2014
Bioassessment Monitoring Program In Los Angeles County

Final Report **March 2015**

Prepared for:
Los Angeles County Flood Control District
Watershed Management Division
900 South Fremont Avenue
Alhambra, California 91803-1331

2014 BIOASSESSMENT MONITORING PROGRAM IN LOS ANGELES COUNTY

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Prepared for:

Los Angeles County Flood Control District
Watershed Management Division
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ACRONYMS AND ABBREVIATIONS

°C	degree Centigrade
°F	degree Fahrenheit
%	percent
ABL	Aquatic Bioassessment Laboratory
bioassessment	biological assessment
Bioassessment Program	biological assessments of various freshwater streams in five Los Angeles County watersheds
BMI	benthic macroinvertebrate
CDFG	California Department of Fish and Game
CSCI	California stream condition index
Cfs	Cubic feet per second
cm^2	square centimeter
County	Los Angeles County
CRAM	California Rapid Assessment Method
CSBP	California Stream Bioassessment Procedure
CWMW	California Wetlands Monitoring Workgroup
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FFG	functional feeding group
ft^2	square foot
GIS	Geographic Information System
HtB	Heal the Bay
IBI	Index of Biotic Integrity
ID	identification
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LALT	Los Angeles [River] lower tributary
LARWMP	Los Angeles River Watershed-wide Monitoring Program
LASGRWC	Los Angeles and San Gabriel River Watershed Council
LVMWD	Las Virgenes Municipal Water District
MCWMP	Malibu Creek Watershed Management Program
mg/L	milligram per liter
Mh	macrophyte herbivore
Mm	millimeter
MQO	minimum quality objective
MS4	Municipal Separate Storm Sewer System
mS/cm	millisiemen per centimeter
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
O/E	Observed taxa/Expected taxa

ACRONYMS AND ABBREVIATIONS

Om	omnivore
Pa	parasite
Ph	piercer herbivore
Public Works	County of Los Angeles Department of Public Works
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
RWQCB	Los Angeles Regional Water Quality Control Board
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project
SGRRMP	San Gabriel River Regional Monitoring Program
SGUT	San Gabriel [River] upper tributary
SGLT	San Gabriel [River] lower tributary
SMBW	Santa Monica Bay Watershed
SMC	Stormwater Monitoring Coalition
SMC Program	Stormwater Monitoring Coalition Southern California Regional Watershed Monitoring Program
SOW	scope of work
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TV	tolerance value
USEPA	United States Environmental Protection Agency
WESTON®	Weston Solutions, Inc.
Xy	xylophage/woodeater

EXECUTIVE SUMMARY

Background

Weston Solutions, Inc. (WESTON®) was contracted by the Los Angeles County Flood Control District (LACFCD) to perform biological assessments (bioassessments) of various freshwater streams in Los Angeles County (County) (Bioassessment Program). The Bioassessment Program is required for National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit compliance, (Board Order No. 01-182, NPDES Permit No. CAS004001), under the enforcement of the Los Angeles Regional Water Quality Control Board (RWQCB). The goals of this program are to assess biological integrity and to detect biological trends and responses to pollution in receiving waters throughout the County. To achieve these goals, the program focuses on the sampling and analysis of freshwater stream benthic macroinvertebrates (BMI). The program was initiated in October 2003 and monitoring surveys have been conducted annually since that time, for a total of twelve surveys to date. Surveys were conducted in October 2003, October 2004, October 2005, July (San Gabriel River Watershed only) and October 2006, June (San Gabriel River Watershed only) and October 2007, November 2008, June 2009, June/July 2010, June/July 2011, June 2012, June 2013, and April-June, 2014.

In the 2014 sampling year, the Bioassessment Program continued to incorporate three collaborative monitoring programs in addition to the basic NPDES Program. The three programs included the San Gabriel River Regional Monitoring Program (SGRRMP) which began in 2006, the Los Angeles River Watershed-Wide Monitoring Program (LARWMP) which began in 2008, and the Stormwater Monitoring Coalition (SMC) Southern California Regional Watershed Monitoring Program (SMC Program) which began in 2009. The SMC program in 2014 was an interim year that included a non-perennial stream study and a trend site monitoring study.

Study Area and Monitoring Sites, 2014

The study area consisted of 16 stream monitoring sites within the five primary watersheds of the County. The watersheds and number of sites sampled in each were as follows:

- San Gabriel River Watershed: four sites.
- Los Angeles River Watershed: six sites.
- Dominguez Channel Watershed: one site.
- Santa Monica Bay Watershed including Malibu Creek Watershed and Ballona Creek Watershed: three sites.
- Santa Clara River Watershed: two sites.

Sampling was performed from April 15, 2013 to June 27, 2014. Three of the historical monitoring sites (SGUT-501–San Gabriel River, SGUT-504–San Gabriel River, and 6–Arroyo Seco) were considered reference sites because they were located in areas with minimal upstream urban development and runoff, and were in un-altered channels. Two additional SMC sites (404-TCC–Temescal Canyon and 403GCC–Gleason Canyon) were also in reference condition. Four of the sites were located in concrete-lined channels: LALT500–Rio Hondo, LALT501–Arroyo Seco, LALT503–Tujunga Wash, and 19–Dominguez Channel. The seven remaining sites were in unlined channels.

Methodology

Field sampling followed the standard protocols described in the Surface Water Ambient Monitoring Program (SWAMP) physical habitat assessment protocol (Ode, 2007). Organisms were identified to standard taxonomic Level II effort as specified in the *Southwest Association of Freshwater Invertebrate Taxonomists* (SAFIT) *List of Freshwater Invertebrate Taxa* (Richards and Rogers, 2011). Data analysis included the calculation of standard community-based metric values and a southern California Index of Biotic Integrity (IBI) (Ode et al., 2005). In addition to the SWAMP physical habitat assessment, the California Rapid Assessment Method (CRAM) for riverine wetlands was performed at the SMC sites. Data analyses also included Bray–Curtis-based cluster analysis of taxa and monitoring sites, comparisons of IBI scores and metric values over time.

Findings

Taxonomic evaluation of the 2014 samples yielded 134 different taxa from 11,571 individual organisms. Ostracoda (seed shrimp) were the most abundant organism collected throughout the County, and midges in the family Chironomidae were collected at every site. The majority of organisms collected from the monitoring sites were moderately or highly tolerant to stream impairments. Fifteen of the 16 sites were dominated by organisms in the collector feeding groups (collector–gatherers and collector–filterers), which typically become more abundant in response to water quality impairment.

Until recently, the IBI score of a monitoring reach was considered the strongest analytical tool for rating overall benthic macroinvertebrate community quality. In 2014, a new index referred to as the California Stream Condition Index (CSCI) was finalized, but at the time of this report was still in review for publication. Therefore, this report will continue to apply the IBI as the primary indicator of BMI community quality. The IBI score is in points on a raw scale of 0 to 70, which is then standardized to a 0-100 range, where higher scores indicate higher quality BMI communities. Sites rated Poor or Very Poor have a raw IBI score of 26 or lower and are considered impaired (i.e., 26 is the impairment threshold). The IBI scores for the 2014 study ranged from 3 to 61 of the possible 70 points (Table ES-1), and the ratings for quality of BMI communities ranged from Very Poor to Very Good. The monitoring reaches located in highly modified, concrete-lined channels all had Poor and Very Poor IBI ratings. Analysis of individual metrics as well as total IBI scores showed that monitoring sites located in the lower-elevation, urban watershed areas had lower-quality benthic communities than sites located in the middle to upper and natural reaches of the watersheds. Prior correlation analyses of elevation and IBI scores have indicated a positive and significant correlation countywide. When individual watersheds were considered, a positive and significant correlation between elevation and IBI scores existed in the San Gabriel River Watershed and Los Angeles River Watershed, whereas a negative but insignificant correlation (i.e., IBI scores were somewhat lower at higher elevation monitoring sites) existed in the Santa Monica Bay and Santa Clara River Watersheds. This was likely due to differences in the amount of urbanization relative to the location of the monitoring sites, particularly considering the relatively pristine and isolated conditions of the sub-watersheds along the Malibu coast that are at low elevation. Analysis of the IBI scores for the 11 survey years through 2014 did not indicate any substantial trend through time toward degradation or improvement at any of the sites.

An analysis of the benthic community quality in concrete-lined sites versus unlined sites for all survey years through 2012 concluded that the difference between concrete-lined sites and unlined sites was statistically significant for most watersheds. When reference sites were included in the analysis, all watersheds had higher quality BMI communities in the unlined sites, although the difference was not significant in the Los Angeles River Watershed (where reference sites were underrepresented). Linear regression analysis between CRAM scores for physical habitat quality and IBI scores for 2009 through 2014 data combined had an R^2 of 0.565, indicating a significant relationship between the two.

A cluster analysis was performed to test for similarities between site location and BMI community structure. The analysis was based on a two-way Bray–Curtis similarity matrix calculated on relative abundances of taxa by site. Results indicated that there was a clear separation between urban and open space sites based on taxonomic composition. Sites fell into three general clusters that corresponded to: a) concrete-lined and highly urbanized sites; b) natural bottom sites in moderately urbanized areas; and c) open space/reference sites. These results were consistent when the analysis was applied to the 2014 data only as well as the combined 2003-2014 data.

For targeted sites with long-term monitoring data, an analysis of physical habitat stability was performed in 2012 to assess whether any sites were degrading in physical habitat quality. None of the sites have shown any trends for improvement or degradation either through anthropogenic or natural processes. Two of the sites had major streambed and BMI community alteration due to storm and/or fire events, and biotic integrity at both sites recovered within about two years, although physical habitat integrity (primarily stream bank vegetation) was slower to recover. In the 2013 and 2014 surveys, there have been no major scouring or erosional events at any of the monitored sites.

An analysis of parameters with the potential to degrade the BMI community was performed in 2012. These parameters were divided into physical habitat attributes and water quality constituents and were compared to IBI scores. The results indicated that substrate complexity and channel alteration were the two physical conditions that were most strongly correlated to IBI scores and that dissolved ionic constituents and organic carbon were the water quality constituents most strongly correlated to IBI scores. Using a step-wise multiple regression approach, several significant relationships between IBI scores and a combination of predictors were found. However, although significant relationships were found, the predictive ability of the model was poor. Therefore, it was not possible to accurately predict IBI scores based on constituent values, although several analytes are useful as indicators that biotic integrity will likely be impaired (e.g., high total dissolved solids, chloride, and sulfate). An analysis of the possible effect of organophosphorus and pyrethroid pesticides showed that all of the sites where pesticides were detected had impaired biotic integrity.

Conclusion

Stream bioassessment monitoring of the watersheds of the County has been conducted for twelve consecutive years beginning in October 2003, at a total of 73 different sites. Monitoring sites located in highly urbanized areas of the watersheds have consistently had BMI communities that were considered impaired based on the Southern California IBI. Reference monitoring site BMI communities have been rated unimpaired for the duration of the study, with the exception of 6–Arroyo Seco, which was rated impaired in the 2010 survey after severe wild fire impacts, but has since recovered. Sampling and analysis methodology has been altered somewhat in the standard protocols, but overall results have been relatively consistent for most of the monitoring sites. One site, 7-Arroyo Seco, had shown a general trend toward BMI community quality improvement through 2011, but the 2012-2014 IBI scores did not continue that upward trend. None of the sites that have been sampled for multiple years have shown any significant trend for decreasing biotic integrity. Correlations between IBI scores and channel type (i.e., concrete-lined versus unlined), elevation, and CRAM habitat scores indicated that all three factors are significantly related to IBI scores when all areas of a watershed are well represented in the data. These relationships were also confirmed by two-way cluster analysis of sites and their corresponding BMI taxa.

Table ES-1. Index of Biotic Integrity Scoring Results for 2014

Receiving Waterbody	Site Code	IBI Score (0–70 scale)	IBI Rating
San Gabriel River Watershed			
San Gabriel River (unlined channel)	SGUT-501	61	Very Good
San Gabriel River (unlined channel)	SGUT-504	39	Fair
San Gabriel River (unlined channel)	SGUT-505	24	Poor
Walnut Channel (unlined channel)	5, SGLT-506	10	Very Poor
Los Angeles River Watershed			
Arroyo Seco (unlined channel)	6	44	Good
Arroyo Seco (unlined channel)	7	20	Poor
Rio Hondo (lined channel)	LALT500	9	Very Poor
Arroyo Seco (lined channel)	LALT501	16	Poor
Compton Creek (unlined channel)	8, LALT502	7	Very Poor
Tujunga Wash (lined channel)	LALT503	3	Very Poor
Dominguez Channel Watershed			
Dominguez Channel (lined channel)	19	3	Very Poor
Santa Monica Bay Watershed			
Temescal Canyon (unlined channel)	404TCC (2 surveys)	32 / 36	Fair / Fair
Medea Creek (lined channel)	SMC04264/SMC04264 Dup	14 / 13	Poor / Very Poor
Malibu Creek (unlined channel)	SMC01384	24	Fair
Santa Clara River Watershed			
Gleason Canyon (unlined channel)	403GCC (2 surveys)	51 / 37	Good / Fair
Santa Clara River (unlined channel)	SMC17056	32	Fair

1.0 INTRODUCTION

Weston Solutions, Inc. (WESTON®) was contracted by the Los Angeles County Flood Control District (LACFCD) to perform biological assessments (bioassessments) of various freshwater streams in five Los Angeles County (County) watersheds (Bioassessment Program). The Bioassessment Program is required for National Pollutant Discharge Elimination System (NPDES) Permit compliance as enforced by the Los Angeles Regional Water Quality Control Board (RWQCB) (i.e., Region 4). The goals of the program are to assess biological integrity and to detect possible biological trends and responses to pollution in receiving waters throughout the County. Sampling and analysis followed the protocols described in the Surface Water Ambient Monitoring Program (SWAMP) physical habitat assessment protocol (Ode, 2007) and also incorporated the Stormwater Monitoring Coalition (SMC) technical report Regional Monitoring of Southern California's Coastal Watersheds (SCCWRP, 2007). The County program was initiated in October 2003, and monitoring surveys have been conducted annually since that time. In 2014, the Bioassessment Program incorporated three monitoring programs in addition to the NPDES Program. These included the San Gabriel River Regional Monitoring Program (SGRRMP) which began in 2006, the Los Angeles River Watershed-Wide Monitoring Program (LARWMP) which began in 2008, and the Stormwater Monitoring Coalition (SMC) Southern California Regional Watershed Monitoring Program (SMC Program) which began in 2009. More information on the San Gabriel and Los Angeles River Monitoring Programs is available at http://www.watershedhealth.org/programsandprojects/watershedmonitoring.aspx and information on the SMC program is available at http://www.socalsmc.org/.

The Bioassessment Program includes the collection and identification of stream benthic macroinvertebrates (BMI) and also assesses the quality and condition of the in-stream physical habitats and adjacent riparian zones. Using species-specific tolerance values (TVs) and community composition, numerical biometric indices are calculated that determine the ecological health of streams. Over time, this information may be used to identify ecological trends and aid analyses of the appropriateness of water quality management programs (Yoder and Rankin, 1998).

BMI reside in streams for periods ranging from about one month to several years and have varying sensitivities to physical, biological, and chemical disturbances in the stream. By assessing the invertebrate community structure of a stream, a realistic, long-term measure of stream habitat health and biological response is obtained. This information may complement monitoring programs that test water quality parameters, which provide a measure of habitat conditions only at the moment sampling occurs. The addition of bioassessment to chemical, bacterial, and toxicological approaches to watershed monitoring programs gives a comprehensive indication of water quality and the effects of ecological impacts.

This report presents the results of stream bioassessment surveys from 16 monitoring sites in the Los Angeles Basin conducted from April 15, 2013 to June 27, 2014, as well as analyses of historical data. No significant rain events occurred during the sampling period or during the month prior to sampling. A taxonomic list of all identified BMI, biological metrics and Index of Biotic Integrity (IBI) calculations, physical habitat information, and a discussion and analysis of the results are included in this report. Representative photographs of the monitoring sites are presented in Appendix A, details of the results of the Countywide survey are included in data tables in Appendix B, and other relevant documentation, such as field data sheets, chain-of-custody forms, and quality assurance (QA) documentation, is included in Appendix C.

2.0 STUDY AREA OVERVIEW

The monitoring sites assessed in this study were located in five major watersheds throughout the County. These included the San Gabriel River Watershed, Los Angeles River Watershed, Dominguez Channel Watershed, Santa Monica Bay Watershed (including the Malibu Creek Watershed and the Ballona Creek Watershed), and Santa Clara River Watershed. The monitoring reaches are described in Table 1, along with the rationale for monitoring each site. Figure 1 is a map of the monitoring site locations.

Four of the monitoring sites were located in concrete-lined channels: LALT500–Rio Hondo, LALT501–Arroyo Seco, LALT503–Tujunga Wash, and 19–Dominguez Channel. Five of the soft bottomed (unlined) monitoring sites were considered reference sites with minimal upstream urban development: SGUT-501–San Gabriel River, SGUT-504–San Gabriel River, 6–Arroyo Seco, 404TCC–Temescal Canyon, and 403GCC–Gleason Canyon. All remaining sites were in unlined channels with some influence from urban runoff.

Table 1. Los Angeles County Flood Control District Stream Bioassessment Monitoring Stations, 2014

Site	Targeted (T) or Random (R) SMC Site	Receiving Waterbody	Location, Date Sampled	Coordinates	Justification	Elevation (feet above sea level)
San Gabriel River Watershed: four sites						
SGUT-501	T	San Gabriel River Unlined Channel	San Gabriel River upstream of the confluence with Bear Creek, 6/26/2014	N 34.24067° W -117.88192°	Upstream reference site, targeted/fixed site for SGRRMP	1,620
SGUT-504	T	San Gabriel River Unlined Channel	Upper San Gabriel River near East Fork Road, 6/27/2014	N 34.23609° W -117.81751°	Upstream reference site, targeted/fixed site for SGRRMP	1,512
SGUT-505	T	San Gabriel River Unlined Channel	Upper San Gabriel River below Morris Reservoir, 6/26/2014	N 34.16929° W -117.88872°	Targeted/fixed site for SGRRMP	898
5, SGLT-506	T	Walnut Creek Unlined Channel	Walnut Channel upstream of San Gabriel River, 6/24/2014	N 34.06170° W -117.99400°	Targeted/fixed site for SGRRMP	298
Los Angeles River Watershed: six sites						
6	T	Arroyo Seco Unlined Channel	Upstream of Arroyo Seco Spreading Grounds, 6/25/2014	N 34.20319° W -118.16648°	Upstream reference site with minimal impact from residential land use	1,118
7	T	Arroyo Seco Unlined Channel	Arroyo Seco downstream from Interstate 134, 6/25/2014	N 34.14489° W -118.16531°	Assess impacts of residential land use	725
LALT500	T	Rio Hondo Lined Channel	Rio Hondo at Los Angeles River, 6/19/2014	N 33.93642° W -118.17151°	Offset site for the LARWMP	82
LALT501	T	Arroyo Seco Lined Channel	Arroyo Seco at Los Angeles River, 6/18/2014	N 34.08046° W -118.22491°	Offset site for the LARWMP	300
8, LALT502	T	Compton Creek Unlined Channel	Compton Creek at Los Angeles River, 6/19/2014	N 33.84545° W -118.20802°	Offset site for the LARWMP	22

Table 1. Los Angeles County Flood Control District Stream Bioassessment Monitoring Stations, 2014

Site	Targeted (T) or Random (R) SMC Site	Receiving Waterbody	Location, Date Sampled	Coordinates	Justification	Elevation (feet above sea level)
LALT503	T	Tujunga Wash Lined Channel	Tujunga Wash at Los Angeles River, 6/18/2014	N 34.14560° W -118.38889°	Offset site for the LARWMP	578
Dominguez Channel Watershed: one site						
19	T	Dominguez Channel Lined Channel	Dominguez Channel upstream of Vermont Avenue, 6/16/2014	N 33.87114° W -118.29676°	Assess impacts from upper Dominguez Channel Watershed	3
Santa Monica Bay Watershed: three sites						
404TCC	R	Temescal Canyon	Temescal Canyon, 4/16/2014; 5/20/2014	N 34.068086° W -118.536576°	Non-perennial reference site for the SMC Regional Monitoring Program	785
SMC04264	R	Medea Creek Unlined Channel	Medea Creek 325m downstream Silver Creek Road, 6/17/2014	N 34.130100° W -118.75480°	Trend site for the SMC Regional Monitoring Program	775
SMC01384	R	Malibu Creek Unlined Channel	Malibu Creek at mile marker 1.31 on Malibu Canyon Road, 6/17/2014	N 34.064400° W -118.69980°	Trend site for the SMC Regional Monitoring Program	285
Santa Clara River Watershed: two sites						
403GCC	R	Gleason Canyon Unlined Channel	Gleason Canyon ~ 1 mile upstream of Aliso Canyon Road, 4/15/2014; 5/19/2014	N 34.419738° W -118.150922°	Non-perennial reference site for the SMC Regional Monitoring Program	3525
SMC17056	R	Santa Clara River Unlined Channel	Santa Clara River upstream of Interstate 5, 6/20/2014	N 34.42630° W -118.57790°	Trend site for the SMC Regional Monitoring Program	1060

SGUT = San Gabriel River Upper watershed Targeted site
SGLT = San Gabriel River Lower watershed Targeted site
LALT = Los Angeles River Lower watershed Tributary site
SMC = Stormwater Monitoring Coalition

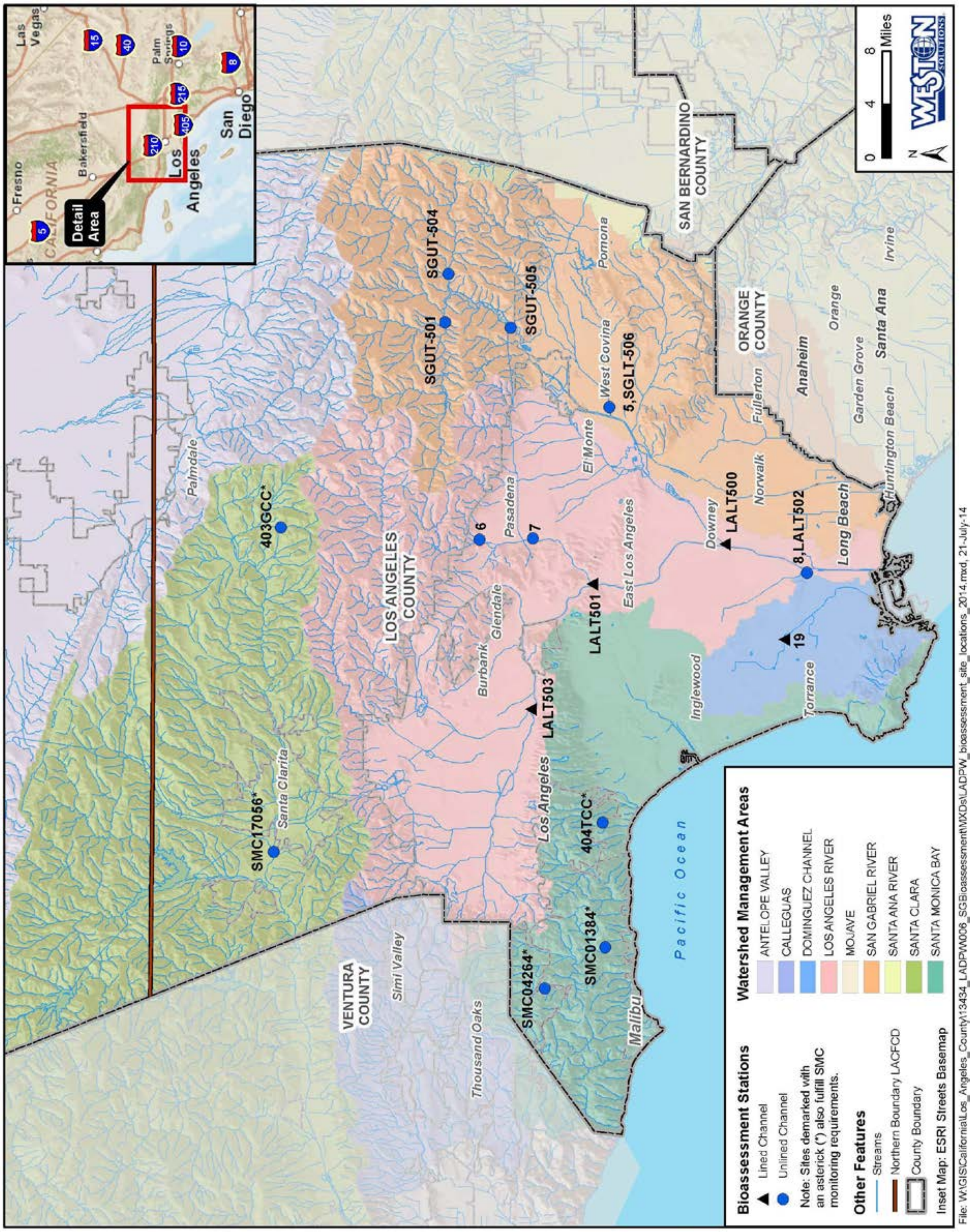


Figure 1. Stream Bioassessment Monitoring Locations for 2014

3.0 METHODS

A general description of the methods incorporated in the sampling program is presented below. WESTON personnel followed the protocols of the SWAMP physical habitat assessment procedure (Ode, 2007), the SMC regional bioassessment workplan (SCCWRP, 2007), and Quality Assurance Project Plan (QAPP) (SCCWRP, 2009). The California Rapid Assessment Method (CRAM) for riverine wetlands (CWMW, 2013) was also performed at the SMC sites. Laboratory methods incorporated the SWAMP laboratory SOP (Woodward et al., 2013) beginning in 2013, although this had no effect on taxonomic results. These documents may be referenced for more detailed procedural information.

The SMC Program, in a departure from the first five years of monitoring in which all sites were part of a probabilistic study design and selected randomly, conducted two special studies in 2014 in which the sampling sites were targeted. The two special studies of the 2014 SMC Program included a non-perennial stream study and a trend site monitoring study. These studies are summarized in the SMC 2014 Research Plan (an SMC technical workgroup internal document, available upon request) as follows:

- Non-perennial Stream Study. The objectives of this study are to determine whether existing assessment tools (e.g., the California Stream Condition Index and the Southern California algae Indexes of Biotic Integrity) apply for assessment of intermittent streams, and/or what modifications are necessary for use in these systems. The study will also help define the condition of BMI communities in non-perennial reference streams. To achieve these objectives, sites will be selected and sampled multiple times through the spring season, three to six weeks apart. If a site unexpectedly dries up, a replacement site will be selected.
- Trend Monitoring Study. The objectives of this study are to determine if stream condition has changed over time since the inception of the SMC regional monitoring program. To achieve this objective, sites that were originally sampled in 2009 and 2010 will be re-sampled and analyzed for any trends toward improvement or degradation in biotic integrity.

The selected monitoring sites were approved by Raphael Mazor, the SMC coordinator at the Southern California Coastal Water Research Project (SCCWRP). The non-perennial stream monitoring was initiated in April, 2014, with site re-visits in May, 2014. Sampling included BMI, algae, SWAMP physical habitat, and CRAM. At the non-perennial SMC sites, automated level loggers were deployed during the first sample collection. The level loggers were used to determine when/if the study reach dried in an effort to determine if the current analytical tools for BMIs and algae (IBIs) that were developed for use in perennial streams are applicable to non-perennial streams. The level loggers were retrieved after the stream reach had dried or at the end sampling index period. The trend site monitoring was conducted during the standard index period (i.e., from mid-May through July). Sampling for trend site monitoring included all of the parameters and constituents of the original SMC bioassessment program.

Sampling and analysis for the 2014 survey was performed using the same protocols as in the 2009–2013 surveys. Throughout the history of the program, there have been varying levels of effort concerning the in-stream sampling area and the number of organisms processed for each site. These variances have been dictated by changes in the standard protocols and were not at the discretion of the LACFCD or its consultants. Sample area size has varied from 9 square feet (ft^2)

to 18 ft^2 and has been 11 ft^2 since 2009. The sampling strategy within the sites has changed from targeted riffle sampling to a reachwide sampling technique where collections were made at evenly spaced 15-meter transects. In the laboratory, the target number of organisms identified varied from 500 to 900 organisms and has been 600 organisms since 2009, with a randomly selected count of 500 organisms used for data analyses.

3.1 Sampling Site Selection

Historically, the Bioassessment Program consisted of 20 targeted sites. In 2003, Los Angeles County Department of Public Works (LACDPW) staff performed a field reconnaissance of the monitoring reaches prior to program initiation to determine the suitability of the 20 original proposed sites. Over the years, various sites have been "offset" to contribute to other watershed-specific monitoring programs. For example, Sites 11, 12, and 13 in the Los Angeles River Watershed were offset in 2008 with Sites LALT500, LALT501, and LALT503 as a contribution to the LARWMP for the Council for Watershed Health (Council), formerly known as the Los Angeles and San Gabriel River Watershed Council (LASGRWC). Other programs that have been incorporated include the San Gabriel River Regional Monitoring Program (SGRRMP), also for the Council, and the SMC Program. Sites that contributed to the SGRRMP have site codes beginning with "SG," sites that contributed to the LARWMP have site codes beginning with "LALT," and sites that contributed to the SMC program typically have site codes beginning with "SMC."

In 2014, the 16 sites sampled included 11 targeted sites that have been sampled multiple times historically. Five additional targeted sites for the SMC Program were sampled in 2014 for the trend assessment and non-perennial stream special studies, and these were selected in coordination and with approval by SCCWRP's SMC Program Manager, Raphael Mazor.

3.2 Monitoring Reach Delineation

Historically (i.e. from 2003-2008), monitoring sites were established in stream reaches with ample current flow and riffle habitat, where available. Surveys followed the California Stream Bioassessment Procedure (CSBP) (Harrington, 2003) which targeted riffle habitat. This document may be consulted for detailed information regarding the historical sampling protocols. An ideal riffle is an area of variable flow regimes with some surface disturbance and a relatively complex and stable substrate. These areas provide increased colonization potential for benthic invertebrates. Riffles typically support the greatest diversity of invertebrates in a stream.

Beginning in 2009, all of the monitoring sites were delineated to encompass a 150-meter stream reach, regardless of site conditions. Historical targeted sites sampled in 2014 were in the same or relatively identical locations as in past surveys.

3.3 Sample Collection

Once a sampling transect was established, BMI were collected using a 1-foot-wide, 0.5-millimeter (mm) mesh D-frame kick-net. Depending on the protocol, a 1-ft^2 or 2-ft^2 area upstream of the net was sampled by disrupting the substrate and scrubbing the cobble and boulders so that organisms were dislodged and swept into the net by the current or by hand sweeping. In areas with little or no current, the substrate was disturbed, and the net was swept back and forth to capture the organisms. The duration of the sampling generally ranged from 1 to 3 minutes, depending on substrate complexity. For the CSBP protocol, three points within each transect were sampled and combined into one composite sample. The three sample points on the transect were usually taken near the right and left margins and in the middle of the stream, or the three sample points were selected to best represent the diversity of habitat types present. This procedure was repeated for the next two riffles, proceeding from downstream to upstream. Sample material was transferred from the kick-net to 1-quart jars, preserved with 95 percent (%) ethanol, and returned to WESTON's benthic laboratory for processing.

Kick Net Sampling

Benthic Macroinvertebrate Sample

Beginning in 2009, BMI samples have been collected at evenly spaced 15-meter transects for a total of 11 transects in each 150-meter reach (transects are labeled alphabetically, A through K). The physical conditions at all of the 2013 sites allowed for sampling over an uninterrupted 150-meter reach. BMI were collected using a standard 1-foot-wide kick-net, and each sample point consisted of a 1-ft^2 area. The samples were collected in a repeating alternating margin-center-margin pattern (at 25%, 50% and 75% of the transect width) and were otherwise collected and preserved as in the past.

Every monitoring site was sampled from downstream to upstream and photographed, at a minimum, at Transects A, F and K. Representative photographs of the monitoring sites are presented in Appendix A.

3.4 Physical Habitat Quality Assessment

Historically, for each monitoring reach sampled the physical habitat of the stream and its adjacent banks were assessed using the CSBP methods modified from the United States Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (Barbour et al., 1999). Habitat quality parameters were assessed to provide a record of the overall condition of the reach. Parameters such as channel alteration, frequency of riffles, width of riparian zones, and vegetative cover help to provide a more comprehensive understanding of the condition of the stream. Additionally, specific characteristics of the sampled riffles were recorded, including riffle length, depth, gradient, velocity, substrate complexity, and substrate composition.

Beginning in 2009, the SWAMP physical habitat assessment protocol was implemented. This protocol is more comprehensive and quantitative than the CSBP protocol. Detailed measures (e.g., substrate size, bank vegetation, human influences, and in-stream features) were taken at the same 11 transects where BMI collections were taken. A subset of the physical habitat measures were also assessed at inter-transects 7.5 meters apart. Copies of the SWAMP field data sheets are presented in Appendix C (electronic version only).

Also beginning in 2009, the CRAM protocol for assessing riverine wetland quality was incorporated into the monitoring program and has been conducted at the SMC sites. CRAM assesses a number of wetland attributes (e.g., in-stream habitat complexity, riparian vegetation, buffer zone width and quality, adjacent land uses, and hydrologic connectivity). CRAM incorporates a broader landscape scope than the SWAMP physical habitat assessment, and yields a single score for a site. The range of possible scores is 25 to 100 points, with higher scores representing higher quality wetlands. The scoring system has yet to be calibrated to give ratings such as 'Poor' or 'Good' that correspond to specific score ranges.

In situ physical water quality measurements were taken at each of the monitoring sites. Measurements included water temperature, pH, specific conductance, salinity, dissolved oxygen, and turbidity. Water samples were collected and analyzed for alkalinity and hardness in the laboratory to achieve greater accuracy than the standard field methods.

3.5 Laboratory Processing and Analysis

At the laboratory, samples were relinquished under chain of custody to the laboratory sample custodian. Each sample was assigned a unique laboratory ID name and 10% of the sample lot was checked for proper ethanol concentration (i.e. >70%). The sample was poured over a No. 35 standard testing sieve (i.e., 0.5-mm stainless-steel mesh), and the ethanol was retained for reuse. The sample was gently rinsed with fresh water, and large debris (e.g., wood, leaves, and rocks) was removed. The sample was transferred to a tray marked with grids approximately 25 square centimeters (cm^2) and was spread homogenously to a thickness of approximately 0.25 inch. One grid was randomly selected, and the sample material contained within the grid was removed and processed. In cases where the animals appeared abundant, only a fraction of the sample in the grid may have been removed. The material from the grid was examined under a stereomicroscope, and the invertebrates were removed, sorted into major taxonomic groups, and placed in vials containing 70% ethanol. This process was repeated until the specified number of organisms was removed from the sample (i.e., 300, 500, or 600, depending on the protocol). Organisms from a grid in excess of the specified number were placed in a separate vial labeled "extra animals," so that a total abundance for the sample could be estimated. All sample processing information was entered onto a Stream Bioassessment Sorting Sheet (Appendix C). Processed material from the sample was placed in a separate jar and was labeled "sorted," and the unprocessed material was returned to the original sample container, checked in to the sample tracking logbook, and archived. Sorted material was retained for QA purposes.

Historically, all organisms were identified to standard taxonomic Level I as specified in the *Southwest Association of Freshwater Invertebrate Taxonomists* (SAFIT) *List of Freshwater Invertebrate Taxa* (Richards and Rogers, 2011), genus level for most insects, and order or class for non-insects. The taxonomic levels are fixed under this document to prevent inconsistencies in taxonomic effort between laboratories. The level of taxonomic effort was consistent from 2003 through 2008. Beginning in 2009 to meet SMC requirements, the taxonomic effort level was increased to SAFIT Level II, in which insects are identified to species level when possible, and Chironomidae are identified to genus level. With the exception of some beetles, nearly all of the insects identified in the program were in larval or pupal stages of development, which metamorphose into an aerial adult form. Nearly all of the non-insect taxa are aquatic for their entire life history.

Quality Assurance/Quality Control**—**After sample processing was completed, 100% of the BMI samples were checked to ensure a 95% or better organism removal efficiency. Results of the sorting quality assurance/quality control (QA/QC) were entered onto the Stream Bioassessment Sorting Sheet (Appendix C). To ensure accuracy of the taxonomic identifications, at least 20% of the samples (i.e., four samples) were sent to the California Department of Fish and Game (CDFG) Aquatic Bioassessment Laboratory (ABL) for taxonomic verification. Any discrepancies between ABL identifications and the original identifications were reconciled in the taxonomic database. Taxonomic QA/QC results for one sample were also sent to the SMC to determine whether minimum quality objectives (MQOs) were met. Results of the sorting and taxonomic QA/QC analyses are presented in Appendix C.

3.6 Data Analysis

Taxonomic data were entered into an electronic file using Microsoft Word and were converted into a SAS® database for QA/QC and data reduction. For calculation of BMI community-based metrics and the IBI (described below), the database was randomly reduced to a 500-organism count (Ode et al., 2005). A list of the standard CSBP metrics, a brief description of what they signify, and their predicted responses to impairment are presented in Table 2. A taxonomic list of the macroinvertebrates present in each sample was created in Microsoft Excel, including the designated TV and Functional Feeding Group (FFG) of each taxon. Rare feeding groups such as macrophyte herbivores (mh), piercer herbivores (ph), omnivores (om), parasites (pa), and xylophages/wood-eaters (xy) were combined into a group designated “other.” Note that for some organisms identified at the Family level or above, a single TV or FFG was not assigned because the taxa within the group have a broad range of tolerances or feeding strategies, and a single designation is not representative.

In addition to the individual metric values, a multi-metric IBI was calculated for each monitoring reach (Ode et al., 2005). The IBI is a quantitative scoring system for assessing the quality of BMI assemblages and is currently the most useful tool for reducing a complex macroinvertebrate dataset to a qualitative rating for each monitoring reach. The IBI score is derived from the cumulative value of seven biological metrics (Table 2). Percent collector–filterers and percent collector–gatherers are combined into a single IBI metric. The total scores were categorized into ratings of the benthic community, ranging from Very Poor to Very Good. It has been noted that the southern California IBI was developed with very few reference sites located at low elevations in the County. The development of a new BMI index, the California Stream Condition Index (CSCI) is currently underway and should be available in the near future.

Using the IBI and metric data, comparative analyses of mean biological metrics and IBI scores for all years of monitoring was performed for each major watershed. Historical analyses relating channel type and elevation to IBI scores were performed for past reports, and the results are summarized in this report. Analyses in 2013 included a summary of records of invasive species county-wide as well as a review of data collected in the Malibu Watershed by other researchers to identify conditions that may naturally affect the biological integrity of the watershed.

Table 2. Bioassessment Metrics Used to Characterize Benthic Invertebrate Communities

Metric	Description	Expected Response to Impairment
Richness Measures		
Taxa Richness	Total number of individual taxa	Decrease
Coleopteran Taxa*	Number of taxa in the insect order Coleoptera (beetles)	Decrease
EPT[1] Taxa*	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	Decrease
Dipteran Taxa	Number of taxa in the insect order Diptera (true flies)	Increase
Non-Insect Taxa	Number of non-insect taxa	Increase
Predator Taxa*	Number of taxa in the predator feeding group	Decrease
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly, and caddisfly larvae	Decrease
Sensitive EPT Index	Percent composition of mayfly, stonefly, and caddisfly larvae with TVs between 0 and 3	Decrease
Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver, 1963)	Decrease
Margalef Diversity	Measure of sample diversity weighted for richness	Decrease
Tolerance/Intolerance Measures		
TV	Value between 0 and 10 of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	Increase
Dominant Taxon	Percent composition of the single most abundant taxon	Increase
Percent Chironomidae	Percent composition of the tolerant dipteran family Chironomidae	Increase
Percent Intolerant Organisms*	Percent of organisms in sample that are highly intolerant to impairment as indicated by a TV of 0, 1, or 2	Decrease
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a TV of 8, 9, or 10	Increase
Percent Tolerant Taxa*	Percent of taxa in sample that are highly tolerant to impairment as indicated by a TV of 8, 9, or 10	Increase
Percent Non-Insect Organisms	Percent of organisms in sample that are not in the Class Insecta	Increase
Percent Non-Insect Taxa*	Percent of taxa in sample that are not in the Class Insecta	Increase
FFGs		
Percent Collector–Gatherers*	Percent of macrobenthos that collect or gather fine particulate matter	Increase
Percent Collector–Filterers*	Percent of macrobenthos that filter fine particulate matter	Increase
Percent Scrapers	Percent of macrobenthos that graze upon periphyton	Increase
Percent Predators	Percent of macrobenthos that feed on other organisms	Variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	Decrease
Percent Other	Percent of macrobenthos that are pa, mh, ph, om, and xy	Variable
Abundance		
Estimated Abundance	Estimated number of organisms in entire sample	Variable

*Metrics used to calculate the IBI
[1]EPT = Ephemeroptera, Plecoptera, and Trichoptera
Source: SDRWQCB, 1999

4.0 COUNTYWIDE SURVEY RESULTS

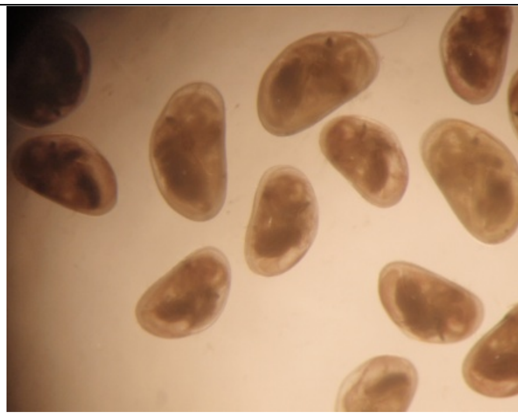
A discussion of the 2014 survey results is presented below. A complete list of the benthic invertebrates identified at all sites and replicates is presented in Appendix B.1. Ranked total abundance for each species at all sampling sites combined is presented in Appendix B.2, and the calculated BMI metric values for each monitoring site are presented in Appendix B.3.

The reader may notice seeming discrepancies between the number of unique taxa in the taxa list and the values in the metrics tables. This was due to fact that the metrics were calculated on a randomly selected subset of 500 organisms and also because of the presence of immature or damaged specimens that were identified at a higher systematic level but were not considered to be unique taxa. It should also be noted that the increased taxonomic effort since the 2009 surveys substantially increased the apparent taxa richness; therefore, comparisons with past surveys need to consider this difference.

4.1 Benthic Macroinvertebrate Community – 2014 Study Area Summary

When all sites in the County study area are combined, a total of approximately 134 unique taxa were identified from 11,571 individual organisms (Appendix B.1 and Appendix B.2). The five most abundant taxa in descending order were Ostracoda (seed shrimp) with 2,160 individuals; Oligochaeta (earthworms) with 988 individuals; the amphipod, *Hyalella* sp., with 980 individuals; the New Zealand mud snail *Potamopyrgus antipodarum* with 462 individuals, and the mayfly, *Baetis* sp., with 444 individuals (Appendix B.2 and Figure 2). All of these taxa are moderately to highly tolerant to habitat impairment and are in the collector–gatherer feeding group with the exception of the New Zealand mud snail, which is a scraper. Collector taxa feed on organic detritus, algae, and various microorganisms (Smith, 2001; Usinger, 1956), and high abundances of these organisms are often associated with high levels of urban runoff (Lenat and Crawford, 1994).

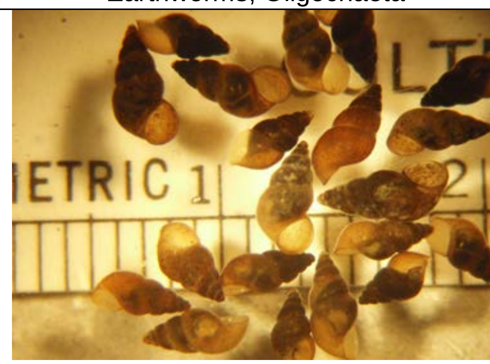
The order Diptera (true flies) had the greatest number of unique taxa identified (57 taxa, including 38 Chironomidae genera and species groups), followed by Coleoptera (beetles) with 15 taxa, Trichoptera (caddisflies) with 14 taxa, and Ephemeroptera (mayflies) with 10 taxa (Appendix B.1). Chironomidae (midges) was the only family of BMI that was collected at every site.



Seed Shrimp, Ostracoda

Earthworms, Oligochaeta

Amphipod, *Hyalella* sp.



New Zealand Mud Snail, *Potamopyrgus antipodarum*

Mayfly, *Baetis* sp.

Figure 2. The Most Abundant Organisms Collected in Los Angeles County for the 2014 Survey

4.2 2014 Benthic Macroinvertebrate Community Metrics

Benthic invertebrate community metric values for each monitoring reach are presented in Appendix B.3. Table 2 above may be referenced for a brief definition of each metric and how its results correspond to impairment. Each metric is based on a different component of the BMI community, and the combination of metric scores gives an indication of overall biotic integrity for a given site.

Taxa Richness

Taxa richness is the total number of unique taxa in a sample, and it is presumed that higher richness indicates higher biotic integrity. This number does not always account for damaged or immature specimens identified at a higher taxonomic level than specified in the SAFIT list (also referred to as indiscriminate or non-distinct taxa). In 2014, taxa richness per sample ranged from 8 taxa at 19–Dominguez Channel to 53 taxa at SGUT-501–San Gabriel River (Appendix B.3). Taxa richness values for historical surveys prior to 2009 were based on Level I taxonomic effort, which is likely why they, for the most part, were substantially lower than for surveys since 2009. The lined sites had a mean of 14 taxa per site, while the unlined sites had a mean of 31 taxa per site, and the reference sites had a mean of 41 taxa per site in 2014.

Diversity and Dominance

Two diversity indices were calculated for each site: Shannon Diversity, which increases with diversity and weights for evenness of distribution among taxa and Margalef Diversity, which increases with raw diversity values. Shannon Diversity values per site ranged from 0.8 at LALT503–Tujunga Wash to 3.1 at SGUT-501–San Gabriel River and 6–Arroyo Seco (Appendix B.3). Margalef Diversity values per site ranged from 1.1 at 19–Dominguez Channel to 8.7 at **S**GUT-501–San Gabriel River (Appendix B.3). Dominance is a metric that is presumed to decrease with increasing biotic integrity. Dominance by a single taxon ranged from 15.0% *Fallceon* sp. at SGUT-504–San Gabriel River to 81.6% Ostracoda at LALT503–Tujunga Wash (Appendix B.1, Appendix B.3).

Ephemeroptera, Plecoptera, and Trichoptera Taxa

This metric represents the number of taxa in the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) that are collected at each site. These orders contain many impairment-sensitive taxa, and greater diversity of these taxa indicates higher biotic integrity. Several of these taxa (e.g., mayflies in the family Baetidae and the caddisflies, *Cheumatopsyche* sp., *Hydropsyche* sp., and *Hydroptila* sp.), have moderate TVs and are tolerant to urban runoff that does not contain high levels of chemical pollutants or dissolved ionic constituents. This means that percent-sensitive EPT (TV $\leq$3) is a much stronger metric than total-percent EPT when assessing the ecological health of a site. All of the stonefly taxa are sensitive to urban runoff.

The Sensitive Caddisfly, *Micrasema* sp.

The greatest number of EPT taxa (19) was collected at SGUT-501–San Gabriel River (Appendix B.3). Two of the monitoring sites, LALT503–Tujunga Wash and 19–Dominguez Channel had 0 EPT taxa collected. EPT individuals were most abundant at SGUT-505–San Gabriel River where they comprised 68.2% of the benthic community (Appendix B.3). The most abundant of the EPT taxa across the survey region included the mayflies *Baetis* sp., *Fallceon* sp., and *Tricorythodes* sp., which were the 9th, 10th and 15th most abundant taxa, respectively (Appendix B.2).

Sensitive EPT taxa (TV 0 to 3) were collected at seven of the sites and were collected in the greatest numbers at SGUT-501–San Gabriel River, where they comprised 31.2% of the benthic community. The high percentage of sensitive EPT at this site was primarily due to a high abundance of the caddisfly, *Micrasema* sp., with 155 individuals (Appendix B.2).

Tolerance Values

For most stream macroinvertebrates, a TV has been determined for each taxon through prior research on each type of animals' life history (Hilsenhoff, 1987). TVs range from 0, for organisms highly intolerant (i.e., sensitive) to impairments, to 10, for organisms that are highly tolerant to impairments. For some taxa, the TV is either unknown or is too diverse within a group to assign a single value and, therefore, no TV is applied. A low to moderate abundance of high TV organisms does not necessarily imply impairment (SDRWQCB, 2001), but more importantly, the presence of sensitive organisms is unlikely when a stream is impaired. The presence of highly intolerant organisms (TV 0 to 2) is likely the strongest individual indicator of good water quality.

Average community TVs for all sites ranged from 4.3 at SGUT-501–San Gabriel River to 7.8 at sites 19–Dominguez Channel and LALT503–Tujunga Wash (Appendix B.3). Highly tolerant organisms (TV 8 to 10) were most abundant at SMC04264–Medea Creek and comprised 94.2% of the community, due to the predominance of Ostracoda. Highly tolerant organisms were least abundant at 403GCC–Gleason Canyon, where they comprised 9.6% of the community in the April survey. Highly intolerant (i.e. sensitive) organisms were collected from seven sites, which were the same sites where sensitive EPT were collected. Sensitive EPT with a TV of 2 or less are also counted in the highly intolerant metric. SGUT-501–San Gabriel River had the greatest number of intolerant organisms, where they comprised 29.0% of the community. The only highly intolerant organism collected in high numbers Countywide was the caddisfly, *Micrasema* (160 individuals), while the caddisfly, *Tinodes* sp. was the second most abundant intolerant organism (43 individuals) followed by the stonefly, *Isoperla* sp. with 20 individuals.

Functional Feeding Groups

As with TVs, FFG designations have been determined through prior life-history research or observations of each taxon. In rare instances, the feeding strategy of an organism is unknown, and for some taxonomic designations at a high level (e.g., family level), the feeding strategies are too diverse to assign a single feeding group to the taxon. The percent composition of the FFGs provides useful information regarding benthic community function, and some feeding groups contain greater numbers of intolerant organisms (Table 2). In general, a more even distribution of the feeding groups indicates a higher quality benthic community. The information from feeding group composition may be particularly useful in detecting physical habitat degradation and impacts from urbanization.

All of the monitoring reaches were dominated by taxa in the combined collector feeding groups (i.e. collector-gatherers plus collector-filterers) including all of the lined channel sites (Appendix B.3). Eight of the ten most abundant taxa in the study region were in the collector-gatherer feeding group, which generally increases in abundance in response to urban runoff in a watershed (SLSI, 2003). One site had scrapers as the single dominant feeding group: SMC01384–Malibu Creek, which was dominated by the New Zealand mud snail. LALT503–Tujunga Wash had the greatest dominance by a single feeding group, where collector–gatherers comprised 99.6% of the community.

Estimated Abundance

The estimated total abundance is the total number of BMI predicted to be in the sample if the entire sample had been processed (e.g., if 50% of the sample was processed to obtain the target of 600 BMI, the estimated total abundance would be 1,200). This value is then divided by 11 to calculate the estimated number of animals living in one square foot of benthic habitat. Response to moderate impairment is often indicated by an increase in total abundance by highly tolerant organisms, with a corresponding decrease in taxa richness and diversity; however, severe impairment can result in a catastrophic decrease in total abundance.

Estimated abundance ranged from 48 organisms per square foot of substrate at SMC01384–Malibu Creek to 681 organisms per square foot at SGLT-506–Walnut Channel (Appendix B.3). Abundance at the reference sites ranged from 57 to 504 organisms per square foot. These values are relatively moderate and none of the sites had extremely high abundance (e.g., in 2010, SMC03944–Cheseboro Channel had an estimated 11,409 organisms per square foot (WESTON, 2011)).

4.3 2014 Physical Habitat Quality Assessment

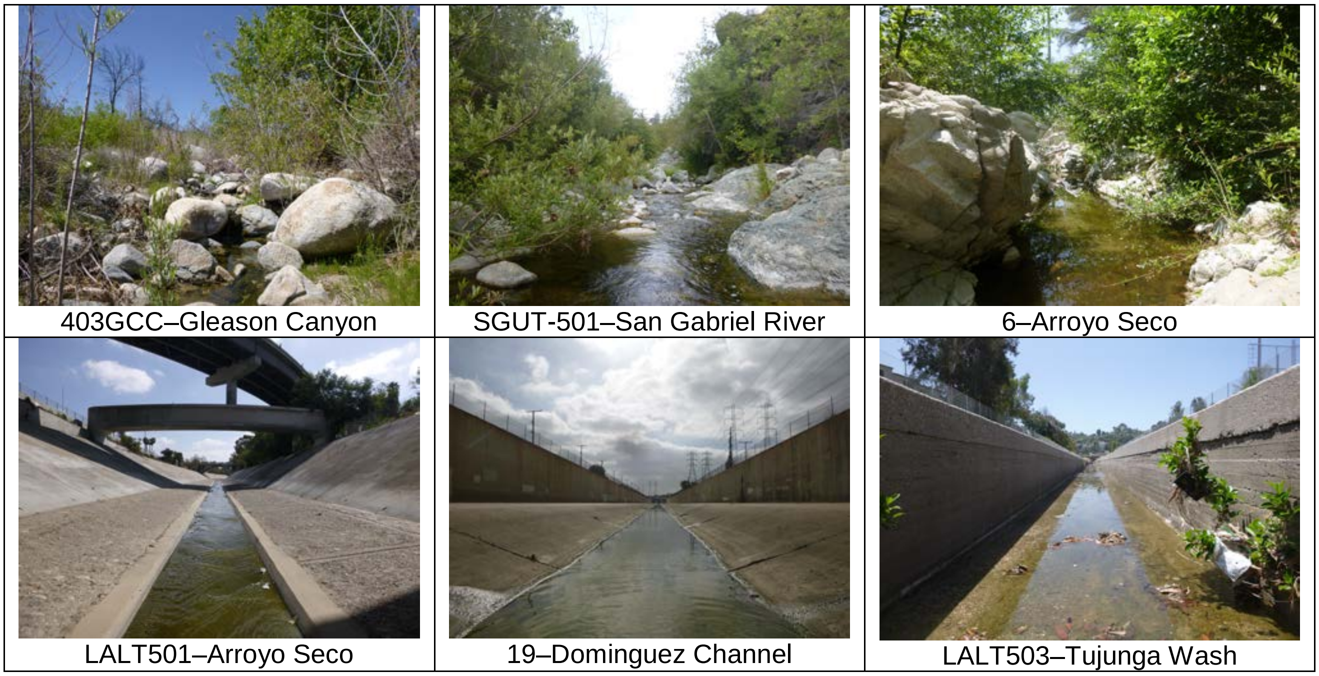
Assessment Methods

The SWAMP physical habitat procedure was performed at all sites. The procedure is much more comprehensive than the historical USEPA method in which ten parameters were assessed qualitatively on a 0 to 20 point scale to give a single habitat score. The SWAMP procedure retained three of these original USEPA parameters, including epifaunal substrate/cover (an estimate of substrate complexity), sediment deposition, and channel alteration. Additionally, many aspects of the reachwide habitat were quantitatively assessed (e.g., substrate size, algal cover, bank vegetation cover, canopy cover, in-stream habitat complexity, and human influences, flow volume, and reach gradient). Qualitative assessments were also made to characterize flow habitats and bank stability. As of the writing of this report, summary indices of the SWAMP physical habitat data have not been developed, although CRAM scores (described below) do provide a multi-attribute summary score to determine relative habitat quality. Table 3 lists the more relevant physical habitat parameters and briefly describes the conditions that are most beneficial to macroinvertebrate communities. Figure 3 presents photographs of good and poor quality physical habitats. Water quality data are presented in Appendix B.4, and physical habitat measures for each monitoring reach are presented in Appendix B.5.

Table 3. Parameters Used to Characterize the Physical Habitat of a Stream Reach

Parameter	Conditions Assessed	Optimal Conditions
Epifaunal substrate/cover*	The percentage of substrate favorable for epifaunal colonization. Most favorable is a mix of snags, submerged logs, undercut banks, cobble, and other stable habitats.	Complex mix of stable substrates occupying a high percentage of the stream bottom.
Embeddedness	The percentage of fine sediment surrounding gravel, cobble, and boulder particles.	Very little embeddedness, with layered substrate.
Flow habitats	The presence of cascades, rapids, riffles, runs, glides, and pools.	A mix of all regimes, dominated by riffles.
Sediment deposition*	The percentage of bottom affected by the deposition of new gravel, sand, or fine sediment.	Little or no new deposition, less than 5% of the bottom affected.
Channel flow	The percentage of the stream channel filled by flowing water and the amount of substrate covered.	Water reaches base of both lower banks and minimal amount of substrate is exposed.
Channel alteration*	The amount of channelization, dredging, embankments, or shoring structures present.	Channelization or dredging absent or minimal; stream with normal pattern.
Riffle frequency	The frequency of occurrence of riffle habitat.	Occurrence of riffles frequent, with variety of habitat.
Bank stability	Evidence of erosion or bank failure.	Evidence of erosion and bank failure absent or minimal.
Vegetative protection	The percent cover by undisturbed, native vegetation on the streambank surfaces and immediate riparian zones.	More than 90% of the streambank surfaces covered by native vegetation.
Riparian vegetative zone width and canopy cover	The width of native riparian vegetation along both streambanks and the amount of overhanging vegetation above the streambed providing shade and coarse organic matter.	Width of riparian zone more than 18 meters; human activities have not impacted zone. Canopy covers majority of streambed.

Source: CSBP, 1999
*Retained by SWAMP procedure



403GCC–Gleason Canyon | SGUT-501–San Gabriel River | 6–Arroyo Seco

LALT501–Arroyo Seco | 19–Dominguez Channel | LALT503–Tujunga Wash

Figure 3. Examples of Good Physical Habitat Conditions (top row) and Poor Physical Habitat Conditions (bottom row) in 2014

Water Quality

Water quality measurements at most of the monitoring sites did not indicate severe impairment, but there were some notable exceptions (Appendix B.4). Water temperatures were variable throughout the County, ranging from 14.8 degrees Centigrade (°C) (58.6 degrees Fahrenheit [°F]) at 403GCC–Gleason Canyon in April to 30.1 °C (86.2 °F) at LALT500–Rio Hondo. Most other sites had temperatures in the range of 17-20 °C (63-68°F) at the time of sampling.

Values for pH ranged from 7.20 to 8.86 at SMC17056–Santa Clara River and LALT503–Tujunga Wash, respectively. Values for pH were generally higher at the lined channel sites.

Specific conductance, a general indicator of dissolved solids, was moderate to low at most sites (e.g., < 2.0 milliSiemens per centimeter [mS/cm]). There were two exceptions, and both were in the Malibu Watershed. These included SMC04624–Medea Creek and SMC01384–Malibu Creek, with values of 3.013 and 2.314 mS/cm, respectively. The reference sites had conductivity values near 0.500 mS/cm with the exception of 404TCC–Temescal Canyon. This site had conductivity values of 1.474 and 1.419 mS/cm for the April and May surveys, respectively, and the site also had somewhat elevated salinity, hardness and alkalinity. It is likely that these values are elevated by the natural geological conditions in the Malibu Creek and Temescal Canyon sub-watersheds.

Dissolved oxygen levels were suitable for BMI at all sites, with the possible exception of 8, LALT502–Compton Creek, which had a value of 3.83 milligrams per liter (mg/L).

Turbidity, a measure of water clarity (clear waters have low nephelometric turbidity unit [NTU] values and the meter range is 0-1,000 NTU), was relatively low at all sites (<6 NTU), with the exception of LALT503–Tujunga Wash, which had a value of 11.8 NTU.

Hardness was moderate to low at most sites, with the exception of the Malibu Watershed sites that also had high specific conductivity. SMC04624–Medea Creek and SMC01384–Malibu Creek had hardness values of 1,560 and 1,340 mg/L Ca, respectively. Alkalinity was also moderate to low at most sites, although the Malibu Watershed and Temescal Canyon sites had somewhat elevated alkalinity. Excessive salts, metallic cations (e.g., calcium, magnesium, and ferrous iron), and limestone formations can naturally elevate water hardness (Sawyer and McCarty, 1978), which may subsequently limit the BMI community to taxa that are tolerant to these constituents. The Monterey/Modelo Formation in the Malibu Watershed has been shown to contribute such constituents from a natural source (discussed further in Section 6.1 below).

Currently, SWAMP has not developed standard metrics summarizing the overall habitat quality, but the more relevant physical habitat measures (e.g., substrate composition, channel alteration, canopy cover, and flow characteristics) are presented in Appendix B.5. For the five SMC sites, the CRAM for riverine wetlands was applied in 2014. The final CRAM scores are presented in Appendix B.5, and a complete list of all CRAM attribute scores are presented in Appendix B.6.

CRAM Analysis

CRAM analysis was performed at the five SMC sites in 2014. The CRAM provides a single score relating to the physical habitat quality and incorporates in-stream quality, buffer zone width and quality of vegetation, and surrounding landscape attributes. The range of scores is 25 to 100 (none of the attributes can score a “0”). Higher scores indicate a higher quality physical habitat, although the scores have yet to be calibrated region-wide to provide quality rating categories such as “Good” or “Poor”. In 2014, the highest quality physical habitat was at 403GCC–Gleason Canyon, with a CRAM score of 85 (Appendix B.6). The poorest quality physical habitat was at SMC04264–Medea Creek with a CRAM score of 62.

4.4 2014 Index of Biotic Integrity

In 2004, a southern California IBI was developed to cover the region extending from southern Monterey County to the Mexican border (Ode et al., 2005). The IBI gives a single quantified score to a site based on a multi-metric evaluation technique, and the scores may be compared across seasons and years of a monitoring program to give an indication of trends over time. The CDFG developed the IBI based on a multi-year, comprehensive assessment of reference and non-reference conditions in southern California to establish an expected range of benthic invertebrate community structure in the region. This IBI will be replaced in the near future with the CSCI described below (Section 8.0); it has been noted that this IBI may lack strength when assessing non-perennial, low-gradient or low-elevation sites (due to the rarity of reference streams sampled in southern California with these characteristics) and that certain natural geological conditions may not be accounted for.

Ode et al. (2005) selected seven metrics that showed a strong and predictable response to ecological impacts and stressors to calculate the IBI (Table 4). The seven metrics include number Coleoptera taxa, number EPT taxa, number predator taxa, percent collector–filterers plus collector–gatherers, percent intolerant individuals, percent non-insect taxa, and percent tolerant taxa. Each metric value was assigned a score from 0 to 10 (e.g., if there were four Coleoptera taxa in a sample, the metric score would be 7). These scores were summed to provide a final IBI score; the highest possible total score was 70. This score is often standardized to a scale ranging from 0 to 100; the raw IBI scores are presented in this report. Each final score was then classified into rating categories ranging from Very Poor to Very Good. Table 4 shows the metric scoring ranges and rating categories for the Southern California IBI.

Table 4. Index of Biotic Integrity Scoring Ranges

Metric Score	Number Coleoptera Taxa	Number EPT Taxa	Number Predator Taxa	Percent CF and CG Individuals	Percent Intolerant Individuals	Percent Non-Insect Taxa	Percent Tolerant Taxa
10	>5	>17	>12	0–59	25–100	0–8	0–4
9		16–17	12	60–63	23–24	9–12	5–8
8	5	15	11	64–67	21–22	13–17	9–12
7	4	13–14	10	68–71	19–20	18–21	13–16
6		11–12	9	72–75	16–18	22–25	17–19
5	3	9–10	8	76–80	13–15	26–29	20–22
4	2	7–8	7	81–84	10–12	30–34	23–25
3		5–6	6	85–88	7–9	35–38	26–29
2	1	4	5	89–92	4–6	39–42	30–33
1		2–3	4	93–96	1–3	43–46	34–37
0	0	0–1	0–3	97–100	0	47–100	38–100
Cumulative Ratings: Very Poor: 0–13 Poor: 14–26 Fair: 27–40 Good: 41–55 Very Good: 56–70							

Source: Ode et al., 2005

The IBI is effective for broadly identifying impairment. Sites rated Poor or Very Poor have an IBI score of 26 or lower and are considered impaired (i.e., the impairment threshold is 26, or 39 on the 0 to 100 scale). It must be noted that small differences in IBI scores are not significant and may be due to natural biological variability within a stream reach. Ode et al. (2005) determined that the minimum detectable difference between IBI scores is approximately 9 points, and may simply be due to natural biological variability within a sampling site. This implies that at least a 9-point difference between two site scores is necessary to determine if one is of significantly higher quality than the other.

The total IBI scores for each monitoring site are shown on Figure 4. The IBI metric values, individual metric scores, and total IBI scores on the 0 to 70 and 0 to 100 scales are presented in Appendix B.7.

The 16 monitoring sites in the County had IBI ratings ranging from Very Poor to Very Good with IBI scores ranging from 3 to 61. Five of the sites were rated above the level of impairment (i.e., Fair Good or Very Good) and SGUT-501–San Gabriel River was the highest-rated site. Five sites were rated Poor, and included four sites at mid elevation that had natural streambeds plus LALT501–Arroyo Seco, which was in a lined channel. The six remaining sites were rated Very Poor, half of which were concrete-lined channel sites.

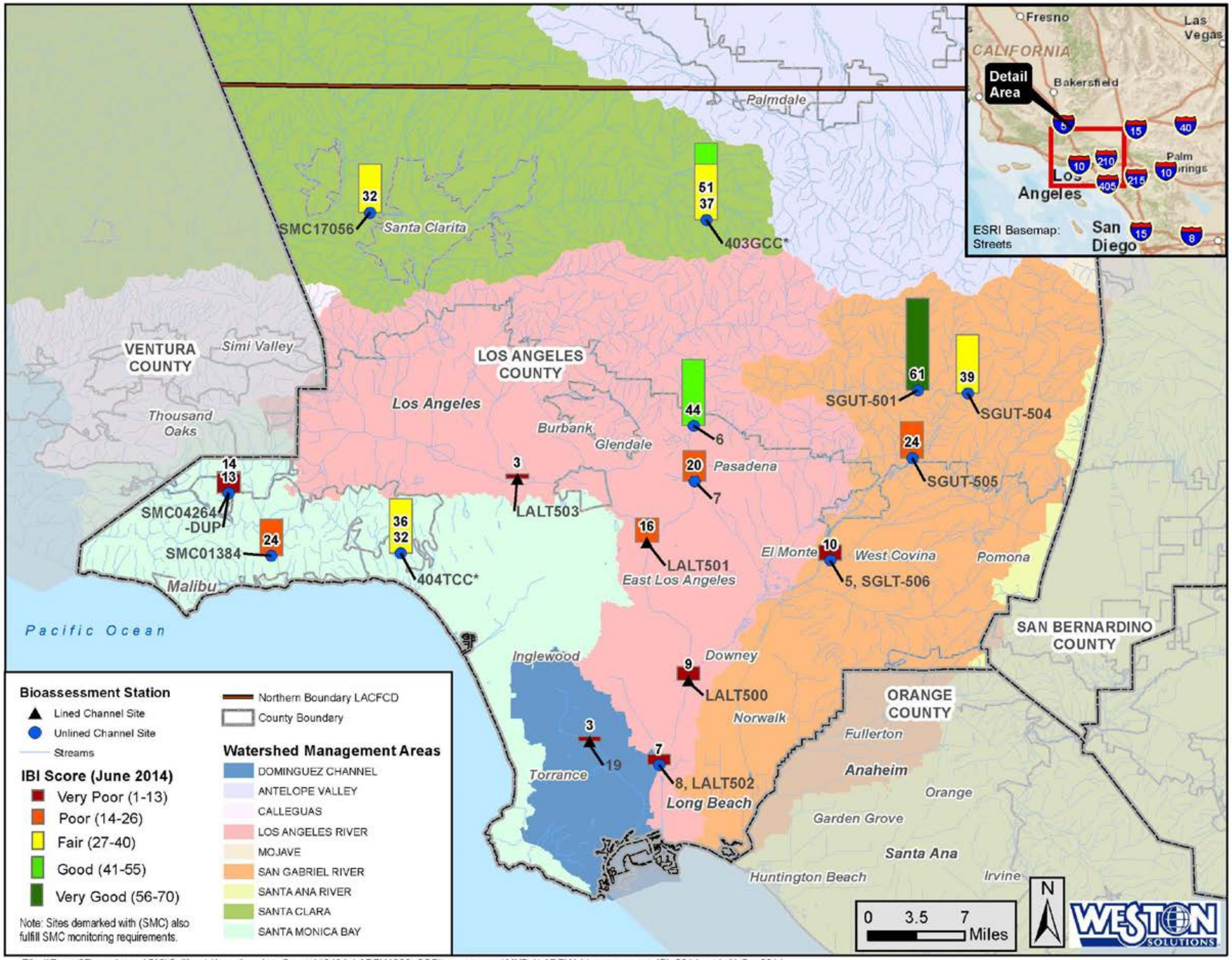


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Figure 4. Index Biotic Integrity Scores for Los Angeles County Bioassessment Sites for 2014 (0–70 scale)

Cluster Analysis

A cluster analysis was performed to test for similarities between site location and BMI community structure. The analysis was based on a two-way Bray–Curtis similarity matrix calculated on relative abundances of taxa by site. Sites with similar communities of taxa will cluster together; likewise, taxa that occur at the same sites will cluster together. The analysis only considers the taxa and sites and is independent of other factors such as channel type or organism tolerance, although this information was added to the cluster diagram to facilitate interpretation (Appendix B.8). The analysis only considered organisms that occur at more than one site and with abundances of three or more individuals.

The 2014 results are portrayed in a two-way table that shows the relative abundance of each taxon by site (Appendix B.8). Results of the cluster analysis showed six major taxa clusters and four site clusters, labeled 1 through 6 and A through D, respectively, and bounded by bold red lines. The graphic also indicates concrete-lined sites (highlighted yellow), unlined sites (highlighted blue), reference sites (with asterisked site names), and the organisms' TVs.

Site cluster D, which contained the two non-perennial reference sites, were the most different from sites A, B, and C. Site cluster D was best represented by taxa in clusters 1 and 2, and there was also a strong correlation between the two samples from 403GCC–Gleason Canyon with taxa cluster 2, and 404TCC–Temescal Canyon with taxa cluster 1.

Site cluster C contained the reference sites of the San Gabriel Mountains as well as two sites in the Santa Clara River and Malibu Creek. Taxa unique to these sites included sensitive mayflies and caddisflies of taxa cluster 5.

Site clusters A and B contained the urban and lined channel sites that had low IBI scores. The taxa of these sites included the tolerant and ubiquitous taxa of clusters 3 and 4 that were present at many of the sites. Most of these taxa are generalists that tolerate a wide range of habitat and water quality conditions.

4.5 All Watersheds' Survey Results for 2003 through 2014

Study information from 2003 through 2013 (BonTerra, 2004; WESTON, 2005; WESTON, 2006; WESTON, 2007; WESTON, 2008; WESTON, 2009; WESTON, 2010; WESTON, 2011; WESTON, 2012; WESTON, 2013; WESTON, 2014) was compared to the 2014 data to assess year-to-year variance and trends in biotic integrity of the streams. Regional macroinvertebrate community structure was relatively similar in the twelve survey years and the 10 most abundant taxa remained fairly consistent, although New Zealand mud snail showed substantial variability due to its patchy and sometimes dense distribution patterns. Additionally, in nearly all of the survey years, the targeted sites with unique, high-quality communities showed year-to-year taxonomic consistency. Historically, two sites in the county have had severe alterations of the physical habitats as a result of high stormwater flows. These include 1–Santa Clara River which was scoured by high storm flows in 2005 and 6–Arroyo Seco, which was impacted in 2009 by sand and gravel deposition resulting from wildfires that occurred above the site. In both of these cases, the subsequent one or two surveys had IBI scores that were significantly lower than surveys conducted in the years before the impacts, but both recovered by the third year of sampling.

Historically, the 2003 to 2008 surveys had taxa richness values ranging from 73 to 99 taxa. Countywide taxa richness values from 2009 to 2014 ranged from 130 to 166 taxa but these values are not comparable to the historical surveys due to increased taxonomic effort to SAFIT Level II. Consequently, the 2009 to 2013 taxa richness values were converted to taxonomic Level I effort in order to calculate the mean richness values for all years. These re-calculated values are presented below in the mean metric tables for each watershed.

5.0 2003–2014 SURVEY RESULTS BY WATERSHED

Study information from 2003 through 2014 was considered for each watershed separately. Most of the targeted monitoring sites were sampled in the same locations and at the same time of year (mid-fall) from 2003 through 2008, except for the four San Gabriel River Watershed sites, sampled in June 2008. Since 2009, the sampling index period has been June to July, with the exception of the non-perennial SMC sites, which were sampled in April and May, 2014. Seasonality may affect the type of species collected, but when developing the IBI, it did not appear to affect the results in a statistically significant way (Ode et al, 2005). Analyses for each watershed are presented in Subsections 5.1 through 5.5.

One site, 19–Dominguez Channel, was permanently moved approximately 0.5 miles upstream in 2006 because high salinity (i.e. tidal influence) was detected at the original site. In 2010, LALT501–Arroyo Seco was temporarily moved approximately 0.8 miles upstream to avoid impacts from channel maintenance activities and was moved back to the original location in subsequent years. Since the Bioassessment Program's inception in 2003, many of the original targeted monitoring sites have also been relocated to accommodate other watershed-specific monitoring programs, including the SMC Regional Bioassessment Program. Some of these sites have switched from a targeted location to a randomly (or stratified randomly) selected site. Random sites have been sampled for a single year and were then relocated the following year. Therefore, multi-year assessments may not be made for a number of sites in some watersheds, although these may be used to give an overall picture of biotic integrity watershed-wide.

5.1 San Gabriel River Watershed Survey Results for 2003–2014

The San Gabriel River Watershed has been sampled 55 times in 18 different locations from 2003 through 2014 (Figure 5). One site, 5, SGLT-506–Walnut Channel, has been sampled in all eleven surveys, but the remaining sites have been sampled a maximum of nine times. Many sites have been sampled only once. Sites with "SG" in the site code prefix were offset sites for the SGRRMP study, and two of these sites, SGLR01278 and SGLR02656, were also designated SMC sites in 2009.

The watershed lacks full hydrologic connectivity between the upper and lower watershed areas, and these two areas are very different in terms of geography and land use. The upper watershed, largely in the Angeles National Forest, is sparsely populated and has many high-gradient natural streams. The lower watershed is highly urbanized with low-gradient streams, many of which have been modified through channelization for flood control. Separating the upper and lower watershed areas are a number of retention basins and spreading grounds that retain water for groundwater recharge. The bioassessment monitoring sites have signaled this difference with higher IBI scores (Table 5) and better physical habitat rankings for the upper watershed sites (4, SGUT-501, SGUT-504, and SGUT-505).

Several relationships exist in the San Gabriel River Watershed that relates IBI scores to physical factors. Past analyses have shown that IBI scores are significantly correlated to elevation and to channel type. Consistently, IBI scores increased with elevation, with a significant difference between upper and lower watershed monitoring sites. There has also been a significant difference in IBI scores between lined channel sites and unlined sites.

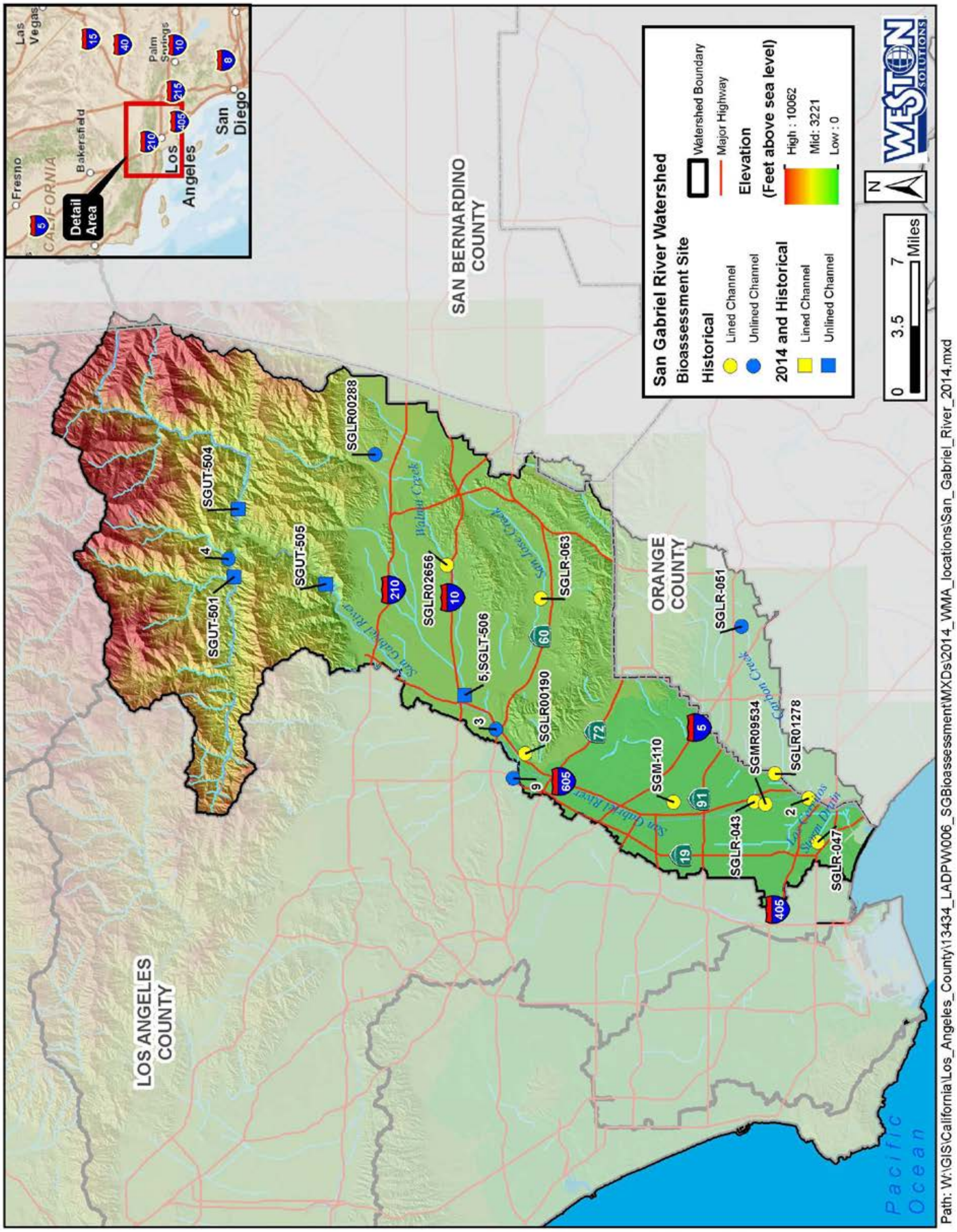

Figure 5. Bioassessment Monitoring Sites in the San Gabriel River Watershed for 2003–2014

Mean Metric Analysis for 2003–2014

Table 5 shows the mean biological metric values of four individual metrics that are considered strong indicators of ecological health. The concrete-lined channel sites are highlighted in yellow and unlined channel sites are highlighted in blue. Reference sites are signified with an asterisk following their site names. For consistency with historical surveys, the 2009 to 2014 taxa richness values were adjusted to taxonomic Level I from Level II.

Table 5. San Gabriel River Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2014

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
San Gabriel River	4*	2	24.0	12.0	3.1%	85.0%
San Gabriel River	SGUT-501*	6	42.8	19.5	37.6%	50.3%
San Gabriel River	SGUT-504*	9	27.2	12.3	9.5%	73.0%
San Gabriel River	SGUT-505	9	24.5	9.3	3.9%	69.4%
San Gabriel River	SGL00190	1	7.0	0.0	0.0%	73.5%
San Gabriel River	SGLR-043	1	13.0	0.0	0.0%	74.0%
San Gabriel River	SGLR-047	1	11.0	0.0	0.0%	90.0%
San Gabriel River	SGLR-063	1	14.0	3.0	0.0%	79.4%
San Gabriel River	SGM-110	1	4.0	1.0	0.0%	100.0%
San Gabriel River	SGLR01278	1	9.0	1.0	0.0%	97.2%
San Gabriel River	SGLR02656	1	11.0	3.0	0.0%	81.6%
San Gabriel River	SGLR00288	1	14.0	2.0	0.0%	50.6%
San Gabriel River	SGMR09534	1	10.0	1.0	0.0%	95.8%
Walnut Channel	5, SGLT-506	12	14.1	2.2	0.0%	86.2%
Zone 1 Ditch	9	1	21.0	5.0	0.0%	74.0%
Coyote Creek	2	2	11.0	2.3	0.0%	92.7%
San Jose Creek	3	2	10.5	2.0	0.0%	84.0%
Carbon Creek	SGLR-051	1	15.0	3.0	0.0%	72.0%

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
* = reference site
**2009-2014 taxa richness values adjusted from Level II to Level I taxonomy values

SGUT-501–San Gabriel River biological metric values indicated the presence of a substantially higher quality benthic community than at any other site in the watershed. Values for mean taxa richness and EPT taxa were much higher than the next highest values at SGUT-504–San Gabriel River, and the value for percent intolerant taxa was nearly four times greater. A clear difference also existed between the lower and upper watershed sites. The lower watershed sites had a maximum mean taxa richness of 21.0, whereas taxa richness in the upper watershed sites ranged from 24.0 to 42.8. The maximum mean number of EPT taxa in the lower watershed was 5.0 (and all other sites had three or less), whereas in the upper watershed, the mean number of EPT taxa ranged from 9.3 to 19.5. Intolerant taxa were absent from all lower watershed sites and comprised from 3.1% to 37.6% of the benthic community in the upper watershed. The percent collector–filterers plus collector–gatherers (i.e., collector taxa) ranged from 50.6% at SGLR-00288 to 100.0% at SGM-110. The ubiquity of these organisms means that, independently, the metric is not always an accurate indicator of impairment, and based on the IBI scoring ranges, a percentage of less than 80% collector taxa is indicative of Good biotic conditions. The reference sites in the watershed ranged from 50.3% to 85.0% collector taxa.

Comparison of Index of Biotic Integrity Scores for 2003–2014

SGUT-501–San Gabriel River was the highest ranking site by IBI scores in the watershed (Table 6) and was also at the highest elevation (Table 1). Of all the sites monitored, the three designated reference sites (i.e., SGUT-501, SGUT-504, and 4) were always rated unimpaired, whereas most other sites were rated impaired in all surveys. SGUT-505 was the only site that had IBI scores on both sides of the impairment threshold of 26 points. This site scored above the impairment threshold three times out of nine surveys, with IBI scores of 33, 29, and 28 in 2009, 2010, and 2013, respectively. It may be noted that this site is subject to variable hydrology due to releases from Morris Reservoir. None of the sites have shown any significant upward or downward trends for the sites sampled five or more times (i.e., SGUT-501, SGUT-504, SGUT-505, and 5, SGLT-506). The total scoring ranges for these sites were up to 20 points, with no consistency among sites for better or worse years (e.g., the highest IBI scores were in 2010, 2009, and 2007, respectively, for SGUT-504, SGUT-505, and 5, SGLT-506). The cause for the relatively wide range of scores for SGUT-504, SGUT 505 and 5, SGLT-506 is unclear, but is likely due to natural biological variability. In 2007, when 5, SGLT-506 had its highest IBI score, there were few Ostracoda compared to 2010; 69 versus 759 individuals, respectively. The 2007 assemblage also had a much greater taxa richness of predators (most notably, large dragonfly nymphs), which likely reduced the ostracod abundance through predation. These fluctuations in population dynamics may occur naturally and are not necessarily due to water quality issues.

Table 6. San Gabriel River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2014

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	IBI Score 2013	IBI Score 2014	Mean IBI Score	IBI Range
San Gabriel River	4*	30	38											34.0	8
San Gabriel River	SGUT-501*							62	56	60	56	54	61	58.2	8
San Gabriel River	SGUT-504*				42	34	33	34	50	30	44	37	39	38.1	20
San Gabriel River	SGUT-505				20	25	18	33	29	14	26	28	24	24.1	19
San Gabriel River	SGLR00288							15						15.0	
San Gabriel River	SGLR02656							10						10.0	
San Gabriel River	SGL00190						6							6.0	
San Gabriel River	SGLR-043			21										21.0	
San Gabriel River	SGLR-047			14										14.0	
San Gabriel River	SGLR-063				17									17.0	
San Gabriel River	SGM-110					19								19.0	
San Gabriel River	SGLR01278							1						1.0	

Table 6. San Gabriel River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2014

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	IBI Score 2013	IBI Score 2014	Mean IBI Score	IBI Range
San Gabriel River	SGMR9534							1						1.0	
San Gabriel River	SGLR-051			10										10.0	
Walnut Channel	5, SGLT-506	7	7	8	9	17	5	5	0	17	9	8	10	8.5	17
Zone 1 Ditch	9	20												20.0	
Coyote Creek	2	3	9											6.0	6
San Jose Creek	3	8	10											9.0	2

yellow highlight = concrete-lined channel site

blue highlight = unlined channel site

no highlight = not sampled

* = reference site

5.2 Los Angeles River Watershed Survey Results for 2003–2014

The Los Angeles River Watershed is similar to the San Gabriel River Watershed in that much of the upper watershed is in the Angeles National Forest, whereas the lower watershed is highly urbanized and has been modified with flood control channels, reservoirs, and spreading grounds. The Los Angeles River Watershed bioassessment monitoring sites have mainly been in the lower watershed, with the exception of 6–Arroyo Seco (Figure 6). Site 6–Arroyo Seco is located near the base of Millard Canyon just above the Arroyo Seco Spreading Grounds and received little or no urban runoff. The spreading grounds disrupt the hydrologic connectivity to such an extent that 7–Arroyo Seco, located approximately 4 miles downstream of 6–Arroyo Seco, is dominated by urban runoff. All other monitoring sites were in highly modified waterways in the lower watershed with either fully or partially concrete-lined channels. Because large areas of wilderness in the upper watershed have not been monitored as part of the Bioassessment Program, the full range of reference conditions has not been documented for this watershed.

The watershed has been sampled 70 times in nine locations from 2003 through 2014. Sites 8, LALT-502–Compton Creek and 7–Arroyo Seco have been sampled in all twelve surveys, and all other sites have been sampled at least five times. Sites with "LALT" in the site code prefix were offset sites for the LARWMP study beginning in 2008 and have been sampled in tributaries to the Los Angeles River immediately above their confluence with the Los Angeles River.

Past analyses relating IBI scores to physical factors in the watershed have shown weak relationships to elevation and channel type. The analyses, however, lacked strength because only one higher elevation site was assessed. It may be noted that the one site in the upper watershed did have a significantly higher IBI score than the lower elevation sites. There was also not a significant difference between IBI scores in lined channel sites and unlined sites in the lower watershed, which may lead to the conclusion that in heavily urbanized areas, higher quality stream bed habitat is not enough to elevate IBI scores. This condition has been described in the scientific literature as "urban stream syndrome" and documented by the failure of some habitat restoration projects to enhance biotic integrity in urban settings (e.g., Walsh et al., 2005).

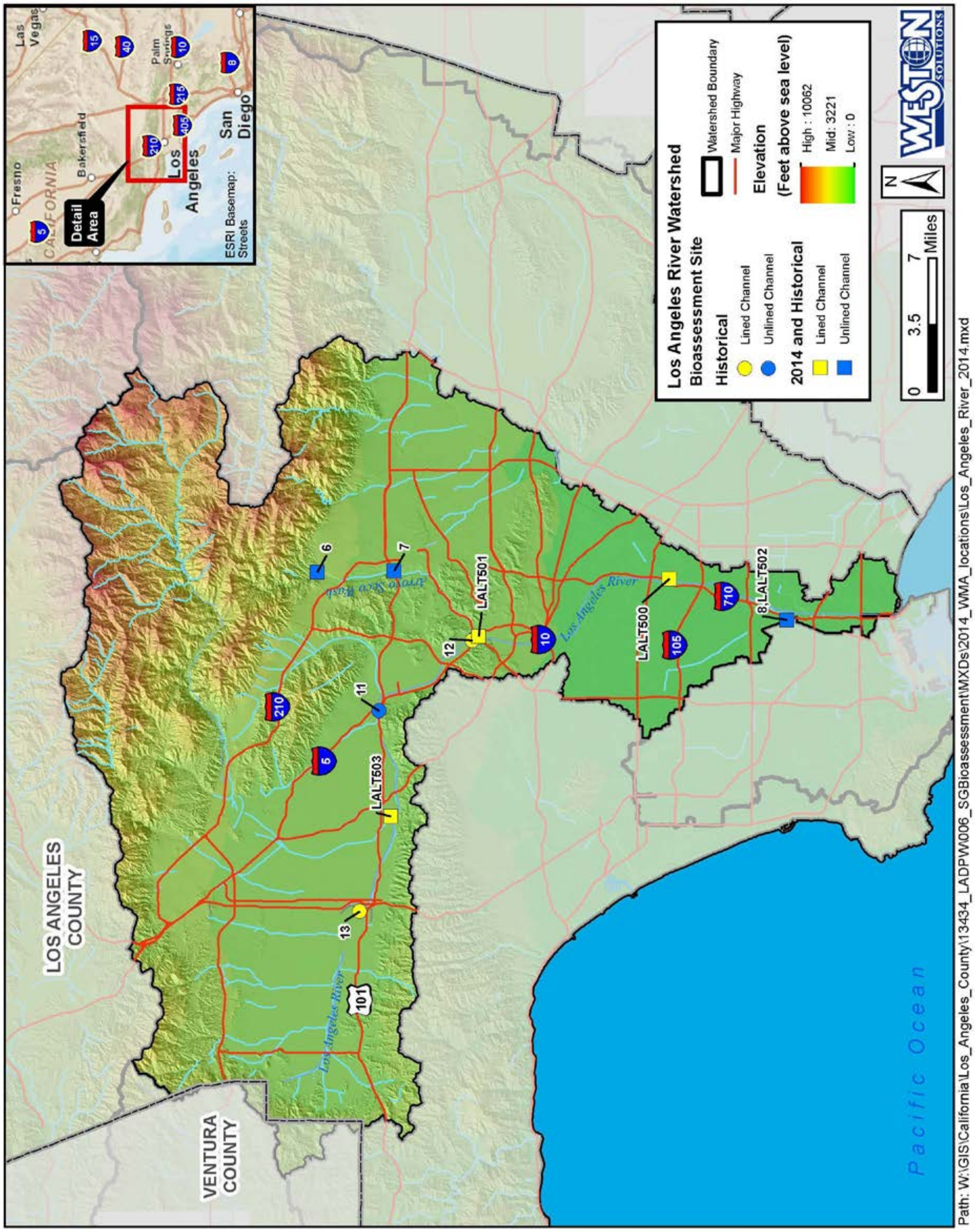

Figure 6. Bioassessment Monitoring Sites in the Los Angeles River Watershed for 2003–2014

Mean Metric Analysis for 2003–2014

Table 7 shows the mean biological metric values of four individual metrics that are considered strong indicators of ecological health. The concrete-lined channel sites are highlighted in yellow and unlined channel sites are highlighted in blue. Reference sites are identified by asterisks following their site names. The biological metric values at 6–Arroyo Seco indicated a higher quality benthic community than at any other site in the watershed. Values for taxa richness and EPT taxa were substantially higher at 6–Arroyo Seco (31.2 and 9.7, respectively), and it was the only site where intolerant (sensitive) taxa were collected. The lower watershed sites had a maximum mean taxa richness of 16.2 and a maximum mean of 2.9 EPT taxa, which were at 7–Arroyo Seco and LALT501–Arroyo Seco, respectively. The mean percent collector–filterers plus collector–gatherers ranged from 79.6% to 98.2% in the lower watershed and was 60.5% at 6–Arroyo Seco. These metrics indicate poor biotic conditions in the lower watershed and good biotic conditions at 6–Arroyo Seco.

Table 7. Los Angeles River Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2014

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Arroyo Seco	6*	10	31.2	9.7	2.6%	60.5%
Arroyo Seco	7	12	16.2	2.7	0.0%	79.6%
Los Angeles River	11	5	10.0	1.0	0.0%	98.2%
Los Angeles River	12	5	9.6	2.2	0.0%	90.3%
Los Angeles River	13	5	11.4	2.0	0.0%	94.7%
Rio Hondo	LALT500	7	11.7	1.4	0.0%	91.8%
Arroyo Seco	LALT501	7	12.7	2.9	0.0%	92.3%
Compton Creek	8, LALT502	12	12.3	1.3	0.0%	90.1%
Tujunga Wash	LALT503	7	11.5	1.5	0.0%	92.8%

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
*= reference site
**2009-2014 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Index Scores for 2003–2014

Site 6–Arroyo Seco has been the highest rated site in every survey since the beginning of the Bioassessment Program, with a mean IBI score of 39.1 and a quality rating of Fair (Table 8). This site also had the greatest range of IBI scores (27 points) with an IBI score of 23 in 2010 that was significantly lower than for any other survey. This was likely due to impacts of the Station Fire and subsequent erosion in the upper watershed that deposited substantial alluvial material in the sampling reach (see photographs below). In 2011, the IBI score was marginally above the impairment threshold, but by 2012 the site had recovered and the IBI score was greater than the eight year mean. All other sites had IBI scores ranging from Poor to Very Poor. Site 7–Arroyo Seco was the second highest rated site with a mean IBI score of 14.6 and a quality rating of Poor, although its 2010 and 2011 IBI scores increased 4 and 5 points, respectively, from any previous sample year. In 2014, three of the four LALT sites had IBI scores that were higher than the long-term mean IBI scores.

6–Arroyo Seco

Pre-fire, October 2008

Post-fire, July 2010

Post-fire, June 2012

Post-fire, June 2013

Site 6, 2010 Overview

Site 6, 2014 Overview

Table 8. Los Angeles River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2014

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	IBI Score 2013	IBI Score 2014	Mean IBI Score	IBI Range
Arroyo Seco	6*			38	50	40	42	50	23	27	40	37	44	39.1	27
Arroyo Seco	7	11	9	12	17	11	18	16	22	23	10	6	20	14.6	17
Los Angeles River	11	1	3	7	0	0								2.2	7
Los Angeles River	12	11	9	9	7	17								10.6	10
Los Angeles River	13	2	7	6	1	4								4.0	6
Rio Hondo	LALT500						3	9	13	8	2	0	9	6.3	13
Arroyo Seco	LALT501						2	6	19	14	20	7	16	12.0	18
Compton Creek	8, LALT502	1	3	4	6	6	3	6	6	12	6	4	7	5.3	11
Tujunga Wash	LALT503						3	5	18	12	6	5	3	7.4	15

yellow highlight = concrete- lined channel site

blue highlight = unlined channel site

no highlight = not sampled

* = reference site

5.3 Dominguez Channel Watershed Survey Results for 2003–2014

The Dominguez Channel Watershed is located in the central portion of the Los Angeles Basin and is almost completely urbanized. The watershed boundary is defined not so much by topography but by a system of storm drains and flood control channels. The largest waterway is the Dominguez Channel, which discharges into the Los Angeles Harbor. The bioassessment monitoring site, 19–Dominguez Channel, has been sampled every year since 2003 (Figure 7). Although the site was relocated approximately 0.5 miles upstream in 2006, the elevation change was approximately five feet and all other physical conditions were similar; therefore, the long-term analyses consider both locations as a single site. The site is within a fully concrete-lined channel and is upstream of any tidal influence. Because only one site was monitored in this watershed, the comparative analyses with unlined sites and elevation performed for the other watersheds were not possible.

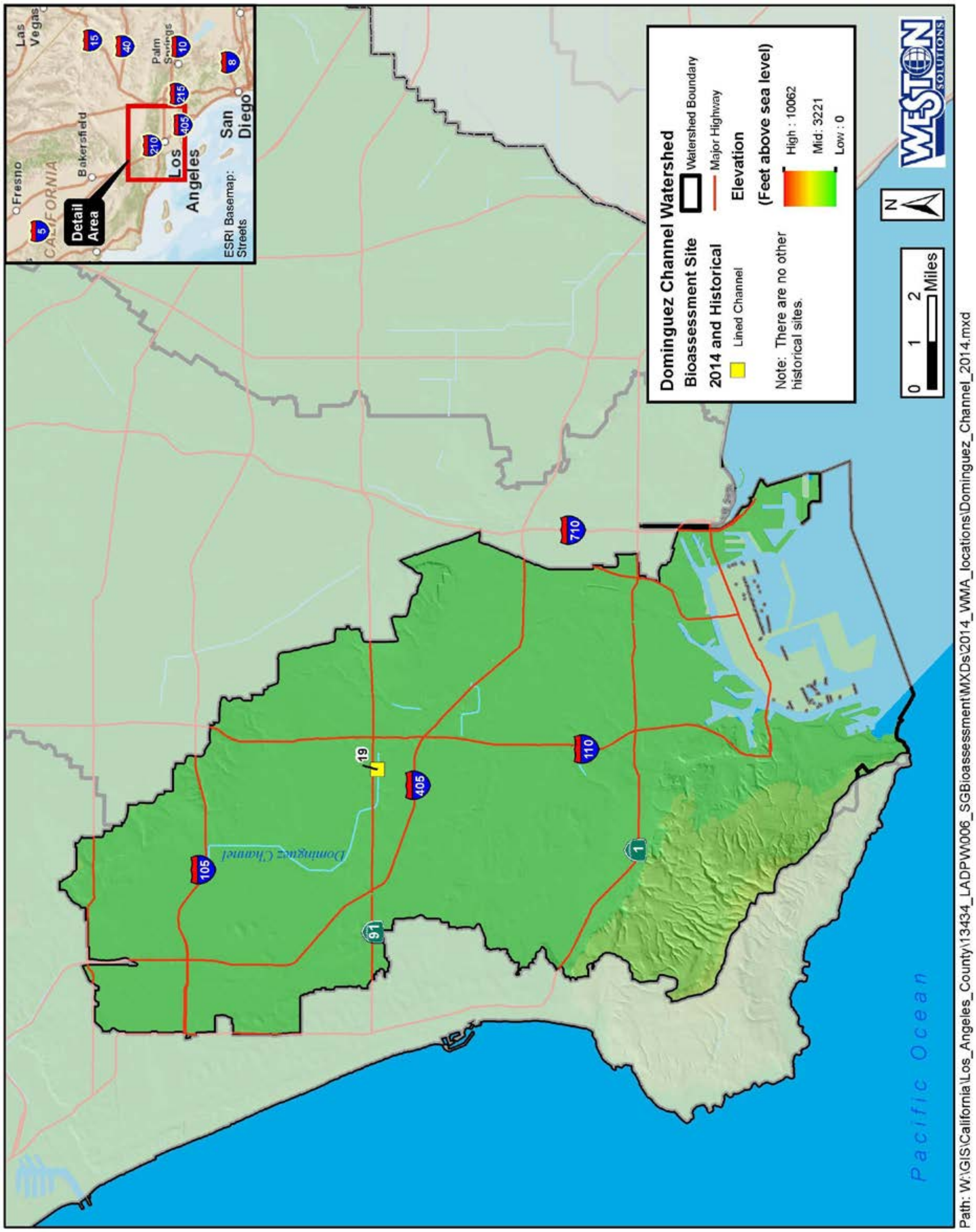

Figure 7. Bioassessment Monitoring Site in the Dominguez Channel Watershed for 2003–2014

Mean Metric Analysis for 2003–2014

Table 9 shows the mean biological metric values for 19–Dominguez Channel, which was sampled in a concrete-lined channel. All of the metrics indicated a low-quality benthic community at the site (i.e., taxa richness and EPT taxa were low, intolerant taxa were absent, and the percent collector taxa was high).

Table 9. Dominguez Channel Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2014

Monitoring Reach	Station Number	Number Samples	Taxa Richness*	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Dominguez Channel	19	12	8.5	0.2	0.0%	95.8%

yellow highlight = concrete-lined channel site

*2009-2014 taxa richness values adjusted from Level II to Level I taxonomy values

The IBI scores for 19–Dominguez Channel have been consistently in the Very Poor range, with a mean IBI score of 1.8 (Table 10). The scores were consistently 0 or 1 for the survey years of 2005 to 2009. The 2010 IBI score of 7 was the highest to date, but was still statistically similar to all previous surveys, and the 2014 IBI score was in the middle of the range of historical scores.

Table 10. Dominguez Channel Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2014

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	IBI Score 2013	IBI Score 2014	Mean IBI Score	Range
Dominguez Channel	19	3	6	0	1	0	1	1	7	0	0	0	3	1.8	7

yellow highlight = concrete-lined channel site

5.4 Santa Monica Bay Watershed Survey Results for 2003–2014

The Santa Monica Bay Watershed shown in Figure 8 encompasses the Ballona Creek Watershed, the Malibu Creek Watershed, and several other small coastal drainages (e.g., Topanga Canyon, Trancas Canyon, and Arroyo Sequit). The Malibu Watershed and the adjacent watersheds contain large undisturbed areas of park land and natural preserves in the Santa Monica Mountains. In contrast to the other Los Angeles County watersheds, the majority of the urban runoff and related impacts occur in the upper reaches of the watersheds from urban centers along the Highway 101 corridor, most of which drain to Malibu Creek. The Ballona Creek Watershed is in a highly urbanized portion of the County.

The watershed has been sampled 56 times in 25 different locations from 2003 through 2014. Historically, four targeted monitoring sites were located in the upper Malibu Creek Watershed area, including one reference site, 17–Cold Creek. All of these were in unlined channels. A historical Ballona Creek monitoring site, 14–Ballona Creek, was within a fully concrete-lined channel. In 2009, all five historical sites were replaced with randomly placed SMC sites. These were then replaced by four new randomly placed SMC sites in 2010 and 2011, and then the effort was reduced to three sites in 2012 and 2013 at the request of the SMC. Two targeted sites in Las Virgenes Creek were sampled in 2013, including historical site 16 and a new site, LV-LHR, which was upstream of the Lost Hills Road crossing. Also of note is that in 2013, the site SMC19466–Medea Creek was in a virtually identical location as the historical site 15–Medea Creek. In 2014, a new site in Temescal Canyon (404TCC) was sampled once during April and once during May of 2014 as part of the SMC Program's Non-perennial Stream Study. Measurable flow was recorded at the site during each survey, although significantly less flow was observed during the May survey. The automated level logger was removed from the site at the end of July 2014. In July, the flow had functionally ceased, although a number of isolated pools were observed.

The invasive New Zealand mud snail (*Potamopyrgus antipodarum*) has been collected from several streams in the watershed. These include Malibu Creek, Trancas Canyon Creek, Cold Creek, and Las Virgenes Creek. In 2014, the mud snail was collected in the SMC Program's trend site SMC04264–Medea Creek, which was previously sampled in 2010 when no mud snails were collected at the site.

Past analyses relating IBI scores to physical factors in the watershed have shown relationships that were somewhat different to what was seen in the Los Angeles and San Gabriel River Watersheds. Comparing lined channel sites with unlined sites showed a clear and significant difference between the two. This was likely due to a greater number of sites sampled for the SMC program that were in relatively pristine watersheds versus the targeted urban sites in other areas of the County. The relationship between elevation and IBI scores was also affected by the low elevation sites in undeveloped sub-watersheds of the Malibu Coast, which often had much higher IBI scores than the higher elevation sites along Highway 101 in the Malibu Watershed.

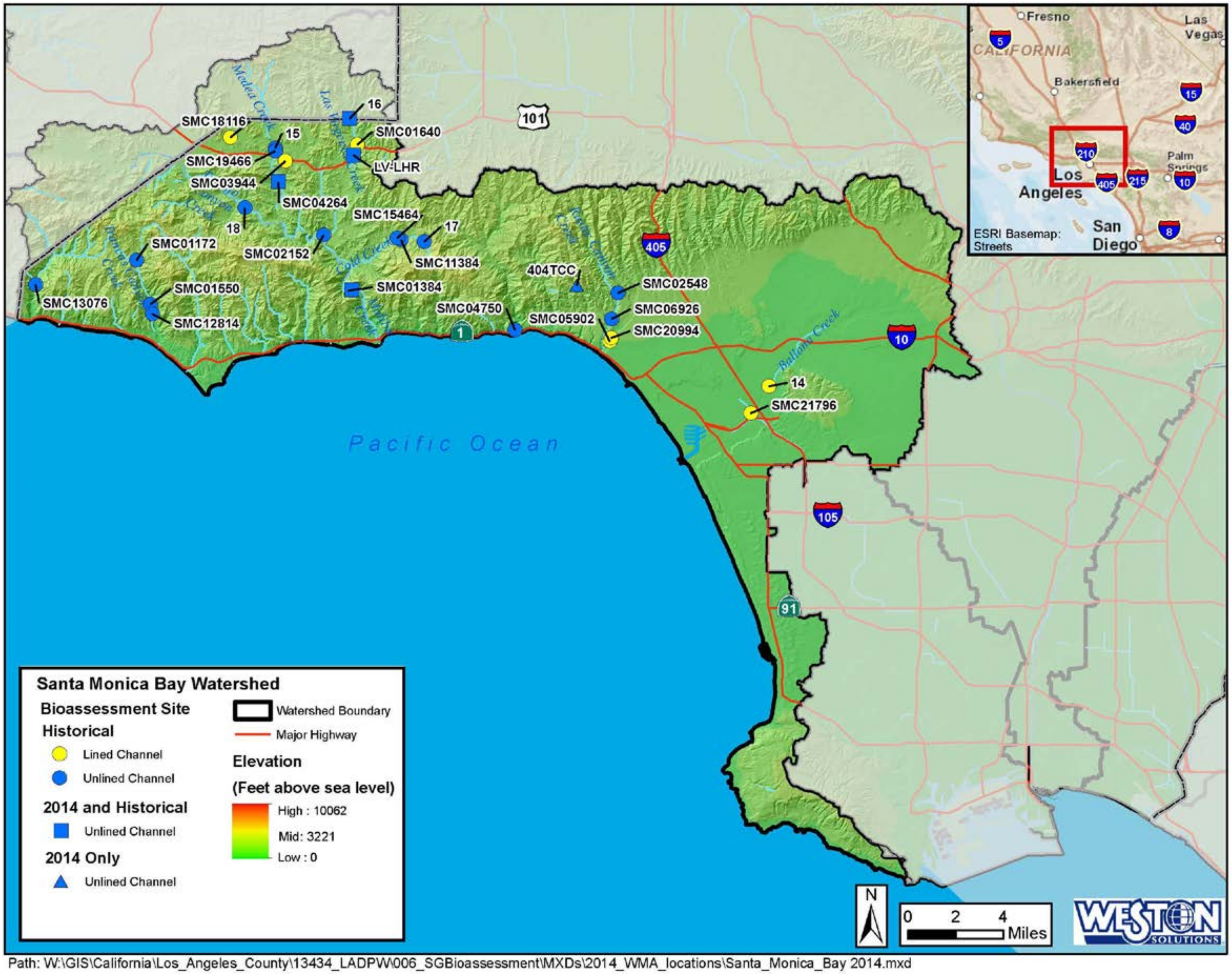

Figure 8. Bioassessment Monitoring Sites in the Santa Monica Bay Watershed for 2003–2014

CRAM Results for 2009-2014

CRAM has been conducted at 20 different SMC sites in the Santa Monica Bay Watershed since 2009 (Table 11). Sites located in fully lined channels had substantially lower CRAM scores than those in natural channels, with a maximum score of 34 points. SMC06926–Rustic Canyon Creek also had a relatively low CRAM score (42 points) and was located in a man-made channel with a natural substrate. The remaining sites had CRAM scores ranging from 62 to 91. All three of the sites monitored in 2014 were in natural channels and had CRAM scores ranging from 62 to 79.

Table 11. Santa Monica Bay Watershed, Comparison of CRAM Scores 2009-2014

Monitoring Reach	Station Number	CRAM Score 2009	CRAM Score 2010	CRAM Score 2011	CRAM Score 2012	CRAM Score 2013	CRAM Score 2014
Ballona Creek	SMC21796					29	
Santa Monica Channel	SMC05902			34			
Santa Monica Channel	SMC20994					28	
Rustic Canyon Creek	SMC02548		79				
Rustic Canyon Creek	SMC06926	42					
Temescal Canyon	404TCC						79
Topanga Canyon Creek	SMC04750			67			
Trancas Canyon Creek	SMC01172	79					
Trancas Canyon Creek	SMC01550	85					
Trancas Canyon Creek	SMC12814			91			
Las Virgenes	SMC01640	27					
Cold Creek	SMC11384			91			
Cold Creek	SMC15464				78		
Malibu Creek	SMC01384	83					74
Malibu Creek	SMC02152		78				
Cheseboro Channel	SMC03944		30				
Medea Creek	SMC04264		68				62
Medea Creek	SMC19466					58	
Arroyo Sequit	SMC13076				81		
Lindero Canyon	SMC18116				28		

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
no highlight = not sampled

Mean Metric Analysis for 2003–2014

Table 12 shows the mean biological metric values of four individual metrics that are considered strong indicators of ecological health. The concrete-lined channel sites are highlighted in yellow, and unlined channel sites are highlighted in blue. Reference sites are signified by an asterisk following their site names. Mean metric values for sites in Rustic Canyon (SMC02548), Trancas Canyon (SMC01172 and SMC12814), Cold Creek (17, SMC11384, and SMC15464), Arroyo Sequit (SMC13076), and Temescal Canyon (404TCC) indicated higher quality benthic communities than at other sites in this watershed. These seven sites had relatively high percentages of intolerant (sensitive) taxa and moderately high diversity of EPT taxa. Streams that were of substantially poorer quality included Ballona Creek (14 and SMC21796), Medea Creek (15, SMC04264 and SMC19466), Las Virgenes Creek (16 and SMC01640), Santa Monica

Channel (SMC05902 and SMC20994), SMC03944–Cheseboro Channel, SMC05902–Santa Monica Channel, and SMC18116–Lindero Canyon. These sites had mean taxa richness of 15 or less, two EPT taxa or less, no intolerant taxa, and 56% or more collector taxa. All other sites had moderate taxa richness, low to moderate EPT taxa, and intolerant taxa were present in most sites in low abundance.

Table 12. Santa Monica Bay Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2014

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Ballona Creek	14	6	10.5	1.8	0.0%	94.8%
Santa Monica Channel	SMC05902	1	6.0	2.0	0.0%	76.6%
Santa Monica Channel	SMC20994	1	9.0	2.0	0.0%	81.0%
Ballona Creek	SMC21796	1	11.0	2.0	0.0%	97.6%
Rustic Canyon Creek	SMC06926	1	21.0	5.0	1.0%	40.2%
Rustic Canyon Creek	SMC02548	1	22.0	11.0	70.0%	16.6%
Temescal Canyon	404TCC	2	22.5	4.0	0.4%	52.9%
Topanga Canyon Creek	SMC04750	1	24.0	8.0	1.2%	74.0%
Trancas Canyon Creek	SMC01172	2	24.5	4.0	3.5%	64.7%
Trancas Canyon Creek	SMC01550	1	21.0	4.0	13.8%	68.0%
Trancas Canyon Creek	SMC12814	1	26.0	9.0	7.0%	22.4%
Las Virgenes Creek	16	5	15.4	0.0	0.0%	90.6%
Las Virgenes Creek	LV-LHR	1	18.0	3.0	0.0%	27.6%
Las Virgenes Creek	SMC01640	1	4.0	0.0	0.0%	96.0%
Cold Creek	17*	7	31.7	11.3	36.9%	23.0%
Cold Creek	SMC11384	1	43.0	13.0	23.2%	32.0%
Cold Creek	SMC15464	1	44.0	13.0	4.2%	37.0%
Triunfo Creek	18	6	26.3	3.0	0.3%	63.0%
Malibu Creek	SMC01384	2	23.5	7.0	2.8%	41.7%
Malibu Creek	SMC02152	1	20.0	3.0	0.0%	24.2%
Arroyo Sequit	SMC13076	1	44.0	14.0	13.6%	60.0%
Cheseboro Canyon Channel	SMC03944	1	6.0	1.0	0.0%	95.8%
Lindero Canyon	SMC18116	1	13.0	2.0	0.0%	73.0%
Medea Creek	15	6	11.7	1.0	0.0%	82.4%
Medea Creek	SMC04264	3	12.6	2.3	0.0%	56.3%
Medea Creek	SMC19466	1	15.0	0.0	0.0%	90.8%

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
* = reference site
**2009-2014 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Integrity Scores for 2003–2014

With the exception of 17–Cold Creek, the IBI scores in the Santa Monica Bay Watershed have indicated impaired biotic conditions in the middle to upper watershed areas in surveys conducted from 2003 to 2008 (Table 13). Site 17–Cold Creek was consistently the highest-rated site in the Bioassessment Program for those years and two SMC sites further downstream in Cold Creek (SMC11384 and SMC15464) also had relatively high IBI scores in 2011 and 2012, respectively. Since 2009, the results from SMC sites sampled in the Santa Monica Bay Watershed have revealed a number of low elevation streams with unimpaired biotic conditions, including Rustic

Canyon Creek, Topanga Canyon Creek, Trancas Canyon Creek, Arroyo Sequit, and Temescal Canyon. Topanga Canyon Creek was notable in that it was located at an elevation of 12 feet, approximately 300 meters from the discharge point into the Pacific Ocean.

In 2014, Temescal Canyon (404TCC) was sampled two times as part of the SMC Non-perennial Stream Study. The IBI scores were similar for each event (36 in April and 32 in May) (Table 13). The study reach for the Temescal Canyon site is a narrow canyon of steep gradient with abundant step pools composed of bedrock. It is likely that the large volume of water retained in the pools serve as refugia for BMIs as the riffle portions of the stream begin to dry. In late July when the level loggers were retrieved flow between the pools had largely ceased, although a moderate volume of water was present in the pools.

The case of the two Rustic Canyon sites is a good example of the impacts of urban runoff on BMI communities. Two sites were sampled, one in 2009 and one in 2010. The sites were approximately one mile apart with a 200-foot elevation difference, yet the quality of the BMI communities was significantly higher at the upstream site, with an IBI score of 51 compared to 26 at the downstream site (Weston, 2012). This was likely due to the fact that the higher quality site, SMC02548, was above the influence of urban runoff while the lower site, SMC06926, was within the urban landscape.

Table 13. Santa Monica Bay Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2014

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	IBI Score 2013	IBI Score 2014	Mean IBI Score	Range
Ballona Creek	14	6	10	7	5	10	4							7.0	6
Ballona Creek	SMC21796											1		1.0	
Santa Monica Channel	SMC05902									13				13.0	
Santa Monica Channel	SMC20994											10		10.0	
Rustic Canyon Creek	SMC02548								51					51.0	
Rustic Canyon Creek	SMC06926							26						26.0	
Topanga Canyon Creek	SCM04750									28				28.0	
Trancas Canyon Creek	SMC01172/ SMC01172 DUP							31/ 29						30.0	2
Trancas Canyon Creek	SMC01550							26						26.0	
Trancas Canyon Creek	SMC12814									34				34.0	
Las Virgenes	16			27	17	20	16					21		20.2	11
Las Virgenes	LV-LHR											18		18.0	
Las Virgenes	SMC01640							7						7.0	
Cold Creek	17*	42	52	49	53	52	55				54			51.0	13
Cold Creek	SMC11384									54				54.0	
Cold Creek	SMC15464										43			43.0	
Triunfo Creek	18	22		20	18	19	15				18			18.7	7

Table 13. Santa Monica Bay Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2014

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	IBI Score 2013	IBI Score 2014	Mean IBI Score	Range
Malibu Creek	SMC01384							29					24	26.5	5
Malibu Creek	SMC02152								17					17.0	
Cheseboro Channel	SMC03944								7					7.0	
Medea Creek	15	3	5	7	4	2	7							4.7	
Medea Creek	SMC04264								14				14/ 13	13.7	1
Medea Creek	SMC19466											3		3.0	
Arroyo Sequit	SMC13076										44			44.0	
Lindero Canyon	SMC18116										13			13.0	
Temescal Canyon	404TCC												36/ 32	34.0	4

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
no highlight = not sampled
* = reference site

5.5 Santa Clara River Watershed Survey Results for 2003–2014

The upper portion of the Santa Clara River Watershed is in the County, with headwaters on the north slope of the San Gabriel Mountains (Figure 9). The lower watershed and outlet to the Pacific Ocean are in Ventura County. The mainstem of the Santa Clara River is unchannelized for its entire length, and a majority of the upper tributaries are non-perennial. Most of the urbanization in the upper watershed is associated with the City of Santa Clarita.

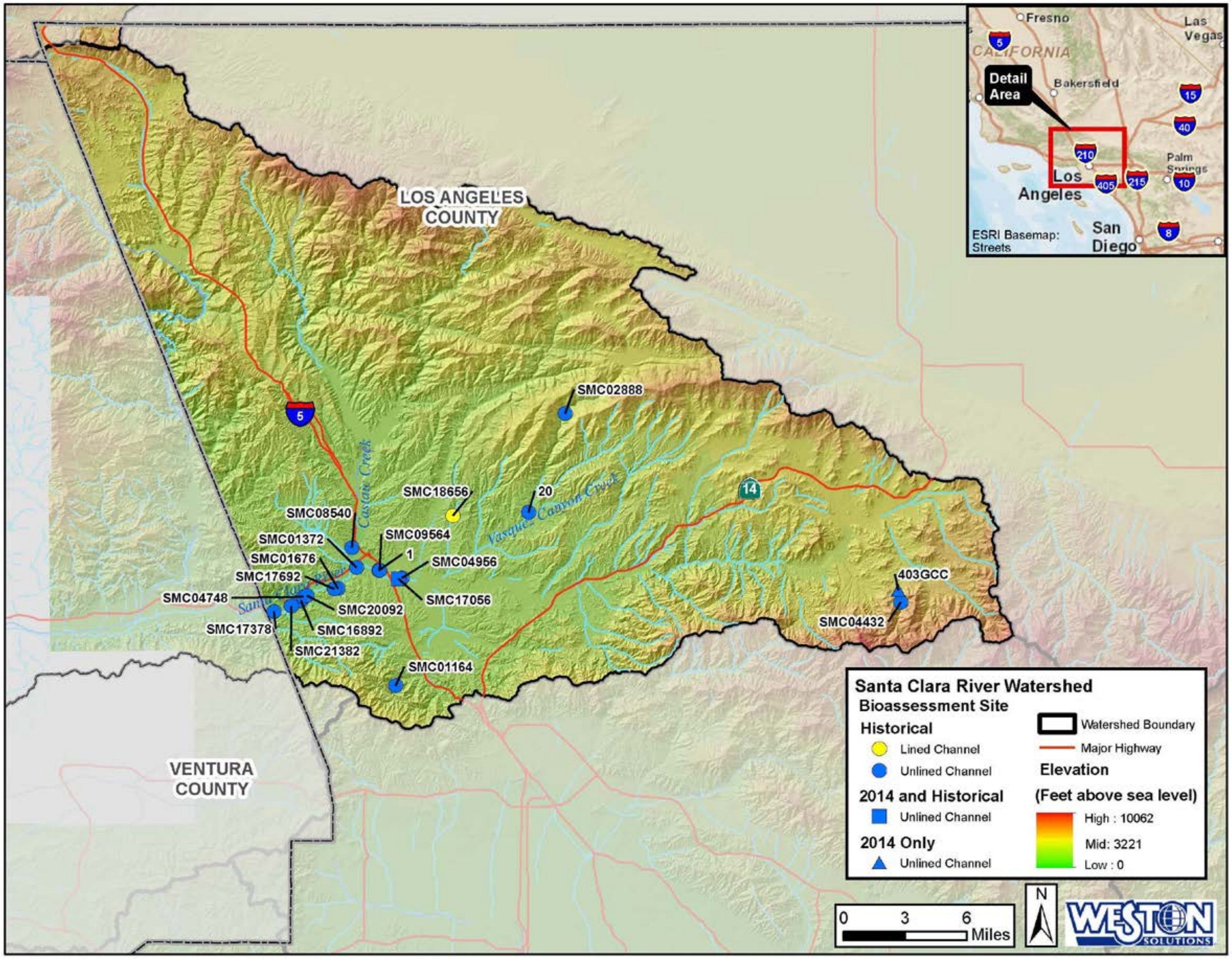

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Figure 9. Bioassessment Monitoring Sites in the Santa Clara River Watershed for 2003–2014

The watershed has been sampled 29 times at 18 different sites, including duplicate BMI sampling at five SMC sites. Historically, one targeted site in the Santa Clara River mainstem, 1–Santa Clara River, was monitored every year from 2003 to 2008. An additional targeted site, 20–Bouquet Canyon, never had flowing water during the sampling period from 2003 through 2008. In 2009, these two targeted historical sites were replaced with two randomly placed SMC sites. In 2010 and 2011, there were three randomly placed SMC sites, and in 2012 and 2013 there were four SMC sites in the watershed. In 2014, two sites were sampled and one (SMC17056–Santa Clara River) contributed to the SMC Program's Trend Site Study, and the other (403GCC–Gleason Canyon) contributed to the Non-perennial Stream Study.

As part of the SMC Non-perennial Stream Study, Gleason Canyon (403GCC) was sampled once during April and once during May of 2014. Measurable flow was recorded at the site during the first survey. In the second survey flow had decreased to an unmeasurable trickle, although sufficient water remained in the creek to conduct sampling per SMC Workplan guidelines. The automated level logger was removed from the site during the second sampling event as flow had ceased at the logger.

Through 2010, all of the sites were in unlined channels of the Santa Clara River mainstem, which have been perennialized by urban runoff. Since 2010, there have been sites located in Castaic Creek (SMC8540), Towsley Creek (SMC01164), Bouquet Canyon (SMC02888), Gleason Canyon (SMC04432) and Seco Canyon Creek (SMC18656).

CRAM Results

CRAM has been conducted at 17 different SMC sites in the Santa Clara River Watershed since 2009 (Table 14). The one concrete-lined site that was assessed had a CRAM score of 27 points, while the natural sites had CRAM scores ranging from 64 to 85 points.

Table 14. Santa Clara River Watershed, Comparison of CRAM Scores 2009-2014

Monitoring Reach	Station Number	CRAM Score 2009	CRAM Score 2010	CRAM Score 2011	CRAM Score 2012	CRAM Score 2013	CRAM Score 2014
Santa Clara River	SMC04748	79					
Santa Clara River	SMC17056	69					77
Santa Clara River	SMC01676		69				
Santa Clara River	SMC01372		67				
Santa Clara River	SMC09564		65				
Santa Clara River	SMC04956			73			
Santa Clara River	SMC16892				76		
Santa Clara River	SMC17378				75		
Santa Clara River	SMC17692					77	
Santa Clara River	SMC20092					80	
Santa Clara River	SMC21382					75	
Towsley Creek	SMC01164			81			
Castaic Creek	SMC08540			64			
Bouquet Canyon	SMC02888				68		
Gleason Canyon	SMC04432				82		
Gleason Canyon	403GCC						85
Seco Canyon Creek	SMC18656					27	

yellow highlight = concrete-lined channel site

blue highlight = unlined channel site

no highlight = not sampled

Mean Metric Analysis for 2003–2014

Table 15 shows the mean values of four individual metrics that are considered strong indicators of ecological health. Twelve of the 18 sites monitored were in the Santa Clara River mainstem. These sites were all located within eight miles of one another and had relatively similar habitat conditions with a willow-lined streambed dominated by sand. The majority of the results from these sites show similar biotic integrity, with moderate taxa richness, 4-6 EPT taxa, and no intolerant organisms. Of the five sites sampled outside of the Santa Clara River, four were of higher quality and two (SMC08540–Castaic Creek and SMC18656–Seco Canyon Creek) were of lower quality. Sites in Towsley Creek, Bouquet Canyon and Gleason Canyon likely qualified as reference sites with little or no direct urban runoff. These three sites had greater taxa richness, had intolerant organisms that ranged from 0.2% to 19.0% of the community, and had substantially higher EPT taxa richness than in other areas of the watershed.

Table 15. Santa Clara River Watershed Selected Metric Values, Annual Surveys for 2003–2014

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Santa Clara River	1	6	20.0	4.0	0.0%	69.4%
Santa Clara River	SMC04748	1	19.0	4.0	0.0%	81.4%
Santa Clara River	SMC17056	2	23.0	4.0	0.0%	69.3%
Santa Clara River	SMC01676	1	25.0	6.0	0.0%	73.6%
Santa Clara River	SMC01372/ SMC01372 Dup	2	21.0	5.0	0.0%	85.8%
Santa Clara River	SMC09564	1	14.0	5.0	0.0%	90.6%
Santa Clara River	SMC04956	1	23.0	4.0	0.0%	92.6%
Santa Clara River	SMC16892	1	24.0	4.0	0.0%	69.6%
Santa Clara River	SMC17378	1	27.0	6.0	0.0%	76.4%
Santa Clara River	SMC17692/SCM17692 Dup	1	24.0	5.5	0.0%	73.5%
Santa Clara River	SMC20092	1	24.0	6.0	0.0%	59.8%
Santa Clara River	SMC21382	1	24.0	5.0	0.0%	61.8%
Seco Canyon Creek	SMC18656	1	2.0	0.0	0.0%	100.0%
Towsley Creek	SMC01164/ SMC01164 Dup	2	32.5	5.0	0.2%	74.4%
Castaic Creek	SMC08540	1	18.0	3.0	0.0%	85.0%
Bouquet Canyon	SMC02888/ SMC02888 Dup	2	28.0	10.5	19.0%	62.5%
Gleason Canyon	403GCC	2	24.0	8.0	1.7%	70.2%
Gleason Canyon	SMC04432	1	33.0	14.0	8.2%	75.0%

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site

**2009-2014 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Integrity Scores for 2003–2014

The 12 sites in the Santa Clara River mainstem had IBI scores in the Poor to Fair range (Table 16). Site 1–Santa Clara River is the only site with multi-year data, and has shown significant variability, with a total range of 17 points that varied across three of the IBI rating categories. This was likely due to the heavy rains of 2005 that substantially eroded the streambed and flushed out most of the emergent vegetation, resulting in a low IBI score for that year. Since 2010, five sites in the Santa Clara River mainstem (SMC01372, SMC01676, SMC04956, SMC17378, SMC20092, and SMC17056) have scored above the impairment threshold, and the 2014 site had the highest IBI score (32) of any Santa Clara River site to date. Generally, the further downstream a site was from Santa Clarita, the higher the IBI score. Four additional sites were rated unimpaired, including SMC1164–Towsley Creek, SMC02888–Bouquet Canyon, SMC04432–Gleason Canyon, and 403GCC–Gleason Canyon.

The 2014 Non-perennial Stream Study site in Gleason Canyon had the highest IBI score in the watershed. Gleason Canyon was sampled two times as part of the study. The IBI scores were significantly higher in the April sampling event (IBI = 51, rating = Good) than the May event (IBI = 37, rating = Fair) (Table 16). The study reach for the Gleason Canyon site is an alluvial canyon of moderate gradient composed of cobble/boulder and coarse granitic sand. Due to stream gradient and streambed substrate composition, the study reach lacks deep pools. As the streambed dries out over time both the quality and quantity of habitat suited to full BMI colonization potential is reduced. It is likely that the lower IBI score in the second sampling event was a natural function of the reduced available habitat as the riffle portions of the stream began to dry.

Table 16. Santa Clara River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2014

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	IBI Score 2013	IBI Score 2014	Mean IBI Score	Range
Santa Clara River	1	21	19	10	24	27	24							20.8	17
Santa Clara River	SMC04748							22						22.0	
Santa Clara River	SMC17056							25					32	28.5	7
Santa Clara River	SMC01676								28					28.0	
Santa Clara River	SMC01372/ SMC01372 Dup								31/ 23					27.0	8
Santa Clara River	SMC09564								17					17.0	
Santa Clara River	SMC04956									27				27.0	
Santa Clara River	SMC16892										21			21.0	
Santa Clara River	SMC17378										31			31.0	
Santa Clara River	SMC17692/ SMC17692 Dup											18/ 21		19.5	3
Santa Clara River	SMC20092											27		27.0	
Santa Clara River	SMC21382											23		23.0	
Towsley Creek	SMC01164/ SMC01164 Dup									34/ 23				28.5	11
Castaic Creek	SMC08540									9				9.0	
Bouquet Canyon	SMC02888/ SMC02888 Dup										47/ 41			44.0	6
Gleason Canyon	SMC04432										45			45.0	
Seco Canyon Creek	SMC18656											0		0.0	0
Gleason Canyon	403GCC												51/ 37	44.0	14

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
no highlight = not sampled

6.0 ADDITIONAL ANALYSES AND FINDINGS

6.1 Past Analyses

Comparison of Concrete-Lined Channels and Unlined Channels – 2003-2012

From 2003-2012, 63 sites had been monitored in the Bioassessment Program and 20 of these sites were in concrete-lined channels. An analysis was performed to determine if there was a relationship between channel type and IBI scores (due to the conclusiveness of past results, this analysis was not updated to include 2013 data).

The Wilcoxon Ranked Sum test was run with no exclusions based on location (i.e., upper or lower) in the watershed. The associated p-value was less than 0.001, indicating that the mean IBI scores of the concrete-lined sites were statistically lower than the unlined sites (p-value less than 0.05 is significant).

Long Term Habitat Trends– 2003-2012

For the thirteen targeted sites assessed in 2012, an analysis of the long term habitat conditions at the sites was performed. With one exception, none of the sites have had intentional physical alteration of the streambed or banks (e.g., habitat restoration or removal). For the four sites located in concrete-lined channels, virtually no changes have occurred to the physical habitat since the initiation of sampling, and while LALT501–Arroyo Seco had some channel re-construction in 2011 that established a low flow channel mid-stream, the site is still fully lined. Some sites however, have had streambed alteration due to natural processes related to large storm events and hydromodified flows. The two notable occurrences have been Site 6–Arroyo Seco in 2009/2010 and Site 1–Santa Clara River in 2005, both of which are discussed in this report in sections 5.2 and 5.5, respectively. For these two sites, the alteration of the streambed and resultant decrease in IBI scores were significant but temporary, and recovery occurred within about two years.

The one site that field personnel have noticed substantial year to year variability has been SGLT-506–Walnut Channel. This site has a soft bottom streambed approximately 100-m wide within concrete/rip-rap lined banks. It is located just downstream of a nearly 10 mile reach of fully lined streambed and therefore receives hydromodified stormwater flows. The streambed of the monitoring site is a mix of unconsolidated, easily eroded sediment, course gravel and cobble which has been frequently altered by wet season flows. For the last four years that the SWAMP protocol has been performed at this site, there has been considerable variability in IBI scores (0 to 17), percent riffle habitat (3% to 36%), and percent cobble (9% to 41%). None of the other physical habitat attributes varied substantially over time. Figure 10 charts the relative values for these attributes and shows that the surveys with the lowest percent cobble and riffle habitat (presumably the worst physical habitat conditions) had both the highest and lowest IBI scores, while the surveys with the best streambed conditions had mid-range IBI scores of 5 and 9. This lack of a consistent response may indicate that the variability of the physical habitat quality is likely overridden by natural BMI variability as expressed by the IBI scores. The conclusion from this analysis is that most sites have not had physical habitat quality changes through time and for the sites that have had alterations, the impacts to biotic integrity have either been temporary or insubstantial.

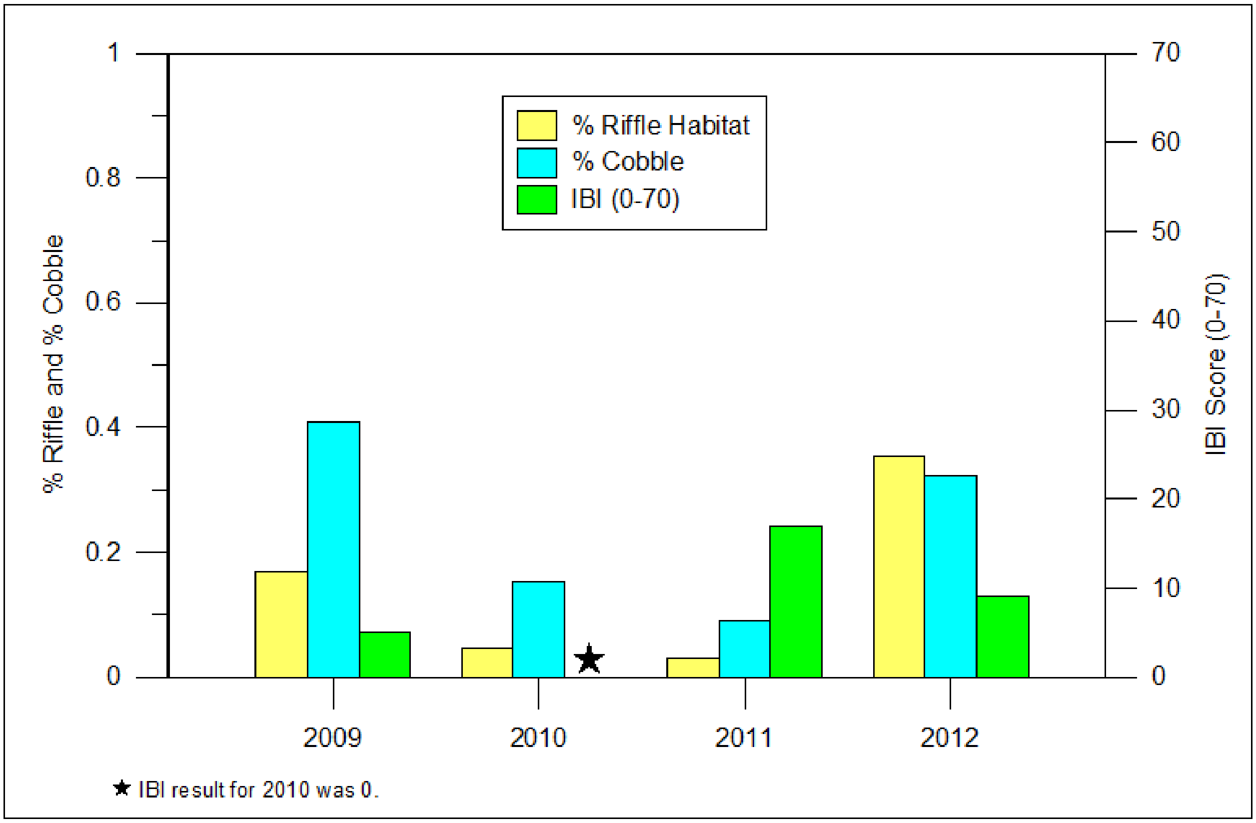

Figure 10. IBI Scores and Physical Habitat Variability at SGLT-506–Walnut Channel, 2009-2012

Analysis of IBI Scores and Various Parameters – 2003-2012

An analysis of the water quality constituents detected during monitoring with the potential to degrade biotic integrity was undertaken. Water samples were collected concurrently with the BMI samples in the Los Angeles and San Gabriel Rivers and analyzed for a variety of constituents. Physical water quality parameters were collected concurrently with all BMI samples county-wide. Only data that was collected within one day and at the same location as the BMI sampling were considered.

This endeavor has been historically difficult since there are still many unknown factors in the interactions between habitat, chemical pollutants, and individual BMI tolerance to individual parameters. For this program, additional confounding factors included the change in physical habitat assessment methods in 2009, chemistry data that was collected only at the Los Angeles and San Gabriel River sites for the Council for Watershed Health, and a limited number of targeted sites with multi-year results. The analysis below was performed on targeted sites that had four to ten years of survey data, and includes a total of 12 sites: four in the San Gabriel River Watershed, six in the Los Angeles River Watershed, and two in the Santa Monica Bay Watershed.

An initial screen was performed on candidate parameters, which were divided into two categories: water quality constituents and physical habitat attributes. Scatter plots of physical habitat attributes with IBI scores were created to assess broad relationships and the results of this were presented in the 2012 report (Weston, 2013). Sediment deposition appeared to have the weakest relationship to IBI scores, even though this parameter is widely considered to negatively impact biotic integrity. The lack of sediment deposition in concrete-lined channels that had low IBI scores likely drove this apparent lack of a relationship, so a separate plot was performed for sites that summed the % concrete and the % fine sediments. Substrate complexity and channel alteration had the highest correlation to IBI scores, with higher IBI scores associated with greater substrate complexity and lower IBI scores associated with greater channel alteration. The % gradient (or slope), % canopy, % riffle habitat, and % fines plus % concrete were moderately to weakly related to IBI scores.

A Spearman rank correlation of IBI scores and chemical analytes indicated a significant, and in each case negative, relationship for ten constituents (Weston, 2013). Pesticides were considered; however, since a large majority of the analyses had "non-detect" results, the data were incompatible with this statistical analysis. A separate method was used for pesticides and is discussed below.

Four of the top six analytes with the strongest negative correlation with IBI scores were related to dissolved solids and ionic constituents. Toxicity tests have shown that BMI are sensitive to elevated concentrations of dissolved ions (e.g., Mount et al., 1997). Total Kjeldahl nitrogen and total and dissolved organic carbon also showed strong correlations with IBI scores, although the effect of organic carbon is usually as a co-factor that affects susceptibility to other more toxic constituents.

Scatter plots relating the chemical analytes with IBI scores were created (Weston, 2013). This also showed that dissolved ions generally had the strongest negative relationships to IBI scores. What was also evident was that while many of the constituents had low values at low IBI sites, the reverse situation was never the case; none of the constituents had high values where there was a high (i.e., unimpaired) IBI score.

A stepwise multiple regression was then performed on the top ten candidate parameters to determine if a constituent or combination of constituents could be used to predict IBI scores based on existing data. Initially, all constituents were used in the analysis, but because of the limited number of samples for some constituents, the regression was re-run using the constituents with the greatest number of samples (sediment deposition, specific conductance, alkalinity, dissolved organic carbon, hardness, nitrate, orthophosphate, phosphorus, and total organic carbon). It is interesting to note that sediment deposition, which did not appear to be related to IBI score by itself, when assessed in conjunction with other variables, was shown to be a strong co-factor. A stepwise model was applied that was optimized to include the following parameters: sediment deposition dissolved organic carbon, and chloride. While this model was "significant", it did a poor job of accurately predicting IBI scores (R^2=0.376). Therefore, although sediment deposition, dissolved organic carbon, and chloride may be good predictors of low IBI scores, they are not useful for the prediction of absolute IBI scores.

Organophosphorus and pyrethroid pesticide data were available from the Council for Watershed Health sites in the San Gabriel and Los Angeles Rivers. Since most analytes were rarely detected, standard statistical analyses were not appropriate for the data. Instead, a whisker box plot was created comparing IBI scores to sites where any pesticide analyte was detected versus sites that had none detected (Weston, 2013). The results show that the IBI scores were lower at sites that had pesticides detected and that the difference was significant with a P value of <0.001. Additionally, for sites that had pesticides detected, none had IBI scores above the impairment threshold, and the highest IBI score was 12.

Malibu Creek Watershed: Biotic Integrity Results from Multiple Agencies and a Discussion of its Unique Geological Attributes, 2013 Analysis

Bioassessment in the Malibu Watershed has been conducted extensively by a number of agencies, most notably by the Las Virgenes Municipal Water District (LVMWD) and Heal the Bay (HtB). Information from these studies was assimilated and IBI scores were used to summarize the distribution of biotic integrity throughout the watershed and to compare third party data to LACFCD data.

Throughout the Malibu Watershed, mean IBI scores at the urban influenced sites were, in almost all cases, below the IBI impairment threshold. In some instances where sites had multiple survey results, individual surveys had IBI scores slightly above the threshold but these were generally outliers and the overall results indicated impaired biotic integrity in the urban environment. Sites in lower Malibu Creek often fell into this category, including the LACFCD site SMC01384, which had an IBI score of 29 in 2009. Cold Creek, as noted above, was unaffected by urban development in the upper reaches and the IBI scores were consistently rated unimpaired by all agencies that monitored there.

In addition to bioassessment surveys, water quality monitoring has been performed in the Malibu Watershed by various stakeholders. Many of the drainages in the Malibu Watershed have shown chronically elevated levels of dissolved ionic constituents. The easiest way to measure the cumulative level of these ionic constituents (i.e., ionic strength) is field testing for specific conductance. Other measures that indicate these constituents but don't specifically identify them include DOC, TOC, TDS, alkalinity and hardness. Laboratory analyses for specific analytes have indicated elevated levels of sulfate and phosphate as well as a variety of salts, metals, nutrients and minerals. It has been shown in laboratory toxicity tests that these constituents are present in some drainages with levels that are toxic to some BMI and algae, and therefore have the potential to degrade overall biotic integrity. It is important to note, however, that the majority of the local BMI have not had their toxic endpoints determined for these ionic constituents. Studies have been performed on standard test organisms; for example, mortality to *Ceriodaphnia dubia* occurs at about 2,000 mg/L chloride and at about 3,000 mg/L sulfate (Mount et al., 1997).

Correlation of ionic constituents to impaired biotic integrity was shown in regression analysis with IBI scores for the LACFCD monitoring sites (Weston, 2012). The majority of the constituents identified to have a strong and significant correlation to impaired biotic integrity were those that contribute to ionic strength, and the top three were TDS, chloride and sulfate. The other constituents with significant correlations were nitrogen and phosphorus based nutrients.

The geology of the Malibu Watershed includes substantial areas of surficial Monterey/Modelo Formation, a petroleum source rock which has been identified as a source for naturally elevated ionic strength in surface waters. This formation is located primarily in the upper watershed areas that ultimately drain to Malibu Creek, and generally does not impact the smaller coastal watersheds along the Malibu Coast. Since urban runoff can also degrade biotic integrity, the challenge in the Malibu Watershed is to determine the relative impacts of naturally occurring constituents versus those from anthropogenic sources.

Drainages monitored by LACFCD with chronically elevated conductivity, salinity, alkalinity, and hardness have included Cheseboro Creek, Las Virgenes Creek, Malibu Creek and Medea Creek while Triunfo Creek has been slightly elevated for these constituents. Excluding Triunfo Creek, all of these streams had conductance values between 2.068 and 3.697 mS/cm. For comparison, in 2013 the range of conductivity at all other LACFCD monitoring sites ranged from 0.385 to 1.612 mS/cm. This makes the upper Malibu Watershed sites unique for their high levels of ionic strength.

One interesting result in these data is the relative increase in hardness in Las Virgenes Creek between 16 and LV-LHR that was detected in 2013. Over a distance of about three miles the hardness increased from 72 to 2,000 mg/L $CaCO_3$. Flow increased from 0.009 to 0.32 cfs, presumably due to urban runoff/irrigation. The flow at Site 16 originates from a spring approximately 175 meters upstream of urban development and 60 meters west of the main channel of Las Virgenes Creek. The spring provides surface flow for about 150 meters in Las Virgenes Creek, and the water has a distinct white cloudiness and sulfidic odor. The cause of the increase in hardness downstream is unknown, but considering the increase in total flow between the two sites, the source is likely from urban runoff, groundwater contributions, or a combination of the two.

Heal the Bay's monitoring program provided a database of conductivity measures throughout the watershed that was summarized in a USEPA 2013 TMDL report. The data show a clear difference between conductivity values for sites located within the Monterey/Modelo Formation (mean value of 3.329 mS/cm) versus those outside the formation (mean value of 1.256 mS/cm). Several of the sites were considered reference sites that received little or no urban runoff and were located both within and outside the Monterey/Modelo Formation. Of note are sites CH-6 and LV-9, both of which had conductivity values that were above the mean value for sites within the formation. IBI results showed that reference sites CH-6 and LV-9 had quite a wide range of scores (34 to 64 and 26 to 59, respectively on the 0-100 scale) that were both above and below the impairment threshold (USEPA, 2013).

6.2 Cluster Analyses 2003-2014

A cluster analysis was performed to test for similarities between site location and BMI community structure. The analysis was performed as described in Subsection 4.4 above and used all BMI taxonomic data from 2003 through 2014. The similarity matrix is shown in Appendix B.9.

Overall results of the analysis indicated there were five major taxa clusters and five site clusters, labeled 1 through 5 and A through E, respectively. This analysis confirmed that the BMI communities are different based on their location in the watershed and also by channel and substrate type.

The site clusters fell into three general groups:

- clusters B and D contained the low to mid-elevation urban sites, including all of the concrete-lined channel sites,
- clusters A and C contained the Angeles National Forest sites and open space sites in the Santa Monica Mountains/upper Santa Clara watershed, respectively,
- cluster E contained all of the sites in the mainstem of the Santa Clara River.

Taxa cluster 1 contained many of the infrequently encountered non-insect taxa, none of which are considered sensitive to impairment (e.g., all leeches were in this cluster). Taxa cluster 2 contained the ubiquitous, generalist taxa that were well-distributed across the region. Taxa clusters 3 and 5 contained the sensitive EPT taxa as well as beetles, dragonflies, and other rare and/or sensitive taxa. Taxa cluster 4 had a concentration of taxa associated with the Santa Clara River sites, including the mayfly *Tricorythodes* sp. and several hydrophilid beetle taxa.

The BMI assemblages and IBI scores of the sites also confirmed that the higher elevation and/or less urbanized portions of the watersheds were of superior quality to the low elevation sites with greater urbanization.

6.3 Comparison of IBI Scores and CRAM Scores

To test the relationship between IBI scores and physical habitat, a linear regression analysis was used to evaluate the relationship between CRAM scores and IBI scores. As noted in Section 3.4, CRAM was initiated in 2009 and was performed at all sites. Since 2010, CRAM was performed only at the SMC sites.

The results of the analysis were a coefficient of determination (R^2) of 0.565 (Figure 11). This result shows that a positive and significant relationship exists between CRAM and IBI scores. Figure 11 shows two groupings of sites: those with the lowest CRAM and IBI scores (i.e. CRAM <40, IBI <26), and those with moderate to high CRAM scores (CRAM >65), but with a wide range of IBI scores. This indicates that sites with good habitat may have low IBI scores, while none of the sites with high IBI scores had low CRAM scores. IBI scores generally correlate better with CRAM scores than with individual physical habitat parameters because it incorporates water source and a wider stream buffer (i.e., CRAM is more likely to incorporate urban aspects of the watershed beyond the streambed and banks).

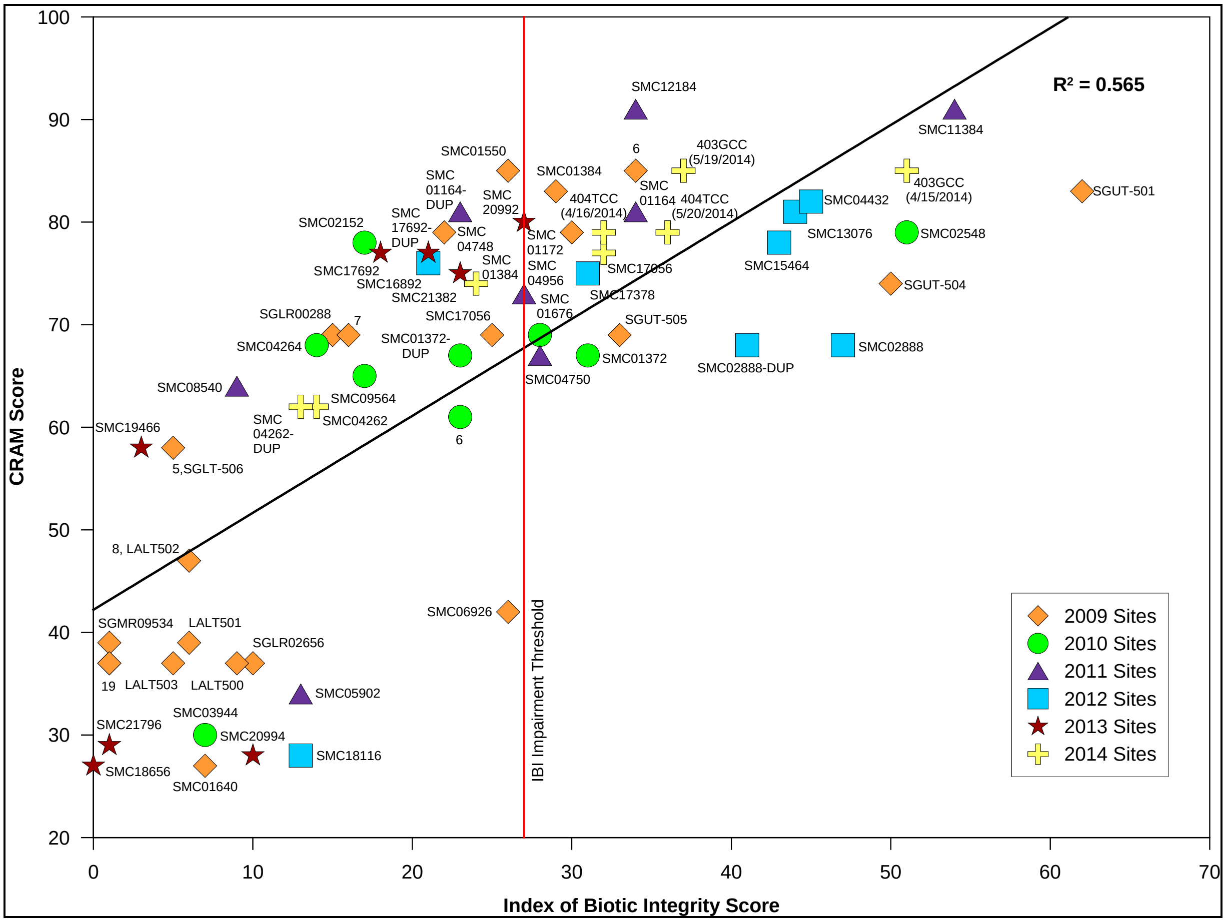

Figure 11. Correlation of California Rapid Assessment Method and Index of Biotic Integrity Scores for 2009 through 2014

6.4 Invasive Species Analysis (2013 Analysis)

An analysis of the spatial extent of invasive BMI taxa in the county was performed. The data included all historical taxonomic data from the LACFCD Bioassessment Program as well as data provided by SCCWRP from various SWAMP and SMC member agencies. Four invasive taxa were identified in the County:

- Cambaridae: *Procambarus clarkii* (red swamp crayfish). Cambarid crayfish, which were introduced from the eastern U.S., are omnivores that may proliferate in lentic or slow flowing stream habitats. They are widespread and frequently encountered throughout southern California. They can have negative impacts on native BMI, amphibian and fish populations through predation, and on water quality through bioturbation (GISD, 2011). Their numbers are generally under-represented in bioassessment samples due to their ability to avoid capture, and it's not unusual for a single individual to comprise more biomass in a sample than all other BMI combined.
- *Corbicula* sp. (Asian clam). The Asian clam is also widespread throughout southern California and beyond, and is typically found in substrates dominated by sand or sometimes filamentous root mats. They are capable of forming dense beds in the substrate but usually are collected in relatively low numbers in bioassessment samples. Their impacts to the natural stream ecology are usually not severe, but high abundances

can alter benthic substrates (Sickel, 1986) and compete with native BMI for resources (Devick, 1991). They have greater impacts as a bio-fouling agent on water-based infrastructures.

- *Melanoides tuberculata* (Malaysian trumpet snail, red-rimmed melania). *M. tuberculata* is the least common and least offensive of these four invasives, with few localities in southern California where they have been collected. They were imported into the U.S. by the aquarium trade and are now widespread, although their range is likely limited by their intolerance to water temperatures <18°C (64°F) (Benson and Neilson, 2013).
- *Potamopyrgus antipodarum* (New Zealand mud snail [NZMS]). The NZMS can form very dense population clusters and can dominate a bioassessment sample numerically (e.g., the 2013 sample from LV-LHR, where they comprised 64% of the total abundance). A relatively recent introduction to the U.S. (circa 1987), studies have shown that negative impacts can occur to native BMI populations when the snail is in extremely high densities (Kerans et al., 2005) but in some cases, moderate populations may have a beneficial effect (Schreiber et al., 2002).

Swamp crayfish were most frequently encountered in the Malibu and Santa Clara Watersheds. In the lower San Gabriel and Los Angeles River Watersheds, they were limited to sites with natural substrates (13–Los Angeles River was only partially lined) and were essentially absent from the lined channel sites. Asian clams were similar in distribution to crayfish, with most records occurring in the Malibu and Santa Clara Watersheds, and also limited to sites with natural substrates. They were collected at one site in the lower San Gabriel and Los Angeles River Watersheds.

The Malaysian trumpet snail was limited to two sites in the lower San Gabriel River that were in concrete lined channels, and were collected (and otherwise observed) in relatively low abundance. The NZMS was limited in distribution to sites in the Malibu Watershed and other sub-watersheds in the Santa Monica Mountains. Individual streams with NZMS included Cold Creek, Las Virgenes Creek, Malibu Creek, Medea Creek, and Trancas Canyon Creek. In addition to the data used for this report, Heal the Bay has extensive monitoring data documenting the locations of NZMS in the Malibu Watershed (Abramson et al, 2009). Four additional streams were identified in their report to harbor NZMS, including Lindero Canyon Creek, Ramirez Canyon Creek, Solstice Canyon Creek, and Triunfo Creek. It was also documented that NZMS abundances have been increasing and their range within the Malibu Watershed has been expanding. As mentioned above, the NZMS has been observed in very high densities and can dominate the abundance of a benthic sample.

7.0 SUMMARY

Sixteen receiving water monitoring reaches representing five watersheds in the County were sampled for BMI and were assessed for physical habitat quality in June 2014. The monitoring reaches were located to provide an assessment of possible impacts associated with urban runoff and to evaluate the biological conditions for trend analysis of the BMI communities of the County. Since program inception in 2003, a total of 73 different sites have been sampled in twelve annual surveys, and four of the sites have been sampled in all twelve surveys.

Taxonomic evaluation of the 2014 samples yielded approximately 134 different taxa from 11,571 individual organisms by SAFIT Level II taxonomic effort. In 2013, the most abundant organism collected throughout the County was Ostracoda (seed shrimp). Midges in the family Chironomidae were collected at all of the monitoring sites. The majority of organisms collected from the urban monitoring reaches were moderately or highly tolerant to stream impairments, and all of the sites were dominated by organisms in the two collector feeding groups combined. When individual feeding groups were considered, two sites, SGUT-501–San Gabriel River and SMC01384–Malibu Creek, were dominated by non-collectors. SGUT-501 was dominated by "others" (a mix of five minor feeding groups), and the Malibu Creek site was dominated by scrapers, which were identified as the invasive New Zealand mud snail, *Potamopyrgus antipodarum*.

The 2014 IBI scores of the monitoring reaches ranged from 3 (Very Poor) to 61 (Very Good) out of a maximum of 70 points. SGUT-501–San Gabriel River was the highest rated site, and 403GCC–Gleason Canyon, 6–Arroyo Seco, and SGUT-504–San Gabriel River were the second, third, and fourth highest rated sites, with IBI scores of 51, 44, and 39, respectively. Six of the 16 sites monitored were rated unimpaired by the IBI, and SMC17056–Santa Clara River was the only urban influenced site that was rated unimpaired. Four of the monitoring reaches were located in highly modified, concrete-lined urban water courses. All of these sites had IBI ratings of Poor or Very Poor.

Comparison of the IBI scores for the eleven survey years did not indicate any substantial trend toward degradation or improvement at any of the sites, and there were very few cases where a site varied between an impaired rating and an unimpaired rating. Trend analysis was not possible for sites that have been sampled for less than 4 years. By 2011, 7–Arroyo Seco appeared be trending toward a statistically significant improvement in biotic integrity, but the 2012-2014 results did not continue this trend.

Correlation analysis between CRAM physical habitat scores and IBI scores indicated a significant relationship between physical habitat and biotic integrity. The analysis also indicated two general groups of sites that corresponded with (1) the concrete-lined and altered channel sites and (2) the natural channel sites. It also revealed that sites with relatively high CRAM scores could have low IBI scores but that all sites with high IBI scores also had high CRAM scores. An additional analysis of physical habitat quality attributes at targeted sites did not indicate degradation through time at any of the sites. Two targeted sites have had temporary degradation of physical habitat due to erosional storm flows with a corresponding decrease in biotic integrity, and both of these sites have since recovered.

Analysis of individual metrics as well as total IBI scores showed that in the San Gabriel, Los Angeles, and Santa Clara River watersheds, monitoring sites located in the lower watershed had lower-quality benthic communities than sites located in the middle to upper reaches of the watersheds. In these three watersheds, a positive and significant difference existed between site elevation and IBI scores. In the Santa Monica Bay Watershed this correlation was very weak, and IBI scores tended to decrease with elevation, although the correlation was not statistically significant. This result was likely due to the fact that many of the lower elevation sites along the Malibu Coast were in relatively pristine sub-watersheds while the higher elevation sites along the Highway 101 corridor were much more developed.

A 2003-2012 analysis of the difference between concrete-lined sites and unlined sites often indicated no statistically significant difference in IBI scores when the analysis was limited to sites located in the heavily urbanized lower watershed areas. When reference and mid- to upper-watershed sites were added to the analysis, the difference in IBI scores between concrete-lined sites and unlined sites was of much greater significance. The magnitude of difference in IBI scores between concrete-lined and unlined sites was variable from year to year. In 2011 and 2012, a greater difference existed between the lined and unlined sites than years prior, due to the addition of a greater number of high quality SMC sites to the analysis. When this analysis was performed by watershed, the lower Los Angeles River and San Gabriel River Watershed results did not show a difference between concrete-lined and unlined sites, whereas in the Santa Monica Bay Watershed, the difference between concrete-lined and unlined sites was much greater. This analysis was not performed in the Santa Clara River Watershed because no lined sites were sampled as of 2012.

The two-way cluster analysis of 2014 taxa and sites indicated clustering by taxa, with all of the sensitive taxa contained within two of the five major clusters. Overall, the sites appeared to cluster more readily according to site physical conditions and location in the watershed relative to urban development, and generally confirmed the correlation between BMI assemblages and these factors. The non-perennial special study sites had a distinct cluster, as did the open space perennial sites with natural channels and complex substrates. The fully concrete-lined sites and highly urbanized sites were contained within two additional clusters. The lower watershed and concrete-lined sites were populated primarily with abundant, ubiquitous, and opportunistic organisms common to most sites, whereas the open space sites often had distinctive benthic communities, with a number of unique and/or sensitive taxa present at each site. Cluster analysis of all taxonomic data from 2003 to 2014 had results similar to the 2014 data, with observable associations between BMI assemblages, site IBI scores, and site physical characteristics.

In the past, an analysis of parameters with the potential to degrade the BMI community was performed for data available through 2012. These were divided into physical habitat attributes and water quality constituents and were compared to IBI scores. The two physical conditions that were most strongly related to IBI scores were substrate complexity (positive relationship) and channel alteration (negative relationship) and the water quality constituents most strongly related to IBI scores were dissolved ionic constituents and total and dissolved organic carbon. Using a step-wise multiple regression approach, several significant relationships between IBI scores and a combination of predictors were found. However, although a significant relationship was found, the predictive ability of the model was poor. Therefore, it is not possible to accurately predict IBI scores although several analytes are useful as "indicators" that biotic integrity will likely be impaired (e.g., high levels of total dissolved solids, chloride, and sulfate). An analysis of the effect of organophosphorus and pyrethroid pesticides showed that all of the sites where pesticides were detected had impaired biotic integrity and the difference in IBI scores was statistically significant.

A past analysis of invasive BMI species throughout the County showed that two species, red swamp crayfish and Asian clam were widespread and frequently encountered in all watersheds. They were, however, limited to sites with natural substrates. The New Zealand Mud Snail was limited to a number of drainages in the Malibu Watershed and along the Malibu coast, and in some cases was highly abundant and dominated the BMI samples. Malaysian trumpet snail was limited to two sites in the lower San Gabriel River and is likely of little threat in the region due to its tropical origin.

A 2013 comparison of IBI scores in the Malibu Watershed for sites sampled by LACFCD and third party stakeholders indicated that results from various sampling programs have been consistent. Urban influenced sites in the watershed were generally impaired, although individual surveys occasionally produced IBI scores slightly above the impairment threshold. The presence of the Monterey/Modelo geological formation likely has some negative impact to biotic integrity, but reference sites in the formation have, albeit with some exceptions, supported unimpaired BMI communities. Quantification of the full effect of the natural geology on biotic integrity in the Malibu Watershed merits additional study.

8.0 FUTURE PROJECTIONS FOR BIOASSESSMENT

As the science of bioassessment monitoring continues to evolve, further modifications in monitoring protocols and methods are likely. Regulatory issues are likely to emerge as well, including the implementation of biological objectives or "biocriteria." This may require NPDES MS4 Permit holders to evaluate and implement ways to increase the biotic integrity of receiving waters (e.g., elevate a stream site's IBI score or another prescribed metric). Preliminary meetings regarding these potential requirements indicate that not all waterbodies will be considered equally and that biological objectives will consider existing (and potentially immitigable) limitations on BMI colonization. These limitations may include attributes such as physical habitat constraints, natural perturbations, and cost-prohibitive mitigations. The development of a scientifically defensible analysis of biotic conditions throughout California has been completed, but the regulatory requirements have yet to be determined.

A new assessment tool has been developed that will likely replace the multi-metric IBI currently in use. The tool is referred to as the "California Stream Condition Index" (CSCI), and it combines a multi-metric IBI with a predictive model (that is expressed as a ratio of the observed (O) taxa at a site to the expected (E) taxa at a site). The CSCI will consider other mitigating factors that could affect BMI colonization independent of water source. These factors include location in the watershed, rainfall, geology, and other natural ecological conditions. The combination of a multi-metric index and a predictive index improves the accuracy of using the two individually, since past experience has shown that both have limitations when assessing unusual BMI assemblages or sites with unique natural conditions. Although the CSCI has been finalized, a threshold of impairment has yet to be established.

The development of a single physical habitat metric is being considered by SWAMP, but the efforts are still in the early stages. Currently, the methodology for stream physical habitat assessment utilizes two separate protocols (i.e., SWAMP and CRAM). Both protocols assess unique attributes of the physical habitat, but there is also some redundancy between them. Streamlining of protocols by a state agency (e.g., SWAMP and/or CDFG) would increase efficiency of the assessment but may require approval by the State Water Resources Control Boards (SWRCBs) and RWQCBs and subsequent incorporation into the NPDES MS4 Permit.

Research to develop algal biological metrics and an algae-specific IBI for southern California is complete and has been published (Fetscher et al., 2013). The research was conducted by SCCWRP through grant funding from the United States Environmental Protection Agency and incorporated data generated from a variety of NPDES monitoring programs. Algae respond more quickly and to different ecological stressors than BMI (particularly nutrients and sedimentation), and there is a general consensus that this monitoring tool is complementary to BMI assessment and that the addition of algal assessments will provide a more comprehensive understanding of anthropogenic impacts to the stream biota. Algal sampling and analysis is currently part of the SMC program SOW, and has the potential to become a requirement for NPDES permit compliance monitoring.

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