SOLANO COUNTY BIOMONITORING

Education Program

2019-2020 FINAL REPORT

Prepared by Allison Martin
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Solano County Biomonitoring Program

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Background

The Solano County Biomonitoring Program ("Biomonitoring Program") began in 2009 as a regionally specific partnership between Solano Resource Conservation District ("SRCD") and Vallejo Flood & Wastewater District ("VFWD"). The goal of the program was to engage local teenagers in conducting biosurveys and restoration activities in the Blue Rock Springs Creek Corridor in Vallejo. Since then, the program has evolved to include 25 classes, with at least one class coming from each high school in Solano County, and is funded by VFWD, Solano County Department of Resource Management ("Solano County"), Solano County Water Agency ("SCWA"), and the City of Benicia.

2020 was the program's 12th year collecting data using the California Streamside Biosurvey, a streamside bioassessment protocol previously used by the California Department of Fish and Wildlife before the statewide implementation of SWAMP, or the Stream Water Ambient Monitoring Program. The Biomonitoring Program continues to use the California Streamside Biosurvey protocols to maintain data coherence and applicability in a student-based setting. Long-term biological, chemical, and habitat monitoring of creeks through standardized procedures helps to quantify the health of a stream for local scientists, agencies, stakeholders, and watershed managers.

By comparing results year by year, we can distinguish both positive and negative trends within each watershed. The data is analyzed and interpreted by Dr. Patrick Edwards of Portland State University. Dr. Edwards has been specializing in citizen science biomonitoring programs since the early 2000s and is a regular program consultant.

The program currently consists of three classroom visits and two field studies in both a winter and a spring session, providing high school students with practical, hands-on experience carrying out scientific research in the field while also helping them develop their understanding of stream ecology, biology, and stewardship concepts. The work students do is completely appropriate to include on curriculum vitaes, resumes, and job applications.

The Solano RCD looks forward to its continuing work with its partners to ensure that students can participate in this on-going citizen science project. It is rare locally and internationally to have such long term data collected primarily by high school students, and therefore this program is valuable not only in its support of educating students on environmental stewardship practices and science, but also in providing valuable and consistent data to the scientific community and regional stakeholders.

Program Goals and Objectives

The guiding question for the Biomonitoring Program is:

> *How can we investigate and describe the health of Solano County watersheds, and furthermore, why is having a healthy watershed important?*

From this guiding question, the program is structured on the following goal:

> *All participating high school students will investigate and collect data to serve as evidence for scientific questions regarding the health of their local watershed*.

The goal is achieved by fulfilling the following program objectives:

- Students participate in two preparatory classroom lessons featuring a hands-on approach to researching and interpreting stream ecology data.
- Students engage in two field study events, measuring physical habitat characteristics for a local creek in the first and collecting chemical and biological data in the second event.
- Students analyze the biological stream data in a final lesson to calculate the stream's Index of Biological Integrity (IBI score), and use the chemical and physical data to help identify environmental stressors influencing creek health.

Beyond its educational component, the Biomonitoring Program also aims to provide long-term data to water agencies, resource managers, and watershed scientists to help these individuals and organizations assess the effectiveness or need for restoration or other remediation activities at local waterways.

Annual Summary

A total of 675 students were registered for the program but only 240 students were able to participate prior to the COVID-19 related school closures. Data was collected with students at Chabot Creek in Vallejo and Union Avenue Creek in Fairfield just prior to the closures.

Once Solano County shelter-at-home restrictions lifted slightly to allow for more outdoor field work, SRCD program staff resumed collecting biological data for the remaining historic program sites: Upper and Lower Blue Rock Springs Creek in Hanns Park, Rindler Creek, and Sulphur Springs Creek in Vallejo; Laurel Creek in Fairfield; Alamo and Ulatis Creeks in Vacaville. Dr. Edwards analyzed the data and provided the summary located later in this report.

Most participating classes were Advanced Placement, meaning that students were focused on preparing for their May 18 Advanced Placement exams for most of the time they continued their learning while sheltering at home. In lieu of offering virtual classes or field trips, SRCD offered teachers the biological data collected by staff and quick videos and templates for students to use to calculate the IBI score. SRCD also shared the program video and links to other program related resources.

Program staff also participated in Justice, Equity, Diversity, and Inclusion trainings to improve the program's cultural relevancy, and dedicated time to organizing historic data and planning for virtual events in the 2020-2021 school year.

Program Methodology

- Students complete a program pre-assessment instrument 1-2 days before the first scheduled lesson. The pre-assessments are administered by the classroom teacher for no more than 10 minutes. Students are requested to respond to each question with a logical response, even if they do not know the correct answer, and without any assistance from their teacher or peers.

- Students watch the Solano County Biomonitoring Program video (2018) as an introduction to the program's purpose and activities. They also record responses to a series of video-related questions.

- Students read pre-lesson text on watersheds and stream ecology, and follow the reading by responding to five reflective questions.

- An SRCD presenter facilitates the first lesson on stream ecology and physical habitat analysis. Students rotate through different stations practicing different field techniques, including describing water appearance and odor, measuring bankfull width and height, classifying substrates and embeddedness, identifying microalgae and macroalgae, and calculating stream discharge rate. This practice allows students to be more autonomous during their first field study.

- Students attend a "Watershed Walk" as their first field study. They carry out physical habitat assessment protocols published by the Environmental Protection Agency *Volunteer Stream Monitoring Methods Manual* and the SWAMP Habitat Characterization protocols. By conducting the habitat assessment, students are more familiar with creek conditions and can start making predictions about the types of organisms they may find during the biomonitoring event.

- An SRCD presenter facilitates a second lesson on macroinvertebrate identification so that students can successfully identify macroinvertebrates during their second field study. Students learn that different types of macroinvertebrates have different tolerances of pollution, and that by analyzing which types of macroinvertebrates are present and how many of each, we can determine creek health.

- Students attend the Monitoring Field Study. They work with partners to complete several chemical analyses, including determining dissolved oxygen, nitrate, phosphate, pH and turbidity levels. Students then collaborate with small groups to collect samples of macroinvertebrates using the California Streamside Biosurvey protocols. Students sort, identify, and count a sample of the macroinvertebrate population and the final data is recorded by SRCD staff.

- The SRCD program manager reviews the collected data and enters it into spreadsheets automatically calculating all of the biological metrics students will calculate during their final lesson. The SRCD presenter uses this data to guide and check student work. Once students complete their IBI score calculations and interpret stream conditions, students examine the chemical and habitat data to come up with explanations for their results.

- Students complete a duplicate post-assessment, which is later analyzed by a data specialist to measure student knowledge gains and response to the program.

- Classroom teachers are strongly encouraged to assign students to work in a group and write up a scientific report and presentation for the entire biomonitoring program. The reports and presentations are observed by or submitted to the SRCD, and select groups are invited to present their findings to the Biomonitoring Program funders and watershed stakeholders.

- Final raw data is submitted to Dr. Edwards for analysis and incorporated into the annual report.

Results

A total of 675 students from 25 classes across Solano County were registered in either the winter (February – March) or spring (April – May) sessions of the program. A summary of program enrollment is in Table 1 below. Those noted by an asterisk (*) did not participate in the program due to school closures.

A total of nine creek sites were assessed, including: Upper and Lower Blue Rock Springs Creek, Rindler Creek, Sulphur Springs Creek and Chabot Creek in Vallejo; Union Avenue Creek and Laurel Creek in Fairfield; and Alamo and Ulatis Creeks in Vacaville. Please note that while the sample site is technically located in Vallejo, Sulphur Springs Creek is a part of Benicia's watershed and not Vallejo's.

Quantitative Impact

Table 1 – Breakdown of Biomonitoring Program Registrants

School by City	Teacher	Course	Total # Students	Total # Classes	Monitoring Site/Watershed
DIXON (Dixon USD)					
Dixon High School	Kaitlin Fairris	AP Env Sci	32*	1	Alamo Creek at Beelard Park, Vacaville
SUB-TOTAL - DIXON			**32**	**1**	**Sacramento River**
FAIRFIELD (Fairfield-Suisun USD)					
Fairfield High School	Heather Handa	AP Env Sci	21	1	Union Ave Creek, Fairfield
Armijo High School	Kim Carter	IB Biology	62*	2	Middle Laurel Creek, Fairfield
Rodriguez High School	Tamara Moore	Biology	25	1	Oakbrook Creek, Fairfield
SUB-TOTAL – FAIRFIELD/SUISUN			**108**	**4**	**Suisun Marsh**
FAIRFIELD (Travis USD)					
Vanden High School	Michael Howell	AP Biology	25*	1	Upper Laurel Creek, Fairfield
SUB-TOTAL - TRAVIS			**25**	**1**	**Suisun Marsh**
VACAVILLE (Vacaville USD)					
Vacaville High School	Erin Gordon	AP Biology	84	3	Ulatis Creek at Andrews Park, Vacaville
Will C Wood High School	Kevin English	AP Env Sci	60	2	Upper Alamo Creek (behind Vacaville Christian), Vacaville
SUB-TOTAL - VACAVILLE			**144**	**5**	**Sacramento River**
BENICIA (Benicia USD)					
Benicia High School	Josh Bradley	Biology	60*	2	Sulphur Springs Creek, Hiddenbrooke Park, Vallejo
SUB-TOTAL BENICIA			**60**	**2**	**Carquinez Strait**
VALLEJO					
Vallejo High School	Vivet Nelson	Biology	112*	4	Rindler Creek, Chabot Creek, Vallejo
Vallejo High School	TBA	BioTech 2	78*	3	Lower Blue Rock Springs Creek, Chabot Creek
Jesse Bethel High	Maria Lavandora	AP Biology	44*	2	Upper Blue Rock Springs Creek, Vallejo
Jesse Bethel High	Diosa Bande	AP Chemistry	22*	1	Middle Blue Rock Springs Creek, Vallejo
Mare Island Technology Academy	Michael Wee	AP Env Sci	50	2	Chabot Creek, Vallejo
SUB-TOTAL - VALLEJO			**306**	**12**	**San Pablo Bay**
GRAND TOTAL			**675**	**25**	

Qualitative Impact

Due to the unexpected school closures, we were unable to complete a pre/post assessment analysis this year. Below are the assessment questions that were developed for this year's program:

Prompt: "*Assume you are out on a hike with friends and you come across a creek. You **want** to know if the creek is healthy.*"

1. Your friends want to know why you care if the creek is healthy. What do you tell them?
   Desired response: open ended

2. What **information** about the creek would you need to know to decide if it is healthy?
   Desired response: Its biological, chemical, and physical habitat data or characteristics

3. Give three or more examples of some **procedures** you can do to collect the information you need to decide the creek's health.
   Desired response(s): Collect a sample of macroinvertebrates and count how many there are; test the pH, dissolved oxygen, nitrate, phosphate, or turbidity levels; measure stream discharge rate, bank and channel vegetation, look at the types of algae present, estimate embeddedness and substrate, etc.

4. Assuming the creek is ***not*** healthy, what could you and others do to help make it healthier?
   Desired response(s): Plant trees and shrubs to cover the water to keep the water cooler and provide food for macroinvertebrates; plant grasses to stabilize the bank from erosion; do trash cleanups; put only rain down the storm drain (limit use of fertilizers, pesticides, keep up on car maintenance to avoid leaky oil).

5. What would **you** do with all of the information you gathered about the creek?
   Desired response(s): Open ended, but ideally mentions bringing the information to city, county, or local officials; teaching peers about the watershed/watershed stewardship; etc.

Biomonitoring Results

Prepared by Dr. Patrick Edwards – see Appendix 1

Recommendations and Next Steps for 2020-2021

Overall, the program was on track to break its record of most number of students involved in its 12-year history. Unfortunately due to COVID-19, far fewer students participated in the program overall. Nonetheless, the program is still a valuable resource for students, agencies, and scientists in Solano County.

The following recommendations are a synopsis of suggestions offered by Dr. Edwards and program staff and are those that the SRCD believes would advance the program goals:

Program Recommendations:

- Incorporate conductivity into chemical data analysis. Purchase a quality field probe that measures conductivity, temperature, and dissolved oxygen. Conductivity levels can provide valuable insight into creek conditions. **Purchased 6/25/20**

- Submit all historic chemical data to Dr. Edwards to analyze, average, and track against all historic biometric data. Use data to search for disturbance events.

- Modify Lesson 1-Practice Lab to eliminate point/non-point source pollutant mapping activity, and bring the bankfull width, height measurements 3-dimensional using student desks or other furniture.

- CEDEN no longer accepts citizen science data. They have never published the program's biomonitoring data. Data and Dr. Edwards' analyses will be shared on the Solano RCD website, but SRCD will also work towards partnering with UC Davis to offer data for master's or PH.D. thesis projects on watershed or water quality.

- Continue searching for other platforms to share program data so that it is accessible to scientists and researchers.

Next Steps:

- Revise 2021 program student manual and teacher program guide.

- Research and prepare opportunities to offer the program virtually in 2021.

- Prepare a new videos for distance learning and/or as lesson supplementation using footage collected in 2020.

- Hire and train new program staff to implement program, as needed.

For questions about the biomonitoring program or this report, please contact the program manager:

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Appendices

Appendix 1 – Biometric Data Analysis by Dr. Edwards

Appendix 2 – Monitoring Site Maps

Appendix 3 – Program Photo Documentation

Appendix 1: Biometric Data Analysis

Analysis of the 2020 Solano RCD stream macro invertebrate data.

Prepared for the Solano RCD
Prepared by Patrick Edwards, Ph.D.
Portland State University
6/24/2020

Summary

For the past twelve years, the Solano Resource Conservation District (RCD) has developed and implemented watershed health curriculum and partnered with high school teachers and students to collect macroinvertebrate, habitat and water chemistry data from nine streams in Solano county. In 2020, Index of Biotic Integrity (IBI) scores based on the macroinvertebrate communities declined from its peak in 2016 and several creeks including Chabot, Rindler and Sulphur Springs creeks showed drops in IBI scores. Blue Rock Springs and Hanns showed the highest IBI scores in 2020, while Rindler and Chabot creeks had the lowest IBI scores. Overall macroinvertebrate richness and abundance have remained about the same over the study period. The drop in IBI scores observed in the 2020 data may indicate a decline the overall health of the study streams or could be the result of modifying the data collecting procedure due to COVID-19 restrictions. Incorporating water chemistry and habitat data will improve understanding of why the streams are experiencing an apparent decline in overall condition.

Introduction

The purpose of this analysis is to examine year-to-year and long-term trends in the macroinvertebrate data collected by students participating in Salon's education program. To this end the data for each year are organized and analyzed for each year and across the twelve-year program. The data collected through this project represents valuable information that can be used by stream manages to monitor the overall health of the streams in the Solano Conservations district and to examine the impact of stream and watershed restoration efforts.

Methods

Under the supervision of Solano RCD staff, high school students collected macroinvertebrates with a d-net and sort them using a non-lethal method modified from Edwards (2016). At each reach, students collected three samples from the left, center and right-hand side of the stream and subsampled and counted at least 100 insects. Typically, three reaches from each stream are sampled and the data are combined across all reaches in the study stream; however, due to COVID-19, not all reaches were sampled in 2020.

Macroinvertebrate data were quantified using richness, density per ft^2 and the California Streamside Biosurvey Index of Biotic Integrity (IBI). Data for each stream were organized and plotted as using mean and standard deviation (figures 1-2), temporally (figures 3-5) and as a function of El Nino strength (figures 6-7).

The relationship between invertebrates and climate was examined using precipitation, air temperature, and El Nino data. Precipitation and temperature data were obtained from NOAA's National Center for Environmental information (Station # USC00042934). El Niño strength was obtained from NOAA's ENSO MEI page (http://www.esrl.noaa.gov/psd/enso/mei/table.html). ENSO MEI values are published as a scaled value with negative values indicating a La Niña condition and positive values indicate an El Niño Condition. Mean MEI index values ranged from -3 to 3. The ENSO MEI values are frequently used in studies of stream invertebrates to characterize general climate conditions in the study area (Mazor et al 2009).

Environmental data (Temperature, precipitation and ESNO MEI) were summarized using data for the year prior to collecting (April-May) and scaled so that the means of all data are zero and each data point is expressed as a deviation from the mean in terms of standard deviation. Environmental data was expressed as total precipitation, mean average air temperature and ENSO MEI for the water years 2009-2020.

For the climate analysis, the mean density and IBI value over the entire study period were correlated with precipitation and the ENSO MEI value. The strength of the relationship was determined using linear regression.

Results

In 2020, Blue Rock Springs (JBHS) and Ulatis had the highest IBI score (23) while Chabot had lowest IBI score (11). The IBI scores for the all other streams ranged between 19 and 23 (Figure 5). For all streams with more than 5 samples, mean total richness from 2009 – 2020 ranged from 9-19 and IBI scores ranged from 11-28 (figures 1-2). In 2020, the richness and density were stable for most of the streams (Figures 3 and 4). However, IBI scores declined for Chabot, Rindler, and Sulphur Springs creeks (Figure 5). Across all streams, mean IBI scores have generally increased since 2009 (Figure 6B) but have recently declined from the peak observed in 2016 (Figure 6B).

The results of the climate analysis show that IBI score is positively correlated with El Niño strength (Figure 6A and 6B, R^2=0.48, $p < 0.05$) while invertebrate density was positively, but insignificantly correlated with total precipitation (Figure 7A and 7B, R^2=0.29, $p > 0.05$).

Discussion

In general, the condition of the study streams appears to be stable after a slight decline from the peak IBI levels observed in 2016. The sharp decline in IBI score observed at Chabot, Rindler and Sulphur Springs creeks is concerning and warrants further analysis and study.

The temporal variability observed in the IBI scores is likely associated with both anthropogenic and climactic factors. The climactic component can be observed in the relatively strong relationship between ENSO strength and IBI scores (Figure 6a and 6b). It is difficult to evaluate the anthropogenic component without corresponding environmental data. The spatial component of variability (i.e. across streams) is most likely associated with the land use characteristics associated with each watershed.

The decoupling of the relationship between ENSO and IBI scores observed in 2020 (Figure 6B) may be an indicator that anthropogenic factors are playing an increasing role in shaping the macroinvertebrate assemblage of streams. However, the change in sampling protocol for 2020 may also explain these findings.

The Solano RCD in collaboration with high school teachers and students is continuing to collect valuable data for the management of the regional streams while at the same time educating student and the public about watershed health and stewardship. As the Solano RCD continues to collect macroinvertebrate and environmental data, it would be valuable to analyze the existing water chemistry and habitat data in the annual analysis.

Citations

Edwards, P. M. (2016). The value of long-term stream invertebrate data collected by citizen scientists. PloS one, 11(4).

Mazor R, Purcell A, Resh VH (2009) Long-term variability in benthic macroinvertebrate bioassessments: A 20-year study from two northern Californian streams. Environmental Management. 43: 1269-1286.

Figures

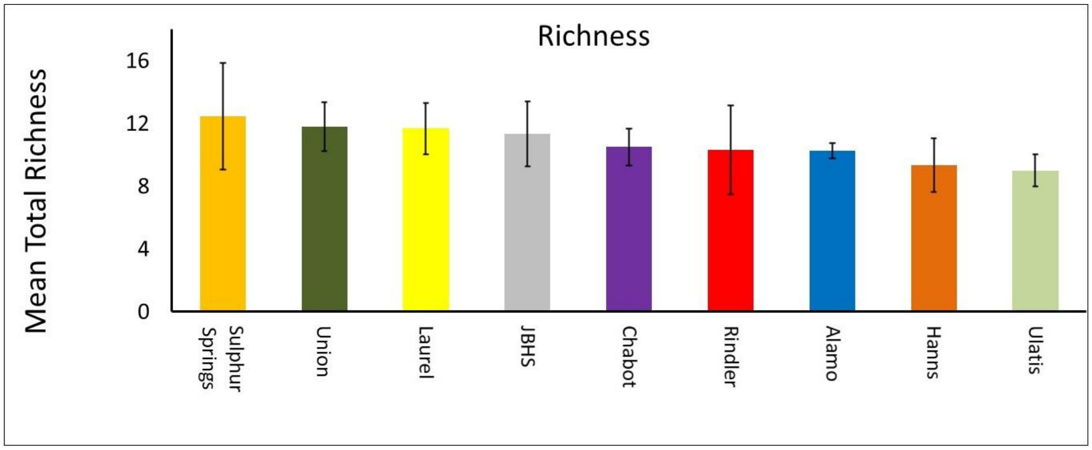


Figure 1: Mean total richness and standard deviation for all study streams.

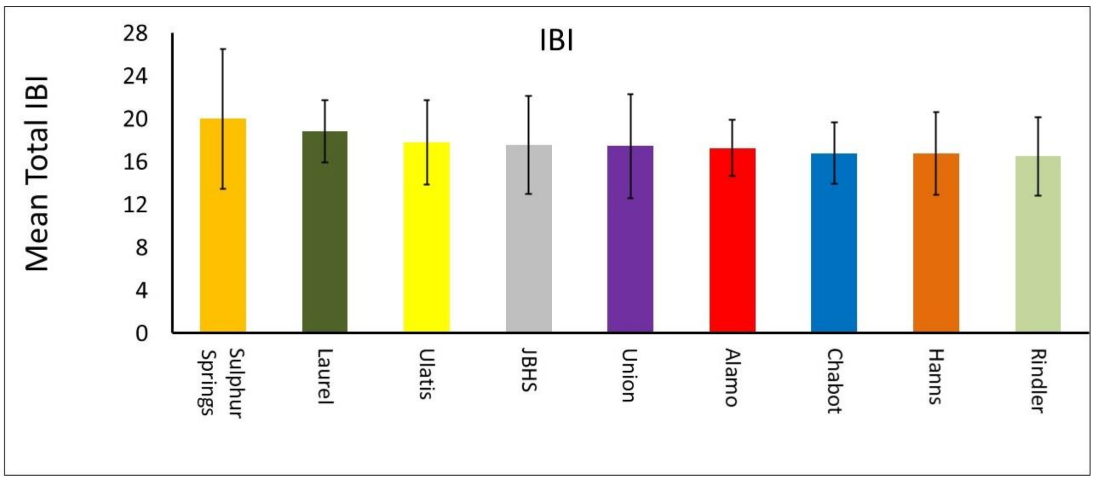


Figure 2: Mean IBI Scores and standard deviation for all study streams.

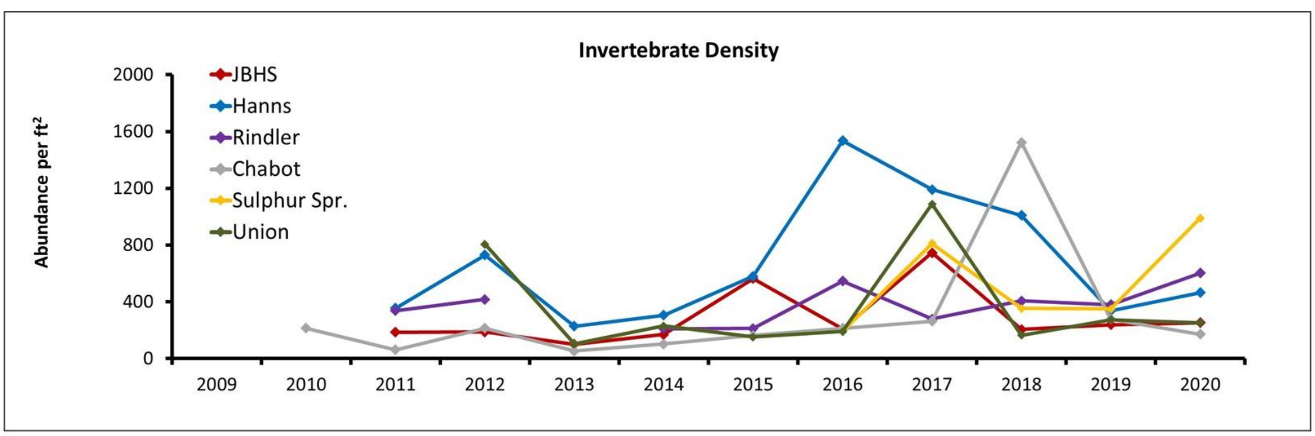


Figure 3: 2009-2020 Invertebrate density at streams with more than five consecutive yearly samples.

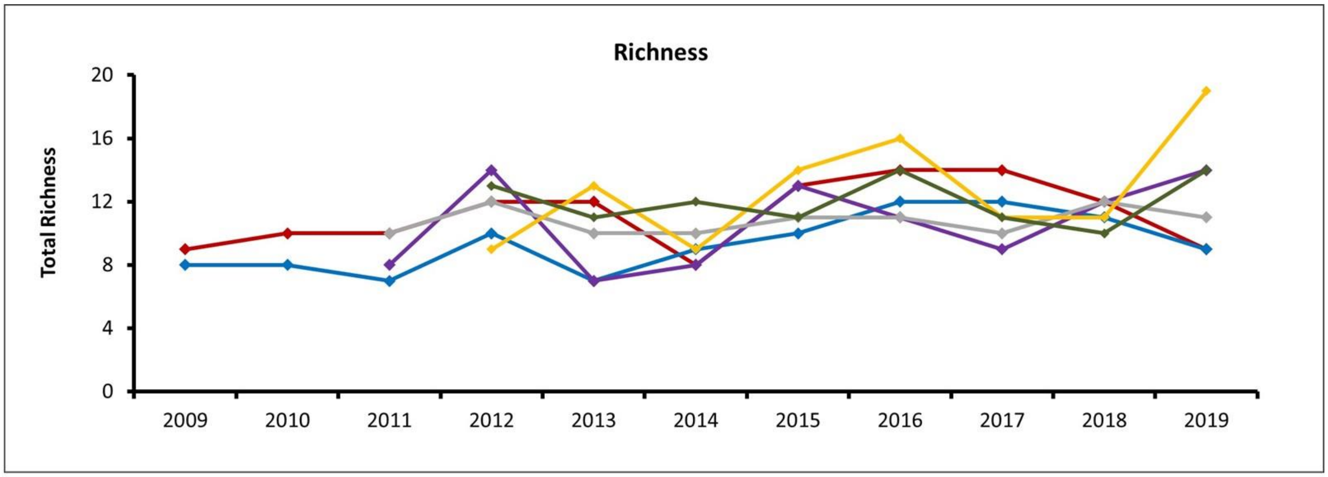


Figure 4: 2009-2020 total invertebrate richness at streams with more than five consecutive yearly samples.

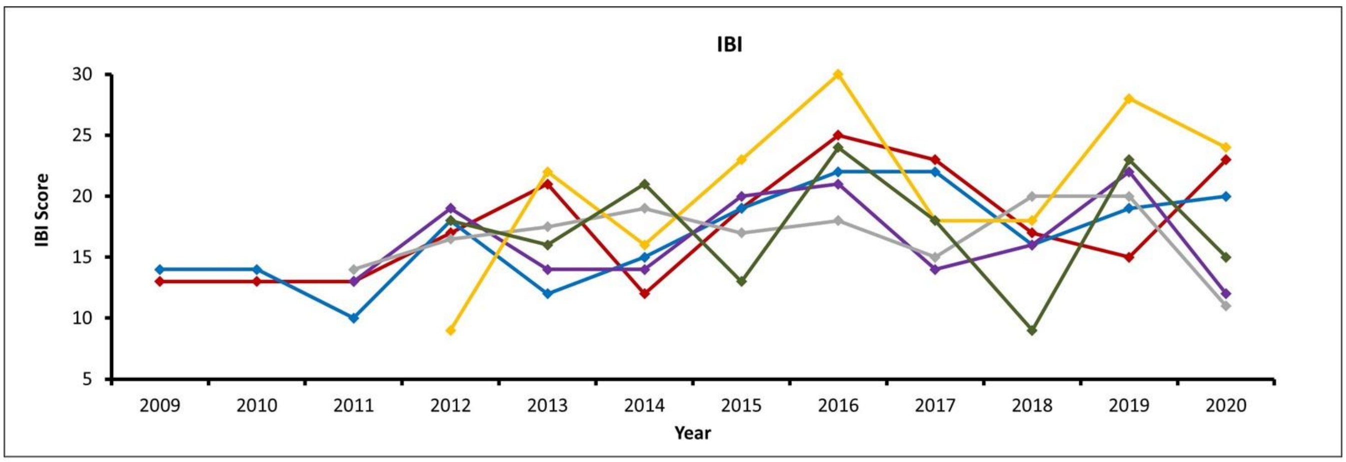


Figure 5: 2009-2020 IBI Scores for streams with more than five consecutive yearly samples.

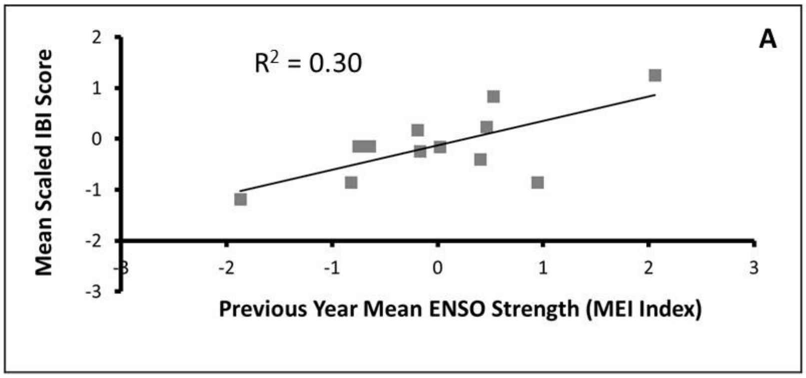
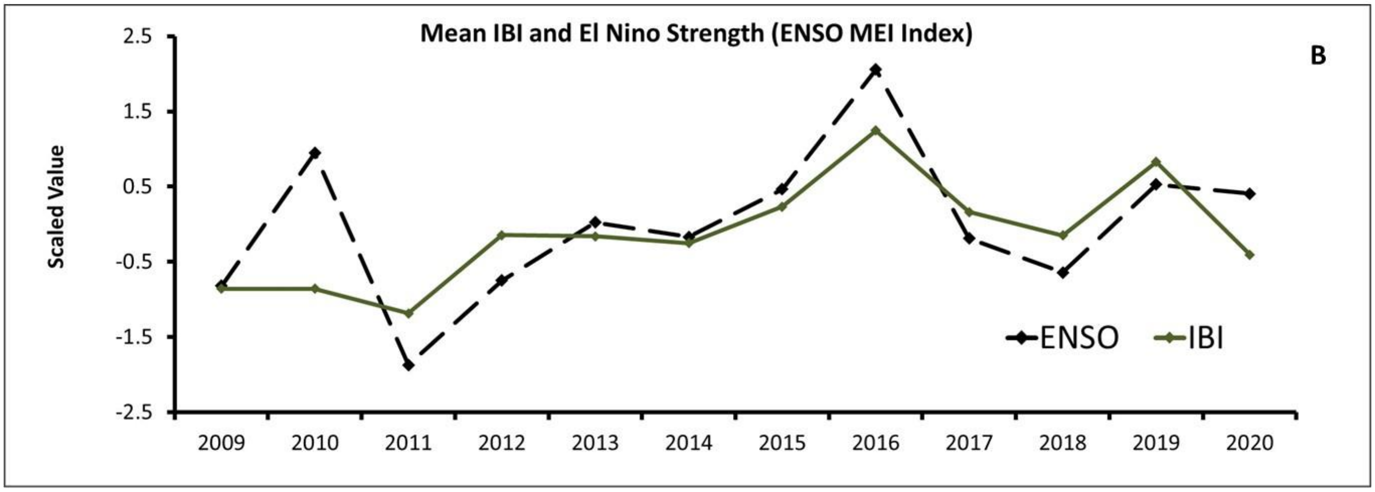


Figure 6: Scatter plot of Scaled Mean IBI score for all streams as a function of mean ENSO (A). Line chart (B) shows mean scaled IBI and ENSO for each year.



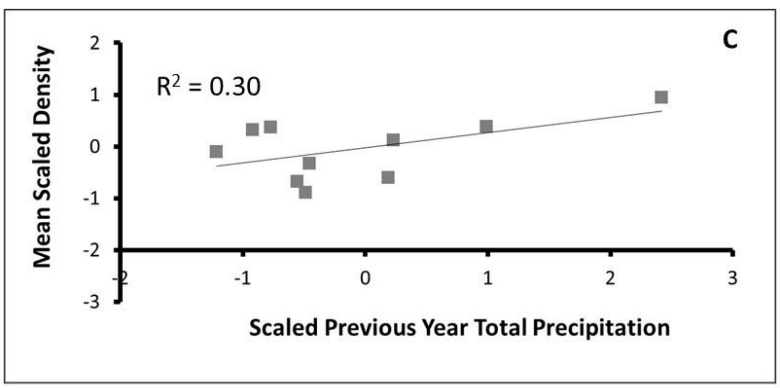
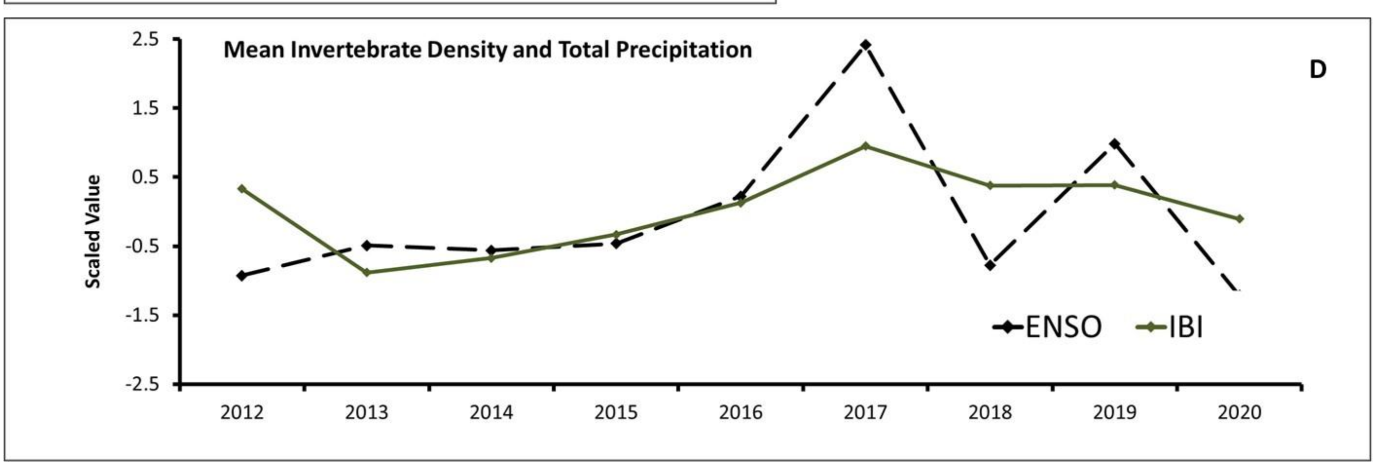
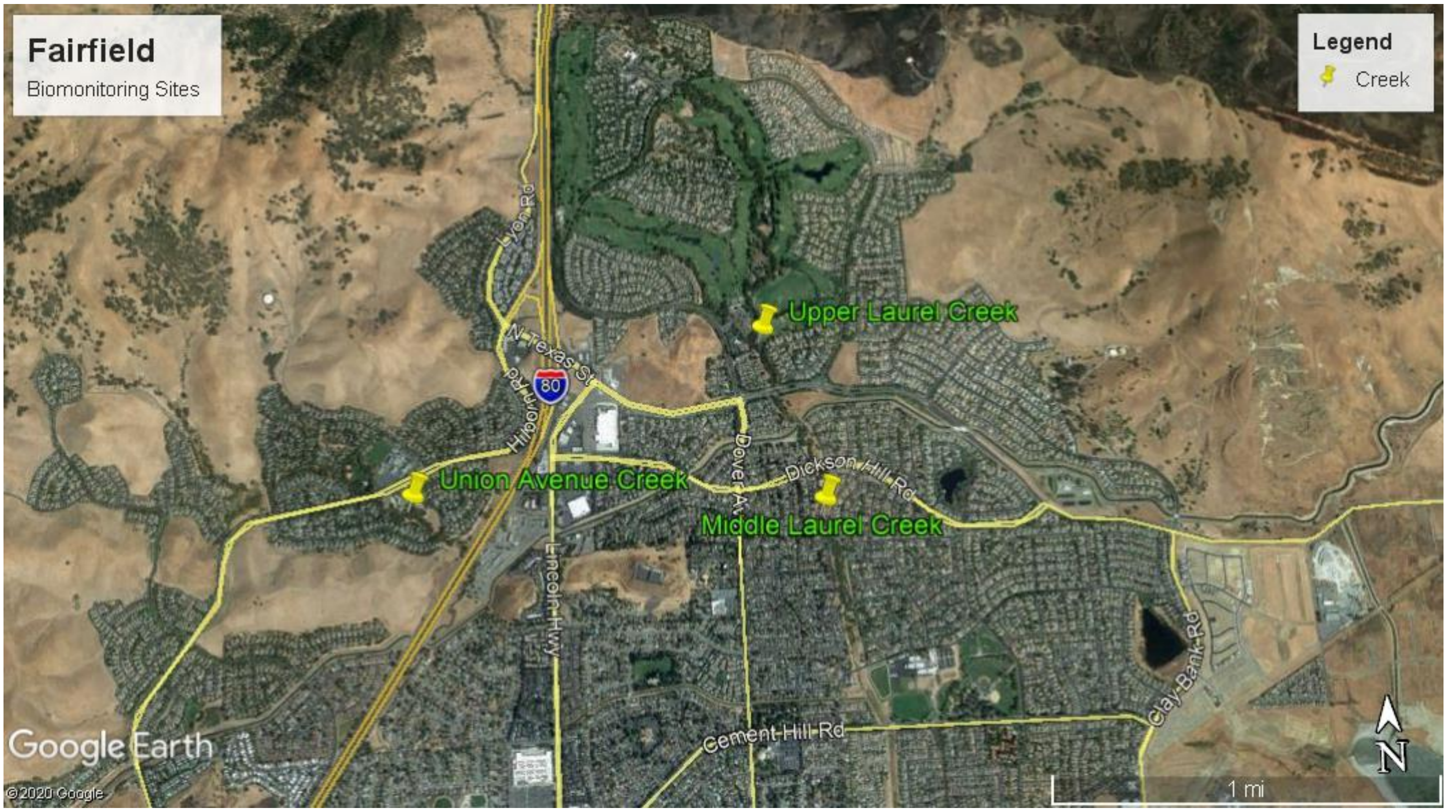
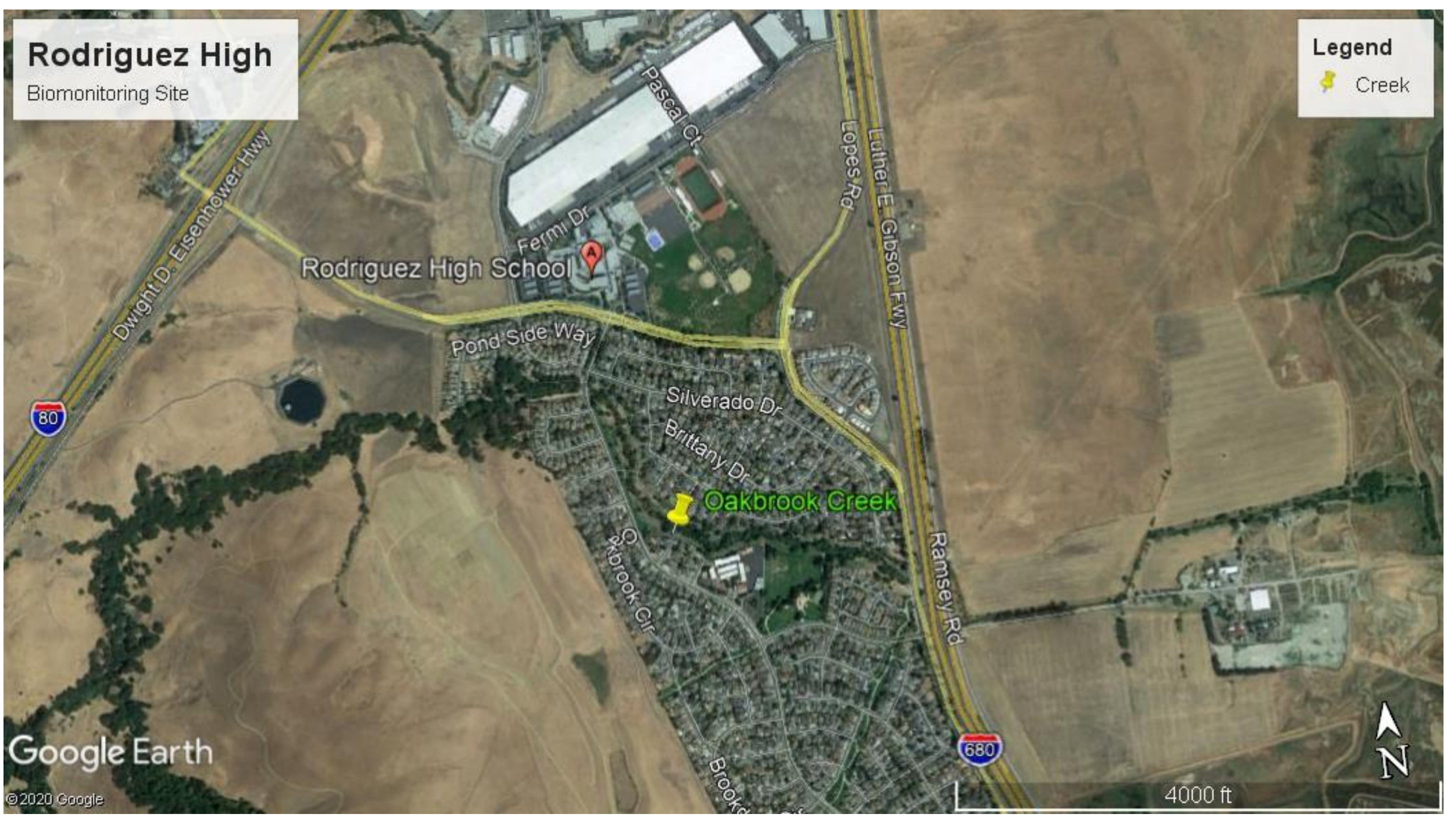


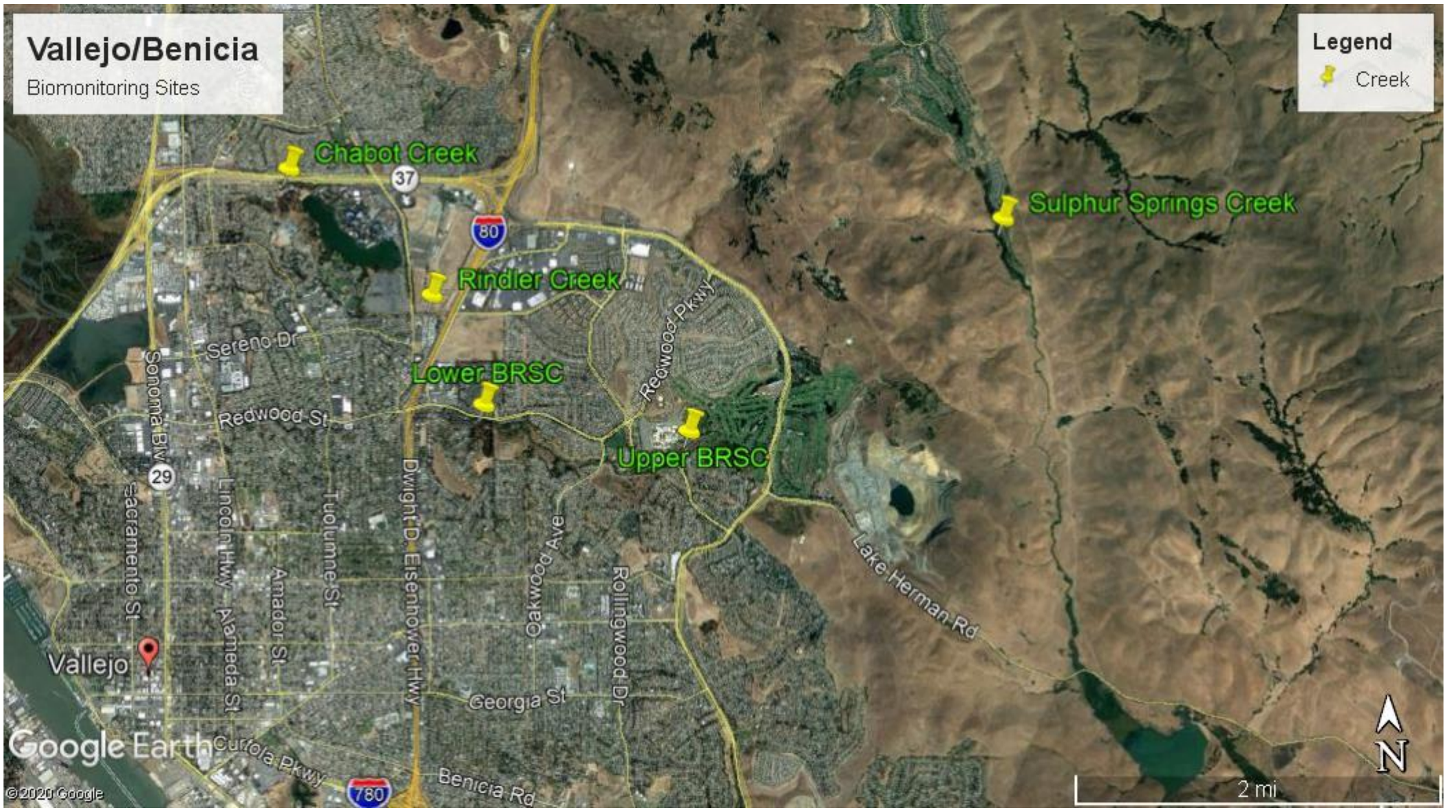
Figure 7: Scatter plot of scaled mean invertebrate density for all streams as a function of scaled water year total precipitation (C). Line Chart (D) shows mean scaled invertebrate density and precipitation.



Appendix 2: Monitoring Site Maps






Vallejo/Benicia
Biomonitoring Sites
Legend
Creek
Chabot Creek
Sulphur Springs Creek
Rindler Creek
Lower BRSC
Upper BRSC
Sereno Dr
Redwood St
Sonoma Blvd
Sacramento St
Lincoln Hwy
Alameda St
Amador St
Tuolumne St
Dwight D. Eisenhower Hwy
Oakwood Ave
Rollingwood Dr
Redwood Pkwy
Lake Herman Rd
Georgia St
Benicia Rd
Curtola Pkwy
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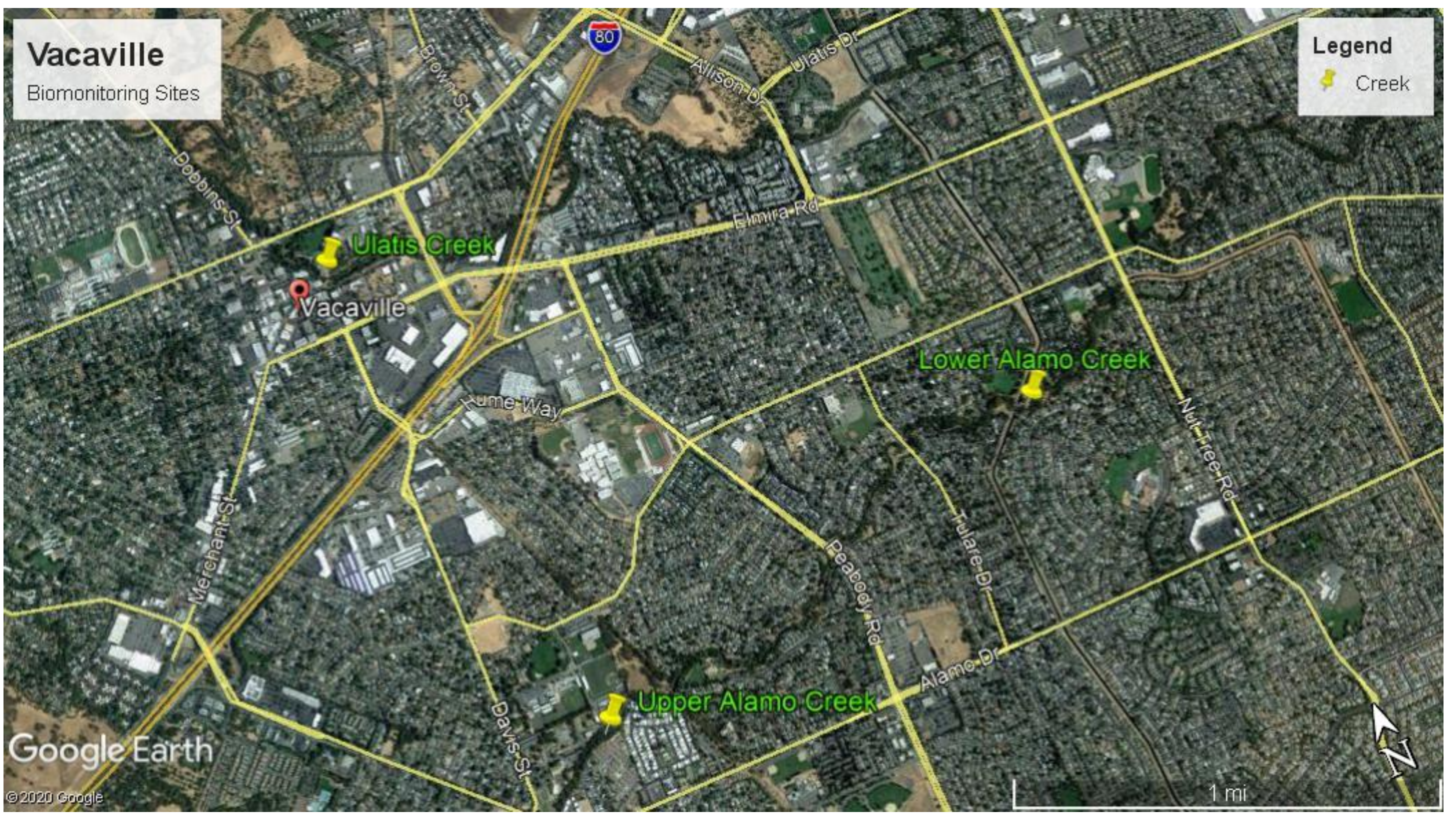
Vacaville
Biomonitoring Sites
Legend
Creek
Ulatis Creek
Lower Alamo Creek
Upper Alamo Creek
Vacaville
80
Brown St
Allison Dr
Ulatis Dr
Dobbins St
Elmira Rd
Hume Way
Nut Tree Rd
Tulare Dr
Peabody Rd
Merchant St
Davis St
Alamo Dr
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Appendix 3: Photo Documentation

A student from Mare Island Technology Academy (MIT) conducts a water odor investigation on a Chabot Creek sample.

An MIT student feels the benthic substrate of Chabot Creek to determine substrate classification.

Using a foldable metric ruler, an MIT student checks their wetted depth reading.

MIT students work in small groups to conduct a physical habitat assessment of Chabot Creek in Vallejo.

Will C. Wood students collect physical habitat data of upper Alamo Creek below Vacaville Christian school.

Will C. Wood students look at substrate collected from the bottom of Alamo Creek to classify its type.

Freshman biology students from Rodriguez High School prepare to measure wetted width and depth of Oakbrook Creek, which is located within walking distance of their school.

Fairfield High students review the procedures while in Union Avenue Creek in Fairfield. Students conduct physical habitat assessments every 5 meters to help describe the creek habitat.

Vacaville High School students collect trash from the bottom of Ulatis Creek near Monte Vista Drive.