



# Fecal Indicator Bacteria and Source Identification in the Pajaro River Watershed, Santa Clara County

## Report Summary

In support of Project B2 of the Safe, Clean Water and Natural Flood Protection Program, the Santa Clara Valley Water District, in collaboration with the County of Santa Clara and cities of Morgan Hill and Gilroy, conducted a source-identification study of pathogen pollution in the northern Pajaro River Watershed. Following an initial pilot study in March and April of 2015, the partners conducted a more comprehensive study in March of 2016. The main components of the study included:

- Testing for fecal indicator bacteria in the Pajaro River Watershed and comparing results to federal water quality criteria.
- Using microbial source tracking (MST) for select sites to determine possible sources of pathogens in the watershed.
- Focusing on sites within the Pajaro River Watershed where the public may be potentially exposed to microbial pathogens in the water.

### Key Findings

- Elevated concentrations of Fecal Indicator Bacteria (FIB) exist throughout the Pajaro watershed in Santa Clara County, particularly within the Llagas Creek sub-watershed.
- Increased FIB concentrations were observed during “first flush” rain events at several sampling sites.
- Sources of fecal pollution within the county are derived from a variety of sources including dog (domestic and potentially wild), ruminant, bird, human, pig, and cattle.
- *E. coli* concentrations at the county line were within acceptable limits for recreational water body contact at the time of sample collection, but enterococci were not.

### Background and Purpose

Pathogens reach water bodies through transport of fecal matter with runoff, combined sewer overflows, leaking sanitary sewer lines, and by direct input from domestic animals, wildlife and occasionally humans. Researchers use fecal indicator bacteria, including *E. coli* and enterococci, to test for the presence of pathogenic microorganisms in water. Previous sampling in Santa Clara County identified that fecal coliforms and fecal indicator bacteria in the Pajaro River Watershed regularly exceed Basin Plan Objectives and Environmental Protection Agency (EPA) recommended thresholds (TMDL for Fecal Coliforms in the Pajaro River Watershed, 2010). A Total Maximum Daily Load program is in place for the Pajaro River and tributaries that contains numeric objectives for acceptable fecal coliform levels, consistent with regulatory objectives (TMDL for Fecal Coliforms in the Pajaro River Watershed, 2010). The objectives of this study were to assess levels of fecal indicator bacteria in South Santa Clara County, identify the specific sources of the fecal indicator bacteria, and inform Morgan Hill, Gilroy, and the County on where to focus pollution prevention projects, outreach, and education to reduce these sources.

## Definitions

**TMDL:** Total Maximum Daily Load, determines the value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

**Fecal Indicator Bacteria:** Bacteria found in the intestinal tracts of warm blooded animals, used to detect the presence of fecal material in water. *E. coli* is used for freshwater, while enterococci is used for both marine and freshwater.

**Best Management Practice (BMP):** Activities or physical improvements that help improve stormwater quality and reduce the amount of stormwater runoff.

**Microbial Source Tracking:** Method used to identify the origins of fecal matter through DNA analysis of bacteria that hold host-specific genetic markers.

**303(d) list:** A state's list of impaired waterbodies, updated every two years under the Federal Clean Water Act. Placement on a 303(d) list may initiate development of a TMDL.

**Basin Plan:** A Regional Water Board water quality control planning document that sets beneficial uses and water quality objectives for surface and groundwater. Basin Plans are mandated under the Federal Clean Water Act and California's Porter-Cologne Water Quality Act

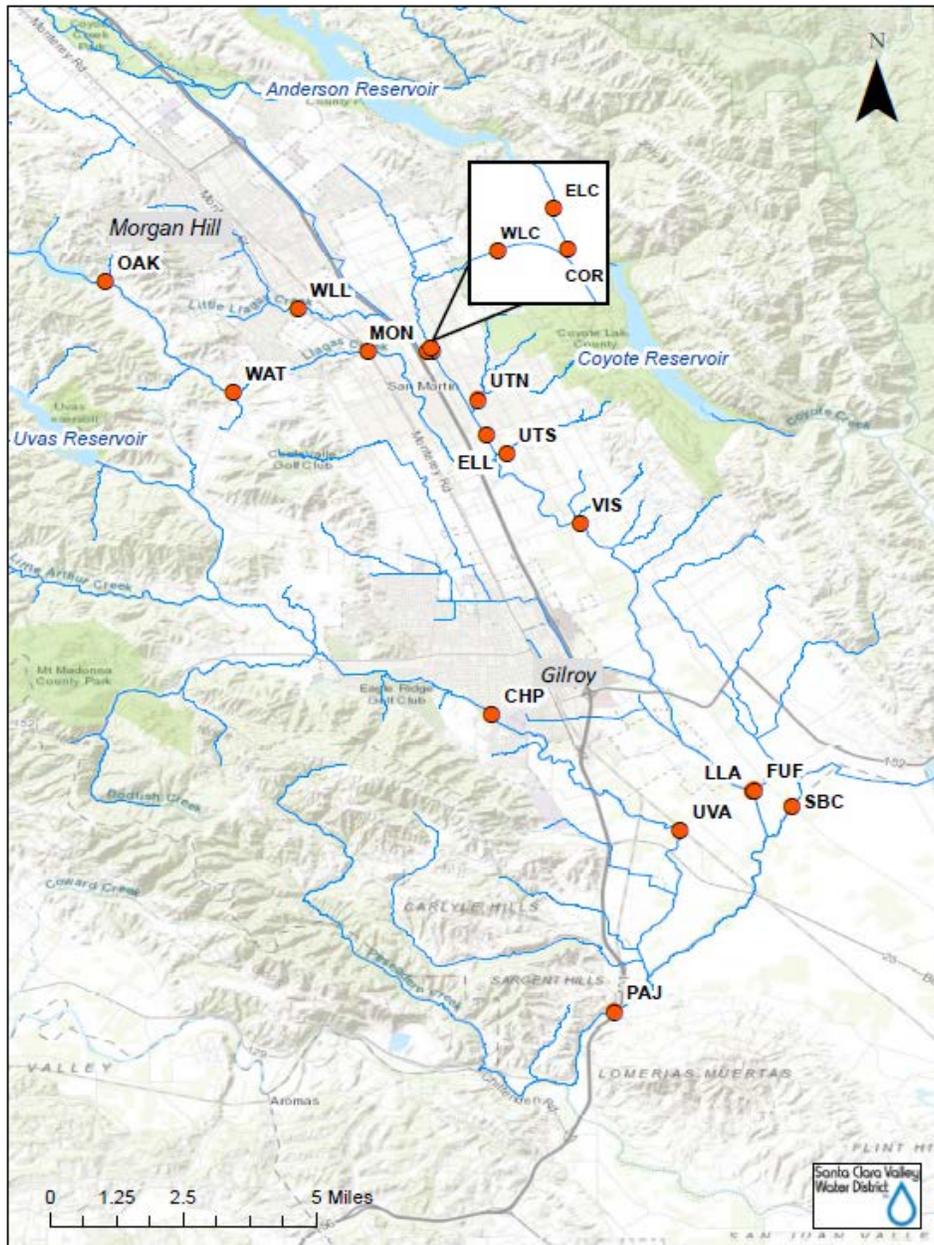
**US EPA Recommendation 1:** Based on an estimated illness rate of 36/1000 when in primary contact with recreational waters, where a high degree of bodily contact with the water, immersion, and ingestion are likely.

## Study Locations and Methodology

The study area included the northern portion of the Pajaro River Watershed within Santa Clara County. The Santa Clara Valley Water District chose sample sites to be consistent with previous monitoring by the Central Coast Regional Water Quality Control Board's Ambient Monitoring Program, and in areas where members of the public could be potentially exposed to pathogens in the water. Initially, seventeen sample sites were selected for the study. The District sampled five sites in 2015 as a pilot study due to drought conditions. In 2016 the study was expanded to include all seventeen sites, however only twelve were sampled due to a lack of stream flow. Locations of the twelve sampled sites are highlighted in grey in the table below and shown in the site map.

Name	Latitude	Longitude	Location description
OAK	37.114735	-121.688343	Llagas Creek at Oak Glen Ave
WAT	37.084610	-121.653496	Llagas Creek at Watsonville Rd
WLL	37.107350	-121.635845	Llagas Creek at Creek at Watsonville Rd
COR	37.095927	-121.599441	Corrallitos Creek upstream of East Little Llagas
ELL	37.072884	-121.584672	East Little Llagas Creek at Church Ave
MON	37.095689	-121.616788	Llagas Creek at Monterey Hwy
VIS	37.048686	-121.559186	Llagas Creek at Buena Vista Ave
UTS	37.067981	-121.579161	Unnamed Tributary South at Columbet Ave
CHP	36.996653	-121.583167	Uvas Creek at Christmas Hill Park
SBC	36.971858	-121.501578	Pajaro River on Frazier Lake Rd.-San Benito County Line
WLC	37.095889	-121.600858	WLL near Corrallitos Creek confluence
UTN	37.082494	-121.587003	Unnamed Tributary North at Columbet Ave
LLA	36.975984	-121.512218	Llagas Creek at Bloomfield Avenue
ELC	37.096756	-121.599742	ELL near Corrallitos Creek confluence
UVA	36.965092	-121.531981	Uvas Creek at Bloomfield Avenue
PAJ	36.915894	-121.549916	Pajaro River at Betabel Road
FUF	36.976164	-121.511836	Furlong (Jones) Creek near confluence w/ Llagas Creek at Bloomfield Avenue

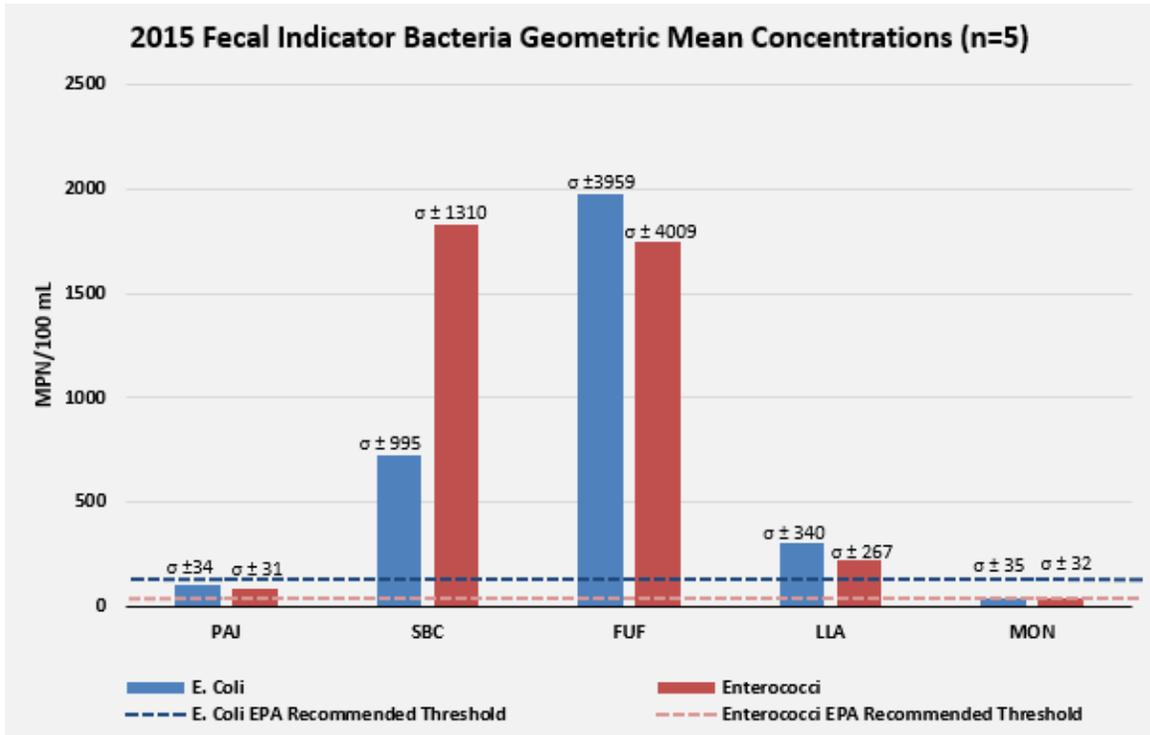
**South Santa Clara County Sample Locations**



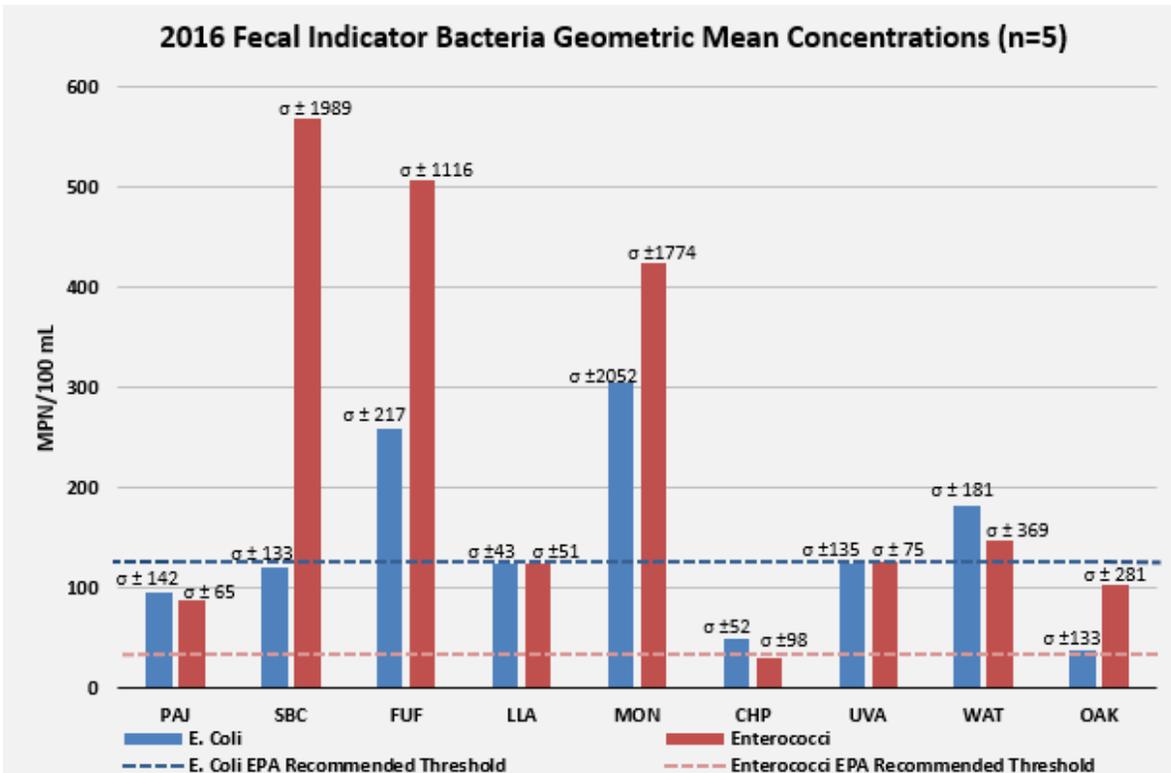
Samples were analyzed for fecal indicator bacteria including *E. coli* and enterococci. Results of fecal indicator bacteria levels were compared to EPA Recommendation 1 for primary water contact (Recreational Water Quality Criteria, 2012). To target specific sources of bacteria to streams, select samples with elevated fecal indicator bacteria results were also analyzed using microbial source tracking. Microbial source tracking identifies origins of fecal matter through DNA analysis of bacteria that hold host-specific genetic markers.

District staff also conducted aerial and ground reconnaissance of potential Fecal Indicator Bacteria (FIB) sources in areas exhibiting elevated FIB concentrations and positive microbial source tracking results during the study timeframe. District staff questioned the initial dog results for rural areas near Chesbro Reservoir, because this area contains few residential dwellings. To evaluate uncertainty, District staff collected coyote excrement in Santa Clara County and sent it for testing against the dog biomarker used in the study. The test revealed coyote fecal matter as a positive indication for the dog marker. Therefore, some of the positive values for dogs, especially those in rural areas, could potentially be from wild coyotes rather than domesticated dogs.

## Results

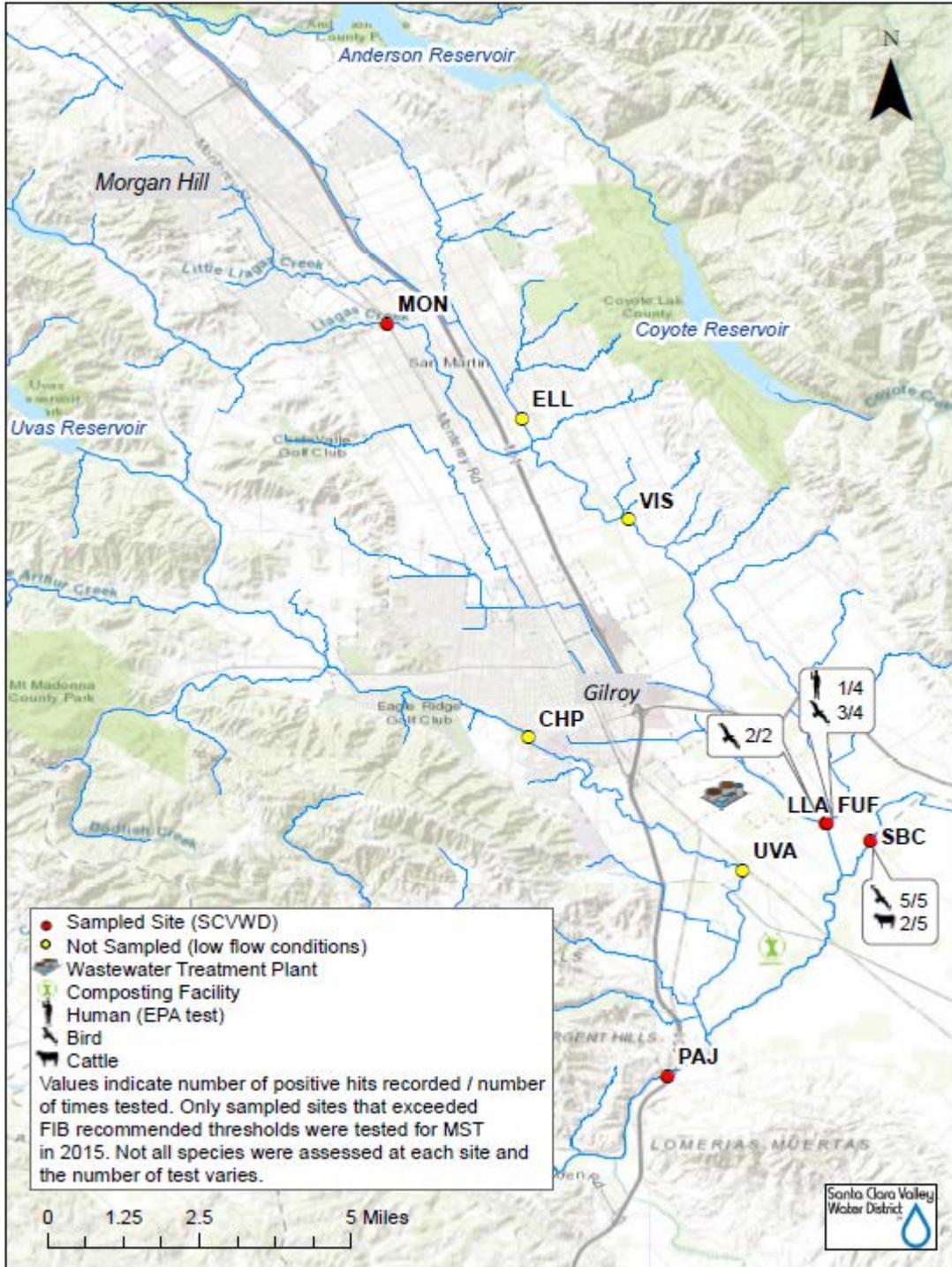


2015 fecal indicator bacteria geometric mean concentrations compared to EPA recommended thresholds for primary water contact recreation. Sigma ( $\sigma$ ) represents the standard deviation in MPN/100 mL from the arithmetic mean.

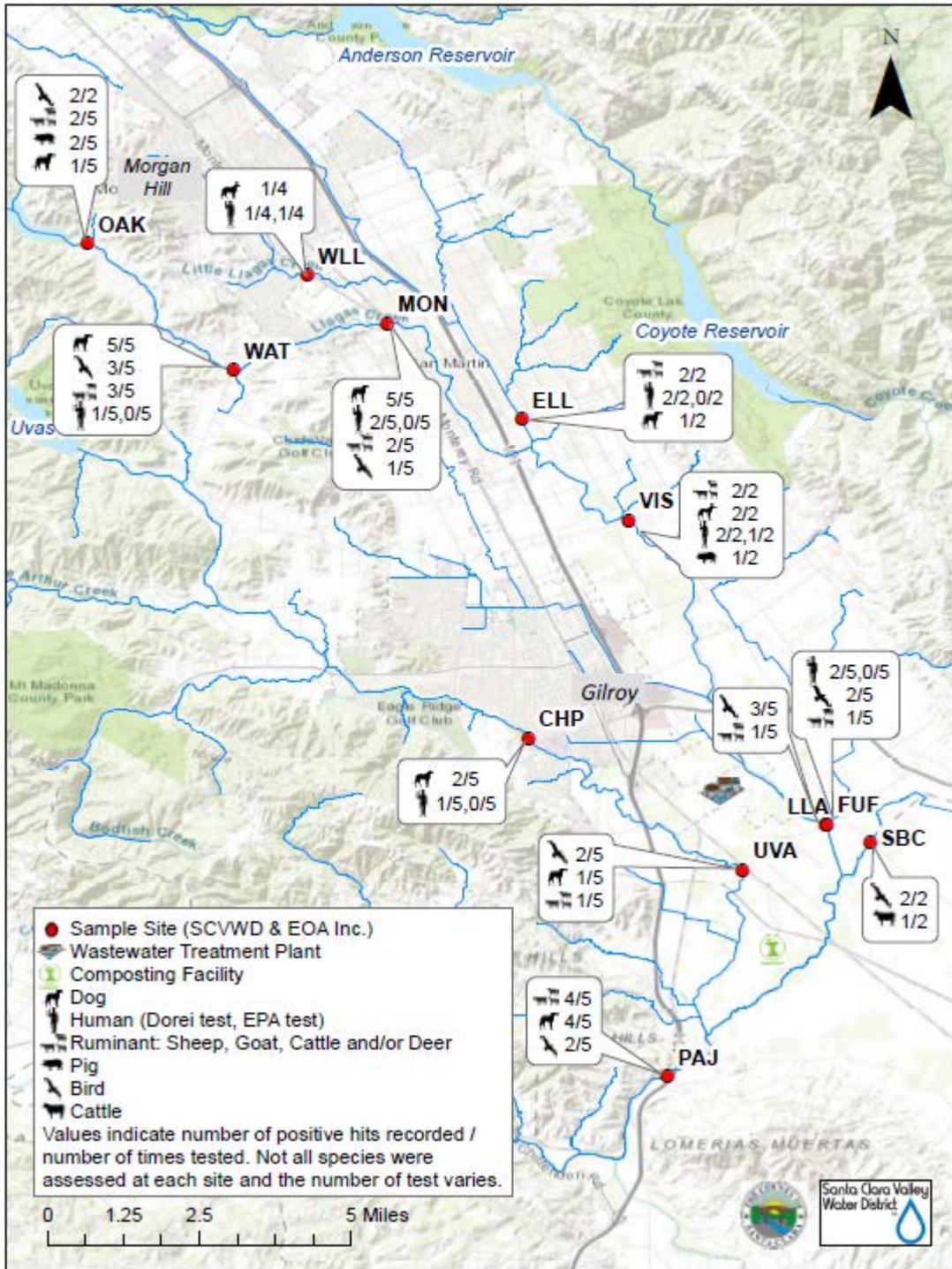


2016 fecal indicator bacteria geometric mean concentrations compared to EPA recommended thresholds for primary water contact recreation. Sigma ( $\sigma$ ) represents the standard deviation in MPN/100 mL from the arithmetic mean.

2015 Microbial Source Tracking Results



2016 Microbial Source Tracking Results



**Fecal Indicator Bacteria:** Results indicate high concentrations of fecal indicator bacteria throughout the Pajaro watershed in Santa Clara County, particularly within the Llagas Creek sub-watershed, when compared to US EPA Recommendation 1 illness rate for primary contact with water for recreational uses (35 cfu/100mL enterococci, 126 cfu/100mL *E. coli*) (Recreational Water Quality Criteria, 2012). The Uvas Creek sub-watershed appeared to be less polluted with pathogens than the Llagas Creek watershed, at the time of this study. Because Llagas and Uvas creeks join to form the Pajaro River, fecal pollution is likely to be less concentrated in its upper reaches. *E. coli* concentration at the county line was within accepted limits for recreational water body contact, but enterococci concentration was not. Enterococci bacteria were found in higher concentrations than *E. coli* at multiple sample sites. Reproduction outside the host species by enterococci bacteria may explain the differences between species concentrations at certain sample locations (Byappanahalli et al., 2012). First flush conditions likely explain the increase in FIB concentrations and fecal source detection at several sampling sites during the first two weeks of the study. First flush is the initial surface water runoff during a rain event that washes pollutants to waterways that have built up on land before the storm. Subsequent rain events often contribute lower levels of pollutants compared to first flush rain events.

**Microbial Source Tracking:** Results of the microbial source tracking analysis identified fecal pollution within the county originates from a variety of sources including dog (domestic and potentially wild) ruminant, bird, human, pig, and cattle. During ground reconnaissance and investigation of sites with positive MST results including ruminant, pig, and cattle, District staff found livestock on properties adjacent to creeks that could benefit from increased buffer zones and setbacks from the creek. District staff also found evidence of dog excrement along walking trails adjacent to Llagas Creek in residential areas upstream of site MON, that received positive results for dog from all five samples. Ground reconnaissance did not reveal obvious human sources, however there was evidence of an encampment 1.5 miles upstream of site WLL.

The 2012 US EPA thresholds used to assess illness rates in this study are specific to primary contact uses of water. The primary contact designations include “*swimming, bathing, surfing, water skiing, tubing water play by children, and similar water contact activities where a high degree of bodily contact with the water, immersion and ingestion are likely*” (Recreational Water Quality Criteria, 2012). Findings show that geometric mean values surpassed the recommended thresholds at multiple sample locations at the time of sample collection. Primary contact recreation during sample collection times at sites with exceedances therefore had potential to result in illness. Because primary contact recreational activities are not widespread in creeks of South Santa Clara County, the risk to public health is considered low. However, the Pajaro River drains to the Monterey Bay, well known for primary contact recreational activities including surfing and swimming. *E. coli* concentrations in the Pajaro River leaving the county line at the time of the study were within acceptable limits for primary contact, while enterococci were not. The extent to which bacteria originating from South Santa Clara County contributes to heavily used recreation areas such as the Monterey Bay is uncertain, as mechanisms of bacteria transport are difficult to quantify and track. Fecal indicator bacteria species have displayed growth in the environment outside of hosts, which brings in to question their use as indicators of recent fecal contamination, and pathogen presence (Byappanahalli et al., 2012; Chandrasekaran et al., 2015; He et al., 2007;). Fecal indicator bacteria have also been shown to settle out of the water column, persist in streambed sediments, and get resuspended in the water column upon physical disturbance (Brinkmeyer et al., 2015). Use of the microbial source tracking results from this study will allow for targeted pollution control efforts to reduce fecal entry to creeks at their sources in the Santa Clara County portion of the Pajaro River watershed, which includes a portion of the Pajaro River itself, and its northern tributaries. The following recommendations were shared with the cities of Morgan Hill and Gilroy and the County of Santa Clara to target their outreach activities.

## Recommendations

To improve surface water quality in the Santa Clara County portion of the Pajaro River watershed, the District recommends the following:

1. Focus fecal pollution control efforts in the Llagas sub-watershed.
2. Focus fecal pollution control efforts on anthropogenic sources- e.g. dogs at MON.
3. Investigate possible point source fecal pollution contributions from existing sanitary sewer systems, or homeless encampments in areas with positive results for human sources.
4. Implement broad outreach to educate domestic livestock owners regarding fecal pollution including:
  - a. Focus on removing animal waste near drainage systems.
  - b. Promote removal and/or covering of animal waste piles.
  - c. Encourage establishments of buffer zones via setbacks and vegetation barriers.

Site specific recommendations to reduce fecal pollution are as follow:

1. MON- Install signs for picking up dog waste, provide dog waste baggies and trash bins, and fencing to discourage dog encroachment to creek especially in residential areas with walking and hiking trails along Llagas Creek upstream of MON and Atherton Way Hidden Pond.
2. CHP- Install signs for picking up dog waste throughout the Christmas Hill Park area.
3. WLL- Discourage homeless encampments near the creek.
4. ELL and VIS- Post illegal dumping signs along road bridges to discourage dumping of animal waste and trash, and neighborhood outreach to encourage BMPs for livestock waste management.
5. WAT- Educate livestock owners about fecal pollution, encourage owners to not allow livestock near the creek, and establish creekside buffer zones.

The full report can be viewed on the Santa Clara Valley Water District's Website at

<https://www.valleywater.org/project-updates/grants-and-environmental-protection/interagency-urban-runoff-program>

## References

- Byappanahalli, M., Nevers, M., Korajkic, A., Staley, Z., & Harwood, V. (2012). Enterococci in the environment. *American Society for Microbiology*, 76(4), 685-706.
- Brinkmeyer, R., Amon, R. M. W., Schwarz, J. R., Saxton, T., Roberts, D., Harrison, S., . . . Elliott, C. (2015). Distribution and persistence of escherichia coli and enterococci in stream bed and bank sediments from two urban streams in Houston, TX. *Science of the Total Environment*, 502, 650-658.
- Chandrasekaran, R., Hamilton, M. J., Wang, P., Staley, C., Matteson, S., Birr, A., & Sadowsky, M. J. (2015). Geographic isolation of escherichia coli genotypes in sediments and water of the seven mile creek - A constructed riverine watershed. *Science of the Total Environment*, 538, 78-85.
- He, L., Lu, J., & Shi, W. (2007). Variability of fecal indicator bacteria in flowing and ponded waters in southern California: Implications for bacterial TMDL development and implementation. *Water Research*, 41(14), 3132-3140.
- U. S. Environmental Protection Agency, Office of Water (2012). *Recreational Water Quality Criteria*. (820-F-12-058). Retrieved on March 6, 2013 from <http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/RWQC2012.pdf>