



MICROBIOLOGICAL WATER QUALITY INVESTIGATION OF LAS PALMAS CREEK, SANTA BARBARA, CA

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ON THE WEB AT [HTTP://FIESTA.BREN.UCSB.EDU/~HOPE](http://fiesta.bren.ucsb.edu/~hope)

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Background

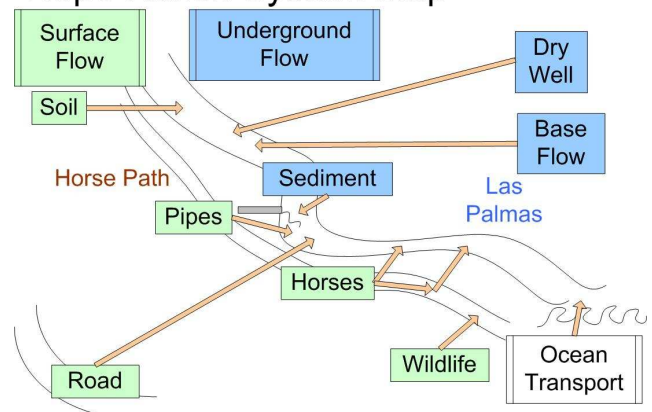
Recreational water quality is one of the pressing environmental issues in southern California, where beach closures, threats to marine life, and occurrence of gastrointestinal illness are all attributed to high fecal indicator bacteria (FIB) levels. Although these indicator organisms are a fast, easy, and cost-effective method for quantifying contamination in aquatic environments, concentrations of FIB can be highly variable in the ocean and are affected by a variety of sources upstream in the watershed. For this reason, water quality specialists across the nation are turning to microbial source tracking (MST) techniques to further explore the sources, in addition to the concentrations, of pollution at a given site.



Hope Ranch Beach in Santa Barbara resembles other southern California beaches in that it occasionally exhibits high levels of FIB, especially during storm events, when they may increase by three orders of magnitude. Some of this pollution may be attributable to Las Palmas Creek, which drains into Hope Ranch Beach. In the area, suspected potential sources of contamination include septic tank leachate and horse manure, as the site is characterized by the presence of both on-site wastewater treatment systems on individual properties, as well as horse trails along the creek.

A handful of concerned residents known as the Hope Ranch Beach Committee initiated this investigation to address such local watershed concerns with solid scientific data and seek the subsequent management recommendations. The result was a year-long assessment of FIB levels and source-tracking studies to differentiate between human and animal sources of contamination in Las Palmas Creek. The project also examined data for the resulting health risk to swimmers.

Hope Ranch System Map



A summary of potential inputs into Las Palmas Creek and Hope Ranch Beach

Project Questions

This study was designed to collect data in response to the following questions:

- First, what are the risks to human health, especially that of the patrons of Hope Ranch Beach, that result from the water quality indicators (including the level of FIB and presence or absence of *Cryptosporidium parvum*) along Las Palmas Creek?
- Second, how might the Beach Committee best manage the creek to mitigate this risk, based on the probable sources of contamination as identified through this project?



Methods

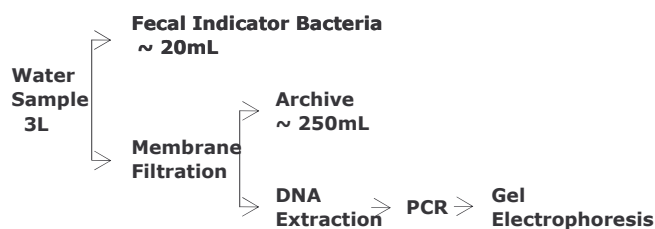
The project involved extensive literature review at its initiation. Protocols were adopted for polymerase chain reaction (PCR) assays that would exhibit the presence or absence of one of four organisms used to characterize the sources of FIB contamination at Las Palmas. In addition, a creek walk was conducted in spring 2005 to develop an understanding of the land uses, geology, and social environment of the project site. At this time, six sample sites were chosen, from the ocean-creek mixing zone (site 1) to the headwaters (site 6), based on a previous study on FIB levels performed by Dr. Hugo Loaiciga in 1999.¹



Parcel Map of Hope Ranch and Sites Sampled Along Las Palmas Creek

Water samples were collected weekly at six sites during the summer of 2005, followed by sporadic "flush" samples taken during rain events in winter 2005-2006. Soil and sediment were collected on a monthly basis during the sampling periods. Using IDEXX Colilert and Enterolert assays, FIB was quantified for all water and soil samples. PCR analysis was focused on identifying *Bacteroides prevotella* varieties and *Rhodococcus coprophilus* indicators for human, herbivore, and horse fecal waste, as well as identifying the potential pathogen

Cryptosporidium parvum. Summer mean FIB levels were compared to the benchmark concentrations adapted directly from California State Law AB 411 standards for ocean water quality, and analyzed for statistically significant exceedences. At the request of the client, they were also statistically compared to other coastal urban and suburban creeks in the County. In order to locate probable inputs and potential reservoirs for fecal waste contamination, statistical analyses were also performed to identify significant relationships between soil texture and FIB concentrations.



Lab Methods: Water Sample Allocation

DNA was extracted from water samples and other media, such as soil, over the nine months. PCR protocols were adopted and employed to test for DNA segments specific to Human-linked *B. prevotella* and herbivore-linked *R. coprophilus*. Water samples that generated a presence result on the subsequent gel electrophoresis were then tested for the presence of the Horse-linked strain of *Bacteroides*, to further specify the probable inputs into the creek. The zoonotic pathogen, *Cryptosporidium parvum*, was tested for at the creek mouth (site 2) to assess the nature of health risk in recreating in or around Las Palmas Creek. This risk was further explored by epidemiological research and assessment using raw data collected in the duration of this project.

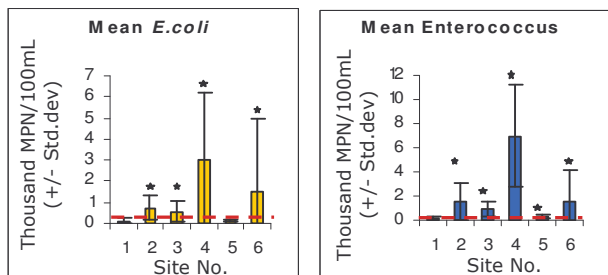
Soil samples were studied for their composition characteristics and organic matter content, as well as FIB concentrations. Extracted DNA was tested for the presence or absence of Human-linked *Bacteroides* and *Rhodococcus*.

¹ Loaiciga, H. and S. Renehan (1999). Report of Bacterial Sampling, Phase 1, Las Palmas Creek, Hope Ranch, California.



Results & Discussion

The FIB data for the summer water samples were analyzed for statistically significant exceedences above the AB 411 standard, while PCR-based assays were used to generate presence-absence results for those organisms.

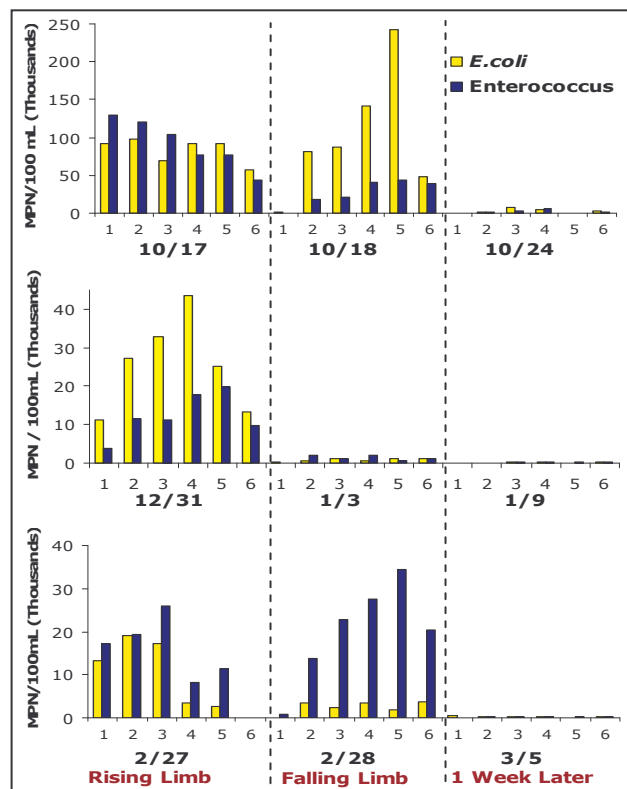


Mean summer FIB concentrations with standard deviation bars. Dashed red lines signify the AB 411 standard, while stars indicate significant difference from the AB 411 by a Wilcoxon Signed-Rank Test.

During the summer, Las Palmas Creek exhibits FIB levels that are statistically above the AB 411 standard, especially at site 4, while the surf zone was statistically in compliance with the standard. When compared to other Santa Barbara County beaches, Hope Ranch has statistically lower FIB levels than city beaches. However, the FIB concentrations measured in the creek during the 1999-2000 wet season were not statistically different from those in urban creeks. The human health implications, based on relative and probabilistic risks calculated from previous epidemiological studies, suggest that even relatively “clean” beaches pose some quantifiable risk of gastrointestinal illness at any time of year, with creek water posing up to 25 times the risk of immersion in pristine water to swimmers during the early season rains.

Each subsequent flush appears to have a cleansing effect on water quality; *E. coli* and Enterococcus levels continued to drop below the summer mean at all sites one week after both the 2nd and 3rd flushes. Multiple regressions of soil type with FIB concentrations also revealed an association between the high contaminant levels observed at site 4 and its clay content. This suggests that some FIB

observed in the water nearby may actually be attributable to release from the stream banks and not directly from horse fecal material inputs above.



1st, 2nd, and 3rd Flush FIB Concentrations by Date

However, the results of DNA-based analyses do not eliminate horse waste from consideration, since the herbivore marker *Rhodococcus* was prevalent in both summer and winter samples. The Horse-linked *Bacteroides* was not found. A nonspecific *Cryptosporidium* species of uncertain pathogenicity was identified at the creek mouth on Oct. 17. Finally, given the absence results for Human-linked *Bacteroides* in this study, human septage cannot be isolated as a source of fecal contamination, although it cannot be eliminated at this point, either.

Organism of Interest	Positive
<i>Bacteroides prevotella</i> (Human)	0
<i>Rhodococcus coprophilus</i>	32 (H ₂ O), 7 (S/S)
<i>Bacteroides prevotella</i> (Horse)	0
<i>Cryptosporidium parvum</i>	0
<i>Cryptosporidium</i> sp.	1

Total Count of Positive Signals



Conclusions & Recommendations

A baseline set of water quality data was successfully produced to characterize Las Palmas creek in the dry and wet seasons. In the summer, FIB levels exceeded the standard for ocean water most often at sample site 4 in the creek, potentially due to the high percentage of clays in the soil which may act as a reservoir for bacteria. At the same time, FIB occasionally exceeded the standard at the mixing zone in the ocean, which has direct human health implications. During the winter, samples taken during the rising limb of the hydrograph reflect the highest levels of FIB, with a gradual return to levels at or below the summer mean across the duration of each storm, as well as across the duration of the rainy season. In addition to indicators, the presence of *Rhodococcus* provides some evidence for contamination of recreational waters at Hope Ranch that may encourage management upon further specifying the sources of pathogens and contaminants.



The following are recommendations to the Hope Ranch Beach Committee regarding the management of Las Palmas Creek:

- *Restrict recreation in water while promoting stewardship:* Posting signs throughout the creek, at locations where children especially are suspected to bathe, and at its mouth at Hope Ranch Beach, will draw attention to human health risks and inspire interest and eventually action in local water quality issues.

- *Educate local residents through public/private programs:* As newsletters, neighborhood meetings, and a local private school are integral parts of life at Hope Ranch, education will be an enduring tool for reducing illness and the quantity of illness-causing microorganisms in the creek and at the surf zone. This includes the adaptation of local government watershed quality programs to residents of all ages.
- *Assess origins and nature of pipe discharge:* Most sampling sites are near pipe outfalls that carry runoff from the parcels above into the confluence at Las Palmas Creek. With additional information on the activities on home sites and/or stables, FIB assays at these points will guide the actions taken to address inputs of fecal material from individual properties as well as common horse trails.
- *Monitor the use of trails:* Concerns about nonresident trail use and its contribution to fecal contamination in Las Palmas Creek necessitate a monitoring program to assess the degree to which outside horses are responsible and to assist in developing an effective trail sweeping program.
- *Adopt County ordinance on waste pick-up:* Section 17-10 of the County Solid Waste Services Code requires horseback riders and dog owners alike to pick up after their pets. The Homeowners Association has a set of bylaws that should apply a similar regulation to all Hope Ranch residents.
- *Increase frequency and thoroughness of trail maintenance and cleanings:* Given observations on trail use and the signs of fecal contamination from horses or other herbivores, direct prevention of bacterial and pathogenic contamination of the creek and ocean will require regular removal of waste left on the trail by riders.

The Bren School thanks the Hope Ranch Beach Committee for their sponsorship of this project.