SWAMP
Surface Water Ambient Monitoring Program

Multiyear Report **2018**

Multiyear Report
Wadeable Streams Bioassessment
Santa Ana
Region 8
Site Sampled: 2016-2017
SWAMP-MR-RB8-2018-0001

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California Water Boards

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WADEABLE STREAMS BIOASSESSMENT
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Executive Summary

As part of ongoing efforts to quantify the ecological health of southern California's freshwater systems, the Santa Ana Regional Water Quality Control Board (Region 8) contracted California State University Long Beach's Stream Ecology and Assessment Laboratory to conduct bioassessment during the years 2016 and 2017. We revisited 11 stream reaches to determine the current biological condition and to estimate the change in biological condition from the most recent time each of these reaches was sampled as part of a previous study. We calculated CSCI scores for each site and noted change that was more than 0.10 CSCI points. The small sample size precluded the use of statistics. Overall, four of the 11 sites increased by more than 0.10 points and two sites declined by 0.09 and 0.03 points. The mean CSCI score was 0.75 and 0.74 for years 2016 and 2017, respectively, indicating a "likely altered" ecological condition.

We also conducted an experiment to determine the effects of restoration efforts for the Santa Ana Sucker on the associated BMI community. In spring 2017, the Orange County Water District installed ten gabions approximately one km upstream from the River Road Bridge on the Santa Ana River as part of their efforts to improve habitat for the Santa Ana Sucker. In a previous deployment, gabions deflected the current causing erosion downstream of the gabion, removing fines and sands, and uncovering underlying gravel. As part of our sampling efforts in 2017 and to understand the effects of gabions on the BMI community, we took two types of BMI samples along the reach with the gabions. One sample followed the SWAMP SOP for margin-center-margin (MCM) and the other sampled immediately downstream of each of the ten gabions. We also revisited sites immediately upstream and downstream of the Santa Ana Restoration Site following the MCM protocols. We then compared the CSCI scores and the BMI species compositions among these samples. BMI sampling downstream of the gabions yielded a BMI community scoring 0.13 CSCI points below surrounding natural margin habitat. This difference was due to 15 taxa that were expected to be present based on the CSCI but were absent immediately downstream of the gabions. The gabions, may however, provide needed habitat for the Santa Ana Sucker independent of the BMI community. We also sampled two targeted sites, one upstream and one downstream of the restoration site; these sites' CSCI scores were 0.78 and 0.71, respectively.

Finally, as part of the Stormwater Monitoring Coalition (SMC), a collaboration among water districts, regional boards, and other agencies in southern California, four sites were sampled in both 2016 and 2017. While the CSCI scores are reported here, further details of the SMC samples and program are reported separately by the Southern California Coastal Water Research Project (SCCWRP) and are not discussed here.

Overall, the results of this study provide valuable information on the ecological health of specific stream reaches throughout the Santa Ana and San Jacinto watersheds. This information can be used by the scientific staff of the Santa Ana Regional Water Quality

Control Board to design future studies investigating the potential causes driving these changes in CSCI scores.

Introduction

Freshwater is an important natural resource. Understanding the health of rivers, streams, and other water resources is essential for the development of management plans that protect the nation's vital water resources. One approach that has been advocated for determining water quality is the "Aquatic Life Use Assessment", which was adopted by the California Environmental Protection Agency (Cal/EPA) for determining water quality. Bioassessment tools utilize direct measurements of biological assemblages occupying various trophic levels and can include plants, macroinvertebrates, vertebrates (fish) and periphyton (diatoms and algae), as direct methods for assessing the biological health of a waterway's ecosystem. Direct measurements of biological communities, when used in conjunction to other relevant measurements of watershed health (e.g. watershed characteristics, land-use practices, in-stream habitat and water chemistry), are effective ways to monitor long-term trends of a watershed's condition (Davis and Simon 1995). Biological assessments, which integrate the effects of water quality over time, are sensitive to many aspects of both habitat and water chemistry and provide a more familiar representation of ecological health to those who are unfamiliar with interpreting the results of chemical or toxicity tests. When integrated with physical habitat assessments and chemical test results, biological assessments describe the health of a waterway and provide an *in vivo* means of evaluating the anthropogenic effects (e.g. sediments, temperature and habitat alteration). As defined by the 2006 EPA Wadeable Streams Assessment (WSA) document, *"biological integrity represents the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitat of the region."* Bioassessment is a proxy for determining stream water quality and habitat quality based on the types and numbers of organisms living there.

The monitoring of water quality using benthic macroinvertebrates (BMIs) is the most utilized bioassessment method when compared with similar assessments that use vertebrates or periphyton. BMIs are not only ubiquitous but are relatively stationary and highly diverse. These traits can provide a variety of predictable responses to a number of environmental stresses (Rosenberg and Resh 1993). Depending on the length of time an individual BMI taxon resides in an aquatic environment (a few months to several years), the sensitivity to physical and chemical alterations to its environment will vary. BMIs are an excellent indicator group in assessing the health of a waterway (Resh and Jackson 1993) and function as a significant food resource for both aquatic and terrestrial organisms. In addition, herbivorous BMIs aid in the control of periphyton populations and many BMI taxa contribute to the breakdown of detritus. Furthermore, the diversity of BMI taxa also plays an important role in the overall ecology and biogeography of a region (Erman 1996).

Biological assessments are often based on multimetric techniques. These techniques use a number of biologic measurements (metrics), each representing a particular aspect of the biological community, to assign a water quality value to the location under study. Locations can then be ranked by these values and classified into qualitative categories such as “likely intact,” “possibly altered,” “likely altered,” and “very likely altered.” Previously the system of ranking and categorizing biological conditions for wadeable California streams was referred to as the Index of Biotic Integrity (IBI) and was the recommended method for the development of biocriteria by the United States Environmental Protection Agency (USEPA; Davis and Simon 1995). The IBI used for southern California was the Southern Coastal California Index of Biological Integrity (SCC-IBI; Ode et al. 2005), developed by the California Department of Fish and Game’s Aquatic Bioassessment Laboratory (Cal/DFG-ABL). The IBI was replaced with the newly developed California Stream Condition Index (CSCI) (Mazor et al. 2017). Like the IBI, this index utilizes biological measurements (metrics) to provide a system of ranking the biological condition of sites being studied. The CSCI incorporates two types of data, biological data generated from BMI samples collected and environmental data. Unlike the IBI, the CSCI is applicable statewide and takes site specific reference conditions into account.

The sites sampled in 2016 and 2017 and reported on here were originally part of a six-year study that ran 2006-2011. This six-year study provided baseline data on the ecological health of the wadeable streams within the Region and each year an annual report was made available to the public on the Surface Water Ambient Monitoring Program (SWAMP) website that detailed the physical habitat, the composition of macroinvertebrates, and the water chemistry of each random site sampled. Based on the results of this probabilistic study, a subset of sites whose biological condition was determined to be ‘very good’ or ‘very poor’ were targeted for resampling during 2016 to 2017. The objective of the resampling was to investigate if and how these sites changed with respect to their CSCI scores over time.

Methods

Site Selection

The original set of coordinates for 750 potential sampling locations was generated using a probabilistic design by Dr. Tony Olsen (from EPA at Corvallis) in 2005 with 182 of those sites being sampled 2006-2011. The mean and standard deviation (SD) of the IBI scores for these sites were placed into one of three categories: sites scoring at least one SD below the mean, sites scoring within one SD (either plus or minus) from the mean, and sites scoring greater than one SD from the mean. From 2012 to 2015, 91 sites from this probabilistic monitoring plan were resampled as they were either plus or minus one SD from the mean. In 2016 and 2017, sites from two sub-regions, mid-elevation (350m-700m) sites in the Santa Ana watershed and sites immediately upstream of Prado Dam, were selected for resampling as part of a longer-term effort to resample the entire region.

Effects of Gabions on the BMI Community within the Santa Ana Restoration Site

In spring 2017, the Orange County Water District installed ten gabions (Figures 1 and 2) approximately one km upstream from the River Road Bridge as part of their efforts to improve habitat for the Santa Ana Sucker. In a previous deployment at another location, gabions deflected the current causing erosion downstream of the gabion, removing fines and sands, and uncovering underlying gravel. As part of our sampling efforts in 2017 and to understand the effects of gabions on the BMI community, we took two types of BMI samples along the 150m reach with the gabions (Figure 3). One sample followed the SWAMP SOP for margin-center-margin (MCM) and the other sampled immediately downstream of each of the ten gabions. We also revisited sites immediately upstream and downstream of the Santa Ana Restoration Site following the MCM protocols (Figure 4). We then compared the CSCI scores and the BMI species compositions among these samples.

Sampling Reach Determination

The sampling procedures used during the 2016-2017 bioassessment survey followed the full level of the Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California (Fetscher et al. 2010). Briefly, at each sample location, a 150-meter reach was established (250-meters for streams with wetted-widths greater than 10 meters). Each reach was broken into 11 equidistant transects, spaced every 15 meters (25 meters for streams with widths greater than 10 meters), with each transect designated with a number representing its location along the reach (0 meters through 150/250 meters, downstream to upstream). BMI sample locations for each transect followed the reach-wide benthos procedure (RWB) for streams with gradients greater than 1% that carry particle size classes larger than sand (> 2mm particle size class); the margin-center-margin (MCM) was used for streams with gradients less than 1% that carry sand (< 2mm particle size class). This is implemented using our best professional judgement whereby sites with substrates dominated by sand were sampled using the MCM method.

Physical Habitat Characterization

At each site, standard Surface Water Ambient Monitoring Program (SWAMP) field protocols were used to survey the physical habitat along the entire reach of the sampling location (Fetscher et al. 2010). Briefly, at every 15-meter interval along the 150-meter reach (25-meter intervals along a 250-meter reach), starting at transect 0-meters, physical habitat quality was determined by recording substrate complexity, consolidation, embeddedness, sediment depth, identifying human influences, and measuring canopy cover. At each transect, a depth profile was obtained at five equidistant points starting at banks edge and ending on the opposite banks edge. Additional substrate measurements and depth profiles were measured midway between main transects throughout the entire reach. Each sampling reach was scored using the

General Habitat Characterization Form. Stream velocity was measured using a 60% stream depth method at a transect representative of the flow throughout the reach using a Flowatch flow-meter that measures velocities directly (buoyant object method was used when 60% depth method could not be performed due to obstructions or depth limitations).

Water Chemistry

Standard *in situ* water parameters were measured at each site using a multiprobe and included: pH, temperature (C), dissolved oxygen (mg/L), salinity, and conductivity (µS/cm). Additionally, 50 ml of water was field filtered (for OPP) and one liter of water was collected and returned to the lab within 36 hours for the determination of the following analytes:

Constituent	Units	Constituent	Units	Constituent	Units
Ammonia-N	mg/L	Nitrite-N	mg/L	Nitrate-N	mg/L
Nitrogen, Total	mg/L	Orthophosphate as P	mg/L	Alkalinity	mg/L
Conductivity	MS	Total Suspended Solids	mg/L	Salinity	ppt
Chloride	mg/L	Dissolved Organic Carbon	% dw	pH	
Hardness as $CaCO_3$	mg/L	Turbidity	NTU	Silica, dissolved	mg/L
Total and Dissolved Metals	Al, Cr, Mn, Ni, Cu, Zn, Ag, Cd, Pb, As, Se		ug/L	Sulfate	mg/L

Water chemistry data are available through the online SWAMP database.

Benthic Macroinvertebrate (BMI) Sampling and Identification

BMI samples were collected following standard protocols (Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California, Ode et al. 2016). The BMIs were collected using a one foot wide, 0.5-milimeter mesh D-frame kick-net by thoroughly manipulating the substrate in a one-foot by one-foot sampling plot directly in front of the net with a consistent sampling effort (approximately one to three minutes). Samples were collected at each of the established eleven transects within the 150-meter sampling reach for the site, alternating among 25%, 50%, and 75% instream of the right bank at each subsequent transect. The resulting 11 samples from a site were composited into 1-liter jars and preserved in the field using 95% isopropanol. The samples were transported back to the laboratory where field alcohol was rinsed and replaced with 70% ethanol.

Samples were then subsampled using a Caton tray such that at least five grids were selected to obtain 600 BMIs. These BMIs were then identified to Level 2b of the Standard Taxonomic Effort produced by the Southwestern Association of Freshwater Invertebrate Taxonomists (SAFIT) using standard taxonomic keys, typically genus level for insects and order or class for non-insects (Brown 1972, Edmunds et al. 1976, Kathman and Brinkhurst 1998, Klemm 1985, Merritt and Cummins 2008, Pennak 1989, Stewart and Stark 1993, Surdick 1985, Thorp and Covich 1991, Usinger 1963, Wiederholm 1983, 1986, Wiggins 1996, Wold 1974).

California Stream Condition Index

Beginning with the 2012 sampling period, we shifted from using the Index of Biological Integrity to evaluate site condition to the California Stream Condition Index. The CSCI was developed to account for some of the shortcomings of the previously used indices, namely regional specificity and an inability to account for the large amount of environmental variability among California's natural stream sites. The CSCI was developed using a statewide dataset representing a broad range of environmental conditions, thus enabling statewide site comparisons as opposed to being limited to within region comparisons. The CSCI is also unique in that it sets biological benchmarks (or 'reference conditions') for each site based on its specific settings and so does not assume 'reference conditions' for each site sampled are alike, thus accounting for variability in natural stream type.

The CSCI incorporates two types of data, biological data generated from BMI samples, collected in accordance with standard SWAMP protocols and identified to required taxonomic level of effort, and environmental data generated following standard geographic information system (GIS) protocols. Briefly, ArcGIS is used to delineate catchment polygons for a site and then to calculate predictors based on the catchment. The resulting environmental predictors are used in conjunction with the field collected taxonomic data to calculate the CSCI score using custom libraries and scripts in the R statistical programming language. For the full protocol on calculating CSCI scores see SWAMP's 'California Stream Condition Index (CSCI): Interim instructions for calculating scores using GIS and R' online.

The CSCI is composed of two separate sub-metrics. The 'observed over expected' (O/E) metric assesses the taxonomic completeness of a site by comparing observed (O) BMI taxa to an expected (E) list of taxa. The expected taxa list for a given site is generated by statistically modeling the relationships between taxa compositions and natural environmental gradients at similar sites identified as 'reference sites' (Mazor et al. 2017). Predictor variables used to predict expected species at a site include average monthly precipitation, average monthly temperature, watershed area, and elevation. These values for a given site are generated using the program ArcGIS. This method is more precise than previous methods, which assumed all taxa have an equal probability of occurrence at all sites. The O/E sub-metric is a simple ratio of observed to expected taxa and so does not require scoring. If a site matches predicted reference conditions (i.e. is 'taxonomically complete') its O/E ratio is equal to one. An O/E ratio less than one for a site indicates degraded biological conditions.

The second component of the CSCI is a multi-metric index (MMI), this metric aggregates several measures of BMI attributes (percent clinger taxa, percent Coleoptera taxa, taxonomic richness, % Ephemeroptera, Plecoptera, and Trichoptera taxa, % shredder taxa, and % intolerant taxa) into a single measure of biological condition. These attributes were chosen based on their ability to distinguish between reference and degraded condition and/or their responsiveness to human disturbance gradients. Again, predictor variables generated by ArcGIS are used to predict metric values for each specific site. Scoring is required for the MMI because individual attributes have different scales and differing responses to stress. Scoring transforms the MMI sub-metric to a standard scale ranging from 0 (most stressed) to 1 (similar to predicted reference conditions). The final MMI score for a site is calculated by averaging the scaled scores for each BMI attribute and then rescaling (dividing) by the average score of reference calibration sites. Rescaling ensures the MMI and the O/E sub-metrics are expressed on similar scales. The final CSCI score of a site is simply an average of the MMI and O/E values.

As the CSCI is a relatively new index, specific categories for scores are still tentative. Currently three thresholds (based on the 30th, 10th, and 1st percentiles of CSCI scores at reference sites) have been established, resulting in four CSCI categories of biological condition: ≥ 0.92 = likely intact condition; 0.91 to 0.80 = possibly altered condition; 0.79 to 0.63 = likely altered condition; ≤ 0.62 = very likely altered conditions.

Quality Control and Quality Assurance

Field duplicates were collected at a rate of five percent for water samples and at a rate of ten percent for BMI samples collected in the field. Furthermore, ten percent of BMI sample identifications underwent external quality control via the Aquatic Bioassessment Laboratory, Chico, CA. Stringent internal quality control was applied to sorting whereby subsamples had to pass at a 95% BMI recovery level.

Beginning in 2009, field crews participated in annual interlab calibration exercises hosted by the Storm Water Monitoring Coalition (SMC) and the Southern California Coastal Water Research Project (SCCWRP). Field audits were also conducted by a SMC member bi-annually.

Results

Between 2016 and 2017 we revisited 11 stream reaches (Figure 5, Table 1) that were originally sampled as part of the probabilistic study undertaken from 2006 to 2011. The objective of the current sampling was to determine how the biologically worst (one SD below the mean) and best (one SD above the mean) sites based on the SoCal IBI had changed since their first sample date. We calculated MMI, O/E, and CSCI scores using SAFIT Level 2b on all samples (Figure 6, Table 2). We also calculated the change in CSCI score between the most recent sample date and the first sample date for each site (Figure 7, Table 3). Two sites showed significant improvement in CSCI score and no sites showed a significant decline in CSCI score (Table 3).

Sites Sampled in 2016

In the previous multiyear report (Fah and Underwood 2017), Region 8 was divided into six subregions. Sites sampled in 2016 were within the subregion “Middle Santa Ana” and were located mid-elevation on San Timoteo Wash, City Creek, and Day Creek (Table 1). The mean CSCI score for these sites was 0.75 (SD=0.20), indicating a “likely altered" ecological condition (Table 2). The large variation across sites was driven by two sites that exhibited significant increases in CSCI score as compared to their most recent past sampling (Table 3). Sites 567 (San Timoteo Wash) and 598 (Day Creek) both increased by 0.20 CSCI points, while the remaining four sites changed an average of 0.02 CSCI points.

Sites Sampled in 2017

Sites sampled in 2017 were all on the Santa Ana River immediately upstream from Prado dam and into Jurupa Valley (Table 1). The mean CSCI score for these sites was 0.74 (SD=0.05), indicating a "likely altered" ecological condition (Table 2). The mean change in CSCI was 0.06 with two sites, 19 and 494, increasing by 0.11 and 0.19, respectively (Table 3).

Effects of Gabions on the BMI Community within the Santa Ana Restoration Site

At the time of sampling, the substrate immediately downstream of the gabions was dominated by sand and silt, not gravel. The CSCI score for the gabion sample (OCR-Gabion) was 0.64, while the CSCI score for the MCM sample (OCR-MCM) within the gabion reach was 0.77 suggesting the presence of gabions does not enhance the habitat for BMIs (Table 2). In fact, this score was the lowest of the seven CSCI scores obtained from sites along the Santa River in 2017. The lower CSCI score for the gabion sample was driven by a lower O/E as compared to the MCM sample; the MM1 values were comparable across all stations on the Santa Ana River samples in 2017. O/E is the ratio of observed taxa to those expected to be found at a given site. Table 4 lists the 15 taxa that should be present and that were found at OCR-MCM but not found at OCR-Gabion. The gabions, may however, provide needed habitat for the Santa Ana Sucker independent of the BMI community. Site 19, immediately upstream from the Restoration Site, scored 0.71, and Site 356, immediately downstream, scored 0.78. It is unclear if the increase in CSCI score spatially associated with the Restoration Site was caused by the restoration efforts.

Conclusions

We revisited 11 stream reaches in Region 8 over the years 2016-2017 to determine the current biological condition and to estimate the change in biological condition from the most recent time each of these reaches was sampled as part of a previous study. We calculated CSCI scores for each site and noted change that was more than 0.10. The small sample size precluded the use of statistics. Overall, four of the 11 sites increased by more than 0.10 points and two sites declined by 0.09 and 0.03 points. The mean CSCI score was 0.75 and 0.74 for years 2016 and 2017, respectively, indicating a "likely altered" ecological condition. BMI sampling immediately downstream of the gabions placed along the margins of the Santa Ana River to enhance habitat for the Santa Ana Sucker yielded BMI communities scoring 0.13 CSCI points below surrounding natural margin habitat. This difference was due to 15 taxa that were expected to be present based on the CSCI but were absent immediately downstream of the gabions. The results from this study will allow the staff scientists at Region 8 to make informed decisions as to the nature of future studies.

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Figure 1. Gabion at bottom left of picture. Note the deeper water to the right, which is downstream of the gabion.

Figure 2. Gabion at bottom left of picture. BMI samples were taken 1m downstream of the gabions.

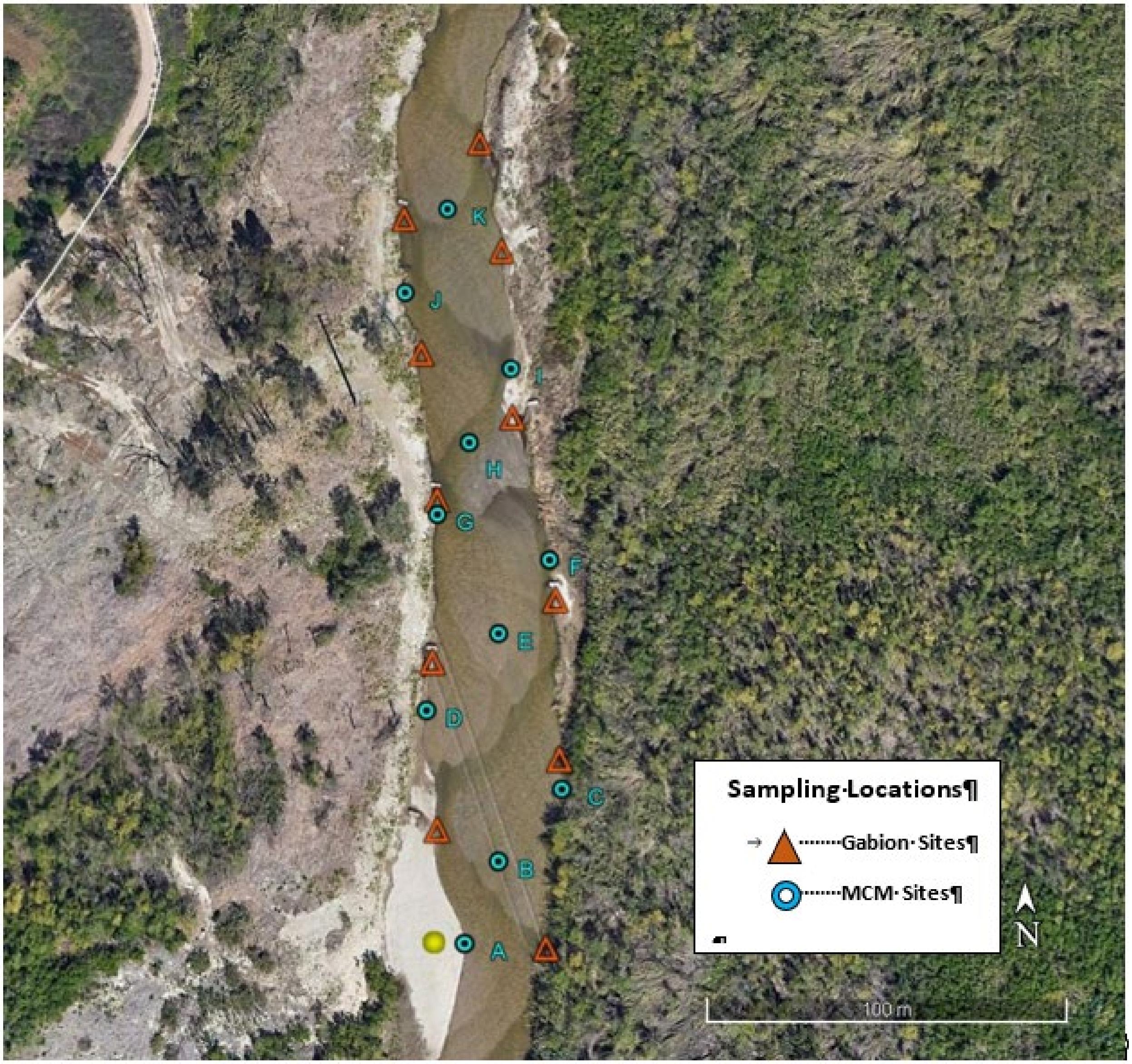


Figure 3. Sampling locations for the gabion sites (indicated in triangles) and MCM sites (circles with transect letters indicated) at the restoration site.

Figure 4. Relationship between the restoration site (indicated as OCR) and the resampled sites upstream (“**356**” = SWAMP Code 801RB8356) and downstream (“**19**” = SWAMP Code 801RFB019) of the restoration site indicated by OCR and the two resampled sites.

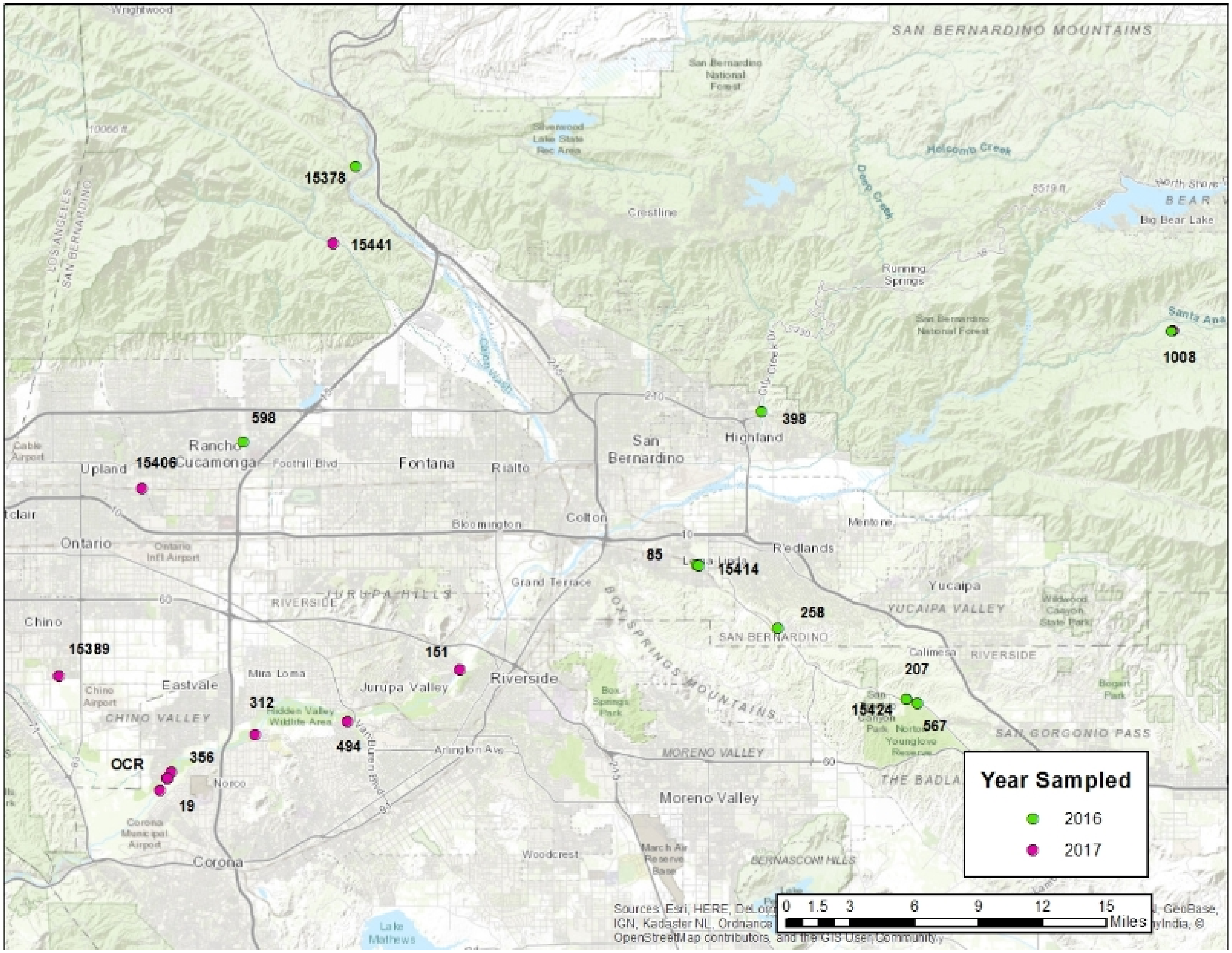


Figure 5. Overview map of Region 8. Sites are identified by the last three digits of their SWAMP code. “OCR” is the Santa Ana Restoration Site. Sites sampled in 2016 and 2017 are designated in green and red, respectively.

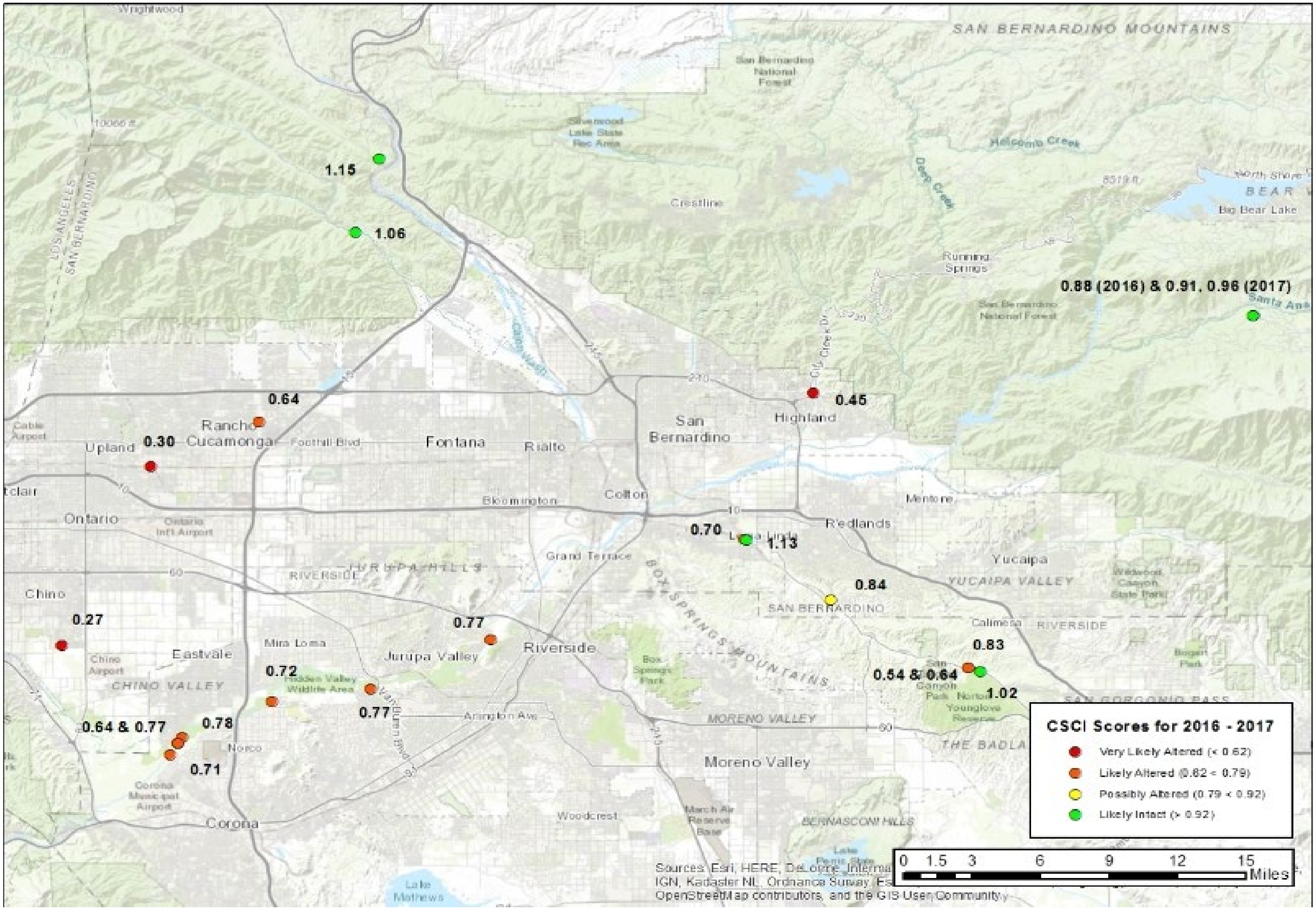


Figure 6. CSCI score map of Region 8. Sites are identified by their CSCI score. Each site is color coded based on the CSCI category in which it falls for the 2016 – 2017 sampling period.

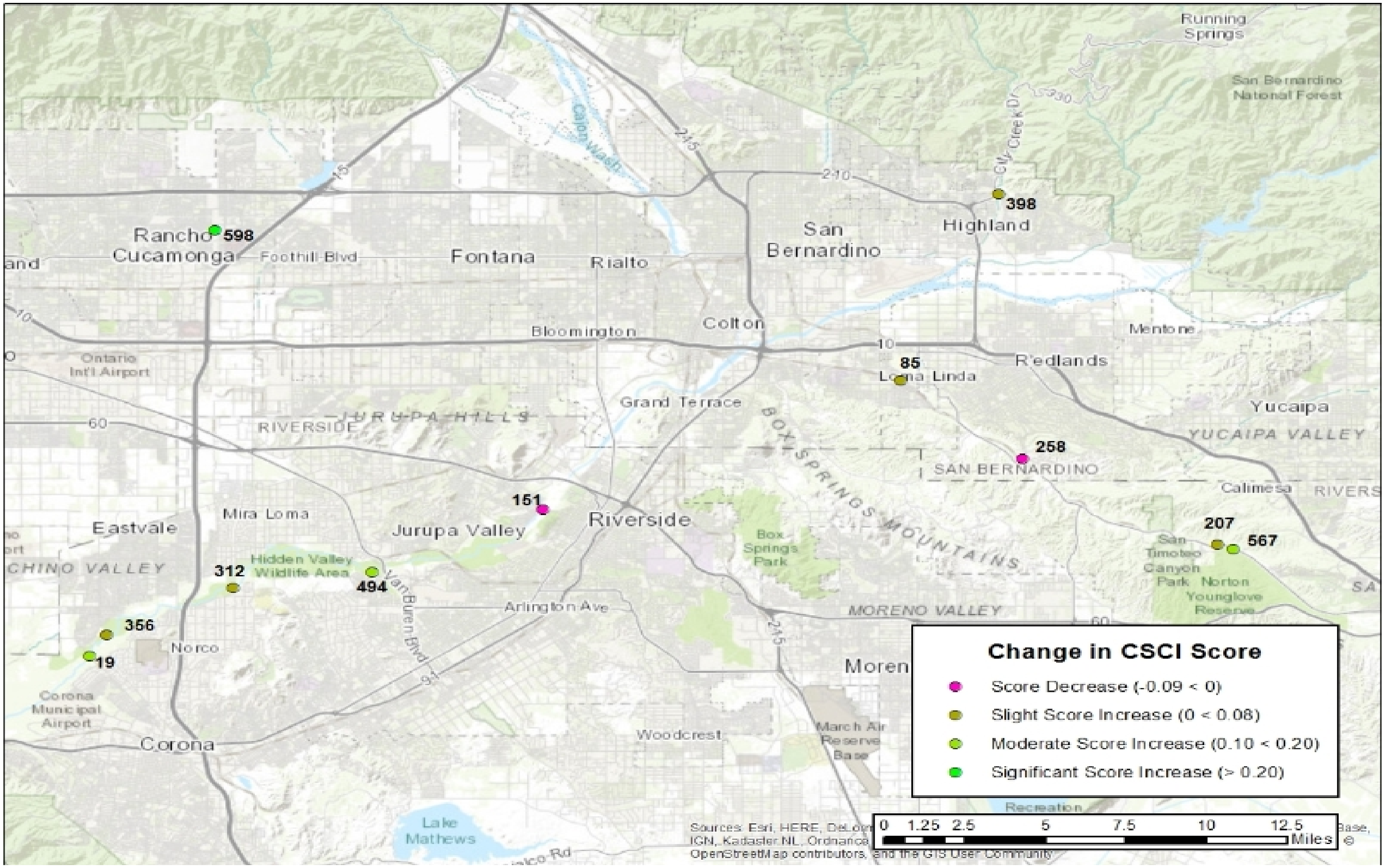


Figure 7. Change in CSCI score map of Region 8. Sites are identified by the last three digits of their SWAMP code. Each site is color coded based on the change in CSCI score between the past and the most recent sampling event. Categories were based on natural breaks in the data

TABLE 1. SITES SAMPLED DURING THE INDEX PERIODS OF 2016 AND 2017.

			Field Recorded			
SWAMP Code	Stream name	County	Latitude	Longitude	Elevation (m)	Collection date
			WGS 84			
801STW085	San Timoteo Wash	San Bernardino	34.05025	-117.23398	353	8-Jun-16
801RB8207	San Timoteo Wash	San Bernardino	33.97496	-117.09237	597	16-Jun-16
801STW258	San Timoteo Wash	San Bernardino	34.01436	-117.17963	439	9-Jun-16
801CYC398	City Creek	San Bernardino	34.13588	-117.19022	453	9-Jun-16
801RB8567	San Timoteo Wash	San Bernardino	33.97276	-117.08497	610	8-Jun-16
801RB8598	Day Creek	San Bernardino	34.11910	-117.54108	394	14-Jun-16
801PFB019	Prado Flood Control Basin	Riverside	33.92374	-117.59751	163	27-Jun-17
801SAR151	Santa Ana River	Riverside	33.99108	-117.39431	235	22-Jun-17
801RB8312	Santa Ana River	Riverside	33.95512	-117.53300	180	27-Jun-17
801RB8356	Santa Ana River	Riverside	33.93373	-117.58964	165	21-Jun-17
801RB8494	Santa Ana River	Riverside	33.96256	-117.47067	203	19-Jun-17
801SAROCR	Santa Ana Restoration Site	Riverside	33.93027	-117.59229	164	21-Jun-17

TABLE 2. MMI AND O/E SUB-METRICS AND CSCI SCORES FOR ALL SITES SAMPLED. All sites were from the original probabilistic draw except OCR, which was the Santa Ana Restoration Site. OCR-Gabion were samples taken immediately downstream of the gabions and OCR-MCM were samples taken following the margin-center-margin sampling protocol. Sites marked with an asterisk indicate a low number of MMI iterations, O/E iterations, or both (and so scores should be interpreted with caution).

Site ID	SWAMP code	Year	MMI	O/E	CSCI
19	801PFB019	2017	0.57	0.85	0.71
85	801STW085	2016	0.64	0.76	0.7
151	801SAR151	2017	0.74	0.80	0.77
207	801RB8207	2016	0.69	0.98	0.83
258*	801STW258	2016	1.13	0.91	1.02
312	801RB8312	2017	0.67	0.77	0.72
356	801RB8356	2017	0.58	0.98	0.78
398	801CYC398	2016	0.51	1.16	0.84
494	801RB8494	2017	0.61	0.94	0.77
567*	801RB8567	2016	0.24	1.04	0.64
598	801RB8598	2016	0.65	0.24	0.45
OCR-Gabion	801SAROCR	2017	0.57	0.70	0.64
OCR-MCM	801SAROCR	2017	0.55	0.99	0.77

TABLE 3. CHANGE IN CSCI SCORES FOR ALL SITES SAMPLED. The sites ordered by the last three digits of their SWAMP code. The change in CSCI score was calculated by subtracting the CSCI score of the original sampling event from that of the most recent. Sites marked with an asterisk indicate a low number of MMI iterations, O/E iterations, or both (and so scores should be interpreted with caution).

Site ID	Station Code	Stream Name	Past Year Sampled	Δ CSCI
19	801PFB019	Prado Flood Control Basin	2014	0.11
85	801STW085	San Timoteo Wash	2014	0.03
151	801SAR151	Santa Ana River	2013	-0.09
207	801RB8207	San Timoteo Wash	2009	0.05
258*	801STW258	San Timoteo Wash	2014	-0.03
312	801RB8312	Santa Ana River	2013	0.08
356	801RB8356	Santa Ana River	2012	0.00
398	801CYC398	City Creek	2014	0.04
494	801SAR494	Santa Ana River	2013	0.20
567*	801RB8567	San Timoteo Wash	2010	0.18
598	801RB8598	Day Creek	2010	0.27

TABLE 4. TAXA EXPECTED TO BE PRESENT (BASED ON THE CSCI) AT THE SANTA ANA RESTORATION SITE THAT WERE ABSENT AT OCR-GABION, BUT PRESENT AT OCR-MCM. These taxa drive the difference in O/E between these two sampling methods.

Taxon	Order	Family	SAFIT Tolerance Value
Argia	Odonata	Coenagrionidae	7
Atrichopogon	Diptera	Ceratopogonidae	6
Bezzia_Palpomyia	Diptera	Ceratopogonidae	6
Caloparyphus_Euparyphus	Diptera	Stratiomyidae	8
Ceratopsyche_Hydropsyche	Trichoptera	Hydropsychidae	4
Fallceon	Ephemeroptera	Baetidae	4
Ferrissia	Class Gastropoda	Planorbidae	6
Lymnaea	Class Gastropoda	Lymnaeidae	7
Menetus	Class Gastropoda	Planorbidae	6
Nemotelus	Diptera	Stratiomyidae	8
Orthocladiinae	Diptera	Chironomidae	5-8
Ostracoda	Class Ostracoda	Subphylum Crustacea	8
Physa_Physella	Class Gastropoda	Physidae	8
Sphaeriidae	Veneroida	Sphaeriidae	8
Tricorythodes	Trichoptera	Leptohyphidae	4

Appendix A: Site Photos for Transect A

Site Photos for 2016

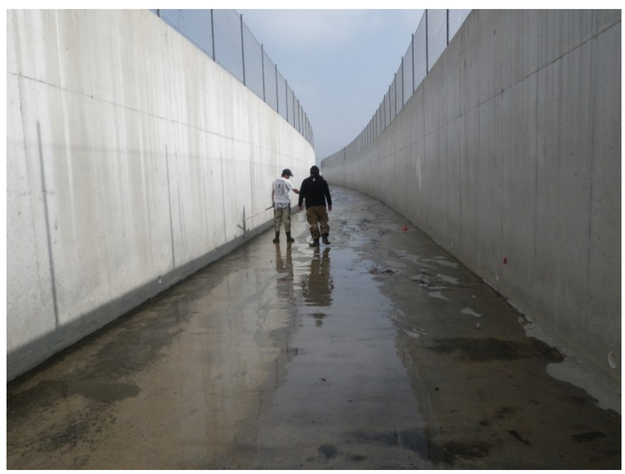
Site 801STW085: San Timoteo Wash

Site 801RB8207: San Timoteo Wash

Site 801STW258: San Timoteo Wash

Site 801CYC398: City Creek

Site 801RB8567: San Timoteo Wash



Site 801RB8598: Day Creek

Site Photos for 2017


Site 801PFB019: Prado Flood Control Basin


Site 801SAR151: Santa Ana River


Site 801RB8312: Santa Ana River


Site 801RB8356: Santa Ana River


Site 801RB8494: Santa Ana River


*Site 801SAROCR: Santa Ana River

Appendix B: Sites Sampled

			Field Recorded			
SWAMP Code	Stream name	County	Latitude	Longitude	Elevation (m)	Collection date
			WGS 84			
801STW085	San Timoteo Wash	San Bernardino	34.05025	-117.23398	353	8-Jun-16
801M15378	West Fork Lytle Creek	San Bernardino	34.24450	-117.50787	962	16-Jun-16
801M15414	West Fork City Creek	San Bernardino	34.18711	-117.18530	753	15-Jun-16
801M15424	Cucamunga Creek	San Bernardino	33.99389	-117.59937	204	14-Jun-16
801WE1008	Barton Creek	San Bernardino	34.18162	-116.91295	1673	29-Jun-16
801RB8207	San Timoteo	Riverside	33.99750	-117.09237	673	16-Jun-16
801STW258	San Timoteo	San Bernardino	34.01436	-117.17905	476	9-Jun-16
801CYC398	City Creek	San Bernardino	34.13588	-117.19022	454	9-Jun-16
801STW567	San Timoteo	Riverside	33.97276	-117.08497	652	8-Jun-16
801RB8598	Day Creek	San Bernardino	34.11910	-117.54108	389	14-Jun-16
801WE1008	Barton Creek	San Bernardino	34.18105	-116.91230	1691	20-Jun-17
801M15441	Lytle Creek	San Bernardino	34.23005	-117.47991	822	28-Jun-17
801M15406	Cucamunga Creek	San Bernardino	34.09269	-117.60931	332	31-May-17
801M15389	Cypress Creek	San Bernardino	33.98758	-117.66572	189	31-May-17
801PFB019	Santa Ana River	Riverside	33.92374	-117.59751	159	27-Jun-17
801SAR151	Santa Ana River	Riverside	33.99108	-117.39431	232	22-Jun-17
801RB8312	Santa Ana River	Riverside	33.95512	-117.53300	180	27-Jun-17
801RB8356	Santa Ana River	Riverside	33.93373	-117.58964	162	21-Jun-17
801RB8494	Santa Ana River	Riverside	33.96256	-117.47067	204	19-Jun-17
801SAROCR	Santa Ana River	Riverside	33.93027	-117.59229	161	21-Jun-17