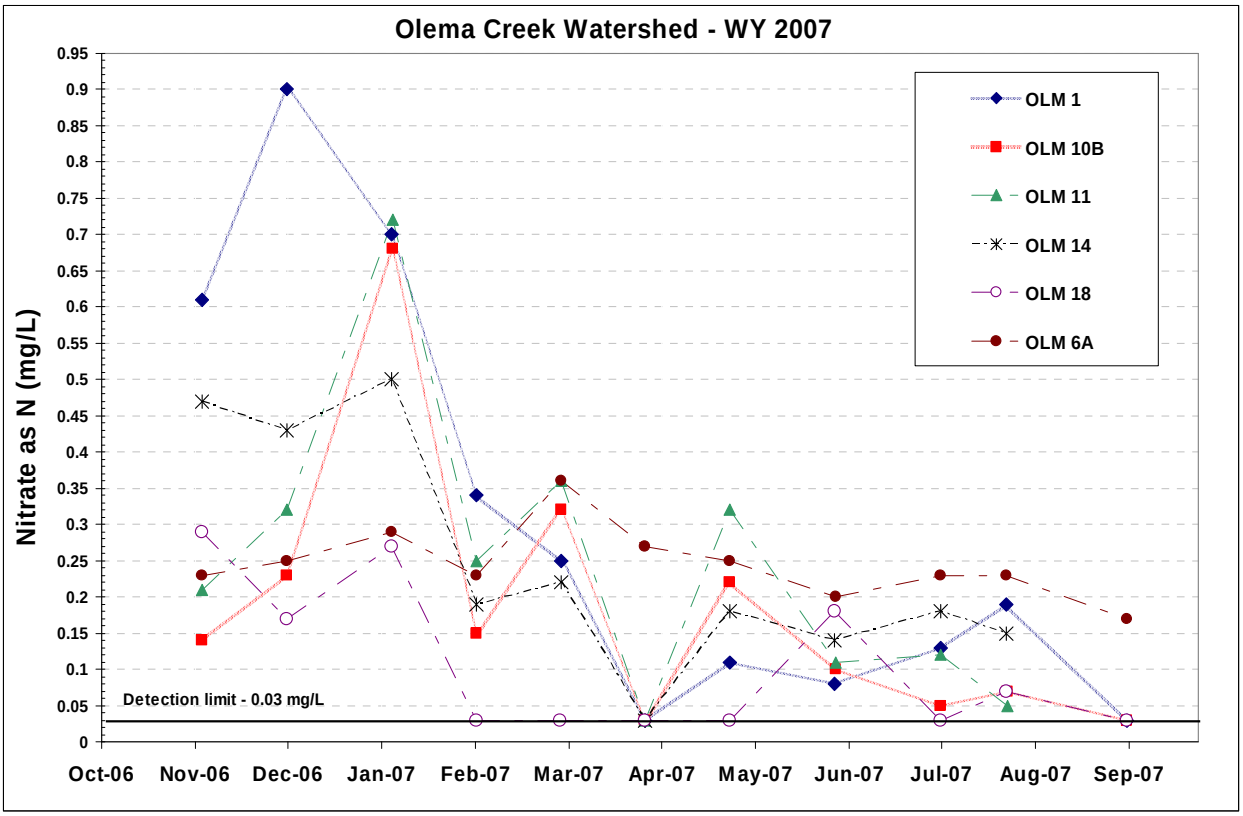

Figure 13. Olema Creek watershed nitrate results; results shown at the 0.03 mg/L detection limit were at or below the laboratory detection limit.

Bacteria analysis: A total of seven exceedences at four sites of the *E. coli* contact recreation criteria (235 MPN/100 mL per single day sample) were observed (Table 21, Figure 14). There are multiple criteria for fecal coliform bacteria. No single sample within a 30-day period may be above 400 MPN/100 mL and the log mean of five consecutive weekly samples must be below 200 MPN/100 mL. There were no exceedences of these criteria during WY 2007 (Figure 15). There were no observed exceedences of the US EPA bacteriological criteria for total coliform bacteria (10,000 MPN/100 mL per single day sample) in the Olema Creek watershed (Table 21).

Table 21. Olema Creek watershed Fecal Coliform and *E. coli* bacteria results - WY 2007.

	Fecal Coliform (MPN/100 ml)					***E. coli* Bacteria (MPN/100 ml)**			
	# of samples	Min	Max	Log Mean[7]	Exceedences	# of samples	Min	Max	Exceedences
OLM 18	10	18	180	49	0	9	10	2400	1
OLM 1	10	7	110	27	0	9	3	180	0
OLM 14	10	11	300	39	0	9	10	1600	2
OLM 6A	10	4	50	20	0	9	<10	1300	2
OLM 11	10	14	140	61	0	9	41	910	2
OLM 10B	10	23	170	84	0	9	10	200	0

Table 22. Olema Creek watershed total coliform results – WY 2007.

	Total Coliform Bacteria (MPN/100ml)				
	# of samples	# of samples > QL	Min	Max	Exceedences
OLM 18	9	0	99	4400	0
OLM 1	9	0	14	850	0
OLM 14	9	0	231	3300	0
OLM 6A	9	0	10	1300	0
OLM 11	9	0	61	3400	0
OLM 10B	9	0	160	2419	0

[7] Geometric mean of 5 weekly samples – 1/2/07 to 2/6/07.

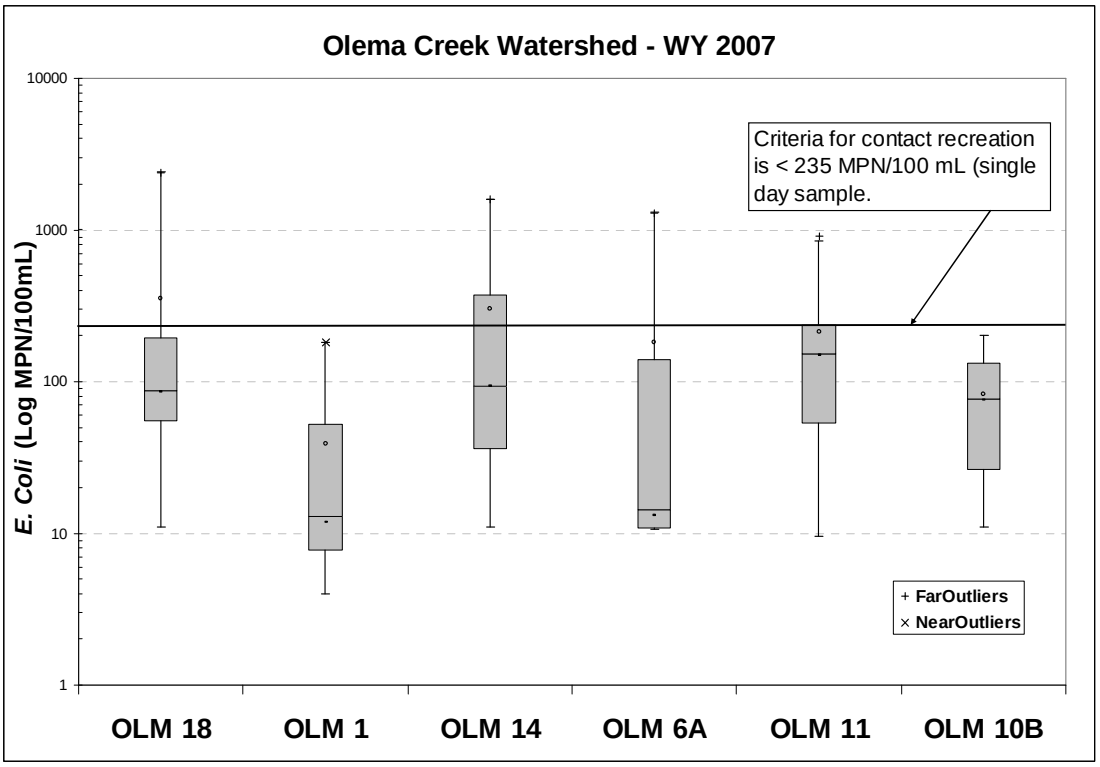

Figure 14. Olema Creek watershed *E. coli* bacteria results.

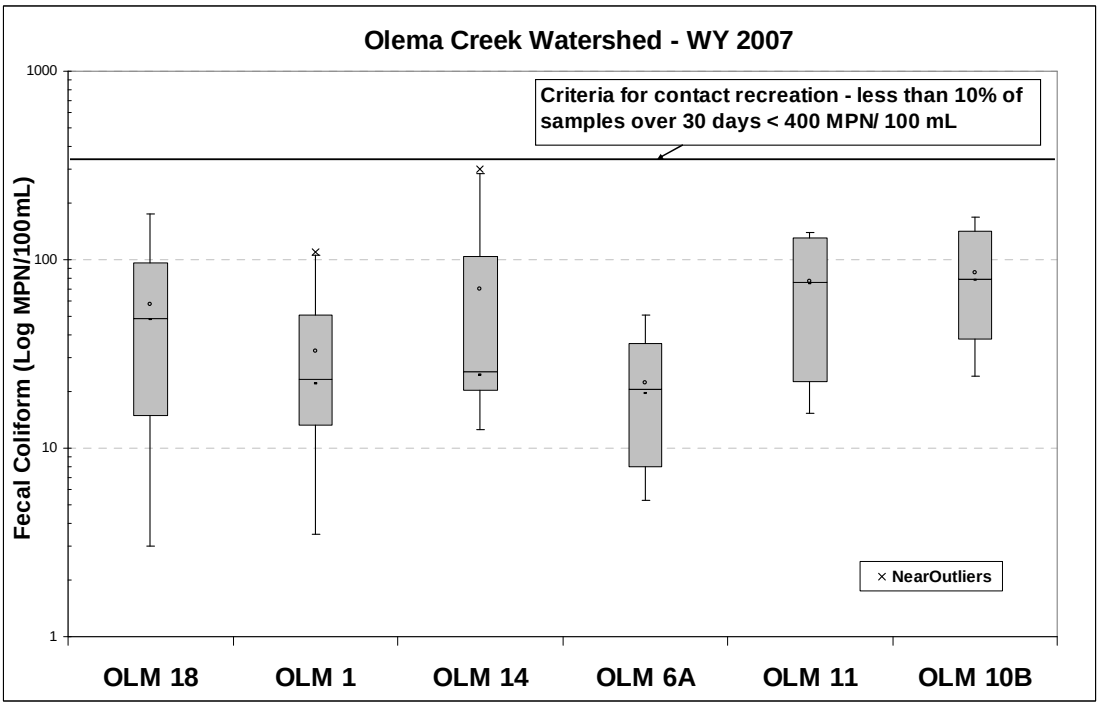

Figure 15. Olema Creek watershed fecal coliform bacteria results.

Pine Gulch Creek

Three sampling sites are located along the length of the watershed. A stream gaging station is located at the furthest downstream site, PNG 1. All sites are on the mainstem of Pine Gulch Creek, have perennial flow and were monitored monthly for the core parameters, discharge, coliform bacteria (total coliform and *E. coli*) and nutrient parameters (nitrate, ammonia and total Kjeldahl nitrogen).

Core parameter analysis: Eleven monitoring visits were made to each site during the 2007 water year (Table 23). Sampling most often took place when streamflow was "normal" or "low", less than eight cfs (Figure 16). The highest instantaneous discharge measurement during a water quality monitoring visit was 13.35 cfs at PNG 1; although the maximum calculated discharge at the gage was approximately 225 cfs, recorded in early December 2006. The instantaneous discharge measurements taken during sampling events are not representative of the actual minimum, mean, and maximum discharge seen at the monitoring sites.

The median pH for all sites was within the water quality criteria; pH results fell below the lower limit of 6.5 during a single sampling event at two of the sites in May 2007 (Figure 17). The mean pH for all sites during WY 2007 was 7.02.

Water quality core parameter values varied little throughout the year. Dissolved oxygen fell throughout the summer while water temperatures rose (Figure 18). Values for dissolved oxygen did not fall below 7 mg/L, the San Francisco Bay Area RWQCB criteria (Figure 19).

Water temperature at all stations in the watershed was consistently within the optimal growth temperature for juvenile coho salmon and did not rise above 16.1º C (Figure 20).

Conductivity varied little throughout the year and between sites. The mean specific conductance in the Pine Gulch watershed was 221.6 µS/cm (Figure 21).

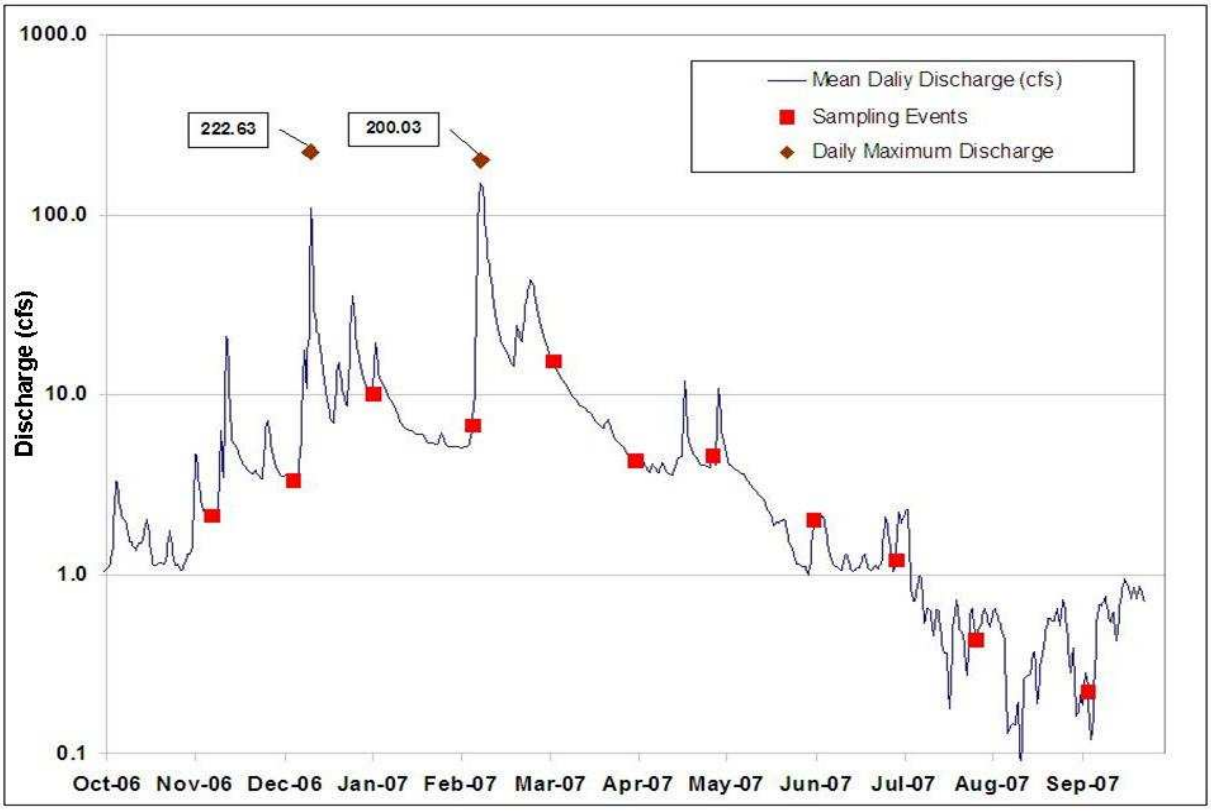

Figure 16. Mean daily discharge at monitoring station PNG 1.

Table 23. Pine Gulch watershed core parameter results – WY 2007.

	# of	Sp. Conductance (µS)		Dissolved Oxygen (mg/l)		pH		H_20 Temp (°C)	
	Samples	Min	Max	Min	Max	Min	Max	Min	Max
PNG 1	11	157.8	268.6	7.84	10.72	5.51	7.29	9.3	16.1
PNG 2	11	145.2	259.2	8.68	11.18	6.3	7.47	9.5	16.0
PNG 3	11	155.9	247.0	8.66	11.91	6.69	7.31	7.3	15.1

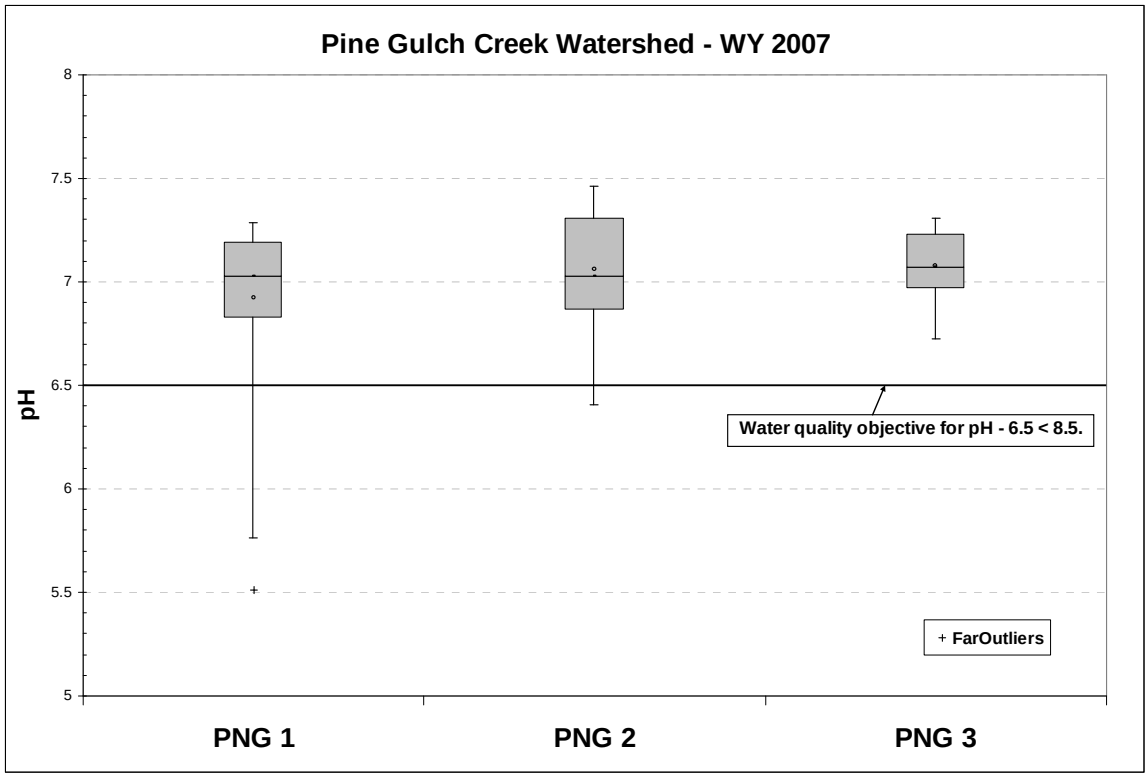

Figure 17. Pine Gulch watershed pH results.

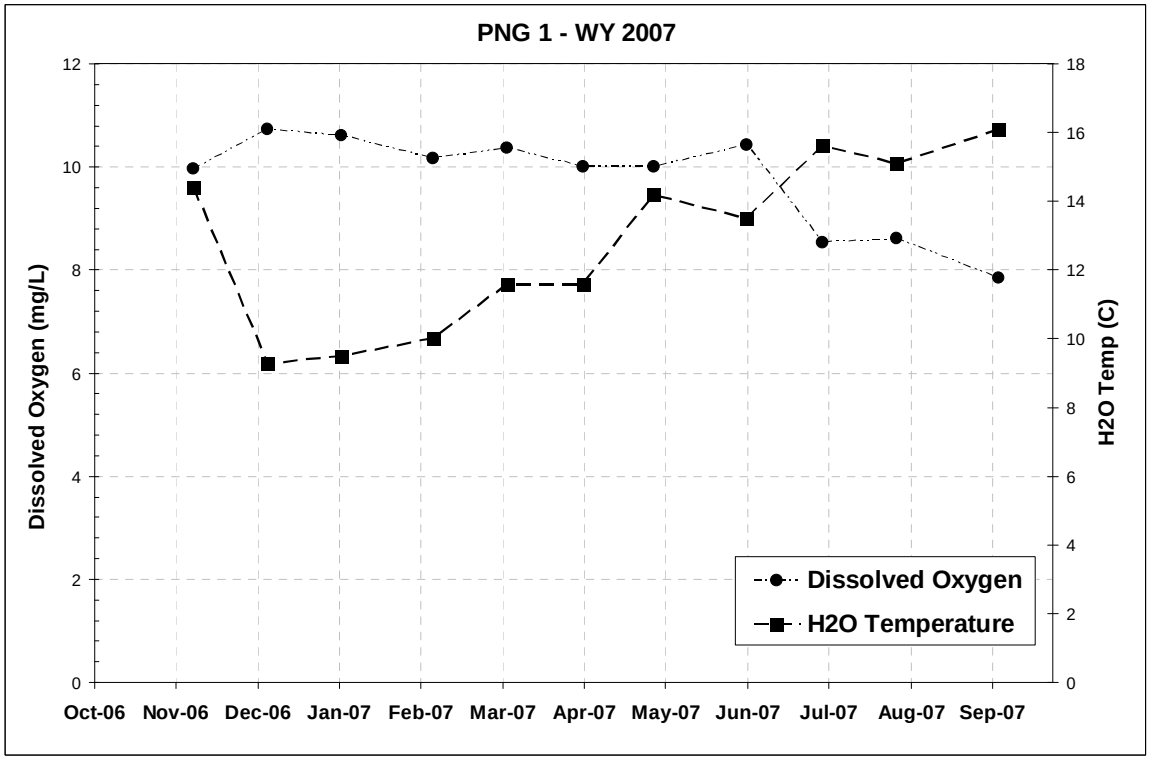

Figure 18. Dissolved oxygen and water temperature results at PNG 1.

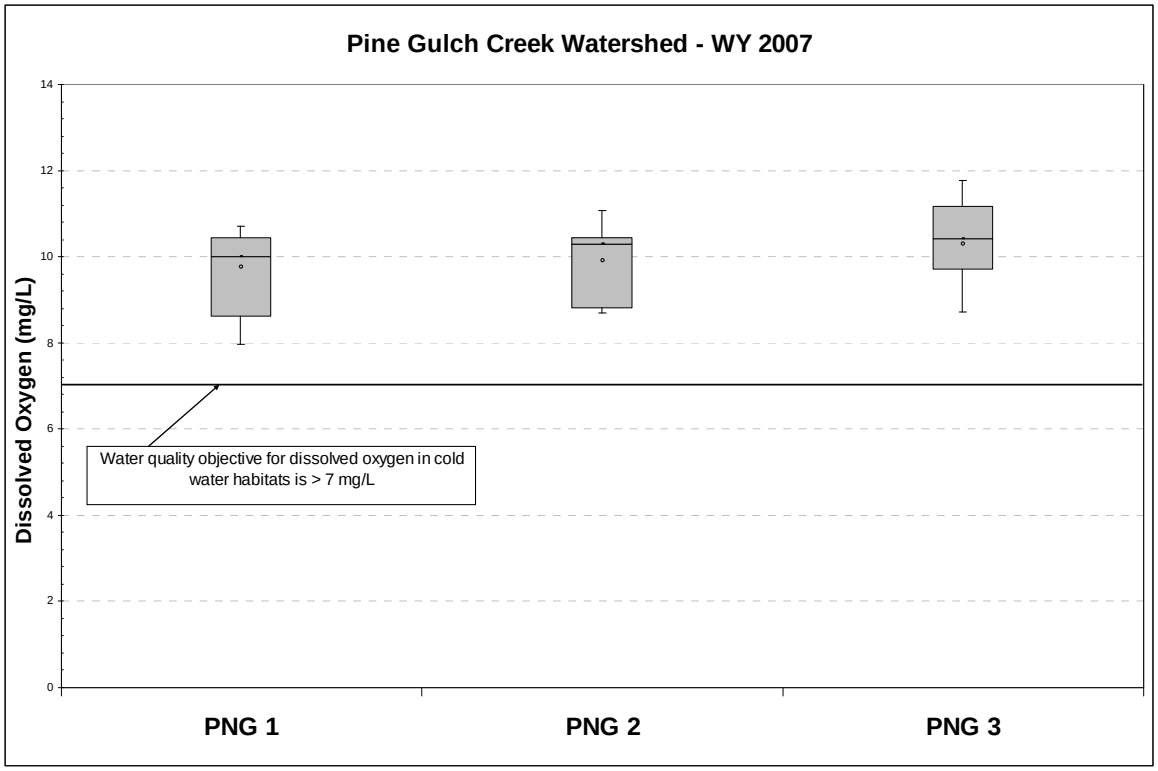

Figure 19. Pine Gulch Creek watershed dissolved oxygen results.

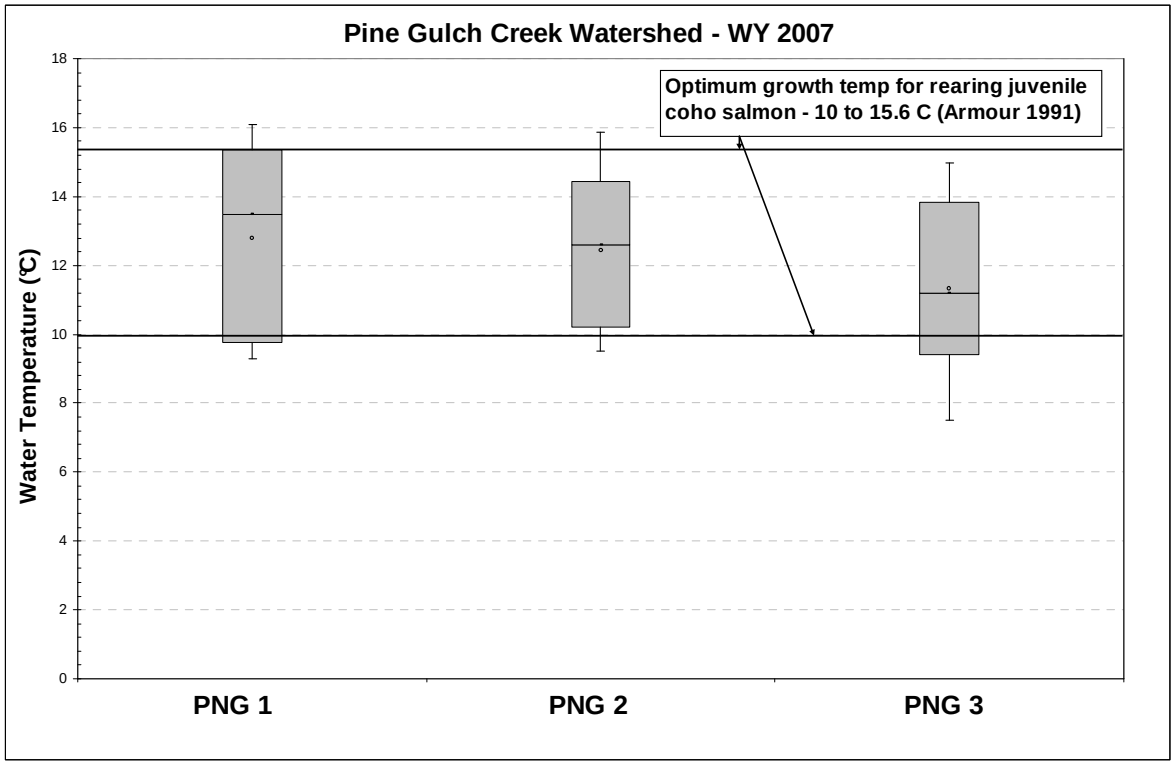

Figure 20. Pine Gulch Creek watershed water temperature results.

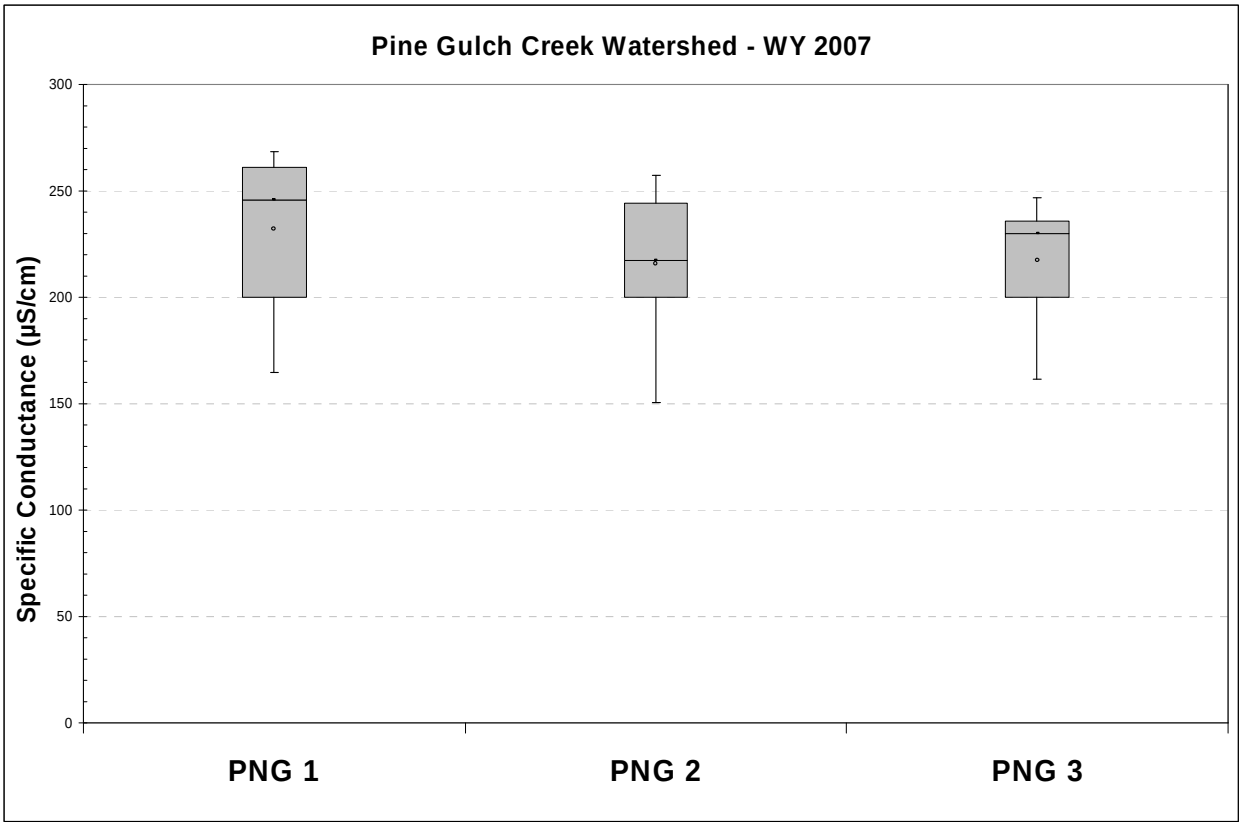

Figure 21. Pine Gulch Creek watershed specific conductance results.

Nutrient analysis: There were no detectable levels of ammonia in the Pine Gulch Creek watershed. TKN was above the laboratory reportable detection limit of 0.25 mg/L during 33 percent of the site visits and nitrate was detected during 100 percent of the visits. TKN levels were highest at PNG 2 with a maximum of 5.0 mg/L on Nov 8, 2006, while nitrate levels were highest at PNG 3 with a maximum of 0.50 on Jan 3, 2007 (Table 24). Figure 22 demonstrates the higher levels of nitrate seen during periods of higher flows such as the Jan 3, 2007 sampling event as well as the trend towards higher nitrate levels at the furthest upstream site and lowest at the furthest downstream site.

Table 24. Pine Gulch Creek watershed nutrient results – WY 2007.

	# of Samples	Nitrate as N (mg/L) No. of Detects	Min/Mean/ Max	TKN (mg/L) No. of Detects	Min / Max	Ammonia as N (mg/L)
PNG 1	11	11	0.08/ 0.21 / 0.45	3	0.73 / 1.30	No Detections
PNG 2	11	11	0.15/ 0.22 / 0.36	3	1.20 / 5.00	No Detections
PNG 3	11	11	0.20/ 0.29 / 0.50	5	0.27 / 1.70	No Detections

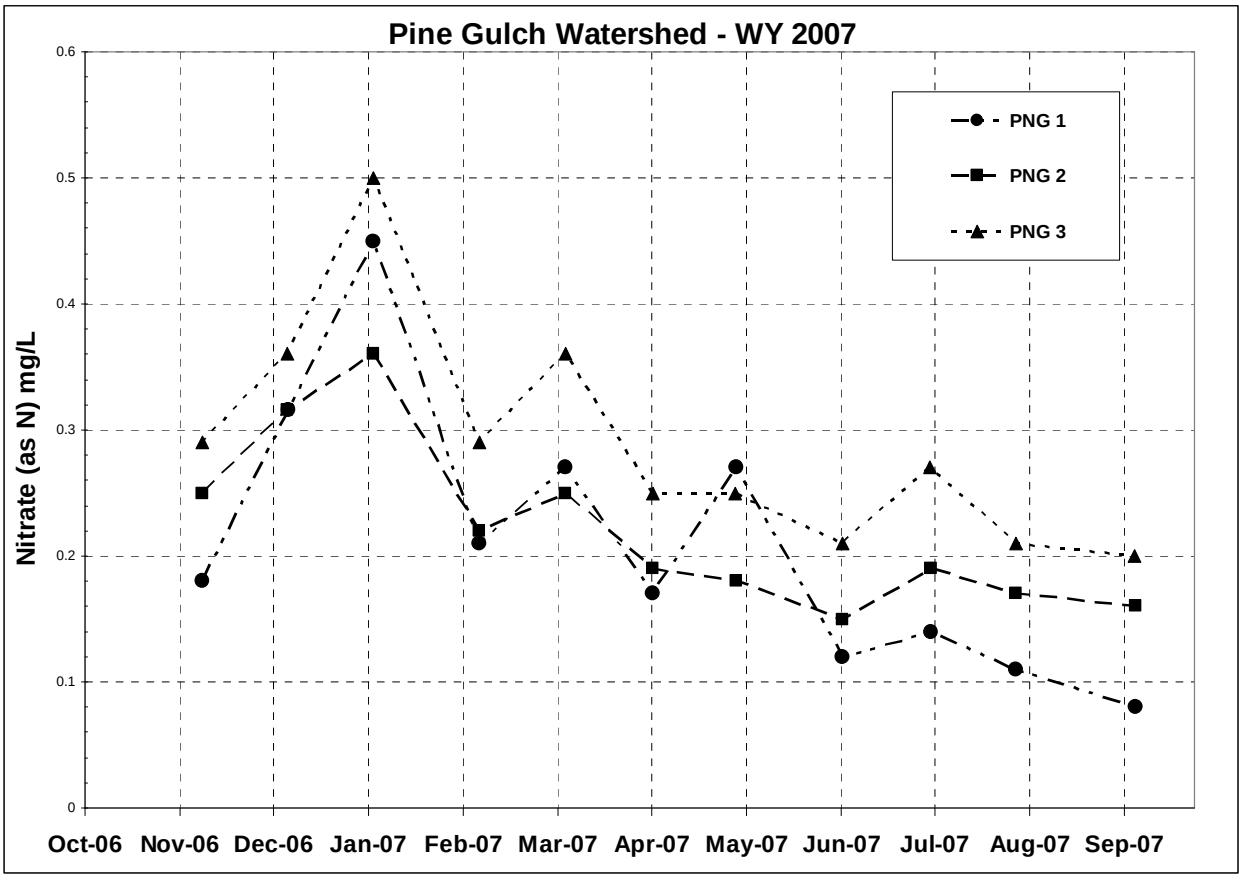

Figure 22. Pine Gulch Creek watershed nitrate (as N) results.

Bacteria analysis: There were no observed exceedences of the US EPA bacteriological criteria for total coliform (10,000 MPN/100 mL per single day sample) in the Pine Gulch Creek watershed (Table 25). Of 33 total samples, 15 percent exceeded the *E. coli* criteria (Figure 23).

Table 25. Pine Gulch Creek watershed bacteria results – WY 2007.

		Total Coliform (MPN/100 ml)				*E. coli* Bacteria (MPN/100ml)		
	# of samples	# of samples > QL	Min	Max	Exceedences	Min	Max	Exceedences
PNG 1	11	0	160	2800	0	6	650	3
PNG 2	11	0	105	2000	0	7	350	2
PNG 3	11	1	34	>2419	0	7	120	0

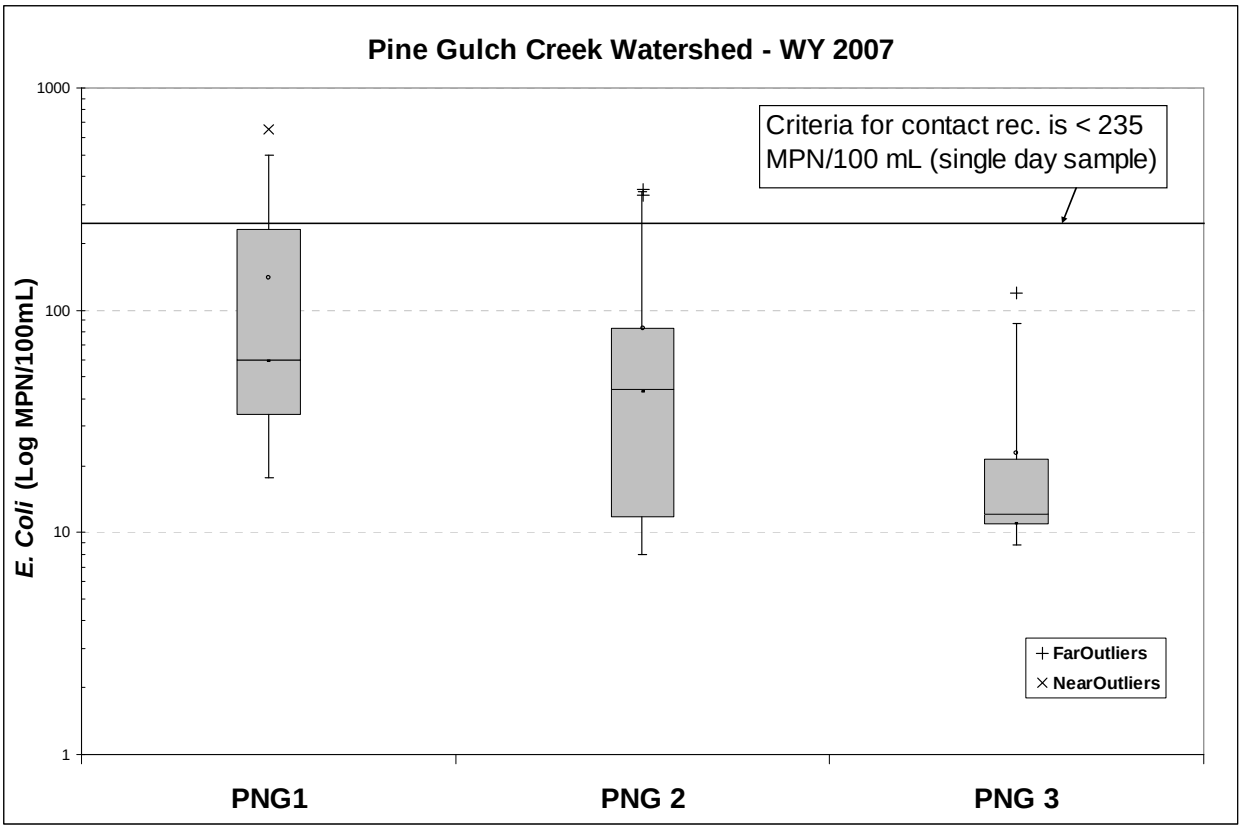

Figure 23. Pine Gulch Creek watershed *E. coli* bacteria results.

Golden Gate National Recreation Area (GOGA)

Rodeo Creek

Three sampling sites were selected in this watershed, two primary sites and a secondary site above the influence of park developments. Primary sites, RC1 and GERB1, were monitored for core parameters (temperature, conductivity, dissolved oxygen and pH), discharge, coliform bacteria (total coliform and *E. coli*), and nutrient parameters (nitrate, ammonia and TKN).

Core parameter analysis: Eleven monitoring visits were made to each primary site in the Rodeo Creek watershed (Table 26). The field data sheets from the September sampling event were lost so there are 10 core parameter samples. Instantaneous discharge during monitoring visits ranged from 0.007 cfs to 2.27 cfs. There is not an automated flow monitoring station in the Rodeo Creek watershed. Flow was too low to obtain a discharge measurement during one visit at each site.

Measurements of pH fell below the water quality objective during 25 percent of the visits and were lower at GERB 1 than RC 1 (Figure 24). Mean pH was 6.55 at GERB 1 and 6.80 at RC 1.

Figure 25 demonstrates the trend of lower dissolved oxygen and higher water temperature results observed throughout the summer.

Dissolved oxygen fell below the water quality objective at RC 1 during two visits, but results were always above the objective at GERB 1 (Figure 26).

The mean water temperature was 11.21 ºC at GERB 1 and 10.87 at RC 1 (Figure 27).

Specific conductance varied little with a maximum of 251.1 µS/cm at RC 1 in November when discharge was measured at 0.15 cfs (Figure 28). Specific conductance decreased in December and results were lowest in January. Salinity at the two primary monitoring sites was always 0.1 ppt.

Table 26. Rodeo Creek watershed core parameter results.

	# of Samples	Sp. Conductance (µS)		Dissolved Oxygen (mg/l)		pH		H_20 Temp (°C)	
		Min	Max	Min	Max	Min	Max	Min	Max
RC 1	10	149.7	251.1	5.53	13.36	6.35	7.46	6.1	13.9
GERB 1	10	117.3	208.3	7.82	13.81	6.27	6.78	8.5	16.5

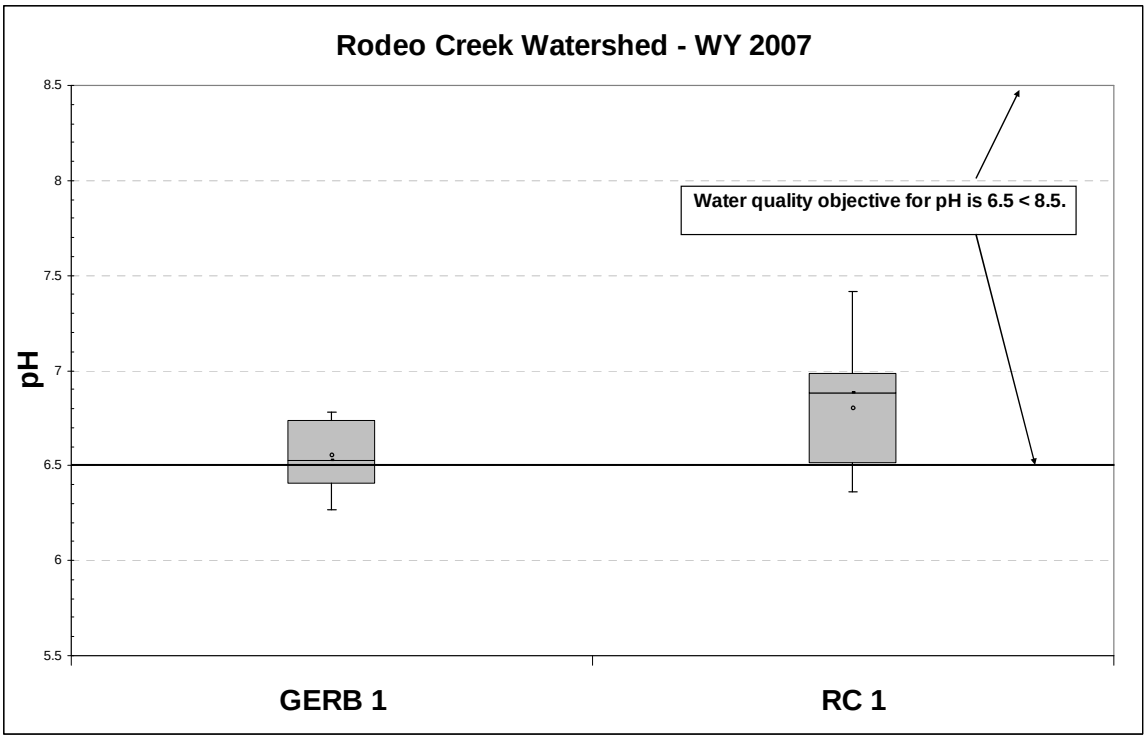

Figure 24. Rodeo Creek watershed pH results.

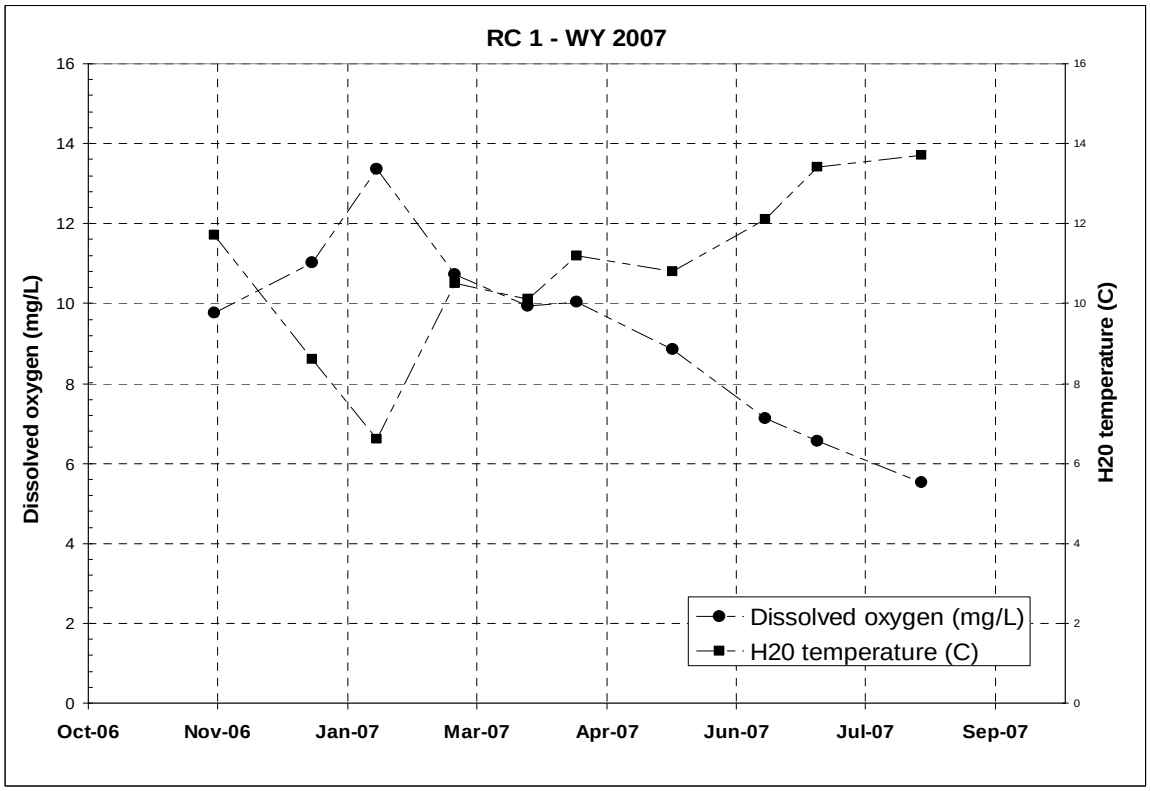

Figure 25. Rodeo Creek (RC1) dissolved oxygen and water temperature results.

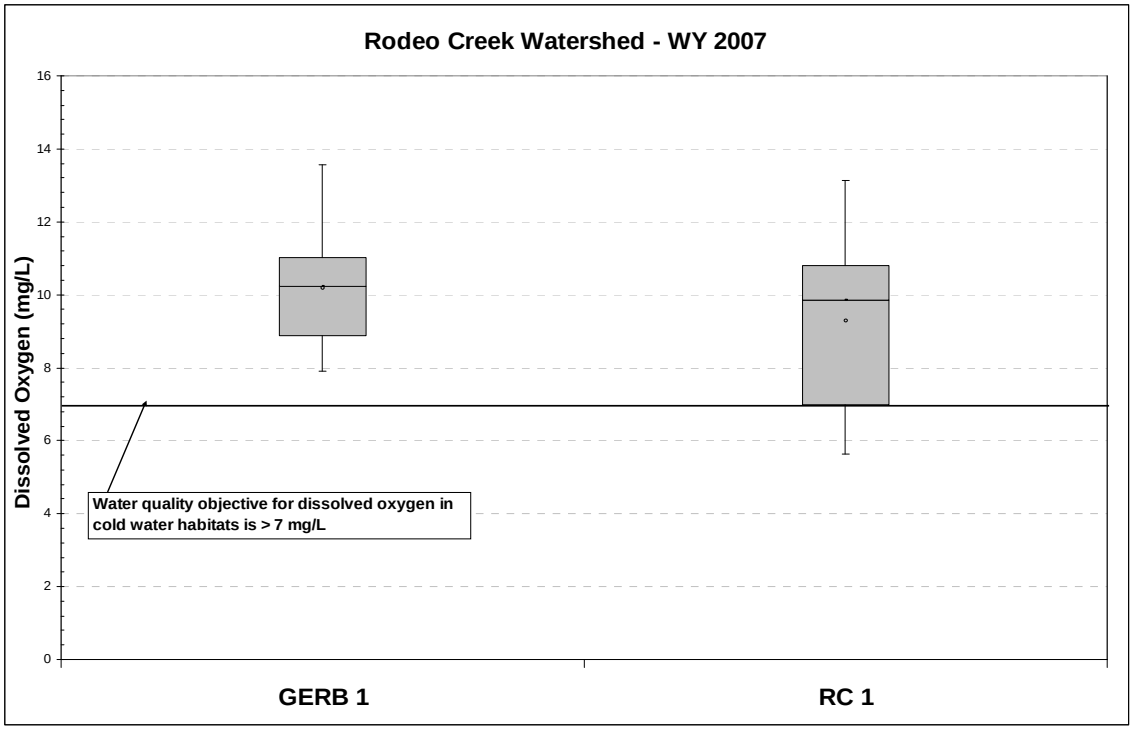

Figure 26. Rodeo Creek watershed dissolved oxygen results.

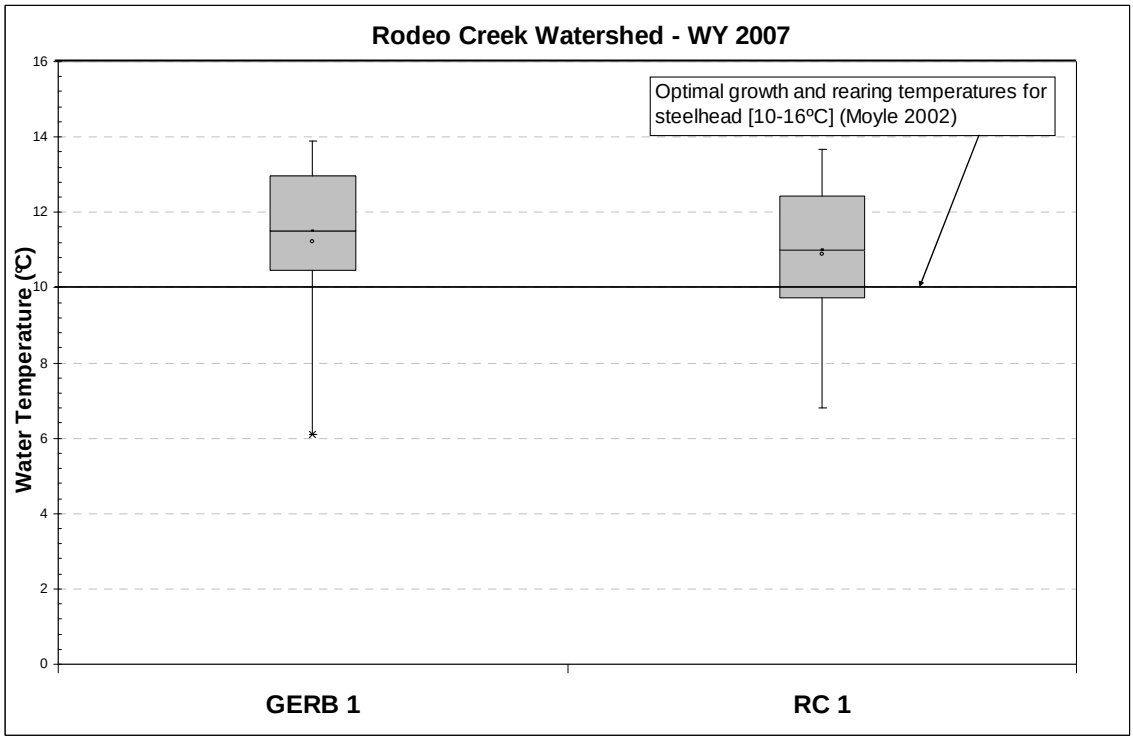

Figure 27. Rodeo Creek watershed water temperature results.

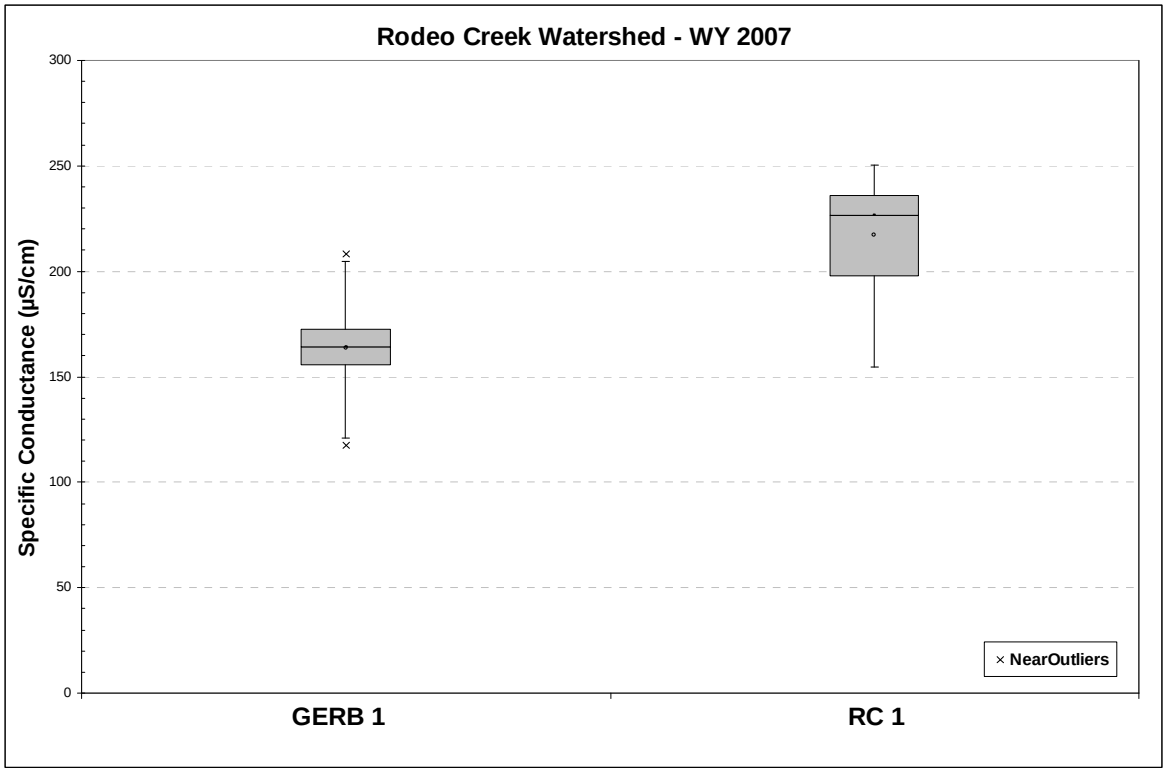

Figure 28. Rodeo Creek watershed specific conductance results.

Nutrient analysis: There were no ammonia detections in the Rodeo Creek watershed (Table 26). TKN was detected 23 percent of the time and nitrate was detected during 14 percent of the visits. The highest levels of nitrate were observed during the Dec 28, 2006 sampling event (Figure 29).

Table 27. Rodeo Creek watershed nutrient results.

	# of Samples	Nitrate as N (mg/L)		TKN (mg/L)		Ammonia as N (mg/L)
		No. of Detections	Min / Max	No. of Detections	Min / Max	
RC 1	11	2	0.11 / 0.45	3	0.73 **/** 1.30	No Detections
GERB 1	11	1	0.15 / 0.36	2	1.20 / 5.00	No Detections

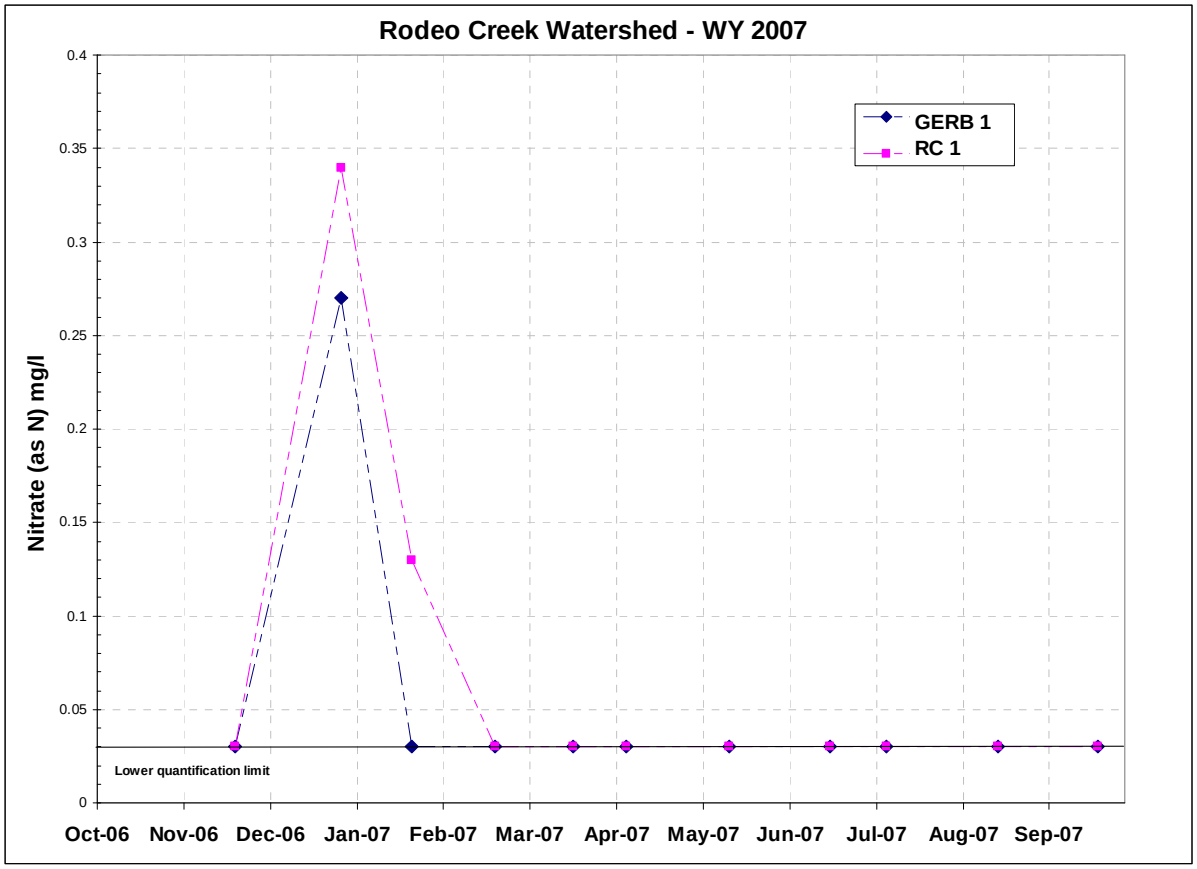

Figure 29. Rodeo Creek watershed nitrate (as N) results; results shown at the 0.03 mg/L detection limit were reported as "non-detect".

Bacteria analysis: Total coliform and *E. coli* bacteria levels were consistently below the US EPA contact recreation water quality criteria (Figure 30). There was one exceedence of the *E. coli* criteria at each monitoring site and no total coliform exceedences (Table 28).

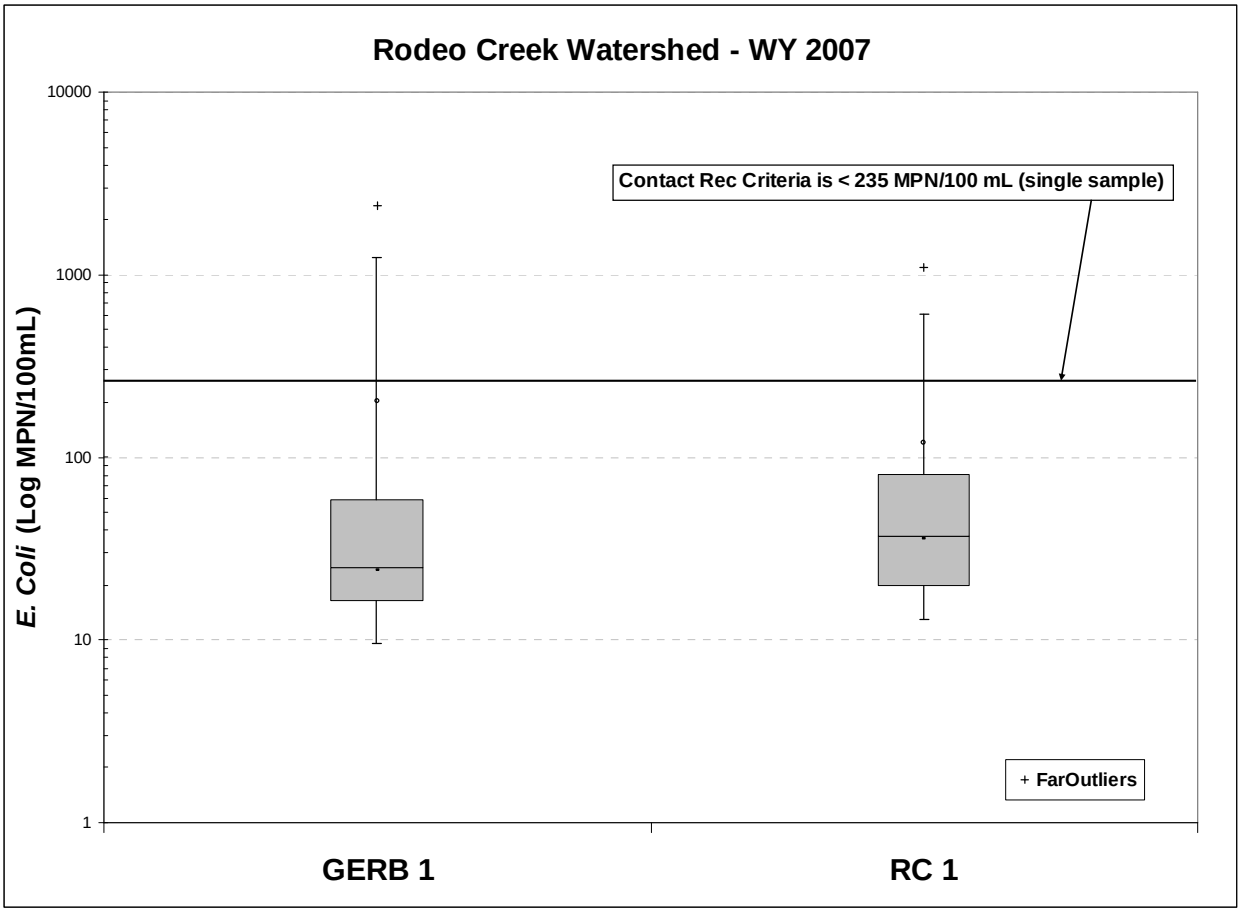

Figure 30. Rodeo Creek watershed *E. coli* bacteria.

Table 28. Rodeo Creek watershed bacteria results.

		Total Coliform (MPN/100 ml)				*E. coli* Bacteria (MPN/100ml)		
	#of samples	# of samples > QL	Min	Max	Exceedences	Min	Max	Exceedences
RC 1	11	0	169	2400	0	11	1100	1
GERB 1	11	2	85	>2400	0	7	2400	1

Tennessee Valley Creek

Three sampling sites are located in this watershed, two primary sites, TV2 and TV3, and a secondary site, TV 1 (Table 29). All three sites are on the mainstem of Tennessee Valley Creek and are being monitored for core parameters (temperature, conductivity, dissolved oxygen and pH), discharge, and coliform bacteria (total coliform and *E. coli*). Nutrient parameters (nitrate, ammonia and total Kjeldahl nitrogen) are also being monitored at the primary sites.

Core parameter analysis: During each monthly sampling event effort was made to visit both primary sites as well as the secondary site. TV 1 and TV 2 commonly do not have water during the summer months. Therefore, eleven visits were made to TV 3, eight visits to TV 2 and four visits to TV 1. The core parameter data was lost from one of the visits; thus, there are ten, seven, and three samples shown in Table 29. Measured flows ranged from 0.003 cfs to 3.47 cfs during sampling events. The highest recorded discharge was 3.47 cfs at TV3 in February 2007.

Measurements of pH commonly fell below the water quality objective of 6.5, most often at TV2 where the pH failed to meet the water quality criteria during 88 percent of the visits (Figure 31). The mean pH at TV2 was 6.08 while the mean pH downstream at TV3 was 6.81.

Dissolved oxygen at TV2 was below the water quality objective of 7 mg/L during 43 percent of the visits, most likely because flow at the site is often low and measurements may have been taken within standing pools of water (Figure 32). Figure 33 shows the trend of lower dissolved oxygen levels and higher water temperature during the summer months. There was no flow at TV 2 when the minimum dissolved oxygen reading, 0.66 mg/L, was observed during the June sampling event. There was not enough water to sample at TV 2 in July, August and September. The maximum water temperature observed, 16.2 ºC, was at TV 2 when measurements were taken in a standing pool. The mean water temperature for both TV 2 and TV 3 was 11.9 ºC (Figure 34).

Specific conductance showed the most variability at TV2 with the highest levels occurring during low flows in November and June (Figure 35).

Table 29. Tennessee Valley Creek watershed core parameter results.

	# of Samples	Sp. Conductance (µS)		Dissolved Oxygen (mg/l)		pH		H_20 Temp (˚C)	
		Min	Max	Min	Max	Min	Max	Min	Max
TV 1	3	115.1	146.5	9.81	10.5	5.72	6.63	9.8	11.0
TV 2	7	139.0	479.9	0.66	10.87	5.11	6.68	9.6	16.2
TV 3	10	163.9	308.0	6.53	12.38	6.28	7.41	7.4	14.7

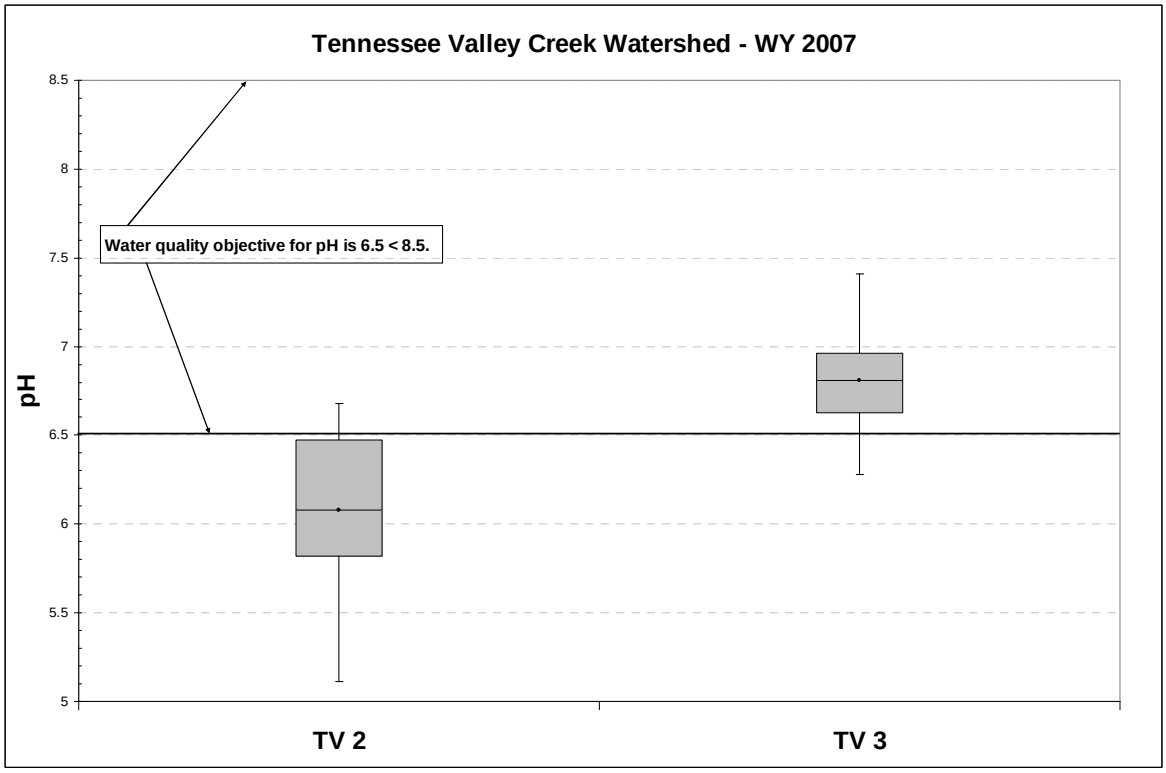

Figure 31. Tennessee Valley Creek watershed pH results.

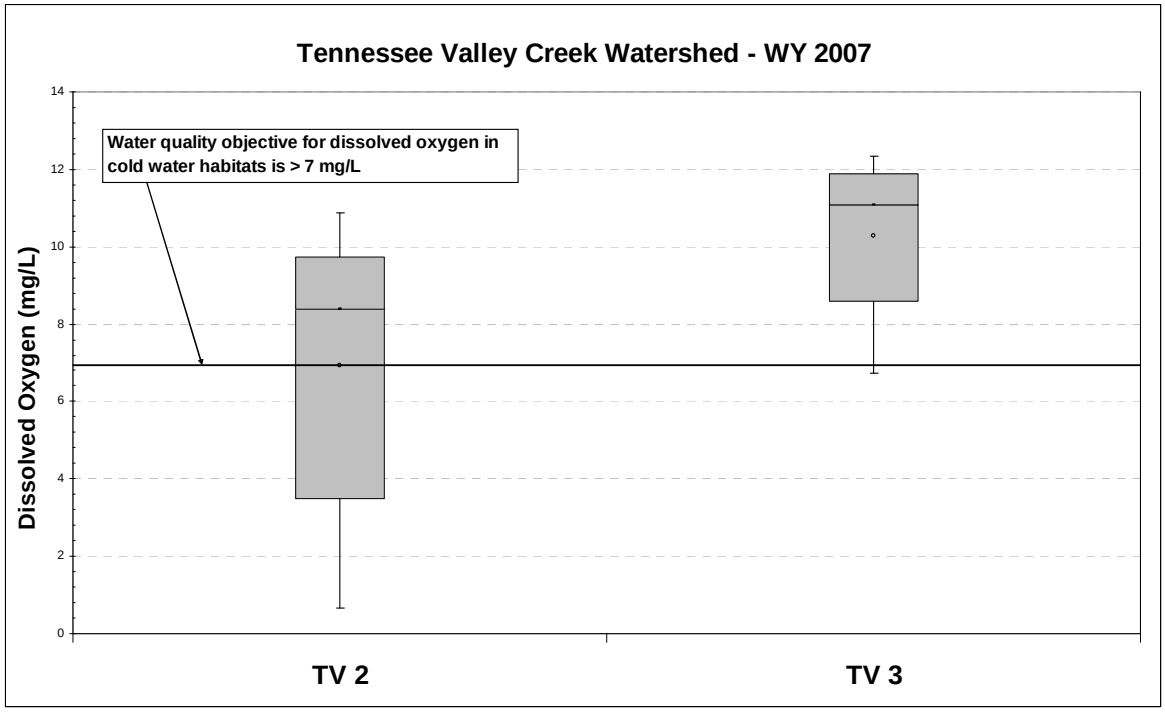

Figure 32. Tennessee Valley Creek watershed dissolved oxygen results.

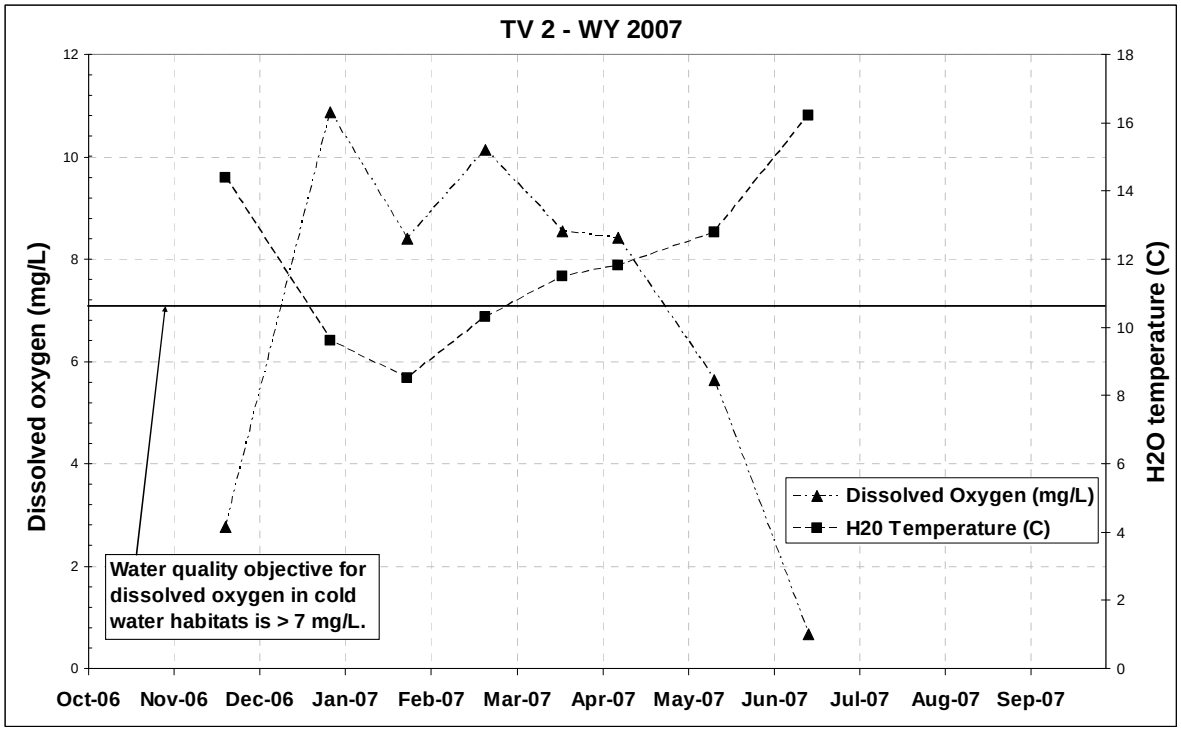

Figure 33. Tennessee Valley Creek (TV 2) dissolved oxygen and water temperature results.

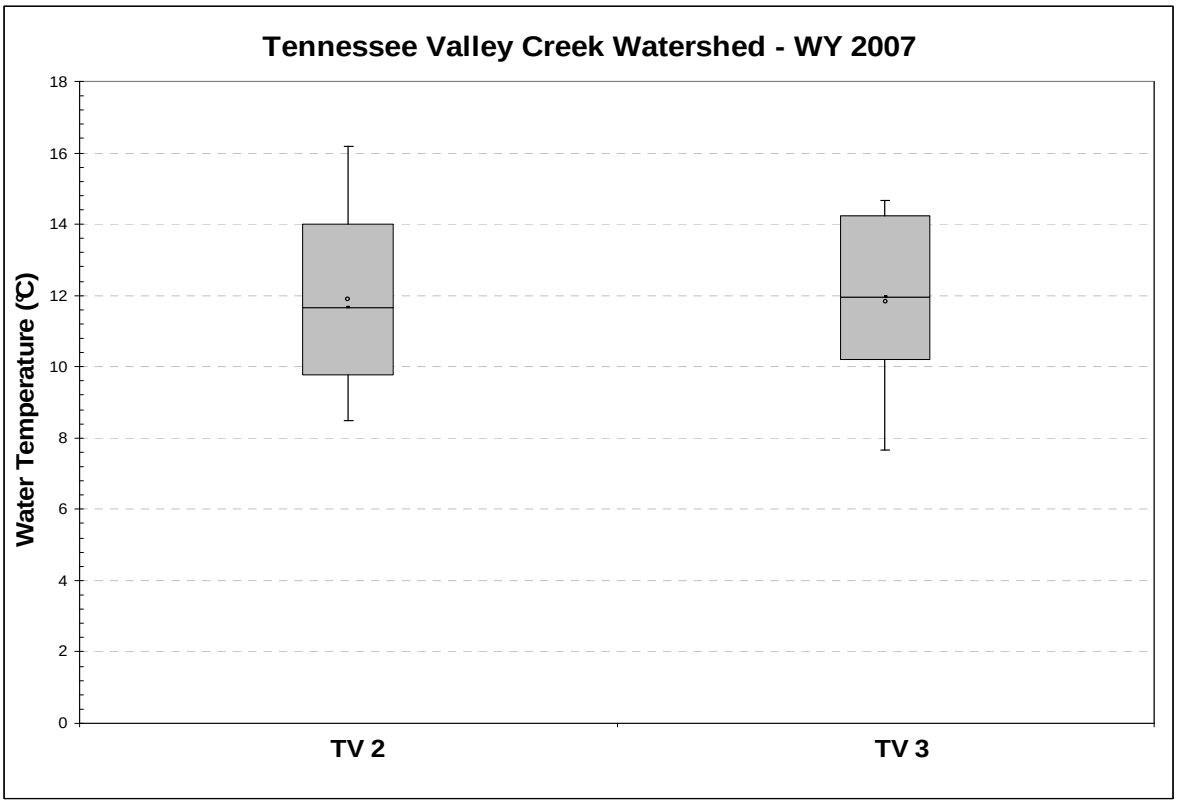

Figure 34. Tennessee Valley Creek watershed water temperature results.

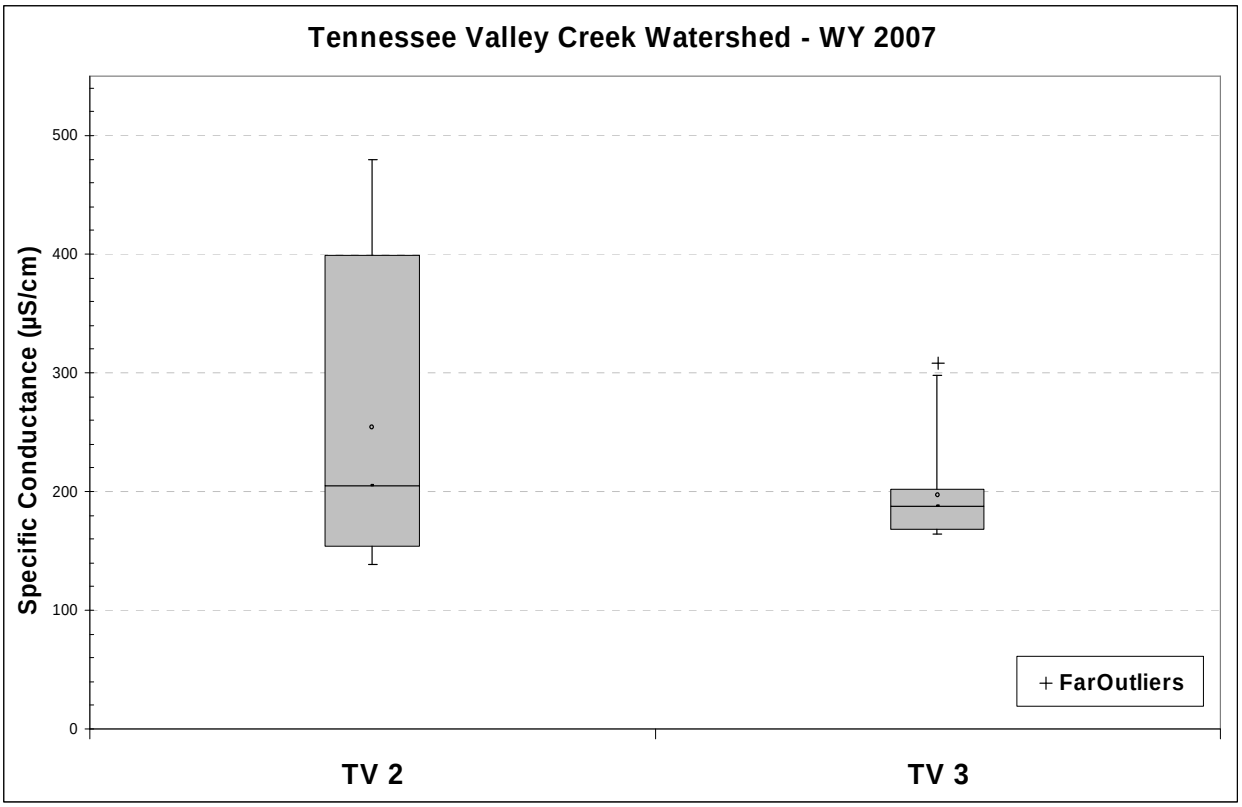

Figure 35. Tennessee Valley Creek watershed specific conductance results.

Nutrient analysis: There were no detectable levels of ammonia observed in the Tennessee Valley Creek watershed. Nitrate levels were detected in 42 percent of the samples and TKN levels were above the detection limit in 37 percent of the samples. The highest observed level of TKN, 6.0 mg/L at TV2 in June 2007, was not representative of the levels observed throughout the remainder of the water-year in the watershed (Table 30). The highest observed nitrate was 0.50 mg/L at TV 3 in November 2006 (Figure 36).

Table 30. Tennessee Valley Creek watershed nutrient results.

	# **of Samples**	**Nitrate as N (mg/L)**		**TKN (mg/L)**		**Ammonia as N (mg/L)**
		No. of Detections	Min / Max	No. of Detections	Min / Max	
TV 2	8	3	0.15 / 0.29	4	0.77 **/** 6.00	No Detections
TV 3	11	5	0.04 / 0.50	3	0.35 / 2.50	No Detections

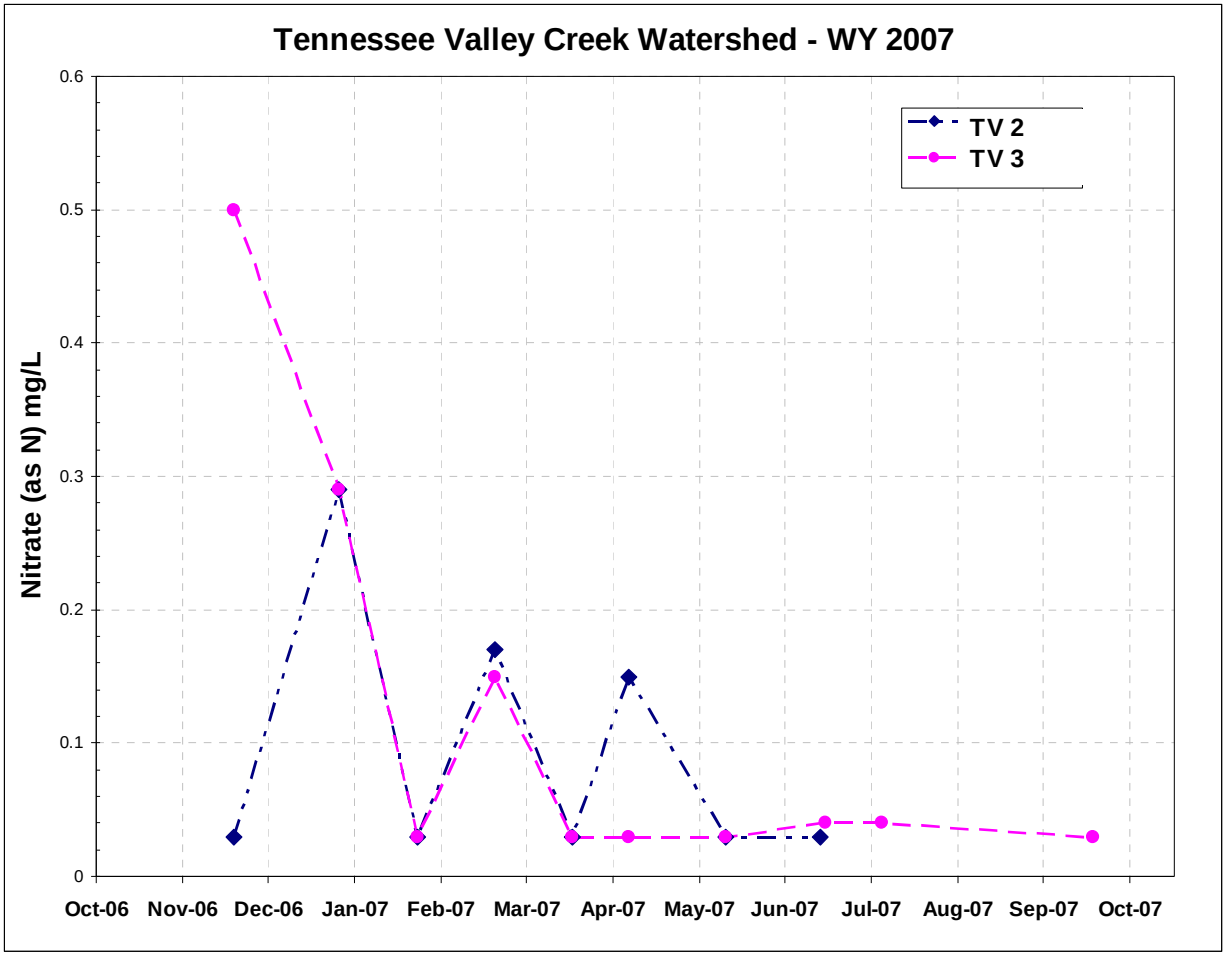

Figure 36. Tennessee Valley Creek nitrate results; results shown at the 0.03 mg/L detection limit were reported as "non-detect".

Bacteria results analysis: There were no exceedences of the total coliform bacteria water quality criteria in the Tennessee Valley Creek watershed. However, 48 percent of the total coliform results from the Tennessee Valley Creek watershed were higher than the quantification limit of 2419 MPN/100mL (Table 31). Tennessee Valley Creek total coliform results are not displayed graphically due to the high number of unquantifiable results. *E. coli* results were above the water quality criteria on 6 occasions; 30 percent of the samples (Figure 37). *E. coli* exceedences occurred most often at TV2, with four of eight samples over the contact recreation criteria. Future sampling will increase dilutions for total coliform in order to obtain more quantifiable results.

Table 31. Tennessee Valley Creek watershed bacteria results.

		Total Coliform (MPN/100 ml)				*E. coli* Bacteria (MPN/100ml)		
	# of samples	# of samples > QL	Min	Max	Exceedences	Min	Max	Exceedences
TV 1	4	1	1011	>2419	0	5	55	0
TV 2	8	5	53	>2419	0	5	1800	4
TV 3	11	5	160	>2419	0	4	520	2

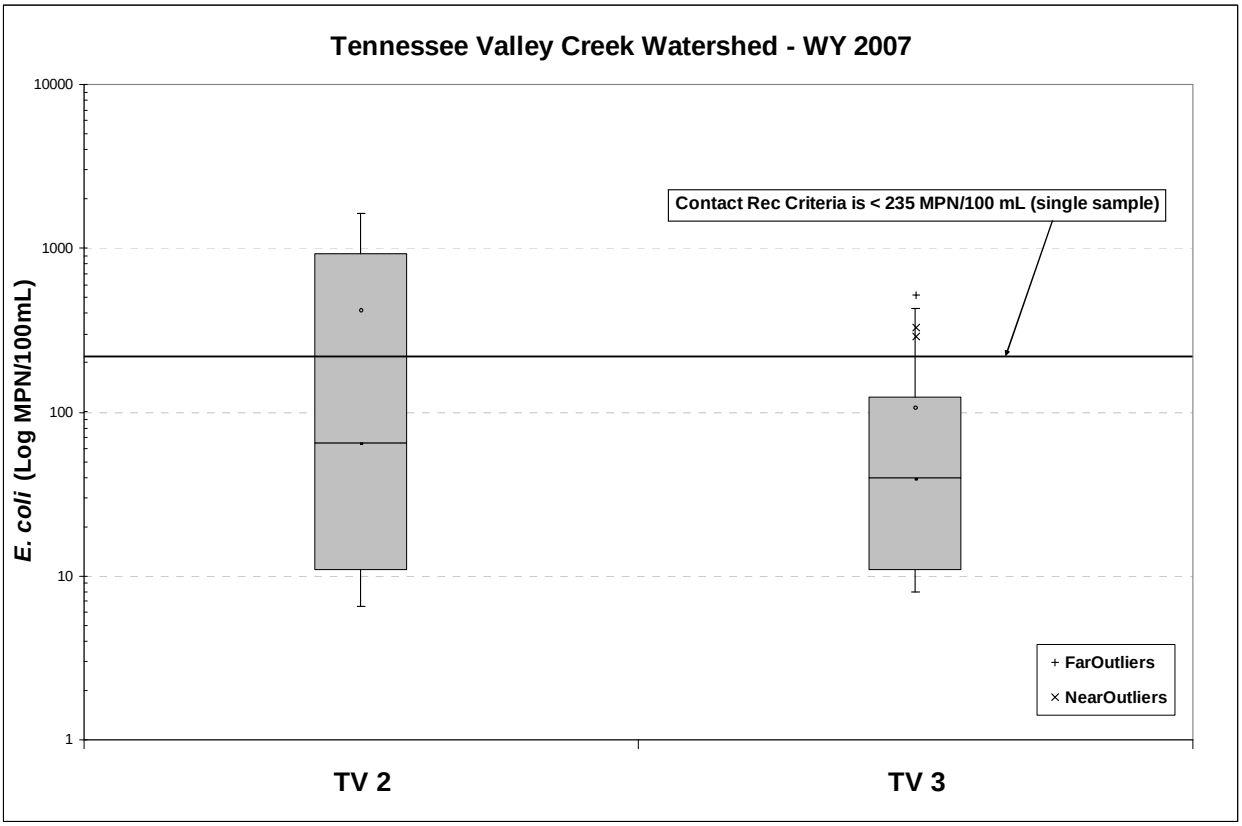

Figure 37. Tennessee Valley Creek watershed *E. coli* bacteria results.

Oakwood Valley and Nyhan Creeks

Nyhan Creek (NYH 1) and Oakwood Creek (OAK 1) are secondary sampling sites for GOGA. These sites were visited on days when Tennessee Valley and Rodeo Creek watersheds were monitored. These secondary sites represent park lands draining to Richardson Bay, where the Regional Water Quality Control Board (RWQCB) is completing a TMDL for pathogens. The sampling location for each creek is just upstream of their confluence, adjacent to Tennessee Valley Road. Both of these sites have intermittent flow and were monitored for core parameters (temperature, conductivity, dissolved oxygen and pH), discharge, and coliform bacteria (total coliform and *E. coli*) during monthly sampling visits. Because these are secondary sites, no nutrient samples were collected.

Core Parameter Analysis: Ten samples were collected at NYH1 and nine at OAK1. The sites were dry during the rest of the sampling dates. The results for water temperature, specific conductance and dissolved oxygen showed high variability through the year (Table 32).

The pH results at OAK 1 were always lower than those at NYH 1. The pH fell below the regional water quality objective of 6.5 during 56 percent of the sampling events at the sites. The mean pH at OAK 1 was 6.51 while the mean pH at NYH 1 was 7.38 (Figure 38).

The maximum water temperature observed, 18.6 C at NYH 1, was in August 2007; the minimum, 6.7 ºC was in January 2007 (Figure 39).

The dissolved oxygen did not fall below the water quality objective of 7 mg/L at NYH 1 and fell below at OAK 1 during two of the nine visits (Figure 40).

The salinity at both sites was either 0.1 or 0.2 ppt; more often 0.2 ppth at NYH 1 than OAK 1. The specific conductance was also higher at NYH 1 (Figure 41). The highest specific conductance seen at NYH 1, 515.0 µS/cm, occurred in Aug 2007 at which time the salinity was 0.3 ppt.

Table 32. Nyhan and Oakwood Creeks core parameter results.

	# **of**	**Sp. Conductance (µS)**		**Dissolved Oxygen (mg/L)**		**pH**		**H_20 Temp (˚C)**	
	Samples	Min	Max	Min	Max	Min	Max	Min	Max
NYH 1	10	204.0	515.0	7.91	11.93	6.81	7.88	6.7	18.6
OAK 1	9	195.7	423.5	0.37	11.00	5.85	7.01	7.5	14.6

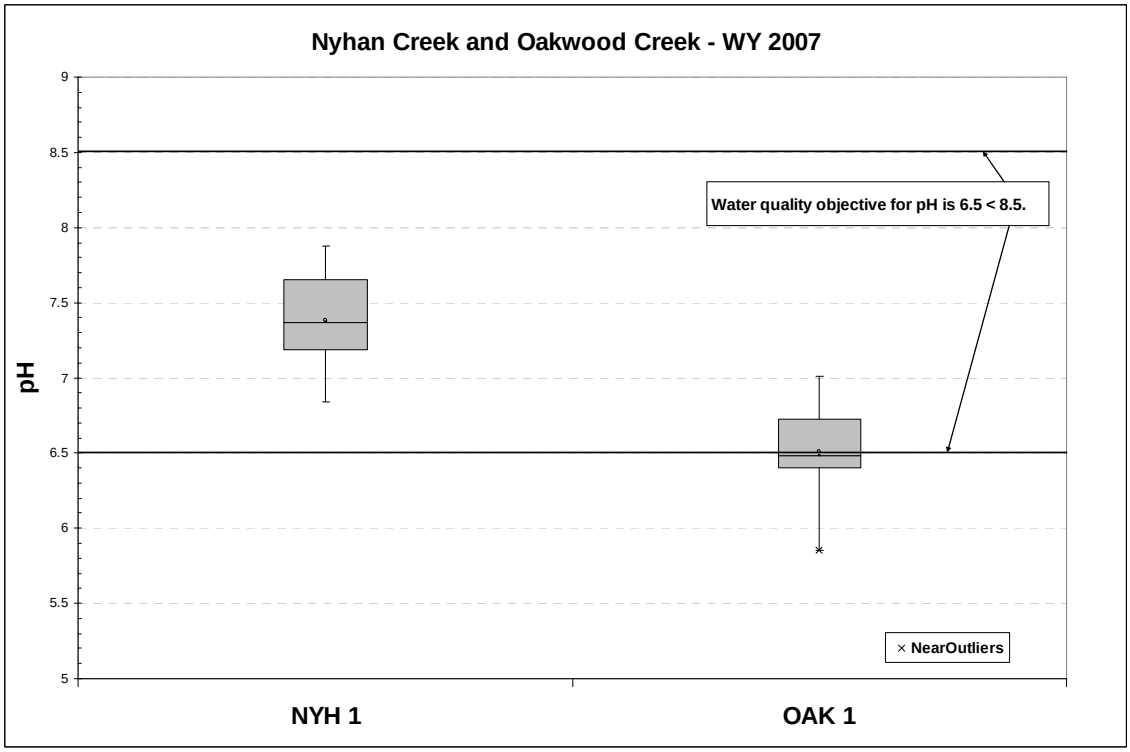

Figure 38. Nyhan Creek and Oakwood Creek pH results.

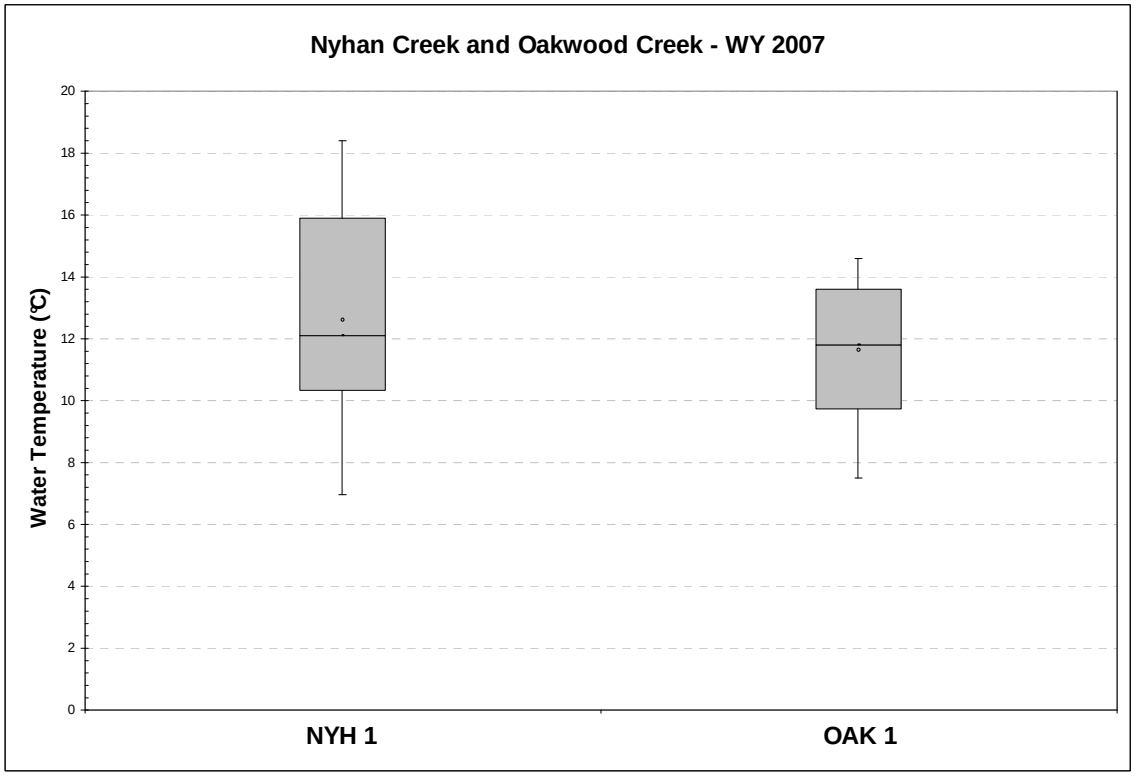

Figure 39. Nyhan Creek and Oakwood Creek water temperature results.

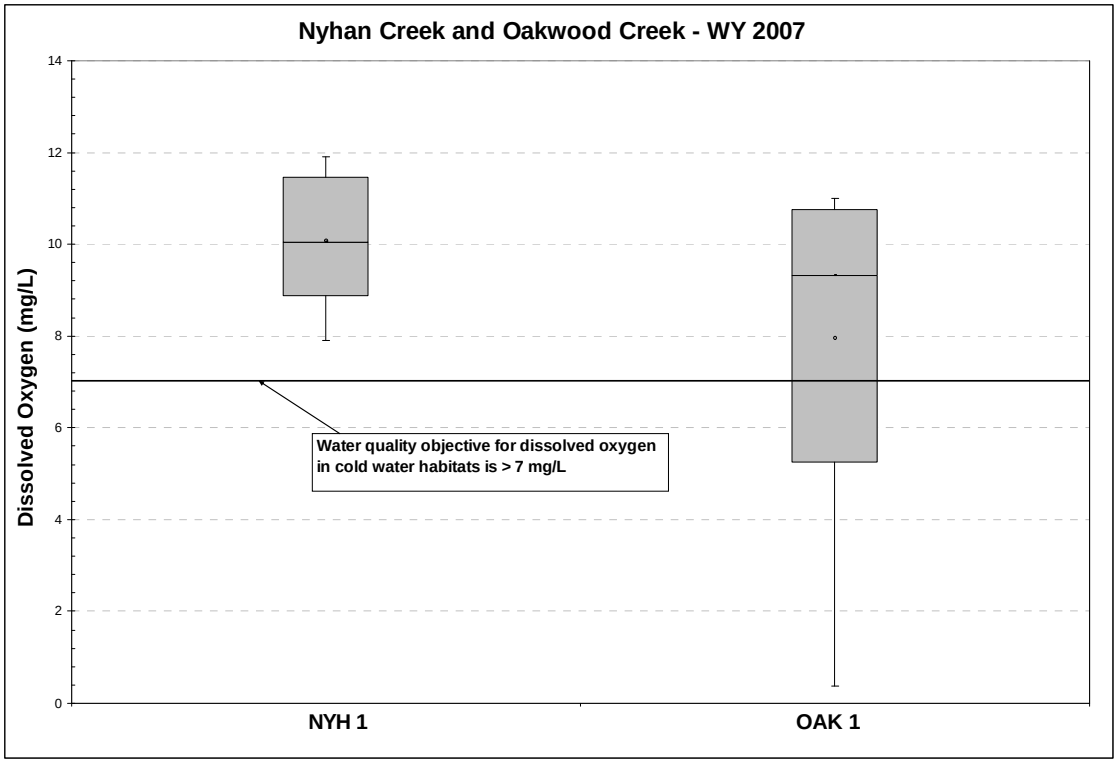

Figure 40. Nyhan Creek and Oakwood Creek dissolved oxygen results.

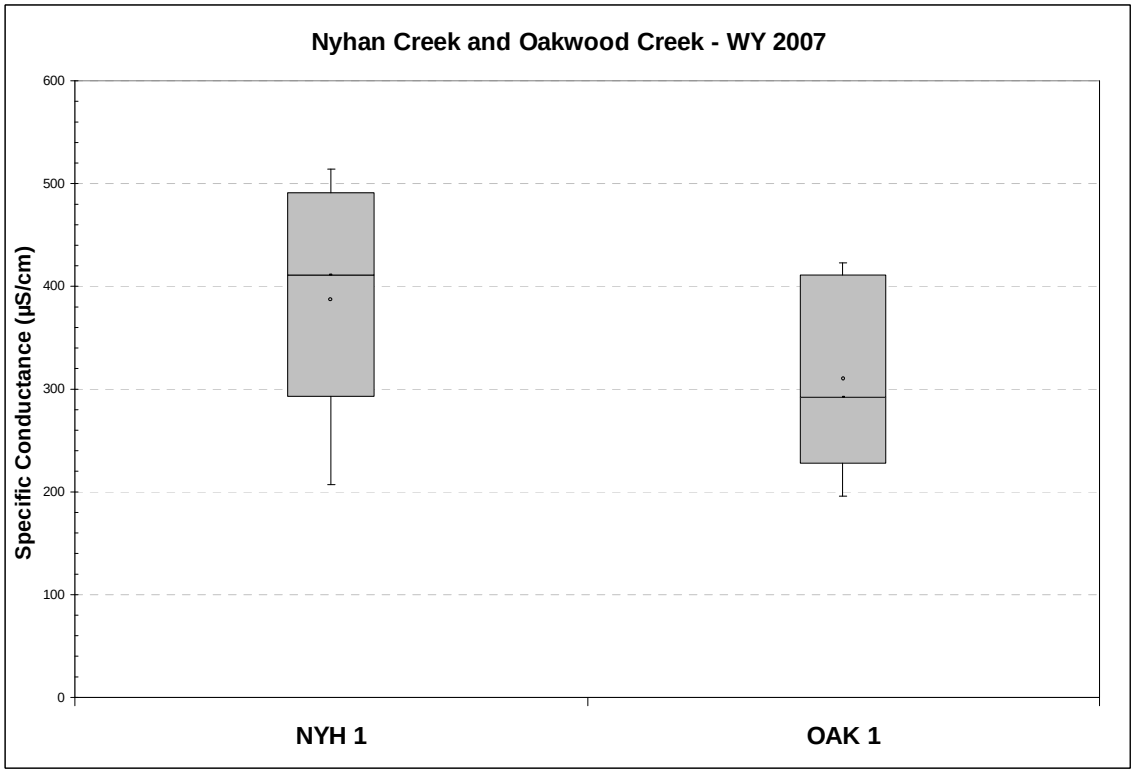

Figure 41. Nyhan Creek and Oakwood Creek specific conductance results.

Bacteria analysis: Total coliform and *E. coli* bacteria results at NYH 1 were higher than those seen at OAK1. There were two exceedences of the total coliform criteria and 5 exceedences of the *E. coli* criteria at NYH 1 (Figure 42). Two *E. coli* exceedences were seen at OAK 1 (Table 33). The high bacteria levels on Nyhan Creek indicate a potential upstream source. These bacteria results are the highest of any sites sampled in the GOGA watersheds and warrant additional investigation. I&M staff have recommended this to GOGA staff for further investigation or follow-up. The monitoring station on Nyhan Creek is located on GOGA land, although much of the upstream and downstream portions of the creek are located on private lands.

Table 33. Nyhan Creek and Oakwood Creek bacteria results.

		Total Coliform (MPN/100 ml)				*E. coli* Bacteria (MPN/100ml)		
	# of samples	# of samples > QL	Min	Max	Exceedences	Min	Max	Exceedences
NYH 1	9	3	520	15530	2	160	3488	5
OAK 1	10	1	160	>2419	0	1	650	2

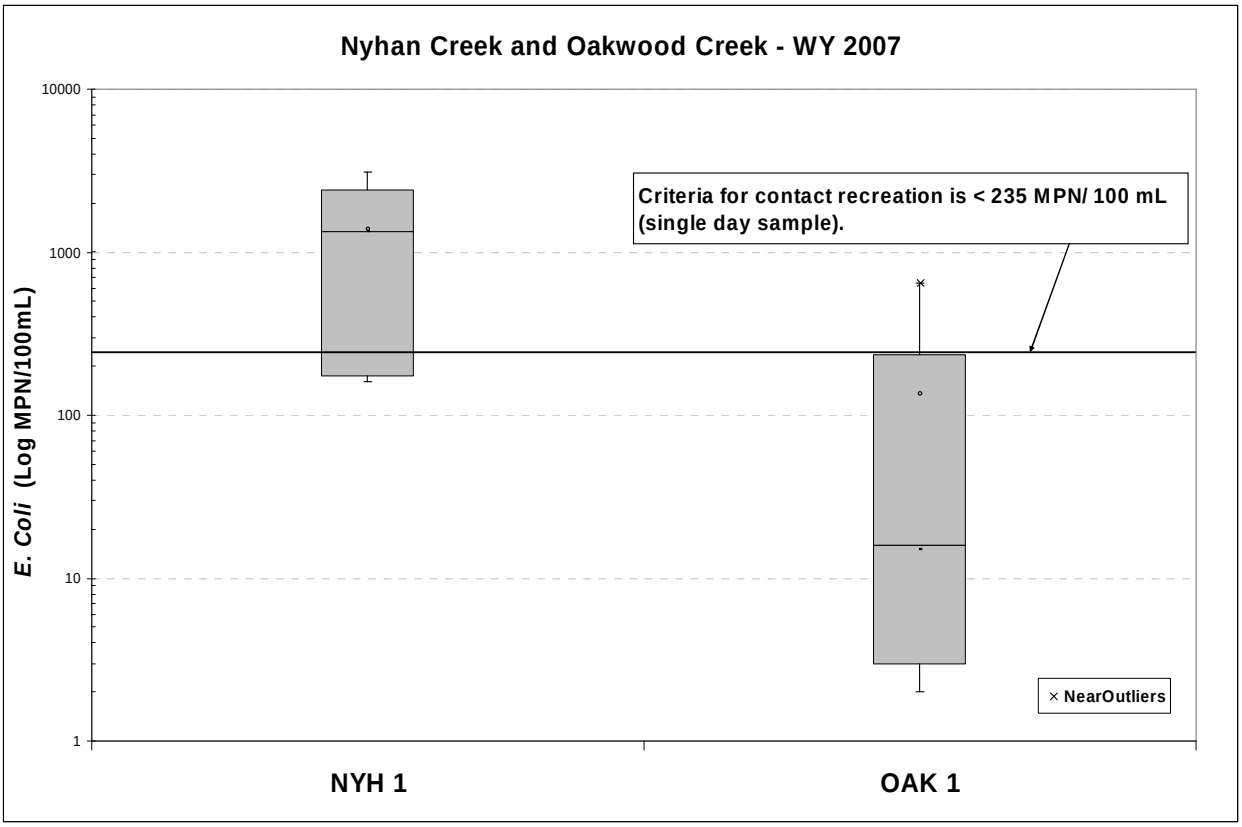

Figure 42. Nyhan and Oakwood Creek *E. coli* bacteria results.

Pinnacles National Monument (PINN)

Chalone Creek

Eight sampling sites were selected within the Chalone Creek watershed, including five primary sites, and three secondary sites. All eight sites have intermittent flow, and were monitored for core parameters (temperature, conductivity, dissolved oxygen and pH), discharge, coliform bacteria (total coliform and *E. coli*), nutrient parameters (nitrate, ammonia and total Kjeldahl nitrogen), and sediment parameters (turbidity, total suspended solids (TSS), and suspended sediment concentration (SSC)). Although some sites were designated as primary and some as secondary, an attempt was made during each monthly visit to sample at each location that had adequate flow. Most often, one or more of the sites did not have enough water to sample. A maximum of seven sites were sampled during any one month. Table 33 lists the number of samples collected from each monitoring station during the 2007 water year.

Core parameter analysis: Monitoring of the Chalone Creek watershed began in January 2007; core parameter data was collected in January, but bacteria and nutrient samples were not collected until February when the lab contract was established. Monitoring events did not occur during or within seven days of any storm event. The total amount of rainfall received during the 2007 water year at the Pinnacles National Monument weather station was 6.46 inches. The highest levels of rainfall were seen in December and February, with 1.75 inches received during both months.

Several of the monitoring stations did not have enough water to collect samples throughout much of the year. One of these stations, CHA 2 has now been moved upstream approximately 100 meters to a location with more perennial flows in order to obtain more samples for the 2008 water year. Results for stations with less than five samples are not displayed graphically.

Five of the eight sites in the Chalone Creek watershed had pH levels which fell below the RWQCB water quality objective of 7.0 most of the time (Figure 43). The pH of surface water at PINN may be influenced by the geology of the area; pH is commonly lower in springs.

Dissolved oxygen was always above the objective for warm water habitat of 5 mg/L at five of the stations; occasionally fell below the criteria at two of the stations and was always below the objective at one station, CHA 1 (Figure 44). Figure 45 shows the sharp decrease in dissolved oxygen and increase in water temperature that occurred throughout the spring and summer months at BG 2 and SC 3. The instantaneous water temperature varied greatly throughout the year at all sites (Figure 46).

Specific conductance in the Chalone Creek watershed varied greatly with a minimum of 74.6 µS/cm at CHA 3 and a maximum of 900 µS/cm at SC 2 (Figure 47). Conductivity results greater than 500 µS/cm suggest high pollutant inputs, although the results may be due in part to the geology of the area contributing higher levels of dissolved solids than creeks in the San Francisco Bay region. In WY 2007 the stations in Sandy Creek always demonstrated levels above 500 µS/cm, and showed high nutrient levels along with indications of bacteria loading. Two samples were excluded from these results due to suspected equipment error; one sample was at MC 1 and one at SC 3.

Table 34. Chalone Creek watershed core parameter results.

	# of Samples	Sp. Conductance (µS)		Dissolved Oxygen (mg/L)		pH		H_20 Temp (°C)	
		Min	Max	Min	Max	Min	Max	Min	Max
CHA 1	7	449.8	616.0	3.32	4.84	6.40	6.90	12.9	23.4
CHA 2	3	472.0	481.0	5.45	6.47	6.72	6.99	16.4	17.1
CHA 3	4	74.6	343.7	5.08	10.10	6.11	6.97	6.0	16.5
BG 2	8	155.1	317.2	3.08	10.56	6.37	6.92	7.0	16.6
MC 1	7	216.0	258.1	6.49	13.86	6.91	7.44	10.4	25.9
SC 1	6	715.0	770.0	6.40	15.00	7.77	8.29	8.9	27.1
SC 2	5	756.0	900.0	2.30	7.85	6.72	7.15	4.7	26.8
SC 3	8	659.0	747.0	7.57	13.85	7.75	8.06	8.8	20.2

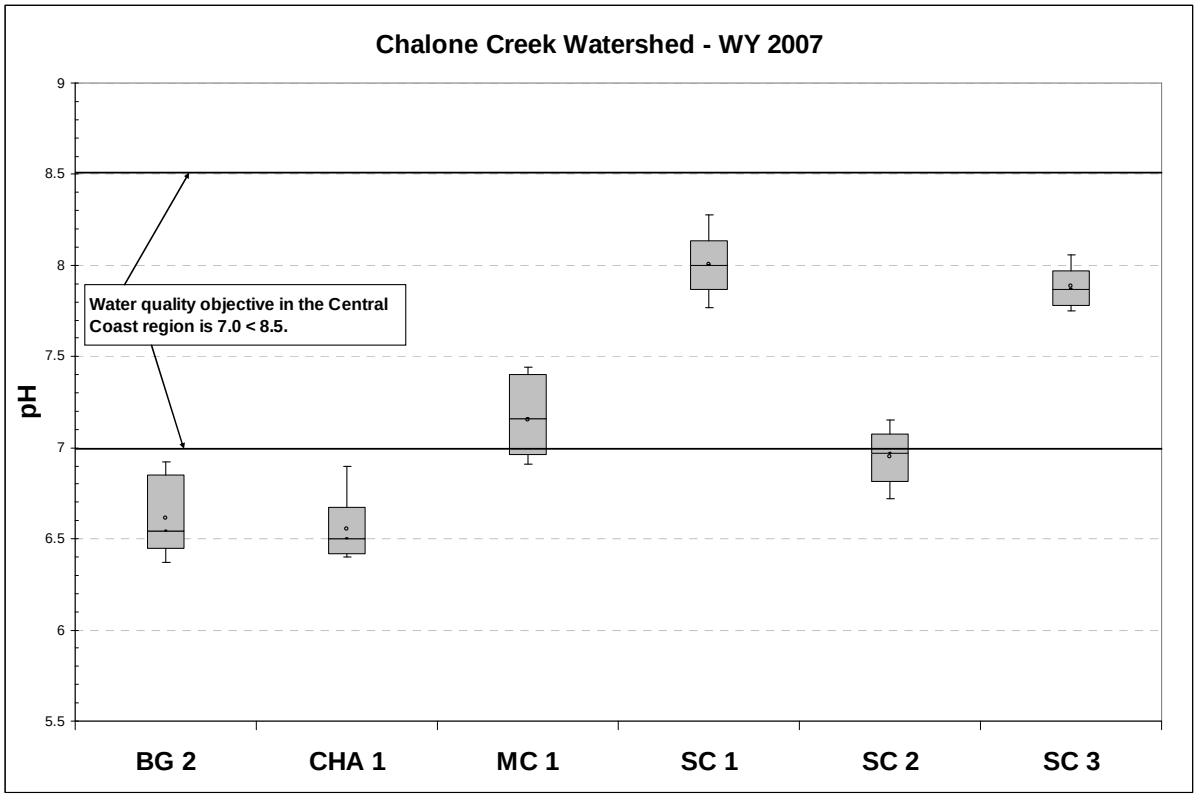

Figure 43. Chalone Creek watershed pH results.

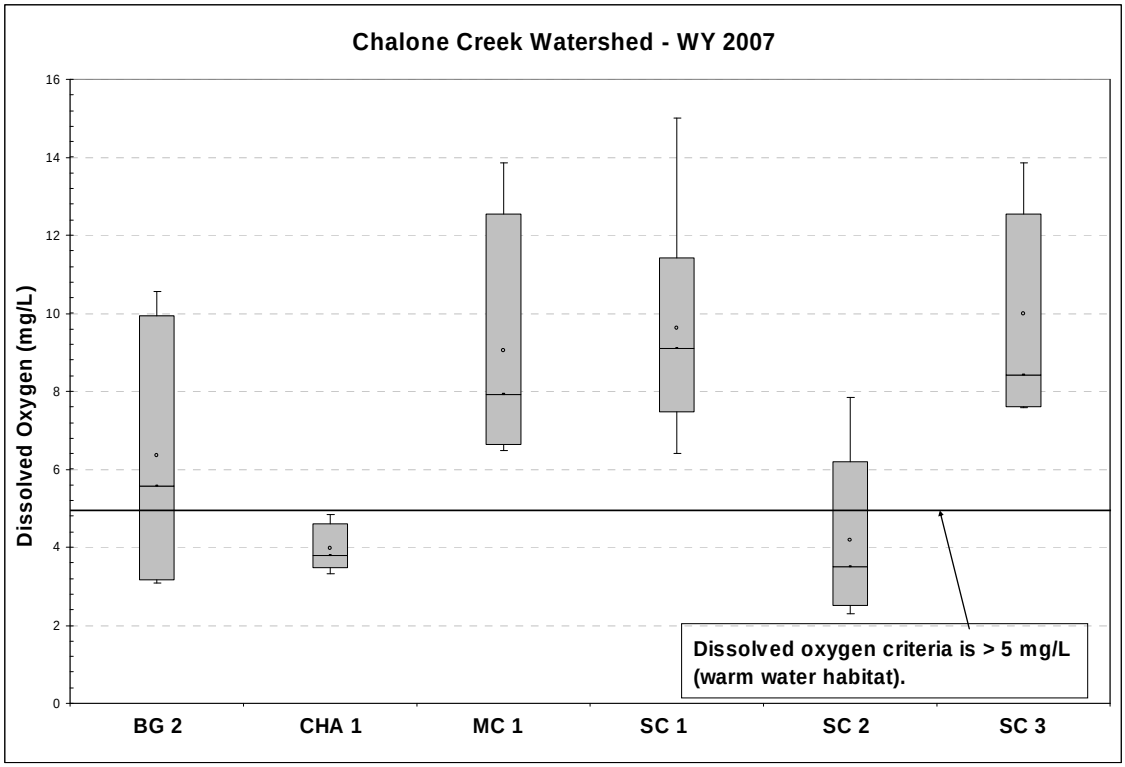

Figure 44. Chalone Creek watershed dissolved oxygen.

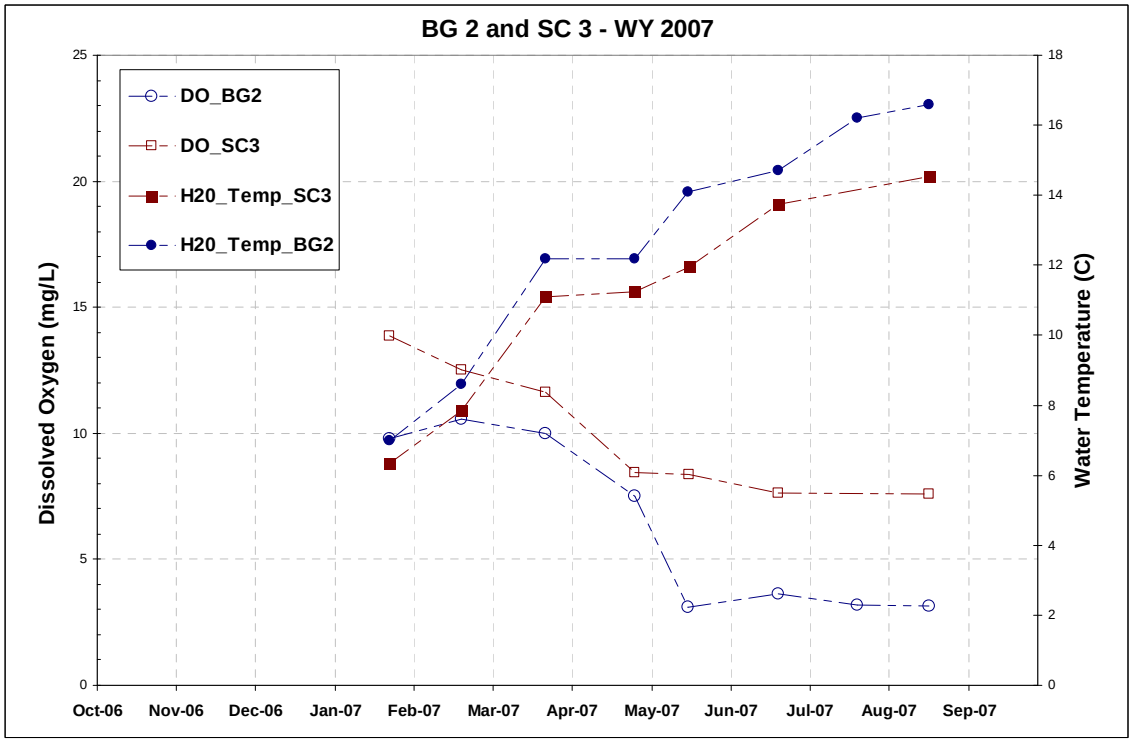

Figure 45. Chalone Creek watershed (BG2 and SC3) dissolved oxygen and water temperature results.

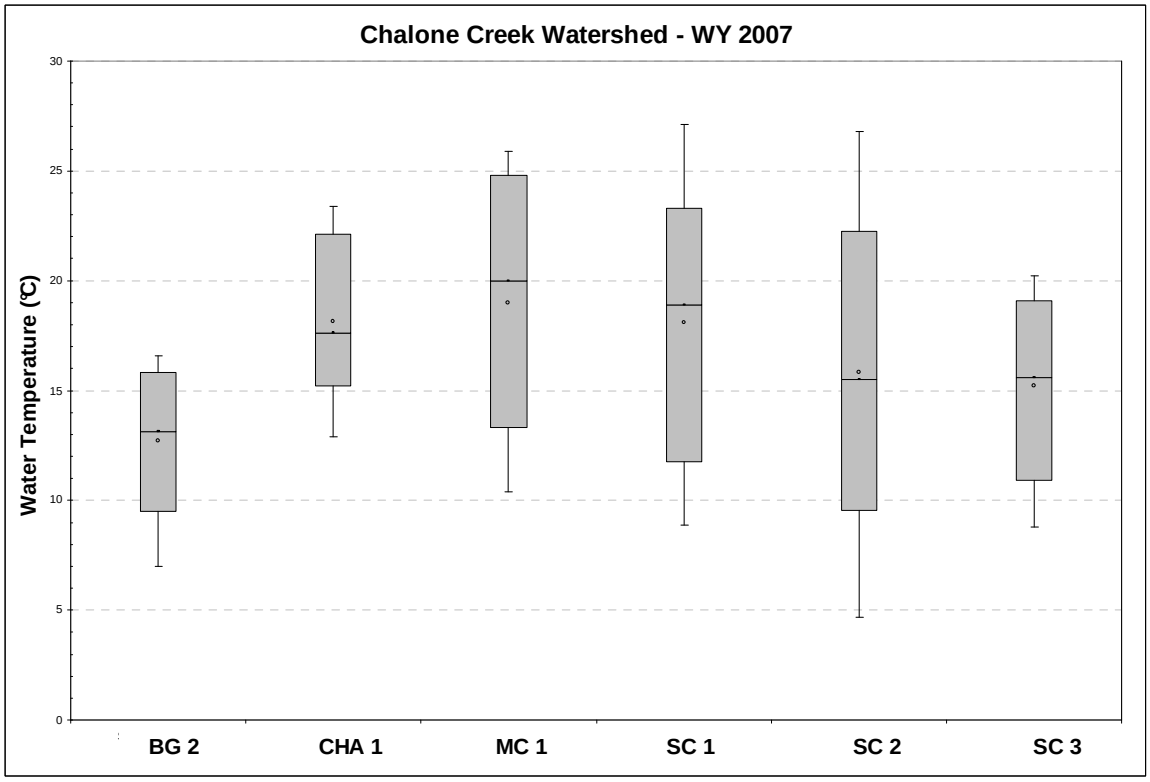

Figure 46. Chalone Creek watershed water temperature results.

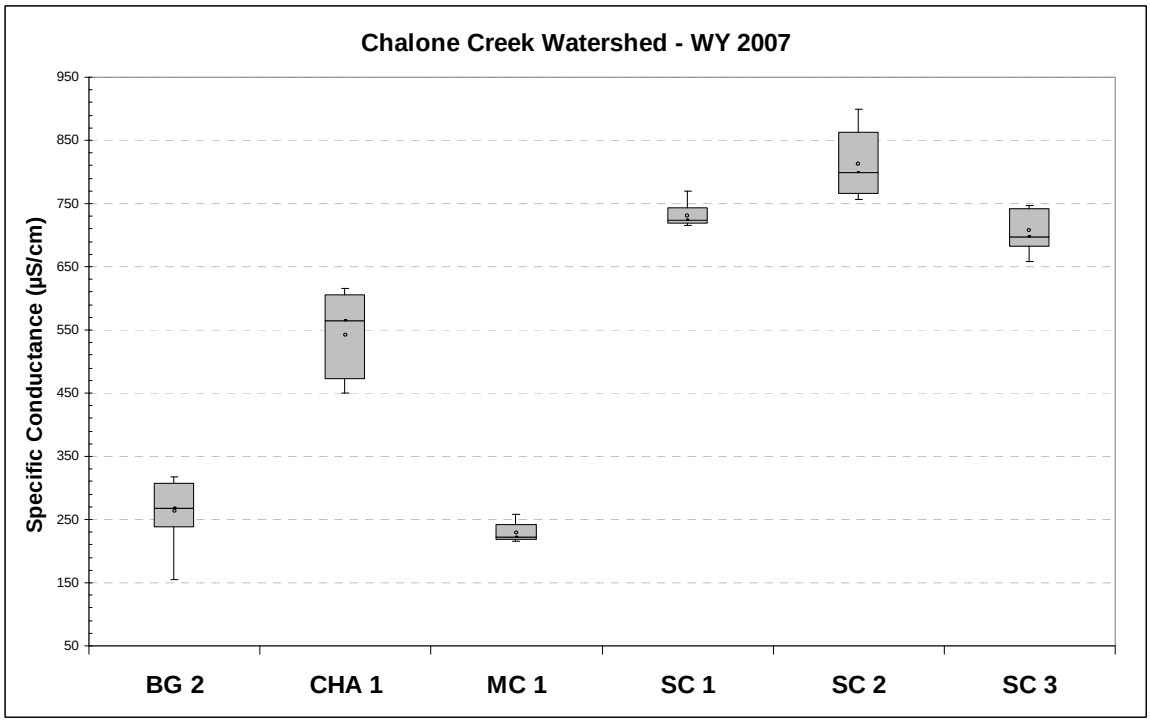

Figure 47. Chalone Creek watershed specific conductance results.

Nutrient analysis: The Chalone Creek watershed was the only SFAN watershed to have detectable levels of ammonia during the 2007 water year, with one detection at MC 1, in March, and one at SC 2, in June (Table 35). On both occasions a pig or evidence of pig activity was observed. Total coliform and TKN results from those visits were also higher than seen during other visits during the same water-year. Nitrogen was most often detected as TKN while nitrate and ammonia detections were low, indicating that organic nitrogen is the dominant form of nitrogen seen in the watershed. TKN levels were highest at MC 1 and SC 1 and results indicated higher summer loading rates (Figure 48). Ammonia results were reported from the lab as total ammonia (as N). When converted to un-ionized ammonia the results were well below the water quality objective of 0.025 mg/L established in the Central Coast RWQCB Basin Plan. Nitrate was rarely detected in the watershed and only at SC 3 and MC 1.

Table 35. Chalone Creek watershed nutrient results – WY 2007.

	# of Samples	Nitrate as N (mg/L)		TKN (mg/L)		Un-ionized Ammonia (mg/L)
		No. of Detects	Min / Max	No. of Detects	Min / Max	
CHA 1	6	0	NA	5	0.27 / 0.38	No Detections
CHA 2	2	0	NA	2	0.37 / 0.37	No Detections
CHA 3	3	0	NA	3	0.37 / 0.74	No Detections
BG 2	7	0	NA	6	0.18 / 0.42	No Detections
MC 1	6	3	0.10 / 0.22	6	1.10 / 3.00	1 detect – 0.0007 mg/L
SC 1	5	0	NA	5	0.38 / 1.10	No Detections
SC 2	4	0	NA	4	0.56 / 1.10	1 detect – 0.005 mg/L
SC 3	7	5	0.10/ 0.14	7	0.31 / 0.47	No Detections

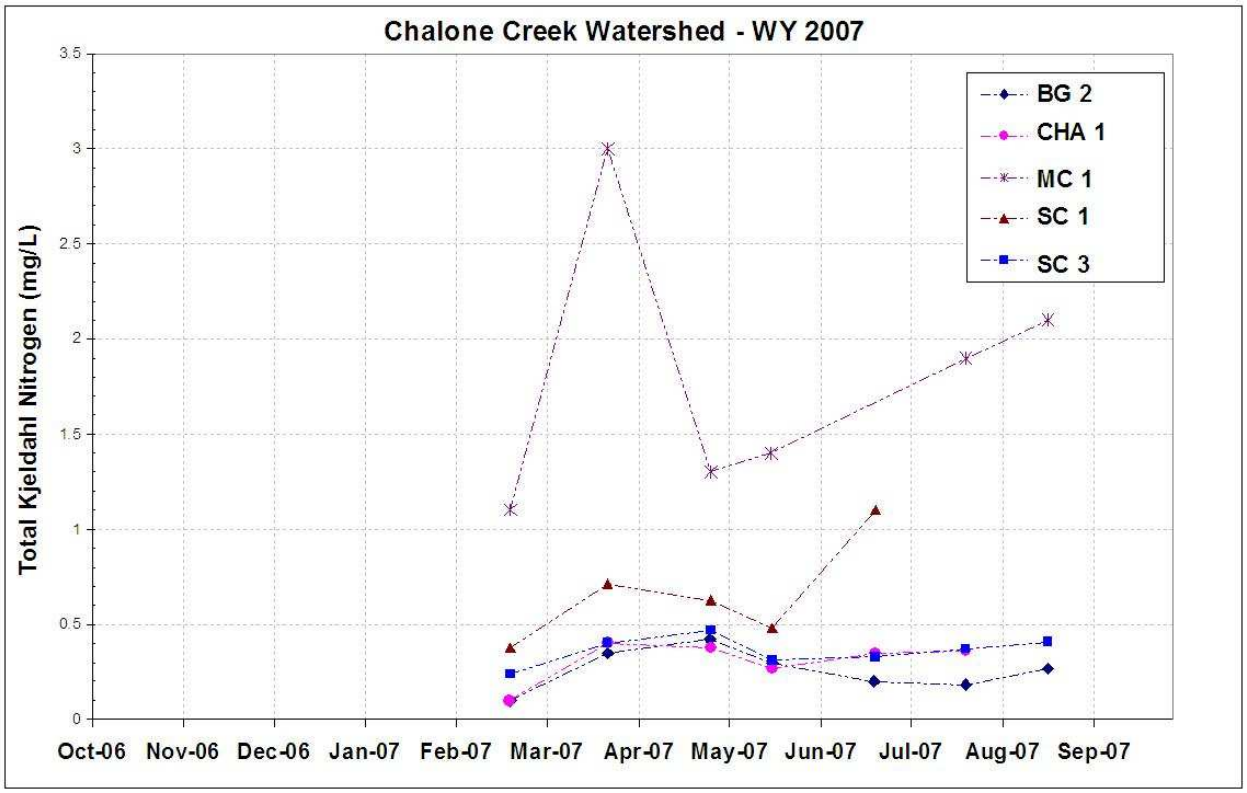

Figure 48. Chalone Creek watershed TKN results.

Bacteria analysis: Bacteria results in the Chalone Creek watershed were higher than those seen in the other SFAN watersheds. *E. coli* results were highest at MC1 where 86 percent of the samples exceeded the water quality criterion for contact recreation (Figure 49). MC 1 also had the highest observed total coliform results, with all results above 2400 MPN/100mL and a maximum of 41,000 MPN/100 mL (Table 35). Total coliform levels at most sites rose throughout the summer which may indicate higher loading rates during those months or may be due to the lower flow at the sites which resulted in a less dilute sample. Bacteria results were also commonly high at SC 1. It may be valuable to test the bacteria levels above the in-holding at MC 1 in order to determine the source of the high results. While there were no quantified results above 2400 MPN/100 mL at BG 2 or the stations on Chalone Creek, there were multiple results above the quantification limit of 2419 MPN/ 100 (Figure 50).

Higher dilutions will be used during the 2008 water year in order to better quantify the bacteria levels. The effects of factors such as septic systems or wildlife near these monitoring stations are extremely localized due to the intermittent and disconnected nature of the streams (Figure 51).

Table 36. Chalone Creek watershed *E. coli* and total coliform bacteria results - WY 2007.

			Total Coliform (MPN/100 mL)			*E. coli* Bacteria (MPN/100mL)		
	#of samples	# of samples > QL	Min	Max	Exceedences	Min	Max	Exceedences
CHA 1	6	1	160	>2419	0	4	610	1
CHA 2	2	1	1700	>2419	0	20	110	0
CHA 3	3	0	920	2000	0	ND	28	0
BG 2	7	3	270	>2419	0	ND	110	0
MC 1	6	2	>2419	41000	2	130	2300	5
SC 1	5	2	1600	23000	1	56	980	1
SC 2	4	0	770	5400	0	50	1100	2
SC 3	7	1	488	>2419	0	9	580	2

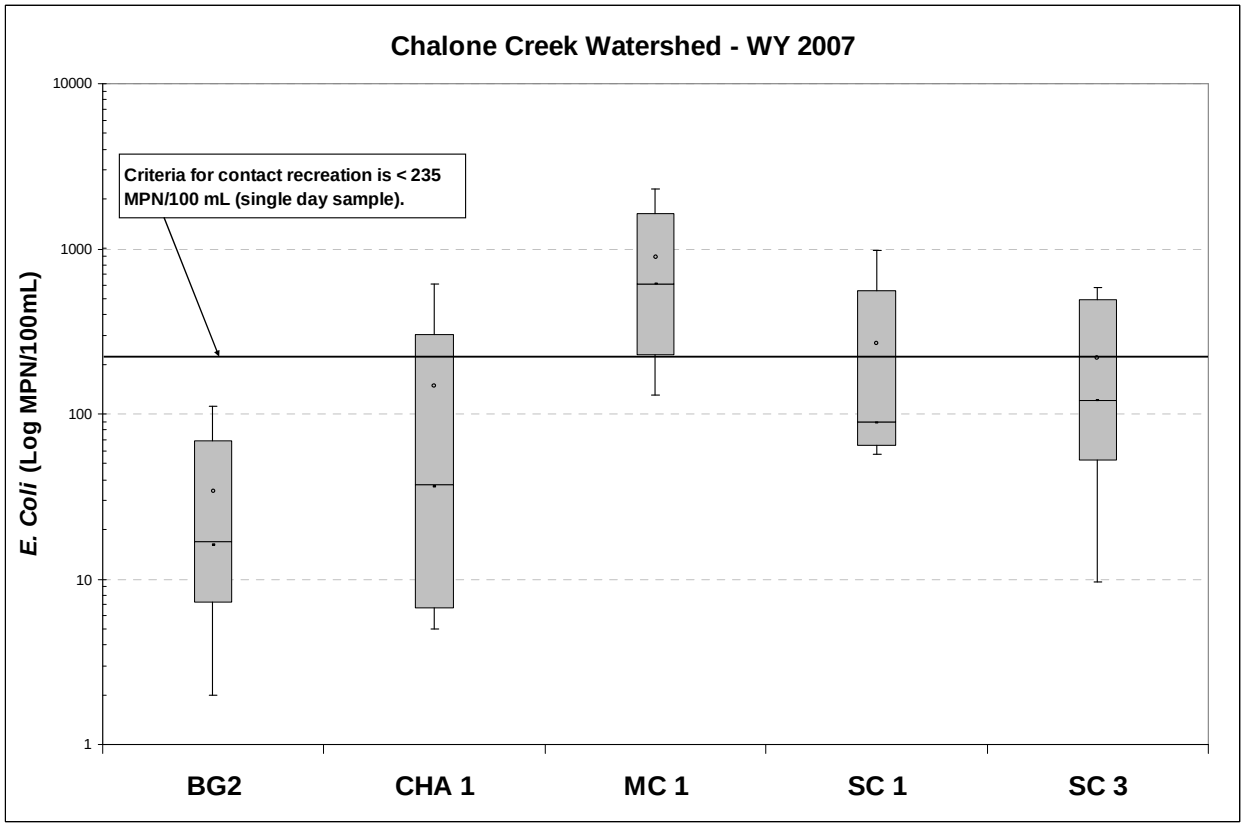

Figure 49. Chalone Creek watershed *E. coli* bacteria results.

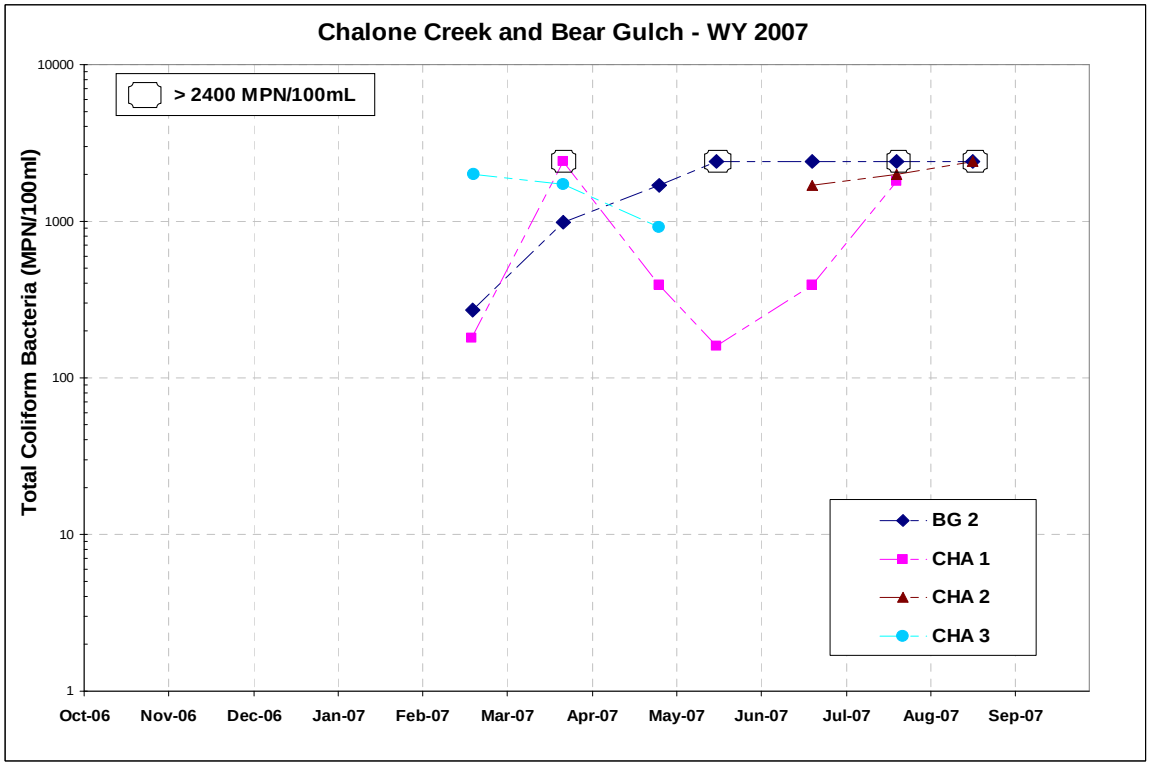

Figure 50. Bear Gulch and Chalone Creek total coliform bacteria results.

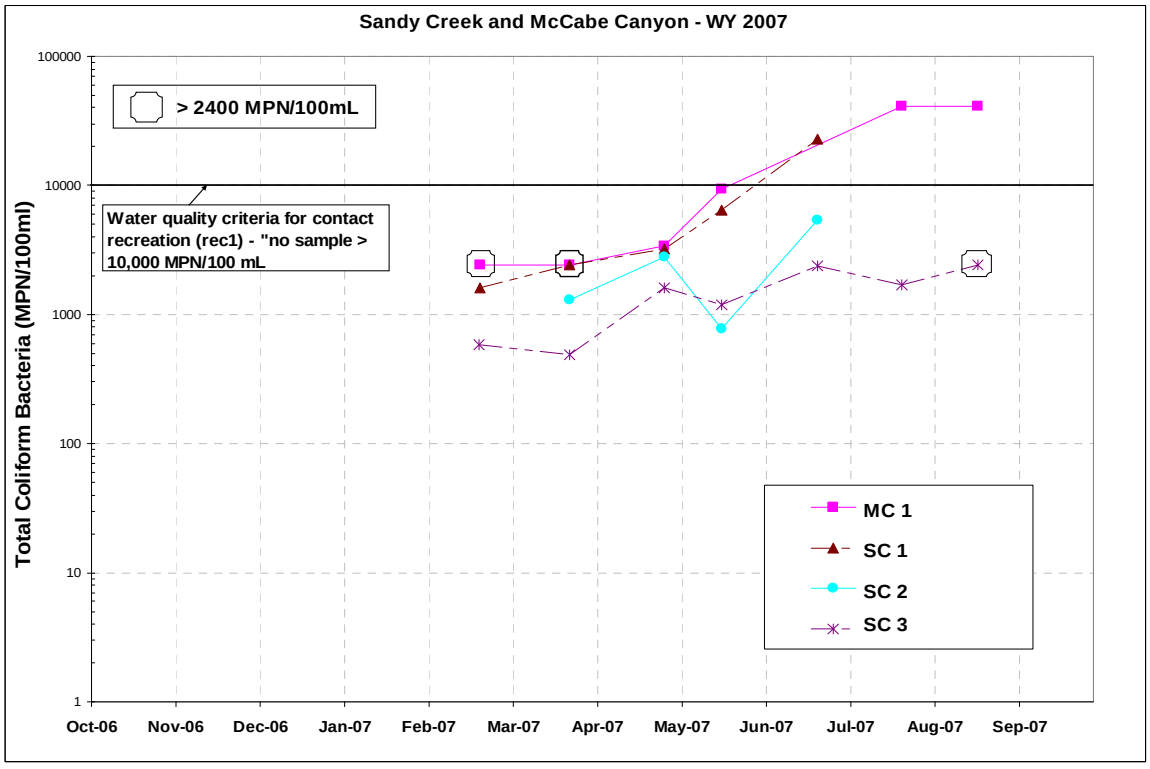

Figure 51. Sandy Creek and McCabe Canyon total coliform bacteria results.

John Muir National Historic Site (JOMU)
Franklin Creek

Approximately 150 meters of Franklin Creek are on NPS property. Here, a single water quality site is monitored for core parameters (temperature, conductivity, dissolved oxygen and pH), discharge, coliform bacteria (total coliform and *E. coli*), and nutrient parameters (nitrate, ammonia and total Kjeldahl nitrogen).

Core parameter analysis: The core parameters results consistently fell within the established water quality objectives for Franklin Creek, although specific conductance values were consistently high. Freshwater streams typically should have conductivity between 150 to 500 µS/cm to support diverse aquatic life; higher levels, such as those seen in Franklin Creek, are an indicator of non-organic solids in the water body (Behar 1997).

In Franklin Creek, pH results varied little and were always within the RWQCB water quality objectives (Figure 52). The mean pH at FRA 1 was 7.97.

Dissolved oxygen fell below the cold water habitat objective of 7 mg/L during two visits (Figure 53).

Specific conductance results were higher than those observed in other SFAN watersheds, with a maximum of 1544 µS/cm in August 2007 (Figure 54). Salinity values ranged from a minimum of 0.4 ppt in December to a maximum of 0.8 ppt during low flow conditions in July and August.

Table 37. Franklin Creek watershed core parameter results.

	# of	Sp. Conductance (µS)		Dissolved Oxygen (mg/l)		pH		H_20 Temp (°C)	
	Samples	Min	Max	Min	Max	Min	Max	Min	Max
FRA 1	10	753	1544	4.67	13.01	7.77	8.2	7.3	17.8

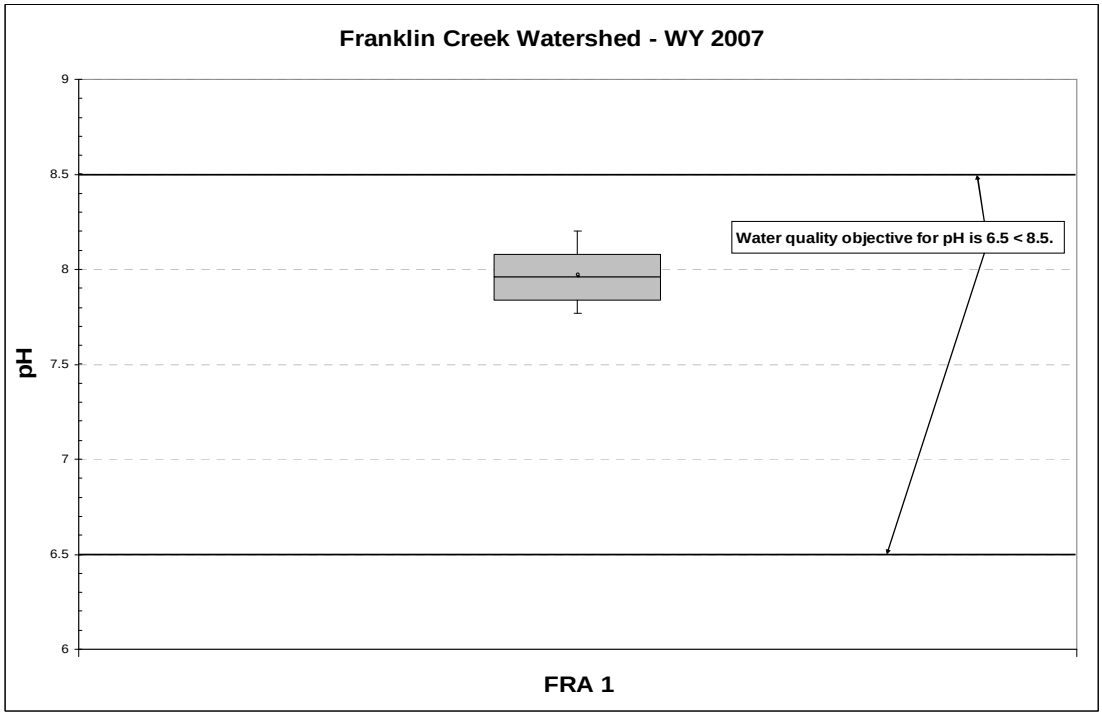

Figure 52. Franklin Creek watershed pH results.

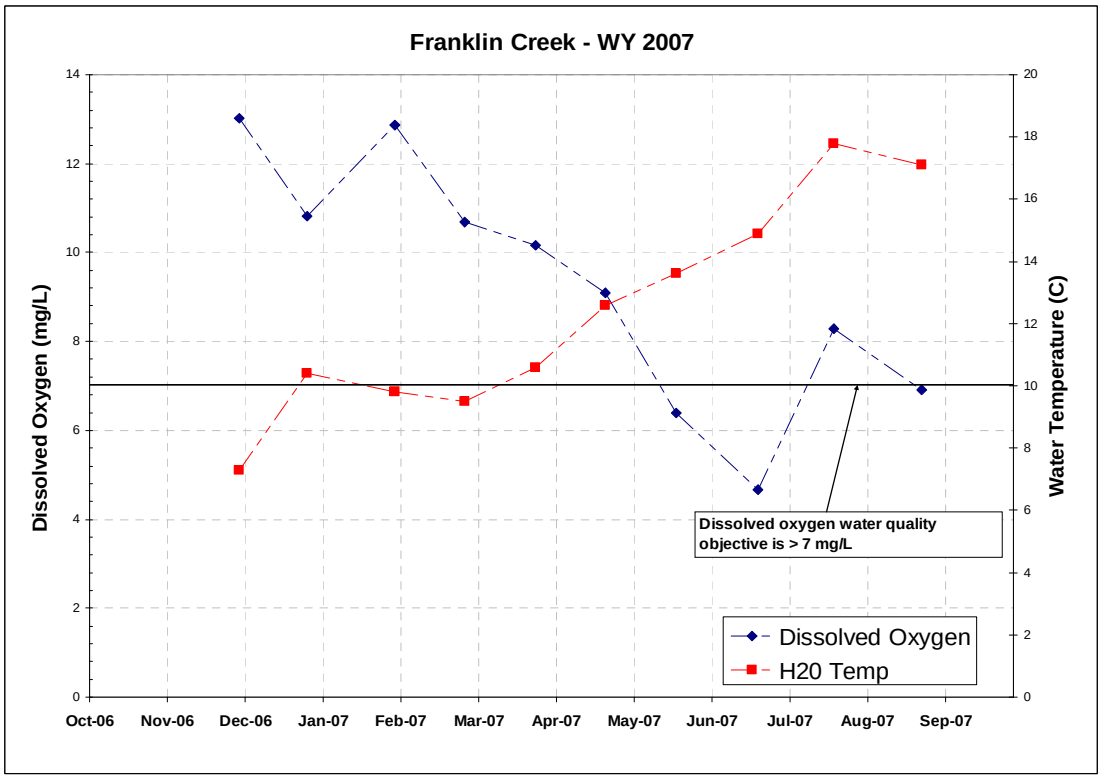

Figure 53. Franklin Creek dissolved oxygen and water temperature results.

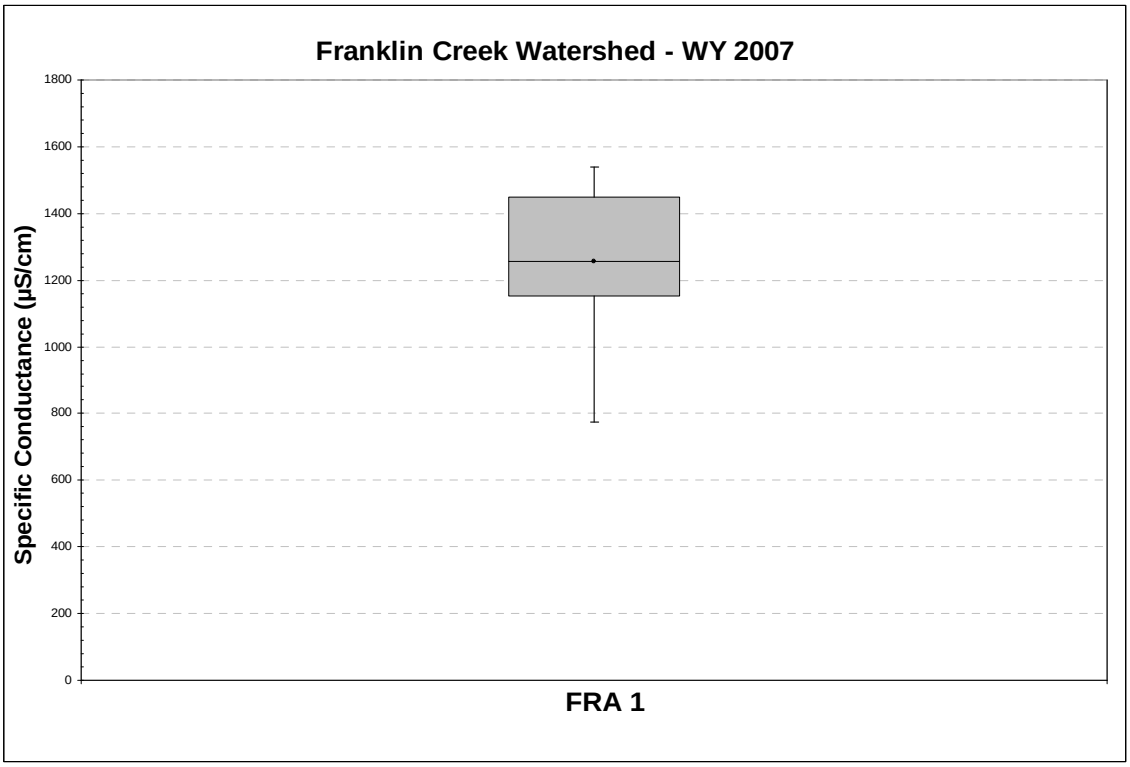

Figure 54. Franklin Creek watershed specific conductance results.

Nutrient analysis: The dominant form of nitrogen in the Franklin Creek watershed was soluble inorganic nitrogen in the form of nitrate. Franklin Creek had detectable levels of nitrate during all ten site visits (Table 38). TKN was above the detection limit on one visit, while there were no detectable levels of ammonia during any visit. Nitrate levels in Franklin Creek were higher than the mean in the other SFAN watersheds.

Table 38. Franklin Creek watershed nutrient results.

	# of Samples	Nitrate as N (mg/L)		TKN (mg/L)		Ammonia as N (mg/L)
		No. of Detects	Min/Mean/ Max	No. of Detects	Min / Max	
FRA 1	10	10	0.84/ 1.28 / 1.95	1	1.70 / 1.70	No Detections

Bacteria analysis: Bacteria results in the Franklin Creek watershed exceeded the water quality standard for contact recreation for both total coliform and *E. coli* bacteria (Figure 55 and Figure 56). The total coliform bacteria criterion of 10,000 MPN/100 mL was exceeded twice and the *E. coli* bacteria criterion of 235 MPN/100 mL was exceeded on three occasions (Table 39). Total coliform results were above the 2419 MPN/100 mL quantification limit on three occasions.

Table 39. Franklin Creek bacteria results.

		Total Coliform (MPN/100 ml)				*E. coli* Bacteria (MPN/100ml)		
	#of samples	# of samples > QL	Min	Max	Exceed	Min	Max	Exceed
FRA 1	10	3	313	13000	2	49	2400	3

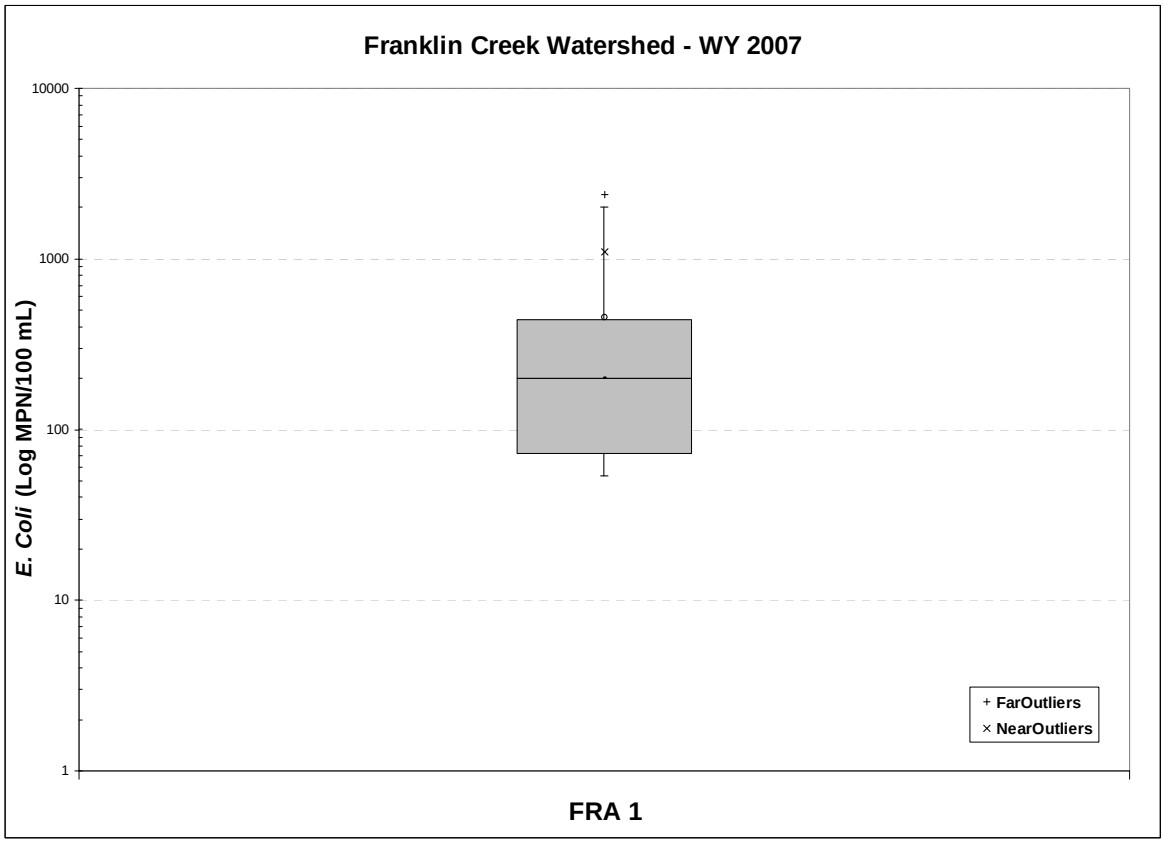

Figure 55. Franklin Creek watershed *E. coli* bacteria results.

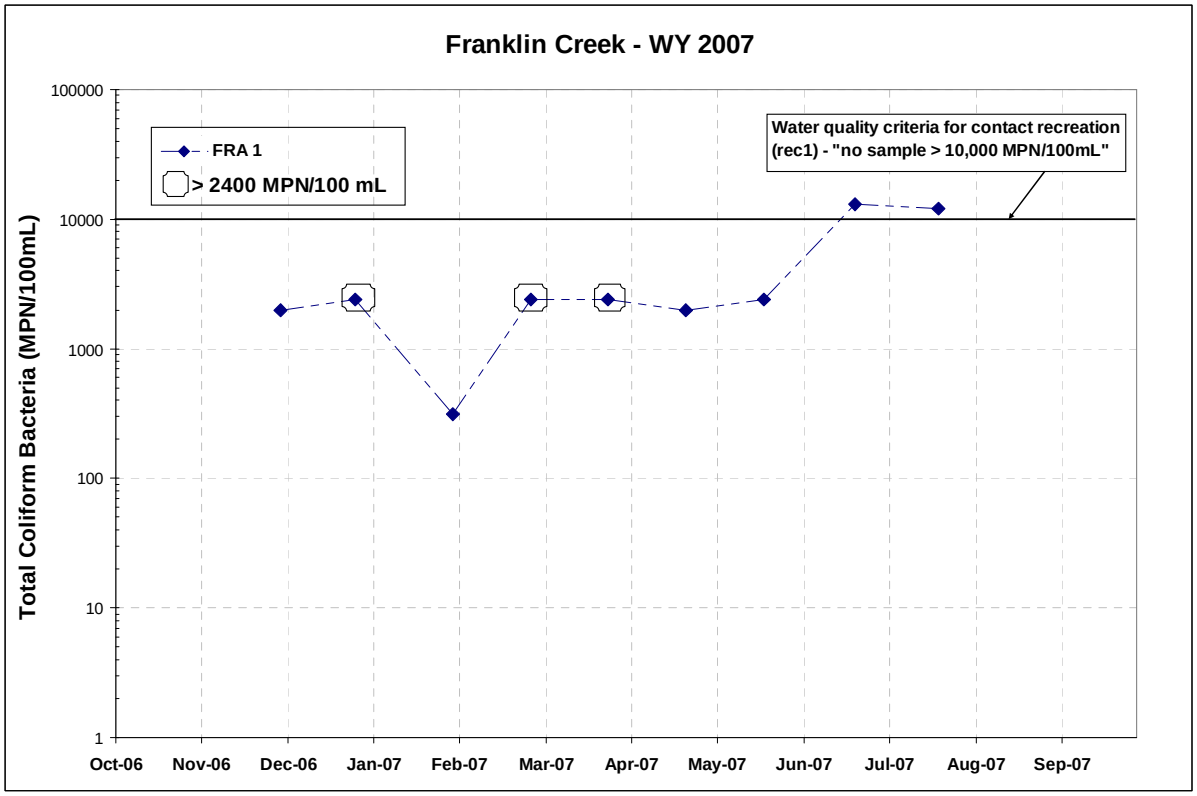

Figure 56. Franklin Creek total coliform bacteria results.

Discussion

Data presented here represent the first year of water quality monitoring under the approved San Francisco Bay Area Inventory and Monitoring Network (SFAN) Water Quality Monitoring Protocol (Cooprider and Carson 2006). While the 2007 water year began in October 2006 and continued through September 2007, monitoring began in November 2006 for most sites and in January 2007 for the sites in Pinnacles NM. Therefore, the data does not reflect an entire water year for any of the sites. Additionally, little historic data exists for many of the sites and collection of any historic data did not follow an approved protocol. While it is not yet possible to observe long-term trends, the data can be viewed in the context of water quality objectives established by the regional water quality control boards and reference levels established for the region through monitoring by the US EPA.

The streams monitored in the SFAN commonly have discharge below one cfs throughout much of the year, with higher flows observed between November and March. During the 2007 water year most of the core parameter results which represented failures to comply with established water quality objectives, such as low pH and dissolved oxygen, were observed under low or no flow conditions. The sites with perennial flow demonstrated less variability in pH, water temperature, and dissolved oxygen throughout the year, although all sites exhibited higher water temperatures and lower dissolved oxygen through the summer months as expected. Conductivity was significantly higher in Franklin Creek at JOMU than throughout the rest of the SFAN; all sites followed the same pattern through the year with the lowest levels in December when streamflow was high and increasing through the year as the volume of water in the streams decreased. Conductivity results were also high in PINN, although not as high as JOMU.

Currently the only water quality objective for nitrate is the public health standard of 10 mg/L (max) established by the US EPA. The US EPA did conduct an extensive survey throughout the US in order to establish regional reference values. The regional reference value for the San Francisco Bay Region is 0.16 mg/L (US EPA 2000). Most stations throughout the SFAN had nitrate levels below 0.50 mg/L except under high flow conditions when they increased slightly. Franklin Creek in JOMU had the highest nitrate levels in the SFAN, with a maximum of 1.95 mg/L in May 2007. The high nitrate levels at JOMU may indicate that the high conductivity is due to inorganic dissolved solids in the stream, whereas in PINN nitrate levels were much lower indicating that higher conductivity levels may be a result of natural geologic influences which contribute organic dissolved solids. TKN, a measure of organic nitrogen and ammonia, periodically spiked throughout the SFAN. The highest TKN result occurred in Olema Creek at one of the sites with intermittent flow, OLM 18, when the sample was collected from a pool of standing water. Within PINN, one site, in McCabe Canyon, showed higher TKN levels than the other stations. Suspected influences on TKN at this station include an inholding with a possible failing septic system and fecal matter from pigs; the site was located outside of the pig exclosure during this sampling period.

Bacteria levels fluctuated throughout the year at all stations. The highest observed *E. coli* levels were at Nyhan Creek in GOGA. Throughout the SFAN, there were six total exceedences of the single day sample contact recreation criteria for total coliform and 41 exceedences of the *E. coli* contact recreation criteria.

Nitrogen within SFAN streams was measured as TKN, the sum of both organic nitrogen and ammonia, nitrate, which is soluble inorganic nitrogen, or ammonia. As ammonia was rarely detected, TKN detections can be assumed to be primarily organic nitrogen. The dominant form of nitrogen observed varied by watershed. Nitrogen in the Rodeo Creek and Chalone Creek watersheds occurred primarily as organic nitrogen while the dominant form of nitrogen in the Pine Gulch and Franklin Creek watersheds was soluble inorganic nitrogen as nitrate. The Olema Creek and Tennessee Valley Watersheds had approximately the same number of detections of both organic and inorganic nitrogen. The observed pH and nitrogen levels throughout the SFAN demonstrated a relationship observed by Willett et al. (2004); pH decreased with higher levels of organic nitrogen in the Rodeo Creek and Chalone Creek watersheds, and increased with higher levels of inorganic nitrogen in the Pine Gulch and Franklin Creek watersheds.

Observed nutrient levels throughout the network were low, with only one percent of samples having ammonia above the 0.10 mg/L detection level, mean nitrate (as N) of 0.34 mg/L and mean TKN of 0.99 mg/L. Based on these observations, it is recommended that nutrient sampling be reduced to include only TKN and nitrate each month with ammonia sampled monthly during the winter months, November through March and quarterly between April and September.

Recommendations

- Evaluate and recommend dilution factors for pathogen samples collected at all sites based on season and discharge, to limit results outside of the quantification level.
- Recommend to GOGA staff investigation of Nyhan Creek watershed, with respect to increased pathogen levels observed during regular sampling.
- Evaluate conditions around stations SC 3 and MC1 in PINN, to identify potential pollutant loading sources which affect water quality, or determine additional sites to bracket potential sources.
- Identify weather or flow stations to be used in reporting with Franklin Creek/Strentzel Canyon information.
- Identify weather or flow stations to be used in reporting GOGA – Marin watershed information, including Rodeo and Tennessee Valley.
- Reconsider nutrient sampling regime based on extensive ammonia (as N) non-detects. Recommended nutrient sampling schedule is monthly sampling of nitrate and TKN with ammonia sampled quarterly, in October, January, April, and July as well as during any storm sampling.

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Appendix A

Definitions

Total and Fecal Coliform Multitube – Analysis performed by Test America. Total coliform was occasionally reported along with fecal coliform results during Olema Creek TMDL sampling.

Total Coliform Quantitray – Analysis performed by Analytical Sciences by Quantitray method.

Total Coliform Idexx Quantitray – Analysis performed by NPS staff using the Idexx Quantitray.

Figures

Tables

OLM 18 – Mainstem of Olema Creek upstream of Randall Gulch.

This station is located 10 to 20 feet above the confluence of Olema Creek and Randall Gulch. Randall Gulch has flow into Olema Creek during the winter months; there is not input during the summer. The flow on Olema Creek above the confluence becomes intermittent in the summer and fall months, typically June through November. Water quality monitoring has occurred at this station since January 2001.

Figure A - 1. OLM 18 during “above normal” flow conditions

Table A - 1. OLM 18 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
10/3/06	Routine	16.8	9.4	142.4	202.8	0.1	36.5	4.18	6.57									
11/7/06	Routine	17.5	13	150.3	195.1	0.1	34.2	3.65	6.27				<2			<0.1	0.29	6.7
12/5/06	Routine	5.5	6.6	98.4	151.8	0.1	79.8	9.81	6.26	0.27			50			<0.1	0.17	<0.25
12/5/06	Quality Control		6.5	97.0	150.2	0.1	79.8	9.82	6.18									
1/2/07	Routine	7.5	8.2	59.7	87.8	0.0	85.8	10.10	6.07	2.07			90					
1/9/07	Routine	7	8	60.2	89.0	0.0	96.4	11.44	6.19	2.04			110				0.27	0.71
1/23/07	Routine		5.2	71.8	115.3	0.1	90.4	11.47	6.18				46					
1/30/07	Routine	7	6.3	77.9	121.2	0.1	80.2	9.90	6.06	0.52		308	33		56.1			
2/6/07	Routine		7.5	81.8	122.7	0.1	77.5	9.29	5.79	0.46		139	18		58.8	<0.1	<0.1	<0.25
3/6/07	Routine		9.6	76.9	109.0	0.1	85.8	9.75	5.94	3.041	180	1553	180	108		<0.1	<0.1	<0.25
4/3/07	Routine	8.5	9.3	79.3	113.0	0.1	76.8	8.80	5.90	0.413		573	50		52.10	<0.1	<0.1	<0.25
5/1/07	Routine	14.9	11.7	91.2	122.4	0.1	80.4	8.76				1120			219	<0.1	<0.1	<0.25
6/5/07	Routine	14.4	12.9	88.2	114.8	0.1	65.5	6.90	7.2	0.230		99			10	<0.1	.18	<0.25
7/10/07	Routine	14.5	13.7	99.6	127.4	0.1	65.3	6.78	5.60			290			170	<0.1	<0.1	<0.25
8/1/07	Routine	13.5	13.3	105.0	135.3	0.1	59.3	6.22	5.76	0		4400			2400	<0.1	.07	<0.25
9/10/07	Routine	14	13.6	119.7	152.8	.1	37.8	3.97	5.85			730			86	<0.1	<0.1	.33

OLM 1 – John West Fork

This monitoring station is located on John West Fork, approximately 100 meters upstream of the confluence with Olema Creek. The flow is intermittent during the summer and fall months.

Figure A - 2. OLM 1, May 2008 view upstream, “low flow” conditions.

Figure A - 3. OLM 1, “above normal” flow conditions. View downstream.

Table A - 2. OLM 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform Multitube (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
10/3/06	Routine	15.6	11.5	163.1	219.1	0.1	54.2	5.88	6.72									
11/7/06	Routine	16.2	14	173.1	219.0	0.1	40.4	4.21					30			<0.1	0.61	1.3
11/7/06	Quality Control		13.5	167.2	214.1													
12/5/06	Routine	3.5	8.6	120.1	175.0	0.1	96.6	11.28	6.81	0.26			50			<0.1	0.90	0.4
1/2/07	Routine	6.5	8.7	70.6	102.7	0.0	90.0	10.50	6.57	1.58			50					
1/9/07	Routine	5	7.9	65.8	97.8	0.0	89.8	10.67	6.65	1.43			110			<0.1	0.70	<0.25
1/23/07	Routine		6	83.1	130.5	0.1	*Not Re	*Not Re	6.58				18					
1/30/07	Routine	6.5	7.1	93.1	141.3	0.1	87.6	10.59	6.61	0.32		130	22		28			
2/6/07	Routine		8.5	99.6	145.3	0.1	89.9	10.59	6.21	0.32		103	7		12	<0.1	0.34	<0.25
3/6/07	Routine		10	85.4	119.9	0.1	94.6	10.68	6.43	1.443	14	517	14		61	<0.1	0.25	<0.25
4/3/07	Routine	8.5	9.8	101.1	142.4	0.1	86.6	9.82	6.18	0.122		226	22		10	<0.1	<0.1	<0.25
5/1/07	Routine	14.2	12.2	107.7	142.4	0.1	98.3	10.54				613			8	<0.1	.11	<0.25
6/5/07	Routine	15.2	13.9	121.5	154.2	0.1	80.2	8.29	7.49	0.161		380			6	<0.1	.08	<0.25
7/10/07	Routine	14.6	14.5	141.1	176.3	0.1	69.9	7.10	6.12			43			3	<0.1	.13	<0.25
8/1/07	Routine	14.5	14.3	154.1	193.7	0.1	52.9	5.41	6.16	0		760			180	<0.1	.19	<0.25
8/1/07	Routine															<0.1	.19	<0.25
8/1/07	Routine											760			180			
9/10/07	Routine	15	14.4	168.7	211.3	.1	41.2	4.21	6.12			850			41	<0.1	<0.1	.25

OLM 14 – Olema Creek at the Five Brooks Bridge

This station is located on the mainstem of Olema Creek approximately 400 meters downstream of the Olema Creek/John West Fork confluence. There is connected flow throughout the year.

Figure A - 4. OLM 14, “low” flow conditions.

Figure A - 5. OLM 14, storm 2006.

Table A - 3. OLM 14 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform Multitube (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
10/3/06	Routine	12.3		228.0	300.6	0.1	80.3	8.55	7.40				27					
10/3/06	Quality Control		12.4				79.9	8.52										
11/7/06	Routine	16.5	13.7	248.1	316.3	0.2	94.3	9.83	7.25				80			<0.1	0.47	1.7
11/7/06	Quality Control						94.5	9.85										
12/5/06	Routine	3.5	6.3	160.0	248.7	0.1	100.1	12.36	7.44	0.87			170			<0.1	0.43	<0.25
12/5/06	Routine												170					
12/5/06	Routine															<0.1	0.43	<0.25
1/2/07	Routine	7	8.1	81.5	120.4	0.1	93.2	11.07	7.02	6.66			300					
1/2/07	Routine												300					
1/9/07	Routine	4.5	7.3	75.1	113.4	0.1	94.6	11.39	7.15	5.88			30			<0.1	0.50	<0.25
1/9/07	Quality Control															<0.1	0.50	0.60
1/23/07	Routine		*Not Reported						7.14	2.02			22					
1/30/07	Routine	8.5	6.7	128.7	198.2	0.1	97.0	11.86	7.61	1.58		231.0	22		50.1			
2/6/07	Routine		7.9	139.7	207.3	0.1	100.5	11.91	7.51	1.18		313.0	20		19.9	<0.1	0.19	<0.25
3/6/07	Routine		10.1	109.1	152.3	0.1	96.4	10.84	7.16	8.195	810	816.41	17		162.42	<0.1	0.22	<0.25
4/3/07	Routine	11	9.2	143.8	205.8	0.1	95.3	10.93	7.35	1.513		441.20	11		10		<0.1	<0.25
5/1/07	Routine	13.8	11.9	148.4	198.2	0.1	92.1	9.98				791.53			52.01	<0.1	.18	<0.25
5/1/07	Quality Control														51.60			
6/5/07	Routine	15.5	14.1	182.3	230.0	0.1	91.8	9.43	8.17	0.945		870			93	<0.1	.14	<0.25
7/10/07	Routine	17.5	15	218.7	270.3	0.1	90.0	9.08	7.08	0.249		1600			1600	<0.1	.18	<0.25
7/10/07	Quality Control											1400			1100			
8/1/07	Routine	15	15.1	232.5	286.7	0.1	81.2	8.17	7.15			990			170	<0.1	.15	<0.25
9/10/07	Routine	16	14.9	246.3	305.4	.1	71	7.18	7.16			3300			570	<0.1	<0.1	.26

OLM 6A – Davis Bucher Creek, tributary to Olema Creek

This monitoring station is located on Davis Bucher Creek, approximately 150 meters upstream of the confluence with Olema Creek. The flow is typically low, below 1 cfs, and perennial. The station is located within the PORE Philip Burton Wilderness Area and should be free of influence from land-use activities such as ranching. Horse riding is common on the trails adjacent to OLM 6A and there has been a horse crossing on the creek 5 to 10 meters below the monitoring station. Monitoring staff have made an effort to sample upstream of this crossing as it may impact water quality. OLM 6A was the only station with nitrate above the detection limit for all WY 2007 samples.

Figure A - 6. OLM 6A, Americorps intern Erin Brown, Jan 2008.

Table A - 4. OLM 6A results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform Multitube (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
10/3/06	Routine	11.4		214.2	289.3	0.1	88.7	9.68	7.80				14					
10/3/06	Quality Control		11.4	214.1	289.3													
11/7/06	Routine	16.8	13	227.3	294.5	0.1	110.9	11.67	7.84	0.29			30			<0.1	0.23	<0.25
12/5/06	Routine	6.5	6.7	184.5	283.8	0.1	104.4	12.76	7.93	0.35			50			<0.1	0.25	<0.25
1/2/07	Routine	8	8.1	121.3	179.2	0.1	97.4	11.51	7.74	0.55			50					
1/9/07	Routine	7	7.8	114.2	170.1	0.1	96.9	11.53	7.84	0.54			17			<0.1	0.29	<0.25
1/9/07	Quality Control		7.7	114.1	170.0	0.1	96.9	11.55	7.84									
1/23/07	Routine		*Not Reported						7.92	0.25			22					
1/30/07	Routine	8	7	200.3	305.0	0.1	95.3	11.55	7.90	0.30		19.9	7		13.2			
2/6/07	Routine		8.3	210.6	308.7	0.1	93.5	10.97	7.76	0.24		547.5	22		9.7	<0.1	0.23	<0.25
3/6/07	Routine		10.9	179.3	245.3	0.1	96.6	10.68	7.37	1.113	140	770.1	7		9.69	<0.1	0.36	<0.25
4/3/07	Routine	11	9.7	186.0	263.1	0.1	95.7	10.88	7.63			9.90	4		^10	<0.1	.27	<0.25
5/1/07	Routine	13.3	11.3	204.3	276.8	0.1	99.1	10.84				980.39			16.60	<0.1	.25	<0.25
6/5/07	Routine	16.3	13.1	218.2	282.7	0.1	93.8	9.87	8.3	0.455		1300			1300	<0.1	.20	<0.25
7/10/07	Routine	16.5	13.7	231.3	294.6	0.1	93.2	9.64	7.79	0.390		50			17	<0.1	.23	0.44
7/10/07	Quality Control											75			31			<0.25
7/10/07	Quality Control											48			21			
7/10/07	Quality Control											31			^10			
8/1/07	Routine	15	13.8	233.5	297.3	0.1	95.8	9.90	7.84	0.225		720			<10	<0.1	.23	<0.25
8/1/07	Quality Control		13.8	236.7	301.0	0.1	95.8	9.92	7.83			1000			10	<0.1	.18	<0.25
9/10/07	Routine	15.5	13.8	246	312.8	.2	94.2	9.73	7.63	0.157		990			260	<0.1	.17	<0.25

OLM 11 – Olema Creek at Bear Valley Bridge

This monitoring station is located on the mainstem of Olema Creek at Bear Valley Bridge near the PORE headquarters. There is a maintained stream gage located at the station.

Figure A - 7. OLM 11 during “above normal” flow conditions.

Figure A - 8. OLM 11 during “low” flow conditions, April 2008.

Table A - 5. OLM 11 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform Multitube (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
10/3/06	Routine	15.2	12.8	225.8	294.1	0.1	92.6	9.80	7.53				120					
11/7/06	Routine	18.8	14.7	255.5	317.7	0.2	99.6	10.08	7.29	0.93			130			<0.1	0.21	0.4
12/5/06	Routine	8.4	5.8	175.8	277.3	0.1	115.2	14.37	7.50	1.95			80			<0.1	0.32	0.8
1/2/07	Routine	9.5	7.7	75.8	113.0	0.1	90.5	10.77	7.14	14.46			70					
1/9/07	Routine	12	7.4	78.8	118.6	0.1	93.4	11.23	7.23	11.19			130			<0.1	0.72	<0.25
1/23/07	Routine								7.38	5.12			46					
1/30/07	Routine	8	6.8	155.0	237.4	0.1	91.5	11.15	7.39			648	140		210			
2/6/07	Routine		8.8	169.2	245.0	0.1	97.9	11.35	7.20	3.40		866.4	14		56	<0.1	0.25	<0.25
3/6/07	Routine		11.7	132.0	177.1	0.1	95.3	10.35	6.69	18.033	180	1553	17		225	<0.1	0.36	<0.25
4/3/07	Routine	12.5	11.3	176.2	239.0	0.1	100.9	11.05	7.31	3.685	61	156.3	23	5	41	<0.1	<0.1	<0.25
4/3/07	Quality Control		11.3	176.4	239.0	0.1	101.2	11.10	7.32							<0.1	<0.1	<0.25
5/1/07	Routine		13.3	188.3	242.1	0.1	90.7	9.49		4.230		571.73			99			
5/1/07	Quality Control		13.3	189.1	243.4	0.1	90.7	9.47				1553			108			
6/5/07	Routine	16.8	16	218.5	263.6	0.1	89.4	8.80	7.84	1.853		1000			140	<0.1	.11	<0.25
6/5/07	Quality Control		16	218.7	263.7	0.1	86.8	8.53	7.85			2400			170	<0.1	.13	<0.25
6/5/07	Quality Control											410			140			
6/5/07	Quality Control											1010			230			
7/10/07	Routine	18.1	18.1	250.6	288.7	0.1	89.8	8.49	7.17	1.034		690			270	<0.1	.12	0.36
8/1/07	Routine	15.5	17.6	257.4	299.7	0.1	84.1	8.02	7.19	0.845		2300			160	<0.1	.05	<0.25
9/10/07	Routine	17.5	15.8	258.7	314	.2	81.3	8.05	7.14	0.591		3400			910	<0.1	.03	<0.25

OLM 10B – Olema Creek near Olema Marsh

This is the furthest downstream monitoring station on Olema Creek. The station is adjacent to Olema Marsh; approximately 300 meters upstream of the confluence with Lagunitas Creek.

Figure A - 9. OLM 10B during “above normal” flow conditions.

Table A - 6. OLM 10B results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform Multitube (MPN/100mL)	TotalColiform Idexx	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
10/3/06	Routine	15.6	12.2	218.2	288.5	0.1	76.9	8.25	7.26				76					
11/7/06	Routine	17.8	15.1	248.0	306.2	0.1	93.9	9.43	7.42	1.25			170			<0.1	.14	1.7
11/7/06	Quality Control															<0.1	0.14	1.3
12/5/06	Routine	11	5.8	182.2	287.3	0.1	112.9	14.11	7.60	2.13			80			<0.1	0.23	<0.25
12/5/06	Quality Control															<0.1	0.25	1.3
1/2/07	Routine	7.6		89.8	134.5	0.1	91.7	10.95	7.07	15.08			110					
1/2/07	Quality Control		7.6	89.5	134.1	0.1	91.5	10.94	7.07									
1/9/07	Routine	14	7.6	88.7	132.9	0.1	102.5	12.25	7.27	12.79			140			<0.1	0.68	<0.25
1/9/07	Quality Control		7.7	90.2	134.5	0.1	102.5	12.17	7.34									
1/9/07	Quality Control		7.7	88.9	132.9	0.1	101.5	12.15	7.27									
1/9/07	Quality Control		7.6	88.3	132.1	0.1	101.7	12.14	7.27									
1/9/07	Quality Control		7.6	89.1	133.1	0.1	103.4	12.52	7.27									
1/9/07	Quality Control		7.6	89.1	133.6	0.1	102.8	12.28	7.26									
1/9/07	Quality Control		7.6	88.9	133.1	0.1	100.3	11.96	7.28									
1/9/07	Quality Control		7.6	88.8	133.1	0.1	96.6	11.54	7.31									
1/23/07	Routine		4.9	131.6	213.2	0.1	103.4	13.21	7.35	5.55			46					
1/23/07	Quality Control		4.9	131.3	212.9	0.1	103.3	13.22	7.35									
1/30/07	Routine	11.5	6.7	160.7	247.3	0.1	95.1	11.63	7.46	4.43		727	140		75			
1/30/07	Quality Control		6.7	160.8	247.3	0.1	95.0	11.61				318			30			
2/6/07	Routine		8.8	175.8	254.6	0.1	102.1	11.85	7.47	3.28		2419	41		153	<0.1	0.15	<0.25
2/6/07	Quality Control		8.8	175.8	254.6	0.1	102.9	11.98	7.51			>2419			133	<0.1	0.15	<0.25
3/6/07	Routine		12.4	137.4	181.0	0.1	92.6	9.87	6.83	20.814	240	3300	85		108	<0.1	0.32	<0.25
3/6/07	Quality Control											1000			121	<0.1	0.32	<0.25
4/3/07	Routine	12.5	11.1	179.3	244.3	0.1	97.8	10.75	7.34	4.735		459	23		10	<0.1	<0.1	<0.25
5/1/07	Routine	16	12.9	190.3	247.7	0.1	95.9	10.12		3.568		870			55	<0.1	.22	<0.25
6/5/07	Routine	17.5	16	215.1	259.5	0.1	80.4	7.93	7.88	1.713		160			93	<0.1	.10	0.27
6/5/07	Quality Control											590			74			
6/5/07	Routine											160			93			
7/10/07	Routine	16	15.9	230.2	277.9	0.1	83.8	8.26	7.21	0.628		560			200	<0.1	.05	0.31
7/10/07	Quality Control		16	230.3	277.9	0.1	84.6	8.34	7.23			560			200	<0.1	.05	0.31
8/1/07	Routine	18.5	16	221.9	268.0	0.1	71.2	7.02	7.00	0.330		680			31	<0.1	.07	<0.25
9/10/07	Routine	18.5	15.5	236.6	288.8	.1	60.1	5.97	6.87	0.253		550			20		<0.1	.29

PNG 3 – Pine Gulch Creek near Texeira Ranch

PNG 3 is the furthest upstream monitoring station on Pine Gulch Creek. The creek and monitoring station are adjacent to the Olema Valley trail and the PORE Philip Burton Wilderness Area. The flow at PNG 3 is perennial.

Figure A - 10. PNG 3 during “normal” flow conditions, April 2008.

Table A - 7. PNG 3 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/8/06	Routine	13.1		190.9	247.0	0.1	98.9	10.41	7.23	0.65	>2400			120		<0.1	0.29	1.7
11/8/06	Quality Control			190.4	246.5	0.1												
12/6/06	Routine	14	7.3	156.0	235.6	0.1	99.0	11.91	7.31	0.93	690		89			<0.1	0.36	0.8
1/3/07	Routine	13.8	9.4	109.7	155.9	0.1	97.5	11.16	7.04	2.83	770			35		<0.1	0.50	1.3
2/7/07	Routine		9.4	161.5	229.8	0.1	94.5	10.80	7.29	1.53	980	33.7		16	14.6	<0.1	0.29	<0.25
3/7/07	Routine		10.6	134.0	184.8	0.1	101.1	11.25	7.07	5.78	550	73		7	22.8	<0.1	0.36	<0.25
4/5/07	Routine	10.5	9.9	150.9	212.1	0.1	94.3	10.65	7.00	1.733	580	151.0		11	11.0	<0.1	.25	<0.25
4/5/07	Quality Control		9.9	150.9	212.0	0.1	94.3	10.67	7.01									
5/2/07	Routine	13.5	12	161.8	215.1	0.1	92.2	9.92	6.69	1.554		35			10	<0.1	.25	<0.25
6/6/07	Routine	16.1	11.8	200	200	0.1	89.6	9.71	6.87	0.959		180			18	<0.1	.21	<0.25
7/5/07	Routine	18.3	13.9	181.3	230.2	0.1	96.0	9.92	6.97	0.838		820			9	<0.1	.27	0.28
7/5/07	Quality Control											560			^10			
8/2/07	Routine	15	13.8	184.6	234.6	0.1	86.3	8.93	7.17	0.636		600			10	<0.1	.21	<0.25
9/10/07	Routine	19	15.1	199.1	245.3	.1	86.1	8.66	7.18	0.408		690			10	<0.1	.20	.27
9/10/07	Quality Control		15.1	199.5	245.2	.1	86.9	8.72	7.19			690			31			<0.25

PNG 2 – Pine Gulch Creek

This station is located on the mainstem of Pine Gulch Creek downstream of the small tributaries McCurdy Creek, Copper Mine Gulch, and Cronin Gulch.

Figure A - 11. PNG 2, May 2008.

Table A - 8. PNG 2 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/8/06	Routine	14.5	13.7	196.8	251.0	0.1	102.3	10.59	7.47	0.864	1400			37		<0.1	0.25	5.0
11/8/06	Quality Control		13.7	196.8	251.0	0.1	102.1	10.60										
12/6/06	Routine	8.3		158.3	232.6	0.1	95.1	11.18	7.43	1.08	980			51		<0.1	0.316	1.3
12/6/06	Quality Control		8.3	157.7	231.7	0.1	95.6	11.24	7.43		1200			55		<0.1	0.294	<0.25
1/3/07	Routine	10.5	9.5	102.3	145.2	0.1	89.3	10.17	6.99	5.38	820			48		<0.1	0.36	1.2
1/3/07	Quality Control		9.5	101.6	144.2	0.1	88.7	10.17	7.01									
2/7/07	Routine		9.7	154.0	217.6	0.1	91.9	10.44	7.31	2.84	2000	1986		60	76.7	<0.1	0.22	<0.25
2/7/07	Quality Control		9.7	154.0	217.6	0.1	91.8	10.43	7.32		2400			53		<0.1	0.22	<0.25
3/7/07	Routine		10.8	124.6	171.0	0.1	92.9	10.30	6.98	11.37	310	106		7	37.86	<0.1	0.25	<0.25
3/7/07	Quality Control		10.8	124.6	171.0	0.1	92.9	10.29	7.02									
4/5/07	Routine	12.5	10.4	148.3	205.6	0.1	92.2	10.33	6.87	2.927	610	167		7	11.0	<0.1	.19	<0.25
4/5/07	Quality Control										330	209		17	20.20	<0.1	.19	<0.25
5/2/07	Routine	14.5	12.8	160.8	209.8	0.1	98.1	10.35	6.30	2.856		1400			37	<0.1	.18	<0.25
5/2/07	Quality Control		12.8	160.9	209.7	0.1	97.7	10.34	6.25			1400			34	<0.1	.19	<0.25
6/6/07	Routine	15.7	12.4	200	200	0.1	88.1	9.39	6.83	1.522		920			330	<0.1	.15	<0.25
7/5/07	Routine	18.5	14.6	188.4	235.4	0.1	87.0	8.82	7.03	0.929		1600			350			<0.25
7/5/07	Quality Control											1400			390			
8/2/07	Routine	15	14.4	194.6	244.0	0.1	85.1	8.68	7.28	0.717		1100			97	<0.1	.17	<0.25
8/2/07	Quality Control		14.4	194.6	243.8	0.1	85.1	8.68	7.25			1200			110			<0.25
9/10/07	Routine	19	16	214.5	259.2	.1	89.1	8.75	7.19	0.396		1100			<1	<0.1	.16	<0.25

PNG 1 – Pine Gulch Creek near Bolinas Lagoon

This monitoring station is located approximately 300 meters upstream of Bolinas Lagoon and is adjacent to an organic farm. During the summer months, water is pumped from the creek, approximately 30 meters upstream of the monitoring station, for irrigation. The station has a stream gage that is maintained by NPS staff.

Figure A - 12. PNG 1 at “above normal” flow conditions, January 2008.

Figure A - 13. PNG 1, May 2008

Table A - 9. PNG 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/8/06	Routine	14.4		213.0	267.0	0.1	97.6	9.96	7.19	0.94	980			220		<0.1	0.18	<0.25
12/6/06	Routine	18	9.3	182.7	261.0	0.1	93.4	10.72	7.29	1.62	1200			55		<0.1	0.316	1.3
12/6/06	Quality Control		9.3	182.7	261.0	0.1	93.3	10.69										
1/3/07	Routine	12	9.5	111.3	157.8	0.1	92.9	10.60	7.12	7.92	770			27		<0.1	.45	0.8
1/3/07	Quality Control										650			30		<0.1	0.45	0.8
2/7/07	Routine		10	175.5	245.9	0.1	90.1	10.16	7.28	3.71	1300	1733		260	344.8	<0.1	0.21	<0.25
3/7/07	Routine	11.6		143.2	192.6	0.1	95.3	10.37	6.79	13.35	610	161		6	34.51	<0.1	0.27	<0.25
3/7/07	Quality Control										1000			5		<0.1	0.27	<0.25
4/5/07	Routine	14.5	11.6	170.5	229.1	0.1	92.3	10.01	7.03	3.824	610	613		29	63.14	<0.1	.17	<0.25
5/2/07	Routine	14.5	14.2	183.0	230.4	0.1	97.7	10.01	5.51	4.009		590			90	<0.1	.27	<0.25
6/6/07	Routine	16	13.5	200	200	0.1	99.9	10.43	6.83	1.406		720			50	<0.1	.12	<0.25
6/6/07	Quality Control											200			39	<0.1	.12	<0.25
7/5/07	Routine	16	15.6	206.6	251.9	0.1	85.9	8.54	7.12	0.8555		2000			46	<0.1	.14	0.73
7/5/07	Quality Control	16	15.6	206.6	251.7	0.1	85.7	8.53	7.13			2400			45	<0.1	.14	<0.25
7/5/07	Quality Control											1400			20			
8/2/07	Routine	16	15.1	199.9	246.7	0.1	85.8	8.62	7.02	0.823		2800			650	<0.1	.11	<0.25
9/10/07	Routine	18.5	16.1	223.1	268.6	.1	79.8	7.84	6.96	0.409		1700			97	<0.1	<0.1	<0.25

TV 1-Tennessee Valley Creek

TV 1 is a secondary monitoring station. The station is adjacent to a small residence and the Miwok horse stables. This portion of Tennessee Valley Creek is dry during the summer and fall months. Monitoring occurs at this station during the months when there is visible flow. Core parameters and a grab sample, which is analyzed for the bacteria parameters, are collected.

Figure A - 14. TV 1, January 2008.

Table A - 10. TV1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
2/22/07	Routine	10.3	10	85.3	119.6	0.1	93.2	10.50	5.72	0.75		2419.57		55.39			
3/22/07	Routine		9.8	89.4	125.8	0.1	92.0	10.42	6.12			1203.33		14.35			
4/11/07	Routine	12	11	84.5	115.1	0.1	89.9	9.90	6.56			1011.16		49.54			
5/16/07	Routine	13.5	10.9	107.2	146.5	0.1	88.6	9.81	6.63			>2419		5			

TV 2-Tennessee Valley Creek

This primary site is located on Tennessee Valley Creek below the Miwok horse stables and adjacent to the Tennessee Valley trail. This portion of the creek is dry throughout the summer months, typically July through November.

Figure A - 15. TV 2 under normal flow conditions.

Table A - 11. TV 2 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/20/06	Routine	15.5	14.4	382.6	479.9	0.2	26.9	2.76	5.11		>2400			7				0.8
12/28/06	Routine		9.6	98.5	139.0	0.1	85.6	10.87	6.48	0.49	2400			42			0.29	2.1
1/25/07	Routine	8.5		135.5	198.0	0.1	71.1	8.39	6.01		490			64			<0.1	<0.25
2/22/07	Routine	13.3	10.3	109.0	151.5	0.1	90.6	10.14	5.96	0.94	>2419	>2419		340	365.4	<0.1	0.17	0.77
3/22/07	Routine		11.5	118.8	160.1	0.1	78.6	8.54	5.77	0.114	>2419	1986.29		10	5.16			<0.25
4/11/07	Routine	13	11.8	175.6	234.6	0.1	78.0	8.41	6.46	0.135	>2419	>2419		920	980.39	<0.1	.15	<0.25
4/11/07	Quality Control	Field parameters dup at TV3									>2419			650		<0.1	.12	<0.25
5/16/07	Routine	13.5	12.8	162.7	212.0	0.1	53.3	5.64	6.15	0.025		53			16			<0.25
6/19/07	Routine	18	16.2	377.6	453.6	0.2	6.6	0.66	6.68			>24000			1800			6.0

TV 3-Tennessee Valley Creek

This primary monitoring station is located downstream of the confluence with the Backdoor tributary which is adjacent to a small horse stable. TV 3 is also adjacent to the Tennessee Valley trail.

Figure A - 16. Amelia Ryan (PORE) sampling at TV 3.

Table A - 12. TV 3 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/20/06	Routine	16	13	237.5	308.0	0.1	117.6	12.38	6.78	0.02	>2400			4			0.50	<0.25
11/20/06	Quality Control										>2400			7			0.50	<0.25
12/28/06	Routine		9.9	119.2	167.5	0.1	99.1	11.21	7.03	2.68	>2400			21			0.29	2.5
1/25/07	Routine		7.4	112.1	168.8	0.1	98.2	11.80	6.90	0.27	1200			10		<0.1	<0.1	<0.25
1/25/07	Quality Control		7.4	111.3	167.9	0.1	98.2	11.81	6.93		1100			12			<0.1	<0.25
2/22/07	Routine		10.6	118.5	163.9	0.1	101.4	11.30	6.28	3.47	>2419	>2419		520	290.93	<0.1	.15	0.70
2/22/07	Quality Control		10.5	118.3	163.4	0.1	101.3	11.29	6.28		>2419			410		<0.1	0.16	0.74
3/22/07	Routine		10.3	136.4	189.7	0.1	108.1	12.09	6.56	0.456	>2419	913.86		38	48.74			<0.25
3/22/07	Quality Control		10.3	136.8	190.2	0.1	108.1	12.09	6.61		>2419			39				<0.25
4/11/07	Routine	13.5	11.7	149.8	200.5	0.1	100.8	10.93	6.81	0.345	>2400	960.61		39	34.05	<0.1	<0.1	<0.25
4/11/07	Quality Control		11.7	149.9	200.8	0.1	100.8	10.93	6.79			752.3			51.6			
5/16/07	Routine	14.5	12.2	147.7	195.6	0.1	89.2	9.57	6.82	0.167		160			49			<0.25
5/16/07	Quality Control											140			66			<0.25
6/21/07	Routine	17.5	14.2	147.8	186.3	0.1	83.9	8.63	7.41	0.003348		270			10	<0.1	<0.1	<0.25
6/21/07	Quality Control															<0.1	<0.1	<0.25
7/11/07	Routine	16.5	14.4	147.3	184.7	0.1	82.9	8.47	6.69	0.0076		920			66	<0.1	<0.1	0.35
8/20/07	Routine	20	14.7	170.6	208.5	0.1	64.3	6.53				1000			330	<0.1	<0.1	<0.25
9/25/07	Routine	Field data lost										630			<1	<0.1	<0.1	<0.25

NYH 1 – Nyhan Creek at Rhubarb Trail bridge

This secondary monitoring station is located adjacent to Tennessee Valley Road approximately 100 meters downstream of the confluence with Oakwood Creek. All of Nyhan Creek downstream of the monitoring station is located on private lands.

Figure A - 17. NYH 1, facing downstream at sampling point.

Table 40. NYH 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/20/06	Routine	16	12.7	330.3	431.9	0.2	112.3	11.93	7.58		>2400			>2400		<0.1	<0.1	0.8
11/20/06	QC		12.7	331.0	432.1	0.2	112.4	11.94										
12/28/06	Routine		9.5	143.8	204.4	0.1	99.4	11.38	7.38	1.01								
1/25/07	Routine		6.7	253.1	389.5	0.2	95.2	11.65	7.86	0.02	520			290		<0.1	<0.1	<0.25
2/22/07	Routine		10.6	167.2	230.6	0.1	98.4	10.94	6.81	1.18								
3/22/07	Routine		10.7	266.3	366.2	0.2	93.7	10.37	7.36	0.140		>2419			>2419			
4/11/07	Routine	12	11.5	232.5	313.5	0.2	88.6	9.67	7.20	0.093		16000			3100			
5/16/07	Routine	18	13.6	340.4	434.5	0.2	93.7	9.71	7.14			870			180			
6/21/07	Routine	18.5	16.5	408.0	486.7	0.2	81.2	7.91	7.88			1000			170			
7/11/07	Routine	19	15.7	413.5	503	0.2	92.7	9.17	7.42			>2419			2400			
8/20/07	Routine	20.5	18.6	452.8	515	0.3	86.1	7.97	7.21			10000			160			

OAK 1 – Oakwood Creek

This secondary monitoring station is located approximately 75 meters upstream of the confluence with Nyhan Creek. Oakwood creek runs adjacent to the Oakwood Valley Trail then adjacent to Tennessee Valley Road for approximately 200 meters before it flows through a culvert under the road and joins Nyhan Creek. The creek is typically dry between September and November.

Figure A - 18. OAK 1 during “normal” flow conditions.

Table A - 13. OAK 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/20/06	Routine	15.5	13	315.3	409.0	0.2	88.6	9.31	6.48		>2400			650		<0.1	<0.1	0.8
12/28/06	Routine		9.3	140.6	200.6	0.1	96.1	11.00	6.92	0.73								
1/25/07	Routine	7.5		194.6	291.9	0.1	91.9	10.97	7.01		650			3		<0.1	<0.1	<0.25
2/22/07	Routine		10.2	140.3	195.7	0.1	93.7	10.54	6.43	1.05								
3/22/07	Routine		11.8	190.3	254.8	0.1	90.4	9.78	6.41	0.131		548			236			
4/11/07	Routine	11.5	11.3	204.9	277.8	0.1	83.4	9.14	6.53	0.083		204			41			
5/16/07	Routine	14.5	12.9	247.9	322.6	0.2	81.2	8.65	6.53	0.029		420			15			
6/21/07	Routine	20	14.2	327.9	413.6	0.2	18.0	1.85	6.39			200			1			
7/11/07	Routine	17.5	14.6	338.9	423.5	0.2	3.4	0.37	5.85			160			2			

RC 1 - Rodeo Creek

This primary monitoring station is located on Rodeo Creek approximately 420 meters upstream of the Gerbode Creek confluence and approximately 600 meters upstream of Rodeo Lake. Rodeo Creek runs adjacent to Bunker Road in the Marin Headlands of GOGA.

Figure A - 19. RC 1 staff plate.

Table A - 14. RC 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/20/06	Routine	16	11.7	187.3	251.1	0.1	89.9	9.76	6.88	0.15	1700			13				0.8
12/28/06	Routine	7.5	8.6	135.8	197.9	0.1	94.3	11.03	6.89	1.75	1700			28		<0.1	0.34	0.8
1/22/07	Routine	11.5	6.6	97.1	149.7	0.1	108.8	13.36	6.98	0.38	980			11		<0.1	0.13	<0.25
2/21/07	Routine		10.5	143.0	198.0	0.1	96.1	10.72	6.89	1.14	1400	1413.61		35	110.61	<0.1	<0.1	<0.25
2/21/07	Quality Control										2000			38		<0.1	0.06	<0.25
3/21/07	Routine		10.1	152.8	213.9	0.1	88.1	9.93	6.53	0.612	2400	219.82		37	40.77			<0.25
3/21/07	Quality Control										2400			38				<0.25
4/9/07	Routine	14.5	11.2	162.9	221.1	0.1	91.5	10.04	6.99	0.451	1400	169.13		19	24.91	<0.1	<0.1	<0.25
4/9/07	Quality Control										1300	169.40		33	10.00	<0.1	<0.1	<0.25
5/16/07	Routine	13	10.8	170.1	233.4	0.1	79.7	8.86	6.55	0.133		400			70			<0.25
6/21/07	Routine	16	12.1	176.0	233.3	0.1	66.3	7.12	7.46	0.007		290			19			<0.25
7/11/07	Routine	16	13.4	180.6	231.9	0.1	62.7	6.55	6.46	0.0295		170			43			0.28
8/20/07	Routine	16	13.7	190.9	243.6	0.1	53.5	5.53	6.35			1600			1100	<0.1	<0.1	<0.25
8/20/07	Quality Control		13.6	190.9	243.9	0.1	53.6	5.57	6.38			840			650	<0.1	<0.1	<0.25
9/25/07	Quality Control											140			31	<0.1	<0.1	<0.25
9/25/07	Routine	Field data lost										280			120	<0.1	<0.1	<0.25

GERB 1 - Gerbode Creek

This primary monitoring station is located on Gerbode Creek adjacent to the Rodeo Valley Trail approximately 300 meters upstream of the confluence with Rodeo Creek. Gerbode Creek has dense vegetation along its banks and across it. Immediately downstream of the sampling point, the creek flows through a culvert under the trail road. During the summer months, an orange substrate is commonly seen on the creek bottom (Figure 20).

Figure A - 20. GERB 1, April 2008.

Table A - 15. GERB 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/20/06	Routine	16	11.6	155.4	208.3	0.1	103.8	11.30	6.69	0.16	1700			7				<0.25
12/28/06	Quality Control		8.5	104.3	152.2	0.1	93.2	10.90	6.79		>2400			54		<0.1	0.52	0.8
12/28/06	Routine	8.5		104.8	152.9	0.1	93.6	10.93	6.78	2.27	2400			50		<0.1	0.27	0.4
1/22/07	Routine	16	6.1	74.7	117.3	0.1	111.0	13.81	6.75	0.40	550			20		<0.1	<0.1	<0.25
1/22/07	Quality Control		6	74.6	116.9	0.1	111.3	13.86	6.79									
2/21/07	Routine		10.8	114.1	156.8	0.1	94.9	10.52	6.38	1.83	1700	510		28	41.95	<0.1	<0.1	<0.25
2/21/07	Quality Control		10.7	114.1	156.9	0.1	94.9	10.53	6.38									
3/21/07	Routine		10.1	118.8	166.1	0.1	97.0	10.92	6.27	0.527	2400	201		19	17.31	<0.1	<0.1	<0.25
3/21/07	Quality Control		10.1	118.8	166.0	0.1	96.7	10.88	6.37									
4/9/07	Routine	13	11.5	128.0	172.30	0.1	91.8	9.97	6.48	0.404	1300	312.3		64	81.62	<0.1	<0.1	<0.25
4/9/07	Quality Control		11.5	127.9	172.3	0.1	91.2	9.95	6.46			268.6			74.50	<0.1	<0.1	<0.25
5/16/07	Routine	12	11	122.3	166.8	0.1	82.2	9.07	6.48	0.323		420			55	<0.1	<0.1	<0.25
6/21/07	Routine	13	12.4	123.1	162.2	0.1	83.8	8.97		0.194		>2400			2400	<0.1	<0.1	<0.25
7/11/07	Routine	16	13.5	124.2	159.1	0.1	82.8	8.62		0.0757		85			20	<0.1	<0.1	0.38
7/11/07	Quality Control		13.5	124.1	158.9	0.1	83.0	8.64	6.60			220			120	<0.1	<0.1	0.30
8/20/07	Routine	16.5	13.9	136.5	173.0	0.1	75.0	7.82	6.57			710			10	<0.1	<0.1	<0.25
9/25/07	Routine		Field sheet missing									310			<1	<0.1	<0.1	<0.25

FRA 1 – Franklin Creek

This primary monitoring station is located within John Muir National Historic Site immediately before Franklin Creek flows outside the JOMU property. The portion of Franklin Creek within the Monument is approximately 150 meters long. Franklin Creek flows into Alhambra Creek approximately 200 meters outside of the Monument.

Figure A - 21. FRA 1, April 2008.

Table A - 16. FRA 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	TotalColiform Idexx Quantitray (MPN/100mL)	FecalColiform (MPN/100mL)	Ecoli QuantiTray (MPN/100mL)	Ecoli Idexx Quantitray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
11/30/06	Routine	12	7.3	804	1213	0.6	109.0	13.01	8.20	0.37	2000		99				1.15	<0.3
11/30/06	Quality Control		7.3	801	1209	0.6	111.8	13.42	8.21		2000		120				1.17	0.4
12/27/06	Routine	9.6	10.4	543	753	0.4	97.1	10.81	7.89	0.70	>2400			2400		<0.1	1.02	1.7
12/27/06	Quality Control		10.4	546	759	0.4	96.6	10.81	7.90		>2400			1600		<0.1	1.04	2.1
1/31/07	Routine		9.8	867	1220	0.6	112.5	12.87	8.14		340	313		70	77	<0.1	0.90	<0.3
1/31/07	Quality Control		9.4	858	1221	0.6	112.3	12.81	8.14		580		93			<0.1	0.95	<0.3
2/28/07	Routine		9.5	692	983	0.5	93.6	10.68	7.95	0.67	>2400	>2419		460	387	<0.1	1.04	<0.25
2/28/07	Quality Control		9.4	708	1008	0.5	93.4	10.66	7.96		>2400			580		<0.1	1.04	<0.3
3/28/07	Routine	12.5	10.6	877	1208	0.6	86.8	10.17	8.02	0.218	>2400	>2419		100	178	<0.1	.91	<0.25
3/28/07	Quality Control		10.6	879	1210	0.6	92.7	10.2	8.02		1600	731		150	202	<0.1	.91	<0.25
4/25/07	Routine	13.5	12.6	984	1289	0.6	85.5	9.10	7.77			1120		62	49	<0.1	.84	<0.25
4/25/07	Quality Control		12.5	978	1286	0.6	85.0	9.11	7.77			870.9		30	31	<0.1	.84	<0.25
5/23/07	Routine	23.5	13.6	1113	1423	0.7	64.5	6.40	7.78			2400			300	<0.1	1.95	<0.25
5/23/07	Quality Control		13.7	1117	1424	0.7	64.6	6.41	7.77			2400			350	<0.1	1.9	<0.25
6/25/07	Routine	18.5	14.9	1158	1435	0.7	44.6	4.67	8.01	0		13000			220	<0.1	1.8	<0.25
6/25/07	Quality Control		14.8	1177	1464	0.7	47.7	4.83				>24000			210	<0.1	1.8	<0.25
6/25/07	Quality Control		15.5	1188	1450	0.7	42.5					>2419			150			
6/25/07	Quality Control		15.3	1186	1456	0.7	44.6	4.51										
6/25/07	Quality Control		14.9	1178	1461	0.7	47.1	4.84	8.01									
6/25/07	Quality Control		15	1181	1460	0.7	48.0	4.96	8.02									
6/25/07	Quality Control		15	1179	1457	0.7	46.2	4.65	8.03									
6/25/07	Quality Control		15.2	1183	1461	0.7	45.0	4.56	8.01									
7/25/07	Routine	22.5	17.8	1297	1495	0.8	87.9	8.29	7.96	0		12000			1100	<0.1	1.30	<0.25
7/25/07	Quality Control		18	1296	1495	0.8	88.5	8.35	7.96			9800			1500	<0.1	1.3	<0.25
8/29/07	Routine	25.5	17.1	1311	1544	.8	72	6.91								<0.1	1.84	<0.25
8/29/07	Quality Control		17.1	1312	1544	.8										<0.1	1.84	<0.25

CHA 3 – Chalone Creek Mainstem

This secondary site is the northernmost SFAN monitoring station in Pinnacles National Monument.

No photo available.

Table A - 17. CHA 3 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
1/24/2007	Routine	22	6	270.9	327.4	.2	78.4	9.69	6.97						
2/21/2007	Routine	14	9.8	284.9	316.1	.2	89	10.1	6.59		2000	<1	<0.1	<0.1	<0.25
3/26/2007	Routine	23	13.4	7.2	74.6	.1	52.4	5.5	6.67		1732.9	7.5	<0.1	<0.1	.37
4/30/2007	Routine	29	16.5	351.8	343.7	.2	52.2	5.08	6.11		920	28	<0.1	<0.1	.74

CHA 2 – Chalone Creek at Bear Gulch Bridge

CHA 2 is a primary monitoring station located on Chalone Creek upstream of the confluence with Bear Gulch. This site was frequently dry during the 2007 water year so the sampling location was moved upstream that has flow during a greater portion of the year. The station has remained upstream of Bear Gulch.

Figure A - 22. CHA 2.

Table A - 18. CHA 2 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
6/25/2007	Routine	27	16.5	485.2	472.0	.3	66.3	6.47	6.72		1700	20	<0.1	<0.1	<0.25
7/26/2007	Routine	19	16.4	491.6	478.2	.3	62.3	6.09	6.92		2000	26	<0.1	<0.1	<0.25
8/23/2007	Routine	24	17.1	500	481	.3	55	5.45	6.99		>2419	110	<0.1	<0.1	.37

CHA 1 - Chalone Creek at Pinnacles boundary

This primary monitoring station is located downstream of the Bear Gulch and Sandy Creek confluences with Chalone Creek.

Figure A - 23. CHA 1 at high flow conditions.

Table A - 19. CHA 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
1/24/2007	Routine	27.5	12.9	432.2	449.8	.3	43.2	4.61	6.9						
2/21/2007	Routine	17.5	15.2	474.3	472.6	.3	34.6	3.47	6.53	.039	180	4	<0.1	<0.1	<0.25
2/21/2007	QC	17.5	15.4	447.5	443.3	.3	33.1	3.33	6.50		140	1	<0.1	<0.1	<0.25
3/26/2007	Routine	25.5	16.7	576	500	.2	49.8	4.84	6.67	.317	>2419	14.6	<0.1	<0.1	.33
3/26/2007	QC	25.5	16.7	516	500	.2	99.6	4.81	6.62	.374	>2419	16.9	<0.1	<0.1	.40
4/30/2007	Routine	26	17.6	593	565	.3	39.8	3.8	6.4	.156	390	200	<0.1	<0.1	.38
5/21/2007	Routine	26	19.2	634	586	.3	44.9	4.14	6.50	.028	160	58	<0.1	<0.1	.27
6/25/2007	Routine	30.5	22.1	690	606	.4	37.4	3.32	6.42	.011	390	6.3	<0.1	<0.1	.35
7/26/2007	Routine	35	23.4	712	616	.4	42.6	3.59	6.48		1800	610	<0.1	<0.1	.36
7/26/2007	QC	21	16.5	491	477.4	.3	61.7	6.02	6.98		1700	16	<0.1	<0.1	<0.25

BG 2 – Bear Gulch

This primary monitoring station is located on Bear Gulch behind the Pinnacles Bear Gulch Visitor Center.

Figure A - 24. BG 2.

Table A - 20. BG 2 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
1/24/2007	Routine	19	7	213.5	251.6	.2	80.8	9.77							
2/21/2007	Routine	5	8.6	135.6	155.1	.1	89.9	10.56	6.68	.143	270	<1	<0.1	<0.1	<0.25
3/26/2007	Routine	14	12.2	221.1	233.4	.1	92.2	9.98	6.85		980.4	6.3	<0.1	<0.1	.35
4/30/2007	Routine	16	12.2	243.9	257.7	.2	70.1	7.52	6.37	.01	1700	13	<0.1	<0.1	.42
5/21/2007	Routine	15.5	14.1	275.1	279.9	.2	29.9	3.08	6.45	.01	>2419	68	<0.1	<0.1	.3
6/25/2007	Routine	25	14.7	301.4	303.8	.2	35.8	3.63	6.48		2400	110	<0.1	<0.1	<0.25
6/25/2007	QC	25.5	14.6	301.8	303.8	.2	34.7	3.50	6.50		1400	88	<0.1	<0.1	.25
7/26/2007	Routine	17	16.2	313.8	308.4	.2	32.4	3.2	6.54		>2419	25	<0.1	<0.1	<0.25
8/23/2007	Routine	21	16.6	326.7	317.2	.2	32.2	3.14	6.92		>2419	16	<0.1	<0.1	.27

SC 3 - Sandy Creek

This secondary monitoring station is the furthest upstream station on Sandy Creek. Sandy Creek is in an area of Pinnacles National Monument that was acquired in 2006 and is not enclosed in the pig exclusion fence. The station is located next to the Pinnacles campground dumpstation.

No photo available.

Table A - 21. SC 3 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
1/24/2007	Routine	14	8.8	611	693	.4	119.7	13.85	8.06	.230					
2/21/2007	Routine	13	10.9	607	659	.4	113.9	12.54	7.82	.166	580	52	<0.1	<0.1	<0.25
3/26/2007	Routine	19.5	15.4	753	747	.5	116.5	11.64	7.97	.122	488.4	8.6	<0.1	<0.1	.4
4/30/2007	Routine	24	15.6	749	741	.5	84.9	8.43	7.77	.251	1600	580	<0.1	.1	.47
5/21/2007	Routine	21.5	16.6	749	727	.4	85.1	8.36	7.88	.094	1200	66	<0.1	.1	.31
5/21/2007	Quality Control	21.5	16.6	748	725	.4	85.9	8.34	7.88	.094	920	86	<0.1	.1	.3
6/25/2007	Routine	26.5	19.1	752	698	.4	82.6	7.62	7.75	.021	2400	490	<0.1	.14	.33
7/26/2007	Routine	23	19.7	743	683	.4	92.9	8.47	7.86	.059	1700	120	<0.1	.12	.37
8/23/2007	Routine	25.5	20.2	7380	6710	.4	84	7.57	7.97	.033	>2419	220	<0.1	.12	.41

SC 2 – Sandy Creek

This secondary monitoring station is located on a flood channel of Sandy Creek. The Pinnacles campground stretches from the upstream monitoring site, SC 3 to this site. There is also a residential inholding located near this monitoring station. This station would only be connected to the other Sandy Creek or McCabe Canyon monitoring sites under extremely high flow conditions.

No photo available.

Table A - 22. SC 2 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
1/24/2007	Routine	22	4.7	610	756	.5	59.7	7.85	7.15						
3/26/2007	Routine	21	14.4	790	799	.5	43.4	4.54	6.97		1299.7	547.5	<0.1	<0.1	.56
4/30/2007	Routine	28.5	15.5	821	827	.5	23.5	2.3	6.72		2800	1100	<0.1	<0.1	.62
5/21/2007	Routine	25.5	17.7	900	900	.5	28.9	2.73	6.91		770	53	<0.1	<0.1	.65
6/25/2007	Routine	31	26.8	953	778	.6	42.9	3.5	7		5400	75	.57	<0.1	1.1

SC 1 – Sandy Creek

This primary monitoring station is the furthest downstream station on Sandy Creek before the confluence with Chalone Creek.

No photo available.

Table A - 23. SC 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (°C)	H2O Temp (°C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
1/24/2007	Routine	27	8.9	640	725	.5	130.1	15	8.28	.299					
2/21/2007	Routine	16	12.7	684	715	.4	96.9	10.23	8.06	.339	1600	56	<0.1	<0.1	.38
3/26/2007	Routine	36.5	18.6	769	720	.4	103.8	9.68	8.09	.280	>2419	88.8	<0.1	<0.1	.71
4/30/2007	Routine	31.5	19.2	778	721	.4	92.6	8.53	7.94	.137	3200	130	<0.1	<0.1	.63
4/30/2007	Quality Control	31	19.3	778	719	.4	94.0	8.65	7.94	.137	>2419	100	<0.1	<0.1	.53
5/21/2007	Routine	30	22	832	734	.4	89.8	7.84	7.90	.039	6400	72	<0.1	<0.1	.48
6/25/2007	Routine	32.5	27.1	948	770	.4	80.6	6.40	7.77		23000	980	<0.1	<0.1	1.1

MC 1 – McCabe Canyon

This primary monitoring site is located in McCabe Canyon a few meters upstream of the confluence with Sandy Creek. There is a residence next to this monitoring site.

No photo available.

Table A - 24. MC 1 results, WY 2007.

Visit Date	Activity Type	Air Temp (ºC)	H2O Temp (ºC)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppth)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	Discharge (cfs)	Total Coliform QuantiTray (MPN/100mL)	E. coli QuantiTray (MPN/100mL)	Ammonia as N (mg/L)	Nitrate as N (mg/L)	TKN (mg/L)
1/24/2007	Routine	19	7	213.5	251.6	.2	80.8	9.77							
2/21/2007	Routine	5	8.6	135.6	155.1	.1	89.9	10.56	6.68	.143	270	<1	<0.1	<0.1	<0.25
3/26/2007	Routine	14	12.2	221.1	233.4	.1	92.2	9.98	6.85		980.4	6.3	<0.1	<0.1	.35
4/30/2007	Routine	16	12.2	243.9	257.7	.2	70.1	7.52	6.37	.01	1700	13	<0.1	<0.1	.42
5/21/2007	Routine	15.5	14.1	275.1	279.9	.2	29.9	3.08	6.45	.01	>2419	68	<0.1	<0.1	.3
6/25/2007	Routine	25	14.7	301.4	303.8	.2	35.8	3.63	6.48		2400	110	<0.1	<0.1	<0.25
6/25/2007	QC	25.5	14.6	301.8	303.8	.2	34.7	3.50	6.50		1400	88	<0.1	<0.1	.25
7/26/2007	Routine	17	16.2	313.8	308.4	.2	32.4	3.2	6.54		>2419	25	<0.1	<0.1	<0.25

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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