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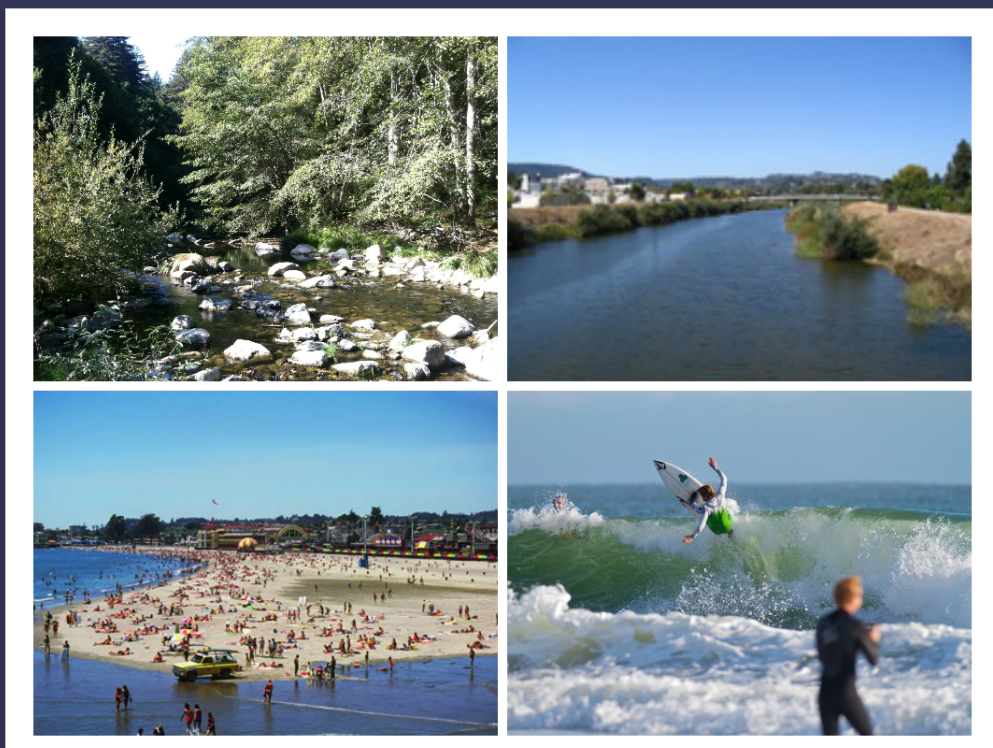
Bacteria Pollution Analysis 2000 - 2014

Lower San Lorenzo River Watershed

Santa Cruz County, CA



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A geospatial analysis of fecal indicator bacteria concentrations in coastal riparian systems

Lower San Lorenzo River Watershed

Santa Cruz County, CA

Water Year 2014

Report and analysis done by:

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Data provided by:

Santa Cruz County, the City of Santa Cruz, the Central California Regional Water Quality Control Board, and the Coastal Watershed Council.

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FORWARD

In the city of Santa Cruz, California, coastal water quality has continued to face impairment from the presence of fecal indicator bacteria (FIB), such as *Escherichia coli (E. coli)* and *Enterococci* (County of Santa Cruz$_A$ 2012). Santa Cruz's Cowell Beach and surrounding areas are routinely classified as impaired throughout the year based on the exceedance of total maximum daily loads (TMDLs), set forth by the Environmental Protection Agency (EPA), for FIB concentrations (County of Santa Cruz$_A$ 2012; EPA 2013). According to a study done by the non-profit Heal the Bay, Cowell Beach has been listed as one of the "Top 10 Dirtiest Beaches" in California, with multiple years being ranked as the dirtiest beach in California, based on FIB bacteria concentrations (HTB 2013). In addition to Cowell Beach, the San Lorenzo River has been classified by the EPA as a 303(d) listed impaired water body, due to multiple TMDL exceedances, including FIB concentrations (County of Santa Cruz$_A$ 2012; EPA 2013).

The area of Cowell Beach, which is located directly north of the San Lorenzo River mouth, poses multiple cultural, ecological, and economical values for the City of Santa Cruz and surrounding areas. Cowell Beach and the San Lorenzo River mouth are located within the Monterey Bay National Marine Sanctuary (MBNMS) (MBNMS 2014). In addition, they lie within a World Surfing Reserve, established by Save the Waves Coalition, with the goal of "preserving wave breaks and their surrounding areas by recognizing and protecting the key environmental, cultural, economic, and community attributes of surfing areas" (WSR 2014). Culturally, the area of Cowell Beach and the San Lorenzo River mouth has significant value for the City of Santa Cruz and the history of surfing, being known as the first place on mainland North America that experienced surfing in 1885 (SurferToday 2015). Lastly, the Santa Cruz Beach Boardwalk, one of Santa Cruz's greatest tourist attractions, is located directly between the San Lorenzo Rivermouth and Cowell Beach. This area receives an estimated 1.5 to 2 million visitors per year, many of whom regularly utilize the beaches for swimming and recreation, creating a potentially significant public health threat for the community of Santa Cruz and those who visit the area (Schiffrin 1986). This may have a direct impact on the economic value of this tourism asset, which provides 1,600 seasonal and full-time jobs annually to the Santa Cruz community, and generates the most visitation of the $513

million tourism industry within Santa Cruz (SCBB 2015; Santa Cruz [Date unknown]).

Though a study has been done by Stanford University's Coastal Water Quality Research Group to assess marine-based and storm water inputs associated with Cowell Beach (Russell et al. 2013), none have been done to assess terrestrial sources along the San Lorenzo River and its associated storm water systems, despite continual evidence of high bacteria levels at the San Lorenzo River mouth (HTB 2013; County of Santa CruzA 2012). Determining the sources and locations of the FIB pollution inputs into the San Lorenzo River, Cowell Beach, and surrounding areas is imperative to protecting human health associated with recreation within these waterbodies, as well as preserving the economic, cultural, and ecological value of the area.

Surfrider Foundation

Surfrider Foundation is an international environmental 501(c) non-profit that focuses on the protection and preservation of ocean, beach, and coastal environments. It was founded in 1984 in Malibu, California with a vision to protect the environmental health and public access of oceans and beaches and has grown to an organization with over 50,000 members and has 90 chapters worldwide (Surfrider Foundation 2015).

Surfrider Foundation, Santa Cruz Chapter, originally founded in 1991, has developed one of the largest community-ran coastal water quality monitoring programs throughout the international organization. Surfrider Foundation, Santa Cruz Chapter has assisted in this project through providing grant funding to the authors/primary investigator of this study and through providing their water quality analysis laboratory and instruments for the duration of the study.

Acknowledgments

A special thanks goes out to Surfrider Foundation, Santa Cruz Chapter and the Water Resources Institute of California State University for their professional and monetary support of this project. In addition, the Coastal Watershed Council, including the San Lorenzo River Alliance Water Quality Working Group, and the Science and Environmental Policy department at CSU Monterey Bay offered great support and guidance throughout the research. Lastly, a few key people made this project possible, including Sarah Mansergh, Co-Chair of Surfrider Foundation, Santa Cruz Chapter; Doug Smith, CSUMB

Science and Environmental Policy program Chair and professor in CSUMB's Applied Marine and Watershed Science MSc program; Rachel Roehl, Surfrider Foundation, Santa Cruz Chapter volunteer, and Samuel B. Blakesley, Surfrider Foundation, Santa Cruz Chapter Blue Water Task Force Coordinator and primary research assistant for the study.

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ABSTRACT

In the county of Santa Cruz, California, coastal and terrestrial water quality have continued to face impairment from the presence of FIB, based on exceedances of TMDLs set for the by the EPA and through analyses conducted by the non-profit Heal the Bay (County of Santa Cruz$_A$ 2012; HTB 2013). To assess the presence and concentration of terrestrial-based FIB within the lower San Lorenzo River watershed and its relationship to FIB concentrations in its associated coastal areas, analyses were conducted for historical and recent concentrations of FIB. The historical analysis evaluated 3,706 FIB water samples within the lower San Lorenzo River watershed from 2000 to 2013. Average geometric means were calculated for samples taken during dry periods (no precipitation) and wet periods (precipitation present). The sites with the greatest average FIB concentrations over the study period included Branciforte Creek at San Lorenzo River, San Lorenzo River at Laurel Street Bridge, and the San Lorenzo Rivermouth at the Trestle for dry samples and San Lorenzo River at Laurel Street Bridge, Branciforte Creek at San Lorenzo River, and the San Lorenzo Rivermouth at the Trestle for wet samples. The results indicated that the primary area of average FIB concentration increase along the San Lorenzo River was down stream of the San Lorenzo River and Sycamore Grove sample site with a noticeable increase beginning at San Lorenzo River and Branciforte Creek confluence. Based on these results, a field analysis was done during the 2014 WY, through 10 terrestrial sites being sampled and tested for *E. coli* twice a month and three coastal sites being sampled and tested for *Enterococci* weekly. A total of 354 samples were tested over the 2014 WY, with the results of the samples being separated into "wet" and "dry" samples based on the presence, or lack of presence, of precipitation (>0.1 in.) within a 72-hour period. The median FIB concentrations were calculated at each sample site for wet and dry periods and the results were illustrated using graduated symbology in GIS. To determine the correlation between precipitation and FIB concentrations, a regression analysis was performed using a goodness-of-fit assessment, which depicted no statiscally significant correlation between the two variates. All sites within the study exceeded TMDL standards for fluvial and coastal water samples numerous times during the study period, with the greatest exceedances occurring at the San Lorenzo River at Water Street Bridge, the Branciforte Creek and San Lorenzo River confluence, and the San Lorenzo Rivermouth. Additional research is needed to determine the source(s) of the contamination and their pathways into the

fluvial systems through microbrial source tracking and the evaluation of other abiotic environmental interactions, such as seawater intrusion and the presence of sandbar barrier development at the San Lorenzo Rivermouth.

Impairment of Local Water Bodies

The County of Santa Cruz is located within the Monterey Bay National Marine Sanctuary (MBNMS) and the Santa Cruz World Surfing Reserve (SCWSR), making it's coastal zone a highly valuable asset to marine and coastal ecosystems, commercial/recreational fishing and other recreational uses, and the local economy, with Santa Cruz County beaches generating approximately 73% of the tourism attraction annually (MBNMS 2014; WSR 2014; Santa Cruz 2010, p. 16). Despite being part of the MBNMS and SCWSR, the County of Santa Cruz has been facing challenges in maintaining water quality objectives in its freshwater and coastal environments (County of Santa Cruz$_A$ 2012; County of Santa Cruz 2014).

In 2013, Heal The Bay, a 501(c)(3) nonprofit, completed it's 2012-2013 Annual Beach Report Card, which listed Cowell Beach in Santa Cruz as the second dirtiest beach in California, based on pathogen impairments (HTB 2013). Out of the last five "Annual Beach Report Cards" (2009-2013), Cowell Beach has been either the dirtiest or second dirtiest beach in the State for four out of the five reports (2010-2013), with multiple beaches within the County being on the "Top-10 Dirtiest Beaches" list for two out of the five reports (2010 and 2011) (HTB 2013). In addition to these reports, the County of Santa Cruz has multiple permanently-posted high bacteria advisories for six beaches

Image 1. Confluence of the San Lorenzo River and the Monterey Bay at Main Beach, Santa Cruz, CA.

within the County, as well as additional temporary advisories for

other beaches throughout the County year-round (County of Santa Cruz 2014).

Research is currently being done by Russell et al. (2013) to address the issues of the pathogen impairment at Cowell Beach, with a focus on investigating potential fecal indicator bacteria (FIB) sources and the relative contributions for the potential sources. The results of this study indicate that the FIB sources are predominantly terrestrial, with the main contributing factors being *Enterococci* bacteria stored in sand and Escherichia coli (*E. coli*) from local groundwater sources (Russell et al. 2013). Though this research has informed potential sources of FIB in the Cowell area, it ruled out the San Lorenzo River as a potential source of the pathogen impairment to Cowell Beach, based on the results from samples taken during a 3-month period in 2011 and 2012 (Russell et al. 2013). Though the San Lorenzo River was ruled out as a potential source of FIB in the Cowell area, the San Lorenzo River and Lagoon, which are listed by the United States Environmental Protection Agency (EPA) as 303(d) impaired water bodies, are potentially contributing to the impairment of Main Beach, Cowell Beach, and surrounding areas, with continual pathogen TMDL exceedances occurring at the San Lorenzo Rivermouth year-round (County of Santa Cruz 2014).

Total Maximum Daily Load

Section 303(d) of the Clean Water Act (CWA) requires states, territories, and authorized tribes to develop list of impaired waters (EPA 2014). The listing of these impaired water bodies are based on TMDL exceedances, with the TMDLs being based on "a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards" (EPA 2014). In California, TMDLs are determined by either the EPA or Regional Water Quality Control Boards (RWQCBs) (SWRCB [date unknown]). For the County of Santa Cruz, which falls under jurisdiction of the State's Central Coast Regional Water Quality Control Board (CCRWQCB), pathogen TMDLs/numeric targets are set as follows:

Table 1. Numeric targets for fecal indicator bacteria in freshwater and coastal recreational areas. FIB: Fecal Indicator Bacteria; MPN: Most Probable Number.

FIB	MPN / 100mL	Comments
Total coliform	10,000	Single sample
	1,000	Single sample - ratio of fecal/total coliform >0.1
	1,000	30-day logarithmic mean of ≥ 5 weekly samples
Fecal coliform	400	Single sample
	200	30-day logarithmic mean of ≥ 5 weekly samples
E. coli	235	Single sample
	126	30-day logarithmic mean of ≥ 5 weekly samples
Enterococcus	104	Single sample
	35	30-day logarithmic mean of ≥ 5 weekly samples

Along with coastal water quality impairments, multiple freshwater/estuarine water bodies are 303(d) listed by the EPA based on TMDL impairments for pathogens and sediment (EPA 2013). The San Lorenzo River and Lagoon, which is one of the water bodies 303(d) listed for pathogen impairment, discharges into the Main Beach coastal zone in Santa Cruz, which neighbors Cowell Beach, making it a potential concern for public health in the area's highly-recreated coastal waters (EPA 2013).

Connection to Public Health

FIB, such as *E. coli* and *Enterococci*, are measured in public waterbodies as an indication of the presence and potential threat of pathogenic bacteria, viruses, and protozoans (EPA 2012). These pathogenic viruses and organisms have been found to cause bacteriological infections and diseases, such as typhoid, cholera, and bacterial dysentery, as well as enteroviruses and pathologies, such as aseptic meningitis, encephalitis, and myopericarditis, as well as many others (NHDES 2011, Leveque and Laurent 2008). Since it would not be feasible to test for all the numerous potentially harmful diseases and viruses within a waterbody, regulatory agencies rely on FIB as an indicator for the possibility and likelihood of their presence (EPA 2012).

Focus and Scope

The primary focus of this report is to assess the feasibility of locating non-point source (NPS) FIB pollution inputs within riparian systems and coastal areas through the use of Geographic Information Systems (GIS), precipitation and stream flow

patterns, and FIB concentration gradients during wet and dry conditions, based on the presence of precipitation. Locating areas of pollution input and the associated potential sources will offer a focused approach to management agencies in the mitigation of NPS FIB pollution within riparian zones and their associated coastal areas.

Determining the feasibility of locating NPS FIB pollution inputs and potential sources will be done through two related assessments. the first being a historical analysis of FIB concentration data provided by Santa Cruz County Department of Environmental Health Services, within the lower San Lorenzo River watershed. This analysis will assess data collected between the water years (WY) of 2000 to 2013, which will provide a long term trend in FIB concentrations within the area. The second assessment will cover a field study analysis that was completed over the 2014 WY. This analysis will provide an understanding of current FIB patterns and how they may relate to terrestrial inputs, such as storm water drain systems, homeless encampments, and associated tributaries. Both assessments will incorporate GIS and statistical analysis, providing an understanding of FIB concentration patterns that span temporal and spatial scales within the lower San Lorenzo River watershed.

The goal of this report is to offer a framework for FIB sourcing, tracking, and prevention in urban and suburban environments, as well as offer an understanding to management agencies of current and historical FIB concentration trends in relation to FIB within the lower San Lorenzo River watershed and associated coastal areas in Santa Cruz County, CA.

HISTORICAL ANALYSIS

To assess past trends in bacteria pollution within the San Lorenzo River watershed, a historical analysis was performed for data collected within the lower San Lorenzo River watershed from 2000 WY to 2013 WY. The objective of the historical analysis was to gain insight on areas of continued impairment, which would yield a greater understanding for site selection and analysis for the 2014 WY study.

Methods

Data Collection

Data was collected from the Santa Cruz County Environmental Health Services Department for fecal coliform and *E. coli* concentrations within the lower San Lorenzo River watershed, from the San Lorenzo River at Big Trees Road to the San Lorenzo River mouth. Though multiple sites were tested by SCCEHS from 2000 to 2013, only sites with data that were temporally representative of the 2000 to 2013 study period were used in the analysis.

Analysis

The data were analyzed by calculating the average (per year) fecal coliform and *E. coli* concentrations at each site from 2000-2013. The data were separated into "Wet" and "Dry" samples, with "Wet" samples being those taken during a precipitation level greater than zero, and "Dry" samples being those taken during a precipitation level of zero. To avoid the effects of "outliers", the days composing the highest 5% of concentrations over the 2000-2013 period were not used in the analysis.

Once the data was collected and organized by precipitation level for the sites within the study area, the average was determined by calculating the geometric mean of the data for each water year. These results were then analyzed and depicted using graduated symbology in the GIS software, ArcGIS by ESRI.

A total of 3,706 samples, taken at eight sites within the lower San Lorenzo River watershed, were analyzed. The eight sites included San Lorenzo River at Big Trees Road, San Lorenzo River at Sycamore Grove, San Lorenzo River at Tait Street, Branciforte Creek at Isbel Drive, Carbonera Creek at Branciforte Creek, Branciforte Creek at San Lorenzo River, San Lorenzo River at Laurel Street Bridge, and the San Lorenzo River at the Trestle, located next to the San Lorenzo rivermouth. These sites

were chosen based on the quantity of samples taken during the study period and their location in regards to the area of study.

Results

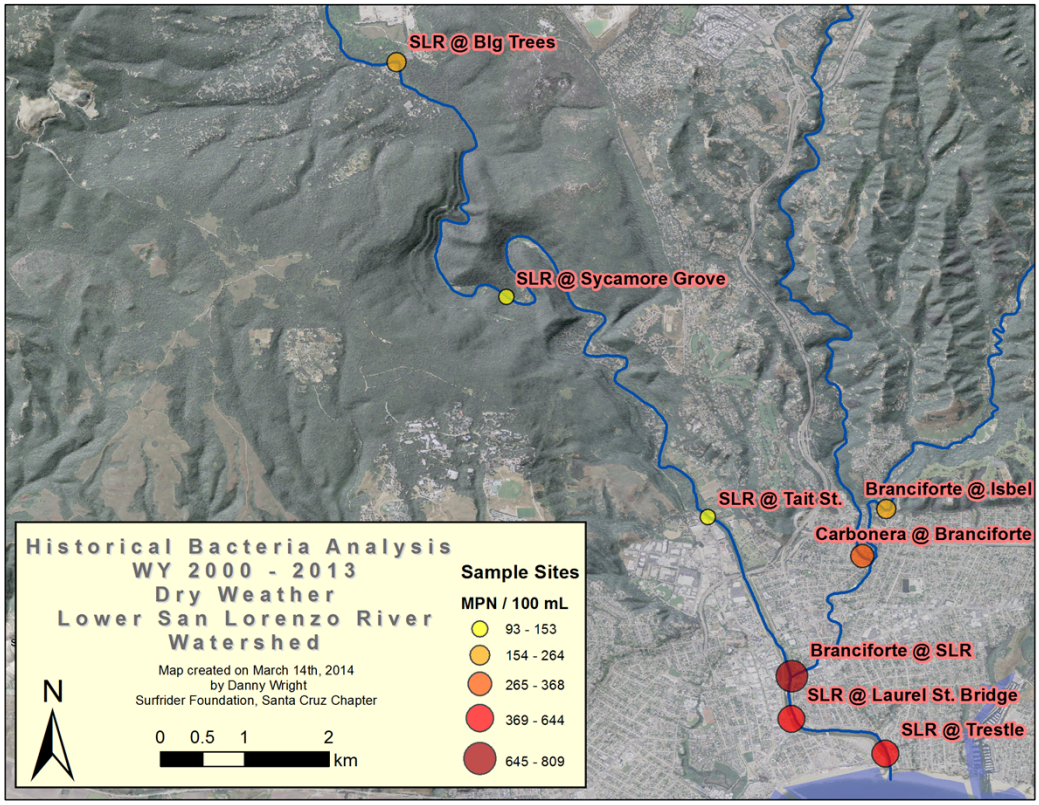
From 2000WY – 2013WY, the average FIB concentrations were 165 MPN/100ml for dry samples and 207 MPN/100ml for wet samples taken at San Lorenzo River at Big Trees, 61 MPN/100ml for dry samples and 106 MPN/100ml for wet samples taken at San Lorenzo River at Sycamore Grove, 95 MPN/100ml for dry samples and 148 MPN/100ml for wet samples taken at San Lorenzo River at Tait Street, 194 MPN/100ml for dry samples and 201 MPN/100ml for wet samples taken at Branciforte Creek at Isbel Drive, 248 MPN/100ml for dry samples and 243 MPN/100ml for wet samples taken at Carbonera Creek at Branciforte Creek, 475 MPN/100ml for dry samples and 362 MPN/100ml for wet samples taken at Branciforte Creek at San Lorenzo River, 389 MPN/100ml for dry samples and 587 MPN/100ml for wet samples taken at San Lorenzo River at Laurel Street Bridge, and 303 MPN/100ml for dry samples and 319 MPN/100ml for wet samples taken at the San Lorenzo River at the Trestle (Table 2).

Table 2. Average geometric means of Fecal Indicator Bacteria (FIB) for wet and dry periods from 2000WY – 2013WY.

Sample Site	Average FIB Geometric Mean (Dry)	Average FIB Geometric Mean (Wet)
San Lorenzo River at Big Trees	165	207
San Lorenzo River at Sycamore Grove	61	106
San Lorenzo River at Tait Street	95	148
Branciforte Creek at Isbel Drive	194	201
Carbonera Creek at Branciforte Creek	248	243
Branciforte Creek at San Lorenzo River	475	362
San Lorenzo River at Laurel Street Bridge	389	587
San Lorenzo Rivermouth at Trestle	303	319

The sites with the greatest average FIB concentrations over the study period included Branciforte Creek at San Lorenzo River, San Lorenzo River at Laurel Street Bridge, and the San Lorenzo Rivermouth at the Trestle for dry samples and San Lorenzo River at Laurel Street Bridge, Branciforte Creek at San Lorenzo River, and the San Lorenzo Rivermouth at the Trestle for wet samples (Fig. 1). Precipitation increased average FIB concentrations on sites along the San Lorenzo River, whereas sites along Branciforte Creek and Carbonera Creek had similar

A



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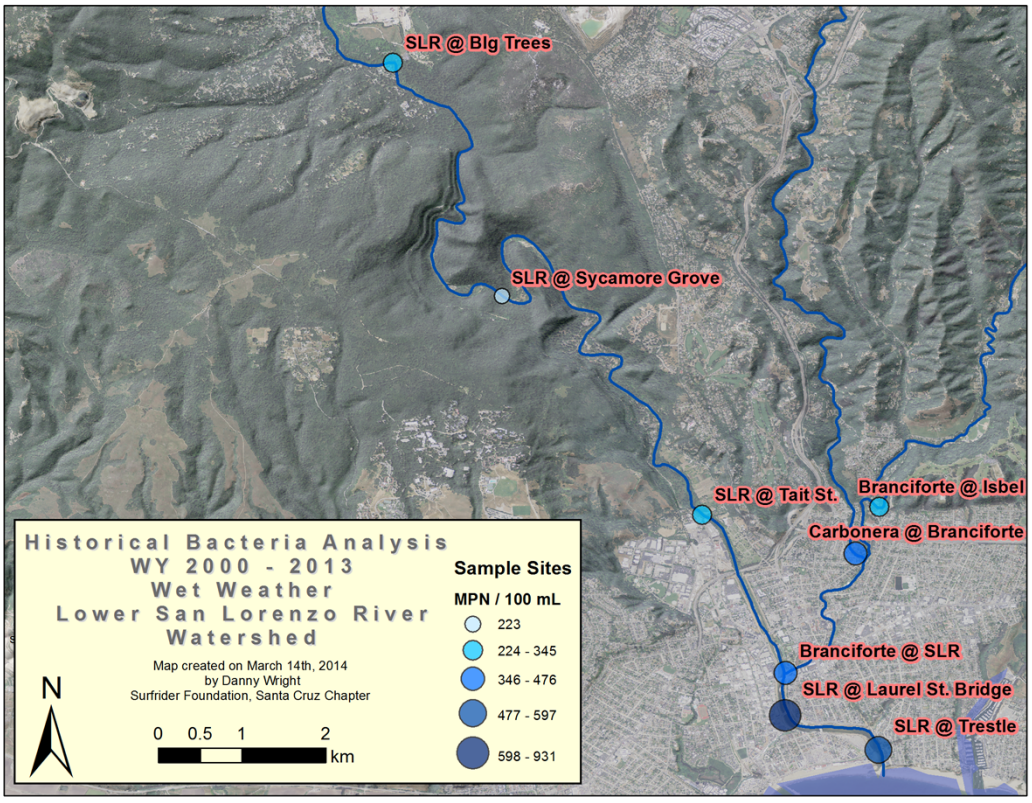


Figure 1. Average FIB concentration trends during dry (a.) and wet (b.) weather sampling periods.

or greater average FIB concentrations during dry periods (no precipitation).

Conclusion

The results indicated that the primary area of average FIB concentration increase along the San Lorenzo River was down stream of the San Lorenzo River and Sycamore Grove sample site with a noticeable increase beginning at San Lorenzo River and Branciforte Creek confluence. These results offer insight into the areas of average FIB concentration increases within the watershed, the effect of precipitation on the individual water bodies and sample site locations, and offer direction for determining sample site locations for the 2014 study.

WATER YEAR 2014 ANALYSIS

Methods

Study Area

The County of Santa Cruz is located in Central California, approximately 65 miles south of San Francisco, forming the northern section of the Monterey Bay (County of Santa CruzB 2012). Santa Cruz County has a Mediterranean climate with a diverse background of habitat types and ecosystems, ranging from redwood forests, coastal shrubland, riparian and estuarine habitats, and beach and rocky/sand bottom intertidal ecosystems. As of 2013, the County of Santa Cruz had a population of approximately 269,419 people (USCB 2014).

This analysis primarily focuses on the lower San Lorenzo River watershed in Santa Cruz County, CA, ranging from Henry Cowell Redwoods State Park to the San Lorenzo Rivermouth, including sites on the lower regions of Branciforte Creek and Carbonera Creek (Fig. 2). This area is made up of different land cover characteristics, including undeveloped coastal redwood forests upstream of the San Lorenzo River, suburban development along the Branciforte Creek and Carbonera Creek tributaries, and developed urban regions located in the lower regions of the San Lorenzo River.

Data Collection

Eight sites along the San Lorenzo River and one site located on both the Carbonera Creek and Branciforte Creek were sampled for *E. coli* bacteria. In addition, three sites between Cowell Beach and the San Lorenzo River mouth were tested for *Enterococcus* bacteria. Sample site selection was determined through the results of the 2000-2013 historical analysis, land use and land cover, and through the use of spatial intervals that would be representative of the area of focus.

The water samples were taken using sterile Whirl-Pak sample bags, incorporating sterile-sampling procedures. To fulfill quality control standards set forth by the Environmental Protection Agency (EPA), internal field duplicates were taken at each site, external field duplicates were tested monthly, and a field blank was taken during each sampling period (EPA 2012). The samples were tested at the Surfrider Foundation, Santa Cruz Chapter laboratory, using IDEXX Laboratories *E. coli* and *Enterococci* testing products, which have been approved by the

EPA as a sufficient bacteria indication and monitoring method (EPA 2002).

Statistical Analysis

The data was analyzed using Microsoft Excel 2008. The data was organized by the location, date, and time of the sample. *E. coli* and Total Coliform concentrations were used for the fluvial sites and *Enterococcus* concentrations were used for the coastal sites. Discharge (cfm) and gage height (ft.) was listed for each fluvial site sample, and precipitation levels were listed for both coastal and fluvial site samples. To determine the influence of precipitation on bacteria concentrations, precipitation levels were listed using a three day (72 hour) sum of local precipitation preceding the sample collection time. Since very low levels of precipitation can be measured by the gage, only a three day sum value of 0.10 inches or grater were classified as "wet weather" samples, with all values less than a three day sum of 0.10 inches classified as "dry weather" samples.

Since the data had a skewed distribution, presence of outliers, and was effected by multiple environmental processes (i.e. precipitation, discharge, anthropogenic influences, etc...), the data was assumed to be non-normal (See Appendix). To determine the average concentrations that would best represent each sample site in dry and wet weather periods, the median was calculated for each site's sample set. The median of the data was used instead of a geometric mean since low values of the FIB concentrations (<10 MPN) were not precise due to testing method resolution and fell between a range of 0 to 10 MPN; since the geometric mean is determined by using a product-root function (APPENDIX), assumptions of FIB concentrations less than 1 MPN significantly affect the resulting geometric mean and cannot result in a real number using a value of zero. Using the median of data sets allowed the inclusion of outlying data points in the analysis when determining a FIB concentration value that would be representative of each site.

Geospatial Analysis

Geospatial Analysis was done using the Geographic Information System (GIS) software, ArcGIS 10.1 by ESRI (citation). Map layer data was provided by the United States Department of Agriculture (USDA), the United States Geological Survey (USGS), the City of Santa Cruz Information Technology Department, and Santa Cruz County Geographic Information Systems Department. Coordinates of each site were determined using a Trimble GPS field computer with Terrasync software.

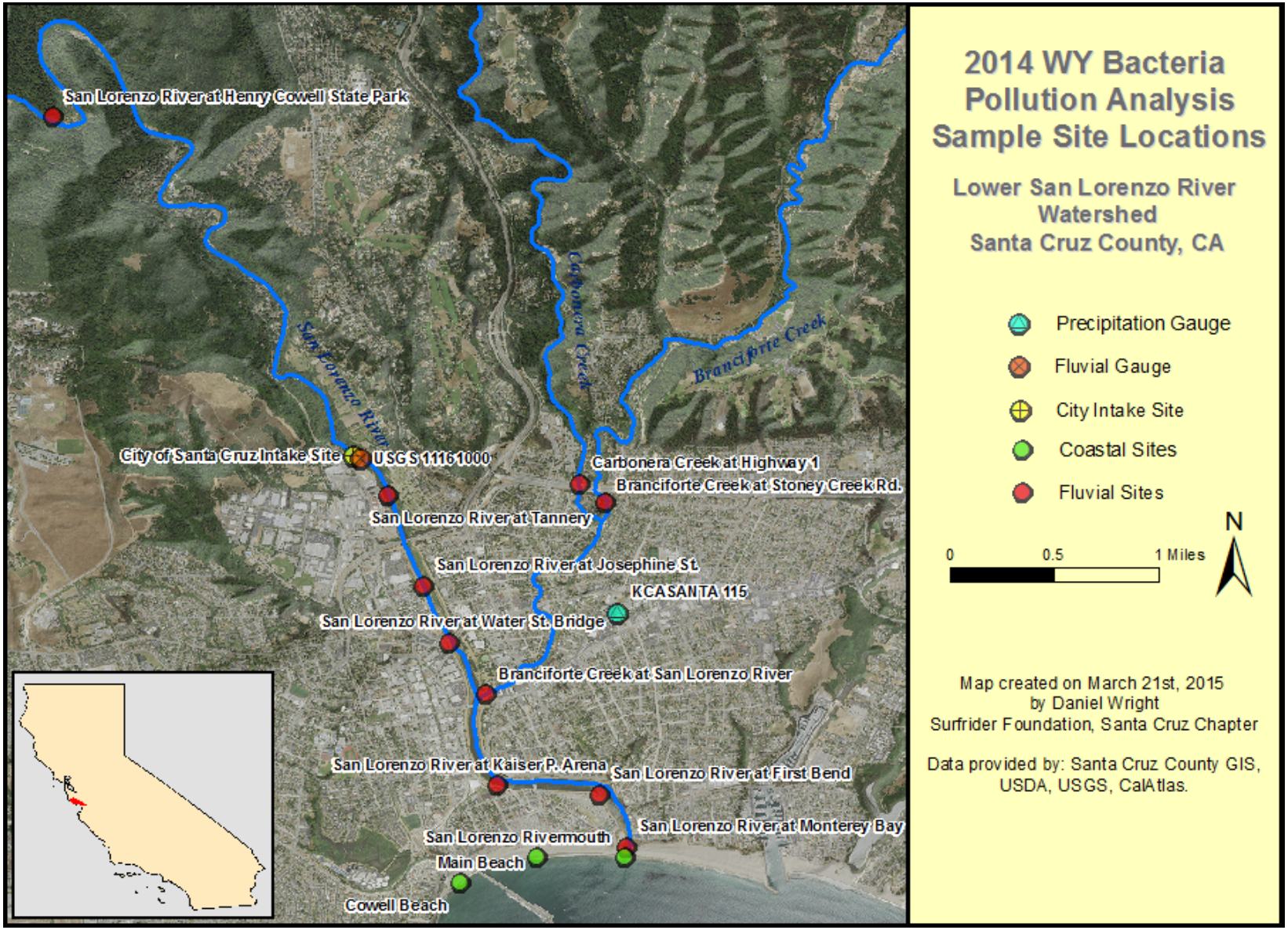


Figure 2. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

Results

Statistical Analysis

A total of 354 samples were taken over the course of the study period. The fluvial sites with the greatest average FIB concentrations were the San Lorenzo River at Monterey Bay for dry weather samples (148 MPN/100 ml) and Branciforte Creek at San Lorenzo River for the wet weather samples (2,098 MPN/100 ml) (Table 3). The fluvial sites with the least average FIB concentrations were the San Lorenzo River at Henry Cowell Redwoods State Park for dry weather samples (10 MPN/100 ml) and the San Lorenzo River at Josephine Street for wet weather samples (31 MPN/100 ml). The coastal site with the greatest average FIB concentrations was the San Lorenzo Rivermouth for both dry weather samples (62 MPN/100 ml) and wet weather samples (974 MPN/100 ml).

b.

Table 3. Average FIB (MPN/100ml) during wet and dry weather sampling for fluvial (a) and coastal (b) sample sites.

a.

Sample Site	Average EC (Dry)	Average EC (Wet)
San Lorenzo River at Henery Cowell Redwoods State Park	10	272
San Lorenzo River at Santa Cruz Tannery	85	428
San Lorenzo River at Josephine Street	47	31
San Lorenzo River at Water Street Bridge	102	638
Carbonera Creek at CA Highway 1	52	41
Branciforte Creek at Stoney Creek Road	110	41
Branciforte Creek at San Lorenzo River	58	2098
San Lorenzo River at Kaiser Permenante Arena	36	1664
San Lorenzo River at First Bend	69	51
San Lorenzo River at Monterey Bay	148	96

Sample Site	Average Enterococcus (Dry)	Average Enterococcus (Wet)
San Lorenzo River Mouth	62	974
Main Beach	46	110
Cowell Beach	20	41

The fluvial site with the greatest percentage of samples exceeding the TMDL requirement of 235 MPN/100 ml was the San Lorenzo River at Water Street Bridge, with 12 samples exceeding 235 MPN/100 ml out of a total of 25 samples collected (48% exceedance) (Table 4). The fluvial sites with the lowest percentage of samples exceeding the TMDL requirement of 235 MPN/100 ml were the San Lorenzo River at Henry Cowell Redwoods State Park and the San Lorenzo River at Josephine

Street, both having 3 samples exceeding 235 MPN/100 ml out of a total of 25 samples collected (12% exceedance). The coastal site with the greatest percentage of samples exceeding the TMDL requirement of 104 MPN/100 ml was the San Lorenzo Rivermouth, with 15 samples exceeding 104 MPN/100 ml out of a total of 38 samples collected (39% exceedance) (Table X). The

b. coastal site with the lowest percentage of samples exceeding the TMDL requirement of 104 MPN/100 ml was Cowell Beach, with 5 samples exceeding 104 MPN/100 ml out of a total of 36 samples collected (14% exceedance).

Table 4. Number of samples within each site exceeding TMDL standards throughout the study period for fluvial (a) and coastal (b) sample sites.

a.

Sample Site	Number of Samples Exceeding E. coli 235 MPN/100ml	Number of Samples Collected	Percentage of Exceedence
San Lorenzo River at Henry Cowell Redwoods State Park	3	25	12%
San Lorenzo River at Santa Cruz Tannery	5	25	20%
San Lorenzo River at Josephine Street	3	25	12%
San Lorenzo River at Water Street Bridge	12	25	48%
Carbonera Creek at CA Highway 1	4	23	17%
Branciforte Creek at Stoney Creek Road	6	23	26%
Branciforte Creek at San Lorenzo River	11	25	44%
San Lorenzo River at Kaiser Permenante Arena	6	25	24%
San Lorenzo River at First Bend	7	25	28%
San Lorenzo River at Monterey Bay	7	24	29%

Sample Site	Number of Samples Exceeding Enterococcus 104 MPN/100ml	Number of Samples Collected	Percentage of Exceedence
San Lorenzo River Mouth	15	38	39%
Main Beach	11	35	31%
Cowell Beach	5	36	14%

To determine the correlation between precipitation and FIB concentrations, a regression analysis was performed using a goodness-of-fit assessment. The R-square values were calculated for each site to relate the two variates, which resulted in minimal correlation between them at the majority of sites. The greatest correlation between precipitation and FIB concentration was found at the San Lorenzo River at Henry Cowell Redwoods State Park sample site, with an R-squared value of 0.86932 (Fig. 3).

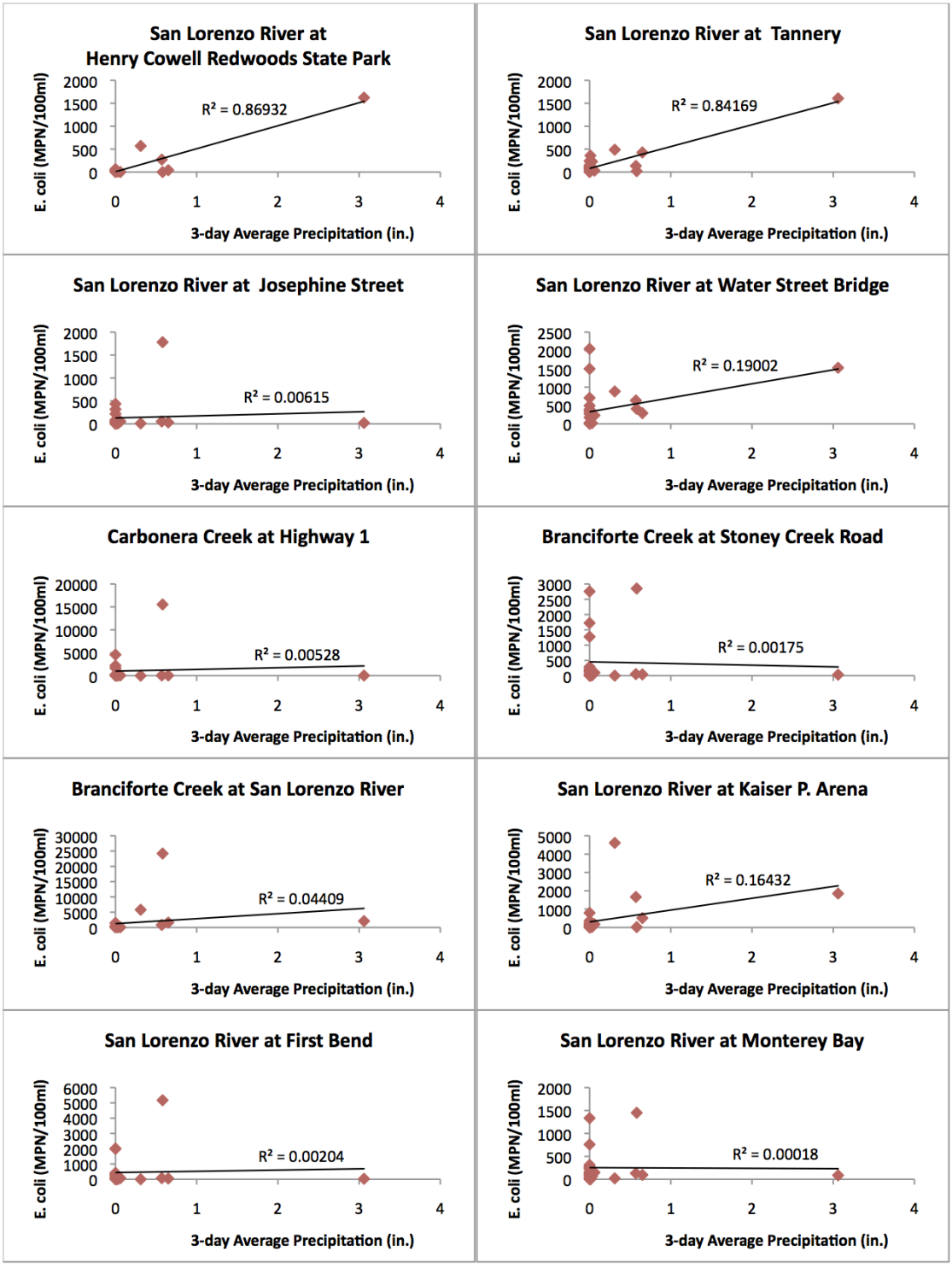


Figure 3. Regression analyses showing goodness-of-fit between E. coli concentrations and 3-day average precipitation at each fluvial sample site.

In addition to the regression analysis, line charts relating the dependent variable, FIB concentration (MPN/100ml), to independent variables precipitation (in.), discharge (cfs), and gauge height (ft), were developed to see how the variables interacted over the time of the study period (Appendix I).

Geospatial Analysis

FIB concentration trends were illustrated at each coastal and fluvial site for both wet and dry periods using the averages calculated in the statistical analysis. Each site depicted the relationship of average FIB concentration patterns during wet and dry periods between sample sites using graduated symbology (Figs. 4-7).

Additional maps were made to illustrate the relationship between sewer pipe systems, storm drain systems, and land zoning to the coastal and fluvial sample sites within the study area (Appendix I).

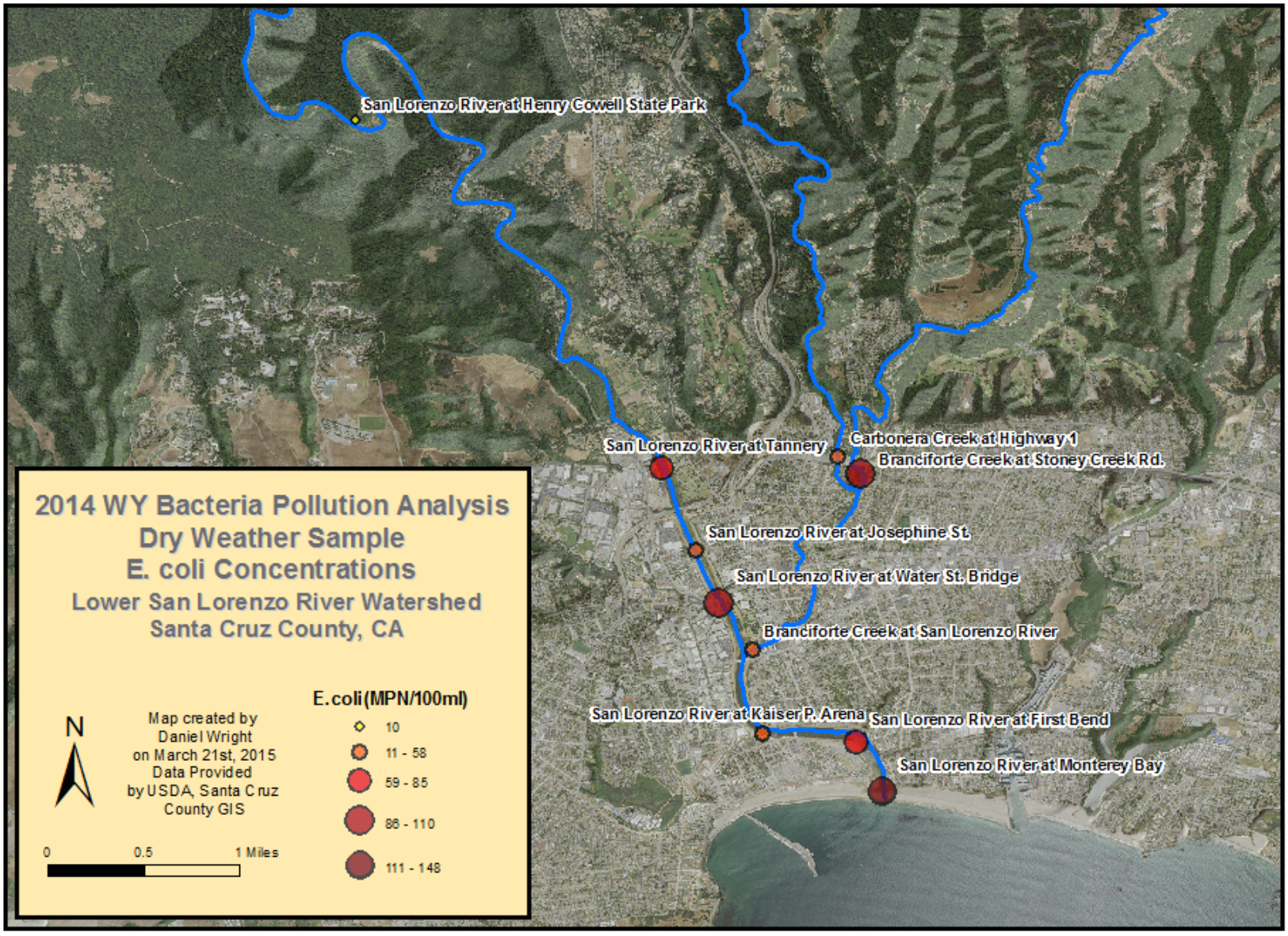


Figure 4. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

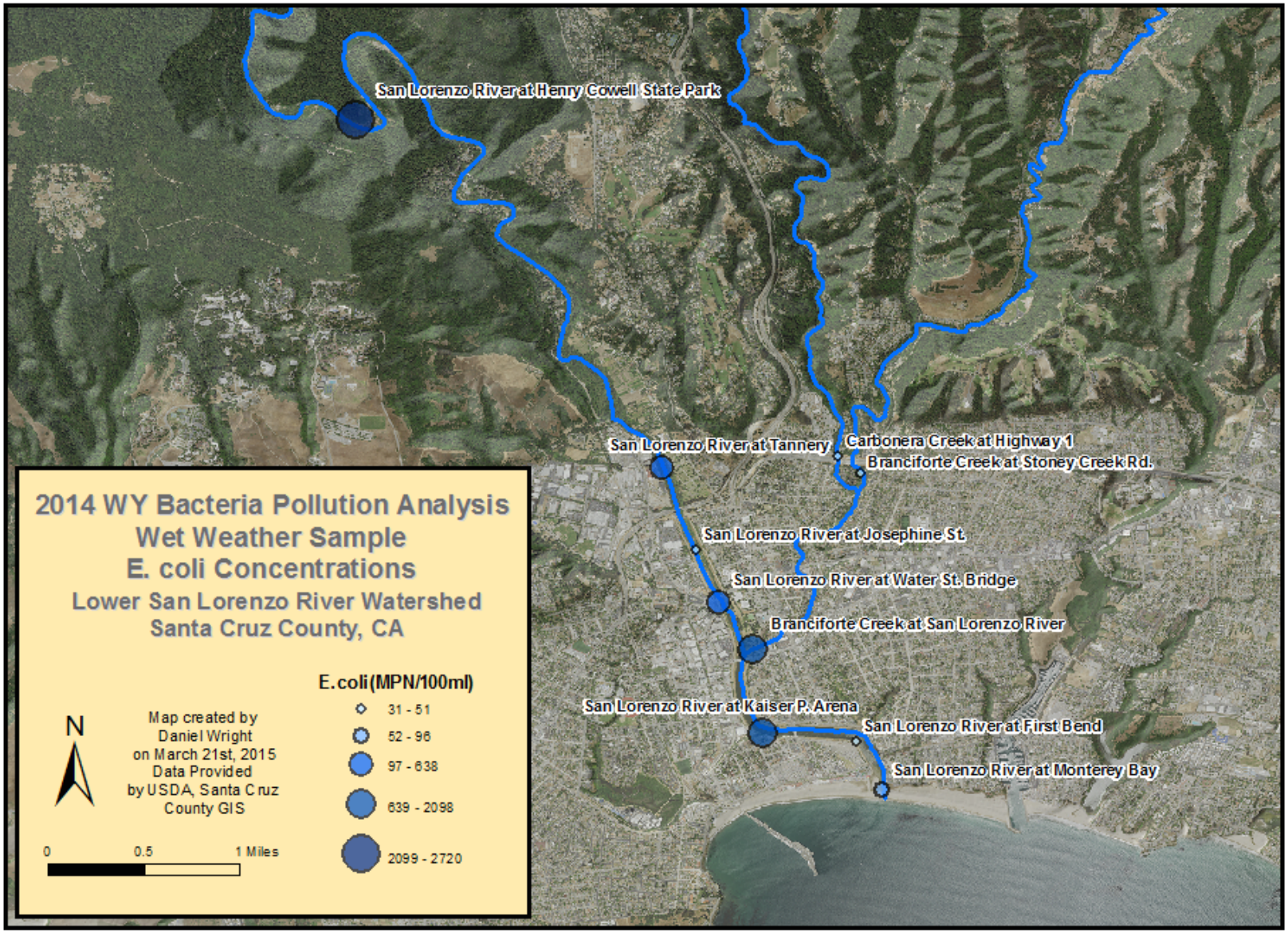


Figure 5. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

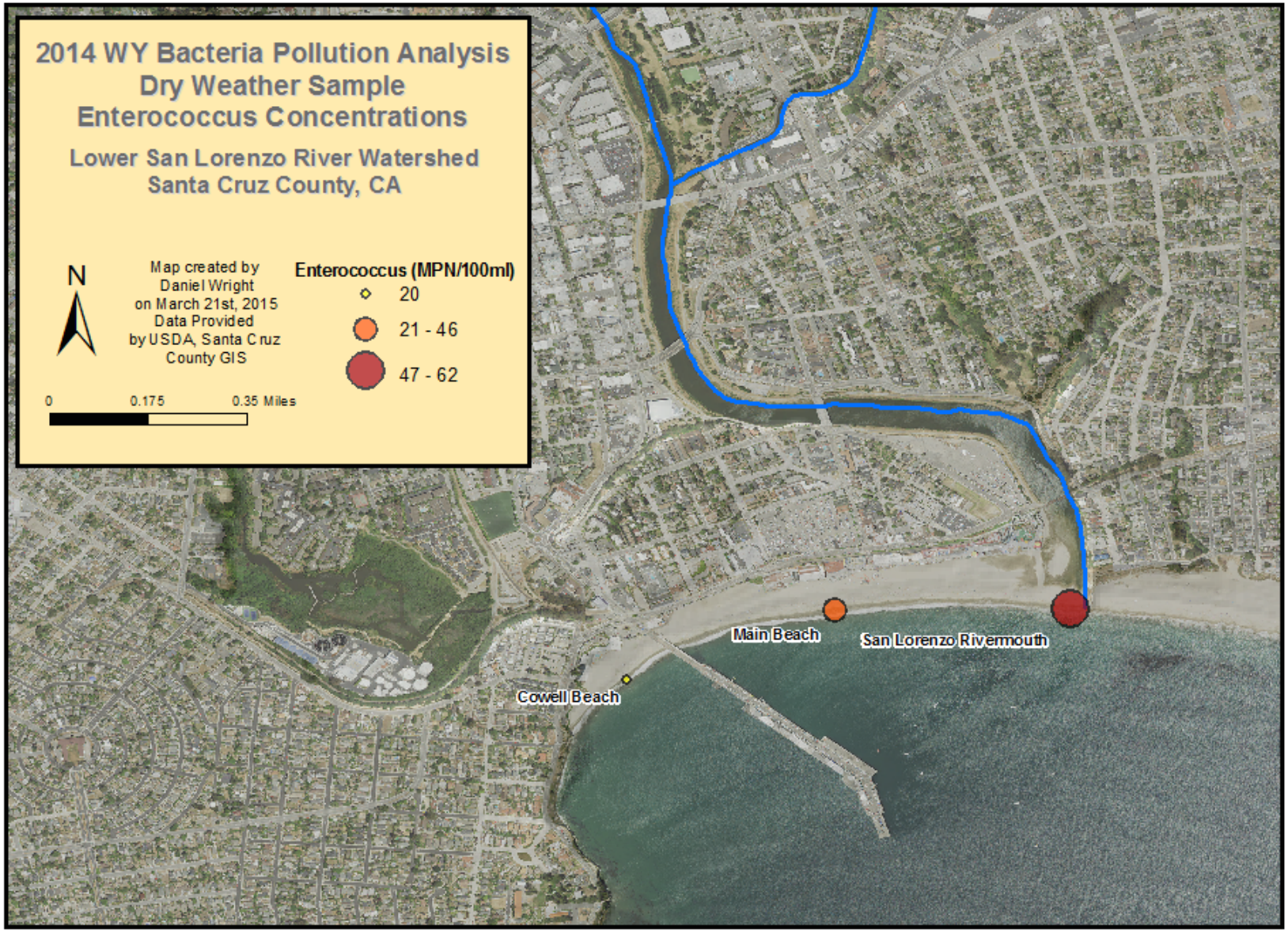


Figure 6. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

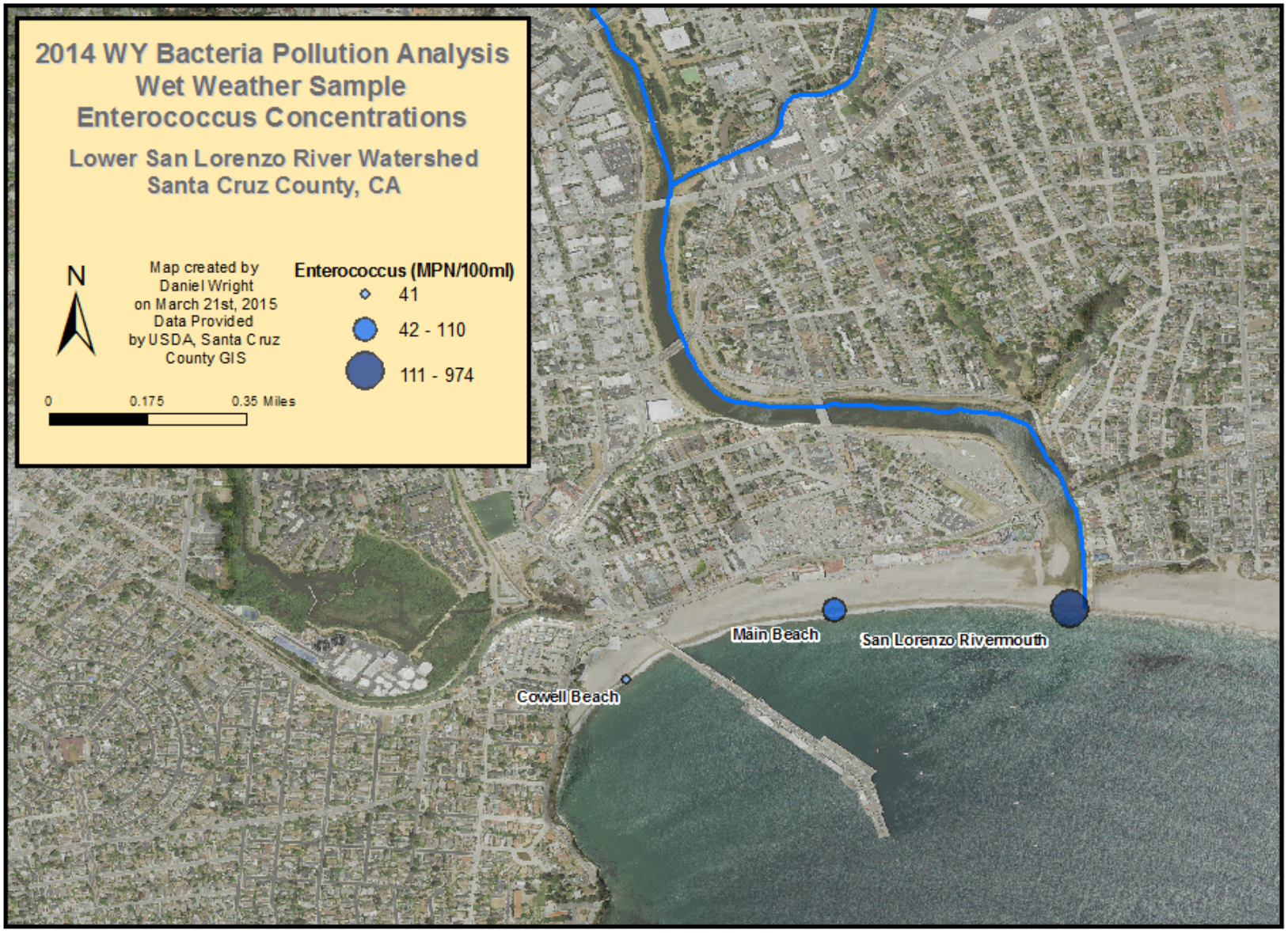


Figure 7. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

Conclusion and Recommendation

Discussion

Based on the results of the analyses, it is clear that the lower San Lorenzo River watershed and adjacent coastal areas are continually facing impairment by FIB. All sites within the study exceeded TMDL standards for fluvial and coastal water samples numerous times during the study period, with the greatest exceedances occurring at the San Lorenzo River at Water Street Bridge, the Branciforte Creek and San Lorenzo River confluence, and the San Lorenzo Rivermouth.

Though the 2014 WY analysis illustrated that precipitation is not statistically correlated with increased FIB concentrations, both analyses suggested that it does influence FIB levels based on site location. The majority of sites located on the San Lorenzo River increased substantially in average FIB concentrations when a precipitation event occurred within 72 hours of the sample being taken, while the majority of sites located on the Branciforte Creek and Carbonera Creek river systems had lower average FIB concentrations when a precipitation event occurred within 72 hours of the sample being taken. This illustrates that precipitation events commonly have a positive (increasing) effect on FIB concentrations along the lower San Lorenzo River, while precipitation events along the Branciforte Creek and Carbonera Creek tributaries usually have a negative (decreasing) influence on average FIB concentrations for samples taken within 72 hours of a precipitation event. This same trend was also found within the historical analysis. Gauge height and discharge were secondary effects to FIB concentrations in response to precipitation events, therefore followed the same trend in FIB concentrations as precipitation.

Coastal sites exhibited an increase in average FIB concentrations for samples taken within 72 hours of a precipitation event. Precipitation had the greatest effect on the San Lorenzo Rivermouth site, most likely due to the large drainage area of the San Lorenzo River watershed opposed to localized stormwater systems. High levels of precipitation and large wave/tide events are the main factors resulting in the opening of the seasonal sandbar formation at the San Lorenzo Rivermouth, allowing the surface flow of the San Lorenzo River to reach the Monterey Bay, which may have a significant impact

on coastal water quality in the areas surrounding the rivermouth.

When evaluating the effects of precipitation, it is important to look at the pathways created for FIB sources entering the river systems. Many sources of FIB are immobile without the presence of precipitation or a similar pathway, such as human (i.e. homeless encampments) and non-human (i.e. urban mammal feces) feces within a riverbank or stormdrain system. In addition, bacteria commonly binds to sediment, therefore erosion events produced from precipitation may have a factor on overall FIB concentrations.

Recommendations

This study analyzed the common trends in FIB concentrations within the lower San Lorenzo River watershed from WY2000 to WY2014. Though it offered insight on areas of common impairment, more research is needed to determine the source(s) of the contamination and their pathways into the fluvial systems. Currently, a microbial source tracking analysis is being conducted by the San Lorenzo River Alliance, Water Quality Working Group. The results of this study will indicate what biological sources are contributing to the impairment and whether they come from anthropogenic sources. Using this information, future research can be done to locate the potential areas where the determined sources are commonly found.

In addition, future research can be done to analyze the effect of saltwater intrusion upstream of the rivermouth and how it effects FIB concentrations and monitoring accuracy. A seasonal sand bar forms at the San Lorenzo rivermouth, creating a reduction in flow and increase in temperature and water depth within the lower region of the river; assessing the effect this has on FIB concentrations in the lower region of the river and coastal zone is also recommended.

The San Lorenzo River and coastal areas hold significant importance to Santa Cruz's history, economy, and community. Though these areas have continually been impaired with FIB, these impairments may or may not be representative to the potential public health threats they are associated with, depending on whether or not the sources are anthropogenic. Determining the biological sources of the FIB concentrations should guide future determinations of TMDL standards and how they guide policy for environmental health and public safety.

REFERENCES

[CDPH] California Department of Public Health. 2014. Beaches and recreational waters: regulations and guidance (interent). Accessed on May 5th, 2014 from: http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Beaches.aspx

City of Santa Cruz. 2010. 2010 Urban Water Management Plan. Chapter 3: Water Supply System (internet). Accessed on March 10th, 2015 from: http://cityofsantacruz.com/home/showdocument?id=24686

County of Santa Cruz$_A$. 2012. Environmental Health Services: water quality (internet). Accessed on May 3rd, 2014 from: http://scceh.com/Home/Programs/WaterResources/WaterQuality.aspx

County of Santa Cruz$_B$. 2012. About Santa Cruz County (internet). Accessed on May 3rd, 2014 from: http://www.co.santa-cruz.ca.us/default.aspx?tabid=130

County of Santa Cruz. 2014. Environmental Health Services: current water quality information (internet). Accessed on May 3rd, 2014 from: http://scceh.com/Home/Programs/WaterResources/WaterResourcesDocumentsLinks/CurrentWaterQualityInformation.aspx

[EPA] United States Environmental Protection Agency. 2002. National beach guidance and required performance criterial for grants (internet). Accessed on March 10th, 2015 from: http://www2.epa.gov/sites/production/files/2014-08/documents/beach-guidance-2002.pdf

[EPA] United States Environmental Protection Agency. 2012. Water: Monitoring & Assessment. 5.11 Fecal Bacteria: What are fecal bacteria and why are they important? (Internet).

Accessed on January 27th, 2015 from: http://water.epa.gov/type/rsl/monitoring/vms511.cfm

[EPA] United States Environmental Protection Agency. 2013. WATERS: my WATERS mapper (internet). Accessed on May 3rd, 2014 from: http://watersgeo.epa.gov/mwm/?layer=LEGACY_WBD&feature=18060002&extraLayers=null

[EPA] United States Environmental Protection Agency. 2014. Water: total maximum daily loads (303d) – impaired waters and total maximum daily loads (internet). Accessed on May 3rd, 2014 from: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/

[HTB] Heal The Bay. 2013. Heal the Bay's 2012-2013 Annual Beach Report Card (internet). Accessed on May 3rd, 2014 from: http://www.healthebay.org/sites/default/files/pdf/beachreportcard/BRC_2013_WEB.pdf

Leveque N and Laurent A. 2008. A novel mode of transmission for human enterovirus infection is swimming in contaminated seawater: implications in public health and in epidemiological surveillance. Clinical Infectious Diseases 47(5):624-626

[MBNMS] Monterey Bay National Marine Sanctuary. 2014. Monterey Bay National Marine Sanctuary overview (interent). Accessed on May 3rd, 2014 from: http://montereybay.noaa.gov/intro/welcome.html

[NHDES] New Hampshire Department of Environmental Services. 2011. Environmental fact sheet: bacteria in surface waters (internet). Accessed on January 27th, 2015 from: http://des.nh.gov/organization/commissioner/pip/factsheets/bb/documents/bb-14.pdf

[NRDC] Natural Resources Defense Council. 2013. Testing the waters 2013: a guide to water quality at vacation beaches – state summary: California (internet). Accessed on May 5th, 2014 from: http://www.nrdc.org/water/oceans/ttw/ca.asp

Russell TL, Sassoubre LM, Wang D, Masuda S, Chen H, Soetjipto C, Hassaballah A, Boehm AB. 2013. A coupled modeling and molecular biology approach to microbial source tracking at Cowell Beach, Santa Cruz, CA, United States. Environmental Science & Technology 47(18):10231-10239

Santa Cruz. 2010. Santa Cruz County visitor profile: March 10th, 2010 (internet). Accessed on May 3rd, 2014 from: http://www.santacruzca.org/documents/publications/research/SCC_Visitor_Profile_Presentation_2010.pdf

[SCBB] Santa Cruz Beach Boardwalk. Date unknown. Just the facts (internet). Accessed on April 9th, 2015 from: http://news.beachboardwalk.com/press-kit/just-facts#.VTbJafnF_Ak

Schiffrin A. 1986. Santa Cruz Beach Boardwalk: survival of the funnest (internet). Accessed on April 9th 2015 from: http://www.santacruzpl.org/history/articles/349/

SurferToday. 2015. The most important dates in the history of surfing (internet). Accessed on April 9th, 2015 from: http://www.surfertoday.com/surfing/10553-the-most-important-dates-in-the-history-of-surfing

Surfrider Foundation. 2015. About us (internet). Accessed on April 9th, 2015 from: http://www.surfrider.org/pages/about-us

[SWRCB] State Water Resources Control Board. Date unknown. Total daily maximum load program: background and information (internet). Accessed on May 3rd, 2014 from: http://www.waterboards.ca.gov/water_issues/programs/tmdl/background.shtml

[USCB] United States Census Bureau. 2014. State & County QuickFacts: Santa Cruz County, California (internet). Accessed on May 3rd, 2014 from: http://quickfacts.census.gov/qfd/states/06/06087.html

[WSR] World Surfing Reserves. 2014. Santa Cruz, CA, USA (interent). Accessed on May 3rd, 2014 from: http://www.worldsurfingreserves.org/santa-cruz

APPENDIX I

Raw Data

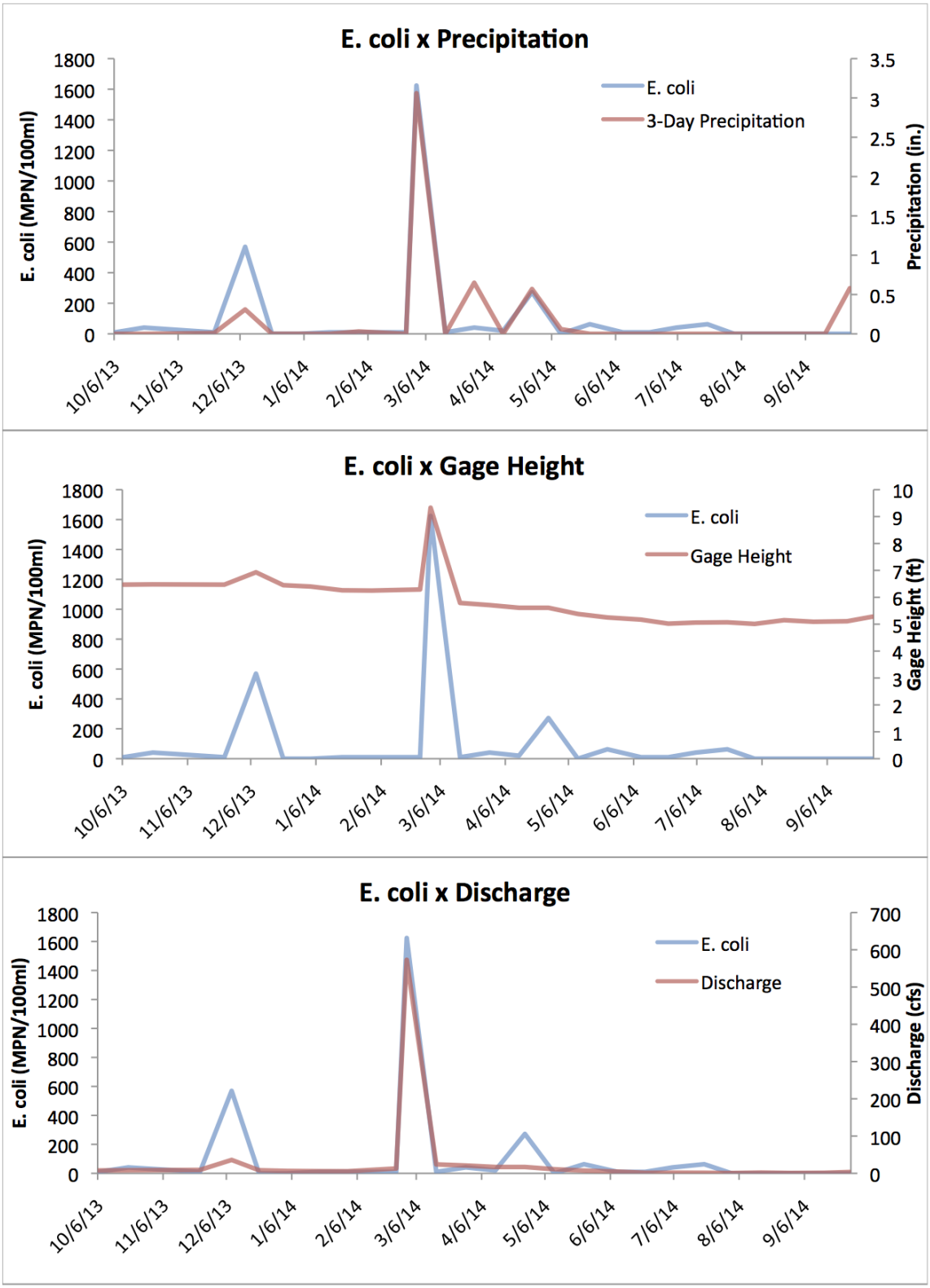
Site #	Site	Date/Time	Date	Total Coliforms (MPN/100 ml)	E. coli (MPN/100 ml)	Enterococcus (MPN/100 ml)	Discharge (cfs)	Gage Height (ft)	3-Day Precipitation (in)	3-Day Precipitation >0.10 in. (Y/N)
1	San Lorenzo River at Henry Cowell State Park	10/6/13 11:00	10/6/13	N/A	10	N/A	7.7	6.47	0	N
1	San Lorenzo River at Henry Cowell State Park	10/20/13 11:00	10/20/13	292	41	N/A	8.2	6.48	0	N
1	San Lorenzo River at Henry Cowell State Park	11/23/13 11:00	11/23/13	121	10	N/A	9.2	6.47	0.01	N
1	San Lorenzo River at Henry Cowell State Park	12/8/13 11:00	12/8/13	5794	569	N/A	36	6.93	0.31	Y
1	San Lorenzo River at Henry Cowell State Park	12/21/13 11:00	12/21/13	20	0	N/A	8.3	6.45	0	N
1	San Lorenzo River at Henry Cowell State Park	1/3/14 11:00	1/3/14	97	0	N/A	6.5	6.4	0	N
1	San Lorenzo River at Henry Cowell State Park	1/18/14 11:00	1/18/14	134	10	N/A	5.8	6.26	0	N
1	San Lorenzo River at Henry Cowell State Park	2/1/14 11:00	2/1/14	52	10	N/A	5.6	6.25	0.03	N
1	San Lorenzo River at Henry Cowell State Park	2/24/14 11:00	2/24/14	292	10	N/A	13	6.29	0	N
1	San Lorenzo River at Henry Cowell State Park	3/1/14 11:00	3/1/14	24000	1624	N/A	573	9.33	3.06	Y
1	San Lorenzo River at Henry Cowell State Park	3/15/14 11:00	3/15/14	98	10	N/A	24	5.79	0	N
1	San Lorenzo River at Henry Cowell State Park	3/29/14 11:00	3/29/14	327	41	N/A	21	5.71	0.65	Y
1	San Lorenzo River at Henry Cowell State Park	4/12/14 11:00	4/12/14	145	20	N/A	17	5.61	0	N
1	San Lorenzo River at Henry Cowell State Park	4/26/14 11:00	4/26/14	3654	272	N/A	17	5.61	0.57	Y
1	San Lorenzo River at Henry Cowell State Park	5/10/14 11:00	5/10/14	331	0	N/A	11	5.38	0.06	N
1	San Lorenzo River at Henry Cowell State Park	5/24/14 11:00	5/24/14	934	63	N/A	7.3	5.25	0	N
1	San Lorenzo River at Henry Cowell State Park	6/9/14 11:00	6/9/14	959	10	N/A	4.6	5.17	0	N
1	San Lorenzo River at Henry Cowell State Park	6/22/14 11:00	6/22/14	988	10	N/A	1.5	5.02	0	N
1	San Lorenzo River at Henry Cowell State Park	7/5/14 11:00	7/5/14	1259	41	N/A	1.8	5.06	0	N
1	San Lorenzo River at Henry Cowell State Park	7/20/14 11:00	7/20/14	1597	63	N/A	1.6	5.07	0	N
1	San Lorenzo River at Henry Cowell State Park	8/2/14 11:00	8/2/14	2143	0	N/A	0.86	5.01	0	N
1	San Lorenzo River at Henry Cowell State Park	8/16/14 11:00	8/16/14	959	0	N/A	2	5.15	0	N
1	San Lorenzo River at Henry Cowell State Park	8/30/14 11:00	8/30/14	546	0	N/A	0.98	5.09	0	N
1	San Lorenzo River at Henry Cowell State Park	9/15/14 11:00	9/15/14	243	0	N/A	1.5	5.11	0	N
1	San Lorenzo River at Henry Cowell State Park	9/27/14 11:00	9/27/14	459	0	N/A	3.6	5.28	0.58	Y
2	San Lorenzo River at Tannery	10/6/13 11:30	10/6/13	N/A	84	N/A	7.3	6.45	0	N
2	San Lorenzo River at Tannery	10/20/13 11:30	10/20/13	246	109	N/A	8.2	6.48	0	N
2	San Lorenzo River at Tannery	11/23/13 11:30	11/23/13	703	359	N/A	9.2	6.47	0.01	N
2	San Lorenzo River at Tannery	12/8/13 11:30	12/8/13	1785	487	N/A	35	6.92	0.31	Y
2	San Lorenzo River at Tannery	12/21/13 11:30	12/21/13	31	0	N/A	8.3	6.45	0	N
2	San Lorenzo River at Tannery	1/3/14 11:30	1/3/14	97	0	N/A	6.5	6.4	0	N
2	San Lorenzo River at Tannery	1/18/14 11:30	1/18/14	573	241	N/A	5.8	6.26	0	N
2	San Lorenzo River at Tannery	2/1/14 11:30	2/1/14	480	228	N/A	5.4	6.24	0.03	N
2	San Lorenzo River at Tannery	2/24/14 11:30	2/24/14	465	0	N/A	14	6.3	0	N
2	San Lorenzo River at Tannery	3/1/14 11:30	3/1/14	19863	1607	N/A	630	9.46	3.06	Y
2	San Lorenzo River at Tannery	3/15/14 11:30	3/15/14	201	0	N/A	24	5.79	0	N
2	San Lorenzo River at Tannery	3/29/14 11:30	3/29/14	12033	428	N/A	22	5.73	0.65	Y
2	San Lorenzo River at Tannery	4/12/14 11:30	4/12/14	213	86	N/A	17	5.61	0	N
2	San Lorenzo River at Tannery	4/26/14 11:30	4/26/14	886	134	N/A	17	5.61	0.57	Y
2	San Lorenzo River at Tannery	5/10/14 11:30	5/10/14	313	31	N/A	11	5.38	0.06	N
2	San Lorenzo River at Tannery	5/24/14 11:30	5/24/14	556	75	N/A	7.3	5.25	0	N
2	San Lorenzo River at Tannery	6/9/14 11:30	6/9/14	1198	85	N/A	4.5	5.16	0	N
2	San Lorenzo River at Tannery	6/22/14 11:30	6/22/14	2987	52	N/A	1.4	5.01	0	N
2	San Lorenzo River at Tannery	7/5/14 11:30	7/5/14	2282	109	N/A	1.8	5.06	0	N
2	San Lorenzo River at Tannery	7/20/14 11:30	7/20/14	712	98	N/A	1.5	5.06	0	N
2	San Lorenzo River at Tannery	8/2/14 11:30	8/2/14	2187	148	N/A	0.86	5.01	0	N
2	San Lorenzo River at Tannery	8/16/14 11:30	8/16/14	1455	98	N/A	2	5.14	0	N
2	San Lorenzo River at Tannery	8/30/14 11:30	8/30/14	448	10	N/A	0.92	5.08	0	N
2	San Lorenzo River at Tannery	9/15/14 11:30	9/15/14	160	0	N/A	1.5	5.11	0	N
2	San Lorenzo River at Tannery	9/27/14 11:30	9/27/14	548	20	N/A	3.6	5.28	0.58	Y
3	San Lorenzo River at Josephine Street	10/6/13 11:45	10/6/13	N/A	73	N/A	7.3	6.45	0	N
3	San Lorenzo River at Josephine Street	10/20/13 11:45	10/20/13	355	63	N/A	8.2	6.48	0	N
3	San Lorenzo River at Josephine Street	11/23/13 11:45	11/23/13	86	52	N/A	9.2	6.47	0.01	N
3	San Lorenzo River at Josephine Street	12/8/13 11:45	12/8/13	422	63	N/A	35	6.92	0.31	Y
3	San Lorenzo River at Josephine Street	12/21/13 11:45	12/21/13	84	20	N/A	8.3	6.45	0	N
3	San Lorenzo River at Josephine Street	1/3/14 11:45	1/3/14	52	10	N/A	6.3	6.39	0	N
3	San Lorenzo River at Josephine Street	1/18/14 11:45	1/18/14	708	0	N/A	5.9	6.27	0	N
3	San Lorenzo River at Josephine Street	2/1/14 11:45	2/1/14	156	10	N/A	5.4	6.24	0.03	N
3	San Lorenzo River at Josephine Street	2/24/14 11:45	2/24/14	2098	52	N/A	14	6.3	0	N
3	San Lorenzo River at Josephine Street	3/1/14 11:45	3/1/14	15531	1782	N/A	667	9.54	3.06	Y
3	San Lorenzo River at Josephine Street	3/15/14 11:45	3/15/14	238	10	N/A	24	5.79	0	N
3	San Lorenzo River at Josephine Street	3/29/14 11:45	3/29/14	187	10	N/A	21	5.72	0.65	Y
3	San Lorenzo River at Josephine Street	4/12/14 11:45	4/12/14	384	52	N/A	17	5.61	0	N
3	San Lorenzo River at Josephine Street	4/26/14 11:45	4/26/14	2224	317	N/A	17	5.61	0.57	Y
3	San Lorenzo River at Josephine Street	5/10/14 11:45	5/10/14	1126	218	N/A	11	5.38	0.06	N
3	San Lorenzo River at Josephine Street	5/24/14 11:45	5/24/14	2382	30	N/A	7.3	5.25	0	N
3	San Lorenzo River at Josephine Street	6/9/14 11:45	6/9/14	1421	74	N/A	4.2	5.15	0	N
3	San Lorenzo River at Josephine Street	6/22/14 11:45	6/22/14	3784	435	N/A	1.3	5.01	0	N
3	San Lorenzo River at Josephine Street	7/5/14 11:45	7/5/14	1607	41	N/A	1.8	5.06	0	N
3	San Lorenzo River at Josephine Street	7/20/14 11:45	7/20/14	2755	31	N/A	1.5	5.06	0	N
3	San Lorenzo River at Josephine Street	8/2/14 11:45	8/2/14	6488	84	N/A	0.86	5.01	0	N
3	San Lorenzo River at Josephine Street	8/16/14 11:45	8/16/14	2481	0	N/A	2	5.14	0	N
3	San Lorenzo River at Josephine Street	8/30/14 11:45	8/30/14	780	10	N/A	0.92	5.08	0	N
3	San Lorenzo River at Josephine Street	9/15/14 11:45	9/15/14	7270	10	N/A	1.5	5.11	0	N
3	San Lorenzo River at Josephine Street	9/27/14 11:45	9/27/14	450	10	N/A	3.6	5.28	0.58	Y
4	San Lorenzo River at Water St. Bridge	10/6/13 12:00	10/6/13	N/A	393	N/A	6.8	6.44	0	N
4	San Lorenzo River at Water St. Bridge	10/20/13 12:00	10/20/13	748	20	N/A	8.2	6.48	0	N
4	San Lorenzo River at Water St. Bridge	11/23/13 12:00	11/23/13	187	31	N/A	9.2	6.46	0.01	N
4	San Lorenzo River at Water St. Bridge	12/8/13 12:00	12/8/13	5794	884	N/A	34	6.91	0.31	Y
4	San Lorenzo River at Water St. Bridge	12/21/13 12:00	12/21/13	63	10	N/A	8.3	6.45	0	N
4	San Lorenzo River at Water St. Bridge	1/3/14 12:00	1/3/14	85	0	N/A	6.3	6.39	0	N
4	San Lorenzo River at Water St. Bridge	1/18/14 12:00	1/18/14	784	20	N/A	5.9	6.27	0	N
4	San Lorenzo River at Water St. Bridge	2/1/14 12:00	2/1/14	336	20	N/A	5.4	6.24	0.03	N
4	San Lorenzo River at Water St. Bridge	2/24/14 12:00	2/24/14	1455	30	N/A	13	6.29	0	N
4	San Lorenzo River at Water St. Bridge	3/1/14 12:00	3/1/14	19863	1529	N/A	706	9.62	3.06	Y
4	San Lorenzo River at Water St. Bridge	3/15/14 12:00	3/15/14	743	20	N/A	24	5.79	0	N
4	San Lorenzo River at Water St. Bridge	3/29/14 12:00	3/29/14	3448	292	N/A	21	5.72	0.65	Y
4	San Lorenzo River at Water St. Bridge	4/12/14 12:00	4/12/14	96	0	N/A	17	5.61	0	N
4	San Lorenzo River at Water St. Bridge	4/26/14 12:00	4/26/14	6867	638	N/A	17	5.6	0.57	Y
4	San Lorenzo River at Water St. Bridge	5/10/14 12:00	5/10/14	8164	233	N/A	11	5.38	0.06	N
4	San Lorenzo River at Water St. Bridge	5/24/14 12:00	5/24/14	2481	173	N/A	7.3	5.25	0	N
4	San Lorenzo River at Water St. Bridge	6/9/14 12:00	6/9/14	1317	272	N/A	4.2	5.15	0	N
4	San Lorenzo River at Water St. Bridge	6/22/14 12:00	6/22/14	8297	1500	N/A	1.3	5.01	0	N
4	San Lorenzo River at Water St. Bridge	7/5/14 12:00	7/5/14	9804	708	N/A	1.8	5.06	0	N
4	San Lorenzo River at Water St. Bridge	7/20/14 12:00	7/20/14	17329	2046	N/A	1.5	5.06	0	N

4	San Lorenzo River at Water St. Bridge	8/2/14 12:00	8/2/14		5794	173	N/A	0.86	5.01	0	N
4	San Lorenzo River at Water St. Bridge	8/16/14 12:00	8/16/14		11199	495	N/A	2	5.14	0	N
4	San Lorenzo River at Water St. Bridge	8/30/14 12:00	8/30/14		6586	336	N/A	0.92	5.08	0	N
4	San Lorenzo River at Water St. Bridge	9/15/14 12:00	9/15/14		5172	10	N/A	1.5	5.11	0	N
4	San Lorenzo River at Water St. Bridge	9/27/14 12:00	9/27/14		4611	489	N/A	3.6	5.28	0.58	Y
5	Carbonera Creek at Highway 1	11/23/13 14:30	11/23/13		399	10	N/A	8.7	6.45	0.01	N
5	Carbonera Creek at Highway 1	12/8/13 14:30	12/8/13		24196	15531	N/A	29	6.87	0.31	Y
5	Carbonera Creek at Highway 1	12/21/13 14:30	12/21/13		148	63	N/A	7.9	6.43	0	N
5	Carbonera Creek at Highway 1	1/3/14 14:30	1/3/14		161	0	N/A	6.1	6.38	0	N
5	Carbonera Creek at Highway 1	1/18/14 14:30	1/18/14		155	41	N/A	6.1	6.28	0	N
5	Carbonera Creek at Highway 1	2/1/14 14:30	2/1/14		231	10	N/A	5.4	6.24	0.03	N
5	Carbonera Creek at Highway 1	2/24/14 14:30	2/24/14		934	20	N/A	14	6.3	0	N
5	Carbonera Creek at Highway 1	3/1/14 14:30	3/1/14		15531	1664	N/A	879	9.94	3.06	Y
5	Carbonera Creek at Highway 1	3/15/14 14:30	3/15/14		63	0	N/A	24	5.8	0	N
5	Carbonera Creek at Highway 1	3/29/14 14:30	3/29/14		1515	41	N/A	31	5.97	0.65	Y
5	Carbonera Creek at Highway 1	4/12/14 14:30	4/12/14		504	226	N/A	17	5.61	0	N
5	Carbonera Creek at Highway 1	4/26/14 14:30	4/26/14		11199	2187	N/A	17	5.58	0.57	Y
5	Carbonera Creek at Highway 1	5/10/14 14:30	5/10/14		527	41	N/A	11	5.39	0.06	N
5	Carbonera Creek at Highway 1	5/24/14 14:30	5/24/14		912	30	N/A	6.9	5.24	0	N
5	Carbonera Creek at Highway 1	6/9/14 14:30	6/9/14		798	132	N/A	4	5.14	0	N
5	Carbonera Creek at Highway 1	6/22/14 14:30	6/22/14		1046	74	N/A	1.1	4.98	0	N
5	Carbonera Creek at Highway 1	7/5/14 14:30	7/5/14		404	52	N/A	1.6	5.04	0	N
5	Carbonera Creek at Highway 1	7/20/14 14:30	7/20/14		984	31	N/A	1.4	5.04	0	N
5	Carbonera Creek at Highway 1	8/2/14 14:30	8/2/14		1968	75	N/A	0.86	5.01	0	N
5	Carbonera Creek at Highway 1	8/16/14 14:30	8/16/14		1565	52	N/A	1.5	5.1	0	N
5	Carbonera Creek at Highway 1	8/30/14 14:30	8/30/14		5493	4569	N/A	0.71	5.05	0	N
5	Carbonera Creek at Highway 1	9/15/14 14:30	9/15/14		384	0	N/A	1.2	5.09	0	N
5	Carbonera Creek at Highway 1	9/27/14 14:30	9/27/14		473	0	N/A	3.4	5.26	0.58	Y
6	Brancifarte Creek at Stoney Creek Rd.	11/23/13 14:00	11/23/13		63	0	N/A	8.7	6.45	0.01	N
6	Brancifarte Creek at Stoney Creek Rd.	12/8/13 14:00	12/8/13		8164	2755	N/A	30	6.88	0.31	Y
6	Brancifarte Creek at Stoney Creek Rd.	12/21/13 14:00	12/21/13		109	31	N/A	7.9	6.43	0	N
6	Brancifarte Creek at Stoney Creek Rd.	1/3/14 14:00	1/3/14		146	41	N/A	6.1	6.38	0	N
6	Brancifarte Creek at Stoney Creek Rd.	1/18/14 14:00	1/18/14		107	10	N/A	6.1	6.28	0	N
6	Brancifarte Creek at Stoney Creek Rd.	2/1/14 14:00	2/1/14		218	98	N/A	5.4	6.24	0.03	N
6	Brancifarte Creek at Stoney Creek Rd.	2/24/14 14:00	2/24/14		474	0	N/A	14	6.3	0	N
6	Brancifarte Creek at Stoney Creek Rd.	3/1/14 14:00	3/1/14		11199	1723	N/A	879	9.94	3.06	Y
6	Brancifarte Creek at Stoney Creek Rd.	3/15/14 14:00	3/15/14		187	0	N/A	24	5.79	0	N
6	Brancifarte Creek at Stoney Creek Rd.	3/29/14 14:00	3/29/14		6867	2851	N/A	26	5.85	0.65	Y
6	Brancifarte Creek at Stoney Creek Rd.	4/12/14 14:00	4/12/14		934	132	N/A	17	5.61	0	N
6	Brancifarte Creek at Stoney Creek Rd.	4/26/14 14:00	4/26/14		10462	1274	N/A	17	5.59	0.57	Y
6	Brancifarte Creek at Stoney Creek Rd.	5/10/14 14:00	5/10/14		886	282	N/A	11	5.39	0.06	N
6	Brancifarte Creek at Stoney Creek Rd.	5/24/14 14:00	5/24/14		1576	288	N/A	7.3	5.25	0	N
6	Brancifarte Creek at Stoney Creek Rd.	6/9/14 14:00	6/9/14		733	183	N/A	4	5.14	0	N
6	Brancifarte Creek at Stoney Creek Rd.	6/22/14 14:00	6/22/14		1259	211	N/A	1.1	4.98	0	N
6	Brancifarte Creek at Stoney Creek Rd.	7/5/14 14:00	7/5/14		487	0	N/A	1.6	5.04	0	N
6	Brancifarte Creek at Stoney Creek Rd.	7/20/14 14:00	7/20/14		1236	121	N/A	1.5	5.05	0	N
6	Brancifarte Creek at Stoney Creek Rd.	8/2/14 14:00	8/2/14		1616	31	N/A	0.86	5.01	0	N
6	Brancifarte Creek at Stoney Creek Rd.	8/16/14 14:00	8/16/14		934	41	N/A	1.6	5.11	0	N
6	Brancifarte Creek at Stoney Creek Rd.	8/30/14 14:00	8/30/14		2014	20	N/A	0.71	5.05	0	N
6	Brancifarte Creek at Stoney Creek Rd.	9/15/14 14:00	9/15/14		226	0	N/A	1.2	5.09	0	N
6	Brancifarte Creek at Stoney Creek Rd.	9/27/14 14:00	9/27/14		4786	51	N/A	3.4	5.26	0.58	Y
7	Brancifarte Creek at San Lorenzo River	10/6/13 12:30	10/6/13	N/A		278	N/A	6.8	6.44	0	N
7	Brancifarte Creek at San Lorenzo River	10/20/13 12:30	10/20/13		3282	546	N/A	8.2	6.48	0	N
7	Brancifarte Creek at San Lorenzo River	11/23/13 12:30	11/23/13		2187	383	N/A	9.2	6.46	0.01	N
7	Brancifarte Creek at San Lorenzo River	12/8/13 12:30	12/8/13		12033	5794	N/A	34	6.91	0.31	Y
7	Brancifarte Creek at San Lorenzo River	12/21/13 12:30	12/21/13		74	20	N/A	8.1	6.44	0	N
7	Brancifarte Creek at San Lorenzo River	1/3/14 12:30	1/3/14		350	0	N/A	6.1	6.38	0	N
7	Brancifarte Creek at San Lorenzo River	1/18/14 12:30	1/18/14		1046	160	N/A	5.9	6.27	0	N
7	Brancifarte Creek at San Lorenzo River	2/1/14 12:30	2/1/14		504	31	N/A	5.4	6.24	0.03	N
7	Brancifarte Creek at San Lorenzo River	2/24/14 12:30	2/24/14		281	0	N/A	14	6.3	0	N
7	Brancifarte Creek at San Lorenzo River	3/1/14 12:30	3/1/14		12997	2098	N/A	768	9.74	3.06	Y
7	Brancifarte Creek at San Lorenzo River	3/15/14 12:30	3/15/14		86	10	N/A	24	5.79	0	N
7	Brancifarte Creek at San Lorenzo River	3/29/14 12:30	3/29/14		24196	1616	N/A	22	5.73	0.65	Y
7	Brancifarte Creek at San Lorenzo River	4/12/14 12:30	4/12/14		183	31	N/A	17	5.61	0	N
7	Brancifarte Creek at San Lorenzo River	4/26/14 12:30	4/26/14		5748	829	N/A	17	5.6	0.57	Y
7	Brancifarte Creek at San Lorenzo River	5/10/14 12:30	5/10/14		627	74	N/A	11	5.38	0.06	N
7	Brancifarte Creek at San Lorenzo River	5/24/14 12:30	5/24/14		6294	1483	N/A	6.9	5.24	0	N
7	Brancifarte Creek at San Lorenzo River	6/9/14 12:30	6/9/14		2014	495	N/A	4.2	5.15	0	N
7	Brancifarte Creek at San Lorenzo River	6/22/14 12:30	6/22/14		10112	148	N/A	1.2	5	0	N
7	Brancifarte Creek at San Lorenzo River	7/5/14 12:30	7/5/14		11199	10	N/A	1.7	5.05	0	N
7	Brancifarte Creek at San Lorenzo River	7/20/14 12:30	7/20/14		24196	1430	N/A	1.5	5.05	0	N
7	Brancifarte Creek at San Lorenzo River	8/2/14 12:30	8/2/14		15531	199	N/A	0.86	5.01	0	N
7	Brancifarte Creek at San Lorenzo River	8/16/14 12:30	8/16/14		3654	41	N/A	1.9	5.13	0	N
7	Brancifarte Creek at San Lorenzo River	8/30/14 12:30	8/30/14		9606	0	N/A	0.81	5.07	0	N
7	Brancifarte Creek at San Lorenzo River	9/15/14 12:30	9/15/14		8164	0	N/A	1.5	5.11	0	N
7	Brancifarte Creek at San Lorenzo River	9/27/14 12:30	9/27/14		24196	24196	N/A	3.5	5.27	0.58	Y
8	San Lorenzo River at Kaiser P. Arena	10/6/13 12:45	10/6/13	N/A		97	N/A	6.8	6.43	0	N
8	San Lorenzo River at Kaiser P. Arena	10/20/13 12:45	10/20/13		1046	0	N/A	8.2	6.48	0	N
8	San Lorenzo River at Kaiser P. Arena	11/23/13 12:45	11/23/13		75	10	N/A	9.2	6.46	0.01	N
8	San Lorenzo River at Kaiser P. Arena	12/8/13 12:45	12/8/13		15531	4611	N/A	33	6.9	0.31	Y
8	San Lorenzo River at Kaiser P. Arena	12/21/13 12:45	12/21/13		160	41	N/A	8.1	6.44	0	N
8	San Lorenzo River at Kaiser P. Arena	1/3/14 12:45	1/3/14		86	10	N/A	6.1	6.38	0	N
8	San Lorenzo River at Kaiser P. Arena	1/18/14 12:45	1/18/14		388	20	N/A	5.9	6.27	0	N
8	San Lorenzo River at Kaiser P. Arena	2/1/14 12:45	2/1/14		345	31	N/A	5.4	6.24	0.03	N
8	San Lorenzo River at Kaiser P. Arena	2/24/14 12:45	2/24/14		580	10	N/A	14	6.3	0	N
8	San Lorenzo River at Kaiser P. Arena	3/1/14 12:45	3/1/14		17329	1850	N/A	800	9.8	3.06	Y
8	San Lorenzo River at Kaiser P. Arena	3/15/14 12:45	3/15/14		132	0	N/A	24	5.79	0	N
8	San Lorenzo River at Kaiser P. Arena	3/29/14 12:45	3/29/14		7701	512	N/A	22	5.73	0.65	Y
8	San Lorenzo River at Kaiser P. Arena	4/12/14 12:45	4/12/14		2400	183	N/A	17	5.61	0	N
8	San Lorenzo River at Kaiser P. Arena	4/26/14 12:45	4/26/14		24196	1664	N/A	17	5.6	0.57	Y
8	San Lorenzo River at Kaiser P. Arena	5/10/14 12:45	5/10/14		15531	175	N/A	11	5.38	0.06	N
8	San Lorenzo River at Kaiser P. Arena	5/24/14 12:45	5/24/14		6131	784	N/A	6.9	5.24	0	N
8	San Lorenzo River at Kaiser P. Arena	6/9/14 12:45	6/9/14		1187	226	N/A	4.2	5.15	0	N
8	San Lorenzo River at Kaiser P. Arena	6/22/14 12:45	6/22/14		938	109	N/A	1.2	5	0	N
8	San Lorenzo River at Kaiser P. Arena	7/5/14 12:45	7/5/14		24196	364	N/A	1.7	5.05	0	N
8	San Lorenzo River at Kaiser P. Arena	7/20/14 12:45	7/20/14		24196	175	N/A	1.5	5.05	0	N
8	San Lorenzo River at Kaiser P. Arena	8/2/14 12:45	8/2/14		19863	31	N/A	0.86	5.01	0	N
8	San Lorenzo River at Kaiser P. Arena	8/16/14 12:45	8/16/14		14136	20	N/A	1.9	5.13	0	N

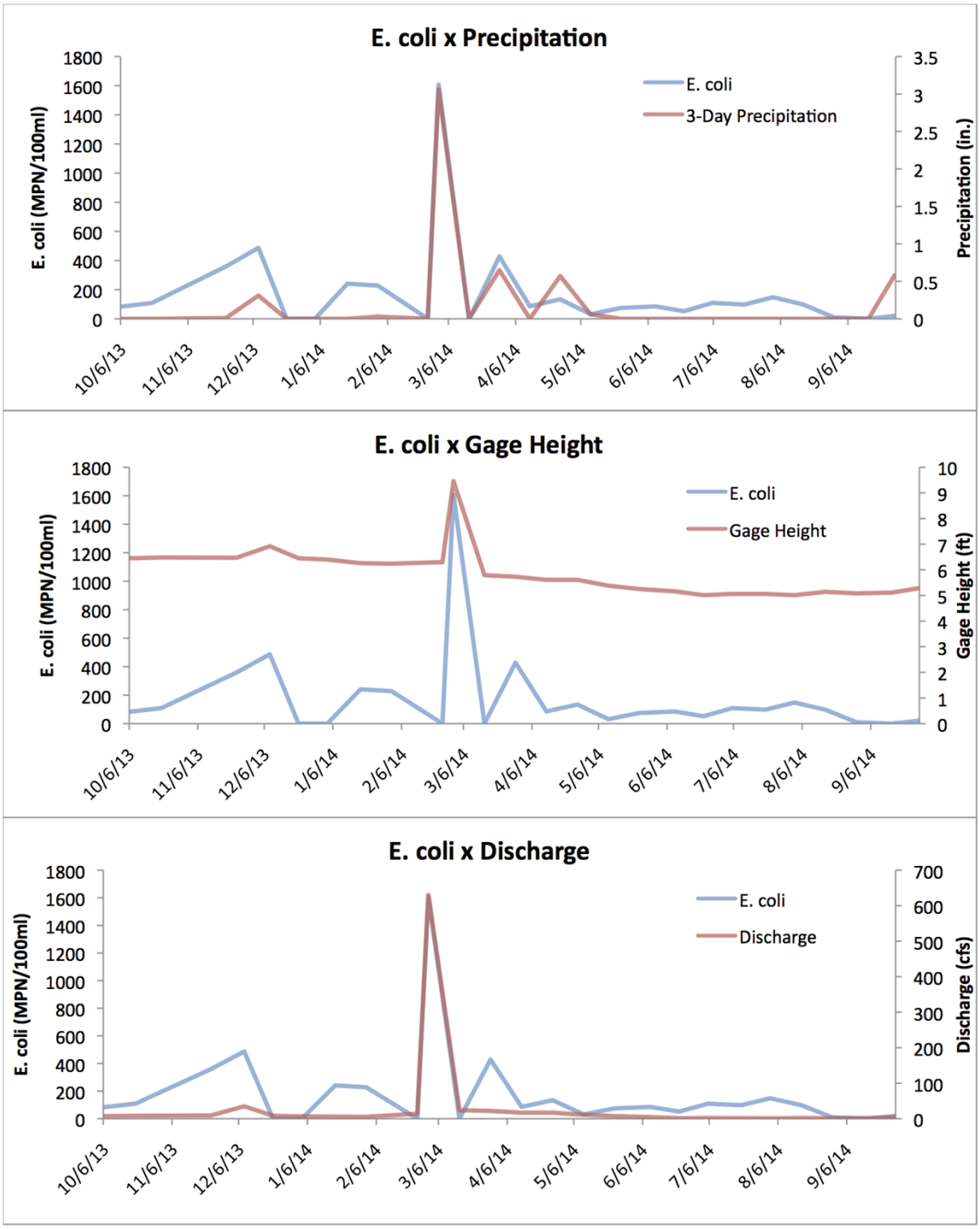
8	San Lorenzo River at Kaiser P. Arena	8/30/14 12:45	8/30/14		10112		41	N/A		0.81	5.07	0	N
8	San Lorenzo River at Kaiser P. Arena	9/15/14 12:45	9/15/14		19863		0	N/A		1.3	5.1	0	N
8	San Lorenzo River at Kaiser P. Arena	9/27/14 12:45	9/27/14		7701		20	N/A		3.5	5.27	0.58	Y
9	San Lorenzo River at First Bend	10/6/13 13:00	10/6/13	N/A			226	N/A		6.8	6.43	0	N
9	San Lorenzo River at First Bend	10/20/13 13:00	10/20/13		1467		75	N/A		8.2	6.48	0	N
9	San Lorenzo River at First Bend	11/23/13 13:00	11/23/13		10		0	N/A		9.2	6.46	0.01	N
9	San Lorenzo River at First Bend	12/8/13 13:00	12/8/13		19863		5172	N/A		33	6.9	0.31	Y
9	San Lorenzo River at First Bend	12/21/13 13:00	12/21/13		41		0	N/A		8.1	6.44	0	N
9	San Lorenzo River at First Bend	1/3/14 13:00	1/3/14		185		30	N/A		6.1	6.38	0	N
9	San Lorenzo River at First Bend	1/18/14 13:00	1/18/14		171		10	N/A		6.1	6.28	0	N
9	San Lorenzo River at First Bend	2/1/14 13:00	2/1/14		148		31	N/A		5.4	6.24	0.03	N
9	San Lorenzo River at First Bend	2/24/14 13:00	2/24/14		226		10	N/A		14	6.3	0	N
9	San Lorenzo River at First Bend	3/1/14 13:00	3/1/14		11199		1989	N/A		827	9.85	3.06	Y
9	San Lorenzo River at First Bend	3/15/14 13:00	3/15/14		771		218	N/A		24	5.8	0	N
9	San Lorenzo River at First Bend	3/29/14 13:00	3/29/14		2098		62	N/A		22	5.73	0.65	Y
9	San Lorenzo River at First Bend	4/12/14 13:00	4/12/14		6131		281	N/A		17	5.61	0	N
9	San Lorenzo River at First Bend	4/26/14 13:00	4/26/14		24196		2014	N/A		17	5.6	0.57	Y
9	San Lorenzo River at First Bend	5/10/14 13:00	5/10/14		4611		97	N/A		11	5.38	0.06	N
9	San Lorenzo River at First Bend	5/24/14 13:00	5/24/14		3873		331	N/A		6.9	5.24	0	N
9	San Lorenzo River at First Bend	6/9/14 13:00	6/9/14		563		51	N/A		4.2	5.15	0	N
9	San Lorenzo River at First Bend	6/22/14 13:00	6/22/14		4160		74	N/A		1.2	4.99	0	N
9	San Lorenzo River at First Bend	7/5/14 13:00	7/5/14		24196		10	N/A		1.7	5.05	0	N
9	San Lorenzo River at First Bend	7/20/14 13:00	7/20/14		8664		414	N/A		1.5	5.05	0	N
9	San Lorenzo River at First Bend	8/2/14 13:00	8/2/14		8664		0	N/A		0.86	5.01	0	N
9	San Lorenzo River at First Bend	8/16/14 13:00	8/16/14		4106		31	N/A		1.9	5.13	0	N
9	San Lorenzo River at First Bend	8/30/14 13:00	8/30/14		9139		0	N/A		0.76	5.06	0	N
9	San Lorenzo River at First Bend	9/15/14 13:00	9/15/14		11199		0	N/A		1.3	5.1	0	N
9	San Lorenzo River at First Bend	9/27/14 13:00	9/27/14		24196		323	N/A		3.5	5.27	0.58	Y
10	San Lorenzo River at Monterey Bay	10/6/13 12:45	10/6/13	N/A			153	N/A		6.8	6.43	0	N
10	San Lorenzo River at Monterey Bay	10/20/13 13:30	10/20/13		908		63	N/A		8.2	6.48	0	N
10	San Lorenzo River at Monterey Bay	11/23/13 13:30	11/23/13		683		122	N/A		8.7	6.45	0.01	N
10	San Lorenzo River at Monterey Bay	12/8/13 13:30	12/8/13		987		246	N/A		31	6.89	0.31	Y
10	San Lorenzo River at Monterey Bay	12/21/13 13:30	12/21/13		20		0	N/A		8.1	6.44	0	N
10	San Lorenzo River at Monterey Bay	1/3/14 13:30	1/3/14		683		74	N/A		6.1	6.38	0	N
10	San Lorenzo River at Monterey Bay	2/1/14 13:30	2/1/14		20		0	N/A		5.4	6.24	0.03	N
10	San Lorenzo River at Monterey Bay	2/24/14 13:30	2/24/14		41		0	N/A		14	6.3	0	N
10	San Lorenzo River at Monterey Bay	3/1/14 13:30	3/1/14		19863		1450	N/A		856	9.9	3.06	Y
10	San Lorenzo River at Monterey Bay	3/15/14 13:30	3/15/14		135		20	N/A		24	5.79	0	N
10	San Lorenzo River at Monterey Bay	3/29/14 13:30	3/29/14		3448		160	N/A		22	5.74	0.65	Y
10	San Lorenzo River at Monterey Bay	4/12/14 13:30	4/12/14		3873		759	N/A		17	5.61	0	N
10	San Lorenzo River at Monterey Bay	4/26/14 13:30	4/26/14		355		86	N/A		17	5.59	0.57	Y
10	San Lorenzo River at Monterey Bay	5/10/14 13:30	5/10/14		3873		226	N/A		11	5.38	0.06	N
10	San Lorenzo River at Monterey Bay	5/24/14 13:30	5/24/14		4106		313	N/A		6.9	5.24	0	N
10	San Lorenzo River at Monterey Bay	6/9/14 13:30	6/9/14		1553		148	N/A		4	5.14	0	N
10	San Lorenzo River at Monterey Bay	6/22/14 13:30	6/22/14		3968		275	N/A		1.2	4.99	0	N
10	San Lorenzo River at Monterey Bay	7/5/14 13:30	7/5/14		24196		96	N/A		1.6	5.04	0	N
10	San Lorenzo River at Monterey Bay	7/20/14 13:30	7/20/14		1022		259	N/A		1.5	5.05	0	N
10	San Lorenzo River at Monterey Bay	8/2/14 13:30	8/2/14		7701		1334	N/A		0.86	5.01	0	N
10	San Lorenzo River at Monterey Bay	8/16/14 13:30	8/16/14		4884		131	N/A		1.7	5.12	0	N
10	San Lorenzo River at Monterey Bay	8/30/14 13:30	8/30/14		10112		31	N/A		0.76	5.06	0	N
10	San Lorenzo River at Monterey Bay	9/15/14 13:30	9/15/14		7701		30	N/A		1.3	5.1	0	N
10	San Lorenzo River at Monterey Bay	9/27/14 13:30	9/27/14		24196		96	N/A		3.4	5.26	0.58	Y
11	San Lorenzo River Mouth	10/13/13 16:00	10/13/13	N/A		N/A			148	6	6.4	0	N
11	San Lorenzo River Mouth	10/27/13 16:00	10/27/13	N/A		N/A			0	9.2	6.48	0.01	N
11	San Lorenzo River Mouth	11/3/13 16:00	11/3/13	N/A		N/A			20	6	6.31	0	N
11	San Lorenzo River Mouth	11/10/13 16:00	11/10/13	N/A		N/A			146	4.8	6.26	0	N
11	San Lorenzo River Mouth	11/24/13 16:00	11/24/13	N/A		N/A			171	7.3	6.37	0	N
11	San Lorenzo River Mouth	12/15/13 16:00	12/15/13	N/A		N/A			83	7.3	6.39	0	N
11	San Lorenzo River Mouth	12/22/13 16:00	12/22/13	N/A		N/A			95	7.5	6.42	0	N
11	San Lorenzo River Mouth	12/29/13 16:00	12/29/13	N/A		N/A			61	8.1	6.47	0	N
11	San Lorenzo River Mouth	1/12/14 16:00	1/12/14	N/A		N/A			41	7.9	6.37	0	N
11	San Lorenzo River Mouth	1/26/14 16:00	1/26/14	N/A		N/A			20	4.6	6.19	0	N
11	San Lorenzo River Mouth	2/2/14 16:00	2/2/14	N/A		N/A			2755	10	6.47	0.48	Y
11	San Lorenzo River Mouth	2/9/14 16:00	2/9/14	N/A		N/A			1291	215	8.35	2.82	Y
11	San Lorenzo River Mouth	3/2/14 16:00	3/2/14	N/A		N/A			657	215	8.01	3.11	Y
11	San Lorenzo River Mouth	3/9/14 16:00	3/9/14	N/A		N/A			41	34	6.02	0	N
11	San Lorenzo River Mouth	3/16/14 16:00	3/16/14	N/A		N/A			62	23	5.76	0	N
11	San Lorenzo River Mouth	3/23/14 16:00	3/23/14	N/A		N/A			223	16	5.55	0	N
11	San Lorenzo River Mouth	3/30/14 16:00	3/30/14	N/A		N/A			20	42	6.19	0.61	Y
11	San Lorenzo River Mouth	4/13/14 16:00	4/13/14	N/A		N/A			0	19	5.66	0	N
11	San Lorenzo River Mouth	4/27/14 16:00	4/27/14	N/A		N/A			15531	17	5.58	0.57	Y
11	San Lorenzo River Mouth	5/4/14 16:00	5/4/14	N/A		N/A			0	11	5.39	0	N
11	San Lorenzo River Mouth	5/11/14 16:00	5/11/14	N/A		N/A			203	9.5	5.33	0.01	N
11	San Lorenzo River Mouth	5/18/14 16:00	5/18/14	N/A		N/A			10	6.9	5.23	0	N
11	San Lorenzo River Mouth	6/1/14 16:00	6/1/14	N/A		N/A			52	6.5	5.23	0	N
11	San Lorenzo River Mouth	6/8/14 16:00	6/8/14	N/A		N/A			0	3.9	5.12	0	N
11	San Lorenzo River Mouth	6/22/14 16:00	6/22/14	N/A		N/A			31	0.92	4.96	0	N
11	San Lorenzo River Mouth	6/29/14 16:00	6/29/14	N/A		N/A			0	2.1	5.1	0	N
11	San Lorenzo River Mouth	7/6/14 16:00	7/6/14	N/A		N/A			336	2	5.08	0	N
11	San Lorenzo River Mouth	7/20/14 16:00	7/20/14	N/A		N/A			201	1.2	5.03	0	N
11	San Lorenzo River Mouth	7/27/14 16:00	7/27/14	N/A		N/A			10	0.49	4.94	0	N
11	San Lorenzo River Mouth	8/3/14 16:00	8/3/14	N/A		N/A			259	0.57	4.97	0	N
11	San Lorenzo River Mouth	8/10/14 16:00	8/10/14	N/A		N/A			52	0.98	5.03	0	N
11	San Lorenzo River Mouth	8/17/14 16:00	8/17/14	N/A		N/A			63	0.71	5.01	0	N
11	San Lorenzo River Mouth	8/24/14 16:00	8/24/14	N/A		N/A			10	0.61	5.02	0.01	N
11	San Lorenzo River Mouth	8/31/14 16:00	8/31/14	N/A		N/A			73	0.66	5.05	0	N
11	San Lorenzo River Mouth	9/7/14 16:00	9/7/14	N/A		N/A			160	0.92	5.08	0	N
11	San Lorenzo River Mouth	9/14/14 16:00	9/14/14	N/A		N/A			908	1.4	5.11	0	N
11	San Lorenzo River Mouth	9/21/14 16:00	9/21/14	N/A		N/A			130	1.5	5.12	0	N
11	San Lorenzo River Mouth	9/28/14 16:00	9/28/14	N/A		N/A			20	1.3	5.11	0.22	Y
12	Main Beach	10/6/13 16:30	10/6/13	N/A		N/A			10	5.6	6.39	0	N
12	Main Beach	11/3/13 16:30	11/3/13	N/A		N/A			0	6	6.32	0	N
12	Main Beach	11/10/13 16:30	11/10/13	N/A		N/A			63	4.8	6.26	0	N
12	Main Beach	11/24/13 16:30	11/24/13	N/A		N/A			173	7.3	6.37	0	N
12	Main Beach	12/15/13 16:30	12/15/13	N/A		N/A			41	7.3	6.39	0	N
12	Main Beach	12/22/13 16:30	12/22/13	N/A		N/A			51	7.5	6.42	0	N
12	Main Beach	12/29/13 16:30	12/29/13	N/A		N/A			10	8.1	6.47	0	N
12	Main Beach	1/12/14 16:30	1/12/14	N/A		N/A			41	7.9	6.37	0	N

12	Main Beach	2/2/14 16:30	2/2/14	N/A	N/A	2098	10	6.47	0.48	Y
12	Main Beach	3/2/14 16:30	3/2/14	N/A	N/A	723	215	8.01	3.11	Y
12	Main Beach	3/9/14 16:30	3/9/14	N/A	N/A	20	33	6	0	N
12	Main Beach	3/16/14 16:30	3/16/14	N/A	N/A	0	23	5.76	0	N
12	Main Beach	3/23/14 16:30	3/23/14	N/A	N/A	10	16	5.56	0	N
12	Main Beach	3/30/14 16:30	3/30/14	N/A	N/A	31	42	6.19	0.61	Y
12	Main Beach	4/13/14 16:30	4/13/14	N/A	N/A	20	19	5.66	0	N
12	Main Beach	4/27/14 16:30	4/27/14	N/A	N/A	110	17	5.58	0.57	Y
12	Main Beach	5/4/14 16:30	5/4/14	N/A	N/A	62	12	5.4	0	N
12	Main Beach	5/11/14 16:30	5/11/14	N/A	N/A	85	9.5	5.33	0.01	N
12	Main Beach	5/18/14 16:30	5/18/14	N/A	N/A	10	6.9	5.23	0	N
12	Main Beach	6/1/14 16:30	6/1/14	N/A	N/A	0	6.3	5.22	0	N
12	Main Beach	6/8/14 16:30	6/8/14	N/A	N/A	10	3.9	5.12	0	N
12	Main Beach	6/22/14 16:30	6/22/14	N/A	N/A	10	0.92	4.96	0	N
12	Main Beach	6/29/14 16:30	6/29/14	N/A	N/A	10	2.1	5.1	0	N
12	Main Beach	7/6/14 16:30	7/6/14	N/A	N/A	691	2	5.08	0	N
12	Main Beach	7/20/14 16:30	7/20/14	N/A	N/A	0	1.2	5.03	0	N
12	Main Beach	7/27/14 16:30	7/27/14	N/A	N/A	134	0.49	4.94	0	N
12	Main Beach	8/3/14 16:30	8/3/14	N/A	N/A	246	0.57	4.97	0	N
12	Main Beach	8/10/14 16:30	8/10/14	N/A	N/A	231	0.98	5.03	0	N
12	Main Beach	8/17/14 16:30	8/17/14	N/A	N/A	327	0.71	5.01	0	N
12	Main Beach	8/24/14 16:30	8/24/14	N/A	N/A	63	0.61	5.02	0.01	N
12	Main Beach	8/31/14 16:30	8/31/14	N/A	N/A	52	0.61	5.04	0	N
12	Main Beach	9/7/14 16:30	9/7/14	N/A	N/A	158	0.92	5.08	0	N
12	Main Beach	9/14/14 16:30	9/14/14	N/A	N/A	63	1.4	5.11	0	N
12	Main Beach	9/21/14 16:30	9/21/14	N/A	N/A	512	1.5	5.12	0	N
12	Main Beach	9/28/14 16:30	9/28/14	N/A	N/A	63	1.4	5.12	0.22	Y
13	Cowell Beach	10/6/13 16:15	10/6/13	N/A	N/A	0	5.6	6.39	0	N
13	Cowell Beach	11/3/13 16:15	11/3/13	N/A	N/A	20	6	6.32	0	N
13	Cowell Beach	11/10/13 16:15	11/10/13	N/A	N/A	0	4.8	6.26	0	N
13	Cowell Beach	11/24/13 16:15	11/24/13	N/A	N/A	262	6.8	6.36	0	N
13	Cowell Beach	12/8/13 16:15	12/8/13	N/A	N/A	41	27	6.84	0.31	Y
13	Cowell Beach	12/15/13 16:15	12/15/13	N/A	N/A	10	7.3	6.39	0	N
13	Cowell Beach	12/22/13 16:15	12/22/13	N/A	N/A	20	7.5	6.42	0	N
13	Cowell Beach	12/29/13 16:15	12/29/13	N/A	N/A	30	8.1	6.47	0	N
13	Cowell Beach	1/12/14 16:15	1/12/14	N/A	N/A	20	7.9	6.37	0	N
13	Cowell Beach	1/26/14 16:15	1/26/14	N/A	N/A	20	4.6	6.19	0	N
13	Cowell Beach	2/2/14 16:15	2/2/14	N/A	N/A	63	212	7.99	3.11	Y
13	Cowell Beach	3/9/14 16:15	3/9/14	N/A	N/A	0	33	6	0	N
13	Cowell Beach	3/16/14 16:15	3/16/14	N/A	N/A	10	23	5.76	0	N
13	Cowell Beach	3/23/14 16:15	3/23/14	N/A	N/A	10	16	5.56	0	N
13	Cowell Beach	3/30/14 16:15	3/30/14	N/A	N/A	0	41	6.18	0.61	Y
13	Cowell Beach	4/13/14 16:15	4/13/14	N/A	N/A	20	19	5.66	0	N
13	Cowell Beach	4/27/14 16:15	4/27/14	N/A	N/A	110	17	5.58	0.57	Y
13	Cowell Beach	5/4/14 16:15	5/4/14	N/A	N/A	9208	12	5.4	0	N
13	Cowell Beach	5/11/14 16:15	5/11/14	N/A	N/A	0	9.5	5.33	0.01	N
13	Cowell Beach	5/18/14 16:15	5/18/14	N/A	N/A	10	6.9	5.23	0	N
13	Cowell Beach	6/1/14 16:15	6/1/14	N/A	N/A	30	6.5	5.23	0	N
13	Cowell Beach	6/8/14 16:15	6/8/14	N/A	N/A	187	3.9	5.12	0	N
13	Cowell Beach	6/22/14 16:15	6/22/14	N/A	N/A	41	0.92	4.96	0	N
13	Cowell Beach	6/29/14 16:15	6/29/14	N/A	N/A	145	2.1	5.1	0	N
13	Cowell Beach	7/6/14 16:15	7/6/14	N/A	N/A	0	2	5.08	0	N
13	Cowell Beach	7/20/14 16:15	7/20/14	N/A	N/A	20	1.2	5.03	0	N
13	Cowell Beach	7/27/14 16:15	7/27/14	N/A	N/A	10	0.49	4.94	0	N
13	Cowell Beach	8/3/14 16:15	8/3/14	N/A	N/A	41	0.57	4.97	0	N
13	Cowell Beach	8/10/14 16:15	8/10/14	N/A	N/A	0	0.98	5.03	0	N
13	Cowell Beach	8/17/14 16:15	8/17/14	N/A	N/A	20	0.71	5.01	0	N
13	Cowell Beach	8/24/14 16:15	8/24/14	N/A	N/A	0	0.61	5.02	0.01	N
13	Cowell Beach	8/31/14 16:15	8/31/14	N/A	N/A	20	0.61	5.04	0	N
13	Cowell Beach	9/7/14 16:15	9/7/14	N/A	N/A	20	0.92	5.08	0	N
13	Cowell Beach	9/14/14 16:15	9/14/14	N/A	N/A	30	1.4	5.11	0	N
13	Cowell Beach	9/21/14 16:15	9/21/14	N/A	N/A	41	1.5	5.12	0	N
13	Cowell Beach	9/28/14 16:15	9/28/14	N/A	N/A	20	1.4	5.12	0.22	Y

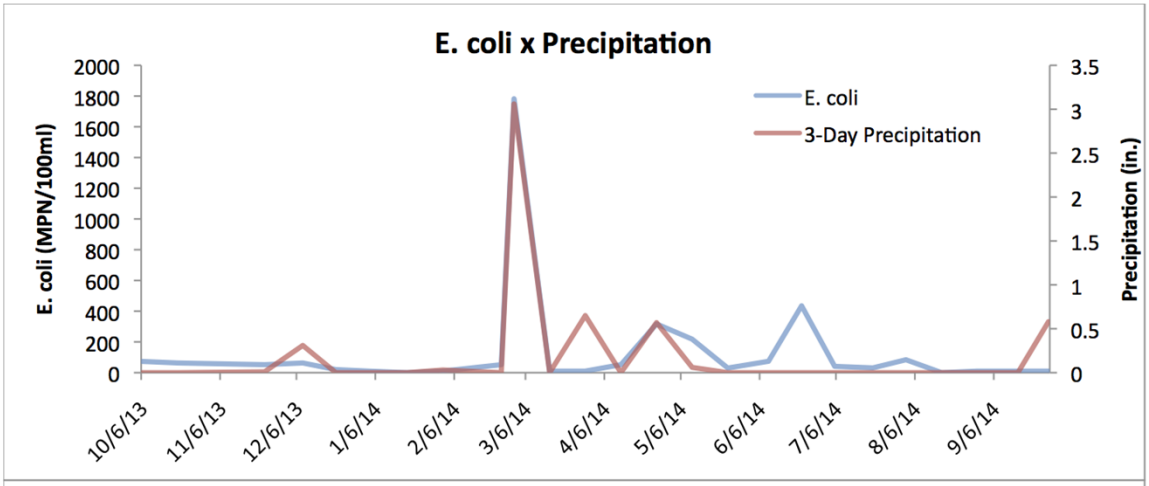
SITE 1: San Lorenzo RIVER AT HENRY COWELL REDWOODS STATE PARK

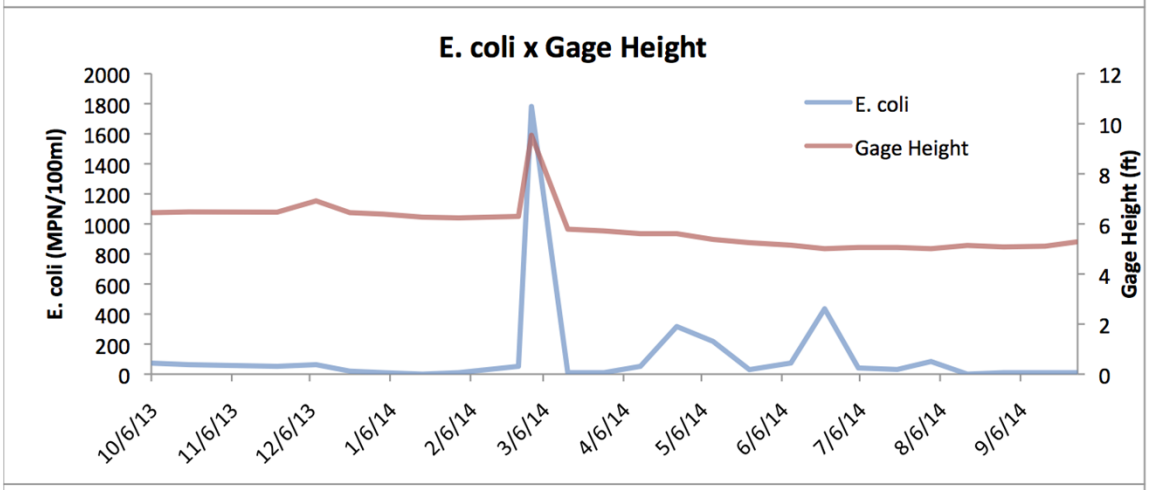


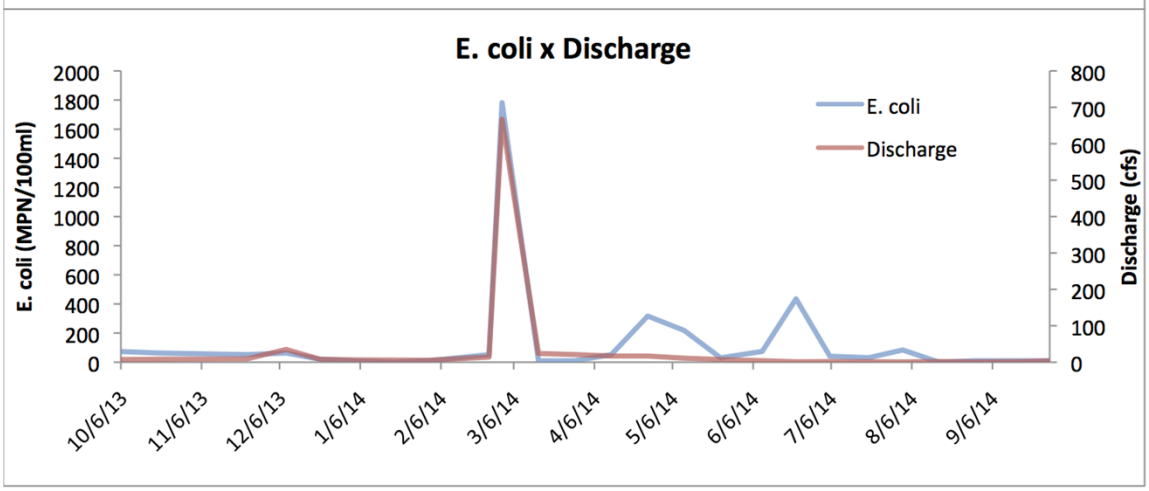
SITE 2: San Lorenzo RIVER AT SANTA CRUZ TANNERY



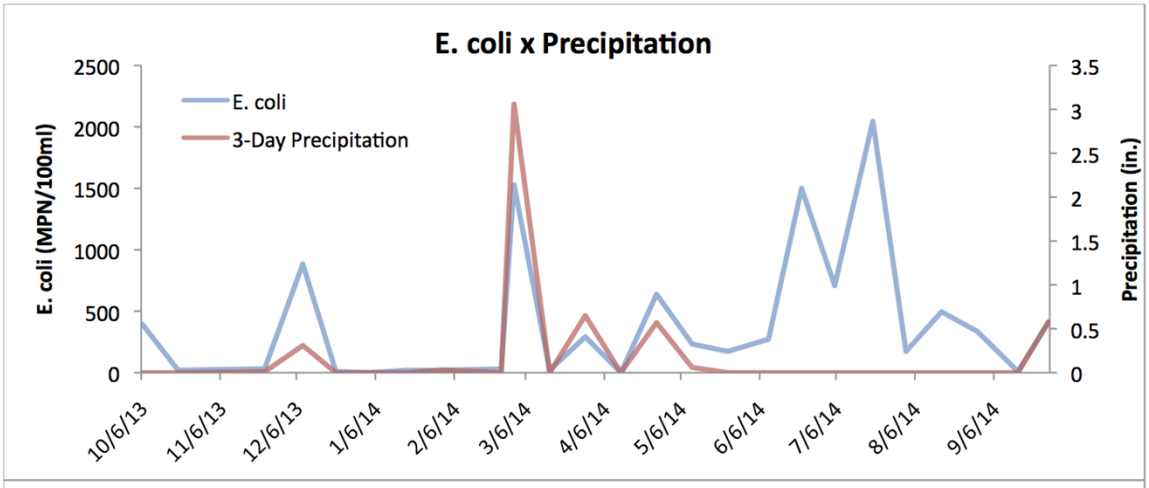
SITE 3: SAN LORENZO RIVER AT JOSEPHINE STREET

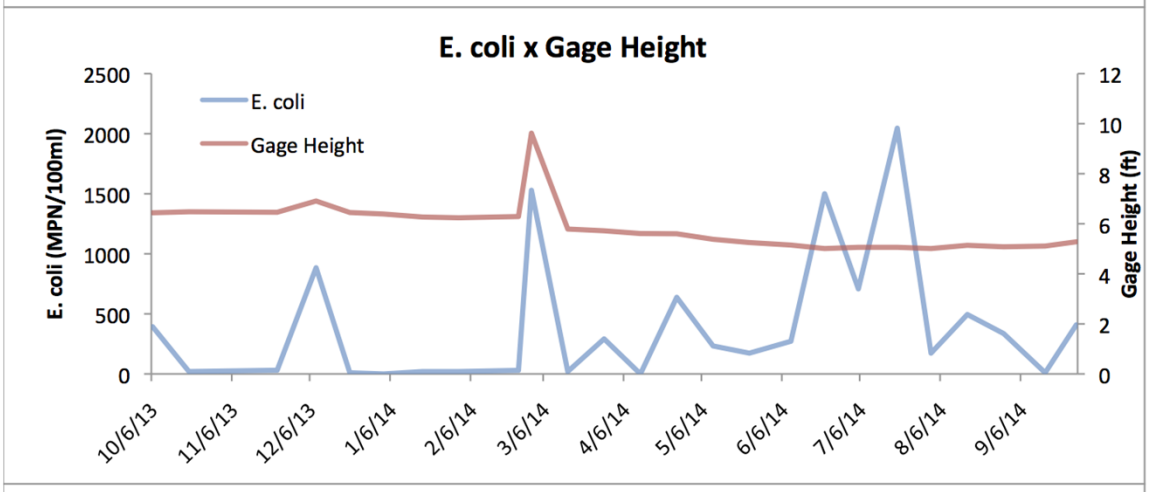


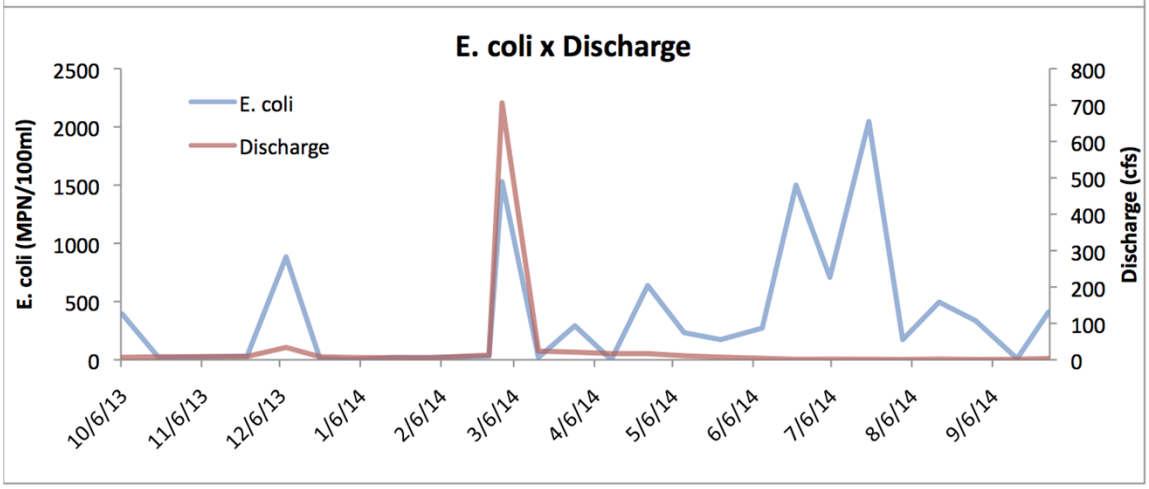




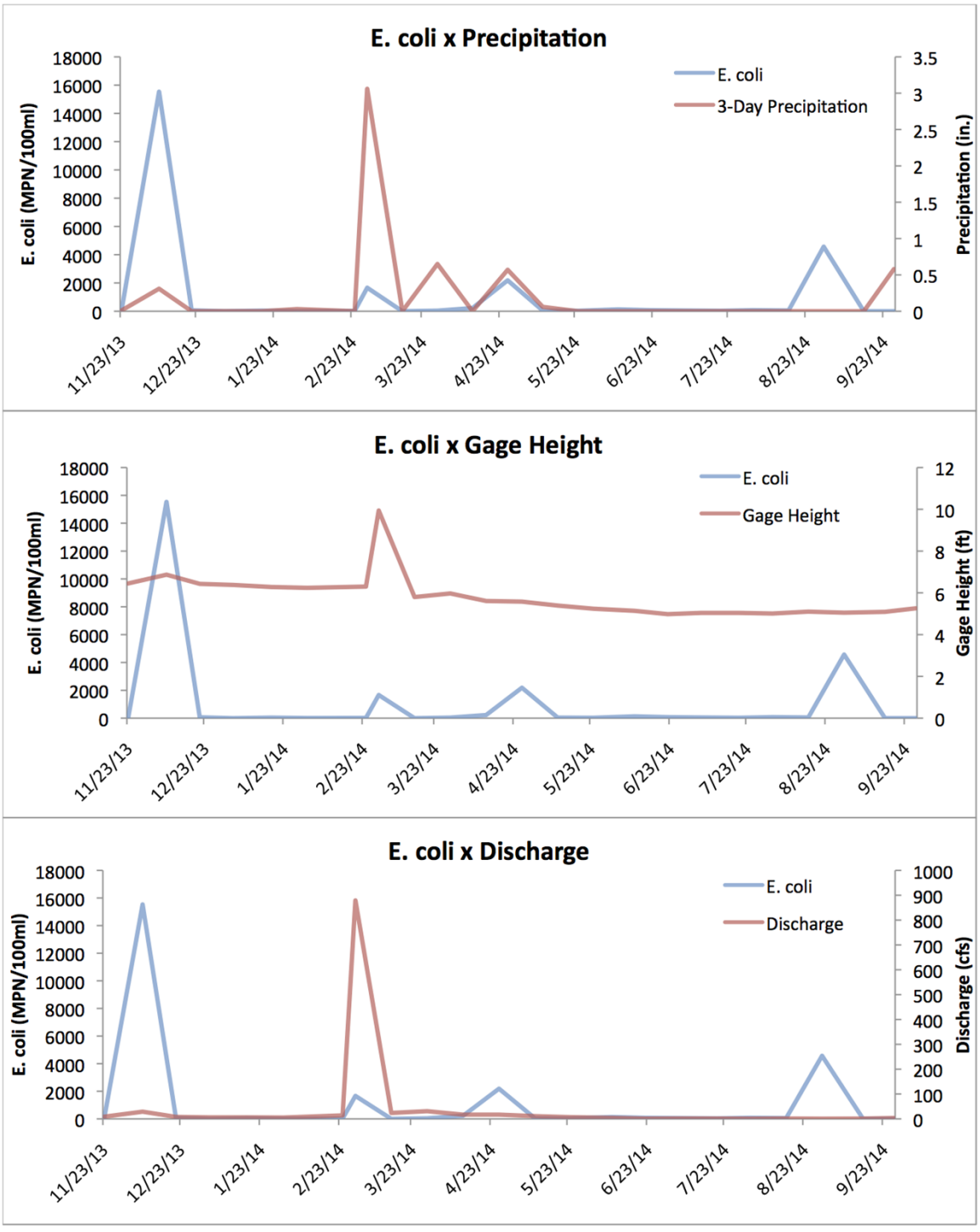
SITE 4: SAN LORENZO RIVER AT WATER STREET BRIDGE



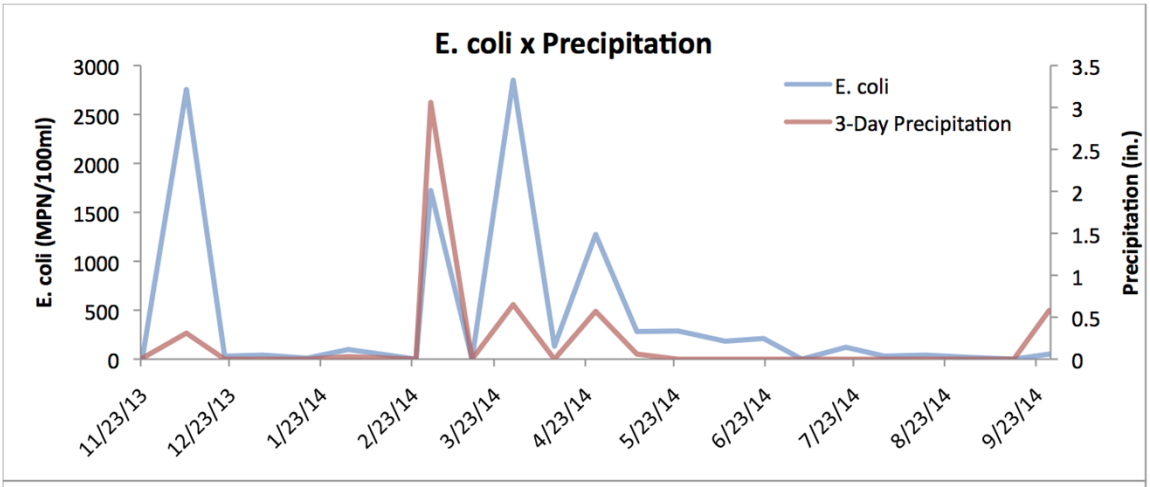


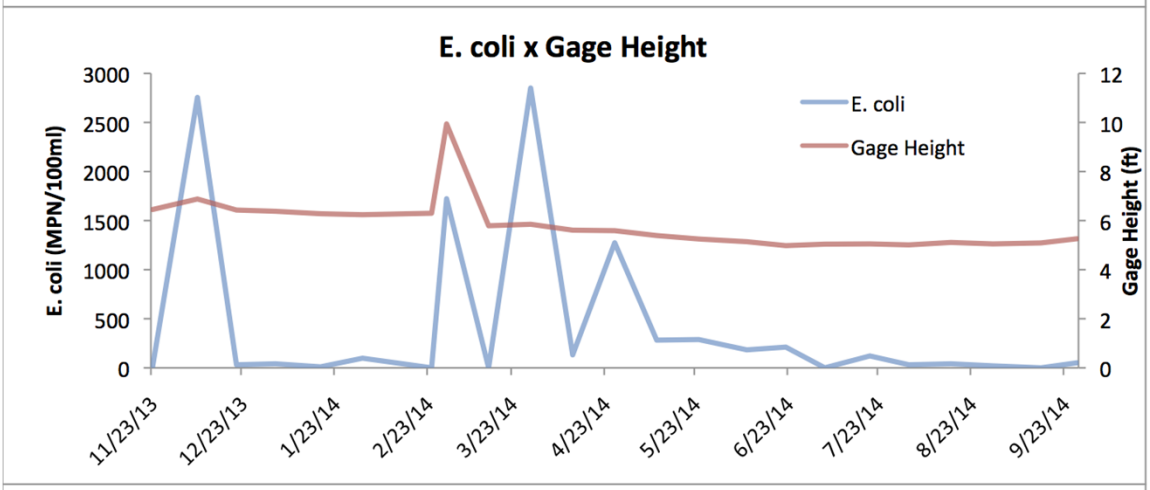


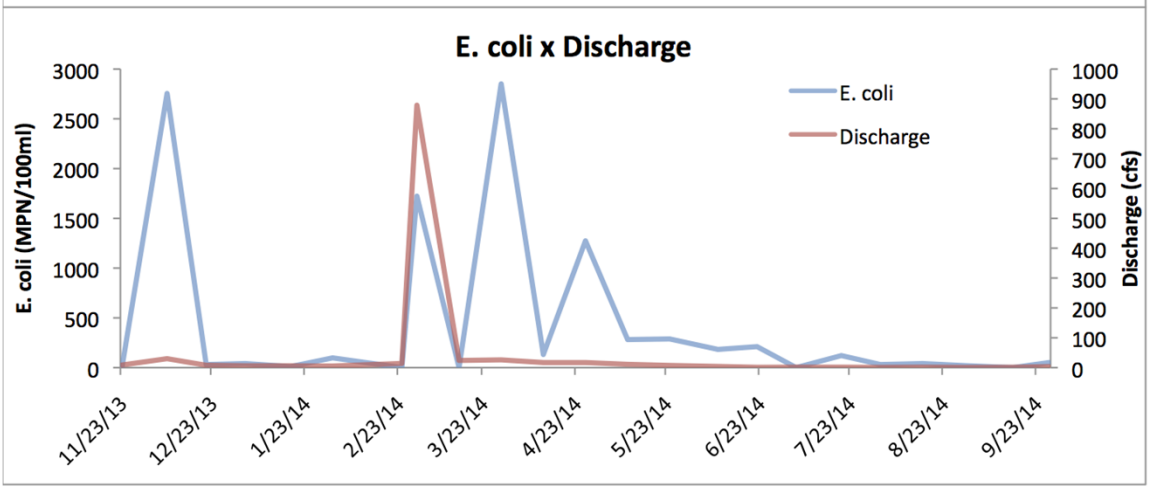
SITE 5: CARBONERA CREEK AT CA HIGHWAY 1



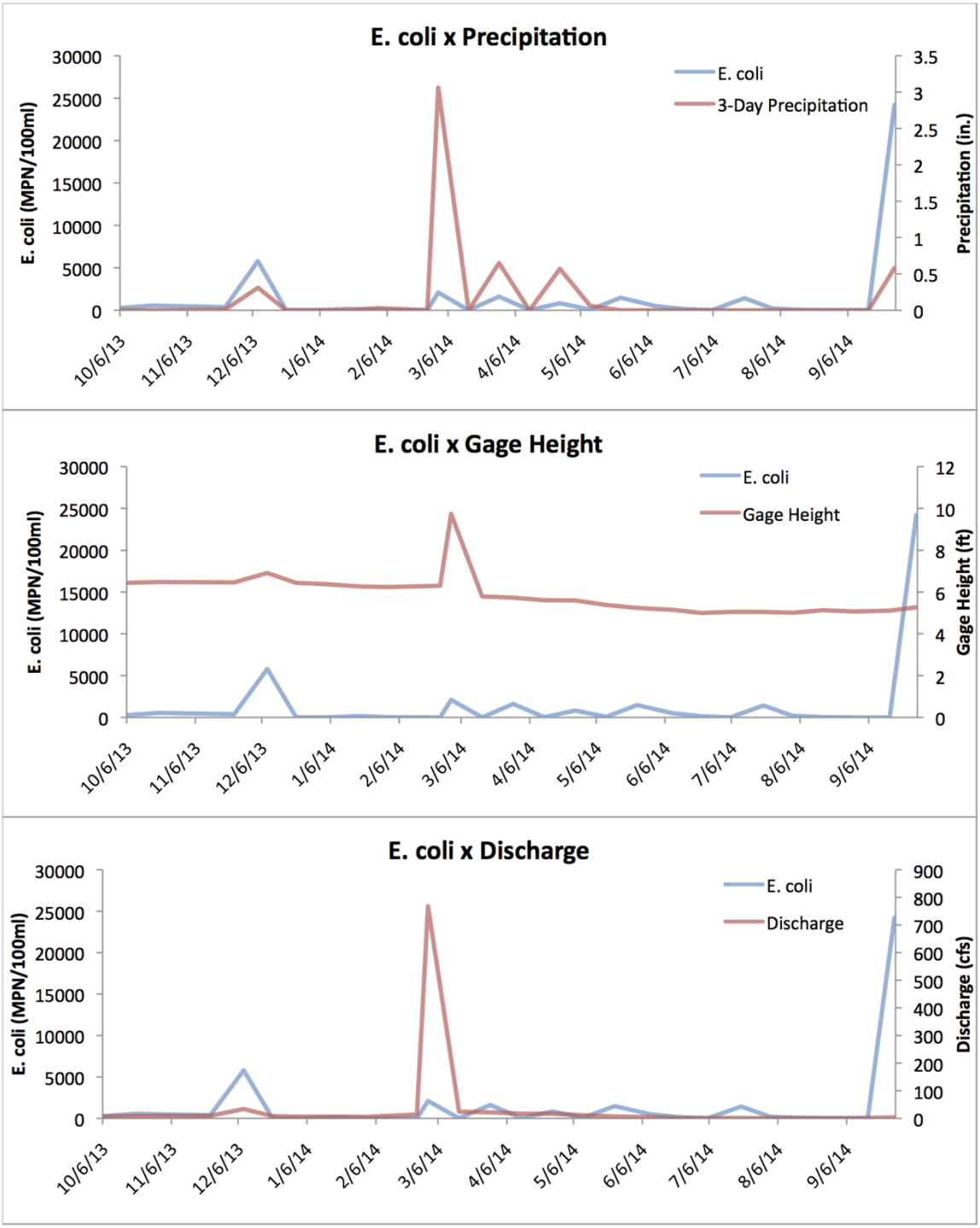
SITE 6: BRANCIFORTE CREEK AT STONEY CREEK BRIDGE



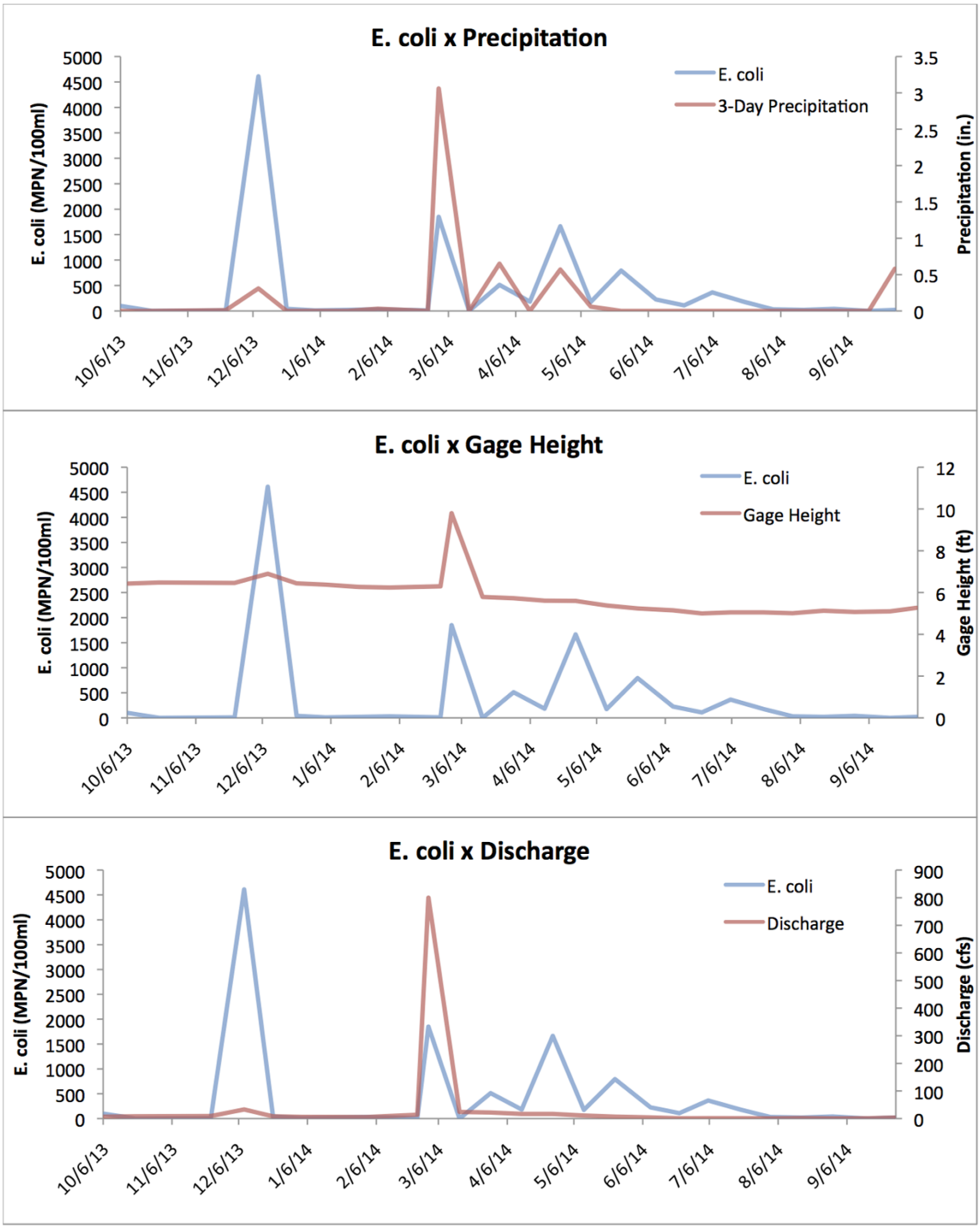




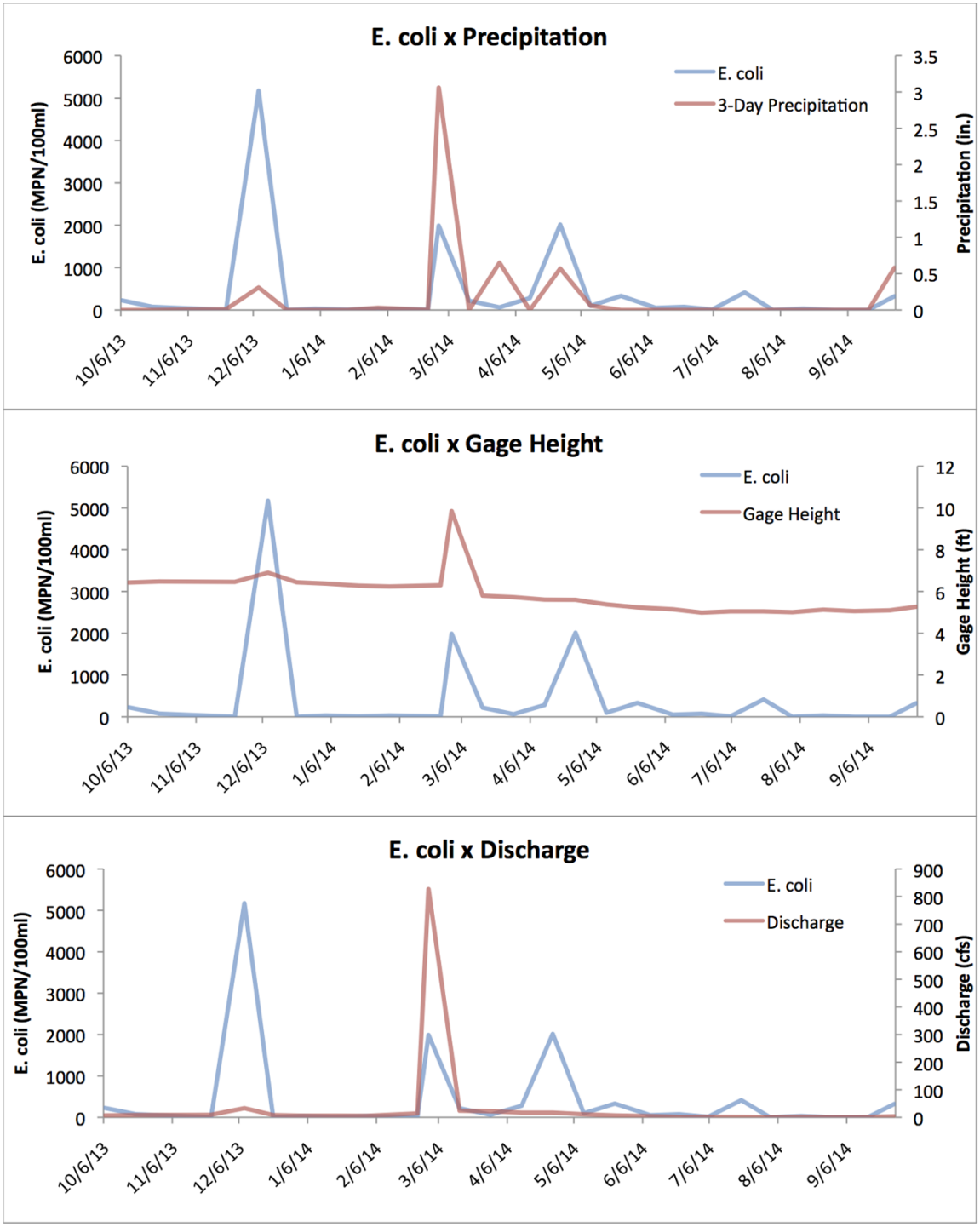
SITE 7: BRANCIFORTE CREEK AT San Lorenzo RIVER



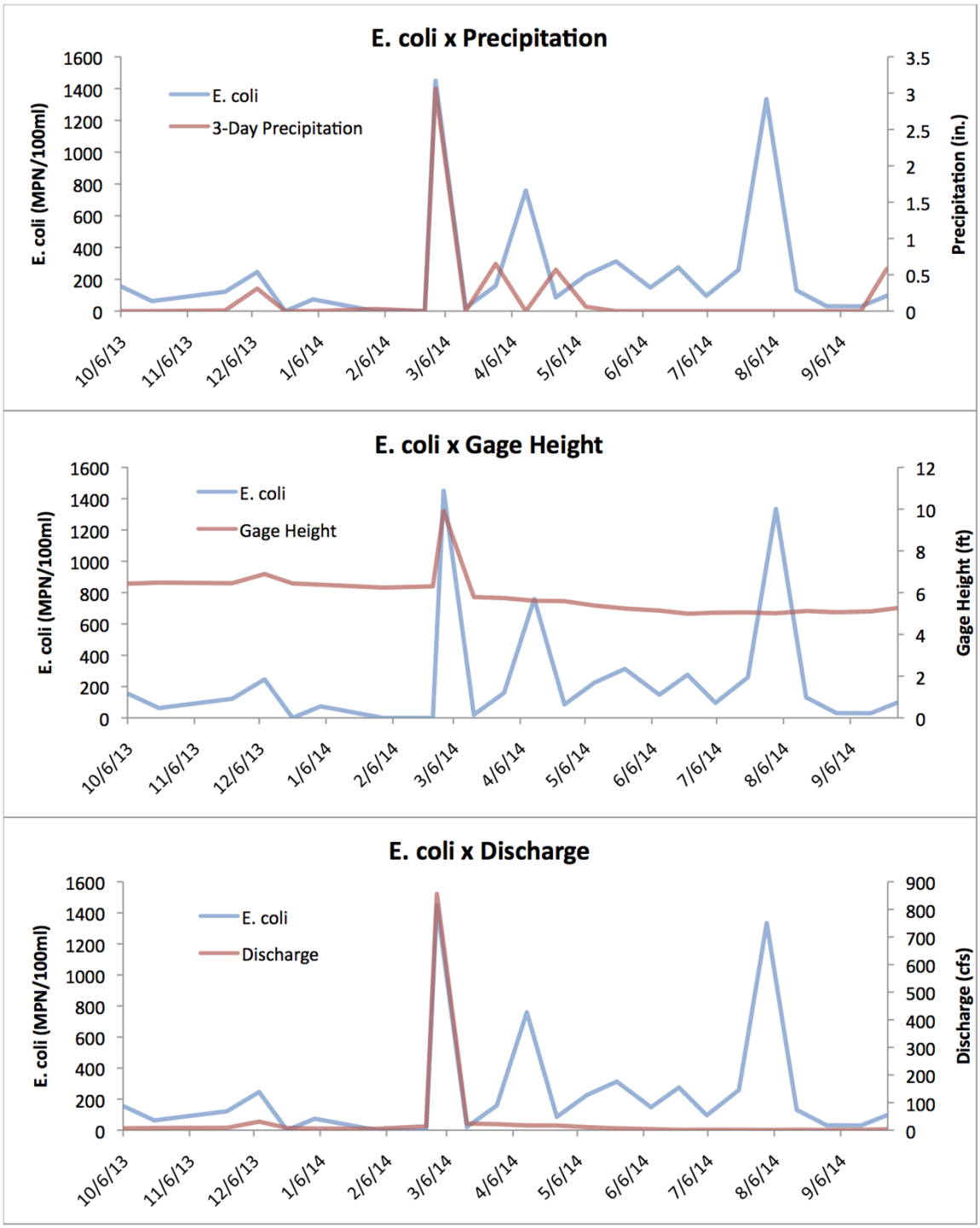
SITE 8: San Lorenzo RIVER AT KAISER PERMENANTE ARENA



SITE 9: San Lorenzo RIVER AT FIRST BEND



SITE 10: San Lorenzo RIVER AT MONTEREY BAY



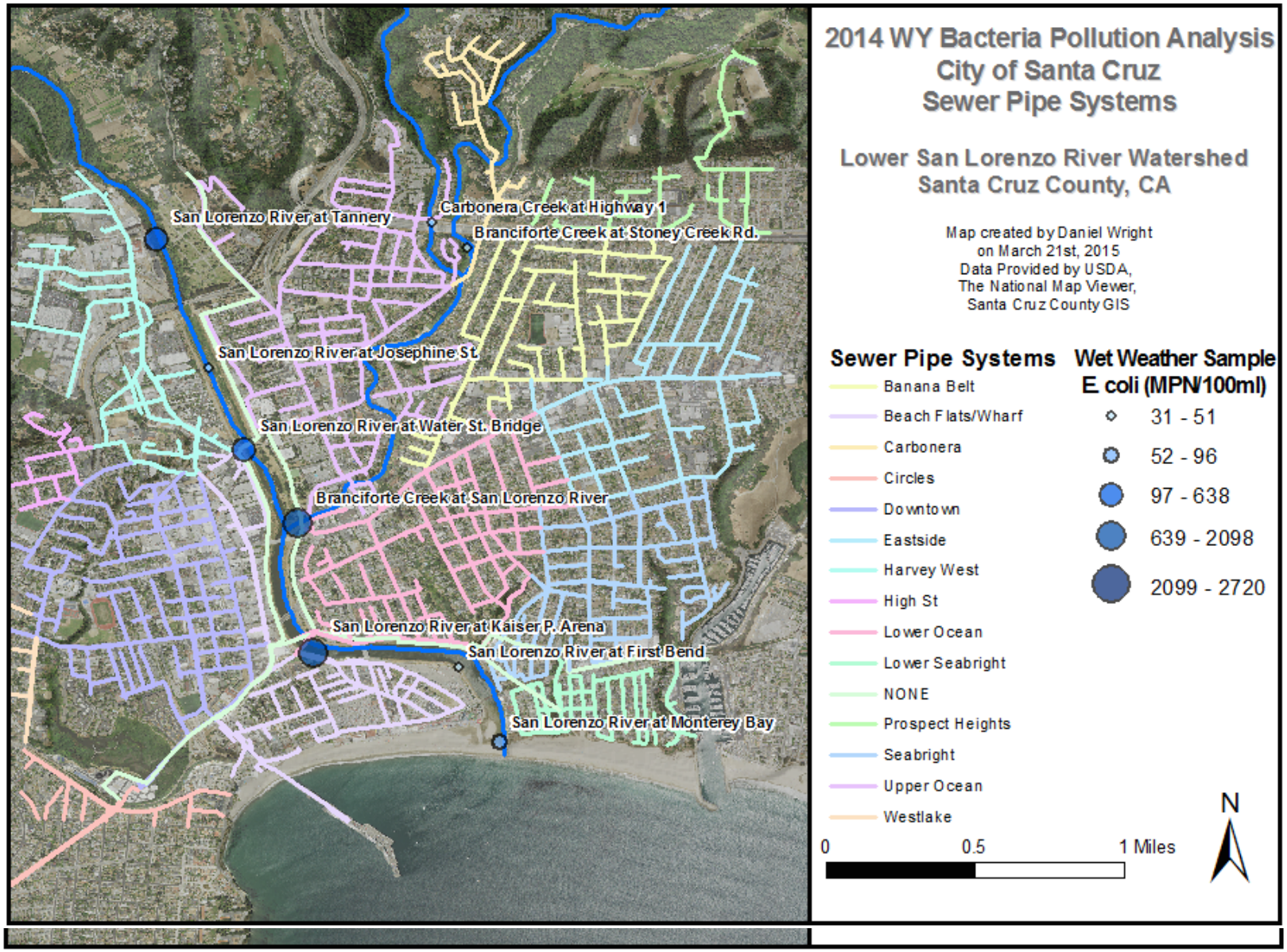


Figure 2. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

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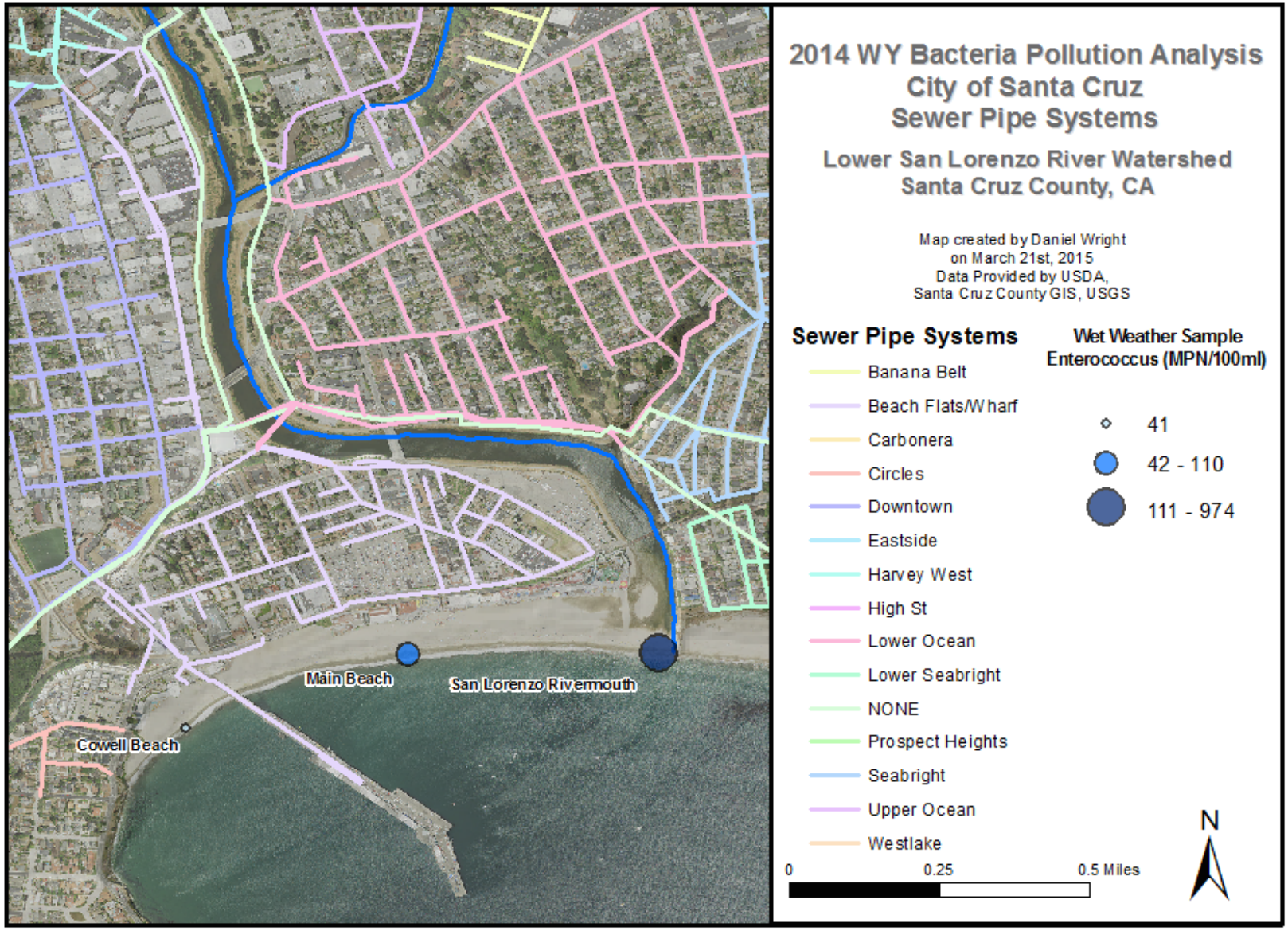

Figure 2. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

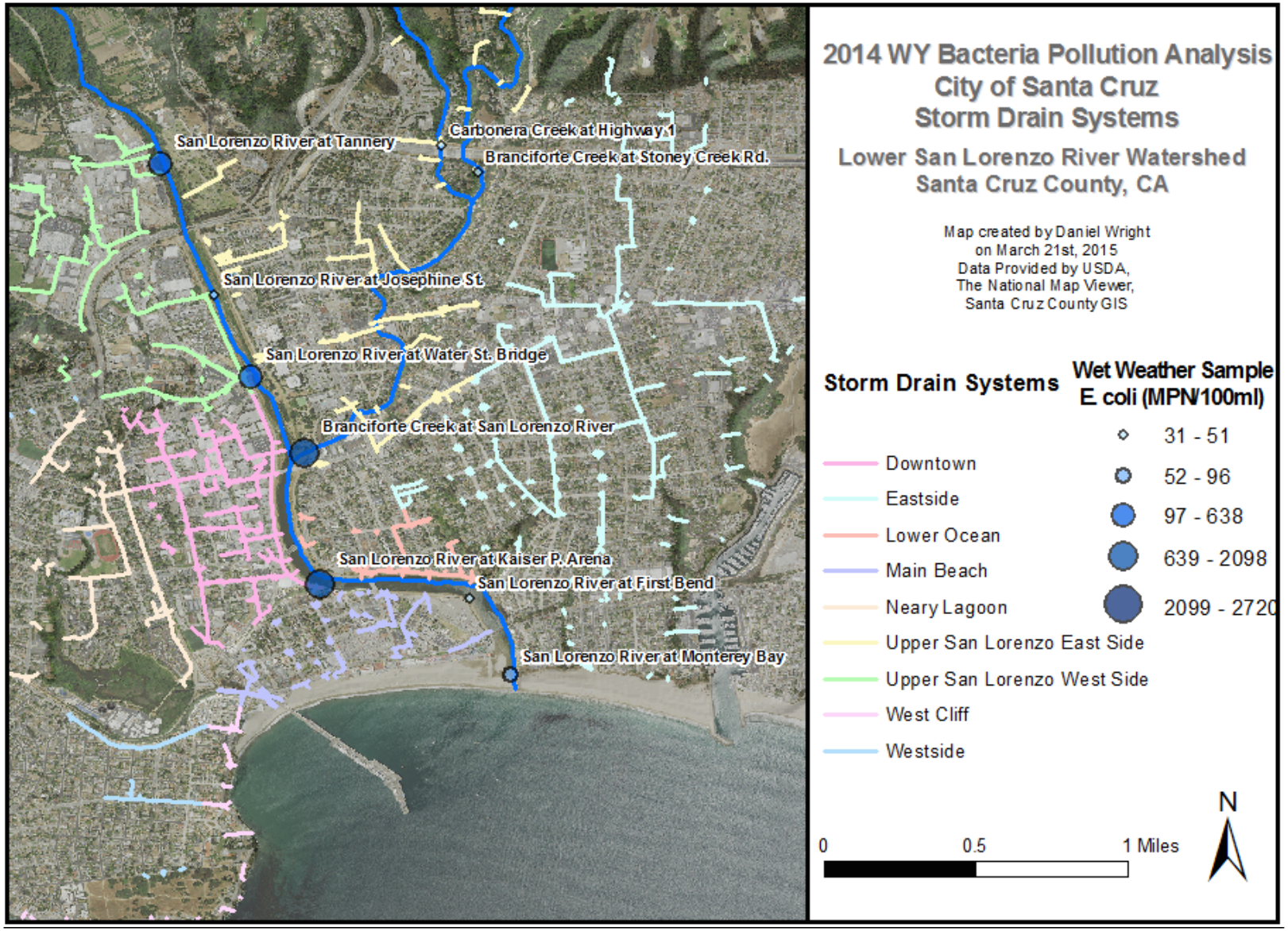

Figure 2: 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

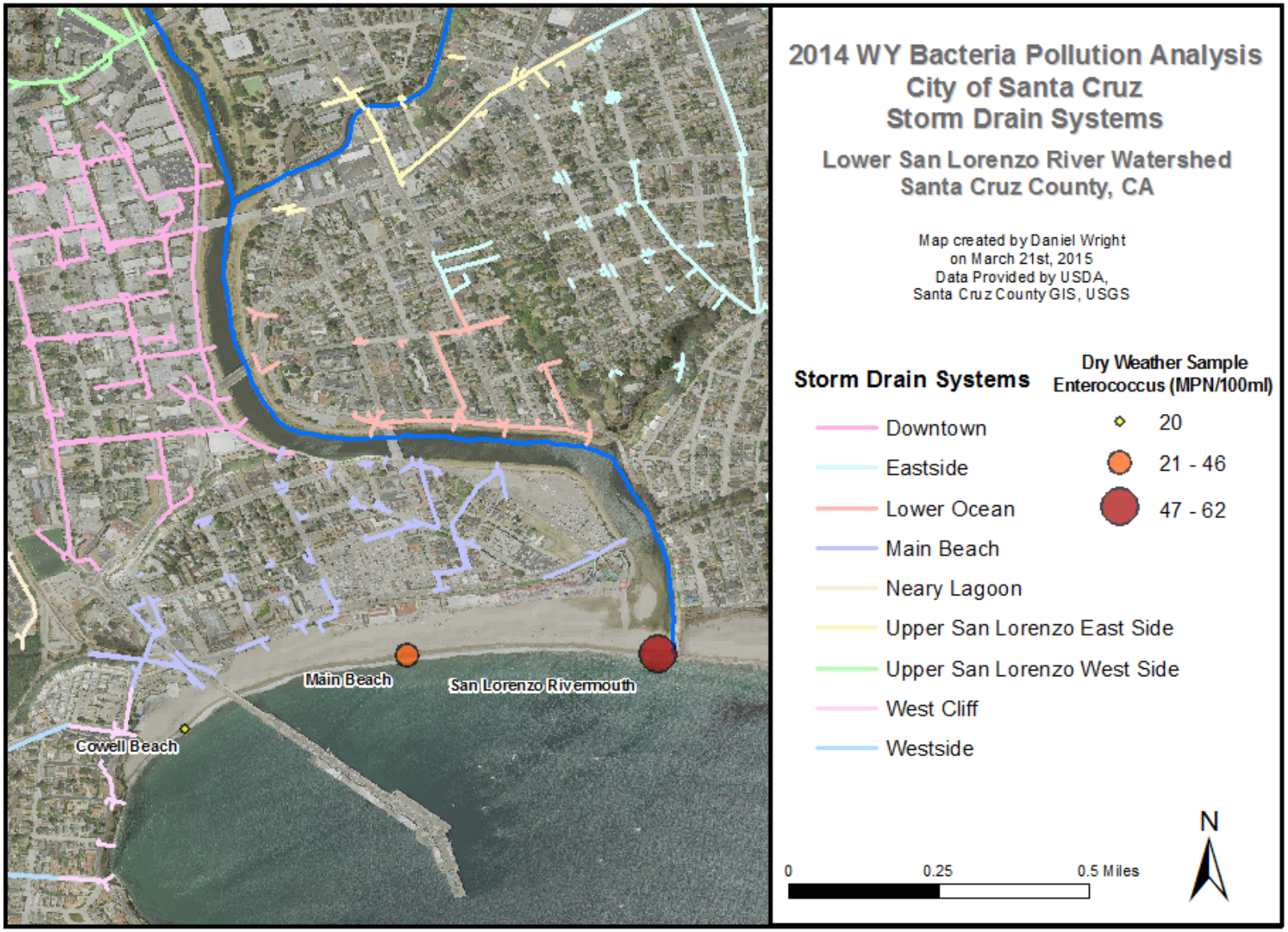

Figure 2. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.

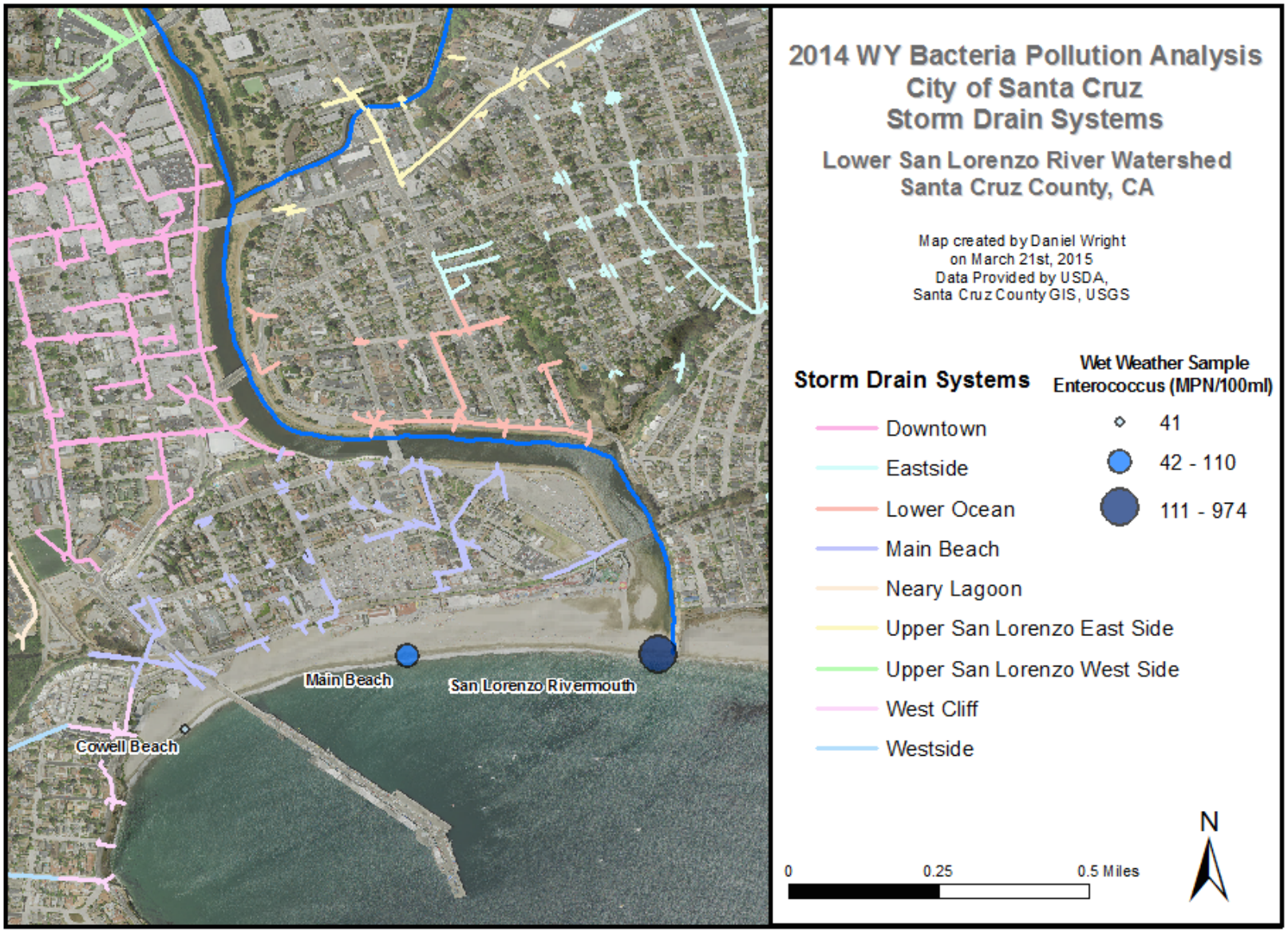

Figure 2. 2014 Water Year bacteria pollution analysis study area, lower San Lorenzo River watershed, Santa Cruz County, CA.