Russian River Pathogen Monitoring Pilot Project

Report Summary

The North Coast Regional Water Quality Control Board (Regional Water Board) is in the process of studying pathogen contamination in the Russian River watershed as part of an effort to protect human health and water quality, as required by the federal Clean Water Act.

A comprehensive monitoring program, scheduled to begin in Spring 2011, is needed to identify sources of pollution and inform recommendations for corrective measures.

As part of the planning process, the Regional Water Board commissioned a pilot study of pathogen contamination in the watershed. Over six months from December 2008 through May 2009, the Aquatic Ecosystems Analysis Laboratory at the University of California, Davis conducted the study, which is summarized in this fact sheet.

The full "Russian River Pathogen TMDL Monitoring Pilot Project: A Summary Report to the North Coast Regional Water Quality Control Board" report is available on the Regional Water Board's webpage at http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/russian_river/.

Key Findings from the Report

- Future pathogen monitoring should include greater sampling frequency, more monitoring locations, and a greater number of samples collected from each site
- *Bacteroides* and stable isotope analysis are recommended for monitoring human-source fecal contamination, in addition to indicator bacteria
- Indicator bacteria species were present in amounts exceeding water quality standards throughout the study area
- Bacteria levels were lower at semi-rural, relatively less developed sites than in urban locations
- Bacteria concentrations were correlated with rainfall: when rainfall increased, pollution increased
- When river flows were low, human-source bacteria were present in significant concentrations in both agricultural and urban areas

Background: Russian River Pathogen Impairments

Levels of pathogenic indicator bacteria in several segments of the Russian River and its tributaries are high enough that these reaches are listed as "impaired" under Section 303(d) of the federal Clean Water Act. Impairment means that these waters are at times unsafe for swimming, wading, and other forms of water contact recreation. The federal Clean Water Act requires the Regional Water Board to identify sources of the contamination and adopt a cleanup plan that, when implemented, will make these waters safe for people to use for recreation.

Previous studies have identified bacteria contamination in the following river and stream reaches:

- Russian River from Fife Creek in Guerneville to Dutch Bill Creek in Monte Rio
- Russian River around Healdsburg Memorial Beach, from the railroad bridge to the Highway 101 bridge
- An unnamed creek near Fitch Mountain in Healdsburg
- Green Valley Creek and its tributaries
- The Laguna de Santa Rosa and its tributaries, including Santa Rosa Creek and its tributaries

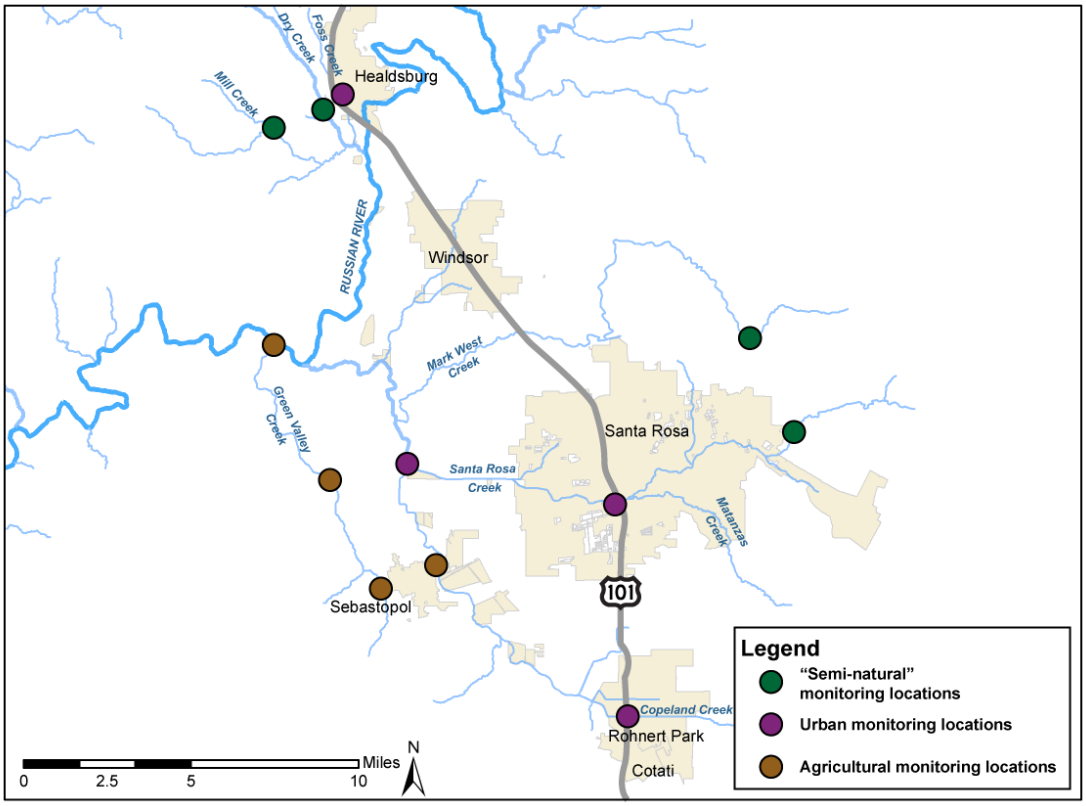
The Pilot Study

The Regional Water Board asked UC Davis researchers to do the following:

- Evaluate emerging techniques *(Bacteroides* and stable isotope analyses) for identifying and quantifying pathogen indicator bacteria
- Document trends in observed pathogen indicator bacteria levels, especially during winter storms
- Provide recommendations to improve detection, quantification, and monitoring methods for pathogens in impaired waterbodies

Study Locations and Methodology

The pilot study area was the lower Russian River watershed, including portions of the cities of Santa Rosa and Healdsburg. Researchers measured bacteria levels in a variety of stream types and sizes. Eight monitoring sites were located in streams that best represented watersheds with agricultural and urban land uses. Four additional "control" locations were monitored to best represent more rural, less developed ("semi-natural") land uses.



Because the types of pathogenic microorganisms that are most harmful to human health are difficult and costly to measure, this study, like others of its type, analyzed water samples for two types of fecal bacteria, *E. coli* and *Enterococcus.* Detection of these "indicator bacteria" tells us that fecal material from warm-blooded animals, such as humans, is present in the water.

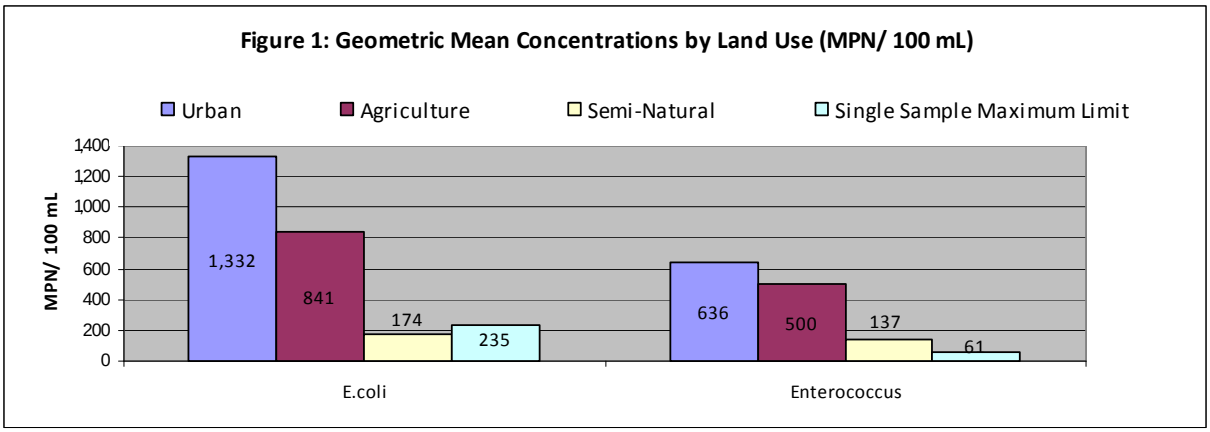
In addition, the study used two newer techniques: measurement of *Bacteroides* and stable isotope analysis. *Bacteroides* is a genus of bacteria that can be used to identify specific host animals, including human and bovine (cattle) hosts. Stable isotope analysis uses isotopes of oxygen and nitrogen in a water sample to trace the source of the contamination.

Pilot study researchers also conducted a land use analysis to investigate possible correlations between land use types (urban, agriculture, and rural/semi-natural) and measured *E. coli* and *Enterococcus* concentrations in surface water.

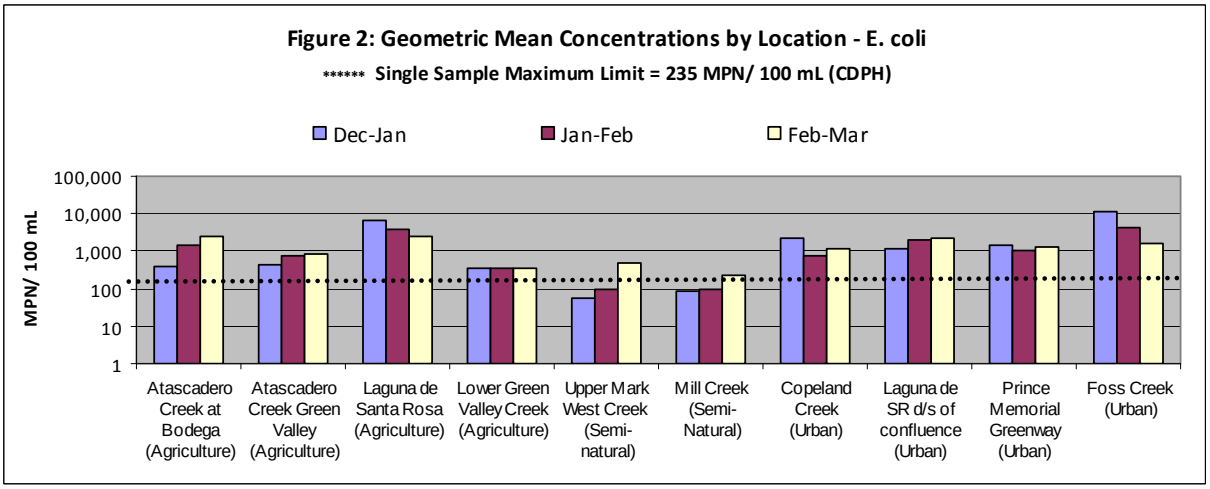
Study Results for *E. coli* and *Enterococcus*

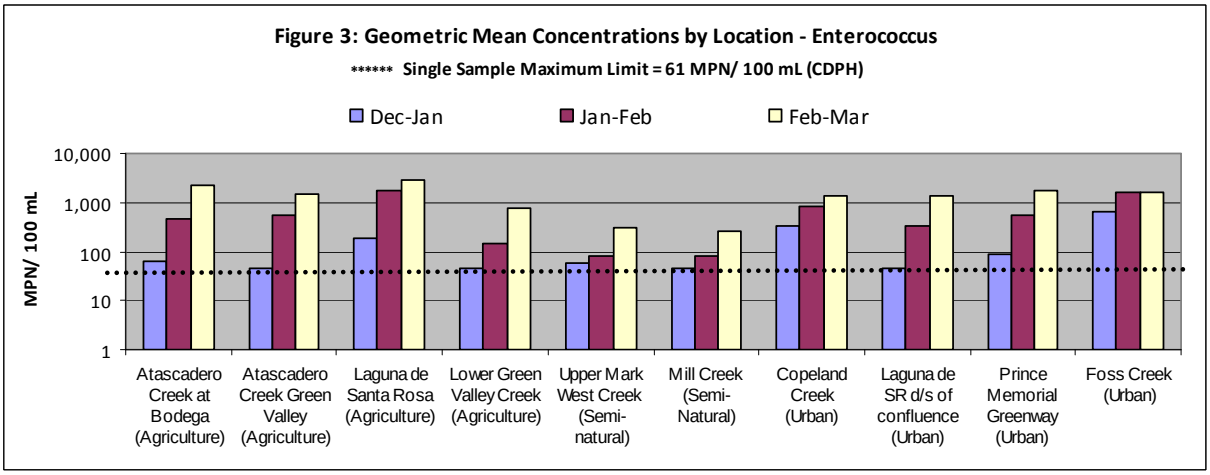
Spatial distribution and correlation with land uses

When compared with the rural/less developed ("semi-natural") sites, concentrations of *E. coli* and *Enterococcus* at the urban and agricultural sites were consistently higher (Figure 1); however, even the less populated sites frequently exceeded the bacteria levels recommended by the U.S. Environmental Protection Agency for recreational beaches.



The sample sites with the highest consistent *E. coli* and *Enterococcus* concentrations were in the Laguna de Santa Rosa and in Foss Creek (see map). Figures 2 and 3 summarize these findings. In these locations, samples revealed between ten and forty times recreational beach standards for *E. coli* and *Enterococcus.*





Concentrations during storm events

The pilot study evaluated trends in *E. coli* and *Enterococcus* concentrations in pre-storm conditions, during storm pulses, and during after-storm "recession" flows as water levels decreased. Results showed that *E. coli* and *Enterococcus* concentrations in surface water samples were significantly correlated to precipitation. For *Enterococcus*, the study showed that even minor rainstorms would mobilize the bacteria in the water, and loads would increase with the amount of precipitation. The correlation was less consistent for *E. coli*, where only three of seven sites showed a relationship between *E. coli* concentrations and precipitation. Concentrations of *Enterococcus* were greater during storm pulses than in the pre-storm and recession flow phases. For *E. coli*, concentrations were higher during pre-storm and storm pulse phases than during the recession flow phase. In some cases, lower *E.coli* concentrations in the recession flow phase may have been the result of dilution from large storm pulses, overland storm flows, and releases of water from upstream dams.

Overall, analysis of the *E. coli* and *Enterococcus* results indicated strong effects of both rainstorms and land uses on indicator bacteria concentrations. For *E. coli*, increasing precipitation, land use/human population density within 500 meters (0.3 miles) of the water body, and animal agriculture within 2,000 meters (1.25 miles) of receiving waters were consistent predictors of elevated concentrations. For *Enterococcus*, the dominant significant factors in predicting bacteria concentrations were either animal agriculture or urban development within 1,000 meters (0.6 miles) of the river or tributary, and heavy precipitation.

The pilot study researchers suggested that significant storms be used as monitoring triggers in the development of benchmarks to measure future loads and the effectiveness of pollution control measures. Additional data, to be collected by Water Board staff in the next phase of project development, will help to explain these complex relationships.

Study Results for *Bacteroides*, Stable Isotopes, and Spatial Land Uses

Pilot study researchers analyzed 44 samples to identify human-source or bovine-source *Bacteroides* in surface water samples collected at twelve monitoring locations. Human-source *Bacteroides* was detected in 88 percent of all samples, which supports the supposition that the source of fecal contamination during storm pulses is human waste.

In general, results showed that in any sample where human-source *Bacteroides* was detected, the amount was between 100 and 10,000 times greater than the amount of bovine *Bacteroides* from locations surveyed. A comparison between *Bacteroides* and traditional pathogen indicator bacteria concentrations showed that neither *E.coli* nor *Enterococcus* measures correlated with human-source *Bacteroides*, except in samples from the rural/semi-natural land use category. These results, taken together, suggest that *E. coli* and *Enterococcus* were not effective indicators of human-source fecal contamination in this study.

While amounts of bovine *Bacteroides* were consistent at all sites throughout the sampling period, they were significantly greater in rural/less-developed land use areas than in urban or agricultural sites. In contrast, human *Bacteroides* were present in significantly greater amounts in the urban and agricultural land use sites.

Stable isotope analysis is used to determine the sources of nutrients in water samples. During storm pulses, this technique revealed that nitrate found in most of the samples was derived from a combination of wastewater treatment effluent, sewer, septic, and manure sources.

Monitoring Recommendations

Pilot Study researchers made a series of recommendations for the monitoring efforts the Regional Water Board will conduct during 2011 to 2012:

- Increase dry weather monitoring to a minimum frequency of weekly; include monitoring on weekends
- Increase monitoring to include more episodic events, such as low flows, first flush conditions, storm events, late winter pulses, and holiday weekends
- Increase the number of samples at each sampling location to a minimum of three samples
- Increase the number of monitoring locations to include tributaries of the Russian River
- Expand monitoring to include *Bacteroides* and stable isotopes in addition to traditional bacteria indicators

For More Information

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