Los Angeles River Watershed Monitoring Program
2016 Annual Report

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Agencies and Organizations
City of Burbank
City of Los Angeles
Los Angeles County Flood Control District
Los Angeles Regional Water Quality Control Board
Council for Watershed Health
Southern California Coastal Water Research Project
U.S. Environmental Protection Agency (USEPA)
U.S. Forest Service

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List of Acronyms

Algal IBI	Algal Index of Biological Integrity
ATL	Advisory Tissue Levels
BMI	Benthic Macroinvertebrate
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CRAM	California Rapid Assessment Method
CRM	Certified Reference Material
CSCI	California Stream Condition Index
CTR	California Toxics Rule
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DQO	Data Quality Objective
EWMP	Enhanced Watershed Management Plan
FCG	Fish Contaminant Goals
IBI	Index of Biological Integrity
LARWMP	Los Angeles River Watershed Monitoring Program
MLOE	Multiple Lines Of Evidence
MQO	Measurement Quality Objective
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ND	Non-detect
OEHHA	Office of Environmental Health and Hazard Assessment (CA)
PAH	Polycyclic Aromatic Hydrocarbons
PCA	Principle Component Analysis
PCB	Polychlorinated Biphenyl
POP	Persistent Organic Pollutant. The listed constituents PCBs and DDTs are both persistent organic pollutants under the Stockholm Convention.
POTW	Publicly Owned Treatment Works
PPM	Parts Per Million
RPD	Relative Percent Difference
RF	Random Forest
SGRRMP	San Gabriel River Regional Monitoring Program

SQO	Sediment Quality Objective
SWAMP	Surface Water Ambient Monitoring Program
TDS	Total Dissolved Solids
TEQ	Toxicity Equivalent
TIE	Toxicity Identification Evaluation
USEPA	United States Environmental Protection Authority
VOC	Volatile Organic Compound
WQO	Water Quality Objective
WRP	Water Reclamation Plant

Executive Summary

The Los Angeles River Watershed Monitoring Program conducts annual assessments to better understand the health of a dynamic and predominantly urban watershed. The guiding questions and corresponding monitoring framework of the LARWMP provide both the public and resource managers with an improved understanding of conditions and trends in the watershed.

What is the condition of streams in the watershed?

The 2016 assessments of random sites within the urban, effluent dominated, and natural regions of the watershed revealed marked and significant differences in condition between upper and lower watershed sites in terms of biological condition, physical habitat, and water chemistry. The majority of random sites in the watershed have biotic conditions that are below reference condition: 65% of sites were altered compared to reference conditions for benthic macroinvertabrates (CSCI), while 60% of sites have altered riparian zone habitat condition (CRAM) and altered attached algal communities (So CA Algal IBI) compared to reference conditions. Total nitrogen and nitrate were significantly higher in the effluent dominated regions of the watershed.

Physical habitat assessments helped quantify the differences in physical condition between urban/effluent and natural sites. Urban/effluent dominated sites had more channel alteration, less epifaunal substrate cover, and less percent canopy cover. Physical habitat metrics (epifaunal substrate, percent concrete, and percent channel alteration) were most closely associated with altered benthic macroinvertebrate communities, while a mix of water chemistry and physical habitat variables were associated with altered attached algae communities, including percent bank stability, total organic carbon, phosphorus, and chloride.

Recommendations: Explore the use of a new Landscape Modelling tool that is currently being developed by the State Water Board and SCCWRP that predicts constrained biological conditions based on data available in the USEPA's StreamCAT GIS layers. The goal of this tool is to allow managers to focus their resources on stream reaches where the biological condition is either under-performing, over-performing, or undetermined.

Are conditions at areas of unique interest getting better or worse?

LARWMP conducts periodic monitoring at sites identified by the Technical Stakeholder Group (TSG) as unique areas of interest, which include confluence points, riparian areas, sentinel sites, and the L.A. River estuary. Regular and recurring assessment can help build upon our understanding of site conditions and how conditions are changing over time.

Monitoring results from confluence sites revealed that in most cases there were no consistent increases or decreases in nutrients and water chemistry parameters over time; however, some interesting trends were detected. Chloride levels at the Tujunga Wash confluence (LALT503) have exceeded the water quality objective (WQO) of 150 mg/L set forth in the Los Angeles Region Basin Plan every year since the inception of the LARWMP, and concentrations have been rising steadily since 2013. Currently, the factors driving this increasing trend in chloride are unknown. Reclamation plants, which contribute to chloride inputs, do not discharge to the Tujunga Wash. Sulfate levels at this site have also been rising since 2013; however, 2016 was the first year we recorded a sulfate concentration that exceeded the site specific water quality objective of 300 mg/L.

Biological and riparian habitat condition generally follows patterns consistent with previous years: good conditions in the upper, more natural portions of the watershed and post-fire sites and degraded conditions in the more urbanized portions. Biological condition is below reference condition at all confluence points, including the soft-bottom site, Compton Creek. Natural sites in the upper watershed are generally the only sites where riparian zone habitat conditions (CRAM) are above reference condition. However, two lower watershed sites, the Haines Creek Pools and Stream (LALT407) and the Arroyo Seco USGS Gage site (LALT450), achieved a CRAM score just above the reference threshold in recent assessments. The Arroyo Seco USGS gage site is downstream of recent fires (LALT450), and was scoured and flooded post-fire. The Haines Creek Pools and Stream site (LALT407) overlaps with restoration activities taking place along the Tujunga Basin. Interestingly, riparian habitat conditions improved at sites in the upper Arroyo Seco and the Tujunga Sensitive Habitat in 2010 and 2011 following the 2009 Station Fire, but declined to the reference threshold in 2015. This may reflect the impact of the four-year drought on riparian habitat condition at these sites. In 2016, scores rebounded and increased above the reference threshold following an above average rainfall season.

E. coli concentrations were consistently elevated at nine, concrete-lined sentinel sites located at confluences of major tributaries with the Los Angeles River. Nearly every site exceeded both the single-sample and 30-day geometric mean REC-1 standards from May to September. The exception to this was a site downstream of the Los Angeles Glendale Water Treatment Plant (LALT101 at Figueroa Street) where the geometric mean was not exceeded in June, July, and September. Non-point sources, such as homeless encampments and pet waste, are likely pollution source contributing to bacteria concentrations. Consistently high exceedances and diffuse sources of bacteria at sentinel sites continue to highlight the difficulty of reducing bacterial concentrations within the lower tributaries and mainstem of the L.A. River watershed.

Recommendation:

- Develop outreach and educational efforts focused on raising public awareness around bacterial contamination in the watershed.
- With fire frequency expected to increase in coming years, there is a need for improved reporting on riparian plant community succession and the impact of fire on water quality and aquatic communities at sites in the LA River Watershed.

Are receiving waters near discharges meeting water quality objectives?

Monitoring efforts assess the potential impacts of POTWs, or NPDES permitted point-source discharges, on the Los Angeles River and its tributaries and whether these discharges meet the Water Quality Objectives detailed by the Los Angeles Basin Plan. The monitoring program assesses common contaminants and acute toxicity in wastewater effluent to determine whether effluents are impacting water quality and the health of aquatic organisms. The single-sample water quality objective for *E. Coli* was met in 55% of downstream samples compared to 78% of upstream samples at D.C. Tillman Water Reclamation Plant. Effluent from the Los Angeles Glendale Water Reclamation Plant and Burbank Water Reclamation Plant had a dilution affect, reducing bacteria concentration in downstream sites compared to upstream sites. At each POTW, acute toxicity was not detected either upstream or downstream of the discharge during the year. Common disinfection byproducts (trihalomethanes) were detected below all discharge points, but concentrations were well below the EPA water quality objective at all sites. Metal concentrations downstream of the POTWs were below CTR chronic and acute thresholds for all metals of concern at each of the three POTWs, although 3 samples upstream of the Tillman Water Reclamation plant exceeded chronic thresholds for selenium.

Is it safe to swim?

The majority of swim sites, particularly those in the upper watershed, regularly met *E. coli* single sample REC-1 standards during the summer sampling season. In 2016, 30% of all samples exceeded the REC-1 bathing water standards. There is considerable variation in percent exceedances across sites. Some recreational sites have consistently high bacterial exceedances every year of monitoring. The Hansen Dam Recreation Area, for example, has persistently elevated *E. coli* concentrations (average of 94.5% of samples exceeded REC-1 standards). The Sepulveda Basin saw a large increase in bacteria exceedances (45% in 2016 compared to 18% in 2015) compared to previous years. The sources of bacteria at these sites are not well studied but may be related to growing homeless populations. All other recreational sites, distributed across both lower and upper watershed regions, have a lower number of exceedances. Hermit Falls and the Delta Day Flat Use site had no exceedances all summer.

There was not a strong relationship between site use, the average number of animals, people on shore, or bathers, and *E. coli* concentration across sites. Hansen Dam, for example, had the highest number of exceedances and an average of only 0.2 bathers, 1.2 animals, and 2.04 people on shore during monitoring visits. Sampling, however, often occurs in the morning, before large crowds arrive and station observations do not include activities occurring upstream. Across the monitoring season, there was also not a significant difference in exceedances between holidays/weekends and weekdays, though the greatest number of exceedances occurred on Memorial Day. A moderately strong relationship, however, was found between turbidity, electrical conductivity, pH and *E. coli* concentrations across all sites. This suggests that sediments may be a source of bacteria at monitored sites, since *E. coli* cells can persist longer in sediments than in open water, and that bacteria distributions are sensitive to environmental factors that impact cell viability, such as pH.

Recommendations:

- Development of public outreach and educational efforts that target recreational users regarding the safety of swimming and watershed stewardship.

- Share *E. coli* monitoring data with public in a format that is easily accessible and easy to interpret.
- Explore how water resource funding can work to address the intersection between water quality and homelessness.

Are locally caught fish safe to eat?

The goal of this portion of the monitoring program is to improve our understanding of the health risks associated with consuming fish in water bodies popular among anglers. In 2016, the program began to collect prey fish in tandem with sport fish to help develop a bio-magnification factor for mercury. A bio-magnification factor helps scientists estimate mercury exposure in wildlife based on concentrations of mercury in lower trophic prey fish. Smaller prey fish constitute a significant portion of the diet for higher trophic level fish, piscivorous birds, and other wildlife.

Fish tissue contaminant monitoring for 2016 revealed that common carp, channel catfish, bluegill, largemouth bass, and tilapia from the Peck Road Lake are safe to eat. The recommended frequency of consumption and serving size, however, vary by species and depend on size, trophic position, and feeding ecology. Based on conservative estimates and OEHHA ATL thresholds, common carp collected from Peck Road Lake should be limited to one 8-oz serving a week due to mercury concentrations (PCB concentrations were also elevated). Mercury levels indicate that one should limit the consumption of channel catfish, bluegill, and largemouth bass to two 8 oz servings a week. Tilapia did not have elevated values for mercury and PCBs, and can be consumed three times a week. While selenium, and to a much lesser extent DDT, was detected in fish tissues, concentrations did not limit consumption beyond three 8-oz serving per week. Prey fish (fish between 50-150 mm in size) collected at Peck Road Lake included largemouth bass and bluegill. Mercury concentration in both species exceeded the draft SWAMP Wildlife Habitat Methylmercury Water Quality Objectives, signaling that concentrations of mercury in prey fish may be a danger to wildlife.

Recommendations

- Work with OEHHA to assist with the development of fish advisories and appropriate signage to help broaden and strengthen outreach to anglers on safe fish consumption.

Introduction

1. Background: The Los Angeles River Watershed

A watershed is the area that drains precipitation to a common outlet. The Los Angeles River watershed (Figure 1) encompasses western and central portions of Los Angeles County. It is bounded by the San Gabriel, Santa Susana, and Santa Monica Mountains to the north and west, the San Gabriel River to the east, and the Pacific Ocean to the south. The Los Angeles River's headwaters originate in the Santa Monica, Santa Susana, and San Gabriel Mountains. The river terminates at the San Pedro Bay/Los Angeles and Long Beach Harbor complex, which is semi-enclosed by a 7.5 mile breakwater. The river's tidal prism/estuary begins in Long Beach at Willow Street and runs approximately three miles before joining with Queensway Bay.

The 824 sq. mi. Los Angeles River Watershed encompasses riparian areas, forests, natural streams, urban tributaries, residential neighborhoods, and industrial land uses. Approximately 324 sq. mi. of the watershed is open space or forest. South of the mountains, the river flows through highly developed residential, commercial, and industrial areas. From the Arroyo Seco, north of downtown Los Angeles, to its confluence with the Rio Hondo, the river is bordered by railyards, freeways, and major commercial development. South of the Rio Hondo, the river flows through industrial, residential, and commercial areas, including major refineries and storage facilities for petroleum products, major freeways, rail lines, and rail yards serving the Ports of Los Angeles and Long Beach. While most of the river in the developed portion of the watershed is lined with concrete, the unlined bottoms of the Sepulveda Flood Control Basin and the Glendale Narrows provide areas of riparian habitat important due to their ecological and recreational value. Compton Creek, just upstream of its confluence with the Los Angeles River, also supports riparian wetland habitat.

2. The Los Angeles River Watershed Monitoring Program (LARWMP)

In 2007, local, state, and federal stakeholders formed LARWMP. This collaborative monitoring effort is shared by partnering agencies, permitees, and conservation organizations. Partners lend technical expertise and guidance and support monitoring efforts and lab analysis either directly or through funding. The 2016 monitoring efforts for bioassessments, bacteria testing, and fish tissue bioaccumulation, detailed in this report, were supported by five sampling teams, three laboratories, and funding from the Cities of Los Angeles, Burbank, and the Los Angeles County Flood Control District (Table 1, Table 2, and Table 3).

Prior to the implementation of the LARWMP, the majority of monitoring efforts were focused on compliance monitoring and little was known about the condition of streams in the watershed. LARWMP incorporated elements of pre-existing water quality and biological monitoring that was occuring in the watershed and the compliance monitoring of publicly owned Water Reclamation Plant (WRPs) and extended it to the entire watershed area.

LARWMP's sampling design provides the ability to track trends at fixed (target) sites and to evaluate them in the context of conditions in the watershed by comparing them to data collected from random (probabilistically-selected) sites. The watershed-scale effort improves the cost effectiveness, standardization, and coordination of various monitoring efforts in the Los Angeles region. Monitoring has also been responsive to the river's evolving beneficial uses and impairments (Table 5, Table 6,

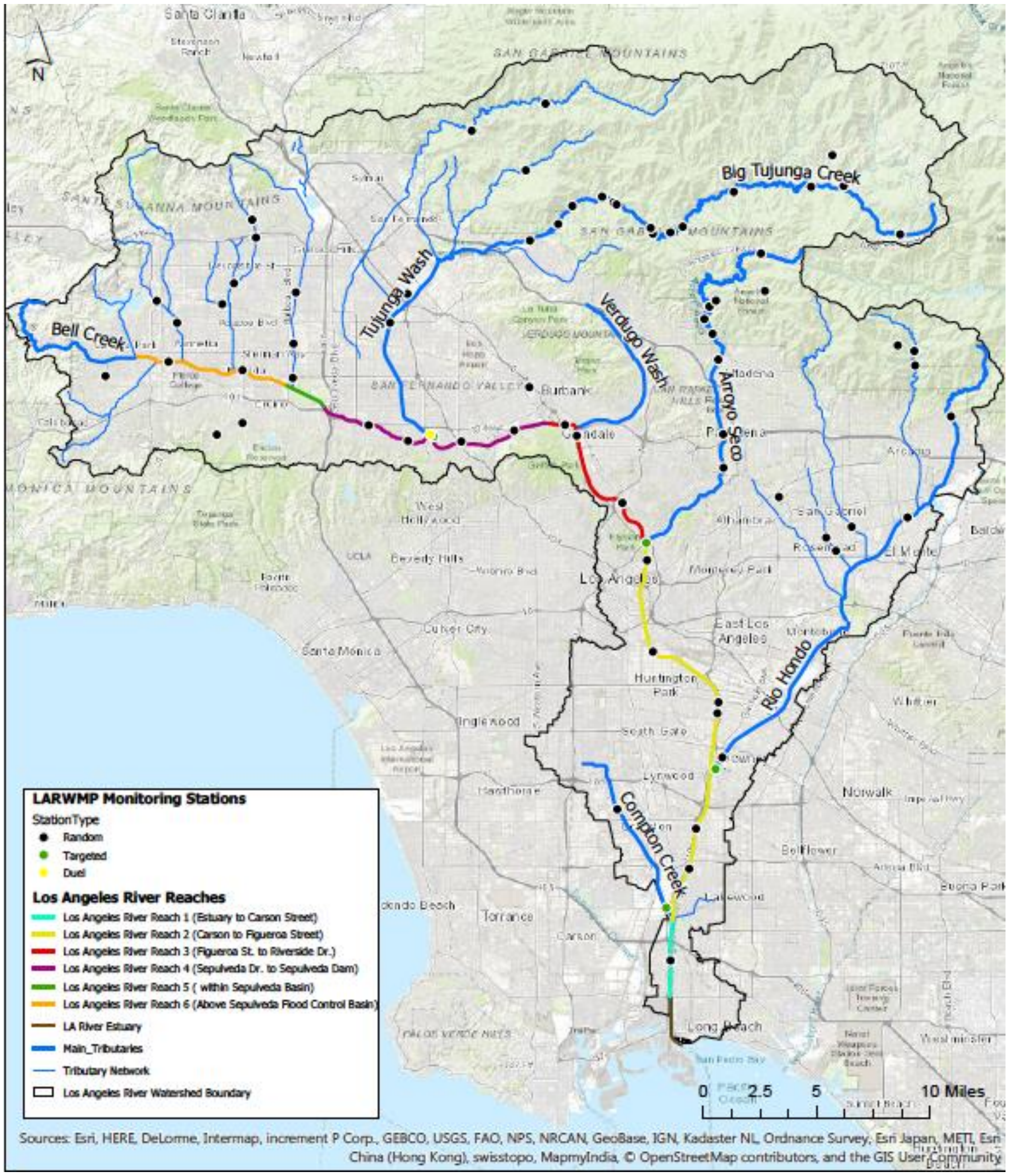

Figure 2) and provided managers and the public with a more complete picture of conditions and trends in the Los Angeles River watershed.

The objectives of the program are to develop a watershed-scale understanding of the condition (health) of surface waters using a monitoring framework that supports comprehensive and periodic assessments of sites along streams, the main channel, in riparian and estuarine habitats, and downstream of treatment works. This report summarizes the monitoring activities and results for 2016. It is one of a series of annual monitoring reports produced for the Los Angeles River Watershed Monitoring Program (LARWMP) since 2008.

LARWMP is designed to answer the following five questions:

1. What is the condition of streams in the watershed?
2. Are conditions at areas of unique interest getting better or worse?
3. Are receiving waters near discharges meeting water quality objectives?
4. Is it safe to swim?
5. Are locally caught fish safe to eat?

Each year, the technical stakeholder group guides the implementation of the program to ensure efforts are responsive to the priorities of both the public and managers and ensures the program is consistent in both design and methodology with regional monitoring and assessment efforts. In the 2016 report, prey fish contaminant levels are analyzed and presented for the first time in support of SWAMP's efforts to protect recreational consumption of fish, protect piscivirous wildlife, and develop site specific bioacculumation factors (Palumbo and Iverson, 2017).

A more complete description of LARWMP regional setting, motivating questions, its technical design, and its implementation approach can be found in the Los Angeles River Watershed Monitoring Program Monitoring Plan (CWH 2009[1]), Annual Reports (CWH 2009, CWH 2010, CWH 2012-2014, CWH 2015) and Quality Assurance Project Plans (CWH 2010 to 2016), which are posted on the project webpage: https://www.watershedhealth.org/resources.

Figure 1. 2009 to 2016 sampling locations for LARWMP.

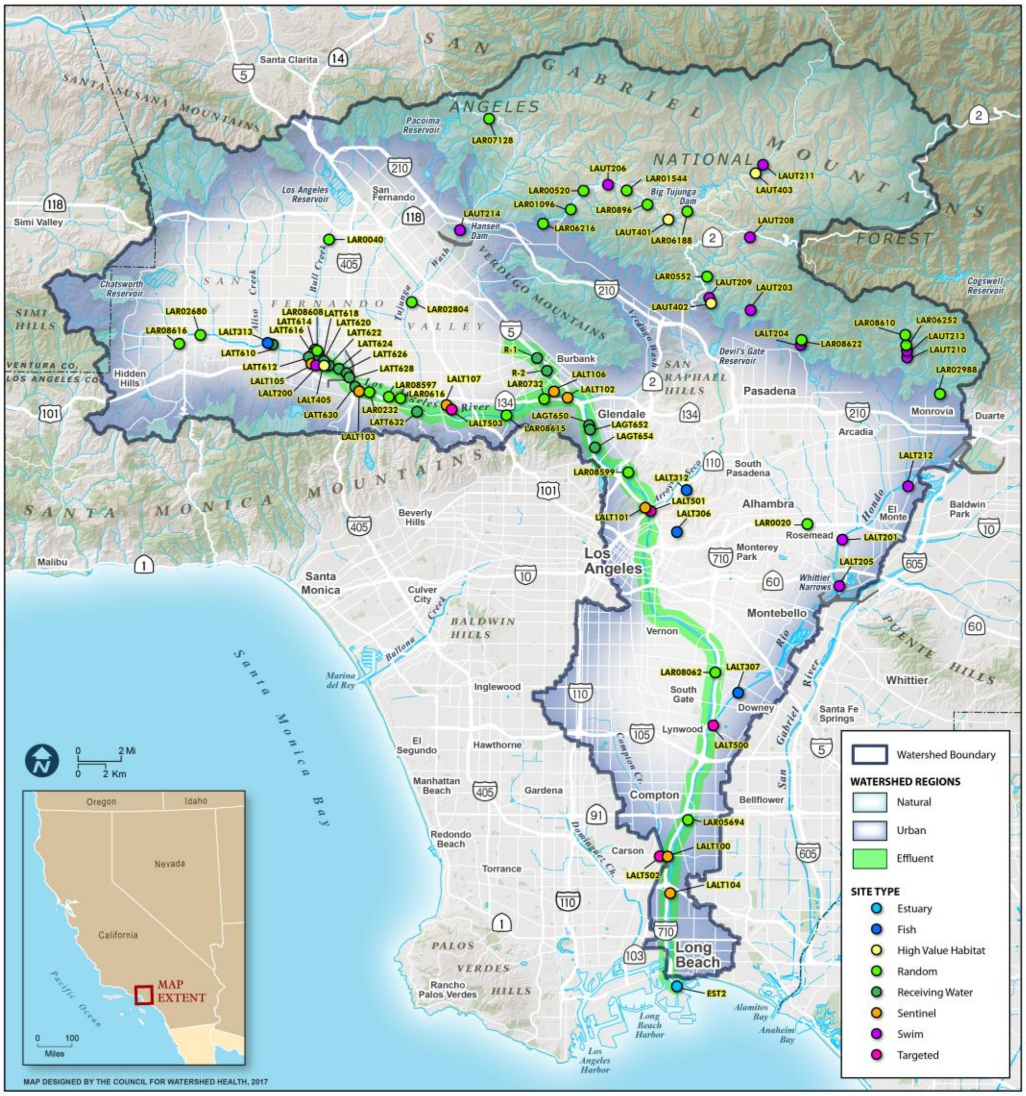

Table 1. Sampling and laboratory analysis responsibilities for random and target sites for 2016.

Spring/Summer 2016 Sampling	Site ID	Chemistry sampling	Chemistry lab analysis	Chemistry funding	Benthic Macroinvertebrates sampling	Benthic Macroinvertebrates lab analysis	Benthic Macroinvertebrates funding	Algae sampling	Algae lab analysis	Algae funding	Toxicity sampling	Toxicity lab analysis	Toxicity funding	CRAM assessment	CRAM funding
Targeted Sample															
Confluence of Rio Hondo and mainstem of LA River	LALT500	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	-	-	-	-	-
Confluence of Arroyo Seco and mainstem of LA River	LALT501	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	-	-	-	-	-
Confluence of Compton Creek and mainstem of LA River	LALT502	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	-	-	-	-	-
Confluence of Tujunga Creek and mainstem of LA River	LALT503	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	-	-	-	ABC	Cities
Random Samples															
Bull Creek (Urban)	LAR08608	ABC	EMD	Cities	ABC	ABC	Cities	-	-	-	-	-	-	ABC	Cities
Santa Anita Wash (Natural)	LAR08610	ABC	EMD	Cities	ABC	ABC	Cities	-	-	-	-	-	-	ABC	Cities
Los Angeles River (Urban)	LAR08615	ABC	EMD	Cities	ABC	ABC	Cities	-	-	-	-	-	-	ABC	Cities
Arroyo Calabasas (Urban)	LAR08616	ABC	EMD	Cities	ABC	ABC	Cities	-	-	-	-	-	-	ABC	Cities
Eaton Wash (Natrual	LAR08622	ABC	EMD	Cities	ABC	ABC	Cities	-	-	-	-	-	-	ABC	Cities
Trend Revisit Sites															
Los Angeles River (Effluent)	LAR0232	ABC	EMD	Cities	ABC	ABC	Cities	ABC	UCSM	SWAMP	-	-	-	ABC	Cities
Arroyo Seco (Natural)	LAR0552	ABC	EMD	Cities	ABC	ABC	Cities	ABC	UCSM	SWAMP	-	-	-	ABC	Cities
Revisit Sites															
Bull Creek (Urban)	LAR0040	ABC	EMD	Cities	ABC	ABC	Cities	ABC	UCSM	SWAMP	-	-	-	ABC	Cities
Alhambra Wash (Urban)	LAR0020	ABC	EMD	Cities	ABC	ABC	Cities	ABC	UCSM	SWAMP	-	-	-	ABC	Cities
Big Tujunga Creek (Natural)	LAR01096	ABC	EMD	Cities	ABC	ABC	Cities	ABC	UCSM	SWAMP	-	-	-	ABC	Cities
Big Tujunga Creek (Natural)	LAR01544	ABC	EMD	Cities	ABC	ABC	Cities	ABC	UCSM	SWAMP	-	-	-	ABC	Cities
Estuary															
Los Angeles River Estuary	LAREST2	EMD	EMD	Cities	EMD	EMD	Cities	-	-	-	EMD	EMD/ABC	Cities	NA	NA

Table 2. Sampling and laboratory analysis responsibilities for bacteria monitoring in 2016.

Spring/Summer Sampling	Site ID	Microbiology sampling	Microbiology lab analysis	Microbiology funding
Swimming Sites				
Bull Creek Sepulveda Basin	LALT200	EMD/ABC	EMD	Cities
Millard Campground[1.]	LALT203	---	---	---
Eaton Canyon Natural Area Park	LALT204	ABC	EMD	Cities
LA-Glendale R7	LALT207	EMD	EMD	Cities
Peck Rd Park	LALT212	CWH	EMD	Cities
Hansen Dam	LALT214	ABC	EMD	Cities
Big Tujunga Delta Flat Day Use	LAUT206	ABC	EMD	Cities
Oakwilde Campground or Switzer Falls/Campground	LAUT208	ABC	EMD	Cities
Gould Mesa Campground	LAUT209	CWH	EMD	Cities
Sturtevant Falls	LAUT210	ABC	EMD	Cities
Hidden Springs	LAUT211	ABC	EMD	Cities
Hermit Falls	LAUT213	CWH	EMD	Cities
Sentinel Sites				
Status &Trend Del Amo	LALT100	LACDPW	EMD	Cities
Status &Trend Figueroa St	LALT101	LACDPW	EMD	Cities
LA River Riverside Dr Cross	LALT102	LACDPW	EMD	Cities
Tillman R7	LALT103	LACDPW	EMD	Cities
LACDPW at Wardlow St	LALT104	LACDPW	EMD	Cities
Tillman Site I	LALT105	LACDPW	EMD	Cities
Status &Trend Burbank	LALT106	LACDPW	EMD	Cities
Status &Trend Tujunga Moorpak	LALT107	LACDPW	EMD	Cities

1. Site was closed to the public.

Table 3. Sampling and laboratory analysis responsibilities for fish tissue bioaccumulation monitoring.

Fish Tissue Bioaccumulaiton Sites	Site ID	Year	Bioaccumulation sampling	lab analysis	funding
Legg Lake	LALT308	2012	ABC/DFG	EMD	Cities
Lake Balboa	LALT301	2013	ABC/DFG	EMD	Cities
Belvedere Lake	LALT310	2014	ABC/DFG	EMD	Cities
Debs Lake	LALT312	2015	ABC/DFG	EMD	Cities
Reseda Lake	LALT313	2015	ABC/DFG	EMD	Cities
Peck Road Park (Lake)	LALT302	2016	ABC/DFG	EMD	Cities

Table 4. Monitoring design, indicators, and sampling frequency.

Question	Approach	Sites	Indicators	Frequency
Q1: What is the condition of streams?	Probabalistic design with streams assigned to natural, effluent dominated, urban runoff dominated sub-regions	6 randomly selected each year, 2 LARWMP re-visit sites, and 2 SMC re-visit sites	Bioassessment using BMIs and attached algae, physical habitat, CRAM, water chemistry	Annually, in spring/summer
Q2: What is the trend of condition at unique areas?	Fixed target sites located to detect changes over time	9 high value habitat sites	Riparian habitat condition: CRAM	2 to 4 sites rotating annually in summer
		4 confluence sites to major tributaries/mainstem	Bioassessment, physical habitat, water chemistry	Annually, in spring/summer
		1 LA River Estuary site	Sediment Quality Objective parameters: sediment chemistry, toxicity, infauna	Annually in the summer
		9 sentinel bacteria sites	*E. coli*	Weekly May to September
Q3: Are receiving waters below discharges meeting water quality objectives?	Use existing NPDES water quality data collected by LA River dischargers from receiving waters upstream and downstream of their discharge points.	Sites located upstream and downstream of discharges: - Los Angeles/Glendale - City of Burbank - Tillman Water Reclamation Plant	Constituents with established water quality standards, e.g. CTR for dissolved metals; *e. coli,* bacteria; trihalomethane(s); toxicity of fathead minnows	Varies depending on permit: monthly, quarterly, annual
Q4: Is it safe to swim?	Swim sites selected based on use by the public	10 sites located in ponds, reservoirs, streams and LA River	*E. coli*	Weekly May to September
Q5: Is it safe to eat locally caught fish?	Focus on popular fishing sites; commonly caught species; measuring high-risk chemicals	1-2 sites located in streams, reservoirs, lakes, rivers and estuary	Measure mercury, selenium, DDT and PCB in commonly caught sport and prey fish at each location	Annually in summer

[1] High-value sites are locations of relatively isolated, unique habitat

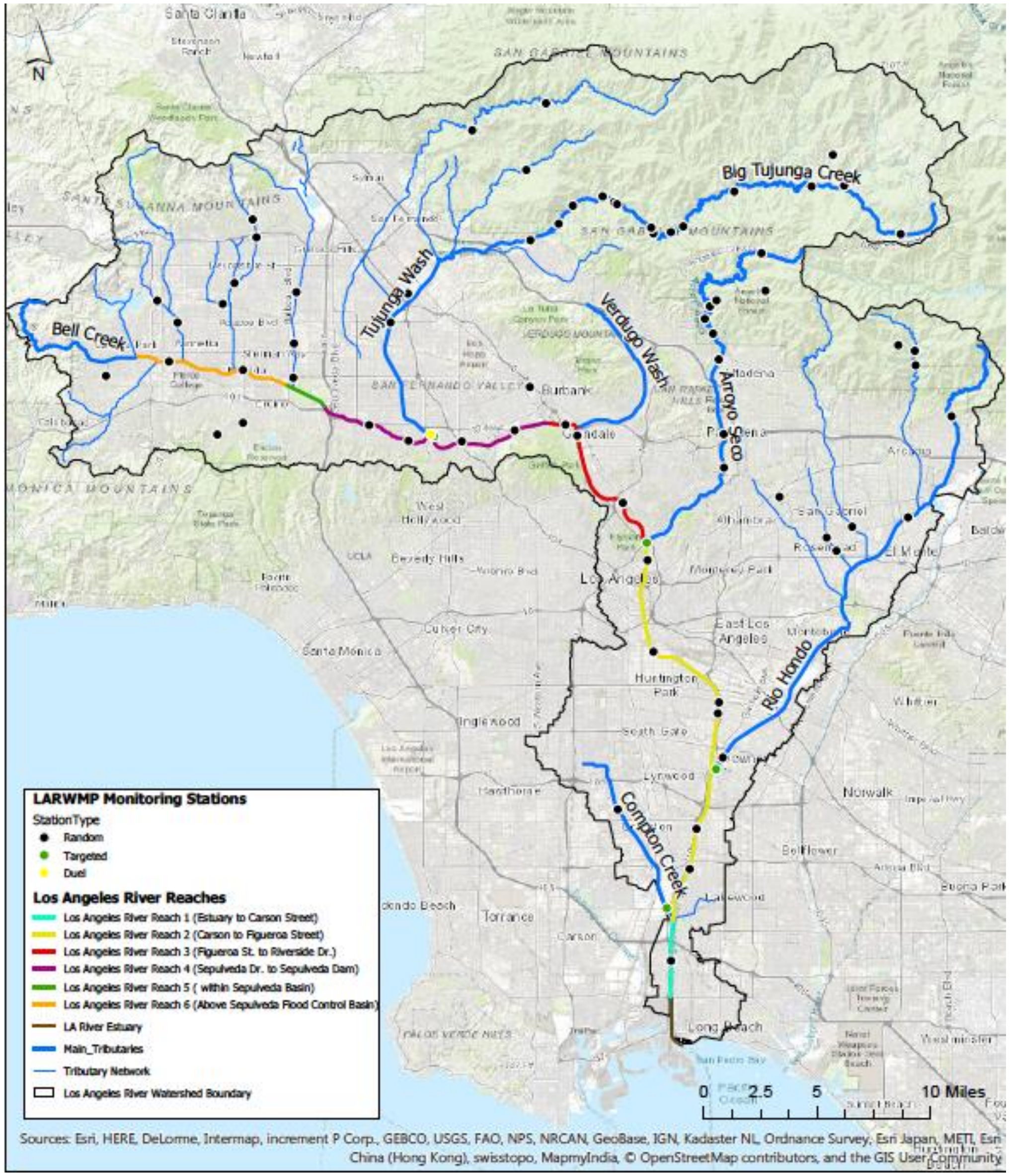

Figure 2. Reaches of the mainstem of the Los Angeles River

Table 5. Impairments (303d listed) along the main stem of the Los Angeles River by reach, only variables monitored by the LARWMP program are presented.

		303(d) listed Impairments															
Reach	Reach Segment	Ammonia	Copper	Lead	Nutrients (algae)	Cadmium	Coliform Bacteria	Copper	Cyanide	Diazinon	Zinc (dissolved)	pH	Selenium	DDT	PCB	Sediment Toxicity	Trash
LA River Estuary	Queensway Bay																
LA River Reach 1	Estuary to Carson St.																
LA River Reach 2	Carson to Figueroa St.																
LA River Reach 3	Figueroa St. to Riverside Dr.																
LA River Reach 4	Sepulveda Dr. to Sepulveda Basin																
LA River Reach 5	Sepulveda Basin																
LA River Reach 6	Above Sepulveda Flood Control Basin																

Table 6. Select beneficial uses of the main stem of the Los Angeles River. Note that * denote reaches where access is prohibited by LA County Department of Public Works. Only sites within the recreation zone are formal, regulated swim sites.

		Existing and Intermittent Beneficial Uses														
Reach	Reach Breaks	GWR	WARM	WILD	WET	REC1*	REC1	REC2	IND	COMM	EST	MAR	RARE	MIGR	SPWN	WET
LA River Estuary	Ends at Willow St.															
LA River Reach 1	Estuary to Carson St															
LA River Reach 2	Carson to Figueroa St															
LA River Reach 3	Riverside Dr to Figueroa St															
LA River Reach 4	Sepulveda Dr to Sepulveda Dam															
LA River Reach 5	Sepulveda Basin															
LA River Reach 6	Above Sepulveda Flood Control Basin															

Question 1. What is the condition of streams in the Los Angeles River Watershed?

1. Background

To determine the condition of streams in the Los Angeles River watershed, data were collected at 73 random sites during eight annual surveys from 2009 through 2016 (10 sites each year including annual site revisits; Figure 3). Sites are selected randomly to facilitate drawing statistically valid inferences about an area as a whole, rather than about just the site itself. Spatially, these sites are representative of the three major sub-regions: natural streams in the upper reaches of both the mainstem and tributaries, effluent-dominated reaches in the mainstem and the lower portions of the estuary, and urban runoff-dominated reaches of tributaries flowing through developed portions of the watershed.

Ambient surveys, which include both physical habitat assessments and bioassessments, can help identify and prioritize sites for protection or rehabilitation based on how sites compare to other regional sites. This type of data provides a measure of ecological health to aid in better understanding whether streams support aquatic life and assigned beneficial uses. Biological communities at stream sites respond to and integrate multiple stressors across both space and time, improving our understanding of the impact of stressors on stream communities (Mazor 2015).

In 2014, the Technical Stakeholder Group (TSG) agreed to modify the LARWMP sampling design based on design changes made by the Southern California Stormwater Monitoring Coalitions (SMC) Regional Monitoring Program. This design change was made to help improve our ability to detect changing conditions not only in the Los Angeles watershed but in the southern California region as a whole. The design incorporates site revisits at random sites previously sampled by the SMC program. In addition, the program began re-visits at sites previously sampled through the LARWMP program, contributing more information that can help us detect changing conditions in the Los Angeles watershed. Additionally, one random site known to be a non-perennial stream was added to the program to help address a regional gap in assessment of non-perennial streams, which make up 25% of stream miles in the watershed (SMC, 2015).

Figure 3. Location of random sampling sites from 2009 to 2016.

2. Methods

LARWMP employed benthic macroinvertebrates (CSCI), attached algae (So Ca Algal IBI), and riparian wetland habitat condition (CRAM) for the purpose of assessing biotic condition. A complete list of biotic condition indicators and water chemistry analytes collected for this program, including methods, units, and detection limits can be found in Appendix C, Table C1.

The field protocols and assessment procedures for BMIs and attached algae followed the protocols described by Ode (2007) and Fetscher *et al.* (2009). Briefly, BMIs were collected using a D kick-net from eleven equidistant transects along a 150-m reach and were identified to Level 2 (generally genus) as specified by the Southwest Association of Freshwater Invertebrate Taxonomists, Standard Taxonomic Effort List (SAFIT; Richards and Rogers 2006). Algal samples were collected one meter upstream of where BMI samples were collected using the protocols of Fetscher *et al.* (2009).

a. California Stream Condition Index

The California Stream Condition Index (CSCI) was used to assess the BMI community condition. The California Stream Condition Index (CSCI) is a statewide biological scoring tool that translates complex data about benthic macroinvertebrates (BMIs) found living in a stream into an overall measure of stream health (Mazor *et al*. 2015). The CSCI incorporates two indices, the multi-metric index, helpful in understanding ecological structure and function, and the observed-to-expected (O/E) index, which measures taxonomic completeness (Rehn et al. 2015). The CSCI was developed with a large data set spanning a wide range of environmental settings. Scores from nearly 2,000 study reaches sampled across California range from about 0.1 to 1.4 (Mazor *et al.,* 2015). For the purposes of making statewide assessments, three thresholds were established based on 30^{th}, 10^{th}, and 1^{st} percentile of CSCI scoring range at reference sites according to Rhen (2015) (Figure 4). These three thresholds divide the CSCI scoring range into 4 categories of biological condition as follows: ≥0.92 = likely intact condition; 0.91 to 0.80 = possibly altered condition; 0.79 to 0.63 = likely altered condition; ≤0.62 = very likely altered condition. While these ranges do not represent regulatory thresholds, they provide a useful method for interpreting CSCI results.

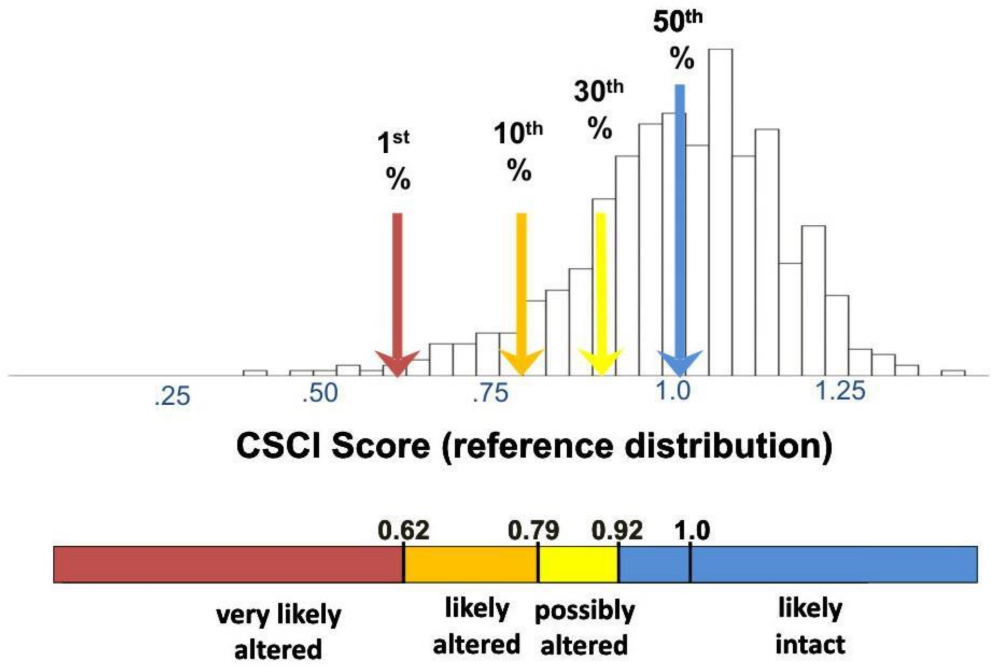

Figure 4. Distribution of CSCI scores at CA reference sites with thresholds and condition categories (Rhen et al., 2015).

b. Southern California Algal IBI

Attached algae compliment a weight-of-evidence approach in understanding stream community response to stress. Algae are useful indicators because they have short generation times, are responsive to a variety of environmental stressors, and are pervasive across stream substratum; they also work well in urbanized environments because BMIs are generally more closely related to habitat features instead of water quality (Fetscher et al. 2006). Both diatoms and soft body algae were used as indicators and identified to the lowest taxonomic resolution possible, which was typically the species level. The standardization of algae naming conventions was "harmonized" among the primary taxonomists at the California State University at San Marcos who developed the protocols. The Southern California multimetric attached algae IBI protocol was developed by Fetscher *et al.* (2013). Streams in reference condition are expected to have algal IBI scores >57.

c. California Rapid Assessment

Riparian wetland condition was assessed using the California Rapid Assessment Method (CRAM; Collins et al. 2008), a method developed by the USEPA and modified by SWAMP for use in California (Fetscher and McLauglin 2008). The method was developed to allow evaluation of statewide investments in restoring, protecting, and managing wetlands. Briefly, the CRAM method assesses four attributes of wetland condition: buffer and landscape, hydrologic connectivity, physical structure, and biotic structure. Each of these attributes is comprised of several metrics and sub-metrics that are evaluated in the field for a prescribed assessment area. The CRAM metrics are ecologically meaningful and reflect the relationship between stress and the high priority functions and ecological services of wetlands. The greater the CRAM score, the better the biotic, physical, hydrologic, and buffer zone condition of the habitat. Streams in reference condition are expected to have a CRAM score ≥72 (Mazor 2015). In addition, because CRAM scores provide insight into a stream's physical condition, they are often used as a surrogate for abiotic stress.

d. Physical Habitat

Physical habitat assessments were completed in conjunction with algal and benthic macroinvertabrate assessments to aid in the interpretation of biological data. Human alteration and the instream and topographical features that effect habitat quality and structure are important factors that shape aquatic communities (Barbour et al., 1999). Briefly, the same 11 equidistant transects that are used for the collection of BMI and algal samples were used in the assessment of wetted width, bank stability, discharge, substrate, canopy cover, flow habitats, bank dimensions, human influence, depth, algal cover, and cobble embededness. Ten inter-transects, at the mid-point of the 11 transects used for sample collection, were also used to collect information related to wetted width, flow habitats, and pebble counts. All physical habitat assessments were completed as specified by Ode (2007).

e. Aquatic Chemistry

Nutrients, major ions, and general chemistry--pH, dissolved oxygen, suspended solids, alkalinity, and hardness--was monitored at each site. Data was collected through the use of digital field probes that were deployed by field crews or via grab sample and lab analysis. Measured analytes and methods are described in Appendix C – Analyte List, Detection Limits and Methods.

f. Data Analysis

The R statistical package and excel were used for the majority of graphing and data analysis. Significant differences between regions were examined using the Kruskal Wallis nonparametric test and a Tukey's HSD test for post-hoc comparisons between regions. Multivariate analysis were done to better understand relationship between sites, measured variables, and to understand the variables that are important in determining CSCI and Algal IBI scores.

- A NMDS plot helps graphically represent the relationship between sites and variables in multidimensional space for non-parametric data. The NMDS was constructed using physical habitat and water chemistry data from 2009-2016. Data was pre-processed using a square root transformation. The dissimilarity between sites was calculated using Euclidian distance and plotted according to measures of similarity/dissimalirity. NMDS analysis do not allow missing data and to avoid discarding a large number of samples, a k nearest neighbor algorithm (k=3) was used to inpute data for the NMDS.
- Variable importance plots for predicting CSCI scores and algal IBI (and diatom and soft algae scores) were constructed using a random forest model. Physical habitat data from 2010-2016 was square root transformed and imputed, as described above, and input into the model. The random forest model shuffles data from a single variable while all other variables remain constant. The model is re-created using the permutated values, re-run, and the mean square error (MSE) compared to the original model to determine the variable importance. This is done for each variable. The random forest model generated variable importance plots shows a ranking of variables according to how much the MSE increased in modeled results when that variable was permutated.

3. Results

Summary results for all biotic condition measurements and water quality analytes by watershed sub-region are presented in Table 7.

a. Biotic Condition

A pattern of better biotic conditions in the natural regions of the watershed compared to the effluent dominated and urban reaches is consistently seen in algal IBI, CRAM, and CSCI scores (Figure 5, Figure 6, Figure 7). CSCI scores, CRAM, and algal IBI scores in the natural regions are significantly higher than the effluent dominated and urban sites ($p<0.001$).

The cumulative frequency distribution for the biotic condition index scores provides insight into the percentage of streams that are in reference and non-reference condition according to three different indicators of ecological health (Figure 8). In the Los Angeles River watershed the majority of sites are not in reference condition and have altered biological conditions. Over the 2009-2016 monitoring period, approximately 65% of all random sites had altered, or below reference condition for benthic macroinvertebrate communities (CSCI scores). Riparian zone habitat condition (CRAM) and algal communities (Algal IBI) were altered, or below reference thresholds, at roughly 60% of sites.

The CSCI scores across sites ranged from 0.21 to 1.35, with greater average and median CSCI scores found at the natural sites compared to the urban and effluent-dominated sites (Table 7, Figure 9). The CSCI scores from 2009-2016 range from 0.65 to 1.35 for natural sites, 0.35 to 0.72 for effluent dominated, and 0.21 to 0.80 for urban sites, showing the wide variability in benthic macroinvertebrate community condition within natural and urban regions.

The CSCI incorporates two indices, the multi-metric index, helpful in understanding ecological structure and function, and the observed-to-expected (O/E) index, which measures taxonomic completeness. For the O/E index, site degradation is reflected by a loss of expected taxa resulting in a lower O/E score. Effluent-dominated and urban sites had lower O/E scores reflecting the poor condition of benthic macroinvertebrates and taxa loss at sites in areas that are heavily urbanized (Figure 9).

Algal IBI scores mirrored other biotic indicators, showing higher median scores for the natural sites than effluent-dominated and urban sites (Figure 9). This pattern was mirrored in both diatoms ($p<0.001$) and soft algae ($p=0.006$), which both had significantly higher scores in natural compared to effluent and urban regions. In contrast, measures of algal biomass were highest at urban and effluent dominated sites. Variables that encourage algal growth, such as nutrients, warm temperatures, and sunlight, were also highest in urban and effluent dominated regions (Table 7).

The CRAM results underscore the contrast between the highly urbanized lower watershed and the relatively natural conditions found in the upper watershed (Figure 9). Development in the lower watershed has virtually eliminated natural streambed habitat and adjacent buffer zones. In most cases, the natural riparian vegetation has either been eliminated or replaced by invasive or exotic species.

Each CRAM score is composed of four individual attribute scores that define riparian habitat condition. They include buffer zone, hydrology, and physical and biotic structure (Figure 9). Natural sites were characterized by wide, undisturbed buffer zones, good hydrologic connectivity, and a multilayer, interspersed vegetative canopy composed of native species. In contrast, the urban and effluent-dominant sites often had no buffer zones, highly modified cement-lined channels, and lacked vegetative cover. Intermediate to these extremes were the effluent dominated sites along less disturbed soft bottom reaches.

Table 7. Summary statistics for biotic conditions and water quality analytes at all random sites combined, collected from 2009 to 2016.

	Watershed				Urban				Effluent				Natural			
Analyte	n=	mean ± stdev	min	max	n=	mean ± stdev	min	max	n=	mean ± stdev	min	max	n=	mean ± stdev	min	max
Biological Condition																
Benthic Macroinvertebrate (CSCI)	69	0.71 ± 0.27	0.21	1.35	26	0.50 ± 0.17	0.21	0.80	13	0.58 ± 0.13	0.35	0.72	30	0.96 ± 0.15	0.65	1.35
MMI	69	0.63 ± 0.26	0.19	1.43	26	0.44 ± 0.13	0.23	0.69	13	0.45 ± 0.11	0.19	0.58	30	0.87 ± 0.17	0.59	1.43
O/E	69	0.80 ± 0.30	0.12	1.32	26	0.55 ± 0.23	0.12	0.99	13	0.71 ± 0.17	0.45	0.89	30	1.05 ± 0.17	0.71	1.32
Attached Algae (So CA IBI)	59	46 ± 22	9	95	21	36 ± 18	11	80	10	25 ± 16	9	54	28	61 ± 17	32	95
S2	60	43 ± 19	13	82	22	35 ± 16	13	70	10	33 ± 10	20	48	28	54 ± 20	17	82
D18	59	50 ± 26	4	100	21	40 ± 24	12	92	10	25 ± 20	4	62	28	66 ± 19	28	100
Riparian Habitat Score (CRAM)	69	55 ± 22	27	99	26	36 ± 7	27	64	13	38 ± 5	27	47	30	78 ± 9	63	99
BioticStructure	69	47 ± 25	22	97	26	28 ± 10	22	69	13	27 ± 5	22	36	30	72 ± 17	39	97
BufferLandscape	69	72 ± 21	25	100	26	54 ± 17	25	88	13	61 ± 11	25	68	30	91 ± 6	75	100
Hydrology	69	56 ± 25	25	100	26	36 ± 9	25	58	13	36 ± 10	25	58	30	82 ± 12	58	100
PhysicalStructure	69	44 ± 24	25	100	26	26 ± 5	25	50	13	25 ± 0	25	25	30	68 ± 17	38	100
InSitu Measurements																
Temperature (C°)	69	21.34 ± 5.86	10.97	35.31	26	24.13 ± 6.28	13.84	35.31	13	24.46 ± 4.43	18.40	32.80	30	17.58 ± 3.52	10.97	25.03
Dissolved Oxygen (mg/L)	69	9.34 ± 2.49	5.10	17.45	26	10.26 ± 2.65	7.31	16.81	13	10.43 ± 3.32	5.10	17.45	30	8.07 ± 0.96	6.40	10.48
pH	69	8.32 ± 0.68	7.10	10.80	26	8.67 ± 0.82	7.42	10.80	13	8.47 ± 0.53	7.42	9.15	30	7.96 ± 0.37	7.10	8.51
Salinity (ppt)	68	0.46 ± 0.35	0.13	1.93	26	0.69 ± 0.44	0.14	1.93	12	0.53 ± 0.07	0.36	0.60	30	0.23 ± 0.06	0.13	0.37
SpecificConductivity (us/cm)	69	886 ± 630	8	3681	26	1289 ± 805	8	3681	13	1072 ± 98	797	1154	30	455 ± 123	245	751
General Chemistry																
Alkalinity as CaCO3 (mg/L)	69	249 ± 525	77	4520	26	350 ± 854	77	4520	13	141 ± 29	100	206	30	209 ± 41	119	272
Hardness as CaCO3 (mg/L)	65	315 ± 355	94	2540	24	479 ± 548	94	2540	13	240 ± 46	178	310	28	209 ± 56	96	370
Chloride (mg/L)	66	82 ± 76	5	295	25	131 ± 70	11	295	13	144 ± 18	109	163	28	9 ± 3	5	15
Sulfate (mg/L)	66	177 ± 350	4	2360	25	345 ± 525	17	2360	13	170 ± 22	146	211	28	30 ± 31	4	135
TSS (mg/L)	54	54 ± 198	0	1330	19	132 ± 324	5	1330	11	30 ± 24	8	94	24	4 ± 4	0	17
Nutrients																
Ammonia as N (mg/L)	69	0.2 ± 1.2	0.0	10.0	26	0.5 ± 1.9	0.0	10.0	13	0.1 ± 0.1	0.0	0.4	30	0.0 ± 0.0	0.0	0.1
Nitrate as N (mg/L)	69	1.2 ± 1.7	0.0	5.8	26	1.1 ± 1.4	0.0	4.3	13	3.9 ± 1.3	1.0	5.8	30	0.1 ± 0.1	0.0	0.5
Nitrite as N (mg/L)	69	0.0 ± 0.1	0.0	0.4	26	0.0 ± 0.0	0.0	0.1	13	0.1 ± 0.1	0.0	0.4	30	0.0 ± 0.0	0.0	0.0
NitrogenTotal (mg/L)	69	3.7 ± 5.5	0.0	38.8	26	5.9 ± 7.8	0.2	38.8	13	6.2 ± 1.2	3.9	8.0	30	0.7 ± 1.2	0.0	6.5
OrthoPhosphate as P (mg/L)	69	0.1 ± 0.2	0.0	1.1	26	0.2 ± 0.2	0.0	0.8	13	0.1 ± 0.1	0.0	0.3	30	0.1 ± 0.2	0.0	1.1
Phosphorus as P (mg/L)	69	0.3 ± 0.4	0.0	2.2	26	0.5 ± 0.5	0.0	2.2	13	0.3 ± 0.1	0.1	0.4	30	0.1 ± 0.2	0.0	1.3
Dissolved Organic Carbon (mg/L)	69	7.2 ± 7.4	1.4	37.6	26	12.3 ± 9.9	1.8	37.6	13	6.8 ± 0.4	6.1	7.4	30	3.0 ± 1.4	1.4	6.8
Total Organic Carbon (mg/L)	69	9.8 ± 14.3	0.2	102.2	26	14.3 ± 11.8	2.5	42.0	13	8.1 ± 1.4	6.8	10.8	30	6.8 ± 18.2	0.2	102.2
Algal Biomass																
AFDM (mg/cm^2)	61	6.44 ± 15.65	0.52	113.38	20	3.14 ± 2.27	1.10	10.49	12	19.55 ± 32.50	1.18	113.38	29	3.30 ± 3.80	0.52	15.87
Chl-a (ug/cm^2)	61	5.12 ± 4.95	0.41	22.58	20	6.52 ± 6.00	0.96	22.58	12	4.49 ± 4.38	0.41	13.87	29	4.42 ± 4.30	0.52	16.95
Dissolved Metals																
Arsenic (ug/L)	56	1.8 ± 1.4	0.0	6.5	24	2.4 ± 1.4	0.1	6.5	7	1.7 ± 1.0	0.3	3.1	25	1.3 ± 1.4	0.0	5.4
Cadmium (ug/L)	60	0.1 ± 0.1	0.0	0.4	26	0.1 ± 0.1	0.0	0.3	7	0.2 ± 0.1	0.0	0.4	27	0.0 ± 0.0	0.0	0.0
Chromium (ug/L)	58	1.7 ± 1.5	0.1	7.5	24	2.0 ± 1.7	0.2	7.5	7	1.6 ± 0.6	0.5	2.5	27	1.5 ± 1.5	0.1	7.3
Copper (ug/L)	60	6.0 ± 7.2	0.0	30.6	26	11.0 ± 8.3	0.6	30.6	7	5.9 ± 3.0	1.5	9.0	27	1.2 ± 0.6	0.0	2.9
Iron (ug/L)	60	58.8 ± 65.8	2.5	337.0	26	69.9 ± 65.3	2.5	253.0	7	43.0 ± 52.0	12.2	156.0	27	52.3 ± 69.7	2.6	337.0
Lead (ug/L)	60	0.2 ± 0.3	0.0	1.3	26	0.3 ± 0.3	0.0	1.3	7	0.3 ± 0.1	0.1	0.5	27	0.1 ± 0.1	0.0	0.2
Mercury (ug/L)	60	0.0 ± 0.0	0.0	0.0	26	0.0 ± 0.0	0.0	0.0	7	0.0 ± 0.0	0.0	0.0	27	0.0 ± 0.0	0.0	0.0
Nickel (ug/L)	60	5.1 ± 11.7	0.5	78.0	26	8.8 ± 17.1	0.7	78.0	7	5.4 ± 2.1	1.7	7.8	27	1.5 ± 0.8	0.5	3.9
Selenium (ug/L)	60	1.0 ± 1.9	0.1	11.5	26	1.8 ± 2.6	0.1	11.5	7	1.2 ± 0.5	0.2	1.6	27	0.1 ± 0.1	0.1	0.3
Zinc (ug/L)	60	8.5 ± 9.1	0.7	42.2	26	9.4 ± 6.9	1.5	24.2	7	25.7 ± 10.5	8.4	42.2	27	3.2 ± 2.3	0.7	13.2

Figure 5. CSCI scores based on probabilistic sites sampled from 2009 to 2016. Likely intact condition = CSCI ≥0.92; possibly altered condition = CSCI 0.91 to 0.80; likely altered condition = CSCI 0.79 to 0.63; very likely altered condition = CSCI ≤0.62.

Figure 6. So Ca Algal IBI Scores for LARWMP probabilistic sites sampled from 2009 to 2016. Sites with scores >57 are in reference condition.

Figure 7. CRAM scores based on probabilistic sites sampled from 2009 to 2016. Likely intact condition = CRAM ≥79; possibly altered condition = CRAM 79 to 72; likely altered condition = CRAM 72 to 63; very likely altered condition = CRAM ≤63.

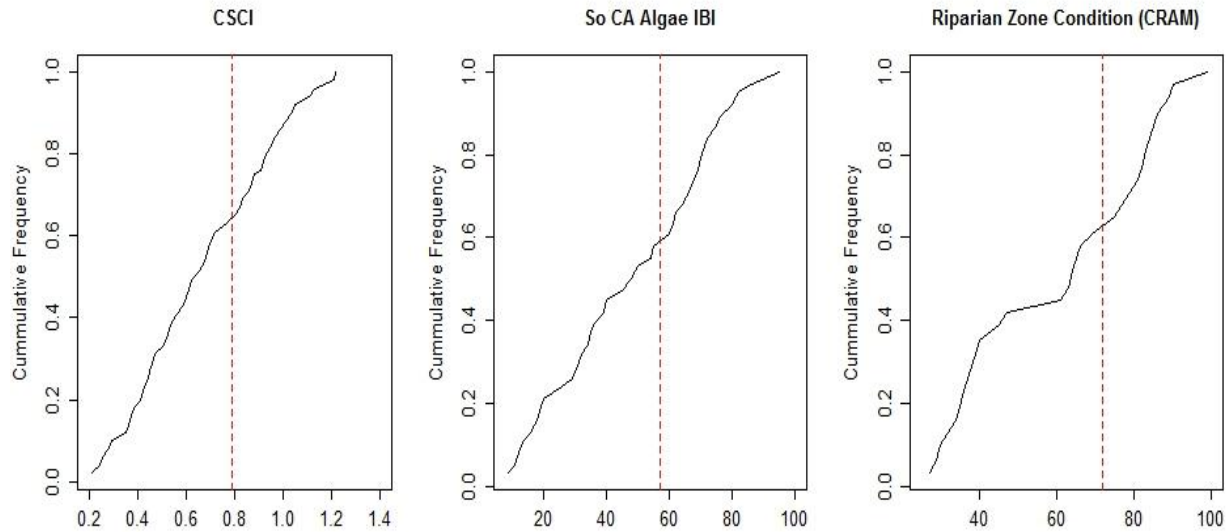

Figure 8. Cumulative frequency distribution of CSCI, Algal IBI, and CRAM scores at random sites from 2009-2016.

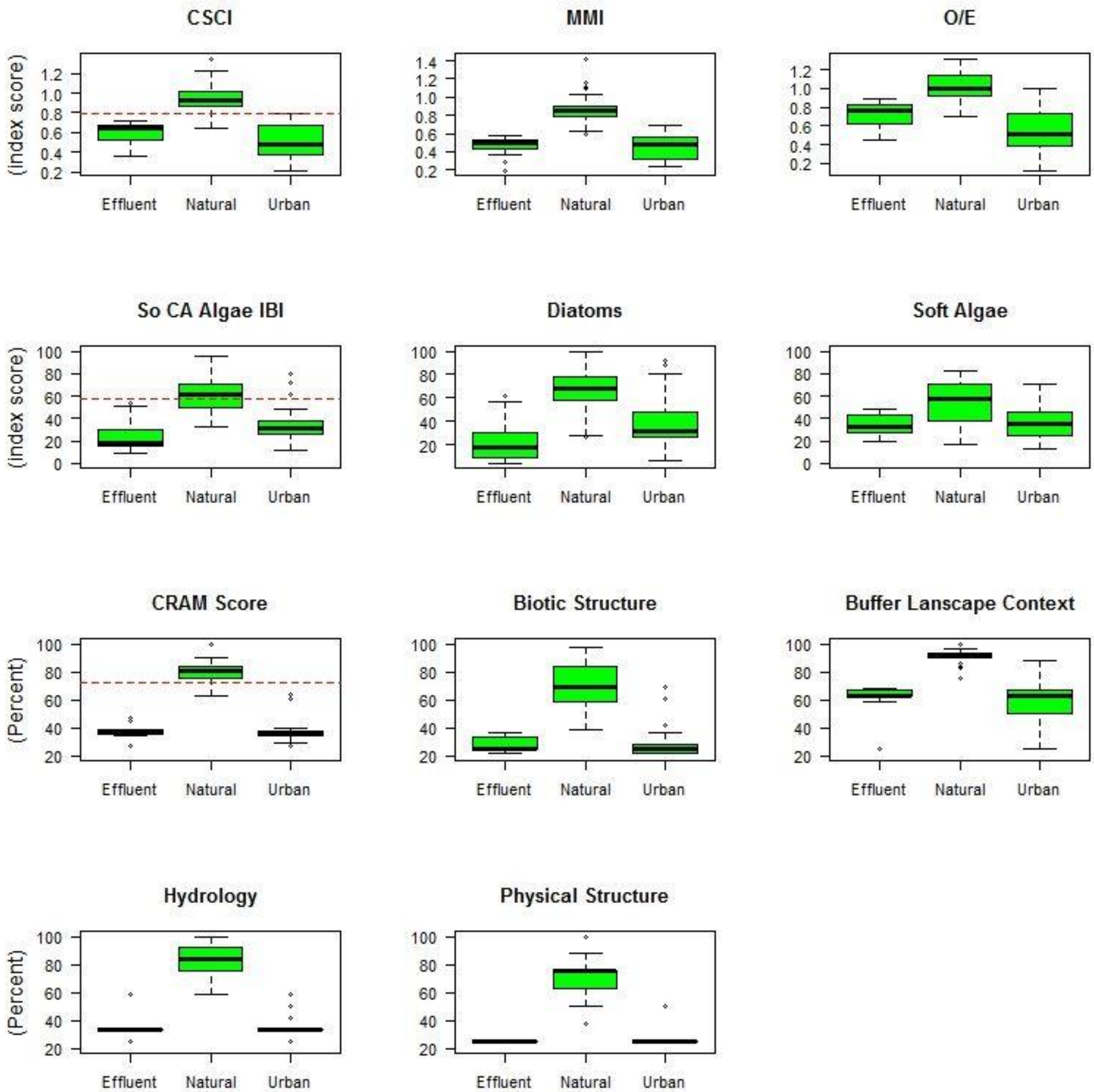

Figure 9. CSCI, Algal IBI, and CRAM scores and attribute scores for effluent, natural, and urban random sites from 2009-2016. CRAM attribute scores include measures of biotic structure, buffer landscape context, hydrology, and physical structure.

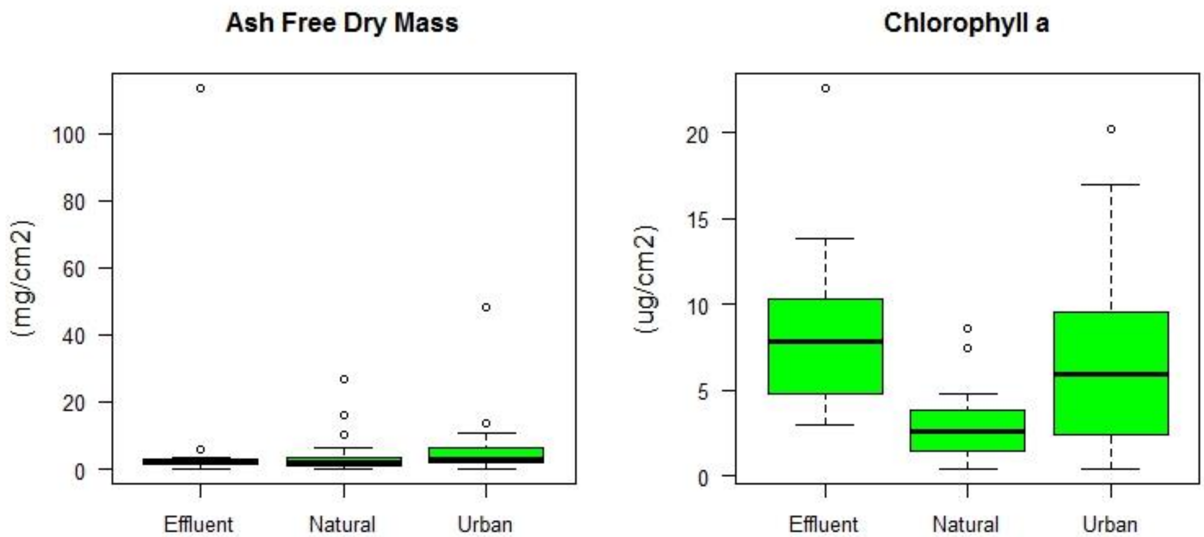

Figure 10. Ash free dry mass and chlorophyll a concentrations, both methods that quantify algal biomass, in effluent, natural, and urban regions in the watershed.

Figure 11 shows the proportion of BMI feeding groups represented in each of the three watershed sub-regions for all random sites from 2009 to 2016. Collectors, a feeding assemblage that feeds on fine particulate organic matter in the stream bottom, were the dominant group in each sub-region. Collectors make up a larger proportion of the total in the effluent-dominated and urban regions of the watershed. Effluent-dominated regions had five feeding groups and urban sites had 4 feeding groups. These regions are mostly concrete-lined and/or highly channelized reaches with little or no canopy cover and substrate complexity. The upper watershed communities had a more balanced assemblage represented by eight feeding groups (omnivores in the natural sites made up a 0.18 proportion of feeding groups but are not represented in the pie chart). Filterers were more prevalent in this sub-region, generally indicating better water quality conditions (Vannote et al. 1980). The parasite feeding group was missing from all sub-regions and despite studies suggesting their importance to community structure and community functioning (Mouritsen and Poulin, 2005), few studies have been done on this BMI feeding assemblage to date.

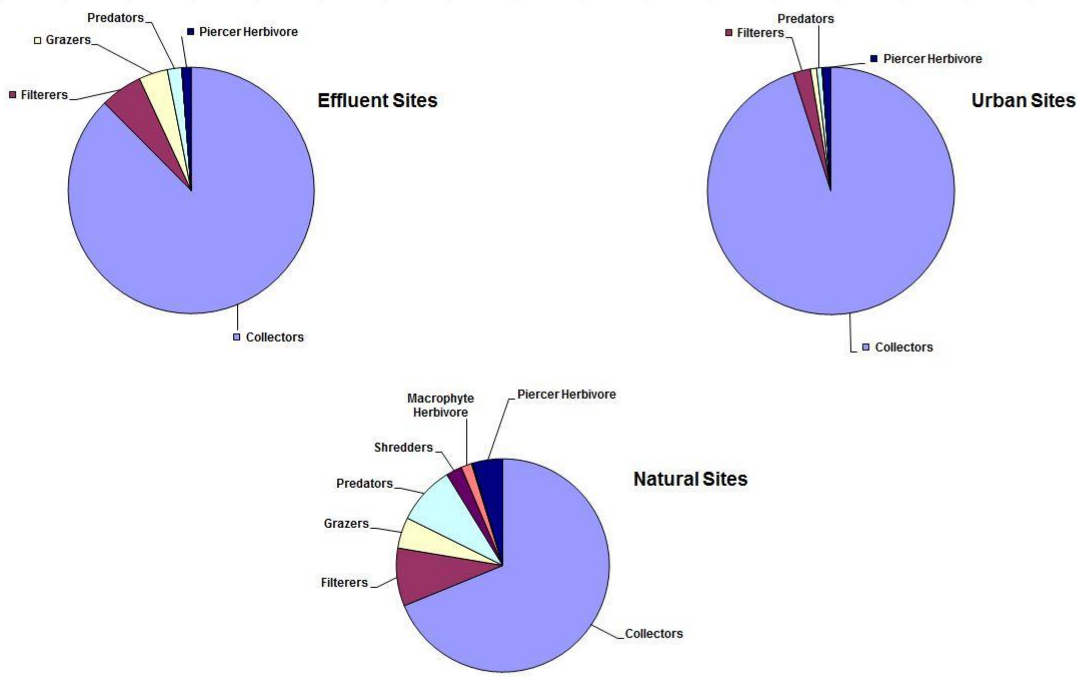

Figure 11. Relative proportion of benthic macroinvertebrate functional feeding groups in each watershed sub-region for 2008-2016 random sites.

b. Aquatic Chemistry and Physical Habitat

The spatial pattern of nutrient concentrations in the watershed is shown in Figure 12. Effluent-dominated and urban sites had greater median concentrations of nutrients compared to natural sites, though nutrient concentrations did not vary significantly by region with the exception of nitrate and total nitrogen ($p<0.05$). Average nitrate and total nitrogen concentrations were highest in the effluent-dominated stream segments. Nitrate-nitrogen concentrations were largely below the Basin Plan objective of 10 mg/L. Other water quality parameters that showed large and statistically significant differences between natural and effluent/urban sub-regions included conductivity, sulfate, temperature, and chloride ($p<0.01$)—all were lowest at natural sites (Table 7) where reduced runoff, salt and nutrient inputs, and surrounding shady habitat likely explain observed patterns.

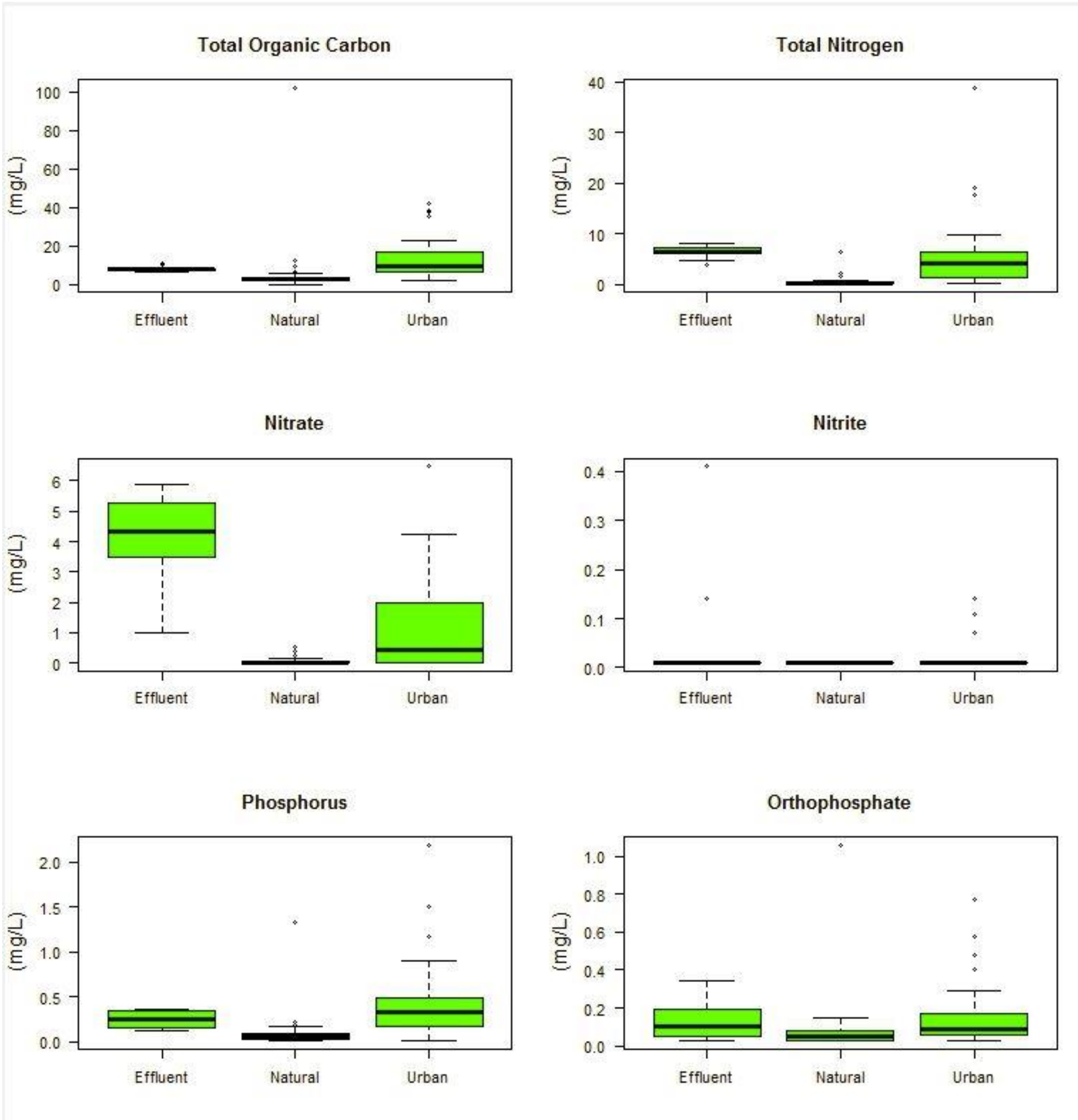

Figure 12. Box-and-whisker plots showing the median and range of representative nutrients measures in each of the three Los Angeles River watershed regions from 2009-2016.

c. Physical Habitat Assessments

Physical habitat was assessed using SWAMP (2007) protocols, which focus on streambed quality and the condition of the surrounding riparian zone out to 50 meters. Physical habitat conditions were generally best in the upper watershed compared to the lower watershed (Figure 13), specifically in terms of percent canopy, channel alteration, and epifaunal substrate cover. The epifaunal substrate is a measure of the amount of natural streambed complexity due to the presence of cobble, fallen trees, undercut stream banks, etc. This complexity is important for healthy benthic macroinvertebrate and fish communities. Channel alteration was limited at natural sites (thus higher scores), while the effluent-dominated and urban sites are mostly channelized and concrete-lined resulting in their poor scores. Percent bank erosion and sediment deposition (low sediment deposition results in a higher score) are misrepresentative in the urban and effluent-dominated reaches due to the high degree of channelization and channel alteration limiting erosional processes.

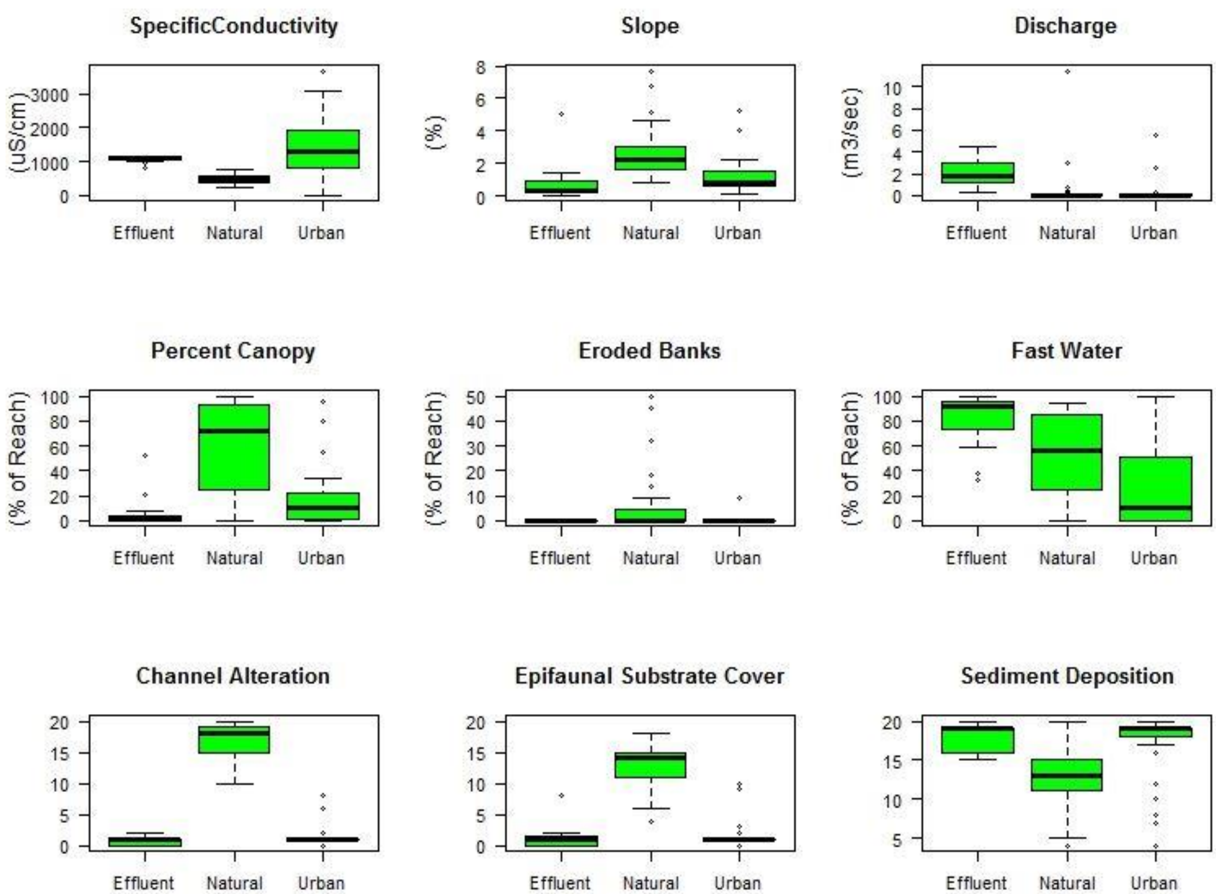

Figure 13. Box-and-whisker plots showing the median and range of representative physical habitat parameters measured in each of the three Los Angeles River watershed regions from 2009-2016. Channel alteration, epifaunal substrate cover, and sediment deposition are scored assessments, higher scores denote better condition.

d. Relationship between Physical and Biological Conditions

Our final step in assessing the health of streams in the watershed was to analyze how physical habitat and environmental variables were associated with observed biotic conditions. Non-metric Multidimensional Scaling (NMDS) was used to ordinate all the physical habitat and chemistry data to look for patterns in the spatial relationship between sites and biotic conditions. Figure 14 shows that the natural watershed sites are clearly separated from effluent dominated and urban sites, which cluster together. While NMDS is not a statistical test, plots can help show the relationship between variables and sites. For example, no single physical habitat or water chemistry variable had a large effect on NMDS clustering. Sites in natural regions are closely associated and clustered with physical habitat variables. Sites in the effluent and urban segments clustered around water chemistry and physical habitat variables that are altered/elevated—such as temperature, nutrients, ionic strength-- in urbanized portions of the watersheds. The urban sites were less tightly clustered and revealed the range of condition at sites along urban tributaries.

Variable importance plots for predicting CSCI scores (Figure 15) and algal IBI and sub-metric scores (Figure 16, Figure 17, Figure 18) were constructed using a random forest (RF) model. The random forest model generated variable importance plots show a ranking of variables according to how much the MSE increased in modeled results when that variable was permutated. Physical habitat variables like stream substrate, channel alteration, and percent asphalt were the most important variables according to the random forest model predictions of CSCI scores (Figure 15).

A combination of physical habitat, ionic strength, and nutrient variables were strong predictors of algal IBI scores according to the RF model (Figure 16). The variables that were important predictors of diatom versus soft algal assemblage scores did vary. Diatom scores were most closely associated with variables related to ionic strength and salinity (Figure 17). Soft algae scores were more closely associated with nutrient variables (Figure 18).

Stressors, as defined by this report, are chemical or physical factors or environmental conditions that alter algal and BMI communities. Stressors can include: temperature, discharge rates, lack of suitable habitat complexity, and chemical contamination. The variables identified as important through the RF model varied depending on the biotic index but included physical habitat, variables impacting ionic strength, and nutrients, consistent with the high priority stressors identified by regional analysis (Mazor, 2015).

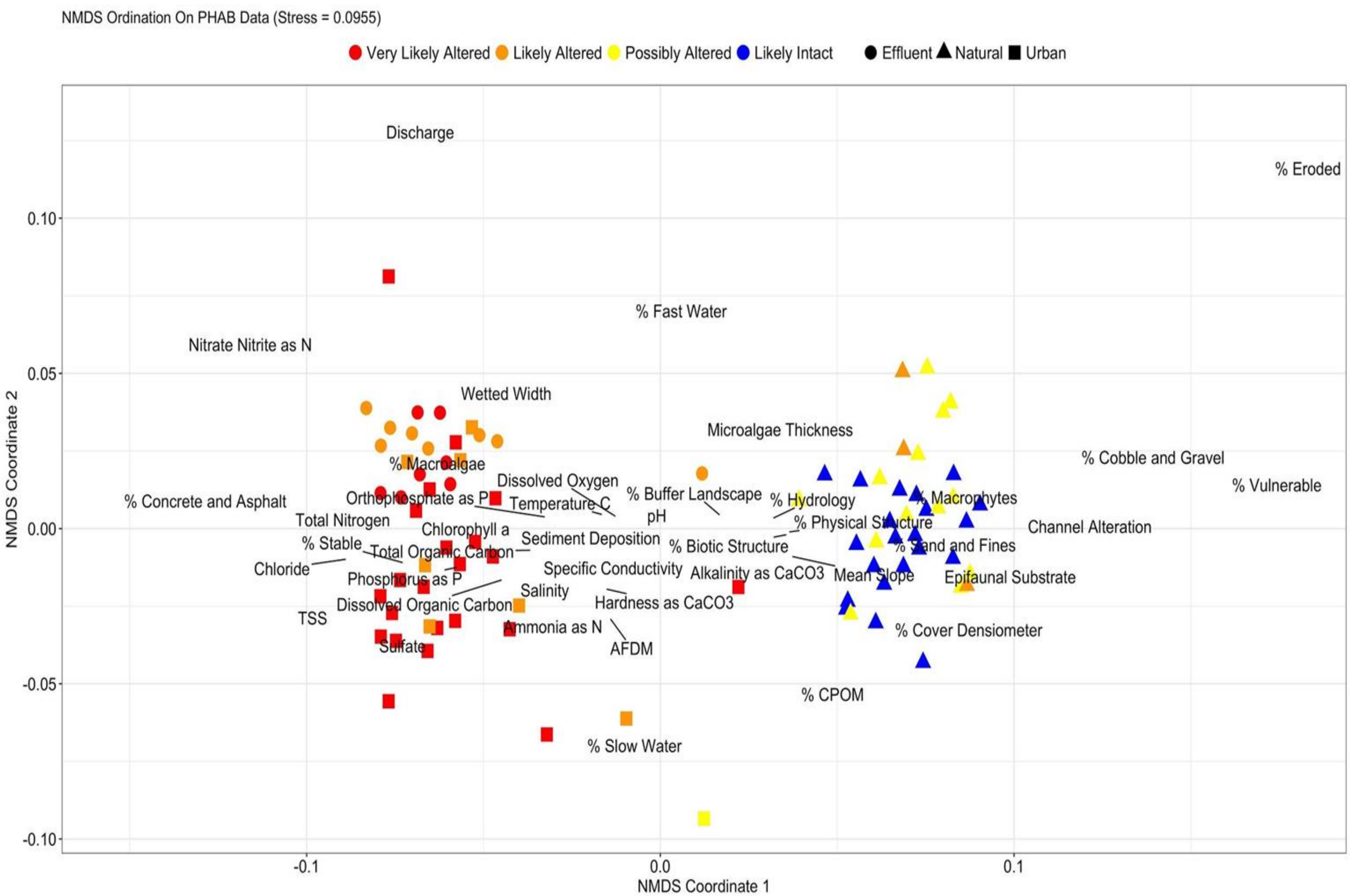

Figure 14. Multi-dimensional scaling using physical habitat data. Watershed sub-regions are depicted by shape, while CSCI scores are represented by color (N = 82, square root transformation, stress = 0.0955).

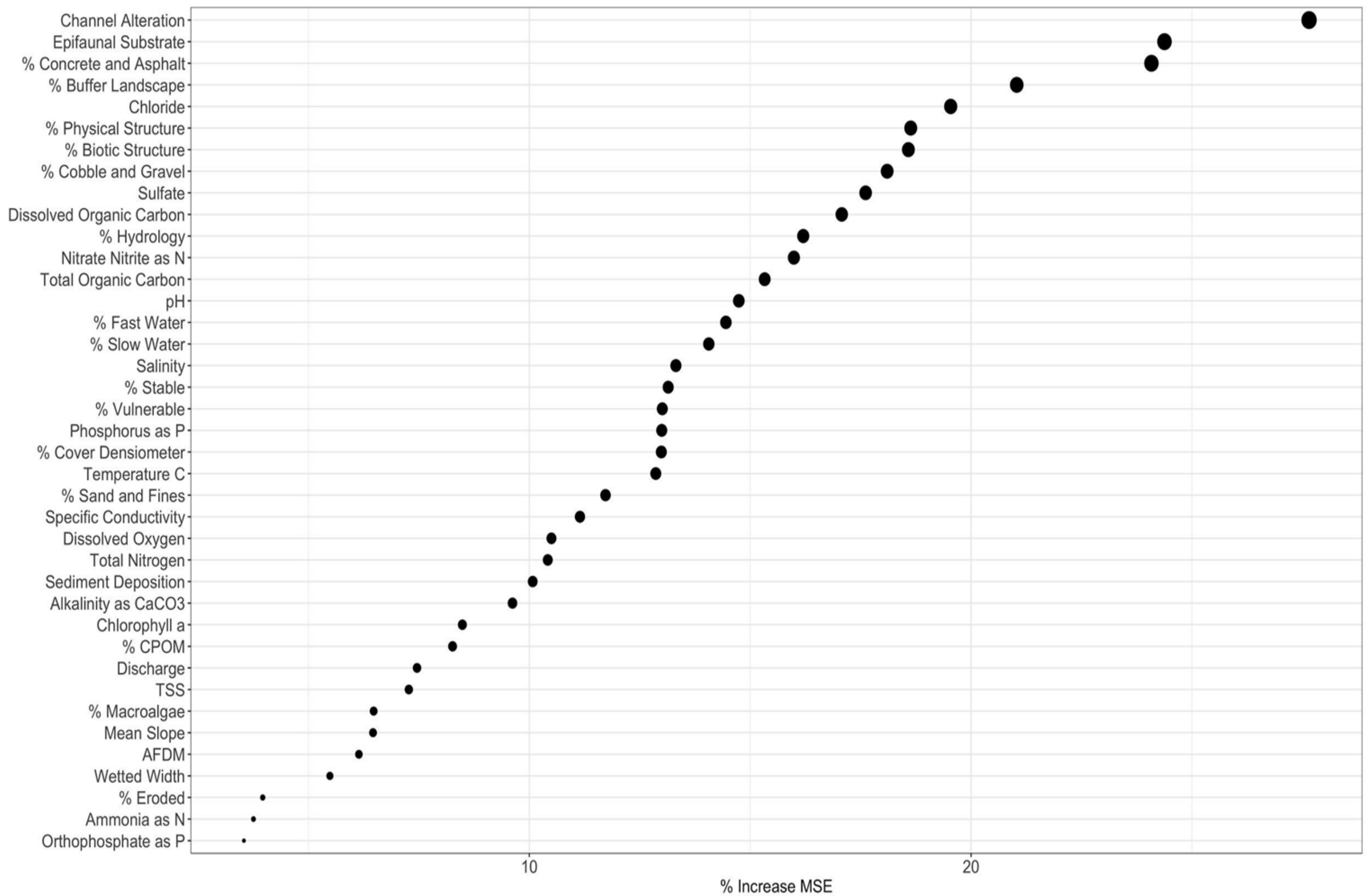

Figure 15. Variable importance plot showing an evaluation of the strength of association of the environmental variables to the biological condition using a random forest model that was created using physical habitat data (2009-2016) to predict CSCI scores (N = 82, square root transformation).

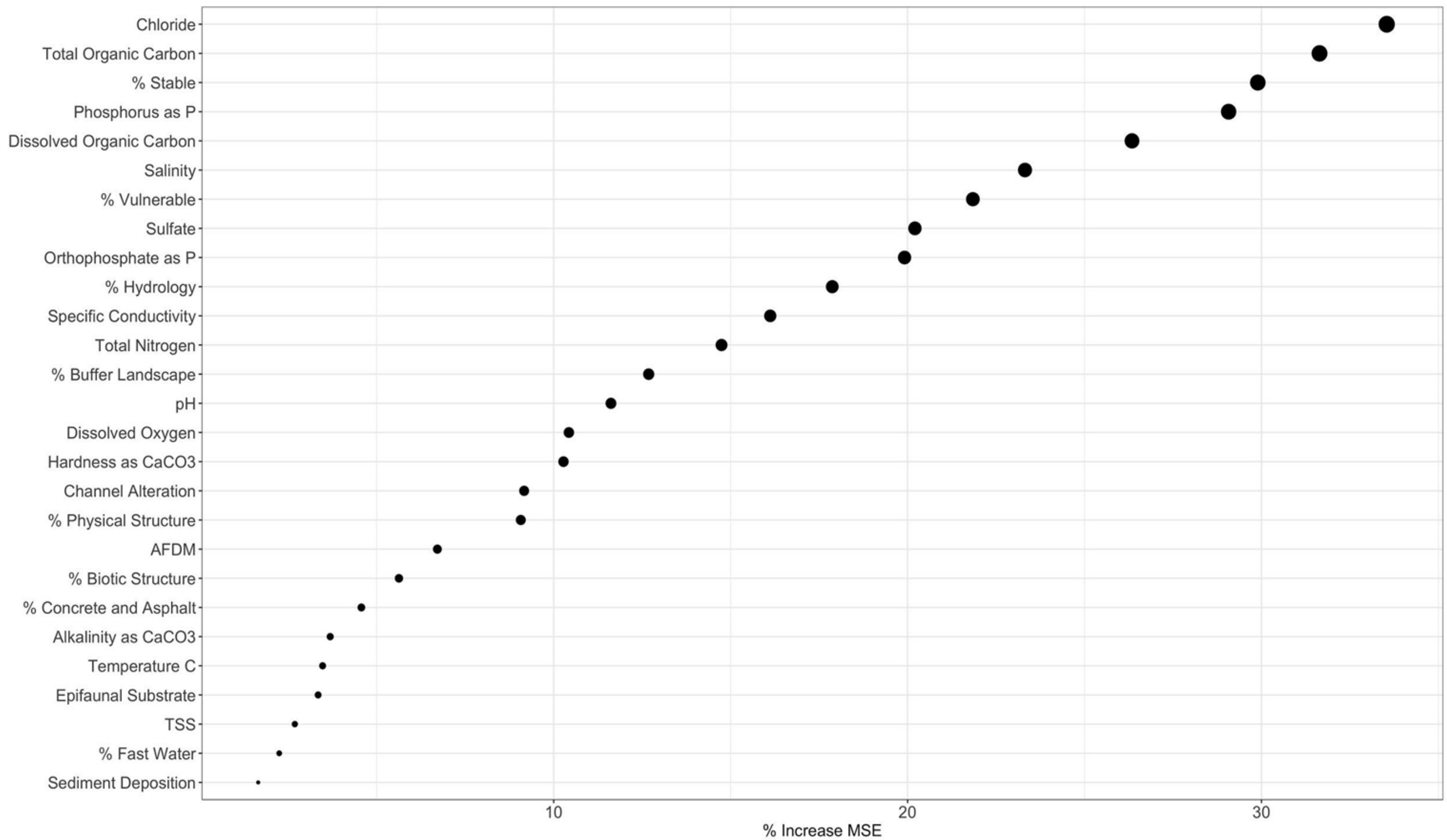

Figure 16. Variable importance plot showing an evaluation of the strength of association of the environmental variables to the biological condition using a random forest model that was created using physical habitat data (2009-2016) to predict algal IBI scores (N =65, square root transformation

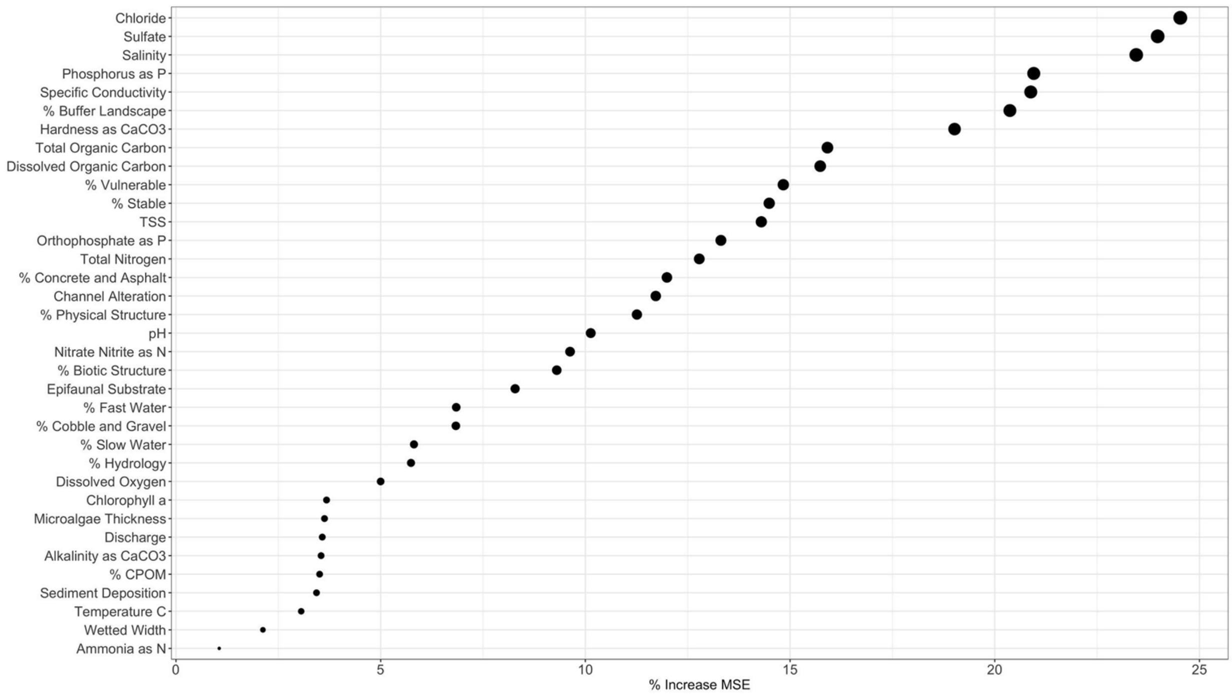

Figure 17. Variable importance plot showing an evaluation of the strength of association of the environmental variables to diatom scores using a random forest model that was created using physical habitat data (2009-2016, N =65, square root transformation).

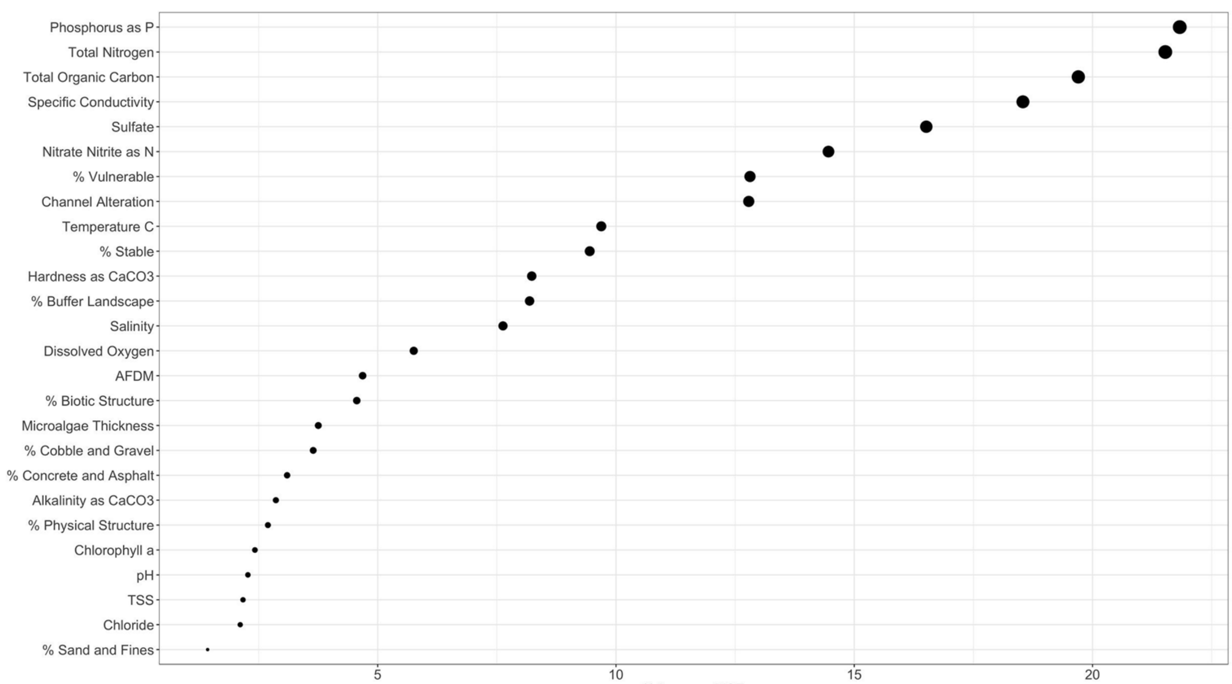

Figure 18. Variable importance plot showing an evaluation of the strength of association of the environmental variable to soft algae scores using a random forest model created using physical habitat data (2009-2014, N = 66, square root transformation).

Chapter Summary: Question 1

This portion of the program is designed to assess the dry-weather ambient condition of streams in the watershed based on a probabilistic sampling design. Seventy-three random sites have been monitored from 2009 to 2016 and measured for biotic and riparian zone condition, water chemistry, and physical habitat condition.

Key findings include:

- Biotic condition was measured using benthic macroinvertebrates (BMIs), algal IBI, and riparian zone condition. Each of the indices showed that biological conditions in the natural sites of the upper watershed were significantly better than effluent and urban sites.
    - Benthic macroinvertebrate communities were altered compared to reference condition at approximately 65% of sites. Riparian zone habitat condition and algal communities were both below the reference threshold in roughly 60% of sites.
    - BMI and algal communities were healthiest in the upper watershed compared to the lower watershed, where lined and altered channels predominate.
    - The condition of physical habitat can play an important role in structuring aquatic communities. Riparian zone physical habitat conditions ranged from nearly pristine in the upper watershed to highly degraded in the channelized lower watershed and effluent-dominated channel, as measured by the California Rapid Assessment Method (CRAM). Physical habitat assessments showed urban/effluent sites to have higher channel alteration, less substrate cover, and lower canopy cover.
- Nutrients were consistently lower at natural sites, when compared to urban and effluent sites from 2009 to 2015. Nitrate and total nitrogen were significantly higher in the effluent-dominated channel, but nitrate concentrations were below the Basin Plan objective of 10 mg/L for nitrate-nitrogen.

- Ordination analysis showed a clear distinction between upper and lower watershed sites. Sites in the upper watershed were associated with physical habitat variables such as epifaunal cover, percent cover, and stream substrate cover-% cobble and % sand and fines-while lower watershed sites clustered around water chemistry and physical habitat variables.

- Variable importance plots for CSCI scores showed that physical habitat conditions (epifaunal substrate, %concrete, and channel alteration) were important variables associated with CSCI scores. Both water chemistry and physical habitat were important variables associated with algal IBI scores.

Question 2. Are conditions at areas of unique interest getting better or worse?

1. Background

Question 2 monitoring efforts focus on specific locations in the watershed that represent unique areas of special concern to the workgroup. These sites are monitored annually to help better understand how conditions in the watershed are changing over time and when protection or restoration is needed. For this purpose, four separate programs were created:

- Four target sites were established upstream of confluence points in the lower watershed to monitor water chemistry and assess biological, riparian, and physical habitat condition (Figure 19). These sites differ from the random sites that assess overall condition of streams in the watershed; their locations are fixed and are sampled each year. Over time these data are being used to assess trends and if changes in these trends can be attributed to natural, anthropogenic, or watershed management changes.

- One site in the Los Angeles River is located at the head of the estuary near the Los Angeles River main stem. This monitoring was designed so that data assessment tools specific to sediment quality objectives (SQOs), developed by SWAMP, could be used to assess the condition of the estuary (Bay et al. 2014).

- The Workgroup chose nine high-value and unique habitat locations to assess trends in riparian zone condition. The emphasis of these assessments is on riparian habitat conditions rather than water quality. Riparian sites provide valuable baseline data for potential habitat restoration or protection efforts.

- Nine sentinel sites were established at major tributaries in the lower watershed and at one site in the estuary near the ocean to assess the concentrations of fecal indicator bacteria emanating from different areas in the lower watershed. Since these sites were established in areas designated as ‘non-swimmable’, they are not part of the swimming safety program discussed later in this report.

The methods that were used to better understand the condition of sites that are unique areas of interest are consistent with those described in the previous chapter. Refer to

Chapter 1 Methods and the LARWMP QAPP for a more detailed description of methodology.

2. Trends at Freshwater Target Sites

A total of 32 samples have been collected from the four target sampling locations during the eight annual surveys from 2009 to 2016 (Figure 19 and Table 8). Samples were collected and analyzed for aquatic chemistry and biological and riparian habitat condition. The goal of repeated annual sampling at these locations is to monitor changing conditions related to water quality and riparian, physical habitat, and biological condition at the four sub-regions of the watershed over time.

Figure 19. Location of confluence, estuary, and high-value habitat sites.

Table 8. Location of targeted confluence sites sampled from 2009 through 2016

Targeted Confluence Locations	Channel Type	Site ID	Latitude	Longitude
Confluence of Rio Hondo and mainstem of LA River	Lined	LALT500	33.93642	-118.17147
Confluence of Arroyo Seco and mainstem of LA River	Lined	LALT501	34.08059	-118.22475
Confluence of Compton Creek and mainstem of LA River	Unlined	LALT502	34.84529	-118.20784
Confluence of Tujunga Wash and mainstem of LA River	Lined	LALT503	34.14833	-118.38916

a. Aquatic Chemistry

Aquatic chemistry results were highly variable for most constituents during the seven-year period but some interesting trends were detected. Sulfate and chloride have had an increasing trend at the Tujunga Wash confluence (LALT503) since 2013. Sulfate concentrations at the Tujunga Wash confluence only exceeded the reach-specific water quality objective of 300 mg/L in 2016. The concentrations for chloride at LALT503 have exceeded the water quality objective of 150 mg/L, for this specific reach, every year since monitoring began (Table 3-10, LARWQCB 2014). Effluent from Burbank Water Reclamation Plant has no impact on the water quality at this site since the plant discharges into the Burbank Western Channel and the LALT503 monitoring site is upstream of the confluence of the Burbank Western Channel and the Los Angeles River. Currently, the factors driving this increasing trend in chloride are unknown.

Total organic carbon levels were also higher at the Tujunga Wash confluence (LALT503) than at any of the other site during every year of monitoring (Figure 20). Nitrate concentrations were greatest at the Arroyo Seco confluence (LALT501) across years but were below the water quality threshold of 10 mg/L, specified in the Los Angeles Basin Plan (LARWQCB 2014). Orthophosphate was consistently elevated at Compton Creek (LALT502) compared to the other sites, except in 2010 when Tujunga Wash (LALT503) orthophosphate levels were also elevated. Total phosphorus concentrations were variable across years with no clear trend at any site.

As shown in Figure 21, hardness at the Arroyo Seco confluence (LALT501) increased slightly but steadily over time from 2009 to 2015, likely due to the 2011-2016 drought. However, from 2015 to 2016 hardness dropped substantially. A large spike in suspended solids was observed at the Rio Hondo (LALT500) confluence in 2014, which may have been caused by turbulent flow associated with a release of water from upstream.

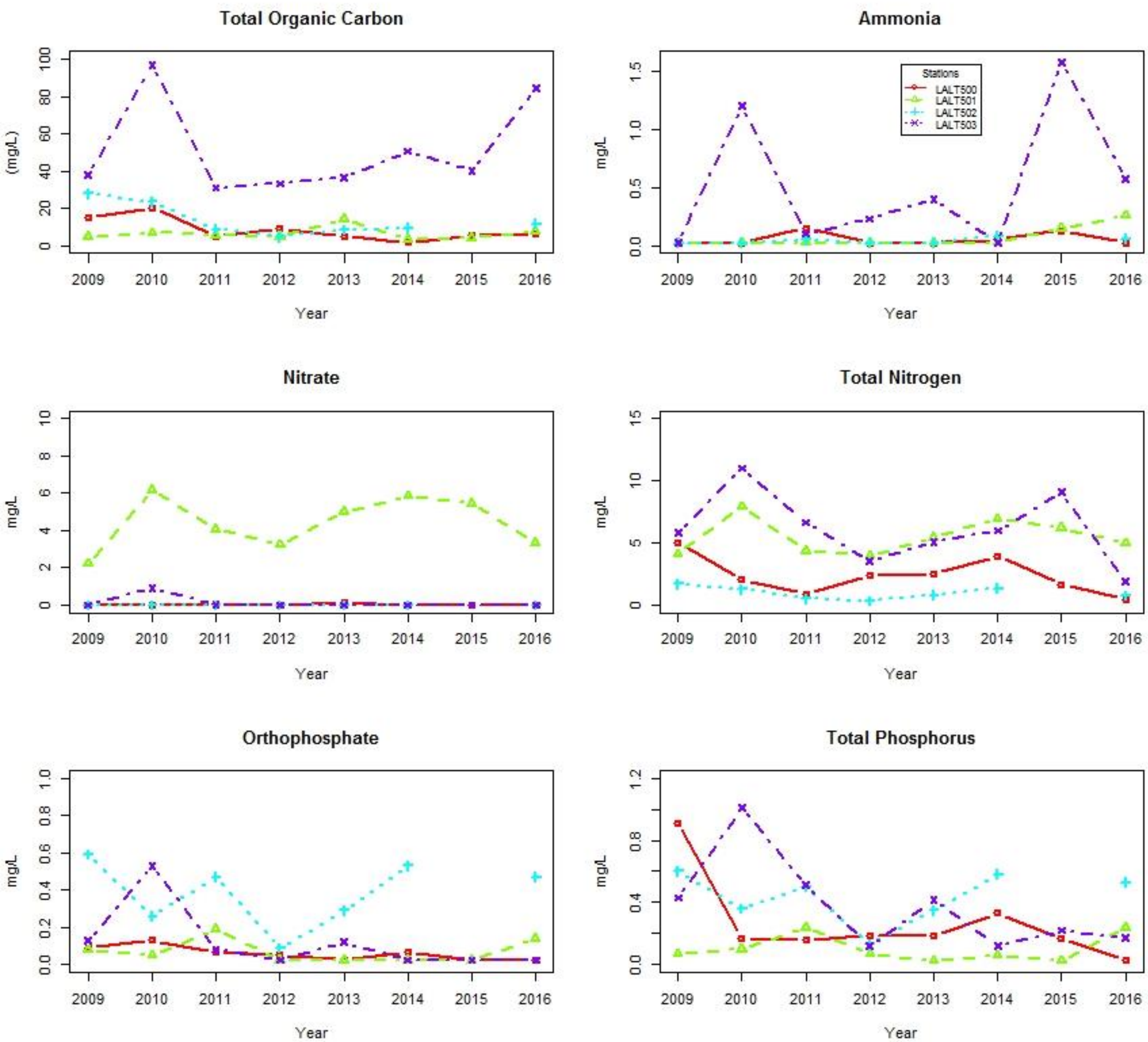

Figure 20. Nutrient concentrations at confluence sites sampled annually from 2009 to 2016.

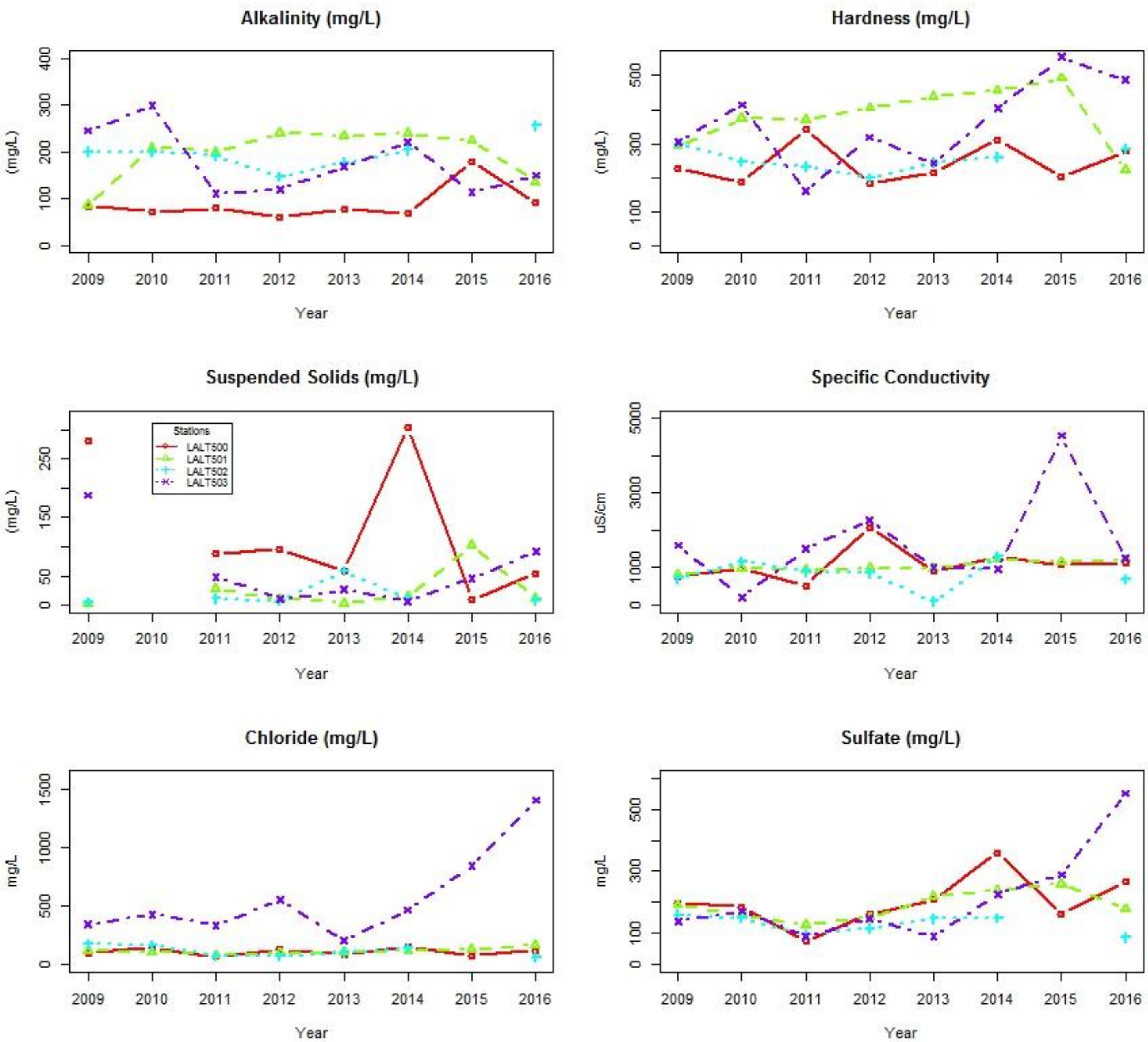

Figure 21. General chemistry at confluence sites sampled annually from 2009 to 2016.

b. Biological and Riparian Habitat (CRAM) Condition

Figure 22 presents the biotic condition index scores for BMI (CSCI) and riparian habitat (CRAM; overall and attribute) for the targeted sites sampled from 2009 to 2016. All targeted sites were in poor condition. CSCI scores at each of the four sites fell in the 'very likely altered' range for all seven years compared to the condition of 'reference site' in California. This is not surprising given that these sites are in highly modified channels in the urbanized portion of the watershed. In addition to good water quality conditions, healthy biological communities require complex instream and riparian cover and a wide and undisturbed riparian and buffer zone. These types of conditions are rare at confluence sites along the L.A. River, as indicated by CRAM scores. CRAM scores at confluence sites were well below the 10^{th} percentile of California sites in reference condition (10^{th} percentile threshold is 72) at all sites.

In 2016, however, CSCI scores at the Tujunga Wash confluence (LALT503) were very close to the reference threshold. Near reference CSCI scores at the Tujunga Wash confluence is an interesting result given elevated chloride and sulfate concentrations at this site and the importance of chloride in predicting CSCI scores (Relationship between Physical and Biological Conditions, pg. 35).

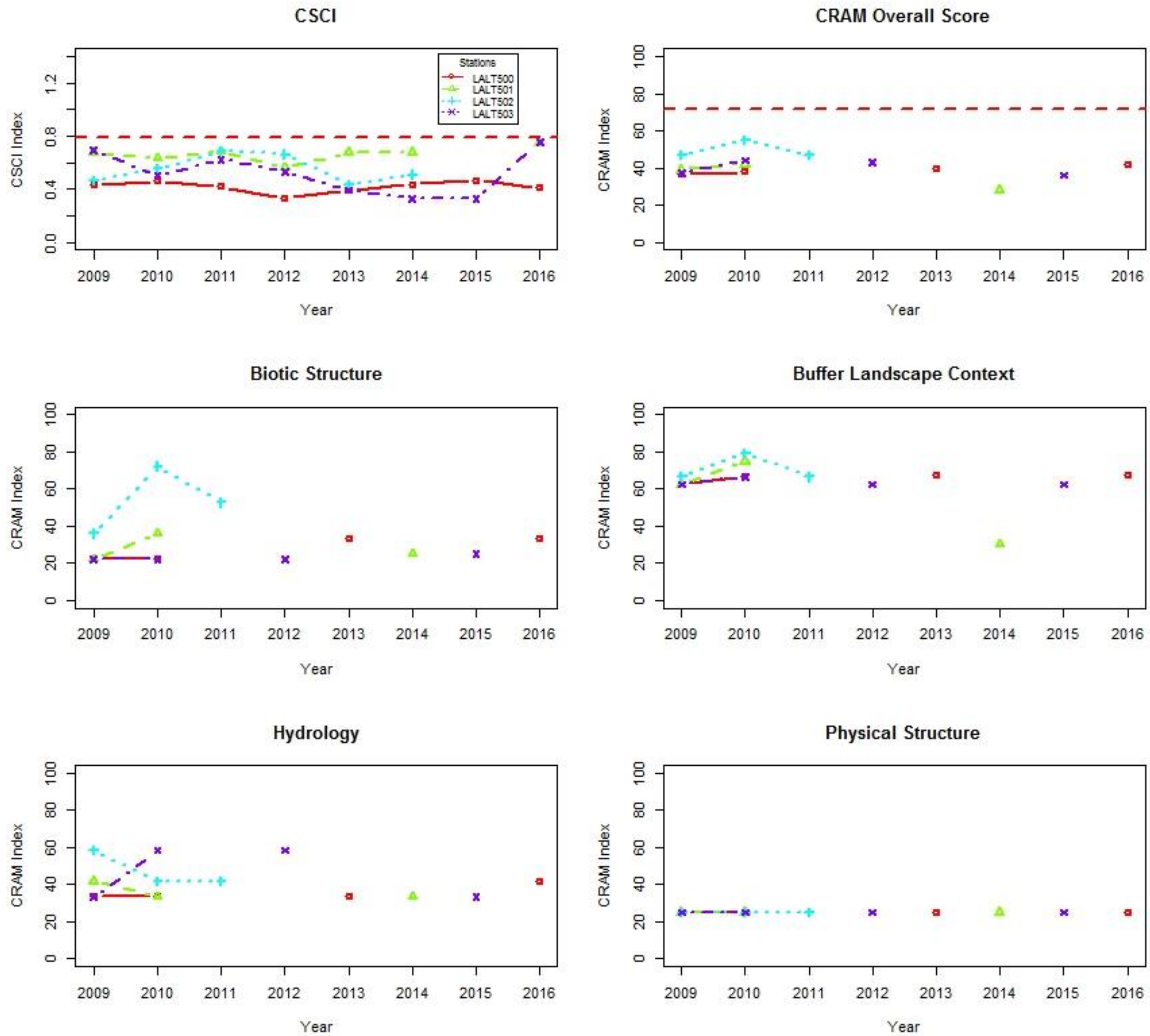

Figure 22. CSCI and CRAM scores (overall and attribute) at confluence sites sampled annually from 2009 to 2016. The red dashed horizontal lines on the CSCI and CRAM Overall Score graphs indicate the threshold, below which the site is in non-reference condition (0.79 for CSCI and 72 for overall CRAM score).

c. Physical Habitat

Figure 23 shows selected metrics of physical habitat condition. The three top plots show transect-based measurements recorded in conjunction with bioassessment sampling, while the three bottom plots show three visual physical habitat assessment scores. For each of the physical habitat metrics presented, Compton Creek confluence (LALT502) differed substantially from the other three confluence sites across years. Specifically, it had more canopy cover (or similar canopy cover to LALT501 for three of the eight years), smaller particle sizes, no concrete or asphalt substrate (the channel is unlined at the sampling site), less channel alteration, and more epifaunal substrate cover and sediment deposition. Improved physical habitat at Compton Creek did not, however, translate to improved biological condition (CSCI score) at this site. The other three sites showed similar trends in all physical habitat metrics, except for the Arroyo Seco confluence (LALT501) which had a higher percentage of canopy cover than the Rio Hondo (LALT500) and the Tujunga Wash (LALT503). Compton Creek confluence (LALT502) experienced a substantial decline in percentage sands/fines in 2011 and again in 2016, indicating a possible streambed scouring event, with the percentage of sands/fines returning to the baseline levels in 2012. All confluence sites performed poorly, in both physical habitat condition (CRAM) and biological condition (CSCI), across monitoring years.

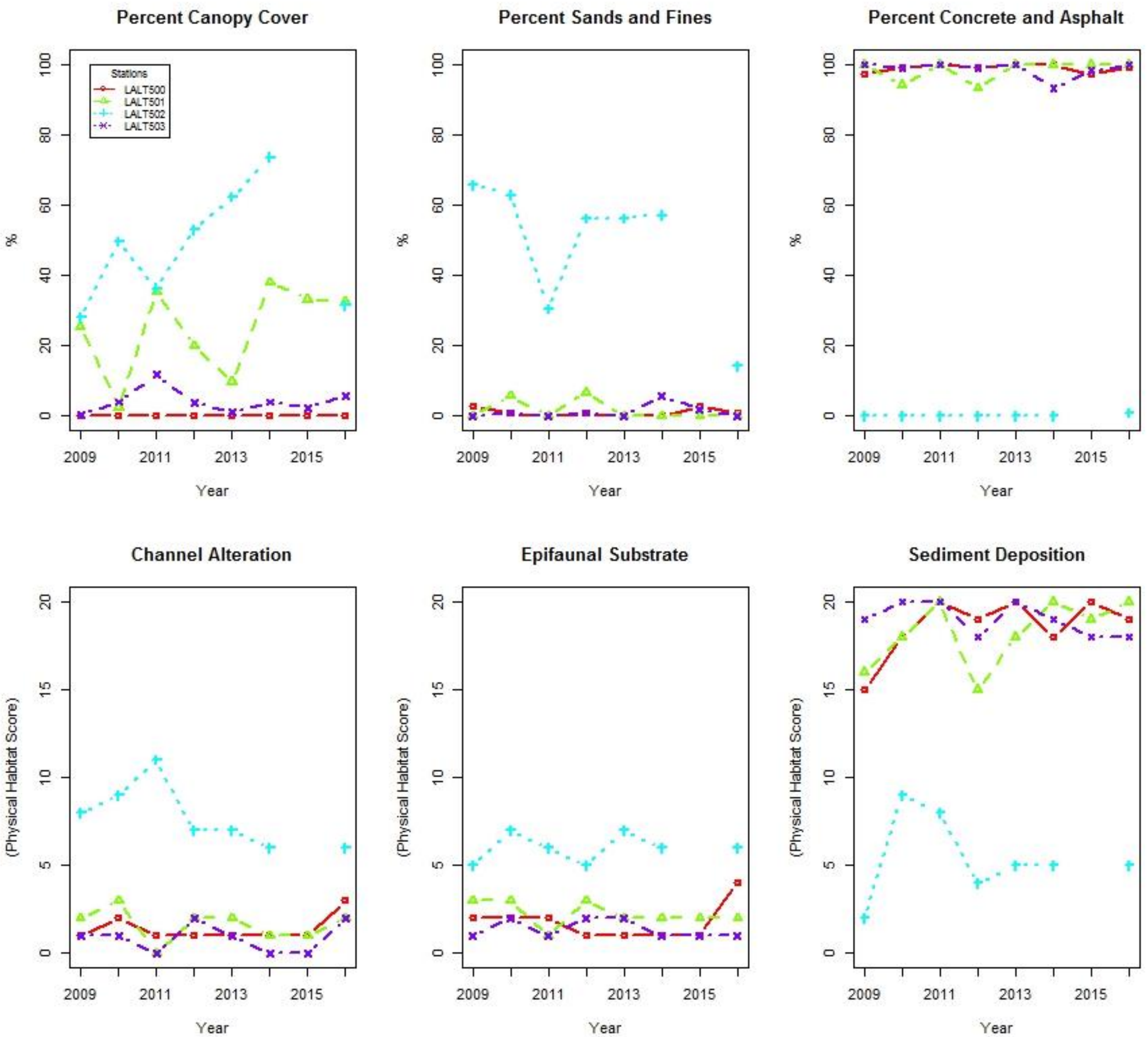

Figure 23. Physical habitat at confluence sites sampled annually from 2009 to 2016.

3. Los Angeles River Estuary

LARWMP monitors sediment at the LA River estuary to ensure sediment quality is suitable for aquatic life and is protective of human health (for seafood consumption). Sediment samples were collected from 2009 through 2016 at the mouth of the Los Angeles River Estuary near Queensway Bridge (LAREST2; Figure 19). The design of LARWMP's estuary monitoring program is based on a multiple lines of evidence (MLOE) approach developed by SCCWRP for the State of California's Sediment Quality Objectives (SQO) program (Bay *et al.*, 2014). This approach incorporates sediment chemistry, toxicity, and biological community assessments to evaluate the condition of sites located in marine embayments in southern California. The results of each of these analyses represent a line of evidence (LOE) that is converted to a condition category score. The three condition category scores are then combined to provide a single-station assessment category.

Sediment chemistry testing included the suite of metals and organic constituents specified in the SQO program (Bay *et al.*, 2014). Toxicity testing included the 10-day amphipod (*Eohaustorius estuarius;* U.S. EPA600/R-94-025) survival test and the 48-hour mussel (*Mytilus galloprovincialis*; Anderson et al. 1996) development test. Infauna samples were collected and analyzed in adherence to protocols of the Southern California Bight Regional Monitoring Program (SCCWRP 2008).

The integrated SQO's category scores for the Los Angeles River Estuary site are provided in Table 9 (Bay *et al.* 2014). Component scores vary from year to year as storms, scouring, and sediment deposition alter sediment quality. In 2010, 2013 and 2014, integrated scores could not be calculated due to missing data for either chemistry or toxicity. For the years when integrated scores could be calculated, EST2 ranked from 'unimpacted' to 'clearly impacted'.

The integrated SQO chemistry scores ranged from 'highly disturbed' in 2009 and 2016, to 'moderately disturbed' in 2010, 2011, 2012 and 2015, indicating some reduction in sediment contaminant concentrations from 2009 to 2015, followed by a recent increase in contaminant levels from 2015 to 2016. The integrated toxicity scores ranged from 'non-toxic' in 2011 and 2015 to 'moderately disturbed' in all other years, except 2013 and 2016 when they were 'minimally disturbed'.

The integrated infauna scores ranged from ‘minimally disturbed’ in 2010 and 2011, to ‘high disturbance’ in 2012 and 2016. Annual scouring due to winter runoff from the Los Angeles River leads to replacement of sediments and can cause large changes in biotic habitat conditions. Notably, total rainfall during the 2010 and 2011 wet seasons in Los Angeles was higher than average on years when lower disturbance to infauna communities were measured. Total seasonal rainfall for all other years was below average (National Weather Service n.d.). Thus, in 2016, although the integrated toxicity score remained relatively low, an increase in the integrated chemistry and infauna scores resulted in the overall designation of “Likely Impacted.”

Table 9. Integration of chemistry, toxicity, and infauna category scores for estuarine sediment quality objectives through 2015. Category scores range from: (1) reference; (2) minimal disturbance; (3) moderate disturbance; (4) high disturbance.

Metric	2009	2010	2011	2012	2013	2014	2015	2016
Chemisty								
CA LRM	4	3	4	4	Not Analyzed	Not Analyzed	4	4
CSI	3	2	2	2	Not Analyzed	Not Analyzed	2	3
Integrated Chemistry Score	4	3	3	3	Not Analyzed	Not Analyzed	3	4
Toxicity								
Eohaustorius estuarius	3	Not Analyzed	1	4	2	4	1	1
Mytilus galloprovincialis	3	3	1	1	1	2	1	3
Integrated Toxicity Score	3	3	1	3	2	3	1	2
Infauna								
BRI	2	1	2	4	1	3	2	4
IBI	3	2	1	4	3	3	2	4
RBI	4	1	2	4	3	3	3	1
RIVPACS	2	2	1	4	4	2	3	4
Integrated Infauna Score	3	2	2	4	3	3	3	4
Site Assesment	Clearly Impacted	NA	Unimpacted	Likely Impacted	NA	NA	Possibly Impacted	Likely Impacted

4. High-Value Habitat Sites

The condition of the riparian zone was assessed at nine sites deemed by members of the Workgroup to be minimally impacted, high-value, or sites at high risk of impact/loss in the watershed (**Table 10**). The goal of measuring the condition of these sites over time is to ensure that conditions are not degrading. The riparian zone was assessed using the California Rapid Assessment Method. CRAM assessments at these sites commenced in 2009. After two to four years of annual visits, the Workgroup determined that subsequent visits would occur every two to three years since conditions at these locations were not changing rapidly.

Figure 24 shows the individual CRAM scores from 2009 to 2016 for the high-value sites. Most of the CRAM scores at the lower watershed sites (prefix LALT) fell below the 10th percentile of the reference distribution of sites throughout California, indicating they were 'likely altered'. The best riparian zone conditions were found consistently at sites located in the upper watershed (prefix LAUT). The exception to this general trend of poorer condition at lower watershed sites and more optimal condition at upper watershed sites are sites downstream of areas that were recently burned and near ongoing restoration activities. For example, Haines Creek Pools and Stream (LALT407), a site near ongoing restoration activities, appears to be slowly improving over time. CRAM scores have improved from a non-reference CRAM score of 61 in 2009, reference scores of 76 in 2012, and 79 in 2015. Additionally, the Arroyo Seco USGS Gage site (LALT450), downstream of sites that burned as recently as 2009, achieved a CRAM score just above the reference threshold in 2014.

Upper watershed sites LAUT401, LAUT402, and LAUT403—located in the Tujunga Sensitive Habitat, Upper Arroyo Seco, and Alder Creek, respectively—burned during the 2009 Station Fire and fell below the 10th percentile threshold in 2009 (except for LAUT 403), but then improved over the next set of site visits to well above the 10th percentile of the reference distribution. Although CRAM scores at the Tujunga Sensitive Habitat and Upper Arroyo Seco dropped to near the 10th percentile of the reference distribution in 2015, perhaps due to the ongoing drought, the following year the CRAM scores for these two sites rebounded, placing them firmly in the reference category.

The impact of fire on riparian systems remains relatively understudied and varies depending on fire extent and severity. In some instances, riparian areas serve as refuge for fire sensitive species. Though, when conditions are dry and fuel loads high, riparian areas can become corridors for fire (Pettit and Naiman, 2007). LARWMP will continue to monitor habitat condition of riparian areas burned during the 2009 Station Fire to aid in better understanding the response of this ecosystem to fire.

Table 10. Location of high value habitat sites

Site Name	Channel Type	Site ID	Latitude	Longitude
Arroyo Seco USGS Gage	Unlined	LALT450	34.18157	-118.17297
Glendale Narrows	Unlined	LALT400	34.139368	-118.2752
Golden Shores Wetlands	Unlined	LALT404	33.76442	-118.2039
Sepulveda Basin	Unlined	LALT405	34.17666	-118.49335
Eaton Wash	Unlined	LALT406	34.17463	-118.0953
Haines Creek Pools and Stream	Unlined	LALT407	34.2679	-118.3434
Tujunga Sensitive Habitat	Unlined	LAUT401	34.28220	-118.22160
Upper Arroyo Seco	Unlined	LAUT402	34.22121	-118.17715
Alder Creek	Unlined	LAUT403	34.30973	-118.14190

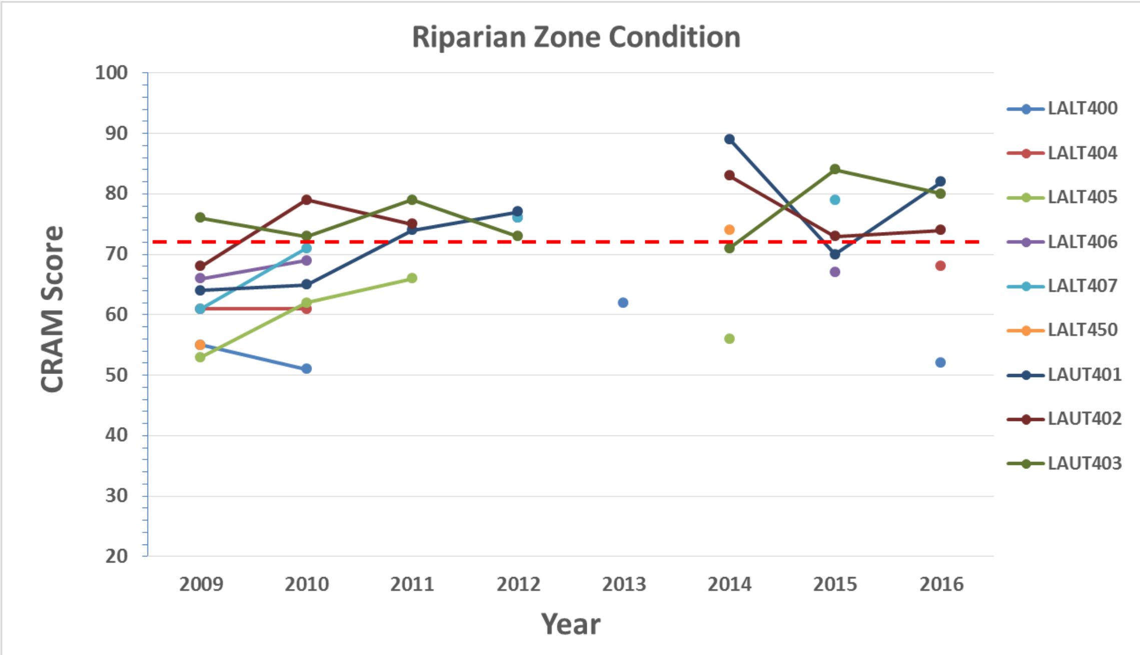

Figure 24. Riparian zone condition (CRAM scores) at high-value sites from 2009-2015. The red horizontal line represents the 10th percentile of the reference distribution of sites in California. Scores below this line represent 'likely altered' habitat.

5. Sentinel Site and Los Angeles River Estuary Bacteria

The sentinel site program includes the weekly collection of samples at six confluence points from May to September. The intent of the program is to quantify the concentrations of *E. coli* emanating from different areas of the lower watershed (Figure 25 and Table 11). Bacteria concentrations measured at these sites are compared against REC-1 standards for context. The sentinel sites are not REC-1 bathing waters and public access has only recently been authorized at two specific locations on the Los Angeles River.

A second component of the program includes twice-weekly sampling for *E. coli* and *Enterococcus* bacteria at Queensway Drive Bridge, located at the lower end of the Estuary before its confluence with the Pacific Ocean. The purpose of including this site is to assess the overall contribution of bacteria from the watershed to the estuary. Eventually, bacteria concentrations in the estuary may be linked to conditions on near shore beaches. It is important to understand that this site is also not within a recreational swimming area.

Analyses for all indicator bacteria were conducted using Colilert™ (SM9223) for *E. coli* and Enterolert™ for *Enterococcus* bacteria. *Enterococcus* is only measured at the estuary site. Each of the bacteria data sets was compared against Los Angeles Regional Water Quality Control Board REC-1 swimming standards (LARWQCB 2014) (Table 12).

Figure 25. Map of all sentinel bacteria sites and the LA River Estuary site sampled in 2015.

Sentinel Sites

Table 11. Sentinel and estuary site station codes.

Program Element	Sampling Sites	Site Codes
Sentinel	Status & Trend Del Amo	LALT100
	Status & Trend Figueroa St	LALT101
	LA River Riverside Dr Cross	LALT102
	LACDPW at Wardlow St	LALT104
	Status & Trend Burbank	LALT106
	Status & Trend Tujunga Moorpark	LALT107
Estuary	Estuary Site 1	LAREST2

Table 12. REC-1 swimming standards (LARWQCB 2014).

Indicator	Single-Sample Standard	30-Day Geometric Mean
E. coli	235	126
Enterococcus bacteria	104	35
Total Coliform	10,000 *or* 1,000 if fecal-to-total coliform ratio exceeds 0.1	1,000

Between May and September 2016, a total of 126 samples were collected from six sentinel sites located at major confluences to the Los Angeles River and analyzed for *E. coli* (Table 13). Note during the month of September, no samples could be taken at the LA River Riverside Drive site (LALT102). Of the 126 samples collected, 79% exceeded the single-sample recreational standard for *E. coli* (235 MPN/100 mL). The frequency of single-sample exceedances at each site was high (86 to 100%), except for LALT101 at Figueroa St. LALT101 exceeded the single-sample standard only 14% of the time. LALT101 is located downstream of the Los Angeles-Glendale Water Reclamation Plant (LAGWRP) and the effluent is likely diluting bacteria concentrations (see Question 3, pg. 76). Monitoring by the City of Los Angeles in the mainstem of the Los Angeles River as part of the Status and Trends Program, demonstrated that dry-season bacteria concentrations below major POTWs were lower due to dilution of urban runoff by the high quality, disinfected tertiary-treated recycled water emanating from these POTWs (CREST 2006).

Exceedances of the 30-day geometric mean standard (126 MPN/100 mL) occurred every month during the sampling period (May to September 2016) at every monitoring station, except in June, July, and September at station LALT101 at Figueroa Street, where the lowest mean values occurred (Table 13). These results indicate that the lower tributaries and main Los Angeles River Channel had persistently elevated *E. coli* concentrations during the entire dry-weather period in 2016.

Each of the other sentinel sites is located just upstream of major confluences to the Los Angeles River and convey mostly urban runoff. It is acknowledged that the control of bacteria in urbanized watersheds poses an immense challenge, and that bacteria discharges can be highly erratic due to a myriad of potential human and nonhuman sources (CREST 2008).

Several of the tributaries described above were previously identified on California's 2006 Clean Water Act Section 303(d) list as impaired for water contact and noncontact recreational beneficial uses (REC-1 and REC-2, respectively) by fecal coliform bacteria. In response, a bacteria Total Maximum Daily Load (TMDL) was developed by the Los Angeles Region Regional Water Quality Control Board (RWQCB), in cooperation with the Cleaner Rivers through Effective Stakeholder-led TMDLs (CREST) stakeholder group. A comprehensive Bacteria Source Identification (BSI) study was undertaken that identified that approximately 85% of storm drain samples exceeded the 235 MPN/100 mL *E. coli* objectives (CREST 2008). It was recognized that although hundreds of storm drain outfalls discharge varying levels of bacteria to the LA River during dry weather, other in-channel sources—including birds and other wildlife, homeless persons, and perhaps environmental re-growth—also are contributing sources of bacteria.

As various watershed management programs, like Enhanced Watershed Management Programs, are implemented with the goal of reducing bacterial loading into the rivers and streams of the watershed, continued measurement of sentinel sites will be important for assessing the performance of control measures with respect to reducing bacterial levels during dry weather flows.

Table 13. 30-day geometric mean *E. coli* concentrations (MPN/100 mL) at sentinel sites in the Los Angeles River Watershed in 2016. Single sample exceedance >235 (MPN/100 mL) *E. coli*; 30-day geometric exceedance >126 (MPN/100 mL) *E. coli*.

Site	30-Day Geometric Mean											Single Sample Exceedances	
	May	n=	June	n=	July	n=	August	n=	September	n=	Σ n=	#	%
LALT100	1898	4	934	4	364	5	943	4	2499	5	22	20	91
LALT101	224	4	107	4	97	5	133	4	82	5	22	3	14
LALT102	660	4	580	4	473	5	539	3	NA	0	16	15	94
LALT104	1301	4	755	4	645	5	1180	4	1541	5	22	21	95
LALT106	1095	4	1295	4	203	5	4403	4	710	5	22	19	86
LALT107	2962	4	3251	4	10586	5	10454	4	4646	5	22	22	100
									Total		**126**	**100**	**79**

"NA" indicates that no samples were collected at this site during the month of September.

Los Angeles River Estuary Bacteria

One hundred twenty-seven samples were collected and analyzed for *E. coli*, *Enterococcus*, and total coliform from the Los Angeles River Estuary during the period from May through September 2016. *E. coli* exceeded the single-sample standard in 2% of samples. The 30-day average standard for *E. coli* was not exceeded during the five-month period (Table 14). *Enterococcus* bacteria exceeded the single-sample standard in 7.5% of samples. The 30-day average standard for *Enterococcus* was exceeded for one of the five months. Lastly, total coliform exceeded the single-sample standard in 50% of samples. The 30-day average standard for total coliform was exceeded for all five months. Since the Los Angeles River Estuary is designated "non-swimmable," the consistent total coliform exceedances do not present a threat to human health. Moreover, recent epidemiological research has shown that total coliform concentrations do not correlate with human health risk at sites for which the dominant contamination sources are nonpoint sources (Colford et al., 2007). Water quality results are compared to regional water quality objectives purely for context.

Table 14. 30-day geometric mean bacteria concentrations (MPN/100 mL) at the Los Angeles River estuary site in the Los Angeles River Watershed during 2016.

Indicator	30-Day Geometric Mean									
	May	n=	June	n=	July	n=	August	n=	September	n=
E. coli	78	8	42	9	54	9	54	9	40	8
Enterococcus	50	8	16	9	9	8	14	7	10	8
Total Coliform	2141	8	2954	9	12638	10	19348	9	21513	8

Chapter Summary

Trends at Freshwater Target Sites

- A total of 32 samples have been collected from the four confluence locations during the eight annual surveys from 2009 to 2016.
- Nitrate concentrations were highest at the Arroyo Seco confluence (LALT501) between 2009 to 2016, but were below the water quality threshold protective of aquatic life (10 mg/L) specified in the Los Angeles Basin Plan.
- Chloride was elevated at the Tujunga Wash confluence (LALT503) compared to the other confluence sites across all years and has been increasing since 2013. According to the City of Burbank, effluent from the Burbank Water Reclamation Plant discharge, upstream of the confluence location, is currently meeting the 150 mg/L chloride WQO.
- Biological conditions, as measured by the CSCI, were below reference conditions at all four sites during the eight-year monitoring period. Compton Creek, a soft bottom site, was also impaired. However, CSCI scores have improved at the Arroyo Seco confluence (LALT501) and the Tujunga Wash confluence (LALT503) compared to 2014 scores.
- Habitat quality was poor at each of these sites, which are mostly cement-lined.
- For each of the physical habitat metrics presented, Compton Creek confluence (LALT502) differed substantially from the other three confluence sites across years. Specifically, it had more canopy cover, no concrete or asphalt substrate (the channel is unlined at the sampling site), less channel alteration, and more epifaunal substrate cover and sediment deposition.
- We did not find a trend of declining physical habitat condition at any of the targeted confluence sites.

Los Angeles River Estuary

- Sediment samples were collected in 2009 through 2016 at the mouth of the Los Angeles River Estuary and assessed using the State of California's Sediment Quality Objectives framework.
- For the years when integrated scores could be calculated, EST2 ranked from 'unimpacted' (2011) to 'clearly impacted' (2009).

- Annual scouring due to winter runoff from the Los Angeles River leads to replacement of sediments and large changes in biotic habitat conditions.
- *E. coli* and *Enterococcus* 30-day geometric mean exceedances at the Los Angeles River Estuary were less frequent during 2016 than they have been in the past three years.

High-Value Habitat Sites

- Most of the CRAM scores for the lower watershed high-value sites fell below the reference site threshold, except for Haines Creek Pools and Stream (LALT407) and Arroyo Seco USGS Gage Site (LALT450). The Haines Creek Pools and Stream (LALT407) and the Arroyo Seco USGS Gage site (LALT450), both below reference in 2009, achieved a CRAM score just above the reference threshold in recent assessments. The Arroyo Seco USGS gage site is downstream of recent fires (LALT450) and was scoured and flooded post-fire. The Haines Creek Pools and Stream site overlaps with restoration activities taking place along the Tujunga Basin.
- CRAM scores for the upper watershed high-value sites—Tujunga Sensitive Habitat, Upper Arroyo Seco, and Alder Creek—have improved since the sites were burned by the 2009 Station Fire. Two of the three sites (LAUT401 and 402) dipped below, or close to below, the reference threshold in 2015, potentially reflecting the impacts of a prolonged drought. However, their scores increased to above the reference threshold the following year (2016).

Sentinel Site Bacteria

- A total of 126 samples were collected from six sentinel sites located on major confluences to the Los Angeles River and analyzed for *E. coli* from May to September 2016. Of these, an average of 79% exceeded the single-sample recreational standard for *E. coli* (235 MPN/100 mL).
- The frequency of single-sample exceedances at all sites was high (86 to 100%), except for LALT101 at Figueroa St, where the single-sample standard was exceeded only 14% of the time.

- LALT101 is located downstream of the Los Angeles-Glendale Water Reclamation Plant (LAGWRP). The lowest bacteria concentrations, and fewest exceedances, occurred at this site. These findings are consistent with those reported by CREST (2008).
- The 30-day geometric mean REC-1 standard was exceeded during each of the study months at all sentinel sites, except in June, July, and September at LALT101, where the lowest mean values occurred.

Question 3. Are permitted discharges meeting WQOs in receiving waters?

1. Background.

Question 3 addresses the potential impacts of permitted point-source discharges on the Los Angeles River, its tributaries, and receiving water' ability to meet the Water Quality Objectives (WQOs) set forth in the Los Angeles Basin Plan (LARWQCB, 2014). The data compiled by LARWMP include metals, bacteria (*E. coli*), nutrients, trihalomethanes, and acute toxicity to fathead minnows. These parameters are measured to provide a basic assessment of water quality and include the contaminants commonly introduced into a stream system via effluent from Publicly Owned Treatment Works (POTWs).

This chapter summarizes NPDES monitoring data for the period from January through December 2016 for three major POTWs that discharge into the Los Angeles River: The City of Los Angeles' Tillman Water Reclamation Plant (DCTWRP), the City of Los Angeles' Glendale Water Reclamation Plant (LAGWRP), and the City of Burbank's Water Reclamation Plant (BWRP). Site codes for the receiving water stations upstream and downstream of each POTW's discharge and their locations are shown in Table 15 and Figure 26, respectively. These receiving water stations are monitored by the permittees as a requirement of their NPDES permits and were chosen to best represent locations upstream and downstream of the discharge locations. Values were compared to LARWQCB Basin Plan Water Quality objectives (Table 16).

Table 15. Station designations for NPDES monitoring sites.

POTW	Upstream Site	Downstream Site
City of Los Angeles- Tillman	LATT612	LATT630
City of Los Angeles-Glendale	LAGT650	LAGT654a
City of Burbank- Burbank	R-1	R-2

Table 16. Water Quality Objectives for nutrients in the Los Angeles Regional Water Quality Control Board Basin Plan and plan amendments.

	NH_3-N (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N + NO_2-N (mg/L)
DCTWRP	1.6 mg/L	8	1	8
LAGWRP	2.4 mg/L	8	1	8
BWRP	2.3 mg/L	8	1	8

Figure 26. Locations of NPDES receiving water sites monitored by the City of Los Angeles and the City of Burbank

2. City of Los Angeles - DCTWRP

The cumulative frequency distributions for *E. coli* above and below the City of Los Angeles' DCTWRP discharge location are shown in Figure 27. The single-sample WQO of 235 MPN/100mL for REC-1 beneficial use was attained for approximately 78% of upstream samples compared to 55% of downstream samples during the 2016 sampling year.

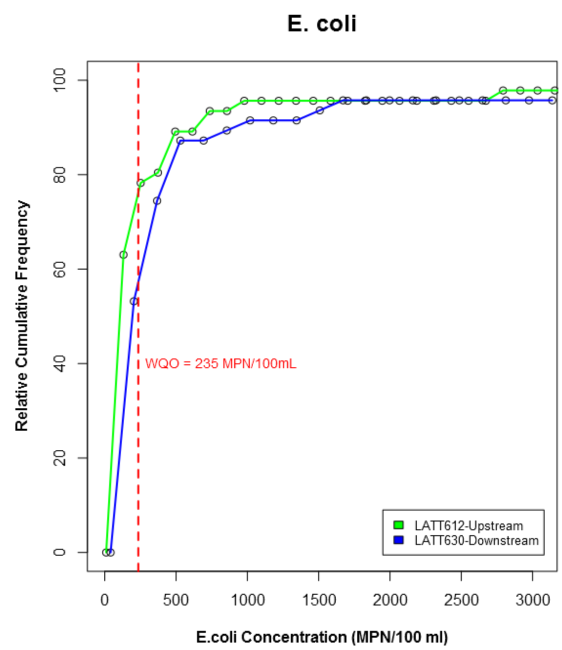

Figure 27. Cumulative frequency distributions of *E. coli* concentrations above and below the DCTWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 17 Range of nutrient concentrations downstream of DCTWRP in 2016.

	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_3-N (mg/L)	ORGANIC N (mg/L)	TOTAL N (mg/L)
MIN	1.96	0.12	0.15	0.76	3.90
MAX	5.90	1.12	1.42	2.49	9.40
MEDIAN	5.10	0.46	0.43	1.61	7.50
MEAN	4.96	0.53	0.53	1.62	7.38

Table 17 shows the range in nutrient concentrations observed at a site downstream of DCTWRP discharge. Nutrient concentrations at DCTWRP were below 30-day average regulatory thresholds (data not shown, Table 16). The largest range in values was observed for NO_3-N and total nitrogen.

Acute toxicity to fathead minnows was not detected upstream or downstream of the DCTWRP outfall in 2016 (Table 18). Of the quarterly samples collected, survival below the discharge (LATT630) ranged from 97.5% to 100%, the same range as seen at the upstream site. Toxicity results were not significantly different (p=0.39) when comparing all upstream and downstream sites collected in 2016.

Table 18. Acute toxicity (survival) to fathead minnows above and below the DCTWRP discharge. LATT612 is the site above the discharge and LATT630 the site below.

	ACUTE TOXICITY			
	SINGLE TEST		NON-COMP.	3 TEST AVG
	LATT612	LATT630	LATT612	LATT630
	Survival		#	Survival
2/24/2016	97.5	100.0	0	100.0
5/17/2016	97.5	97.5	0	99.2
8/17/2016	100.0	100.0	0	99.2
11/15/2016	100.0	100.0	0	99.2

Common disinfection byproducts were detected below the discharge location, but at concentrations that were well below the EPA water quality objective of 80 ug/L for total trihalomethanes (Table 19).

Table 19. Trihalomethane concentrations below the DCTWRP discharge (LATT630).

Trihalomethanes (µg/L)	**Site**	**2/4/2016**	**8/1/2016**
Bromodichloromethane (ug/L)	LATT630	0.97	0.8
Bromoform (ug/L)	LATT630	ND	ND
Chloroform (ug/L)	LATT630	1.97	2.56
Dibromochloromethane (ug/L)	LATT630	ND	ND
Trihalomethanes (Total) (ug/L)	LATT630	**2.94**	**3.36**

Total trihalomethanes were calculated as the sum of bromodichloromethane, bromoform, chloroform, and dibromochloromethane. "ND" indicates the analyte was not detected. The EPA water quality objective for total trihalomethanes is 80 ug/L (U.S. EPA 2002).

The metals concentrations shown in Figure 28 are compared to the California Toxics Rule (CTR) chronic and acute standards, which are typically expressed as dissolved metals concentrations, and applied to hardness-adjusted dissolved metals. It is important to note that total recoverable metals, rather than dissolved metals, were measured by the City of Los Angeles as a requirement of their NPDES permit. Total recoverable concentrations from DCTWRP and LAGWRP were converted to dissolved concentrations, which represent the biologically active fraction of the total metal concentration, using a Metals Translator Guidance document written by the EPA (USEPA 1996).

Figure 28 shows the concentration of select metals upstream and downstream of the DCTWRP discharge location. With the exception of selenium, metals concentrations were below the hardness-adjusted standards at both the upstream and downstream locations. Selenium concentrations upstream of the discharge exceeded the CTR chronic threshold on three of four occasions, while those downstream of the discharge were below both chronic and acute thresholds. In general, metals concentrations at the upstream site were similar to those at the downstream site.

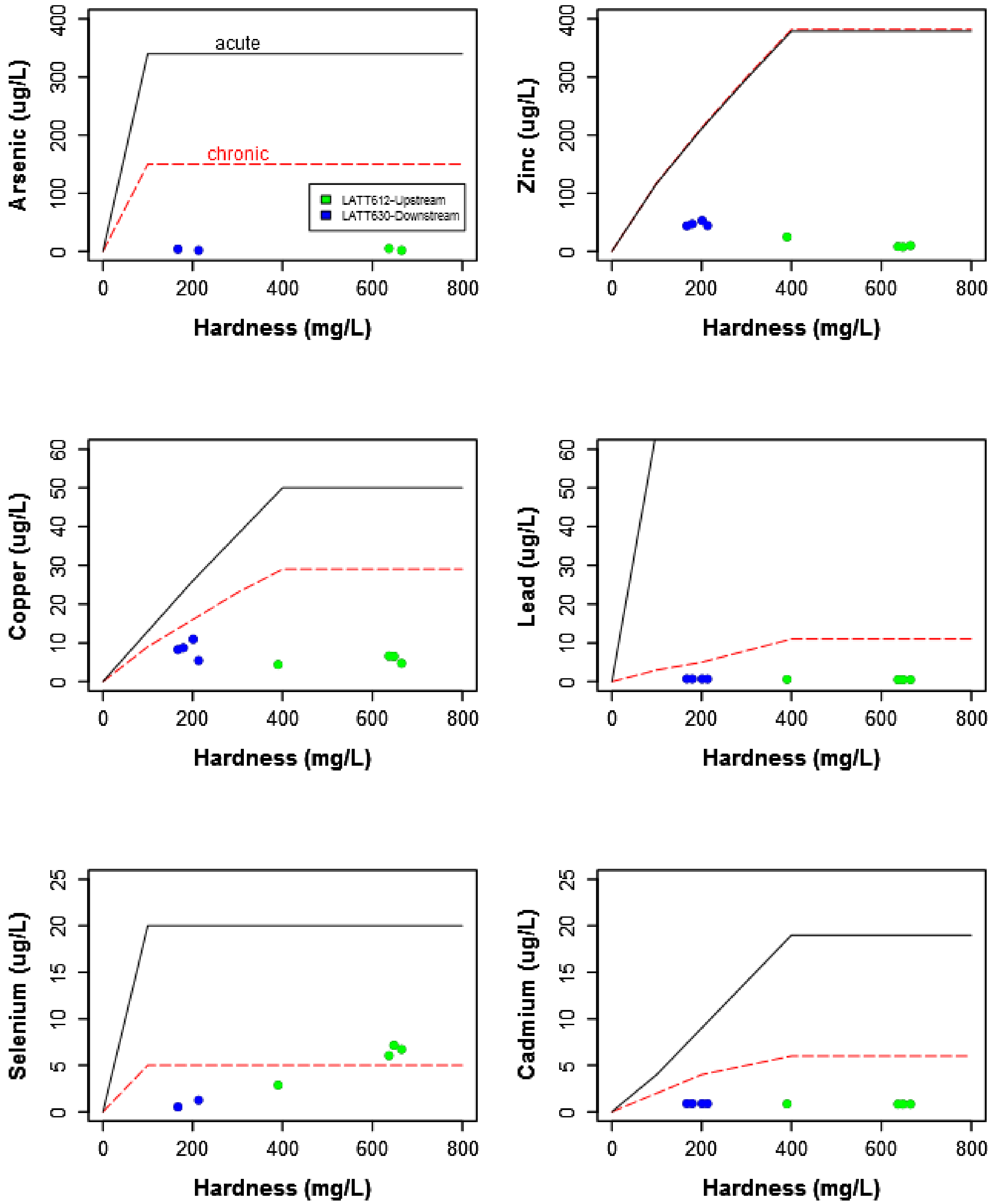

Figure 28. Converted dissolved metals concentrations above and below the DCTWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Includes estimated values for low concentrations that exceeded the method detection limit, but did not meet the laboratory's reporting limit. The acute threshold for lead at hardness values of 400 or greater is 281 ug/L.

3. City of Los Angeles – LAGWRP

From February 2016 through October 2016, monitoring at the sites upstream and downstream of the LAGWRP discharge was suspended due to the construction of a wall along the Los Angeles River. The wall was to serve as a flood control barrier during the El Niño storms that year and was constructed by the Army Corps of Engineers. Thus, no water quality data from either site exists for this period. In November 2016, monitoring resumed at the upstream location, LAGT650, but since access to the downstream location, LAGT654, was still restricted at that time, monitoring at an alternate downstream location, LAGT654a, was conducted instead. The results presented in this section do not encompass a full year of sampling results and include results from an alternate downstream site.

Figure 29 shows the cumulative frequency distributions for *E. coli* at sites above and below the discharge point for the LAGWRP. None of the samples tested for *E. coli* met the WQO at the upstream site, and while nearly all downstream samples also exceeded the standard, concentrations were consistently lower compared to upstream samples indicating a dilution effect as a result of the LAGWRP effluent.

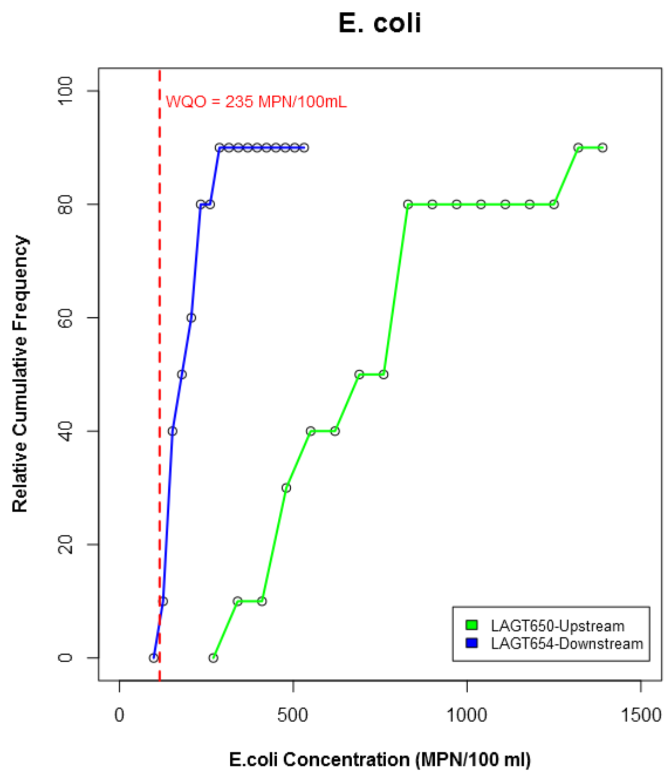

Figure 29. Cumulative frequency distribution of *E. coli* above and below the LAGWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 20 shows the range in nutrient concentration measured below the LAGWRP discharge. The largest median values were observed for NO_3-N and total nitrogen concentrations but monthly averages (data not shown) were below regulatory thresholds (Table 16).

Table 20 Range of nutrient concentrations downstream of LAGRWP discharge in 2016.

	NITRATE NITROGEN (mg/L)	NITRITE NITROGEN (mg/L)	AMMONIA NITROGEN (mg/L)	ORGANIC NITROGEN (mg/L)	TOTAL NITROGEN (mg/L)
MIN	3.07	0.15	0.35	1.03	5.50
MAX	5.12	0.73	0.99	1.89	7.80
MEDIAN	4.11	0.36	0.66	1.55	6.55
MEAN	4.18	0.40	0.68	1.51	6.53

Total recoverable metals were measured both upstream and downstream of the LAGWRP discharge. The converted dissolved metal concentrations were below both the acute and chronic CTR thresholds for each metal (Figure 30). Metals concentrations were similar at upstream and the downstream sites.

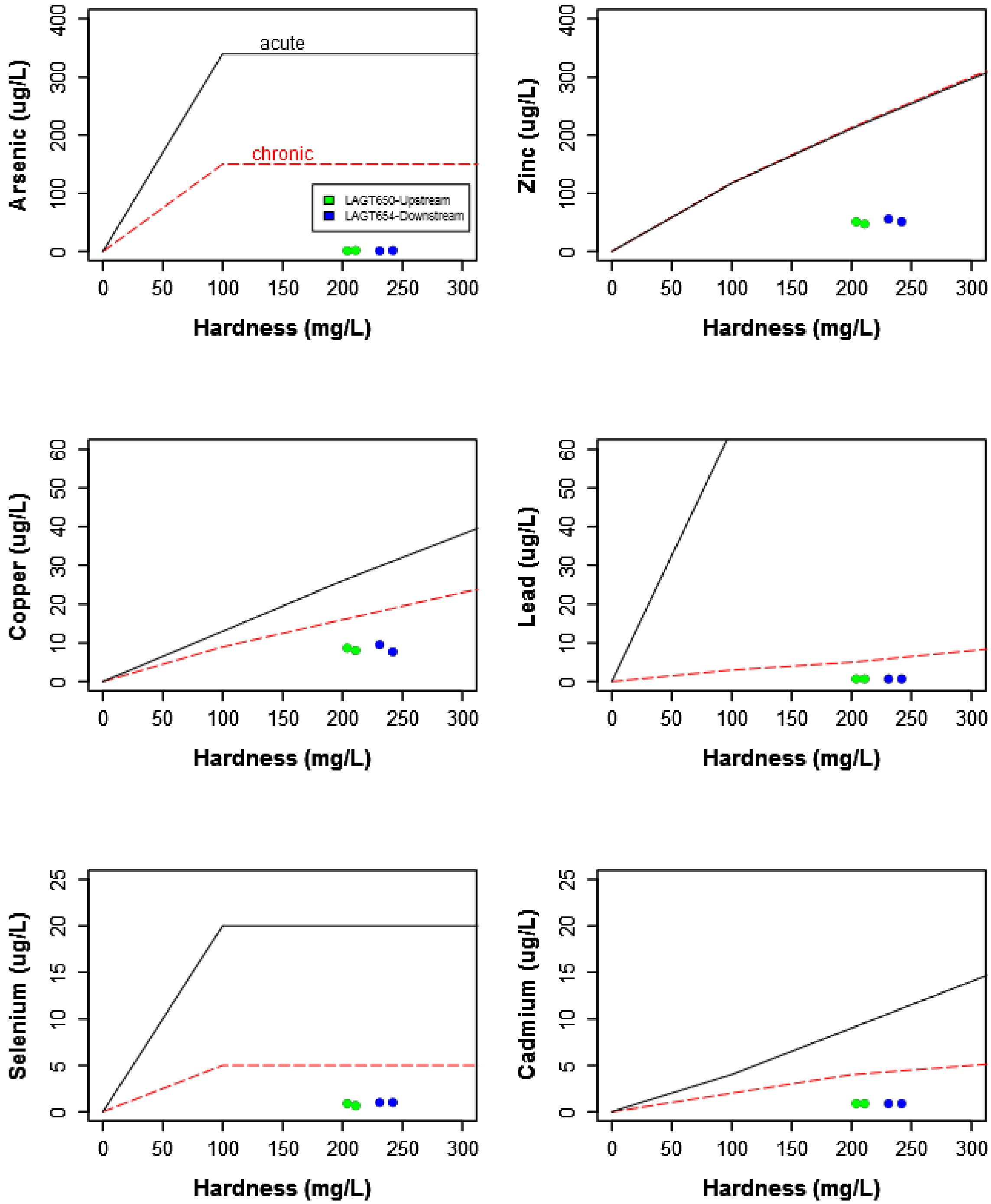

Figure 30. Converted dissolved metals concentrations above and below the LAGWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Includes estimated values for low concentrations that exceeded the method detection limit, but did not meet the laboratory's reporting limit. The acute threshold for lead at hardness values of 400 or greater is 281 ug/L.

Acute toxicity was not measured upstream or downstream of the LAGWRP outfall in 2016 (Table 21), with the exception of a single measurement taken in December, which was non-toxic.

Table 21. Acute toxicity (survival) to fathead minnows above and below the LAGWRP discharge. LAGT650 is the upstream site and LAGT654a the downstream site.

	ACUTE TOXICITY			
	SINGLE TEST		NON-COMP.	3 TEST AVG
	LAGT650	LAGT654a	LAGT654a	LAGT654a
	Survival		#	Survival
12/13/2016	100.0	100.0	0	100.0

Note that there is only one acute toxicity data point due to restricted access to the monitoring locations during the Army Corps of Engineers' construction of a flood control wall along the Los Angeles River from February to November 2016.

Total trihalomethanes were detected below the discharge location, but the concentrations downstream of the discharge were still well below the EPA water quality objective of 80 ug/L (Table 22).

Table 22. Concentrations of trihalomethanes below the LAGWRP discharge (LAGT654a).

Trihalomethanes (µg/L)	Site	12/06/2016
Bromodichloromethane (ug/L)	LAGT654a	1.82
Bromoform (ug/L)	LAGT654a	ND
Chloroform (ug/L)	LAGT654a	4.21
Dibromochloromethane (ug/L)	LAGT654a	0.42
Trihalomethanes (Total) (ug/L)	LAGT654a	**6.45**

Total trihalomethanes were calculated as the sum of bromodichloromethane, bromoform, chloroform, and dibromochloromethane. "ND" indicates the analyte was not detected.

4. City of Burbank - BWRP

The cumulative frequency distributions for *E. coli* upstream and downstream of the City of Burbank's BWRP discharge location are shown in Figure 31. The number of single-sample exceedances was greater upstream of the discharge than below. The single-sample WQO of 235 MPN/100mL for REC-1 beneficial use was attained for 25% of upstream samples compared to 50% of downstream samples. This indicates a dilution effect; BWRP effluent is reducing the concentration of *E. coli* in the receiving water below the discharge.

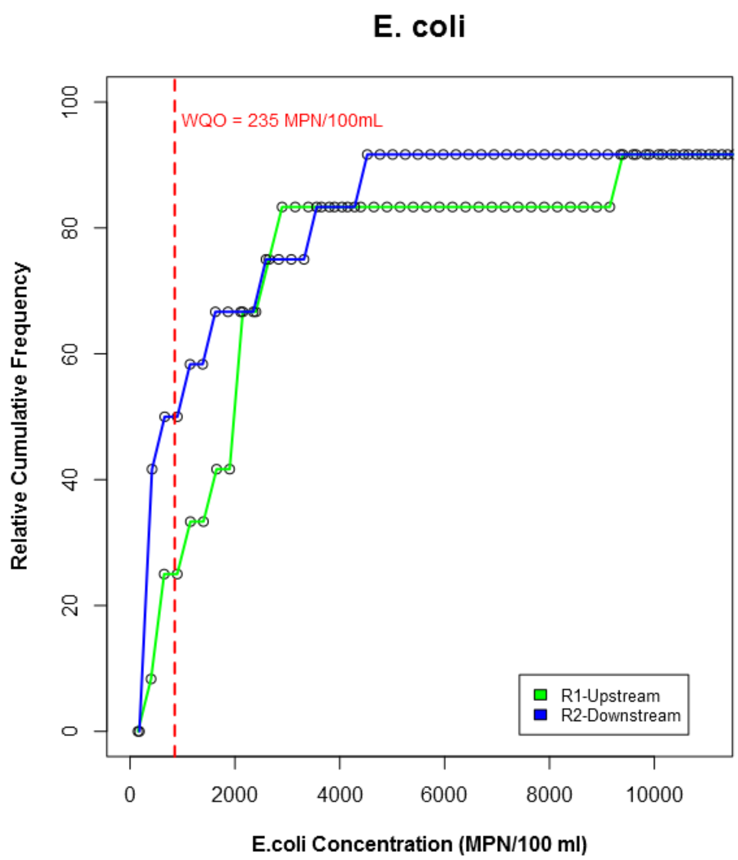

Figure 31. Cumulative frequency distributions for *E. coli* above and below the BWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

The concentration of nitrogenous compounds downstream of BWRP discharge did not exceed WQOs (based on regulatory thresholds for a 30-day average, data not shown, Table 16). The largest median values were observed for NO_3-N and total nitrogen.

Table 23. Range of concentrations of nitrogenous compounds downstream of the BWRP discharge point (R2) in 2016.

	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_3-N (mg/L)	ORGANIC NITROGEN (mg/L)	TOTAL N (mg/L)
MIN	3.00	0.01	0.24	0.19	4.40
MAX	12.00	0.59	1.50	5.30	14.50
MEDIAN	5.50	0.18	0.78	0.90	7.50
MEAN	5.99	0.22	0.78	1.06	8.02

Figure 32 shows the hardness-adjusted dissolved metal concentrations compared to their CTR chronic and acute standards. Concentrations at the upstream site and the downstream site were similar for most metals, with the exception of zinc and copper. Zinc was significantly higher at the downstream site ($p < 0.001$) while copper was significantly higher at the upstream site ($p = 0.015$). Most importantly, metals concentrations at both upstream and downstream sites were below the CTR thresholds. On one occasion selenium was measured to be just below the chronic threshold at the upstream location.

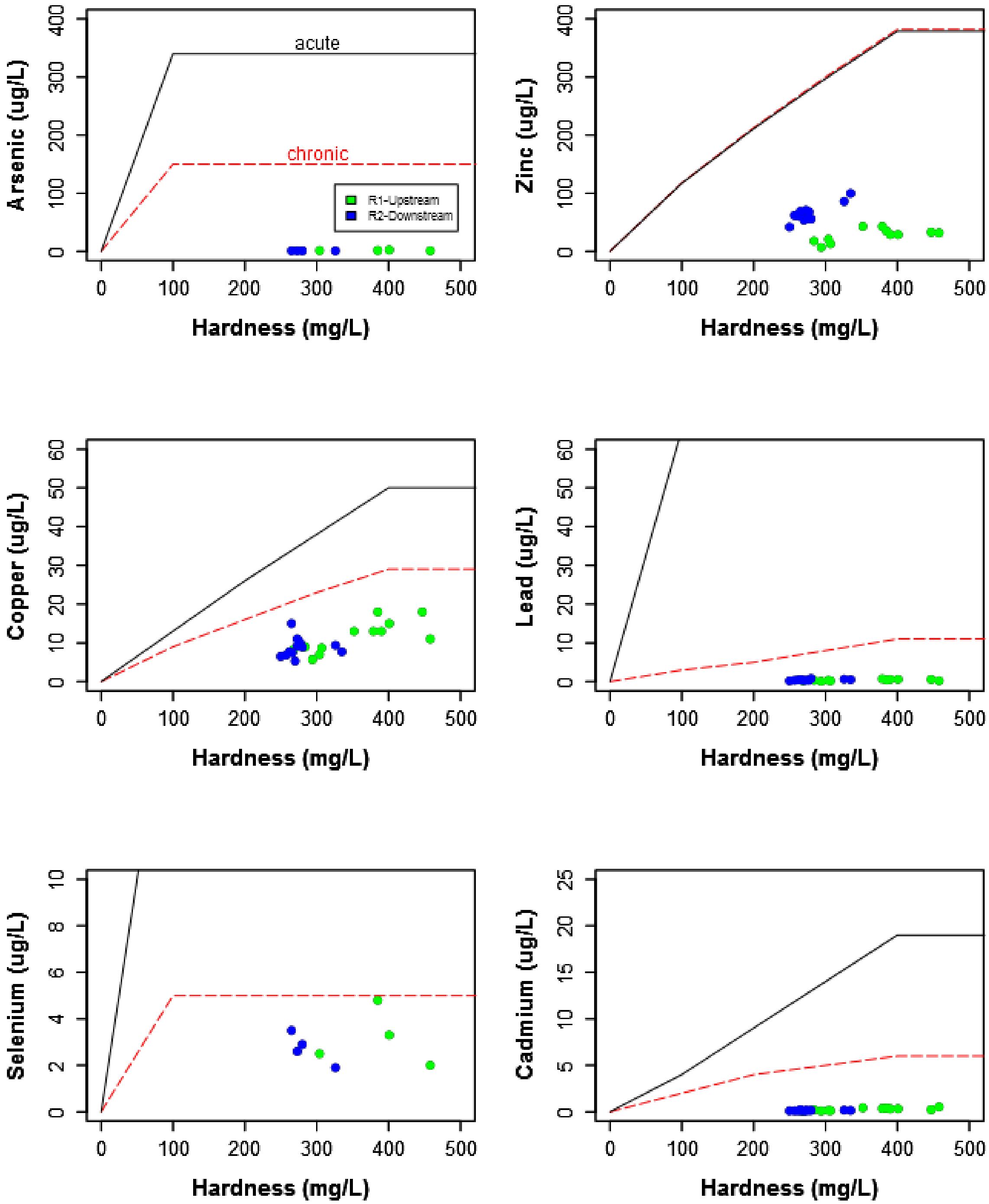

Figure 32. Dissolved metals concentrations above and below the BWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Estimated values for low concentrations that exceeded the method detection limit but did not meet the laboratory's reporting limit are included. The acute threshold for lead at hardness values of 400 or greater is 281 ug/L. The acute threshold for selenium is 20 ug/L.

Acute toxicity was not detected at the upstream or downstream sites of BWRP (Table 24). Survival for the downstream site ranged from 90 to 100% and held steady at 97.5% at upstream sites. However, percent survival did not significantly differ between the upstream and downstream sites (p=0.81).

Table 24. Acute toxicity (survival) to fathead minnows upstream (R1) and downstream (R2) of the BWRP discharge.

Date	Survival %	
	R1	R2
2/10/2016	97.5	100.0
5/18/2016	97.5	100.0
8/3/2016	97.5	90.0
11/9/2016	97.5	97.5

Trihalomethanes were detected below the discharge location (R2), but the concentrations downstream of the discharge were well below the EPA water quality objective of 80 ug/L (Table 25).

Table 25. Summary of trihalomethane concentrations above (R1) and below (R2) the BWRP discharge.

Trihalomethanes (Total) (µg/L)	Site	Min	Max
n=12	R1	ND	8.1
n=12	R2	2.7	15

Total trihalomethanes was precalculated and reported by the City of Burbank. "ND" indicates the analyte was not detected.

Chapter Summary

The Cities of Los Angeles and Burbank monitor receiving waters upstream and downstream of their discharges as a requirement of their NPDES permits. Fecal indicator bacteria, aquatic chemistry, and toxicity results for samples collected in 2016 were evaluated against WQO thresholds. The following patterns were observed:

- The single-sample WQO of 235 MPN/100mL for REC-1 beneficial use was attained for approximately:
  - DCTWRP - 78% of upstream samples compared to 55% of downstream samples.
  - BWRP – 25% of upstream samples compared to 50% of downstream samples.
- Construction of a flood control barrier from February through October limited site access and monitoring activities at LAGWRP. Monitoring resumed in November but an alternate downstream site was chosen due to site accessibility limitations at the previous downstream site. From November to December, 0% of upstream compared to 10% of downstream samples, at an alternate site, met WQO.
- Concentrations of nitrogenous compounds below POTWs discharges did not exceed the monthly average WQOs described in the Los Angeles Basin Plan for NO_3-N, NO_2-N, and NH_3-N.
- Metal concentrations downstream of the three POTW discharge points were below the California Toxics Rule (CTR) chronic and acute standards for every type of metal analyzed. Samples upstream of the DCTWRP exceeded the selenium chronic standard on 3 occasions.
- No acute toxicity to fathead minnows was measured above or below the discharge points for the three POTWs.
- Trihalomethanes were present below the discharges, but in all cases, concentrations were well below the EPA WQO.

Question 4: Is it safe to swim?

1. Background

Thousands of visitors swim at unpermitted sites within the Los Angeles River Watershed each summer. The fourth element of the monitoring program assesses the beneficial use of informal sites in the Los Angeles River Watershed for Water Contact Recreation (REC-1). Prior to the initiation of LARWMP, the concentrations of potentially harmful fecal pathogens and the bacteria that indicate their presence was not known. Monitoring at unpermitted swim sites reflects concerns for the risk of gastrointestinal illness posed by pathogen contamination to recreational swimmers in streams of the Los Angeles River watershed. Depending on the site, sources of indicator bacteria and pathogen contamination could include humans, dogs, wildlife, urban runoff, and refuse from campgrounds and homeless encampments.

Monitoring fecal indicator bacteria is valuable because tests are inexpensive and the body of literature shows *E. coli* to be an adequate predictor for gastrointestinal illness. Standards used by both EPA and LARWQCB are also based on *E. coli* cultivation methodology (EPA, 2010; Wade et al., 2003). However, studies have found that no single indicator is protective of public health and that in many studies, FIB do not correlate well with pathogens (Hardwood et al., 2005). Studies have also highlighted the need to better understand whether faster and more specific microbial methods can better predict health outcomes (Wade et al., 2003), particularly since human fecal sources have an increased pathogenic risk. While microbial source tracking is a promising method for better understanding fecal source and related public health risks, challenges related to performance, specificity, and sensitivity remain and should be addressed before the methods are moved toward the regulatory realm (Harwood et al., 2013).

2. Methods

LARWMP's bacteria-monitoring program established weekly *E. coli* sampling during the summer (Memorial Day to Labor Day) at unpermitted high-use recreational swimming areas (Figure 33 and Table 26). Sites sampled for swimming safety are selected based on the collective knowledge of the workgroup of the most frequently used swimming locations in the watershed. To better understand the relationships between periods of heavy recreational use and *E. coli* concentrations, sampling is conducted on weekends and holidays to capture times when the greatest numbers of people are swimming. The San Gabriel River Watershed program, a similar program to LARWMP, has found that indicator bacteria levels were potentially greater on weekends and holidays when recreational use was greatest (SGRRMP 2009).

Field teams deployed each morning and collected grab samples at swim sites. Observational data was also recorded at each site including information on flow habitats, number of visitors and swimmers, animals present, and site refuse. Hand held meters and probes were used to collect data on wind direction, dissolved oxygen, pH, water conductivity, and water temperature. The bacteria concentrations were compared against State of California REC-1 swimming standards (LARWQCB 2014) (Table 27).

Figure 33. Recreational swimming site locations in 2016.

Table 26. Sampling locations and site codes for indicator bacteria.

Program Element	Sampling Sites	Site Code
Swim Sites	Bull Creek Sepulveda Basin	LALT200
	Eaton Canyon Natural Area Park	LALT204
	Peck Road Water Conservation Park	LALT212
	Hansen Dam	LALT214
	Big Tujunga Delta Flat Day Use	LAUT206
	Switzer Falls	LAUT208
	Gould Mesa Campground	LAUT209
	Sturtevant Falls	LAUT210
	Hidden Springs	LAUT211
	Hermit Falls	LAUT213

The State of California REC-1 bathing water standards (LARWQCB 2014) require that at least five samples be collected per month per site before the 30-day geometric mean standard can be applied. The 30-day geometric mean provides an indication of how persistent elevated bacterial concentrations are at a site. The standard overestimates persistent contamination when fewer than five samples are taken per month. Thus, the geometric means presented herein may represent conservative estimates of this standard. During the summer survey in 2016, there was a goal to collect no fewer than five samples per month at each of the swimming sites. However, site closure, safety considerations, and site conditions prevented the collection of 5 monthly samples at many sites.

3. Results

During the summer of 2016, a total of 188 water samples were successfully collected from 10 swim sites popular with visitors and residents of the LA River watershed (Table 28). Of the 188 samples, 56 exceeded the REC-1 standards, a very slight increase over the previous year. The greatest frequency of single sample exceedances occurred at Hansen Dam (94.5%), followed by Bull Creek Sepulveda Basin (45%), and Eaton Canyon (27%). There was not a pattern of having an increased number of exceedances during holiday/weekends, when more visitors are present at swim sites, compared to weekdays (p=0.18).

Consistent with the pattern that we observed in single sample results, Hansen Dam exceeded the 30-day geometric mean during all three months, followed by Bull Creek Sepulveda Basin which exceeded the geometric mean during two months, and Eaton Canyon exceeded the standard during the month of July (Table 29). Interestingly, the Bull Creek Sepulveda Basin site did not, in 2015, have exceedances in geometric mean and had 2/3 less single sample exceedances than 2016. Elevated *E. coli* concentrations may be related to growing homeless populations near the Sepulveda Dam. None of the remaining sites exceeded the geometric mean for any month, indicating that elevated *E. coli* concentrations are not persistent at 7 of the 10 sites.

Table 27. Indicator bacteria REC-1 standards for freshwaters.

Indicator	Single-Sample Standard	30-Day Geometric Mean
E. coli	235 MPN/100 mL	126 MPN/100 mL

Table 28. Single sample *E. coli* concentrations (MPN/100 mL) at recreational swim sites in the Los Angeles River Watershed from May through September 2016 (<10 MPN/100 mL = non-detect). Blank cells indicate that the site was not sampled on that date. Red-shaded cells indicate exceedance of single-sample REC-1 standard for *E. coli*.

	5/30/2016	5/31/2016	6/5/2016	6/11/2016	6/20/2016	6/23/2016	6/26/2016	7/4/2016	7/5/2016	7/9/2016	7/13/2016	7/24/2016	8/5/2016	8/14/2016	8/18/2016	8/27/2016	8/29/2016	9/1/2016	9/5/2016	9/6/2016	# Exceedance REC 1 Std.	n	% Exceedance REC 1 Std.
Bull Creek Sepulveda Basin	355	246	197	72	74	480	203	281	231	84	41	231	63	241	243	110	52	281	830	305	9	20	45
Eaton Canyon Natural Area Park	473	134	226	63	41	31	119	171	388	173	428										3	11	27
Big Tujunga Delta Flat Day Use	31	52	41	122	110	110	84	84	31	75	201	52	132	85							0	14	0
Switzer Falls	479	84	30	84	20	41	20	74	75	20	10	31	10	134	20	31	97	145	292	253	3	20	15
Gould Mesa Campground	<10	20	31	10	52	63	20	<10	<10	63	121	41	41	20	31	345	63	121	<10	<10	1	20	5
Sturtevant Falls	<10	<10	31	63	74		20		<10	10	<10	256	146	10	10	<10	<10	197		31	1	17	6
Hidden Springs	<10	31	10	31	41	52	10	145	85	85	265	31	10								1	13	8
Peck Road Park	2910	30	323	30	<10	121	63	30	272	160	<10	<10	10	63	10	10	75	<10		20	3	19	16
Hermit Falls	63	<10	10	31	20		63		122	41	52	31	63	20	52	30	<10	<10		31	0	17	0
Hansen Dam	1140	408	556	1860	537	677	744	644	594	650	583		496	545	146	379	644	457	359	341	18	19	95
Hansen Dam Duplicate	11200	638	683	959	556	464	733	545	435	1010	670			576	213	448	602	556	318	393	17	18	94
# Exceedance REC 1 Std.	6	3	3	2	2	3	2	3	4	2	4	1	1	3	1	3	2	3	4	4	56		
n	11	11	11	11	11	9	11	9	11	11	11	8	9	9	8	8	8	8	5	8		188	
% Exceedance REC 1 Std.	55	27	27	18	18	33	18	33	36	18	36	13	11	33	13	38	25	38	80	50			30
Holiday																							31
Weekday																							
Weekend																							

Table 29. 30 day geometric mean *E. coli* concentrations (MPN/100 mL) at recreation swim sites in the Los Angeles River Watershed in 2016.

Location	June	n =	July	n =	August	n =	Exceedances of 30 day Average
Bull Creek Sepulveda Basin	159	5	139	5	116	5	2
Eaton Canyon Natural Area Park	74	5	265	4	NA	0	1
Big Tujunga Delta Flat Day Use	87	5	73	5	106	2	0
Switzer Falls	33	5	32	5	38	5	0
Gould Mesa Campground	29	5	24	5	56	5	0
Sturtevant Falls	41	4	16	4	13	5	0
Hidden Springs	23	5	97	5	10	1	0
Peck Road Park	52	5	32	5	22	5	0
Hermit Falls	25	4	53	4	25	5	0
Hansen Dam	775	5	617	4	395	5	3
Hansen Dam Duplicate	659	5	633	4	427	4	3

To better understand whether there was a relationship between usage patterns and the number of exceedances across sites, we conducted a Spearman's ranked correlation. The number of exceedances did not generally correspond to site usage patterns and the presence of animals, as indicated by the low Spearman's rank correlation coefficients between *E. coli* and the number of bathers (r = -0.105), the number of people on shore (r = -0.03), and the number of animals (r = -0.003) (
Table 30). This pattern holds true for Hermit Falls, one of the most heavily visited sites (Table 31) did not have any single sample exceedances. Despite Peck Road having a comparatively large number of birds present on multiple sampling occasions, the presence of animals did not correspond to heightened *E. coli* concentration at this site or across all sites. However, it is important to note that many sites are sampled in the morning, prior to the arrival of large crowds, and bacteria concentrations may reflect usage patterns of the previous day. However, the program accounts for this by scheduling sampling on both holidays and the day after major holidays (including Memorial Day, the Fourth of July, and Labor Day).

Few environmental and observational variables correlated strongly with *E. coli* concentrations, with the exception of electrical conductivity (r = 0.456) and pH (r = -0.409), which had a mildly strong relationships. When looking at the sites with the highest number of exceedances, both Bull Creek Sepulveda Basin and Hansen Dam had moderately strong relationships with electrical conductivity and turbidity (0.6>r >0.4). Once outside of a host bacteria face multiple stressors, including osmotic stress, UV radiation, predation, and variable pH, that can limit cell numbers and result in patchy distributions (Winfield and Groisman, 2003; EPA, 2010; Sinton et. al, 2002). Additionally, sediments and vegetation can serve as a reservoir of *E. coli*, where bacterial cells can persist longer than in open water (Alm et al. 2003; Garzio-Hadzick et al., 2010). Patchy distributions can make it difficult to detect relationships between use patterns and environmental variables.

A need echoed by monitoring crews is for outreach and education on watershed stewatership, particularly due to the amount of trash and pet waste at swim sites. Human and pet sources may be the most easily controlled through outreach, education, and investment in site facilities like bathrooms and restrooms. Engagement of communities hiking the streams of the watershed or recreating along the river presents a critical opportunity to connect communities to their watershed and to relate water quality to well-being, ecological health, and public health. Visitor surveys can be a key tool for identifying gaps in understanding and for pin pointing the most appropriate tools for better communicating monitoring data.

Table 30. Spearman correlation table analyzing relationship between *E. coli*, site usage, and in-situ measurements.

	Air Temp.	Water Temp.	Ec	pH	Turbidity	People on Shore	Animals	Bathers	Fishermen
Water Temp.	0.678								
Ec	-0.290	-0.054							
pH	0.376	0.256	-0.602						
Turbidity	0.207	0.445	0.068	-0.056					
People on Shore	0.355	0.081	-0.383	0.357	0.082				
Animals	0.292	0.253	-0.402	0.288	0.418	0.427			
Bathers	0.251	-0.139	-0.300	0.203	-0.122	0.538	0.192		
Fisherman	0.194	0.136	0.701	-0.500	0.079	0.836	-0.282	**	
E. coli	-0.151	0.041	0.456	-0.409	0.371	-0.028	-0.003	-0.105	-0.209

**There were not enough data points to determine the correlation coefficient for these two parameters

Table 31. Swim site usage patterns.

Monitored Swim Site	Avg. Number of People on Shore	Avg. Number of Fisherman	Avg. Number of Bathers	Avg. Number of Animals
Big Tujunga Delta Flat Day Use	0.10		0.19	0.07
Bosque del Rio Hondo	0.56	0.00	0.00	1.44
Bull Creek Sepulveda Basin	1.85	1.97	0.14	0.46
Eaton Canyon Natural Area Park	11.06	0.00	3.47	0.66
Gould Mesa Campground	1.93	0.00	0.63	0.27
Hanson Dam	2.04	0.00	0.20	1.20
Hermit Falls	30.04	0.08	8.68	1.13
Hidden Springs Site (Upper Tujunga Wash)	0.00		0.00	0.00
Millard Campground	0.00	0.00	0.00	0.00
Oakwilde Campground or Switzer Falls/Campground	0.62	0.00	0.04	0.00
Peck Road Park	2.48	1.53	0.02	22.90
Sturtevant Falls	30.65	0.01	2.50	1.83
Upper Rio Hondo	0.00	0.00	0.00	2.19

Chapter Summary

To assess the safety of recreational swimming sites in the Los Angeles River Watershed, bacteria sampling was conducted at 10 sites known to be heavily used by the public during the summer of 2016. Major findings of this sampling effort are as follows:

- A total of 188 *E. coli* samples were collected from the ten sampling locations during the summer of 2016. About 30% of these samples exceeded the REC-1 bathing water standard (235 MPN/100 mL).
- Hansen Dam Recreation Area had persistently elevated *E. coli* concentrations. Hansen Dam exceeded the REC-1 standard in 94.5% of the samples collected. This site is frequented by hikers, dogs, horses and people wading in the stream but heavy site use was not observed during time of sampling, often in the early morning.
- Bull Creek at the Sepulveda Basin had 6 more single sample exceedances than the previous year and may be caused by a growing homeless population in the Sepulveda Basin.
- The only sites that had no exceedances during the sampling season were Hermit Falls and the Delta Flat Day Use site.
- The sampling effort was focused on holidays and weekends to capture high-use recreational activity. The greatest number of exceedances occurred on Memorial Day. However, there was not a pattern of elevated bacteria concentrations during the periods of high use that occur on weekends and holidays.
- The number of people on shore and the number of bathers did not have a strong relationship with *E. coli* concentrations.
- Of all the environmental variables measured electrical conductivity and pH had the strongest relationship with bacterial concentration along with a mildly strong, but significant relationship, between *E. coli* concentrations and turbidity.

Question 5: Are locally caught fish safe to eat?

1. Background

Question 5 addresses the human health risk associated with consuming contaminated fish caught at popular fishing locations in the watershed. The monitoring program focuses on 1 or 2 fishing sites each year with the goal of identifying the fish species and contaminant types that are of concern at selected sites. Sites are selected based on the technical stakeholder group's input about popular fishing sites. Data will provide watershed managers with the information necessary to educate the public about the safety of consuming the fish they catch.

Starting in 2016, the TSG authorized the collection of composite prey fish in tandem with sport fish as done by SWAMP since 2012. Efforts are focused on assessing the bio-magnification of mercury in wildlife. As part of SWAMP's efforts birds, sport fish, and prey fish (<100 mm in length) are collected and analyzed for mercury. Smaller prey fish are shorter lived, allowing less time for methylmercury accumulation compared to larger sport fish, but constitute a significant portion of the diet of higher trophic level fish, smaller piscivorous birds, and other wildlife (Palumbo and Iverson 2017). The results are being used in the hopes of developing a bio-magnification factor to estimate mercury exposure in wildlife based on concentrations of mercury in lower trophic prey fish.

2. Methods

Sampling and Tissue Analysis

Sites for contaminant monitoring in fish populations revolve from year to year and have included various lake and river sites throughout the watershed. Lake and river sites are selected based on: angler surveys conducted at recreational sites throughout the watershed by Allen et al. (2008) and the recommendations of the Technical Stakeholder Group. In 2016, LARWMP analyzed tissues from a total of 57 fish that were successfully collected from Peck Road Park Lake (Figure 34).

Fish were collected using a boat outfitted with electroshocking equipment in accordance to OEHHA sport fish sampling and analysis protocols, which allowed specific species and size classes to be targeted (OEHHA 2005). OEHHA specifies that the muscle fillets from at least five individual fish of the same species and size class be combined to form a composite sample. LARWMP analyzes only the muscle tissue of the fish, which is common practice in regional regulatory programs and most fish testing labs. Other body parts, such as the skin, eyes, and organs of fish may contain higher levels of contaminants and are not recommended for consumption by the OEHHA. Four contaminants, mercury, selenium, total DDTs, and total PCBs, were selected for analysis based on their contribution to human health risk in California's coastal and estuarine fishes.

Mercury can transform in the environment, effecting its behavior and tendency for biological accumulation. It is widely assumed that nearly all (>95%) of the mercury present in fish is methyl mercury (Wiener et al. 2007). Consequently, monitoring programs usually analyze total mercury as a proxy for methyl mercury, as was done in this study. The U.S. EPA (2000) recommends using the conservative assumption that all mercury that is present as methyl mercury, since it is most protective of human health.

It is also important to note that this program component does not include rainbow trout; a popularly stocked and locally caught fish. Once rainbow trout are released to a waterbody they are caught very quickly and therefore have a very short residence time, reducing their potential to accumulate contaminants from that waterbody. There is still the potential for stocked fish to accumulate contaminants from the waterbody where they were raised, but that is not the focus of this study.

Advisory Tissue Levels

Concentrations of contaminants in each fish species were compared to State Fish Contaminant Goals (FCGs) and Advisory Tissue Levels (ATLs) for human consumption developed by the State of California's Office of Environmental Health Hazard Assessment (OEHHA 2008) (Table 32 and Table 33). The OEHHA Fish Contaminant Goals (FCGs) are estimates of contaminant levels in fish that pose no significant health risk to individuals consuming sport fish at a standard consumption rate of eight ounces per week (32 g/day), prior to cooking, and over a lifetime. This guidance assumes a lifetime risk level of 1 in one million for fishermen who consume an 8-ounce fish fillet containing a given amount of a specific contaminant.

The OEHHA Advisory Tissue Levels (ATLs), while still conferring no significant health risk to individuals consuming sport fish in the quantities shown over a lifetime, were developed with the recognition that there are unique health benefits associated with fish consumption and that the advisory process should be expanded beyond a simple risk paradigm to best promote the overall health of the fish consumer. ATLs protect consumers from being exposed to more than the average daily reference dose for non-carcinogens or to a lifetime cancer risk level of 1 in 10,000 for fishermen who consume an 8-ounce fish fillet containing a given amount of a specific contaminant. For specific details regarding the assumptions used to develop the FCGs and ATLs, go to: http://oehha.ca.gov/fish/gtlsv/crnr062708.html (OEHHA, 2008).

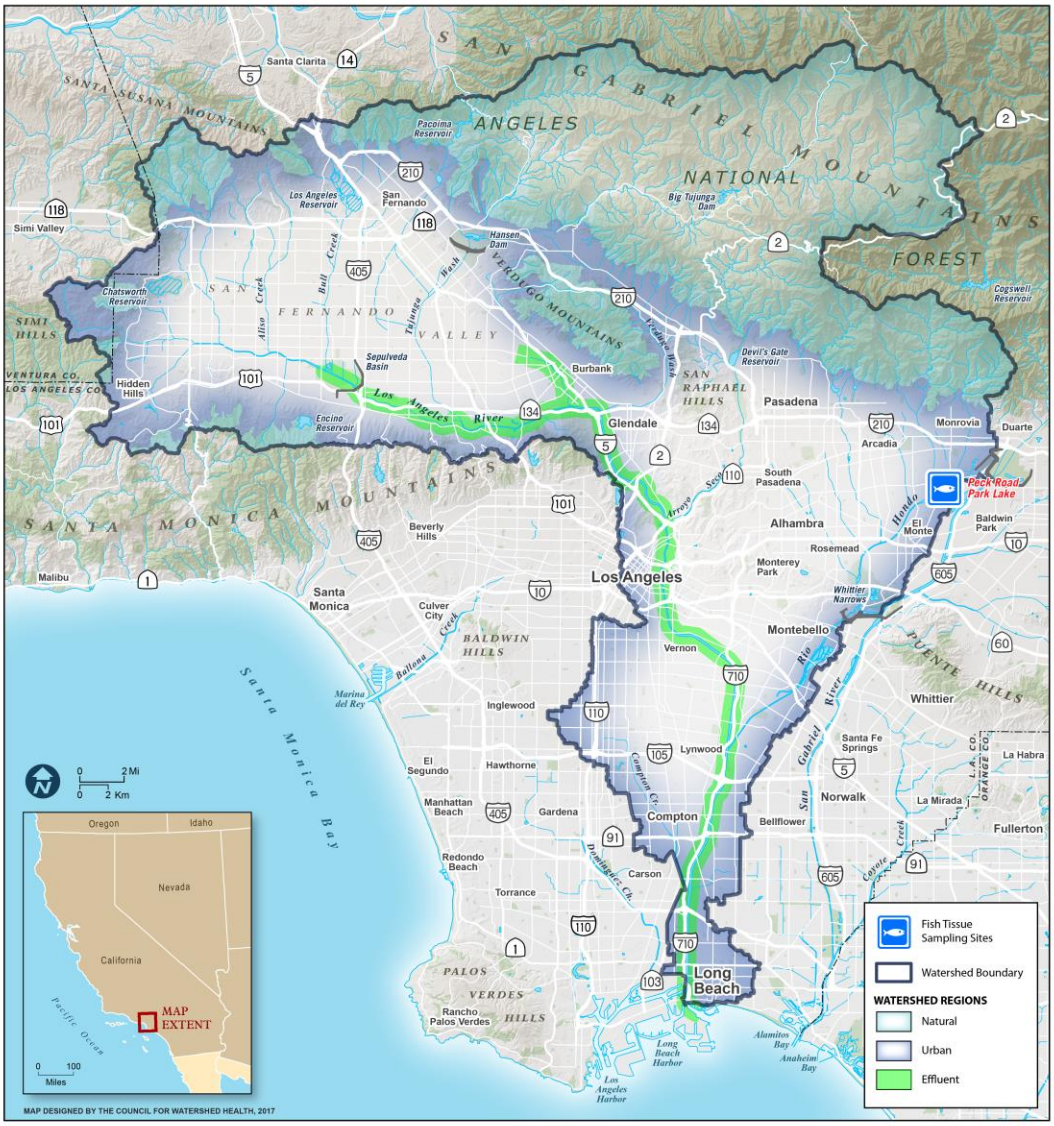

Figure 34. Fish tissue sampling locations for the 2016 bioaccumulation survey.

Table 32. Fish contaminant goals (FCGs) for selected fish contaminants based on cancer and noncancer risk * using an 8-ounce/week (prior to cooking) consumption rate (32 g/day). **

	FCGs (ppb, wet weight)
Contaminant Cancer Slope Factor (mg/kg/day)-1	
DDTs (0.34)	**21**
PCBs (2)	**3.6**
Contaminant Reference Dose (mg/kg-day)	
DDTs (5x10-4)	1600
Methylmercury (1x10-4)[S]	**220**
PCBs (2x10-5)	63
Selenium (5x10-3)	**7400**

*The most health protective Fish Contaminant Goal for each chemical (cancer slope factor-
**g/day represents the average amount of fish consumed daily, distributed over a 7-day
[S]Fish Contaminant Goal for sensitive populations (i.e., women aged 18 to 45 years and children aged 1 to 17 years.)

Table 33. OEHHA (2008) advisory tissue levels (ATLs) for selected fish contaminants based on cancer or non-cancer risk using an 8-ounce serving size (prior to cooking; ppb, wet weight)

Contaminant	Three 8-ounce Servings* a Week	Two 8-ounce Servings* a Week	One 8-ounce Servings* a Week	No Consumption
DDT[snc]**	≤520	>520-1,000	>1,000-2,100	>2,100
Methylmercury (Women aged 18-45 years and children aged 1-17 years)[nc]	≤70	>70-150	>150-440	>440
Methylmercury (Women over 45 years and men)[nc]	≤220	>220-440	>440-1,310	>1,310
PCBs[nc]	≤21	>21-42	>42-120	>120
Seleniumn[c]	≤2500	>2500-4,900	>4,900-15,000	>15,000

[c]ATLs are based on cancer risk
[nc]ATLs are based on non-cancer risk
*Serving sizes are based on an average 160 pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts (for
**ATLS for DDTs are based on non-cancer risk for two and three servings per week and cancer risk for one serving per week.

The Mercury Water Quality Objective for prey fish focuses on sampling of smaller trophic level fish. While many programs collect data on sport fish, data on prey fish is limited. These smaller fish are shorter lived but they constitute a significant portion of the diet in higher trophic level fish, smaller piscivorous birds, and other wildlife. Concentrations of methyl mercury are of concern in piscivorous wildlife like the California Least Tern and for protection of subsistence fishers. Draft objectives for prey fish (Table 34) that are 50-150 mm in length should not exceed 50 ug/kg (Palumbo and Iverson 2017).

Table 34. California State Water Resources Control Board Draft Mercury Objectives.

Objective	Beneficial Uses	Objective (methylmercury in fish tissue)
Sport Fish	Wildlife Habitat*	200 ug/kg in filet of the highest trophic level fish, 150-500 mm
Prey Fish	Wildlife Habitat* (where no trophic level 4 fish)	50 ug/kg, in whole fish 50-150 mm
California Least Tern Prey Fish	California Least Tern Habitat	30 ug/kg in whole fish < 50 mm

* Also Marine Habitat; Rare, Threatened, or Endangered Species; Warm Freshwater Habitat; Cold Freshwater Habitat; Estuarine Habitat; and Inland Saline Water Habitat

3. Results

A total of 57 fish were successfully collected from Peck Road Park Lake (Table 30). Five species were collected at Peck Road Park Lake including, common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus)*, bluegill (*Lepomis macrochirus)*, largemouth bass (*Micropterus salmoides*) and tilapia (*Oreochromis sp)* and were combined, by species, into 10 separate composites. Composites were further separated into sportfish and prey fish, based on average standard length (Table 35).

On average, the largest fish captured in the lake was common carp (4450 g), while the smallest fish caught was largemouth bass (1.2 g) (Table 35).

The feeding strategies for each of the five species are as follows:

- Common carp adults feed on bottom-dwelling invertebrates and aquatic plants that provide habitat for invertebrates (McGinnis 1984).
- Channel catfish are omnivorous and opportunistic, feeding on fish and plant material, crustaceans, aquatic insects and clams (Marsh 1981) (LaBounty 2004).
- Bluegill populations are bottom feeders, consuming all available food including largemouth bass eggs (McGinnis 2006). Their diet also includes aquatic insects and their larvae; up to 50% of their diet can consist of midge larvae (Page, 1991).
- Largemouth bass has a diverse range of prey, ranging from benthic macroinvertebrates and zooplankton to amphibians and fishes. Their foraging is relatively opportunistic (Hodgson and Kitchell, 1987). As young fry, however, they feed on ostracods and small insect larvae, adding other small fish to their diet before the end of their first growing season (Hatch and Paulson, 2002).
- Tilapia are opportunistic omnivores with an inclination toward herbivory. They are filter feeders and have diverse food sources including phytoplankton, algae, and plants (Riedel, 2005).

During the 2016 monitoring season, levels of contaminants in common carp, channel catfish, bluegill, largemouth bass, and tilapia at Peck Road Park Lake were assessed. Common carp, channel catfish, bluegill, largemouth bass and tilapia are safe to eat. The frequency and recommended servings size, however, do vary by species based on the fish tissue contaminant levels (Table 36).

Table 35. Number, average standard weight, and length of the individual and composite fish samples collected in 2016.

Waterbody	Comp #	Sample Type	n	Species Name	CommonName	Avg. Weight (g) Weight (g)	Standard Length Avg. (mm)	Standard Length Min (mm)	Standard Length Max (mm)	Total Length Avg. (mm)	Total Length Min (mm)	Total Length Max (mm)
Peck Road Park Lake (LALT302)	1	Consumption	2	*Cyprinus carpio*	common carp	4450.0	580.0	560	600	700.5	661	740
	2	Consumption	2	*Cyprinus carpio*	common carp	1825.0	386.0	384	388	479.0	475	483
	1	Consumption	3	*Ictalurus punctatus*	channel catfish	2383.3	489.3	412	535	572.3	487	630
	2	Consumption	3	*Ictalurus punctatus*	channel catfish	4083.3	604.0	557	632	708.3	642	742
	1	Consumption	1	*Lepomis macrochirus*	bluegill	150.0	147.0	147	147	184.0	184	184
	1	Consumption	5	*Micropterus salmoides*	largemouth bass	1220.0	357.6	316	408	410.4	366	464
	2	Consumption	3	*Micropterus salmoides*	largemouth bass	750.0	325.7	312	341	377.0	361	393
	1	Consumption	1	*Oreochromis sp*	tilapia	700.0	242.0	242	242	287.0	287	287
	1	Prey Fish	20	*Micropterus salmoides*	largemouth bass	1.2	39.0	31	49	45.6	37	59
	1	Prey Fish	17	*Lepomis macrochirus*	bluegill	5.9	54.8	29	83	65.6	37	98

Total Fish	**57**
Total Composites	**10**

Table 36. Sport fish consumption chemistry results: concentration of contaminants in fish tissues relative to the OEHHA ATL thresholds.

Sport Fish Peck Road Park Lake - LALT302					
Common Name	**Comp. #**	**Mercury (ppb)**	**Selenium (ppb)**	**DDTs (ppb)**	**PCBs (ppb)**
common carp	1	164	380	ND	37
common carp	2	36	290	ND	2
channel catfish	1	81.6	310	0.5	18
channel catfish	2	135	260	1.3	15
bluegill	1	89.3	350	ND	1
largemouth bass	1	149	320	ND	1
largemouth bass	2	147	340	ND	3
tilapia	1	ND	380	ND	ND

Three 8-oz servings a week ATL
Two 8-oz servings a week ATL
One 8-oz serving a week ATL
No consumption ATL.

Table 37. Prey fish chemistry results for Peck Road Lake during the 2016 monitoring season.

Prey Fish Peck Road Park Lake - LALT302					
Common Name	**Comp. #**	**Mercury (ppb)**	**Selenium (ppb)**	**DDTs (ppb)**	**PCBs (ppb)**
largemouth bass	1	**76**	360	ND	20
bluegill	1	**59**	320	ND	9

Wildlife Habitat Methylmercury Threshold: 50 PPB wet weight for fish 50 - 150 mm (Palumbo and Iverson, 2017)

Sportfish

Of the four contaminants measured in each of the composites of fish tissue, mercury exceeded the OEHHA ATL threshold (for women below 45 years old and children under 17) of one servings per week in one composite of common carp and the two servings per week threshold in channel catfish, bluegill and largemouth bass. PCBs in one of the composites exceeded the two serving threshold in common carp (Table 34, Table 37). Selenium and DDT concentrations did not exceed any ATL thresholds in any of the species tested.

Based on the most conservative estimates, common carp from Peck Road Park Lake is only safe to eat once per week at an 8 ounce serving, due to elevated mercury and PCB levels. Channel catfish, bluegill and largemouth bass are safe to eat at a maximum level of two times a week due to mercury fish tissue concentrations. Tilapia is safe to eat, for all contaminants tested, at a consumption level of three times a week in a 8 ounce portions.

Bluegill and common carp are trophic level three, channel catfish and largemouth bass are trophic level four (LARWQCB, 2017). Both trophic level four fish and trophic level three fish are some of the most common fish that recreational anglers catch and consume (Palumbo and Iverson 2017).

The concentrations of harmful contaminants are generally consistent with predictions based on size, trophic position, and feeding ecology. According to the State Water Resources Control Board, methylmercury concentration in fish tissue is often directly related to fish length and, for methyl mercury, trophic position. Largemouth bass is a predatory, trophic level 4 fish and has consistently high mercury levels in both composites. Bluegill has an elevated mercury level relative to its size and is a main food source for largemouth bass (McGinnis 2006). Largemouth bass' trophic level and carnivorous feeding habits likely explain high mercury concentrations. Even though common carp is a lower trophic level three fish, it was the second longest fish caught and had the largest weight (4450.0 g), which can explain why it had the highest mercury level of all the species.

Since sport fish size at Peck Road Park Lake correlates with chemical concentration, consumers should follow OEHHA recommendations when eating larger fish. OEHHA recommends using more caution by eating smaller portions of large fish and spacing out meals over time. Smaller portions of large fish can be frozen and stored for later consumption.

Additionally, while it is not uncommon for fish consumers to consume many parts of the fish they catch, it is important to note that the results of this report are based on the concentration of contaminants in fish filet. According to OEHHA, contaminants can be much higher in the eggs, guts, liver, skin and fatty parts of fish. They do not recommend consuming these parts of the fish because of the increased risk of chemical build-up in humans. Interestingly, a study by Regine et al. (2006) found that fish who feed on bacteria and small benthic invertebrates had higher organ to muscle ratios of mercury in their liver and kidneys. Fish who fed on other fish had higher ratios of mercury in their muscle tissue.

Prey Fish

Prey fish are determined by their size in the Wildlife Habitat Methyl Mercury Water Quality Objectives (Table 34). Both prey fish, largemouth bass and bluegill, from Peck Road Park Lake exceeded mercury water quality objectives for wildlife.

Chapter Summary

The monitoring design for Question 5 is focused on assessing whether the consumption of recreationally caught fish in the Los Angeles River Watershed is safe. During 2016 monitoring season, 57 individual fish from two species were collected from Peck Road Park Lake. Ten composite samples were analyzed for total mercury, selenium, total DDT, and total PCB. For the first time in the history of the LARWMP program, prey fish were collected in tandem with sport fish and sport fish tissue concentrations were compared to draft Water Resources Control Board consumption thresholds for prey fish.

- Based on the most conservative estimates, consumption of common carp from Peck Road Park Lake should be limited to once per week based on its elevated mercury and PCB levels. Channel catfish, bluegill, and largemouth bass are safe to eat at a maximum level of two times a week due to levels of mercury found in fish tissue. Tilapia from Peck Road Park Lake is safe to eat three times a week in 8 ounce portions. For men and women over 45 years old, OEHHA thresholds allow for three 8-ounce servings per week of all species collected.

- PCB levels correlated with size across all species collected and mercury was elevated in larger fish. OEHHA recommends eating smaller fish as they generally are younger and contain lower levels of contaminants. If consuming a larger fish, OEHHA suggests freezing and eating the fish in smaller portions and spaced out over time. They also recommend eating only the filet of the fish and avoiding the skin, organs, guts, and eggs.

- Largemouth bass and bluegill were classified as prey fish in at least one composite and exceeded draft mercury water quality objectives for wildlife.

Caution should be taken in applying these recommendations, as OEHHA recommendations are based on a higher number of composite fish samples.

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Appendix A – Quality Assurance/Quality Control

LARWMP includes an emphasis on QA/QC for each phase of the program including the standardization of data formats so that monitoring results can be shared with local, state, and federal agencies. The data quality objectives for the program are outlined in LARWMP's QAPP and were finalized prior to the 2009 survey and it was updated each year thereafter (https://www.watershedhealth.org/resources). Therefore, the data reported herein from the 2008 survey were based on field sampling and laboratory analysis protocols agreed upon by the participants.

Measurement or Data Quality Objectives (MQOs or DQOs) are quantitative or qualitative statements that specify the tolerable levels of potential errors in the data and ensure that the data generated meet the quantity and quality of data required to support the study objectives. The DQOs for LARWMP are detailed in the Program QAPP (CWH 2016). The MQOs for the processing and identification of benthic macroinvertebrate samples are summarized in LARWMP's QAPP and detailed in the Southern California Regional Watershed Monitoring Program: Bioassessment Quality Assurance Project Plan, Version 1.0 (SCCWRP 2009). The DQOs and MQOs focused on five aspects of data quality: completeness, precision, accuracy, representativeness, and sensitivity.

Completeness

Completeness describes the success of sample collection and laboratory analysis (biology, chemistry, and toxicity) which should be sufficient to fulfill the statistical criteria of the project. One estuary, 1 lake, 10 randomly selected, and 4 targeted sites, and 3 postfire sites were sampled in 2016.

Freshwater targeted and random analysis completeness was 100% for general chemistry, nutrients, major ions, and bioassessment. The only exception was turbidity, which had 71% completeness due to sampling crew error (Table A-1).

Estuary sediment completeness was 100% for organochlorine completeness. PCB completeness was 100% for 43 analytes and 0% for 21 analytes due to missing standards. The laboratory PAH analysis was 100% for all analytes except 1 (Table A-2).

Percent completeness for bioaccumulation samples analyzing organochlorine pesticides was 100% in 2016. PCB's were 100% for 43 constituents and 0% for 21 analytes due to missing standards.

The sampling team and laboratories were notified of completeness deficiencies.

Accuracy

Accuracy provides an estimate of how close a laboratory or field measurement of a parameter is to the true value. Field sampling accuracy was assessed by calibration of the water quality probes with standards of known concentration. The accuracy of physical habitat measurements was assessed during a field audit conducted by the Southern California Coastal Water Research Project (SCCWRP) as part of the Stormwater Monitoring Coalitions (SMC) Southern California Regional Monitoring Survey, field calibration exercise. BMI sorting accuracy was assessed by a recount of 10% of sorted materials. The MQO of 95% was met for each lab reporting results for this program. Taxonomic identification accuracy was assessed through the independent re-identification of 10% of samples by the Department of Fish and Games Aquatic Biology Laboratory. MQOs for taxa count, taxonomic identification, and individual identification rates were met.

Analytical chemistry accuracy measures how close measurements are to the true value. For analytical chemistry samples Certified Reference Materials (CRM), matrix spike / matrix spike duplicates and laboratory control standards are used to assess method accuracy. LARWMP followed SWAMP protocols, which allow one of these elements to fail in a batch and still be compliant. If data fails accuracy checks, it is noted in data and an accuracy qualifier is associated with that result.

Precision

Field duplicates were collected for chemistry, toxicity, and benthic macroinvertebrates at 10% of the random sites visited in 2010. The MQO for field duplicates was a relative percent difference (RPDs) <25%, except for benthic macroinvertebrates. At this time, no MQO has been developed for benthic macroinvertebrate duplicate samples. For analytical chemistry results matrix spike (MS), matrix spike duplicates (MSD), and laboratory duplicates (DUP) were used to assess laboratory precision. RPDs <25% for either the MS/MSD or DUPs were considered acceptable. Of the analytes measured in 2016, 4 did not meet the precision criteria (Table A-4).

Toxicity testing precision is measured through the development of control charts that include 20 reference toxicant tests for each organism. Each new reference toxicant test must fall within ± 2 standard deviations (SD) of the control chart average to be acceptable. All tests met this criterion.

Taxonomic precision was assessed using three error rates: random errors which are misidentifications that are made inconsistently within a taxon; systemic errors occur when a specific taxon is consistently misidentified; taxonomic resolution errors occur when taxa are not identified to the proper taxonomic level. Error rates of <10% are considered acceptable and all precision requirements were met.

Laboratory Blanks

Laboratory blanks were used to demonstrate that the analytical procedures do not result in sample contamination. The MQO for laboratory blanks were those with values less than the reporting limit (RL) for the analyte. During the 2016 surveys, there were no laboratory blanks with concentrations above the RL.

Program Improvements and Standardization

An intercalibration study was conducted in 2006 sampling season by the Stormwater Monitoring Coalition's (SMC) Chemistry Workgroup. This intercalibration included all participating laboratories and covered nutrient and metal analyses. Intercalibration studies will be ongoing as part of the SMC Regional Monitoring Program.

Sampling procedures for each field team collecting samples for LARWMP were audited by biologists from the Southern California Coastal Water Research Project during summer surveys. The audit covered the SWAMP bioassessment and physical habitat protocols, including algae and benthic macroinvertebrate collection, and CRAM assessment (Ode, 2007, Fetscher *et al.,* 2009, CWMW 2012, and CWMW 2013). Each team passed their audit.

Table A-1. Percent completeness and nondetects by watershed sub-region for water chemistry samples collected in 2016.

Analyte	2016					
	Number of Sites	Completeness (%)	Number of Non-Detects (<MDL)			
			Effluent (n=3)	Natural (n=7)	Urban (n=4)	Total
Genreal Chemistry						
Alkalinity as CaCO3	14	100	0	0	0	0
Hardness as CaCO3	14	100	0	0	0	0
Total Suspended Solids	14	100	0	6	0	6
Turbidity	14	71	0	0	0	0
Chlorophyll a	6	100	0	0	0	0
Ash-Free Dry Mass	6	100	0	0	0	0
Nutrients						
Ammonia as N	14	100	0	6	2	8
Dissolved Organic Carbon	14	100	0	0	0	0
Nitrate as N	14	100	0	3	2	5
Nitrite as N	14	100	3	7	4	14
OrthoPhosphate as P	14	100	0	5	0	5
Phosphorus as P	14	100	0	1	0	1
Total Nitrogen (calculated)	14	100	0	0	3	3
Total Organic Carbon	14	100	0	0	0	0
Major Ions						
Chloride	14	100	0	0	0	0
Sulfate	14	100	0	0	0	0
Bioassessment						
Benthic Macroinvertebrate ID	14	100	NA	NA	NA	NA
Algae ID	6	100	NA	NA	NA	NA

Table A-2 Percent completeness and non-detects for estuary samples collected in 2016.

Estuary Sediment	Number of Sites	2016 % Completeness	2016 Number of Non-Detects (<MDL)
Nutrients			
Phosphorus as P	1	100	0
Total Kjeldahl Nitrogen	1	100	0
Total Organic Carbon	1	100	0
Metals			
Arsenic	1	100	1
Cadmium	1	100	0
Chromium	1	100	0
Copper	1	100	0
Iron	1	100	0
Lead	1	100	0
Mercury	1	100	0
Nickel	1	100	0
Selenium	1	100	1
Zinc	1	100	0
Organochlorine Pesticides			
Aldrin	1	100	1
Chlordane, cis-	1	100	0
Chlordane, trans-	1	100	0
DDD(o,p')	1	100	1
DDD(p,p')	1	100	0
DDE(o,p')	1	100	1
DDE(p,p')	1	100	0
DDT(o,p')	1	100	1
DDT(p,p')	1	100	0
Dieldrin	1	100	0
Endosulfan I	1	100	1
Endosulfan II	1	100	1
Endosulfan Sulfate	1	100	1
Endrin	1	100	1
Endrin Aldehyde	1	100	1
HCH, alpha	1	100	1
HCH, beta	1	100	1
HCH, delta	1	100	1
HCH, gamma	1	100	1
Heptachlor	1	100	1

Estuary Sediment	Number of Sites	2016 % Completeness	2016 Number of Non-Detects (<MDL)
Heptachlor Epoxide	1	100	1
Methoxychlor	1	100	1
Mirex	1	100	1
Nonachlor, cis-	1	100	0
Nonachlor, trans-	1	100	0
Oxychlordane	1	100	1
Toxaphene	1	100	1
PCBs			
PCB 003	1	0	NA
PCB 008	1	0	NA
PCB 018	1	100	1
PCB 027	1	0	NA
PCB 028	1	100	0
PCB 029	1	0	NA
PCB 031	1	0	NA
PCB 033	1	0	NA
PCB 037	1	100	1
PCB 044	1	100	1
PCB 049	1	100	0
PCB 052	1	100	1
PCB 056	1	0	NA
PCB 056/060	1	0	NA
PCB 060	1	0	NA
PCB 064	1	0	NA
PCB 066	1	100	1
PCB 070	1	100	1
PCB 074	1	100	1
PCB 077	1	100	1
PCB 081	1	100	1
PCB 087	1	100	0
PCB 095	1	0	NA
PCB 097	1	0	NA
PCB 099	1	100	1
PCB 101	1	100	0
PCB 105	1	100	0
PCB 110	1	100	0

Estuary Sediment	Number of Sites	2016	
		% Completeness	Number of Non-Detects (<MDL)
PCB 114	1	100	1
PCB 118	1	100	0
PCB 119	1	100	1
PCB 123	1	100	1
PCB 126	1	100	1
PCB 128	1	100	1
PCB 128/167	1	100	NA
PCB 137	1	0	NA
PCB 138	1	100	1
PCB 141	1	0	NA
PCB 146	1	0	NA
PCB 149	1	100	1
PCB 151	1	100	1
PCB 153	1	100	1
PCB 156	1	100	1
PCB 157	1	100	1
PCB 158	1	100	1
PCB 167	1	100	1
PCB 168	1	100	1
PCB 168/132	1	0	NA
PCB 169	1	100	1
PCB 170	1	100	1
PCB 174	1	0	NA
PCB 177	1	100	1
PCB 180	1	100	0
PCB 183	1	100	1
PCB 187	1	100	1
PCB 189	1	100	1
PCB 194	1	100	0
PCB 195	1	0	NA
PCB 198/199	1	0	NA
PCB 200	1	100	1
PCB 201	1	100	1
PCB 203	1	0	NA
PCB 206	1	100	1
PCB 209	1	0	NA

A-3 **Percent completeness and non-detects for bioaccumulation samples collected in 2016.**

Bioaccumulation	2016		
	Number of Samples	% Completeness	Number of Non-Detects (<MDL)
General Chemistry			
Lipids	10	100	0
Metals			
Mercury	10	100	1
Selenium	10	100	0
Organochlorine Pesticides			
Aldrin	10	100	10
Chlordane, cis-	10	100	10
Chlordane, trans-	10	100	10
DDD(o,p')	10	100	10
DDD(p,p')	10	100	10
DDE(o,p')	10	100	9
DDE(p,p')	10	100	9
DDT(o,p')	10	100	10
DDT(p,p')	10	100	10
Dieldrin	10	100	10
Endosulfan I	10	100	10
Endosulfan II	10	100	10
Endosulfan Sulfate	10	100	10
Endrin	10	100	10
Endrin Aldehyde	10	100	10
HCH, alpha	10	100	10
HCH, beta	10	100	10
HCH, delta	10	100	10
HCH, gamma	10	100	10
Heptachlor	10	100	10
Heptachlor Epoxide	10	100	10
Methoxychlor	10	100	10
Mirex	10	100	10
Nonachlor, cis-	10	100	10
Nonachlor, trans-	10	100	10
Oxychlordane	10	100	10
Toxaphene	10	100	10

A-4 **QA/QC Table. Bold type indicates values that did not meet quality control criteria.**

Analyte	Station ID	Sample Date	Batch ID	Sample Type	Recovery DQO	% Recovery	Dup % Recovery	RPD	RPD DQO
PCBs (Sediment)									
PCB 153/168	000NONPJ	13-Sep-17	WG385847	MS	50 - 150 %	**34**	**43**	3	25%
Organochlorine Pesticides (tissue)									
Total Kjeldahl Nitrogen	LALT302	3-May-17	WG381974	MS	50 - 150 %	76	**49**	**43**	25%
PCBs (tissue)									
PCB087	LALT302	3-May-17	WG382904	MS	50 - 150 %	**41**	**46**	12	25%
PCB210	LALT302	3-May-17	WG382904	MS	50 - 150 %	**49**	50	2	25%

Appendix B – Biotic Condition Index Scores for the CSCI & CRAM

Table B-1. CSCI and CRAM scores, including sub-metrics, for each random station sampled from 2009 to 2016.

Stratum	Station	Station Description	CSCI	CSCI Percentile	MMI	MMI Percentile	O/E	O/E Percentile	Overall CRAM Score	Biotic Structure	Buffer and Landscape Context	Hydrology	Physical Structure
2009													
Effluent	LAR00436	Los Angeles River	0.62	0.01	0.49	0	0.74	0.09	27	8	6	12	6
	LAR02228	Los Angeles River	0.70	0.03	0.55	0.01	0.84	0.21	27	8	6	12	6
Urban	LAR00440	Aliso Canyon Wash	0.80	0.1	0.60	0.01	0.99	0.48	64	25	21	18	12
	LAR00756	Tujunga Wash	0.68	0.02	0.51	0	0.85	0.21	37	8	15	12	6
	LAR01004	Arroyo Seco	0.67	0.02	0.51	0	0.83	0.19	29	8	8	12	6
Natural	LAR00476	Little Bear Canyon	1.22	0.92	1.16	0.82	1.28	0.93	99	34	24	36	24
	LAR00520	Big Tujunga Creek	1.02	0.55	0.77	0.1	1.27	0.92	80	33	20	21	21
	LAR00924	Arroyo Seco	1.35	0.99	1.43	0.99	1.27	0.93	87	33	20	30	21
	LAR01040	Big Tujunga Creek	1.21	0.91	1.10	0.72	1.32	0.95	89	33	24	27	21
	LAR06216	Big Tujunga Creek	0.85	0.17	0.73	0.07	0.97	0.43	64	23	20	21	12
2010													
Effluent	LAR00318	Los Angeles River	0.35	0	0.19	0	0.51	0.01	36	8	16	9	6
	LAR02622	Los Angeles River	0.44	0	0.37	0	0.52	0.01	36	8	16	9	6
Urban	LAR01208	Los Angeles River	0.54	0	0.58	0.01	0.50	0	38	8	16	12	6
	LAR01452	Eaton Wash	0.37	0	0.30	0	0.44	0	36	10	16	9	6
	LAR01716	Bull Creek	0.43	0	0.48	0	0.39	0	38	8	16	12	6
	LAR01972	Bull Creek	0.42	0	0.44	0	0.40	0	38	8	16	12	6
Natural	LAR00080	Lynx Gulch	0.75	0.06	0.64	0.02	0.86	0.23	55	17	18	21	9
	LAR00520	Big Tujunga Creek	0.75	0.06	0.73	0.07	0.76	0.11	63	15	22	24	12
	LAR00924	Arroyo Seco	0.68	0.02	0.55	0.01	0.81	0.16	70	20	24	27	12
	LAR01096	Big Tujunga Creek	0.65	0.01	0.59	0.01	0.71	0.06	63	15	20	27	12
	LAR01196	Big Tujunga Creek	0.82	0.13	0.79	0.12	0.85	0.21	65	21	22	21	12
	LAR01320	Big Tujunga Creek	0.69	0.03	0.62	0.02	0.77	0.12	66	21	22	27	9
	LAR01544	Big Tujunga Creek	0.84	0.15	0.77	0.1	0.90	0.3	66	18	22	30	9
2011													
Effluent	LAR02804	Los Angeles River	0.72	0.04	0.55	0.01	0.88	0.27	39	13	15	12	6
Urban	LAR00632	Tarzana	0.44	0	0.33	0	0.55	0.01	32	15	7	12	6
	LAR00684	Rio Hondo Spillway	0.44	0	0.43	0	0.44	0	38	8	16	12	6
	LAR00748	Rubio Wash, Rosemead	0.25	0	0.27	0	0.24	0	35	10	15	9	6
	LAR00830	Rio Hondo	0.43	0	0.47	0	0.39	0	38	8	16	12	6
	LAR01358	Compton Creek	0.37	0	0.23	0	0.51	0.01	37	8	15	12	6
Natural	LAR00080	Lynx Gulch	0.89	0.25	0.81	0.14	0.98	0.45	78	20	22	36	15
	LAR00520	Big Tujunga Creek	0.80	0.1	0.75	0.08	0.85	0.21	71	15	20	30	18
	LAR00924	Arroyo Seco	0.79	0.1	0.80	0.13	0.79	0.13	76	19	22	30	18
	LAR01692	Arroyo Seco	0.83	0.15	0.67	0.03	0.99	0.48	63	16	18	30	12
	LAR01808	Alder Creek	0.87	0.21	0.80	0.14	0.93	0.37	86	26	23	36	18
	LAR02088	Big Tujunga Creek	0.86	0.2	0.71	0.05	1.02	0.54	66	14	20	33	12
	LAR02092	Big Tujunga Creek	0.88	0.23	0.72	0.06	1.04	0.58	77	21	22	30	18
2012													
Effluent	LAR04532	Los Angelese River	0.68	0.02	0.51	0	0.85	0.21	47	13	16	21	6
Urban	LAR01464	Aliso Canyon Wash	0.70	0.03	0.60	0.01	0.80	0.14	34	8	7	21	6
	LAR01656	Cabarello Creek	0.69	0.03	0.52	0	0.86	0.22	36	13	12	12	6
	LAR01772	Alhambra Wash	0.60	0.01	0.52	0	0.67	0.04	39	12	15	12	6
	LAR01912	Santa Susana Creek	0.36	0	0.32	0	0.39	0	34	8	13	12	6
	LAR02028	Arroyo Seco	0.68	0.02	0.57	0.01	0.78	0.13	34	10	12	12	6
Natural	LAR00080	Lynx Gulch	0.85	0.17	0.85	0.2	0.85	0.21	79	25	24	30	15
	LAR00520	Big Tujunga Creek	1.01	0.52	1.03	0.57	0.99	0.47	61	16	18	27	12
	LAR00924	Arroyo Seco	0.82	0.13	0.87	0.23	0.77	0.11	74	20	22	30	15
	LAR02568	Big Tujunga Creek	0.97	0.42	0.91	0.31	1.02	0.55	79	23	22	30	18
	LAR02712	Pacoima Canyon	1.04	0.59	0.84	0.18	1.24	0.89	77	21	24	27	18
	LAR04204	Santa Anita Wash	0.99	0.48	0.81	0.14	1.18	0.83	69	25	22	27	9
	LAR04880	Big Tujunga Creek	1.04	0.6	0.83	0.17	1.25	0.91	82	20	23	36	18

Table B-1. continued.

Stratum	Station	Station Description	CSCI	CSCI Percentile	MMI	MMI Percentile	O/E	O/E Percentile	Overall Score	Biotic Structure	Buffer and Landscape Context	Hydrology	Physical Structure
2013													
Effluent	LAR03646	Los Angeles River	0.61	0.01	0.48	0	0.73	0.08	38	25	67.67	33.33	25
Urban	LAR02232	Limekiln Canyon Wash	0.24	0	0.30	0	0.18	0	40	25	50	58.33	25
	LAR02484	Tujunga Wash	0.56	0	0.55	0.01	0.56	0.01	30	36.11	25	33.33	25
	LAR02488	Wilbur Wash	0.21	0	0.30	0	0.12	0	40	25	50	58.33	25
	LAR02796	Rubio Wash	0.28	0	0.28	0	0.29	0	27	25	25	33.33	25
	LAR02936	Bell Creek Tributary	0.46	0	0.46	0	0.46	0	37	27.78	55.17	41.67	25
Natural	LAR05020	Arroyo Seco	0.95	0.37	0.90	0.29	1.00	0.49	84	69.44	93.29	100	75
	LAR05640	Big Tujunga Creek	0.92	0.31	0.95	0.39	0.89	0.29	81	77.78	93.29	91.67	62.5
	LAR05848	Gold Creek	0.91	0.28	0.87	0.23	0.95	0.4	84	77.78	100	83.33	75
	LAR06044	Arroyo Seco	1.13	0.79	1.10	0.72	1.15	0.79	84	75	93.29	91.67	75
2014													
Effluent	LAR05694	Los Angeles River	0.45	0	0.45	0	0.45	0	35	25	58.54	33.33	25
Urban	LAR02680	Los Angeles River	0.41	0	0.34	0	0.48	0	38	25	67.67	33.33	25
	LAR02988	Sawpit Wash	0.70	0.03	0.69	0.04	0.72	0.07	36	25	62.5	33.33	25
	LAR02996	Big Tujunga Wash	0.47	0	0.38	0	0.55	0.01	34	25	62.5	25	25
Natural	LAR00520	Big Tujunga Creek	0.86	0.2	0.81	0.14	0.92	0.34	74	61.11	90.29	83.33	62.5
	LAR00924	Arroyo Seco	1.13	0.79	1.02	0.55	1.24	0.89	81	86.11	93.29	83.33	62.5
	LAR06188	Big Tujunga Wash	1.11	0.75	0.95	0.38	1.27	0.92	83	97.22	93.29	66.67	75
	LAR06216	Big Tujunga Creek	0.92	0.31	0.84	0.18	1.01	0.51	81	88.89	90.29	83.33	62.5
	LAR06252	Santa Anita Wash	0.82	0.13	0.88	0.25	0.76	0.1	83	83.33	85.38	75	87.5
	LAR07128	Pacoima Canyon	1.05	0.63	0.99	0.48	1.11	0.72	90	97.22	96.54	91.67	75
2015													
Effluent	LAR0232	Los Angeles River	0.66	0.02	0.50	0	0.82	0.17	36	25	62.5	33.33	25
	LAR08597	Los Angeles River	0.69	0.03	0.48	0	0.89	0.28	38	25	67.67	33.33	25
	LAR08599	Los Angeles River	0.70	0.03	0.51	0	0.89	0.28	45	33.33	62.5	58.33	25
	LAR08602	Los Angeles River	0.38	0	0.28	0	0.47	0	39	33.33	62.5	33.33	25
	LAR0616	Los Angeles River	0.68	0.02	0.58	0.01	0.77	0.12	36	25	62.5	33.33	25
	LAR0732	Los Angeles River	0.59	0	0.42	0	0.75	0.1	36	25	62.5	33.33	25
Natural	LAR0552	Arroyo Seco	0.98	0.45	0.89	0.27	1.07	0.64	79	75	93.29	83.33	62.5
	LAR00520	Big Tujunga Creek	0.92	0.3	0.83	0.17	1.01	0.51	77	80.56	82.92	83.33	62.5
	LAR0896	Big Tujunga Creek	0.93	0.33	0.87	0.24	0.98	0.47	85	77.78	100	75	87.5

Appendix C – Analyte List, Detection Limits and Methods

Table C-1 Analyte list and method for each program element in 2015.

Analyte	Method	Units	Reporting Limit
Conventional Water Chemistry			
Temperature	Probe	ºC	-5
pH	Probe	None	NA
Specific Conductivity	Probe	mS/cm	2.5
Dissolved Oxygen	Probe	mg/L	N/A
Salinity	Probe	ppt	N/A
Water Chemistry: freshwater			
Alkalinity as CaCO3	SM 2320 B	mg/L	10
Hardness as CaCO3	SM 2340 B	mg/L	1.32
Turbidity		NTU	
Suspended Solids	SM 2540 D	mg/L	3
Nutrients			
Ammonia as N	EPA 350.1	mg/L	0.1
Nitrate as N	EPA 300.0	mg/L	0.1
Nitrite as N	EPA 300.0	mg/L	0.1
TKN	EPA 351.2 (1° Method) or SM4500-NH3 C (2° Method)	mg/L	0.1
Total Nitrogen	Calculated	NA	NA
Total Organic Carbon	SM 5310 C	mg/L	0.1
Dissolved Organic Carbon	SM 5310 C	mg/L	0.1
OrthoPhosphate as P	SM 4500-P E	mg/L	0.1
Phosphorus as P	SM 4500-P E	mg/L	0.1
Major Ions			
Chloride	EPA 300.0	mg/L	1.0
Sulfate	EPA 300.0	mg/L	1.0
Taxonomy: Freshwater			
Benthic Macroinvertebrate	SWAMP (2007), SAFIT STE	Count	NA
Qualitative Algae	SWAMP, In Development	Count	NA
Quantitative Diatom	SWAMP, In Development	NA	NA
Quantitative Algae	SWAMP, In Development	NA	NA
Habitat Assessments: Freshwater			
Freshwater Bioassessments	SWAMP (2007)	NA	NA
Freshwater Algae (collected in conjunction with bioassessments)	SWAMP (2010)	NA	NA
California Rapid Assessment Method (CRAM)	Collins et al., 2008	NA	NA

Water Chemistry: Estuary Seawater			
Alkalinity as CaCO3	SM 2320 B	mg/L	10
Hardness as CaCO3	SM 2340 B	mg/L	1.32
Suspended Solids	SM 2540 D	mg/L	3
Dissolved Solids	SM 2540 C	mg/L	37
Nutrients			
Ammonia	SM 4500-NH3 B&C; EPA 350.1	mg/L	0.1
Nitrate	EPA 300.0 or EPA 353.2	mg/L	0.1
Nitrite	EPA 300.0 or EPA 353.2	mg/L	0.1
TKN	EPA 351.2 (1° Method) or SM4500-NH3 C (2° Method)	mg/L	0.1
Dissolved Organic Carbon	SM 5310 C	mg/L	0.1
Total Organic Carbon	SM 5310 B	mg/L	0.1
OrthoPhosphate as P	SM 4500-P E	mg/L	0.1
Phosphorus as P	SM 4500-P E	mg/L	0.1
Metals (Total & Dissolved)			
Arsenic	SM 3114 B	mg/L	1
Cadmium	EPA 200.8 or 200.7	mg/L	0.2
Chromium	EPA 200.8 or 200.7	mg/L	0.5
Copper	EPA 200.8 or 200.7	mg/L	0.5
Iron	EPA 200.8 or 200.7	mg/L	50
Lead	EPA 200.8 or 200.7	mg/L	0.5
Mercury	SM 3112 B	mg/L	0.2
Nickel	EPA 200.8 or 200.7	mg/L	1
Selenium	SM 3114 B	mg/L	1
Zinc	EPA 200.8 or 200.7	mg/L	1
Organics			
Pyrethroid Pesticides	EPA 625-NCL	µg/L	0.002-0.005
Sediment Chemistry: Estuary			
Sediment Particle Size (% fines)	SM 2560 D	um	<2000->0.2
Metals			
Arsenic	EPA 6010 B	mg/Kg dw	1
Cadmium	EPA 6010 B	mg/Kg dw	1
Chromium	EPA 6010 B	mg/Kg dw	1
Copper	EPA 6010 B	mg/Kg dw	1
Iron	EPA 6010 B	mg/Kg dw	100
Lead	EPA 6010 B	mg/Kg dw	0.5
Mercury	EPA 7471 A	mg/Kg dw	0.01
Nickel	EPA 6010 B	mg/Kg dw	2
Selenium	EPA 6010 B	mg/Kg dw	1

Zinc	EPA 6010 B	mg/Kg dw	2
Nutrients			
Total Kjeldahl Nitrogen (TKN)	EPA 351.2; SM4500-N ORG B	mg/Kg dw	0.5
Total Organic Carbon	SM 5310 B	mg/Kg dw	0.05
Phosphorus as P	SM 4500-P E	mg/Kg dw	0.05
Organics			
Organochlorine Pesticides (DDTs)	EPA 8081A	µg/Kg dw	1.7-83.3
Polychlorinated Biphenyl (PCBs)	EPA 8082	µg/Kg dw	0.5
Polynuclear Aromatic Hydrocarbons (PAHs)	EPA 8270C	µg/Kg dw	1.7
Sediment Toxicity: Estuary			
Chronic *Eohaustorius* sp. (sediment) 10 day survival	EPA 600/R-94/025	% survival	N/A
Chronic *Mytilus* Sediment Water Interface	EPA 600/R-95-136m	% development	N/A
Taxonomy: Sediment			
Infauna	SCCWRP (2008)*, SCAMIT STE	N/A	N/A
Habitat Assessments: Estuary			
California Rapid Assessment Method (CRAM)	Collins et al., 2008	NA	NA
Tissue Chemistry: Fish			
Percent Lipids	Bligh, E.G. and Dyer ,W.J. 1959.	%	NA
Metals			
Mercury	EPA 7471A	mg/kg ww	0.02
Selenium	EPA 6010B	mg/kg ww	0.25
Organics			
Organochlorine Pesticides (DDTs)	EPA 8081A	µg/kg ww	1.7-83
Polychlorinated Biphenyl (PCBs)	EPA 8082	µg/kg ww	2
Indicator Bacteria			
Total Coliform and E. coli	SM 9223 B	MPN/100mL	10
Enterococcus	SM 9230 D (21st ed. on line)	MPN/100mL	10

* Southern California Regional Monitoring Program, 2008 Field and Laboratory Operating Procedures, SCCWRP.