San Lorenzo River Alliance Water Quality Working Group
Fiscal Year 2015-16 Progress Report

City of Santa Cruz Public Works Department
City of Santa Cruz Water Department
Coastal Watershed Council
County of Santa Cruz Department of Public Works
Central Coast Regional Water Quality Control Board
Surfrider Foundation

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INTRODUCTION

The Water Quality Working Group of the San Lorenzo River Alliance (SLRA) was first assembled in 2013 to help address water quality issues in the San Lorenzo River and its tributaries. Participants include water quality experts from:

- City of Santa Cruz Public Works and Water Departments,
- County of Santa Cruz Environmental Health Services,
- Central Coast Regional Water Quality Control Board staff, and
- Nonprofit organizations Surfrider Foundation and Coastal Watershed Council.

The Working Group has taken a collaborative approach to improving water quality in the San Lorenzo River watershed. The initial focus of the Working Group's activity has been to address impairment of river water quality by fecal indicator bacteria. The reasons for this focus are:

1. The SLRA wishes to improve the general quality and beneficial uses in the San Lorenzo River, and
2. The SLRA seeks to participate with other stakeholders and help municipalities in the response to the impairment of beneficial uses of the river, as described in the San Lorenzo River Watershed Pathogen Total Maximum Daily Load (TMDL) regulation (Central Coast Water Board Resolution R3-2009-0023).

The TMDL Problem Statement characterizes the impairment as follows:

> "The beneficial use of water contact recreation is not protected in the impaired reaches of the San Lorenzo River Estuary (also known as San Lorenzo River Lagoon), San Lorenzo River, Branciforte Creek, Camp Evers Creek, Carbonera Creek, and Lompico Creek because fecal coliform concentrations exceed existing Basin Plan numeric water quality objectives protecting this beneficial use. All reaches in these water bodies are impaired with the exception of Carbonera Creek, where the impairment extends from the mouth of Carbonera Creek upstream to its intersection with Bethany Road."

The Working Group approach to date involves using water quality monitoring data to help further characterize conditions in the impaired waters, identifying and prioritizing bacteria sources for further investigation, and subsequently identifying best management practices (BMPs) to reduce bacteria discharges from the high-priority sources. The major elements of this strategy to address the bacteria impairment are:

- Monitor/assess receiving water conditions to characterize the bacterial impairment.
- Identify and prioritize the sources of bacteria from urban runoff within the urban watershed.
- Identify applicable BMPs and implement additional BMPs as needed to help further control high-priority sources of bacteria from urban runoff within the urban watershed.

Progress to date for these three components of the bacteria strategy (water quality monitoring, bacteria source identification/prioritization, and BMP identification/source matching) are further described below.

WATER QUALITY MONITORING

To provide more information relevant to the recreational water quality beneficial use impairment, the Working Group designed and conducted water quality monitoring during the peak recreational water contact period (May-October) in both 2014 and 2016. The methods and results of the monitoring to date are summarized below.

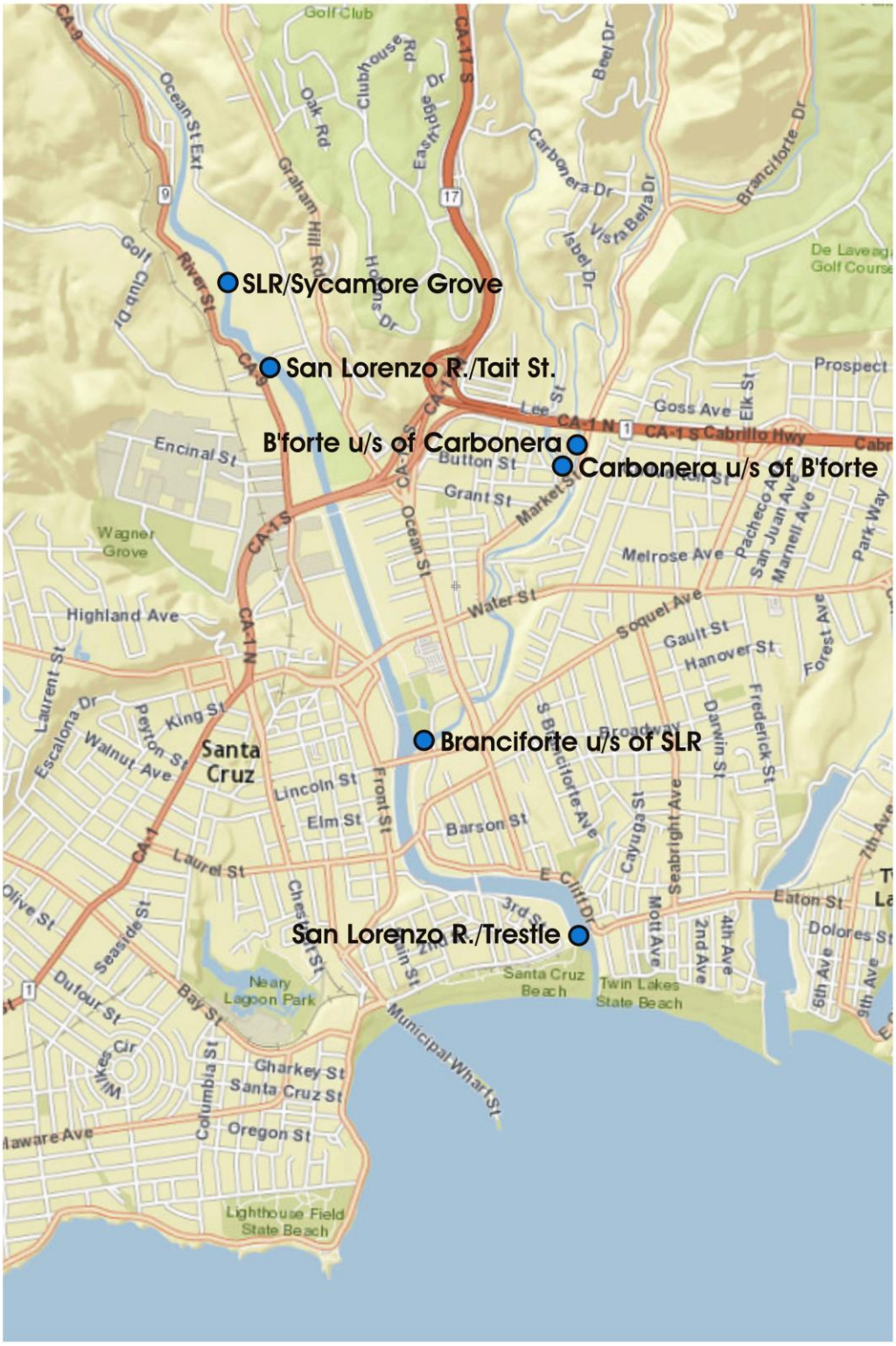

Figure 1. SLRA Monitoring Sites, Lower San Lorenzo River Watershed[1]

[1] Notes re: abbreviations used in figures/tables: “u/s” = upstream; “SLR” = San Lorenzo River; “B’forte” = Branciforte Creek. See List of Sites on p. 3 for site descriptions.

Summer 2014 Study

The Working Group designed a water quality monitoring program to characterize bacteria-related water quality conditions in the lower San Lorenzo River watershed during the peak 2014 recreational water contact period (May-October). Samples were collected monthly by Coastal Watershed Council (CWC) staff and volunteers from six sites located at strategic points within the lower watershed (see Figure 1 and list of sites in Table 1, below). Samples were collected using clean sample handling techniques, according to protocols specified in CWC's creek sampling Quality Assurance Project Plan (QAPP).

Focusing on the water contact recreation beneficial use cited in the TMDL, the guiding questions developed by the Working Group in this initial study of bacterial contamination issues were:

- What is the level of human bacterial contamination in the surface waters of the lower San Lorenzo River watershed?
- What are the key sources of human and other anthropogenic bacterial contamination in the lower San Lorenzo River?

To distinguish between human or anthropogenic bacterial contamination and non-human contamination, the Working Group utilized a multiple-lines-of-evidence approach, cross-referencing levels of the ubiquitous fecal indicator bacteria with the measurement of chemical and biological constituents as markers for human contamination.

Analytical Constituents

The multiple-lines-of-evidence approach was used to quantify the relative contributions of human sources to in-stream levels of fecal indicator bacteria, using a diverse range of possible human markers. All analyses were performed at analytical laboratories with ELAP (Environmental Laboratory Accreditation Program) and/or NELAC (National Environmental Laboratory Accreditation) certification. Water samples were analyzed for the following constituents:

- Fecal sterols and stanols
- Caffeine
- Human Bacteroides
- Fecal indicator bacteria (FIB), including E. coli, Total coliform, and Enterococcus
- Standard field parameters (dissolved oxygen, temperature, conductivity, pH)

Fecal sterols, stanols and caffeine are considered to be chemical tracers that can be used to help identify potential contributions from human sources (c.f., Standley et al., 2000). The use of chemical source tracking methods represents an important additional line of evidence among the several lines of evidence previously applied in the investigation of bacteria sources in the San Lorenzo River watershed. The fecal sterol cholesterol is ubiquitous in the digestive tracts of animals and in the environment. Cholesterol is mostly metabolized in the human gut to the fecal stanol coprostanol. By contrast, in the environment cholesterol normally reduces to cholestanol. Coprostanol is therefore often used alone or in ratio to other fecal sterols/stanols to identify human fecal sources (c.f., Ahmed et al., 2011).

Caffeine is widely consumed in modern cultures, and while caffeine is readily metabolized by the human body, up to 10% of the consumed caffeine may be excreted, mostly via the urine (Ferreira, 2005). Caffeine has been shown to be a reliable indicator of human contamination in surface waters, and detection of caffeine can be interpreted as representative of the presence of human sewage (c.f., Ferreira, 2005).

Bacteroides are anaerobic bacteria prevalent in the gastrointestinal tracts of mammals; species that are specific to the human gut may be used as indicators of human sewage contamination in environmental samples (Sauer et al., 2011).

Sample collection and field measurements/observations were performed monthly by Coastal Watershed Council (CWC) staff and volunteers at six sites situated at strategic points within the lower San Lorenzo River watershed (see Figure 1 and list of sites in Table 1, below).

Table 1. SLRA Monitoring Sites

Monitoring Site	Description
San Lorenzo River (downstream)	at the lagoon, beneath trestle bridge
San Lorenzo River (upstream A)	upstream of main urban area inputs, near City water intake at Tait Street
San Lorenzo River (upstream B)	at Sycamore Grove
Branciforte Creek (downstream)	upstream from confluence with San Lorenzo River, at start of concrete channel
Branciforte Creek (upstream)	just upstream from confluence with Carbonera Creek
Carbonera Creek	just upstream from confluence with Branciforte Creek

2014 Results/Discussion

The following summarizes the results of the 2014 monitoring (Ruby, 2015):

- For the fecal sterols and stanols analyses, very few samples indicate the presence of human contributions to the in-stream chemistry, while most samples exhibit indications of avian (bird) contributions.

- For caffeine, all 36 river and creek samples were reported as below the analytical detection level (commonly referred to as “non-detect”). By contrast, the City of Santa Cruz has detected caffeine in samples from certain problem sites in the storm drain system, where there is presumed to be cross-contamination from sewage sources.

- Human Bacteroides were only detected at quantifiable levels in three of the 36 samples; two of those were at the Carbonera Creek site (upstream of the confluence with Branciforte Creek).

- FIB levels were highly variable from site to site and month to month; highest results were most often obtained at the Branciforte Creek site upstream of the confluence with the San Lorenzo River, and at the Carbonera Creek site (upstream of the confluence with Branciforte Creek).

- The Bacteroides results don’t correlate well with either the concurrent FIB results or the chemical tracer results.

Summer 2016 Study

In May 2016, the Water Quality Working Group began its second year of bacterial monitoring, replicating the 2014 study. Monitoring was performed at the same sites, with the goal of developing data in a wetter, near normal precipitation year to compare with the 2014 monitoring performed under drought conditions. A sub-question was then added to the study:

- How do levels of human bacterial contamination in drought conditions (2014) compare to levels in a near normal precipitation year (2016) in the surface waters of the lower San Lorenzo River watershed?

Monitoring events were scheduled monthly on the following dates:

Monday, May 16, 8 AM start

Monday, June 13, 9:30 AM start

Wednesday, July 13, 8 AM start

Thursday, August 11, 7 AM start

Monday, September 12. 9:30 AM start

Monday, October 10, 8:30 AM start

An identical multiple-lines-of-evidence strategy was utilized in the 2016 study, replicating the sites and analytical constituents monitored in 2014, and again monitoring monthly from May-October. Analysis of fecal sterols and stanols was done by Physis Laboratories and jointly funded by the City of Santa Cruz Public Works Department and County of Santa Cruz. Caffeine testing was done by the City of Santa Cruz Environmental Laboratory. Fecal indicator bacteria analysis was done by Santa Cruz County Environmental Health laboratory. Initial processing for human bacteroides analysis, which includes sample water filtering and then freezing the filters, was performed monthly by the Surfrider staff at the County Environmental Health lab. Analysis of the filters using the HF183 method will be performed by the City of Santa Cruz Environmental Laboratory upon completion of the fieldwork.

2016 Results/Discussion

The findings from the available data for the first two months of the 2016 study, conducted during May and June 2016, are outlined below. Data are available for fecal sterols and stanols, caffeine, FIB, and field parameters. Bacteroides analyses will be conducted on all samples at the conclusion of the six month sampling program. Results of the six month study, which concludes in October 2016, will be analyzed and published after project completion.

Fecal sterols and stanols:

Water samples were tested for six commonly detected fecal sterols and stanols. In May, coprostanol was measured at high levels, indicative of anthropogenic inputs at the Branciforte Creek u/s of Carbonera Creek site. All other sites for that month indicated low concentrations or were below analytical detection. In June, coprastanol levels at all sites were below detection (see Appendix A, Table 1).

Three chemical tracer ratios were used to evaluate fecal sterols and stanols per Ahmed et al. (2011); see Appendix A, Tables 2 and 3. Two ratios are designed to indicate the presence of human fecal contamination, and one is designed to indicate the presence of avian fecal contamination. In the May samples, due principally to high coprastanol levels, the Branciforte u/s of Carbonera site exceeded both human fecal indicator ratio limits at a level >0.5, indicating the presence of anthropogenic contamination (see Appendix A, Table 2). Three of the five other sites monitored in May strongly indicated avian bacteria contamination, based on the avian indicator ratio >67% (Ratio #10 per Ahmed et al., 2011). In the June samples there was no indication of human contamination as determined by the fecal sterols and stanols ratios, while five of six sites demonstrated an avian fecal indicator ratio > 67% (see Appendix A, Table 3).

Caffeine:

Caffeine was not detected by the City of Santa Cruz Environmental laboratory at levels ≥ 0.175 µg/L at any of the six sites in May or June monitoring (see Appendix A, Table 1), suggesting minimal human impact on water quality at those sites. Typically, the presence of caffeine associated with high levels of fecal indicator bacteria suggest the presence of domestic sewage.

Fecal indicator bacteria:

Fecal indicator bacteria levels were variable from site to site in May and June (see Table 4 in Appendix A, and Figures 2 and 3, below), with no clear pattern in the E. coli results for these two months. Enterococcus levels were highest at the Branciforte u/s of Carbonera site ("304-BRANC-26") in both May and June, while the Carbonera u/s of Branciforte site ("304-CARBO-21") had the second highest level of Enterococcus in both months. Both sites are approximately 500 feet apart and in a residential neighborhood.

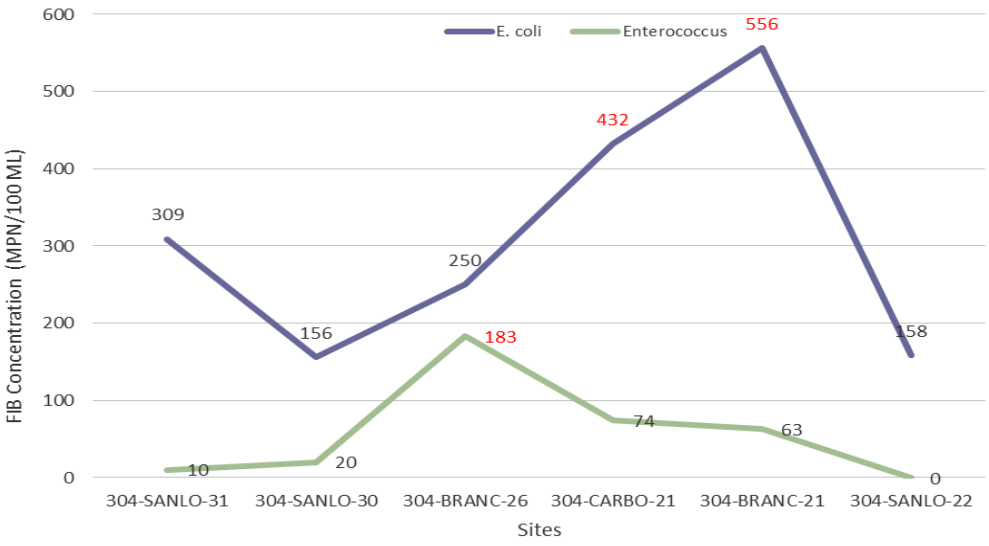

Figure 2: Fecal indicator bacteria levels on May 16, 2016, exceedances highlighted in red

For the May 16 monitoring event, both the Carbonera u/s of Branciforte ("304-CARBO-21") and Branciforte u/s of San Lorenzo River site ("304-BRANC-21") exceeded the USEPA 2012 Recreational Water Quality Criteria for E. coli of <410 MPN/100 mL. Only Carbonera u/s of Branciforte site ("304-CARBO-21") exceeded USEPA criteria for Enterococcus of <130 MPN/100 mL.

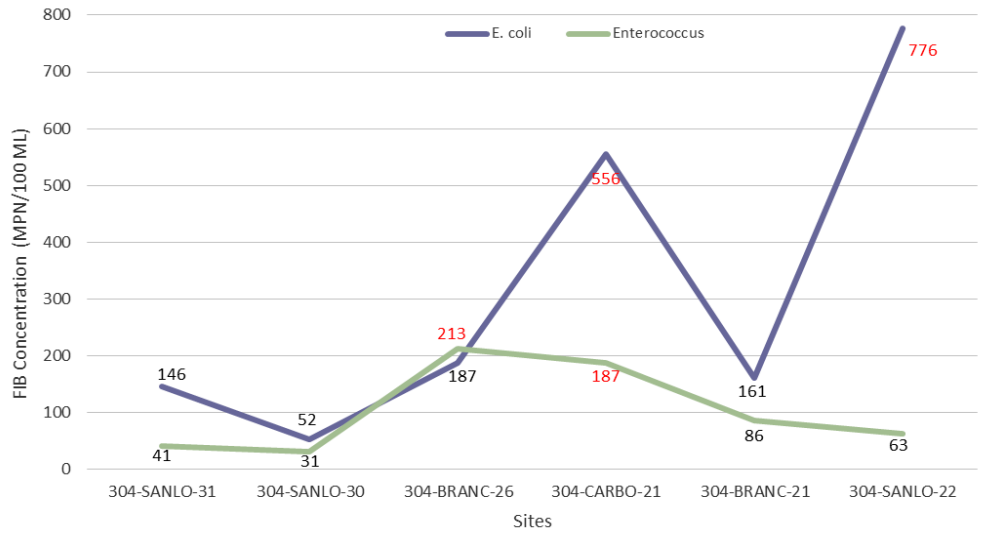

Figure 3: Fecal indicator bacteria levels on June 13, 2016, exceedances highlighted in red

For the June 13 monitoring event, again the Carbonera u/s of Branciforte site ("304-CARBO-21") exceeded USEPA 2012 Recreational Water Quality Criteria for E. coli of <410 MPN/100 mL along with the San Lorenzo River at Trestle Bridge site ("304-SANLO-22"). The Branciforte u/s of Carbonera and Carbonera u/s of Branciforte exceeded USEPA criteria for Enterococcus of <130 MPN/100 mL.

The 2016 monitoring study concludes with a final monitoring event planned for October 12, 2016. Study findings will be published shortly thereafter. These findings will be used to further characterize the receiving water conditions and to answer the monitoring questions posed above. The results then will provide context for the Working Group's ongoing identification of sources of bacteria and analysis of best management practices to address those sources.

BACTERIA SOURCE PRIORITIZATION PROCESS

The Bacteria Source Prioritization process developed by the San Lorenzo River Alliance Water Quality Working Group is helping to identify, characterize, and prioritize bacteria sources in the study area of the lower reaches of the San Lorenzo River and its major tributaries (Ruby, 2016).

The Working Group recognized that bacteria sources should be identified by their relationship to human activity and by extension, controllability, particularly in regards to TMDL compliance for controllable bacteria sources. The Working Group established the following broad categories of bacteria sources:

- Human origin (i.e., from the human body)
- Anthropogenic, non-human origin (resulting from or caused by human activities, but not from the human body), and
- Non-anthropogenic origin (independent of human activity)

In 2015, conceptual modeling was used to illustrate the various sources and transport pathways associated with each of the three categories of sources listed. From these models, the Working Group produced lists of possible bacteria sources. Only sources with a potential pathway into a municipal separate storm sewer system (MS4) or receiving water (creek, river, lagoon, ocean) were allowed on the list. The potential sources were further aggregated according to common characteristics, and grouped accordingly into a draft list of sources. The current list of potential sources is attached as Appendix B, organized first by major sources type (human, anthropogenic non-human, non-anthropogenic) and then by subcategory.

In modeling transport pathways, the Working Group considered the possible impact of hydrologic conditions on bacterial deposition and mobilization into surface waters. Upon evaluation, most of the identified sources were considered to be available for transport to MS4s or receiving waters during both wet and dry weather. However, because the magnitude, frequency and means of transport to receiving waters could vary substantially for a given source in dry vs. wet weather, the Working Group agreed to perform the source prioritization scoring separately for wet vs. dry weather conditions.

Prioritization Factors

The Working Group agreed to use the following factors in bacteria source prioritization for the San Lorenzo River watershed:

- **Human Health Risk**: the degree to which humans could experience negative health effects from exposure during water contact recreation, if/when the source is present in the receiving waters (i.e., health risk here refers to potential effects that may accrue upon contact with the bacteria produced by the source, not whether the bacteria derive from a human source)
- **Magnitude**: the relative amount of contaminated material likely to be contributed to receiving waters on an episodic basis from this source (magnitude here refers to the relative amount of bacteria available from a particular source during either dry or wet conditions, watershed-

wide, when the source is present and discharging; the Frequency factor addresses how often a source may discharge)

- **Frequency**: how often within the course of the wet or dry season this source is likely to occur (assumes wet weather sources dominate during wet season)
- **Transport Feasibility**: how likely it is that the source will be transported to listed receiving waters when the source is present in the watershed; this factor includes consideration of both the proximity of the source to the receiving waters, as well as the characteristics of the transport pathway (for example, whether transport occurs via a storm drain or overland flow)
- **Controllability**: how likely it is that the source can be controlled through reasonable municipal agency and/or stakeholder efforts; this factor will be used separately, for the control identification phase, following completion of the source prioritization process

Scoring Sources

All sources were scored based on these factors and with respect to transport to the principal receiving waters in the lower San Lorenzo River watershed (defined as San Lorenzo River below Sycamore Grove, Branciforte Creek below Isbel Drive, and Carbonera Creek below Carbonera Estates), as follows:

- Each factor is assigned a score from 1 to 5; i.e., within the possible range, 1 is lowest/least, 5 is highest/most.
- Sources that are not found within a given watershed are given zero scores for all factors.
- Sources with no apparent transport mechanism from source to MS4 or receiving waters also are given zero scores for all factors.

In Scoring, the Working Group considered locations of key features, such as areas served by sanitary sewer, areas served by septic systems, landfills, homeless encampments, commercial and residential land uses. Within the scoring spreadsheet table, there was also the option to check a box if the source is from “upstream only”, meaning above the limits of the study area as defined by the Working Group (above Sycamore Grove, Isbel Dr., Carbonera Estates for the listed receiving waters).

While proceeding through the scoring, attention was paid to wet conditions relative to dry conditions, to consider comparative scores for sources within a given source category, and to continue the relative scoring for the sources within various source categories. The scoring is done separately for wet weather transport (assumed to dominate loadings during the wet season) and dry weather transport (assumed to be the sole means of transport during the dry season).

Source Prioritization

The prioritization process involves summing the scores for the Human Health Risk, Magnitude, Frequency, and Transport Feasibility factors, drawing on available information about the watershed and its potential bacteria sources, to the extent possible. Where watershed-specific information is lacking, the Working Group made use of available information from the literature, and when necessary, best professional judgment.

ADDRESSING SOURCES WITH BEST MANAGEMENT PRACTICES

In Spring 2016, the Working Group began using the prioritized bacteria sources as a framework for identifying and prioritizing best management practices (BMPs), beginning with BMPs that are included in existing City and County programs. The Working Group reviewed the City of Santa Cruz and Santa Cruz County Stormwater Program Effectiveness Assessment and Improvement Plan (PEAIP) and Wasteload Allocation Attainment Plan (WAAP) documents, identifying proposed and implemented best management practices that address the bacteria sources in question.

The Working Group continues to review BMPs, including those implemented by the City and County, nonprofit partners and community groups. Once an inventory of applicable BMPs is completed and organized based on the bacteria sources each one addresses, it will be used to assess potential gaps in BMPs being implemented, and determine if additional BMPs should be added to existing BMP strategies. The bacteria source prioritization process and BMP identification will be further refined based on the findings of the 2016 bacterial monitoring study.

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Updated SWAMP QA/QC parameters (measurement quality objectives) and sample handling protocols can be found at the following links:

- Conventional Parameters in Fresh and Marine Water: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/mqo/1_conv_water.pdf
- Field Measurements in Fresh and Marine Water: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/mqo/fld_msmt_water.pdf
- Indicator Bacteria in Fresh Water (revised 08/03/15): http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/mqo/ind_bact_water.pdf
- Inorganic Analytes in Fresh and Marine Water: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/mqo/2_inorg_water.pdf
- Nutrients in Fresh and Marine Water: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/mqo/3_nut_water.pdf
- Solid Parameters in Fresh and Marine Water: http://www.waterboards.ca.gov

/water_issues/programs/swamp/docs/mqo/5_solid_water.pdf

USEPA. 40 CFR Part 136: Guidelines Establishing Test Procedures for the Analysis of Pollutants. See July 1, 2015 Federal Register notice: https://www.gpo.gov/fdsys/pkg/CFR-2015-title40-vol23/xml/CFR-2015-title40-vol23-part136.xml ; subject to updating.

Appendix A. May and June 2016 Monitoring Results

Table 1: Chemical Tracer Analytical Results, 2016 Monitoring, May and June

Constituent/Site ID	Measured Concentrations mg/L by Sample Collection Date	
Cholestanol	**5/16/2016**	**6/13/2016**
San Lorenzo River @ Sycamore Grove	32	20.3
San Lorenzo River @ Tait Street	27	21.7
Branciforte u/s of Carbonera	17.6	22.4
Carbonera u/s of Branciforte	17.3	14.8
Branciforte u/s of SLR	31.3	33.4
San Lorenzo River @ Trestle	32.9	51
Monthly Average	26.4	27.3
Cholesterol		
San Lorenzo River @ Sycamore Grove	629.2	438.6
San Lorenzo River @ Tait Street	452.9	424.4
Branciforte u/s of Carbonera	492.1	576.9
Carbonera u/s of Branciforte	348.6	347.9
Branciforte u/s of SLR	992	958.8
San Lorenzo River @ Trestle	603.3	856.7
Monthly Average	586.4	600.6
Coprastanol		
San Lorenzo River @ Sycamore Grove	7.6	ND
San Lorenzo River @ Tait Street	ND	ND
Branciforte u/s of Carbonera	25.9	ND
Carbonera u/s of Branciforte	6.9	ND
Branciforte u/s of SLR	11.7	ND
San Lorenzo River @ Trestle	ND	ND
Monthly Average	8.7	ND
Epicoprastanol		
San Lorenzo River @ Sycamore Grove	ND	ND
San Lorenzo River @ Tait Street	ND	ND
Branciforte u/s of Carbonera	ND	ND
Carbonera u/s of Branciforte	ND	ND
Branciforte u/s of SLR	ND	ND
San Lorenzo River @ Trestle	ND	ND
Sitosterol		
San Lorenzo River @ Sycamore Grove	464.3	165
San Lorenzo River @ Tait Street	246.7	177.9
Branciforte u/s of Carbonera	370.4	362.1
Carbonera u/s of Branciforte	260.4	190.9
Branciforte u/s of SLR	514.3	460.4
San Lorenzo River @ Trestle	151.4	168.7
Monthly Average	334.6	254.2
Stigmasterol		
San Lorenzo River @ Sycamore Grove	79.9	ND
San Lorenzo River @ Tait Street	63.1	21
Branciforte u/s of Carbonera	102.9	61.5
Carbonera u/s of Branciforte	65.3	ND
Branciforte u/s of SLR	124.4	88.8
San Lorenzo River @ Trestle	ND	51.7
Monthly Average	72.6	37.2
Caffeine		
San Lorenzo River @ Sycamore Grove	ND	ND
San Lorenzo River @ Tait Street	ND	ND
Branciforte u/s of Carbonera	ND	ND
Carbonera u/s of Branciforte	ND	ND
Branciforte u/s of SLR	ND	ND
San Lorenzo River @ Trestle	ND	ND

Table 2: Human and Avian Fecal Indicator ratios for 5/16/2016

	Ratios per Ahmed et al. (2011)		
	Coprastonal/ Cholestanol	Coprastonal/ (Coprastanol+ Cholestanol)	Cholestanol/ (Coprastanol+Cholestanol +Epicoprastanol)
Site	c/ch	c/(c+ch)	ch/(c+ch+e)
San Lorenzo River @ Sycamore Grove	0.24	0.19	72%
San Lorenzo River @ Tait Street	0.19	0.16	73%
Branciforte u/s of Carbonera	1.47	0.60	36%
Carbonera u/s of Branciforte	0.40	0.29	59%
Branciforte u/s of SLR	0.37	0.27	65%
San Lorenzo River @ Trestle	0.15	0.13	77%
Note: Ratios were calculated substituting a value equal to 1/2 the reporting limit for non-detect data.			
Human Fecal Indicator	>0.5 [Ahmed Ratio 1]	>0.7 [Ahmed Ratio 4]	
Avian Fecal Indicator			>67% [Ahmed Ratio 10]

Table 3: Human and Avian Fecal Indicator Ratios for 6/13/2016

	Ratios per Ahmed et al. (2011)		
	Coprastonal/ Cholestanol	Coprastonal/ (Coprastanol+ Cholestanol)	Cholestanol/ (Coprastanol+Cholestanol +Epicoprastanol)
Site	c/ch	c/(c+ch)	ch/(c+ch+e)
San Lorenzo River @ Sycamore Grove	0.25	0.20	67%
San Lorenzo River @ Tait Street	0.23	0.19	68%
Branciforte u/s of Carbonera	0.22	0.18	69%
Carbonera u/s of Branciforte	0.34	0.25	60%
Branciforte u/s of SLR	0.15	0.13	77%
San Lorenzo River @ Trestle	0.10	0.09	84%
Note: Ratios were calculated substituting a value equal to 1/2 the reporting limit for non-detect data.			
Human Fecal Indicator	>0.5 [Ahmed Ratio 1]	>0.7 [Ahmed Ratio 4]	
Avian Fecal Indicator			>67% [Ahmed Ratio 10]

Table 4: Fecal Indicator bacteria, 2016 Monitoring, May and June*

Consituents/Site ID	Measured level MPN/100mL by collection date	
Total Coliform (MPN/100 mL)	**5/16/2016**	**6/13/2016**
San Lorenzo River @ Sycamore Grove	1,500	1,314
San Lorenzo River @ Tait Street	1,046	1,918
Branciforte u/s of Carbonera	862	1,789
Carbonera u/s of Branciforte	1,650	2,382
Branciforte u/s of SLR	6,867	1,334
San Lorenzo River @ Trestle	537	10,462
Monthly Average	2,077	3,200
E. Coli (MPN/100 mL)		
San Lorenzo River @ Sycamore Grove	309	146
San Lorenzo River @ Tait Street	156	52
Branciforte u/s of Carbonera	250	187
Carbonera u/s of Branciforte	432	556
Branciforte u/s of SLR	556	161
San Lorenzo River @ Trestle	158	776
Monthly Average	310	313
Enterococcus (MPN/100 mL)		
San Lorenzo River @ Sycamore Grove	10	41
San Lorenzo River @ Tait Street	20	31
Branciforte u/s of Carbonera	183	213
Carbonera u/s of Branciforte	74	187
Branciforte u/s of SLR	63	86
San Lorenzo River @ Trestle	<5	63
Monthly Average	58.3	103.5

*All water quality standard exceedances for fecal indicator bacteria are highlighted based on following criteria: Total coliform levels should be <10,000 MPN/100 mL based on San Francisco Basin Plan; E. coli should be <410 MPN/100 mL and Enterococcus should be <130 MPN/100 mL based on USEPA 2012 Recreational Water Quality Criteria.

Appendix B. List of Potential Bacteria Sources by Category

HUMAN WASTE
Leaky Failing Septic Systems
Leaky Sewer Pipes (Exfiltration)
Sanitary sewer overflows (SSOs)
Illegal Connections
Homeless Encampments
Bathers
Dumpsters
Trash cans
Porta-Potties
Pools
Hot Tubs
Gray Water Discharges
RVs (mobile)
Garbage trucks
Septage trucks
Ocean Inflow
MS4s Infrastructure - Biofilm/Regrowth
ANTHROPOGENIC NON-HUMAN
Solid/Liquid Waste
Dumpsters
Trash Cans
Grease Bins
Green Waste
Compost
Garbage Trucks
Washwater from above sources
Litter
Vectors
Commercial/Industrial
Food Processing
Outdoor Dining/Fast Food
Domestic Animals
Pets
Livestock
Agriculture
Livestock
Manure/Manure Re-use
Irrigation Tailwater
Soil and Decaying Plant Matter
Landscaping
Green Waste
Soil
Manure/Compost
Secondary Wildlife
Rodents, Racoons, Rabbits, etc.
Birds (Gulls, Pigeons, etc.)
Ocean Inflow
MS4s Infrastructure - Biofilm/regrowth
NON-ANTHROPOGENIC
Soil - Streambank Erosion
Soil - Windblown Erosion
Wildlife (Birds and Others)
Plants
Ocean Inflow
Wrackline (Birds, Flies, Dogs and Plants)
MS4s Infrastructure - Biofilm/regrowth