PREPARED BY Council for Watershed Health

Los Angeles River 2018
STATE OF THE WATERSHED REPORT

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The City of Los Angeles, LA Sanitation and Environment

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MISSION: To protect public health and the environment.

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The key objectives of the Public Works Department are to provide for the efficient operation of public works systems and programs such as wastewater treatment, sewer maintenance, street design and maintenance, street sweeping, solid waste collection, recycling and landfill disposal, public building maintenance, equipment maintenance, traffic and parking management, and graffiti removal; while protecting the environment and responding to the changing needs of the citizens.

Acknowledgements

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Cover photos (clockwise from top): 1) Kayaking on the Los Angeles River above Sepulveda Basin, 2) Fishing on the Los Angeles River in Long Beach (Photo courtesy of William Preston Bowling), 3) Swimming at Hermit Falls in the Angeles National Forest, 4) Horseback riding near Hansen Dam.

Purpose of the Report

The Los Angeles Watershed is a dynamic system that is undergoing constant change. Regular recurring monitoring allows us to better understand this dynamic system and to respond to changes. The Los Angeles River Watershed Monitoring Program (LARWMP), which is the basis for this report, is a collaborative effort to assess the health of the Los Angeles Watershed from a regional perspective. The motivation for this program came from the Los Angeles Regional Water Quality Control Board (Los Angeles Water Board or LARWQCB) using a unique permit condition for the Cities of Los Angeles and Burbank that initiated a monitoring program designed to increase awareness of issues at the watershed scale through the improved coordination and integration of monitoring efforts.

The Council for Watershed Health[1] manages the LARWMP on behalf of stakeholders, including the major permittees, regulatory and management agencies, and non-profit organizations in the region. The intent of this report is to describe current conditions and trends of the Los Angeles River Watershed by addressing 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?

The results presented in this report follow nine years of monitoring multiple indicators of watershed health. The results will assist watershed managers and other interested persons to identify areas of concern and prioritize management actions. The detailed assessments, methods and quality assurance for this program can be found in the individual Los Angeles River Watershed Monitoring Program annual reports from 2008 through 2017.[2] Efforts to better understand the condition and the changing nature of the watershed will continue in future years.

1 Originally formed as The Los Angeles & San Gabriel Rivers Watershed Council

2 http://www.watershedhealth.org/reports

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ATL	Advisory Tissue Levels
BMI	Benthic Macroinvertebrates
BWRP	City of Burbank Water Reclamation Plant
CFP	California Floristic Province
CFS	Cubic Feet per Second
CMAP	California's Monitoring and Assessment Program
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
CTR	California Toxics Rule
CWA	Clean Water Act
DCTWRP	Donald C. Tillman Water Reclamation Plant (City of Los Angeles)
DDT	Dichlorodiphenyltrichloroethane
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
FIB	Fecal Indicator Bacteria
FoLAR	Friends of the Los Angeles River
IBI	Index of Biological Integrity (Southern California)
LACC	Los Angeles Conservation Corps
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LADWP	Los Angeles Department of Water and Power
LAGWRP	City of Los Angeles Glendale Water Reclamation Plant
LARC	Los Angeles Regional Collaborative for Climate Action
LARWMP	Los Angeles River Watershed Monitoring Program
LARWQCB	Los Angeles Regional Water Quality Control Board
MGD	Million Gallons per Day
MLOE	Multiple Lines of Evidence
MPN	Most Probable Number
MRCA	Mountains Recreation and Conservation Authority
MS4	Municipal Separate Storm Sewer Systems
NDN	Nitrification/Dentrification
NPDES	National Pollutant Discharge Elimination System
OEHHA	Office of Environmental Health Hazard Assessment (State of California)
PBDE	Polybrominated Diphenyl Ethers
PCB	Polychlorinated biphenyls
POTF	Publicly Owned Treatment Facilities
POTW	Publicly Owned Treatment Works
PPB	Parts Per Billion
PSA	Perennial Streams Assessment
QAPP	Quality Assurance Project Plan
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SMC	Stormwater Monitoring Coalition
SQO	Sediment Quality Objectives
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USFS	United States Forest Service
USGS	United States Geological Survey
WQO	Water Quality Objectives
WRP	Water Reclamation Plants

FIGURE 1. The Los Angeles River Watershed.

Introduction to the Los Angeles River Watershed

A resilient watershed, one that offers equitable access to clean water, reliable local water supplies, restored native habitats, recreational opportunities, ample and connected parks, open spaces, and integrated flood management, is a watershed that enhances biodiversity, environmental health, social well-being, and economic vitality.

Water quality concerns and the need for a watershed-wide monitoring program are better understood when the watershed is viewed not simply as a hydrologic system where surface waters drain to a single water body, but as the product of its geophysical processes, biological conditions, cultural and historical context, socioeconomic patterns, and regulatory framework. Current and historical anthropogenic activities including land use practices, industrial development, and modifications to the natural hydrology, have dramatically impacted the nation's watersheds, with consequences for both human and ecological communities. This is particularly true in the Los Angeles River Watershed, an area that is home to an estimated 4.5 million people (U.S. Census, 2017), and which provides habitat for countless native flora and fauna, including endangered species found nowhere else on earth.

Watershed-wide long-term monitoring provides an appropriate scale to accurately assess the impacts of the aforementioned anthropogenic activities. Long-term monitoring can also begin to capture the impact of anthropogenic activities and a changing climate to ecosystems and surface waters. Topography, geology, land-use, soil types, climate, and hydrology, including hydrologic modifications, are factors that have shaped the watershed, influencing runoff behavior, water quality, and the diversity and health of habitats.

1.1 ENVIRONMENTAL SETTING

The boundaries of the Los Angeles River Watershed encompass 834 square miles of land stretching from the San Gabriel Mountains on the northern end of the Los Angeles Basin to the Pacific Ocean. With straightening, through channelization, the river measures 51 miles. The first 32 miles are within the City of Los Angeles. The watershed is shaped roughly like a large comma, stretching from the western edge in the Santa Susana Mountains and Simi Hills and curving southward around the intrusion of the Santa Monica Mountains to discharge into the Pacific Ocean at Long Beach Harbor in San Pedro Bay *(Figure 1)*.

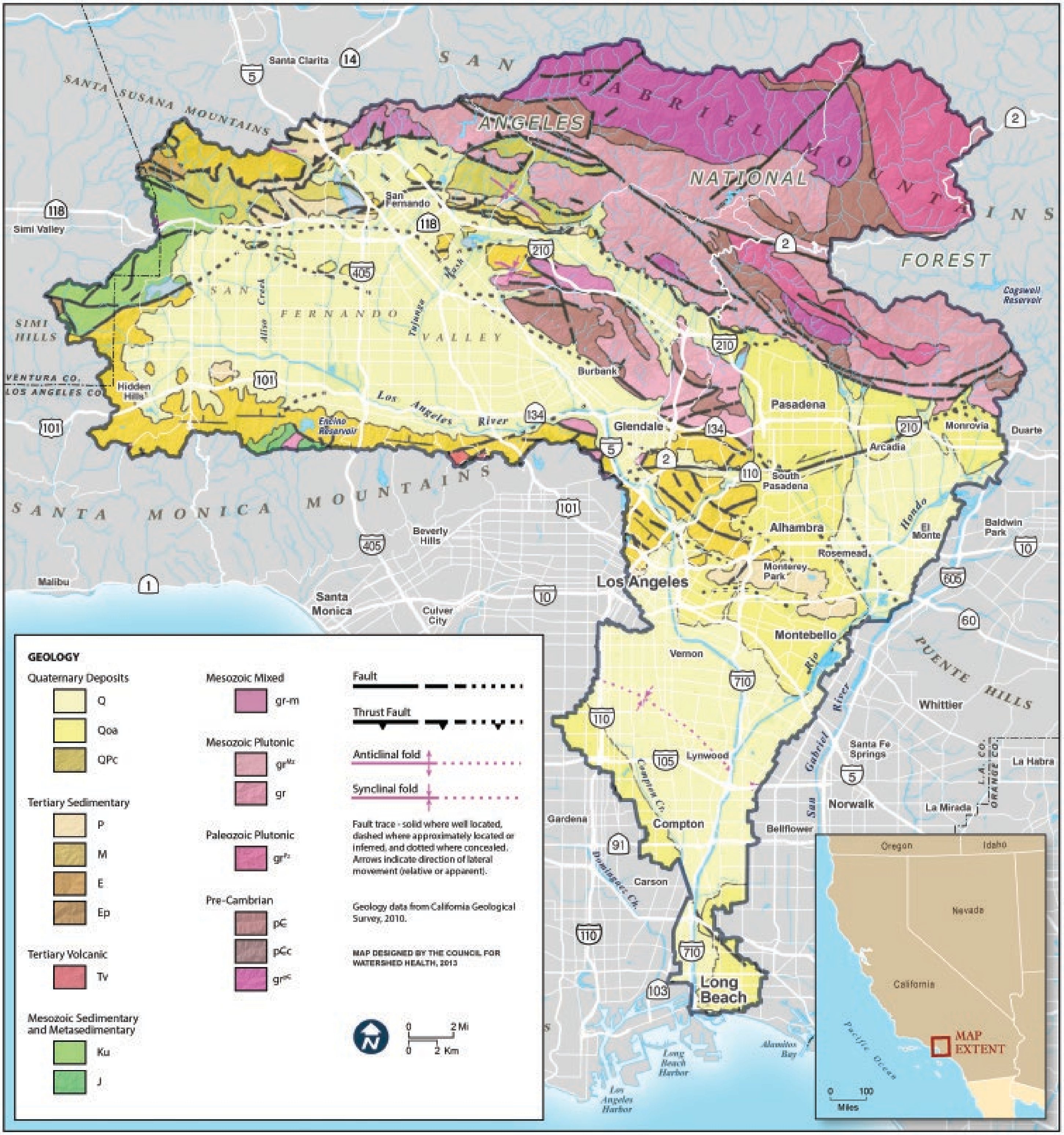
The topography of the Los Angeles River Watershed is dramatic, dropping from 7,103 feet in the northwestern San Gabriel Mountains to sea level over a mere 51 miles. This corresponds to an average drop of 31 feet per mile. For comparison, the Mississippi River is 2,348 miles long and drops approximately 1 foot per mile. The deeply incised mountain slopes are as steep as 65-70% grade and are some of the steepest in the world. The most recognizable peak in the watershed, although not the highest, is Mount Wilson *(Table 1)*.

The Verdugo Mountains and the San Rafael Hills lie between the eastern edge of the San Fernando Valley and the San Gabriel Mountains. Verdugo Peak, at 3,126 feet, is the highest point in these small ranges and lies entirely within the watershed. To the southeast lies the

TABLE 1. Elevation of mountain ranges.

RANGE	HIGHEST PEAKS IN THE L.A. RIVER WATERSHED	ELEVATION (feet/meters)
San Gabriel Mountains	Mount Pacifico	7,103/2165
San Gabriel Mountains	Mount Wilson	5,712/1741
Santa Susana Mountains	Oat Mountain	3,747/1142
Verdugo Mountains	Verdugo Peak	3,126/953
Simi Hills	Chatsworth Peak	2,314/705
Santa Monica Mountains	San Vicente Peak	1,965/599

FIGURE 2. Geology of the Los Angeles River Watershed.



San Gabriel Valley, the western portion of which is within the Los Angeles River Watershed. Elevations in the mountain-rimmed San Fernando Valley range from 3,747 feet in the north against the Santa Susana Mountains to 1,965 feet in the Santa Monica Mountains. South of the Elysian Hills the coastal plain slopes gently southward with elevations dropping from about 300 feet to sea level over a distance of 20 miles.

1.1.1 GEOLOGY AND SOILS

Mountain ranges within or partially within the watershed are part of the Transverse Ranges, so named because they are east-west trending, running counter to the north-south orientation of most ranges in California. These mountain ranges are a work in progress, a product of ongoing tectonic activity still forming the mountains.

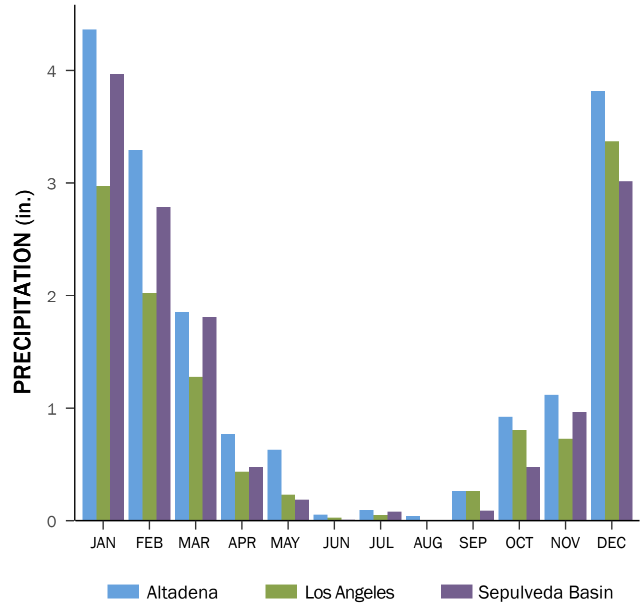
The Transverse Ranges are among the youngest and fastest rising mountains on earth. Uplift is partially counteracted by debris flows and rock falls, expedited by the steepness of the mountain slopes and aided and abetted by fire, which denudes the landscape of stabilizing brush, and intense rain storms, which lubricate the slide. Uplift rates in the Transverse Ranges are estimated to be roughly 7.6 meters per 1,000 years, while the rate of erosion is closer to 2.3 meters per 1,000 years (Wohlgemuth, 2006).

Closest to the mountains, coarse gravel predominates. The granularity of the deposits diminishes in size with distance from the San Gabriel Mountains, graduating down to sand, silt, and clay. In the central and western portions of the San Fernando Valley, the deposits are fine-grained materials resulting from the erosion of shale, sandstone, and clay, with most of the material having been deposited by streams entering the valley from the southern slopes of the Santa Susana Mountains *(Figure 2)*.

1.1.2 CLIMATE

The Los Angeles River watershed is situated in a Mediterranean climate zone, characterized by warm, dry summers and cool, wet winters. The seasonal variability in precipitation *(Figure 3)* demonstrate characteristic Mediterranean climate conditions. It is this climate that is largely responsible for the settlement of Native Americans and later promoted westward migration and settlement in the Los Angeles region. From medical doctors who sent tuberculosis patients west to recuperate, to the promotion of the region for growing citrus and other crops, the climate enticed people to Los Angeles.

FIGURE 3. Mean monthly rainfall across the Los Angeles River watershed (2008-2017) at LACDPW precipitation stations.



The spatial variation in local climate is largely a result of the topography of the region. Moisture-laden air from the ocean moves up the slopes of the San Gabriel Mountains, cooling as it rises and creating a barrier that traps moist ocean air against the mountain slopes and partially blocks summer heat from the desert and winter cold from the interior northeast. Rainfall in the mountains increases with elevation. Altadena, nestled in the San Gabriel Mountain foothills at roughly 1,300 feet, receives the greatest amount of precipitation, compared to Los Angeles and the Sepulveda Basin. Historically the San Gabriel Mountains have experienced high intensity record-breaking storms, during which heavy rainfall occurs over a relatively short period of time.

Dry periods are common in California's history (CADWR, 2015), though the most recent drought, spanning from 2012 to 2017 *(Figure 4)*, was unique in that it coincided with a period of record warmth. Drought conditions, like those that recently gripped the state, result in reduced water delivery from the State Water Project, a significant source of drinking water for Southern California, and increase reliance on groundwater.

REGIONAL CLIMATE CHANGE

In the 2012 State of the Los Angeles River Watershed Report, we presented the results of a study by the University of California Los Angeles (LARC, 2012) which projected that by the end of the century, the Los Angeles region would experience warmer temperatures in the

HISTORICAL HYDROLOGY

Prior to development, the Los Angeles River system was typical of other streams in the southwest. Winter storms carried debris from the mountains and spread eroded materials across the expansive plain. The deposition of eroded materials over millennia shaped the flow and form of the river. The infrequent nature of strong storm events and the fine soils deposited along the coastal plain meant that forceful flows were not able to carve the steep banks that could contain the River. As a result, the River's channel was broad and often-shifted location within the flood plain; the mouth of the river moved frequently between Long Beach and Ballona Creek (Gumprecht, 2001). Between 1815 and 1825, the river turned southwest after leaving the Glendale Narrows, where it joined Ballona Creek and discharged into Santa Monica Bay in present Marina del Rey (LACDPW, 2006). During a catastrophic flash flood in 1825, its course was diverted again close to its present one, flowing due south just east of present-day downtown Los Angeles and discharging into San Pedro Bay. At that time, the coastal plain was a network of creeks, springs, lakes, and wetlands, only remnants of which remain today.

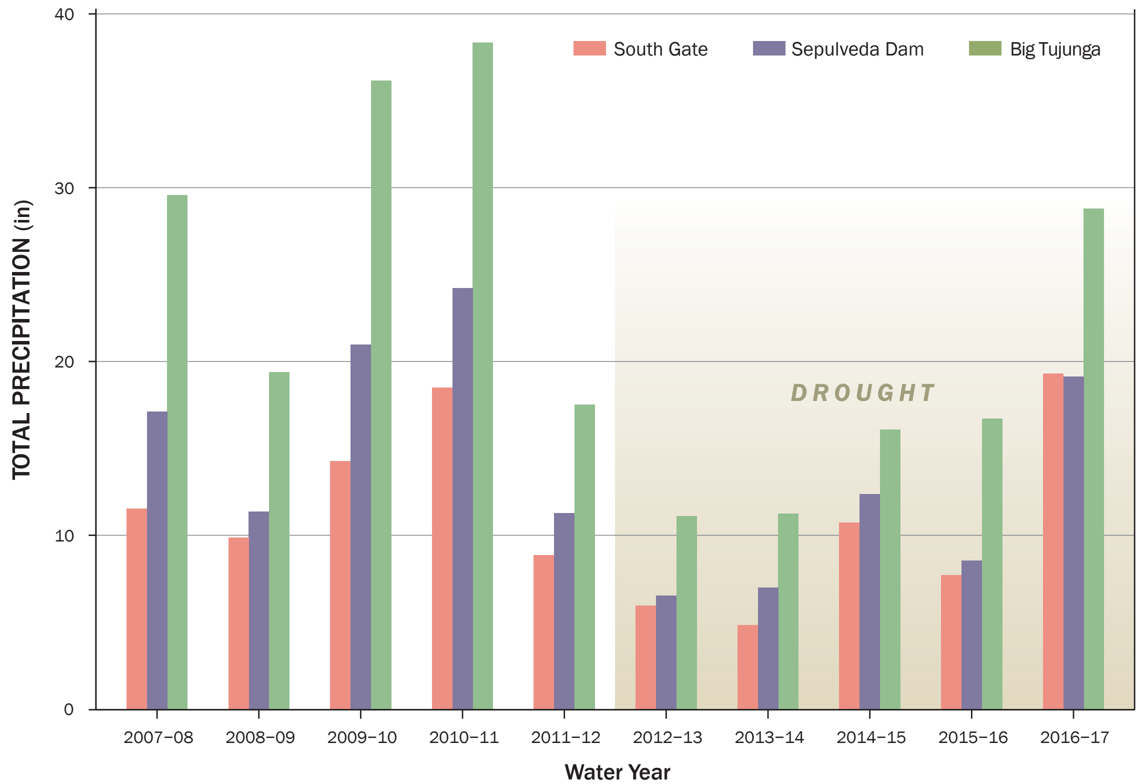
FLOOD CONTROL

Following the damaging flood of 1914 and the creation of the Los Angeles County Flood Control District in 1915, a program of flood control and water conservation was initiated in the County. Local residents supported this effort through voter-approved storm drain bond issues in 1952, 1958, 1964, and 1970 for a total of over $900 million (LACDPW, 1996). The County Board of Supervisors approved an additional $200 million bond issue in 1993. In the Los Angeles River Watershed this funded the construction of several dams. The Los Angeles County Flood Control District constructed three major dams, which were completed between 1920 and 1931: Pacoima, Big Tujunga, and Devil's Gate. In the Rio Hondo drainage area, several dams were constructed including Eaton Wash, Sierra Madre, Santa Anita, and Sawpit. As the need outstripped the ability to fund further flood control efforts, the federal government stepped in during the Great Depression. The US Army Corps of Engineers constructed three major dams between 1940 and 1954: Hansen Dam, Sepulveda Dam, and Lopez Dam.

The concrete sections of the Los Angeles River were constructed between the late 1930's and the 1950's in a trapezoidal or rectangular configuration to minimize the costly acquisition of rights-of-way. Most of the channel was lined in concrete to prevent erosion of the native soils. The system was designed to be a low maintenance and durable approach to moving floodwaters through the coastal plain. Three significant portions of the river, however, still exist in a semi-natural or soft-bottom state: Sepulveda Basin, Glendale Narrows, and the intertidal estuary below Willow Street. In contrast to the concrete-lined portions, today these areas support a variety of habitat and wildlife.

Photos: (above) 1850 Los Angeles River through downtown - photo courtesy of Historical Photo Collection of the Department of Water and Power, City of Los Angeles;
(above right) present day Glendale Narrows

FIGURE 4. Total precipitation from 2007-2017. The most recent drought spanned from 2012-2017.



valleys and inland areas, a higher frequency of extreme heat days, and a much higher regional land temperature increase under a "Business As Usual" emissions scenario compared to a "Mitigation" scenario by the end of the century. The findings of this high-resolution regional climate modeling study are still relevant today, but now six years later, we have also fleshed out the answers to questions such as:

- How will climate change affect Los Angeles County's water supply?
- How will climate change affect precipitation patterns in California?

A study published in 2016 by UCLA researchers reports that snowpack in the Sierra Nevada Mountains, a major water source for Los Angeles as well as the entire state of California, could decrease by up to 64% by the end of the century if nothing is done to curb greenhouse gas emissions. This change would accompany changes in the timing of seasonal snowmelt, which would occur 50 days earlier than normal, and shift precipitation type, which would fall primarily as rain instead of snow. As a result, Los Angeles would have less water in its snowpack reserves and a meager water supply to rely on during the driest parts of the year. If action is taken to reduce greenhouse gas emissions (the "Mitigation" scenario), snowpack would be reduced by about 30% and the runoff of snowmelt into mountain streams would occur 25 days earlier than normal. This indicates that changes to the region's water supply due to climate change are inevitable, but the impacts by the end of the century are roughly half as severe if action is taken to reduce emissions.

In April 2018, UCLA researchers published a study on the impact of climate change on precipitation extremes in California during the 21st century under the "Business as Usual" scenario (Swain *et al.*, 2018, Hall, 2012). Notably, the researchers found that precipitation extremes—both the number of very wet and very dry events—will increase, even while average annual precipitation stays the same. To put this change into perspective, the authors model the likelihood that a sequence of storms with a magnitude comparable to the storms that caused California's Great Flood of 1862 will occur statewide by the end of the century. The storms were so powerful they created an inland sea in the Central Valley and inundated Sacramento in 10 feet of floodwaters (Ingram, 2013). A series of storms as intense as the one that caused the Great Flood of 1862 would lead to a substantial loss of life and economic losses nearing $1 trillion. Such an event is over three times more likely to occur compared to the pre-industrial period in California. The state's major cities including Los Angeles are more likely than not to

FIGURE 5. Land use in the Los Angeles River Watershed.

TABLE 2. Land use in the Los Angeles River Watershed[1].

Location		Agriculture	Commercial	Industrial	Recreation/Forest	Residential	Total
Watershed	Acres	3,153	28,420	74,773	228,767	198,518	533,630
	%	0.59	5.33	14.01	42.87	37.20	100.00
Upper Watershed	Acres	238	21	2,242	176,142	671	179,314
	%	0.13	0.01	1.25	98.23	0.37	100.00
Middle and Lower Watershed	Acres	2,915	28.399	72,531	52,625	197,847	354,316
	%	0.82	8.02	20.47	14.85	55.84	100.00

1 Land use information was obtained from the 2005 Southern California Area Governments (SCAG) Aerial Land Use study. The land use categories shown in here were generalized from the categories shown in *Figure 5*.

experience such an event between 2018 and 2060. The study also projects a 25-100% increase in "precipitation whiplash", a term coined by the authors explaining the phenomenon when weather changes from very dry to very wet. Such volatility would pose a serious challenge to California's existing water and flood control infrastructure.

Another important impact to consider is the cumulative impact of drought and more frequent intense storm events. The region already experienced this phenomenon in January of 2018, when intense rains caused hillsides that had been stripped of vegetation by the Thomas Fire, the largest wildfire in California history, to become destabilized, resulting in deadly mudslides and debris flows. Prolonged dry seasons coupled with windy conditions breed wildfires, which remove vegetation that would otherwise hold soil in place and prevent erosion along sloped landscapes. When intense rains follow these dry periods, slopes near man-made developments are particularly likely to become the site of mudslides that may cause property damage and loss of life.

1.2 LAND USE

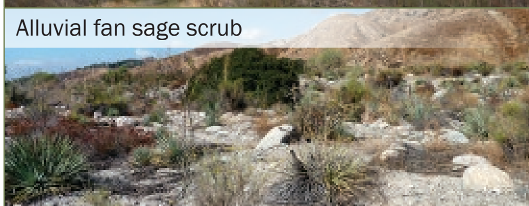
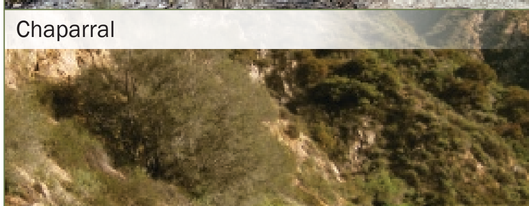
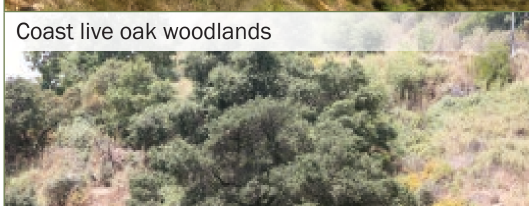
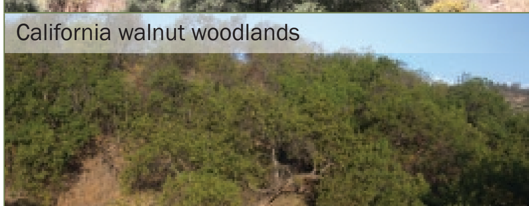
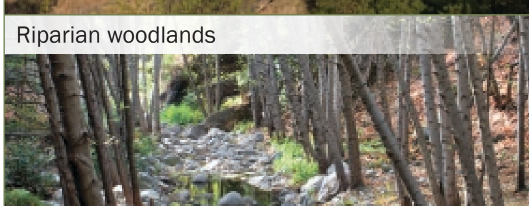
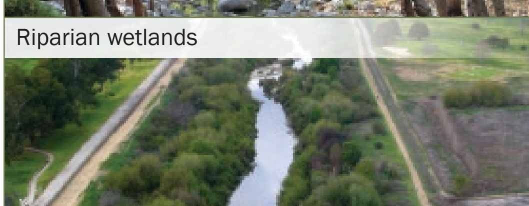
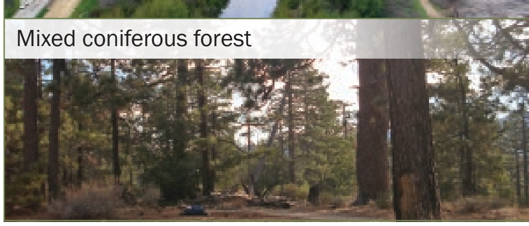
Surface water quality depends greatly on, and reflects differences in, various land uses in the Los Angeles River Watershed *(Figure 5)*. The Los Angeles River Watershed is the most urbanized watershed in Southern California. The upper watershed is predominantly forested open space that provides recreational opportunities such as hiking and swimming. In contrast, the highly urbanized lower watershed supports primarily residential and industrial land uses *(Table 2)*.

1.3 BIODIVERSITY

The Los Angeles River Watershed lies within the California Floristic Province, one of the world's biodiversity hotspots. Biodiversity hotspots are regions that support especially high numbers of endemic species, or species that occur naturally nowhere else on Earth. The concept was defined in 1988 by British ecologist Norman Myers to address the dilemma that conservationists face: what areas are the most immediately important for conserving biodiversity? Destruction of habitat is the leading cause of biodiversity loss, but invasive species, pollution, overexploitation, and climate change pose major threats as well.

Since the last report, biodiversity of the Los Angeles region has received increasing attention, strengthened by community science efforts, the City of Los Angeles' Biodiversity Motion, and strong local academic institutions and research-based organizations. Along the Los Angeles River, lower summer flows were identified as key to increasing in-channel biodiversity (TNC, 2016). In the City of Los Angeles, the Biodiversity Motion propelled efforts to quantify biodiversity city-wide using the Singapore Index assessment tool. The application of the Singapore Index revealed high scores for the percentage of natural areas, the number of native bird species, and protection of sensitive species and ecosystems. The assessment signaled opportunities for investment in urban tree canopy and educational programs focused on local biodiversity (LASAN, 2018). The next phase of local biodiversity efforts will be to develop a customized LA City Index to better characterize biodiversity within the city, implement pilot projects and implement policies that enhance biodiversity within the City of Los Angeles.

TABLE 3. Plant communities in the Los Angeles Basin.

PLANT COMMUNITY	CURRENT STATUS	LOCATIONS
Coastal sage scrub 	Fragmented throughout its range; considered endangered habitat; 10-15% of its historic range remains.	Santa Monica Mountains, Verdugo Mountains, San Gabriel Mountains, Simi Hills, Santa Susana Mountains, Arroyo Seco
Alluvial fan sage scrub 	Eliminated from most of its former range.	Big Tujunga Wash
Chaparral 	Still abundant within the mountains of Southern California. Fire is an important factor in ecology of this community.	Santa Monica Mountains, Verdugo Mountains, San Gabriel Mountains, Simi Hills, Santa Susana Mountains, Arroyo Seco
Coast live oak woodlands 	Impacted by development, overgrazing and, most recently, now threatened by gold-spotted oak borer.	Santa Monica Mountains, Verdugo Mountains, Simi Hills, Santa Susana Mountains, Arroyo Seco, San Gabriel Mountains, south facing foothills
California walnut woodlands 	Designated sensitive habitat type by CA Fish and Wildlife. Only 14,332 acres remain.	Santa Monica Mountains, Simi Hills, Santa Susana Mountains, Arroyo Seco, San Gabriel Mountains, south facing foothills, Repetto Hills
Riparian woodlands 	Only 3-5% of its historic range remains.	Santa Monica Mountains, Simi Hills, Santa Susana Mountains, Arroyo Seco, San Gabriel Mountains, Big Tujunga, Los Angeles River segments
Riparian wetlands 	Eliminated from most of its former range.	Small under-developed patches in soft-bottomed reaches: Compton Creek, Sepulveda Basin, Hansen Dam, Glendale Narrows, Los Angeles River estuary
Mixed coniferous forest 	Heavily impacted by forest management practices and recreational use.	Upper Big Tujunga, Arroyo Seco, San Gabriel Mountains

1.3.1 FLORA

Naturally occurring plant communities of the Los Angeles River Watershed include coastal sage scrub, alluvial fan sage scrub, chaparral, coast live oak woodlands, California walnut woodlands, riparian woodlands, riparian wetlands, and mixed coniferous forest *(Table 3)*. Many of the plant and animal species associated with these plant communities are listed as rare, sensitive, threatened, or endangered by state and federal agencies. Due to the channelization and loss of protective vegetative cover, many species have declined or are extirpated. Urbanization has greatly diminished and fragmented the distribution of all of these plant communities. Coastal sage scrub, for example, is an endangered plant community with only 10-15% of its historic range remaining.

1.3.2 FAUNA

Few comprehensive studies summarize the richness of wildlife within the Los Angeles River system. One study from 1993 concluded that, although highly urbanized, the Los Angeles River watershed continues to support a variety of wildlife in the habitats that remain (Garrett, 1993). The mountain and foothill areas of the upper watershed support more native species than the coastal plain and many species have federal or state protected status.

Birds in particular thrive in the soft-bottom riparian habitats at Sepulveda Basin, Glendale Narrows (the 2-mile stretch of soft-bottom channel between Atwater Village and Elysian Park), and the highly disturbed reach of the Rio Hondo to the confluence with Compton Creek (Bloom et al., 2002). Over 400 bird species have been recorded throughout the watershed, and the concrete lined channels of the lower Los Angeles River has been identified as a novel habitat type used by migrating shorebirds (Cooper, 2006).

In contrast, channelization and concomitant impacts on flow, temperature, and habitat quality have dramatically impacted native fish populations. Four of the seven native fish species are extirpated. The three remaining species include Santa Ana sucker, arroyo chub, and Santa Ana speckled dace. Habitat destruction has also reduced the historic number of mammal, reptile and amphibian species. Grizzly bears and the western pond turtle are examples of charismatic species that have been extirpated from the watershed.

1.4 RE-INVIGORATING CITIES AND URBAN RIVERS

Water is interwoven into every thread of the Los Angeles River's story and into the stories of the communities that have lived along its banks. Thousands of years ago, the Los Angeles River and its tributaries were the sole source of water in the region. As the population in the region grew so did its thirst and surface water diversion and groundwater pumping reduced the amount of water dependably available from the river to a trickle. Meanwhile, the sudden flushes of water brought by winter storms ultimately hemmed the river to the rectangular and trapezoidal channels we recognize today. The large investments in water conveyance projects, which allowed Los Angeles to grow and thrive, also changed the nature of the River and the connection communities had to it (Gumbrecht, 2008). As the region plans for a sustainable and more water resilient future, the River will play an integral role and our connection to its history, its ecology, and our region's thirst for water will again define it.

The Los Angeles River, like many urban rivers and waterfronts throughout the country, is receiving renewed attention. Beyond ongoing economic and property interests, waterfront re-invigoration work is connecting communities to the River's water and providing social, environmental, and recreational benefits. The communities living along the River are distinct and their differences stark, in terms of socioeconomics, their exposure to pollution, educational attainment, and the proximity and accessibility to open space (Douglas, 2017). Many of the planning efforts in the watershed attempt to balance equity and the amenities that communities value, while also balancing climate risks, habitat restoration, water resource needs, and greening, all with the realities of a flashy, Mediterranean and highly urbanized river.

There are several efforts currently underway that are focused on revitalizing the Los Angeles River and restoring its beneficial uses to the public:

The Lower Los Angeles River Revitalization Plan (LLARRP) and Working Group. Completed in 2017, the LLARRP prioritizes maintaining flood control functions of the River while identifying opportunities to restore natural features, create recreational opportunities, and address issues related to economics, health, equity, safety, accessibility, and connectivity.

The Los Angeles River Master Plan. Los Angeles County is updating the 1996 Master Plan to be a comprehensive blueprint that unifies community, technical, planning, and policy expertise to transform and re-imagine the 51 miles of the River.

The Water Resilience Plan is currently in development by LA County. It is designed to increase drought preparedness, water capture, green neighborhoods and parks, and improve the management of water supplies.

Integrated Regional Water Management Plan focused on water resource management for the greater Los Angeles Area with regional priorities in the topic areas of water supply, surface water quality, habitat enhancement, open space and recreation, flood risk, and climate change.

One Water LA is focused on creating an integrated framework for the management of watersheds, water facilities, and water resources to improve, among other objectives, climate resilience, the reliability of local water, and the health of local watersheds.

1.5 WATER RESOURCES

1.5.1 SURFACE WATER

Annual stream flows in the Los Angeles River reflect flood management, publically owned treatment works (POTW) activities, a Mediterranean climate, and water conservation practices. The average daily stream flow at eight sites located throughout the watershed highlight the seasonal and spatial variability *(Figure 6)*. In general, flows increase in the downstream urban portions of the watershed *(Figure 7)*. Flows in the Los Angeles River, Compton Creek, Verdugo Wash, and Burbank Western Channel have steadily increased since the 1940s as impervious cover has increased.

The typical dry-weather period from May through September is characterized by little or no rainfall. Steady flows range from less than 1 cubic foot per second (CFS) in urban tributaries and headwater streams to a maximum of 329 CFS at the Wardlow Gauge. In the upper watershed, natural springs feed Tujunga Wash, Pacoima Wash, Santa Anita, and other tributaries above their respective dams. Flow in the lower watershed is sustained by treated effluents from three publicly-owned treatment works (POTWs): the City of Los Angeles' Glendale Water Reclamation Plant (WRP) and Donald C. Tillman WRP, and the City of Burbank WRP. The proportion of annual stream flow POTWs contribute to the Los Angeles River varies both annually and seasonally, ranging from 19% during wet weather to 92% during dry weather. The Glendale Narrows, a seven-mile long soft-bottom section of the Los Angeles River adjacent to Griffith Park, is an area where rising groundwater also contributes significant dry-weather flows into the River. Historically this rising groundwater ensured that the River had year-round flow (LASGRWC, 2001).

Generally, urban runoff is the source of most of the dry-season flow in many of the tributaries and channels of the lower watershed. Approximately 100 million gallons of runoff from landscape irrigation, car washing, and other inadvertent sources flows through the Los Angeles County storm drain system daily and into the flood control channels, including the Los Angeles River and its tributaries (Sheng, 2009).

The typical wet weather period for this region spans October through April. Storms range in duration from one to three days and flows ranging from below 1 CFS in urban tributaries to 2,109 CFS at the Wardlow Gauge. Larger storms can increase runoff volume to 10 billion gallons (Sheng and Wilson, 2009).

FIGURE 6. Average stream flow (CFS) in the Los Angeles River Watershed from 2008-2017.

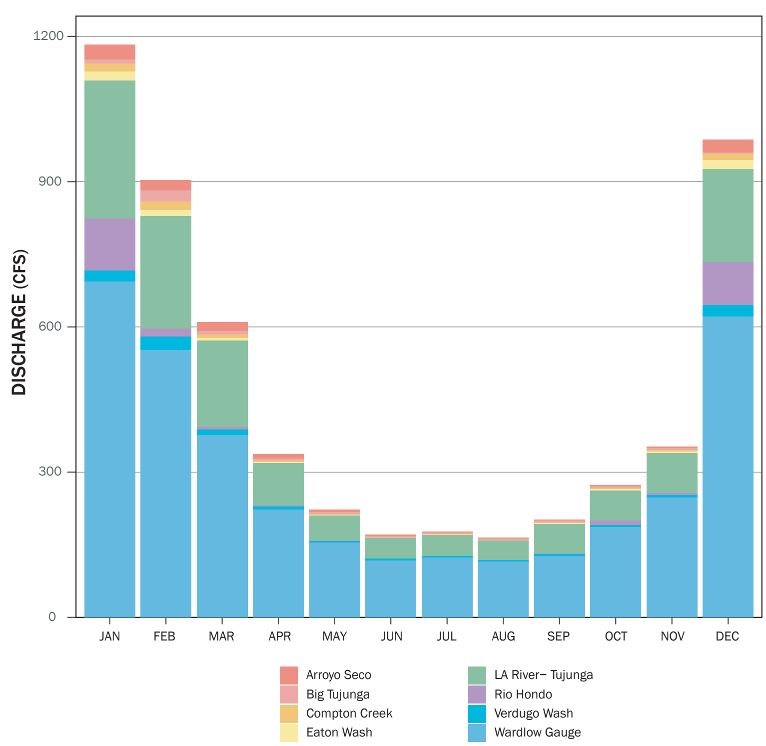


FIGURE 7. Map of LACDPW flow gauges in the Los Angeles River watershed. Symbol size represents daily average from 2008-2017.

Adapted from Appendix A of the Los Angeles River Master Plan

Nourishing an Expanding Population

HISTORICAL OVERVIEW OF THE

1769

Arrival of the Spanish explorer Gasper de Portola. Juan Crespi, the expeditions diarist, described the river:"… through a pass between low hills we entered a very spacious valley, well grown with cottonwoods and alders, among which ran a beautiful river from northwest and then, doubling the point of a steep hill, it went afterwards to the south." An estimated 5,000-10,000 Native Americans live in the region.

POPULATION (IN MILLIONS)

4

3

2

1

1771

The San Gabriel Mission is founded. The Rio Hondo and several springs fed an aqueduct, reservoirs, and a canal system that provided abundant water to the mission and its extensive vineyards, orchards, gardens, and mills.

1797

San Fernando Mission is founded. Several deep wells feed the mission's irrigation systems.

Average Precipitation for Downtown Los Angeles (Civic Center)

15.14 Inches

1870s-1880s

The transcontinental railroad lines reach Los Angeles. Manufacturing boomed along railway lines and thousands of settlers migrated from the east increasing the population of the City of Los Angeles from 11,000 in 1880 to 50,000 in 1890.

1860s

An epic flood in the winter of 1861-1862 followed by severe drought from 1862 -1865 kills most of the livestock in the region and ends the dominance of cattle ranching in Southern California.

48,000+ Years Ago	1000+ Years Ago	1760s	1770s	1780s	1790s	1800s	1810s	1820s	1830s	1840s	1850s	1860s	1870s

Earliest human inhabitants occupy the coastal plain, supported by the waters of the Los Angeles River and its tributaries.

The Tongva people (later called Gabrielino by the Spanish) inhabit villages throughout the region, including the village of Yangna, near the river on the current site of City Hall. Tongva forage, fish, and hunt for food and derive nearly half their nutrition from acorns, with a preference for those of the coast live oak.

1774

Spanish land grants begin increasing pressure on water bodies for cattle ranching and farming.

1824

Mexican land grants begin further increasing pressure on water bodies for cattle ranching and farming.

1854

Prompted by increasing population and a lowering of the water table the city appointed a water overseer to administer the distribution of irrigation and drinking water.

1781

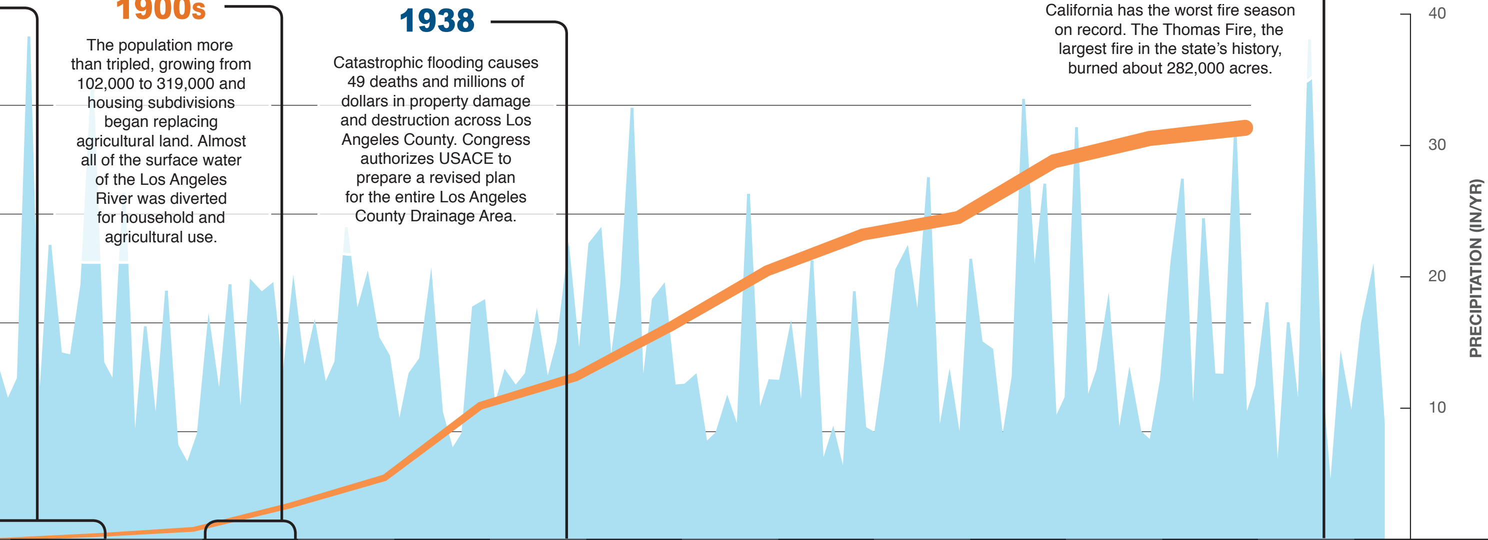
Water diversions from the Los Angeles River for domestic use started with the Zanja Madre Dam. The Zanja Madre, or the mother ditch, along with three other ditches formed the primary water distribution system in Los Angeles from 1781 to the early 1900s.

LOS ANGELES RIVER

1900s
The population more than tripled, growing from 102,000 to 319,000 and housing subdivisions began replacing agricultural land. Almost all of the surface water of the Los Angeles River was diverted for household and agricultural use.

1938
Catastrophic flooding causes 49 deaths and millions of dollars in property damage and destruction across Los Angeles County. Congress authorizes USACE to prepare a revised plan for the entire Los Angeles County Drainage Area.

2017
California has the worst fire season on record. The Thomas Fire, the largest fire in the state's history, burned about 282,000 acres.



1880s | 1890s | 1900s | 1910s | 1920s | 1930s | 1940s | 1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s

PLANNING

1930
Frederick Law Olmsted Jr. and Harland Bartholomew and Associates' report, "Parks, Playgrounds and Beaches for the Los Angeles Region" is a proposal to create for the County of Los Angeles an interconnected system of parks and greenways, parts of which could have served as wildlife corridors and flood buffer zones.

1990
The Los Angeles Mayor's Task Force is formed to study ways to increase opportunities along the LA River and to improve the appearance of the river.

1996
The LA River Master Plan is completed and approved by the Los Angeles County Board of Supervisors, highlighting opportunities for revitalizing the river.

2007
The Los Angeles City Council adopts the LA River Revitalization Master Plan establishing a blueprint for future revitalization of the River.

2017
The Lower LA River Revitalization Plan is unveiled and identifies multi-benefit project opportunities within 1-mile of the river.

LEGISLATION / POLICY

1892
The City approved a sewer system to convey sewage to the ocean, discharging it into near-shore waters after the riverbed becomes the dumping ground for sewage, trash, animal carcasses, and industrial waste products. The Angeles National Forest is established by President Harrison as a 1.5 million acre preserve "primarily for the purpose of watershed protection and improvement of water flow conditions."

1936
The Flood Control Act of 1936 initiated the United States Army Corps of Engineers (USACE) twenty-year project to channelize the river and its tributaries, over 400 miles in all, and to complete a system of dams and diversions that had already been started following the Act's passage.

1941
Congress approves the Los Angeles County Drainage Area plan, authorizing $230 million for construction of a comprehensive system that will include five major flood control basins (Hansen, Sepulveda, Santa Fe, Whittier Narrows, and Lopez), debris basins in 31 tributary canyons, construction of 93 miles of main channel and 147 miles of tributary channels, and reconstruction of 316 bridges on the Los Angeles, Rio Hondo and San Gabriel Rivers. Construction of the Los Angeles River Channel takes 20 years to complete and requires three million barrels of concrete and 10,000 workers.

2010
Los Angeles River is affirmed as a Traditionally Navigable Waterway under the Federal Clean Water Act.

2015
Legislation initiating the establishment of the Lower Los Angeles River Working Group passes state assembly.

INFRASTRUCTURE

1913
The Owens Valley Aqueduct opens, bringing water to the city from the eastern Sierra Nevada.

1920
Devil's Gate Dam is completed - the first dam built by Los Angeles County Flood Control District.

1925
The first wastewater treatment plant begins operating at the Hyperion site.

1930s
Groundwater levels are dropping by 2 to 20 feet per year. The first spreading grounds are constructed.

1966
Burbank Water Reclamation Plant starts operating.

1976
Los Angeles-Glendale Water Reclamation Plant starts operating.

1985
D.C. Tillman Water Reclamation Plant starts operating.

2013
Pilot program establishes a recreational zone in the Glendale Narrows portion of the Los Angeles River. Kayaking is allowed, for the first time, in the Los Angeles River.

2017
The City of Los Angeles acquires the G2 parcel, an industrial lot adjacent to the River. The parcel connects Rio de Los Angeles Park and the bowtie parcel creating a large, vibrant, riverfront park along the Los Angeles River.

1.5.2 FLOOD MANAGEMENT AND WATER CONSERVATION

Expanding urban development and periodic droughts have increased the need to conserve stormwater runoff behind dams and to recharge groundwater basins. Flood management and water conservation in the Los Angeles River Watershed is the responsibility of the Los Angeles County Flood Control District (LACFCD) and the U.S. Army Corps of Engineers (USACE). The present system is a sophisticated integration of the natural drainage system with heavily engineered hydrologic components.

Within the Los Angeles River Watershed, USACE operates and maintains three major flood control reservoirs: Hansen, Sepulveda, and Lopez *(Table 4)*. In addition to providing flood protection, these facilities control upstream debris flows and provide recreational opportunities. The LACDFC operates and maintains three major dams and numerous sediment entrapment basins in the Watershed. LACFCD, cities, Caltrans, and specific homeowner associations maintain local storm drains and pump stations (LACDPW, 1996).

1.5.3 GROUNDWATER BASINS AND RECHARGE AREAS

Groundwater accounts for most of the Region's local supply of freshwater and a priority of LACFCD is to conserve the maximum amount of stormwater possible to recharge groundwater basins (LACDPW, 1996). The amount of water that is recharged annually is determined by the quality and quantity of water sources, which include, imported water (from the Colorado River and the Owens Valley), recycled water, and stormwater, the capacities of the spreading grounds, and the geologic and groundwater conditions. LACFCD, in concert with the Los Angeles Department of Water and Power (LADWP) and the Water Replenishment District of Southern California, operates and maintains 3,361 acres of spreading grounds and soft-bottom channel spreading areas in the County. In contrast to the neighboring San Gabriel River Watershed, much of the Los Angeles River Watershed is underlain with extensive clay layers that limit groundwater recharge. The most important spreading basins are in the San Fernando Valley where the underlying soils are permeable (Trim, 2001).

Four major groundwater basins underlie the extent of the Los Angeles River Watershed: San Fernando Basin, Raymond Basin, Main San Gabriel Basin, and the Central Basin. The West Coast Basin underlies a small portion of the watershed to the south (*Figure 8* and *Table 5*).

TABLE 4. Dams and reservoirs in the Los Angeles River Watershed.

				Facility Use			
Dam/Reservoir	Construction Date	Capacity (Acre-Feet)	Operator	Flood Control	Water Conservation	Debris Control	Recreation
Devil's Gate	1920	1,928	LACFCD	X	X		
Pacoima	1929	3,929	LACFCD	X	X		
Big Tujunga	1931	6,027	LACFCD	X	X		
Hansen	1940	28,380	USACE	X			X
Sepulveda	1941	22,493	USACE	X			X
Lopez	1954	212	USACE	X		X	

Local priorities are focused on increasing local sources of water. The large groundwater basins in the region present a prime opportunity for storage. For example, LACFCD's goal is to conserve the maximum amount of stormwater possible to recharge groundwater basins. LADWP has prioritized groundwater remediation in the San Fernando Valley groundwater basin, where historical water supply has been reduced by 50% due to legacy contaminants (LADWP, 2018). The City of LA's Groundwater Replenishment Project is piloting treatment processes to increase the use of recycled water for groundwater replenishment.

1.5.4 STORMWATER

During an average storm, billions of gallons of stormwater are shuttled to the ocean. Since the majority of drinking water sources in the region originate from more than 200 miles away and are increasingly threatened by climate change, local sources of water are a priority for water agencies.

By slowing, capturing, and infiltrating stormwater, we can increase groundwater recharge and offset the demand for potable water. Centralized stormwater capture facilities, such as spreading grounds, dams, and reservoirs, capture 100 acre-feet of water a year. The highly urbanized nature of the watershed, however, limits the opportunities for large scale capture projects beyond those that currently exist and the strategic use of large open spaces (like parks and unlined channels).

Distributed smaller-scale green infrastructure projects, like bio-swales, green alleys, and infiltration

FIGURE 8. Groundwater basins of the Los Angeles River Watershed.

TABLE 5. Groundwater basins in the Los Angeles Watershed[1].

BASIN	AREA (SQ.MI.)	STORAGE CAPACITY (AF)	RECHARGE
San Fernando Basin	226	3.67 million	Spreading grounds downstream of Tujunga, Hansen, and Pacoima dams
Main San Gabriel Basin	167	10.74 million	San Gabriel River and Rio Hondo spreading grounds , Raymond and Chino Basins
Raymond Basin	40	1.45 million	Hahamongna, Eaton, Sierra Madre, and Santa Anita spreading grounds
Central Basin	270	13.8 million	Montebello forebay, Hollywood Basin, Rio Hondo and San Gabriel River spreading grounds, Dominquez Gap Wetlands
West Coast Basin	140	6.5 million	Direct injection and Central Basin lateral flow

1 California. (1968). Planned utilization of groundwater basins: Coastal Plain of Los Angeles County. Sacramento.
California. (2003). California's groundwater. Sacramento, Calif.: Dept. of Water Resources.

galleries, are an important multi-functional approach to increasing local water sources. The ease by which green infrastructure projects can fit within the urban landscape, in homes, parks, and neighborhoods, allows green infrastructure to be more easily integrated into heavily urbanized areas. Soils and vegetation that mimic natural structures slow stormwater and remove pollutants through physical processes and bioremediation. When implemented watershed-wide, green infrastructure can reduce pollutants and modulate the high flow of water entering local streams, common sources of stress to aquatic communities (Walsh, 2005), as well as provide community benefits like reduced flooding, shade, greening, and native habitat (LADWP, 2015). The local capture of stormwater can provide up to 31,100 acre-feet per year of stormwater, 266 acres of habitat, and 204 miles of trails (USBR, 2016).

Regulatory provisions like Low Impact Development (LID) ordinances and MS4 permits have encouraged the implementation of green infrastructure projects across the LA River Watershed.

1.6 WATER QUALITY

1.6.1 WATER QUALITY OBJECTIVES

Under the Porter Cologne and Clean Water Act (CWA), all regulated water bodies have a designated beneficial use and corresponding water quality objectives based on those uses. Water quality objectives (WQOs) are either numeric concentrations or narrative characteristics (for example, water shall not contain taste or odors that cause nuisance) that are protective of a given beneficial use. WQOs are meant to be protective of public health, welfare, and to protect water quality. The Los Angeles Basin Plan contains WQOs for a variety of constituents such as: bacteria, dissolved oxygen, temperature, turbidity, pH, and nutrients. Under the CWA, the discharge of waste into a body of water requires a permit and discharge limits are established so as to not impair a designated beneficial use (LARWQCB, 2016).

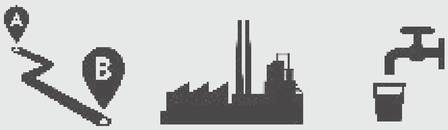
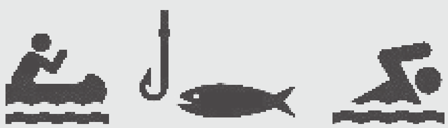
1.6.2 BENEFICIAL USES

The Los Angeles Regional Water Quality Control Board, through the Basin Plan, regulates the protection of surface water and groundwater quality in the Los Angeles River Watershed for the Coastal Watersheds of Los Angeles and Ventura Counties (LARWQCB, 1994). The Basin Plan identifies surface and groundwater bodies, designates applicable beneficial use classifications to each water body *(Table 6)*, establishes general and water body-specific WQOs, and suggests an implementation plan for maintaining or restoring the WQOs. Each stream segment may have multiple beneficial use designations. The table below lists all the beneficial use classifications in the watershed.

1.6.3 PERMITTED DISCHARGES

The Los Angeles Regional Water Quality Control Board controls pollution in the Los Angeles River and some of its tributaries by issuing permits to point source dischargers.

TABLE 6. Beneficial uses of water bodies in the Los Angeles River Watershed.

<table>
<tr><th>USE CATEGORY</th><th>ESTUARY</th><th>ABOVE ESTUARY</th></tr>
<tr><td rowspan="2">POPULATION USES
</td><td></td><td>Municipal and domestic supply
Industrial process supply
Groundwater recharge</td></tr>
<tr><td colspan="2">Navigation
Industrial service supply</td></tr>
<tr><td rowspan="2">RECREATION AND COMMERCIAL USES
</td><td>Commercial and sport fishing</td><td></td></tr>
<tr><td colspan="2">Non-contact water recreation
Water contact recreation</td></tr>
<tr><td rowspan="2">HABITAT-RELATED USES
</td><td>Estuarine habitat
Marine habitat
Migration of aquatic organisms</td><td>Warm freshwater habitat
Cold freshwater habitat</td></tr>
<tr><td colspan="2">Wetland habitat
Wildlife habitat
Rare, threatened, or endangered species
Spawning, reproduction, and/or early development</td></tr>
</table>

The Los Angeles Water Board utilizes National Pollution Discharge Elimination System (NPDES) permits and waste discharge requirements to limit the discharge of contaminants and protect surface water quality and groundwater quality. NPDES general permits are issued to multiple point source dischargers within specific categories, based on similarity of operations, discharges, required effluent limitations, monitoring requirements, and other factors. This allows a large number of facilities to be covered under a single permit. Individual permits are tailored to the activity, discharge, and receiving water quality of a facility. The three water reclamation plants in the watershed hold individual NPDES permits. Of the 144 entities that hold NPDES discharge permits, 132 are covered under general permits and 12 hold individual permits.

Other minor general permits cover miscellaneous wastes such as groundwater dewatering, recreational lake overflow, swimming pool wastes, and groundwater seepage. Other permits are for discharge of treated contaminated groundwater, non-contact cooling water, and stormwater. As of April 23, 2018, there were 376 dischargers covered under a construction stormwater permit and 1,320 dischargers covered under an industrial stormwater permit.

A majority of the 144 NPDES permittees discharge directly into the Los Angeles River. A small number discharge into Burbank Western Channel, Compton Creek, Arroyo Seco, Bull Creek, and Rio Hondo. The largest numbers of general industrial stormwater permits occur in the cities of Los Angeles (many within the community of Sun Valley), Vernon, N. Hollywood, South Gate, Long Beach, Compton, and Pacoima. Metal plating, transit, trucking and warehousing, and wholesale trade are a large component of these businesses. The larger construction sites are located in the upper watershed, including the San Fernando Valley, and are fairly evenly divided between commercial and residential construction sites. The Los Angeles River Watershed has about twice the number of industrial stormwater dischargers than the San Gabriel River Watershed and the most in Los Angeles County and Ventura County watersheds.

1.6.4 WATER QUALITY IMPROVEMENTS

The Clean Water Act (CWA) requires each State to assess the status of water quality in the State (Section 305(b)) and provide a list of impaired water bodies (Section 303(d)) to the U.S. Environmental Protection Agency (USEPA) every two years. The majority of the Los Angeles River is considered impaired by a variety of point and nonpoint sources. The 2016 303(d) list identifies pH, ammonia, a number of metals, coliform, trash, odor, algae, oil, DDT as well as other pesticides, and volatile organics for a total of 81 individual impairments (reach/constituent combinations). Some of these constituents are of concern throughout the length of the river while others are of concern only in certain reaches *(Table 7)*.

Impairment may be a result of water column exceedances, excessive pollutant levels in sediments, or bioaccumulation of pollutants. The beneficial uses most often threatened or impaired by degraded water quality are aquatic life, recreation, groundwater recharge, and municipal water supply.

The CWA requires a Total Maximum Daily Load (TMDL) be developed to restore impaired water bodies to their full beneficial uses by allocating allowable loadings from point sources and nonpoint sources. TMDLs have been established for trash (2001), and bacteria (2012) for the Los Angeles River, for nitrogen compounds and related effects for the Los Angeles River (2004), for metals for the Los Angeles River and its tributaries (2006), and for nitrogen, phosphorus, trash, organochlorine pesticides, and polychlorinated biphenyl for Los Angeles Area Lakes (2012).

1.6.5 THE LOS ANGELES RIVER WATERSHED MONITORING PROGRAM

Following the successful establishment of a watershed-wide monitoring program in the San Gabriel River Watershed in 2005, the Los Angeles Regional Water Quality Control Board (LARWQCB) required the Cities of Los Angeles and Burbank to develop a similar monitoring program for the Los Angeles River Watershed. The Los Angeles River Watershed Monitoring Program (LARWMP) was developed in 2007-2008 by a work group consisting of representatives from stakeholder agencies throughout the watershed. The work group included representatives from the Cities of Los Angeles, Burbank and Downey, LARWQCB, Los Angeles County Department of Public Works, Friends of the Los Angeles River, Arroyo Seco Foundation, Las Virgenes Municipal Water District, San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy, U.S. Environmental Protection Agency (USEPA), Council for Watershed Health (CWH), Southern California Coastal Water Research Project (SCCWRP), and U.S. Forest Service. Following program development, the LARWQCB changed the City of Los Angeles and City of Burbank NPDES permit conditions to require implementation of the plan and CWH was selected as the program manager by the stakeholders.

Prior to the implementation of the LARWMP, little was known about the condition of streams throughout the watershed. Permit conditions required discharges to monitor their effluents and the receiving water area adjacent to their outfalls; however, these were located primarily in the mainstem and the lower watershed tributaries. These uncoordinated monitoring programs resulted in limited data comparability, lack of coordination on the constituents sampled, and unsynchronized data management and data quality objectives.

The monitoring program integrated as much as possible with pre-existing monitoring, as well as including additional new monitoring components: sampling at random sites throughout the watershed in order to assess overall watershed health; monitoring sites at high habitat value areas, and at the base of subwatersheds *(Table 8)*; monitoring contaminants in the tissues of fish that are caught and consumed in lakes and streams; and monitoring fecal indicator bacteria at popular freshwater recreational sites. Each chapter of this State of the Watershed Report describes the monitoring plan and summarizes the results for each of these monitoring components. This report also provides recommendations for future monitoring. This Report summarizes the results from the last 9-10 years of monitoring and provides a benchmark to assess the success of future management actions.

Monitoring Subregions

To understand the substantial differences in hydrology, as well as habitat and water quality, the LARWMP identifies and monitors three hydrologically distinct watershed subregions, as well as the LA River estuary. These subregions are defined:

- Upper Watershed streams dominated by natural flows
- The Los Angeles River mainstem (including the Burbank Western Channel) dominated by effluent flows from treatment plants
- Tributaries in the lower watershed dominated by urban runoff
- The intertidal Los Angeles River estuary

TABLE 7. Water quality impairments [303(d) list].

WATER BODY NAME	SIZE AFFECTED (ACRE/MILES)	POLLUTANT
Aliso Canyon Wash	10.1	Selenium, Indicator Bacteria, Copper
Arroyo Seco reach 1 (LA River to West Hollywood Ave.)	5.2	Indicator Bacteria, Trash
Arroyo Seco reach 2 (West Hollywood Ave. to Devils Gate Dam)	4.4	Indicator Bacteria, Trash
Bell Creek	8.9	Indicator Bacteria
Bull Creek	6.5	Toxicity, Indicator Bacteria, Ammonia
Burbank Western Channel	13.2	Indicator Bacteria, Cyanide, Selenium, Copper, Lead, Trash
Colorado Lagoon	13.2	PCBs, Toxicity, DDT, Zinc, Chlordane , Dieldrin, PAHs, Indicator Bacteria, Lead
Compton Creek	8.5	Copper, Lead, pH, Indicator Bacteria, Trash, Zinc, Benthic Community Effects
Dry Canyon Creek	3.9	Indicator Bacteria, Selenium (total)
Echo Park lake	13.0	Trash, PCBs, Algae, Eutrophic
Lake Balboa	27.0	Ammonia, Dissolved Oxygen, Toxicity
Legg Lake	24.8	Odor, Ammonia, pH, Trash, PCB, DDT
Lincoln Park Lake (Carson to Figueroa Street)	3.8	PCBs, Ammonia, Eutrophic, Odor, Organic Enrichment/Low Dissolved Oxygen, Trash
Los Angeles River Estuary (Queensway Bay)	207.0	PCBs, Chlordane, DDT, Toxicity, Trash
Los Angeles River Reach 1 (Estuary to Carson St.)	3.4	Indicator Bacteria, Cyanide, Ammonia, Cadmium, Dissolved Copper, Lead, Nutrients (Algae), Trash, Dissolved Zinc, pH
Los Angeles River Reach 2	18.8	Indicator Bacteria, Oil, Ammonia, Copper, Lead, Nutrients (Algae), Trash
Los Angeles River Reach 3 (Figueroa St. to Riverside Dr.)	7.9	Ammonia, Copper, Toxicity, indicator Bacteria, Nutrients (Algae), Trash
Los Angeles River Reach 4 (Sepulveda Dr. to Sepulveda Dam)	11.1	Toxicity, Indicator Bacteria, Nutrients (algae), Trash
Los Angeles River Reach 5 (within Sepulveda Basin)	1.9	Ammonia, Copper, Lead, Benthic Community Effects, Toxicity, Oil, Nutrients (Algae), Trash
Los Angeles River Reach 6 (Above Sepulveda Flood Control Basin)	6.9	Selenium, Indicator Bacteria, Toxicity, Copper
Machado Lake	45.0	Trash, Ammonia, Nutrients, Copper, Lead, Indicator Bacteria, Oil
McCoy Canyon Creek	4.0	Indicator Bacteria, Nitrogen, Nitrate, Total Selenium
Monrovia Canyon Creek	3.4	Lead
Peck Road Park Lake	103.2	Chlordane (tissue), DDT (tissue), Odor, Organic Enrichment/ Low Dissolved Oxygen, Trash
Rio Hondo Reach 1 (Confluence LA River to Santa Ana Fwy)	4.6	Indicator Bacteria, Toxicity, Copper, Lead, Trash, Zinc, pH
Rio Hondo Reach 2 (At spreading grounds)	4.9	Coliform Bacteria, Cyanide
Tujunga Wash (LA River to Hansen Dam)	9.7	Indicator Bacteria, Ammonia, Copper, Trash
Verdugo Wash Reach 1 (LA River to Verdugo Rd.)	2.0	Copper, Indicator Bacteria, Trash
Verdugo Wash Reach 2 (Above Verdugo Rd.)	7.6	Trash, Indicator Bacteria

COMMUNITY SCIENCE

Community science can be a powerful tool to understanding the ecology of urban areas, areas that are otherwise difficult to assess because of expense and the difficulty in accessing a patchwork of private land. It can be critical to understanding the impact of urbanization and climate change to species distributions. Community science can also help inform land use decisions and identify helpful sites and land use practices for sustaining wildlife (McCaffrey, 2005, Dickinson *et al.*, 2012, Parker *et al.*, 2018). For community scientists, the experience can enhance learning outcomes and social capital, and support inclusive decision-making (Bonney *et al.*, 2009; Dickinson *et al.*, 2012; Whitelaw *et al.*, 2003).

COMMUNITY SCIENCE IN THE LOS ANGELES RIVER WATERSHED

Fish of the Los Angeles River Project: A citizen science project on iNaturalist that encourages the angling community to help characterize the fish in the River.

River Assessment Fieldwork Team: Teams of volunteers are trained to assess sources of pollution and their impact to streams, rivers, and the ocean.

City Nature Challenge: An annual global competition among cities to document plants and wildlife in a novel and complex ecosystem, cities.

RASCals Blitz: An iNaturalist project that allows community members to contribute to scientist's knowledge of native and non-native reptiles and amphibians in Southern California.

NATURAL

Approximately one-third (272 square miles) of the Los Angeles River Watershed is in the boundary of the Angeles National Forest and largely managed by the United States Forest Service (USFS). This includes the western portion of the San Gabriel Mountains, the Santa Susana Mountains, the Verdugo Hills, and the northern slope of the Santa Monica Mountains. Big Tujunga Wash is the largest natural perennial stream in the upper watershed.

EFFLUENT

Tertiary-treated effluents from three publicly owned treatment works (POTWs) dominate dry-weather flows in the River on the coastal plain. Their treatment capacities range from 9 million gallons per day (MGD) for the Burbank Water Reclamation Plant (BWRP) to 20 MGD and 80 MGD for the Los Angeles Glendale Water Reclamation Plant (LAGWRP) and D.C. Tillman Water Reclamation Plant (DCTWRP), respectively *(Table 9)*. Las Virgenes Municipal Water District's Tapia Plant is permitted to discharge 2 MGD to the Los Angeles River during the summer months, but generally discharges much less. These facilities produce recycled water for landscape irrigation and industrial processes. The rest is discharged to surface waters, with the Tillman Plant's discharge first being used for recreation enhancement in Lake Balboa, Wildlife Lake, and Japanese Garden Lake, before flowing into the River.

URBAN

More than 4.5 million people live in the highly urbanized lower watershed. The urban region of the lower watershed include the major tributaries to the Los Angeles River, downstream of Sepulveda dam, and includes the lower Tujunga Wash, Burbank Western Channel, Verdugo Wash, Arroyo Seco, Rio Hondo, and Compton Creek. During the dry times of the year, flows in these tributaries are dominated by urban runoff that can contain pollutants such as trash, human and animal waste, automobile fluids, industrial pollutants, fertilizers, and pesticides.

LOS ANGELES RIVER ESTUARY

The intertidal Los Angeles River estuary connects the Los Angeles River to San Pedro Bay. The estuary begins where the concrete-lined river ends near Willow Street and flows to Queensway Bay before entering San Pedro Bay. The banks of the soft-bottom estuary are stabilized with rock riprap. During high tide, the estuary receives most of its flow from San Pedro Bay. A relatively small area along either bank drains directly to the estuary (approximately 6,000 acres in total land area). Land use in the area is largely residential and commercial (USEPA, 2012).

TABLE 8. Drainage Area of Sub-watersheds in the Los Angeles Region.

SUB-WATERSHED	DRAINAGE AREA (sq. mi.)
Sub-watersheds upstream from Sepulveda Dam	152
Tujunga Creek and Wash	225
Burbank Western Channel	26
Verdugo Wash	30
Arroyo Seco	47
Rio Hondo	142
Compton Creek	42
Direct drainage to Los Angeles River	170
TOTAL LOS ANGELES RIVER WATERSHED	**834**

TABLE 9. POTW Discharges to the Los Angeles River, their design capacities and recycled water production (million gallons per day).

POTW DISCHARGER	DATE BUILT	DESIGN DISCHARGE CAPACITY	RECYCLED WATER PRODUCTION
Las Virgenes Municipal Water District Tapia Plant Waste Water Reclamation Plant (WWRP)	1999-outfall to LA River	2	0
City of Burbank WRP	1966	9	1
City of Los Angeles-Glendale WRP	1976	20	4.5
City of Los Angeles-Tillman WRP	1984	80	26

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What are the Conditions of the Streams in the Los Angeles River Watershed?

2.1 BACKGROUND

The goal of the LARWMP is to assess the condition of streams throughout the Los Angeles River Watershed to inform watershed management decisions. In the past century the physical, biological, and chemical conditions of streams in the urbanized lower watershed of the Los Angeles River have been dramatically altered due to development. In contrast, streams in the more remote areas of the upper watershed maintain some pre-urbanization integrity, providing an opportunity to assess a gradient of conditions across the watershed. We provide a summary and assessment of the current condition of streams over nine years of monitoring from 2008 through 2017. This information serves as a comprehensive baseline for assessing future management actions.

2.2 MONITORING METHODS

To determine the condition of perennial streams in the Los Angeles River Watershed, a total of eighty sites were sampled from 2008 through 2017. These sites were randomly selected and stratified to ensure that the three watershed subregions were adequately sampled and include the natural portions of the upper watershed, the effluent-dominated reaches of the mainstem channel, and the urban tributaries of the lower watershed. In 2014, the LARWMP program began to revisit previously sampled random sites to better detect changing conditions in the watershed.

The monitoring design of LARWMP is consistent with regional and statewide Perennial Streams Assessment (PSA) programs that in turn are built upon earlier programs, namely US EPA's Environmental Monitoring

ASSESSING BIOLOGICAL CONDITION IN CALIFORNIA'S STREAMS

One of the ways the LARWMP determines the health of our river and streams is by taking a closer look at the organisms that live there. Benthic macroinvertebrates (BMI) are bottom-dwelling organisms without a backbone that are visible to the naked eye. BMI, including insects (such as the Psychodidae shown above), aquatic worms, and snails, can be sensitive to pollution, changes to physical habitat condition, and other types of stress. Many BMI respond to stress in ways we can predict. By observing and collecting data about the BMI at a specific site, we can learn about the health of that stream. Information about BMI communities is packaged into a California Stream Condition Index (CSCI) score, which helps quantify site conditions by comparing our sites to healthy sites or "reference sites."

The CSCI was developed using a large and broad dataset to establish site-specific expectations of "reference condition." It is therefore applicable throughout the state. The index has two components: a measure of the number of species observed at a site compared to what is expected (O/E), and a multi-metric index, which is a measure of the community structure.

Another biological indicator, the So CA Algal IBI, works well in urbanized environments because algae are generally more closely related to water quality than habitat features (Fetscher *et al.* 2008). The LARWMP uses both diatoms and soft-body algae as indicators. Algae are a good indicator because they have short generation times, are responsive to a variety of environmental stressors, and are pervasive across stream substratum.

Photo above: Benthic macro-invertebrate taxa, Psychodidae, captured in LARWMP stream site (Source: Aquatic Bioassay Consulting).

and Assessment Program (EMAP) and California's Monitoring and Assessment Program (CMAP). Sampling is conducted during the dry weather (March through September). While perennial streams (flowing year-round) are targeted for sampling, seasonal variation in flow due to annual rainfall amounts make sampling at non-perennial streams inevitable.

Bioassessment using resident aquatic biota as indicators of the biological integrity of streams is the key component of the monitoring program. The biological condition of streams is assessed using two biological indicators: algae and benthic macroinvertebrates. The California Stream Condition Index (CSCI) is a statewide biological scoring tool that translates complex data about benthic macroinvertebrates (BMI) found living in a stream into an overall measure of stream health (Mazor *et al.*, 2015). The Southern California Algal Index of Biological Integrity (So CA Algal IBI) is a multi-metric index that uses algae as an indicator of stream health (Fetscher *et al.* 2008). Bioassessment is combined with chemical and physical habitat characteristics that provide a multiple lines of evidence (MLOE) approach for assessing stream condition.

2.3 RESULTS

2.3.1 BIOLOGICAL AND RIPARIAN HABITAT CONDITION

During the nine-year monitoring period, the LARWMP found that the majority (57-75%) of sites in the watershed are not healthy based on comparisons to reference condition using So CA Algal Indices and CSCI scores *(Figures 9-10)*. The highest proportion of sites in reference, or healthy, condition for both BMI and algal communities occurred in the natural streams of the upper

FIGURE 9. Proportion of sites in reference condition based on CSCI scores from benthic macro-invertebrate communities for each watershed subregion from 2008-2017.

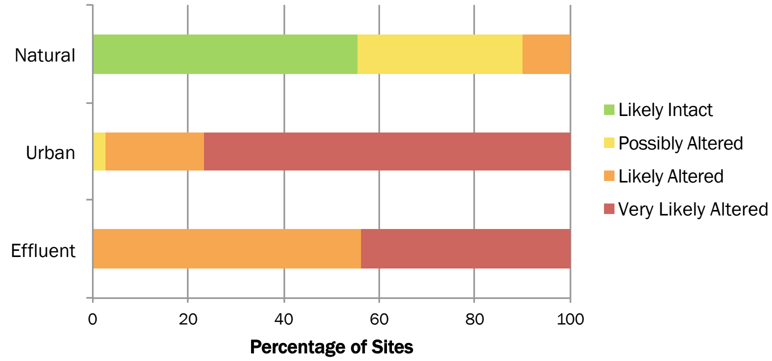

FIGURE 10. Proportion of sites in reference condition based on So Ca Algal IBI scores for each watershed subregion from 2008-2017.

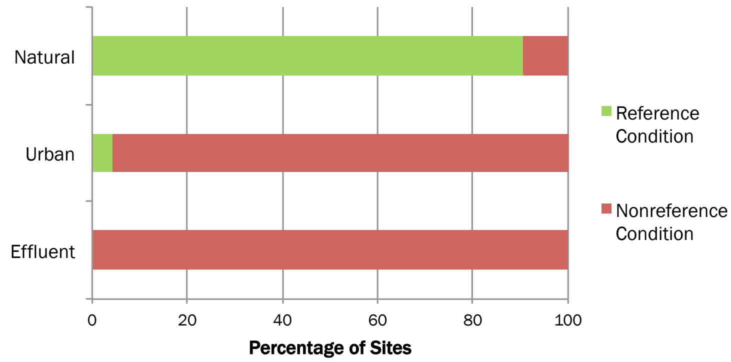

FIGURE 11. Benthic macroinvertebrate feeding assemblages by subregion for samples collected from 2008-2017.

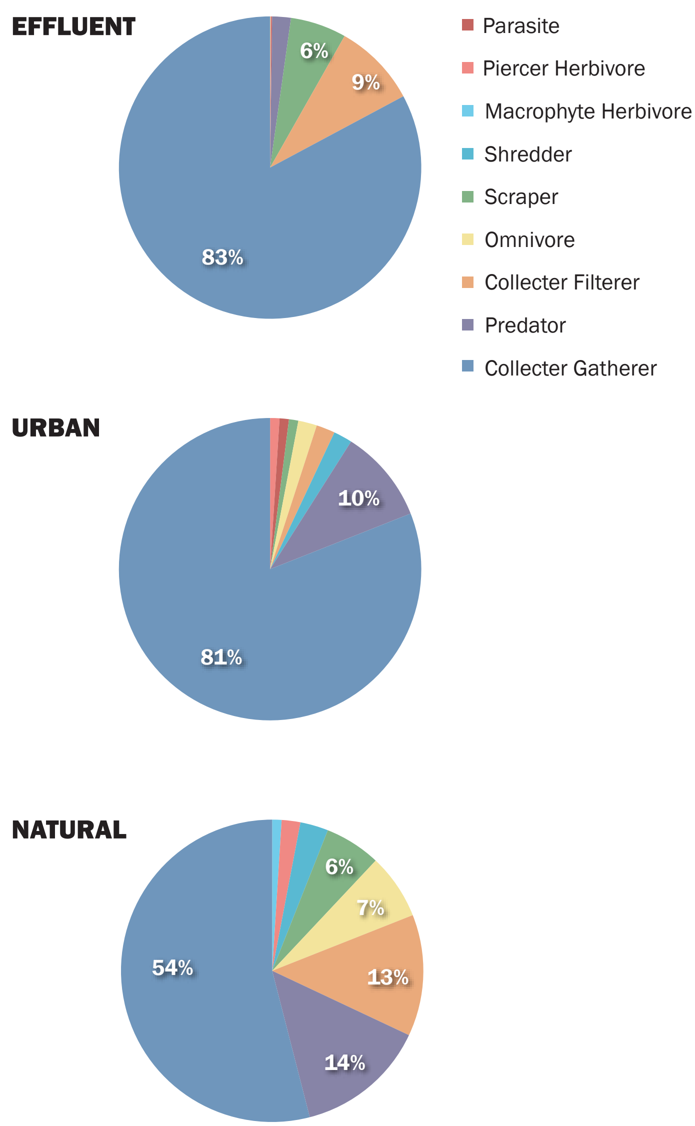

TABLE 10. Relationship between measured variables and CSCI and So CA Algal IBI scores (all listed relationships r >= 0.7, p<0.001).

	CSCI		Algal IBI
+	CRAM Score	+	Physical Structure
+	Reduced Channel Alteration	–	Salinity
+	Epifaunal Substrate	–	Specific Conductivity
+	Cobble Gravel	–	Phosphorus
–	Dissolved Organic Carbon	–	Sulfate
–	Phosphorus	–	Copper
–	Chloride	–	Zinc
–	Copper		
–	Concrete Asphalt		

watershed. Not one effluent site in the watershed was in "healthy" condition. The urban subregion had sites that were in, or near, reference condition but generally more closely resembled the scores of effluent-dominated sites.

Benthic macroinvertebrate communities in the upper watershed exhibited a wide range of feeding strategies and were generally pollution sensitive *(Figure 11)*. In contrast, the biological communities in the lower urban and effluent dominated reaches were more degraded, as evidenced by lower CSCI scores and fewer feeding strategies.

The variables that had the strongest relationship with biological condition were related to water chemistry and physical habitat *(Table 10)*. Physical habitat variables representing habitat complexity had positive relationships with CSCI and algal IBI scores. Water quality constituents that are common in the urbanized regions of the watersheds, such as nutrients, salts, dissolved solids, and heavy metals, have a negative relationship with biological condition. Previous work has prioritized stressors associated with poor biological condition in the South Coast region; those stressors affect a quarter of the region's streams and are similar to those identified by LARWMP. They include nutrients, physical habitat, sulfates, and dissolved solids (Mazor, 2015).

Much like biological condition, urban and effluent regions of the lower watershed had significantly poorer riparian habitat condition than the upper watershed *(Figure 12)*. Development in the lower watershed has nearly eliminated natural streambed habitat and riparian buffers, while sites in natural regions have wide buffer zones, improved hydrological connectivity, and dense, native vegetative canopy. Given the strong relationship between biological communities and physical habitat condition, it is not surprising that scores mirrored each other, particularly for benthic macroinvertebrate communities, which require complex in-stream and riparian cover and a wide and undisturbed riparian buffer zone.

FIGURE 12. Map of CRAM and CSCI scores for random sites sampled from 2008-2017.

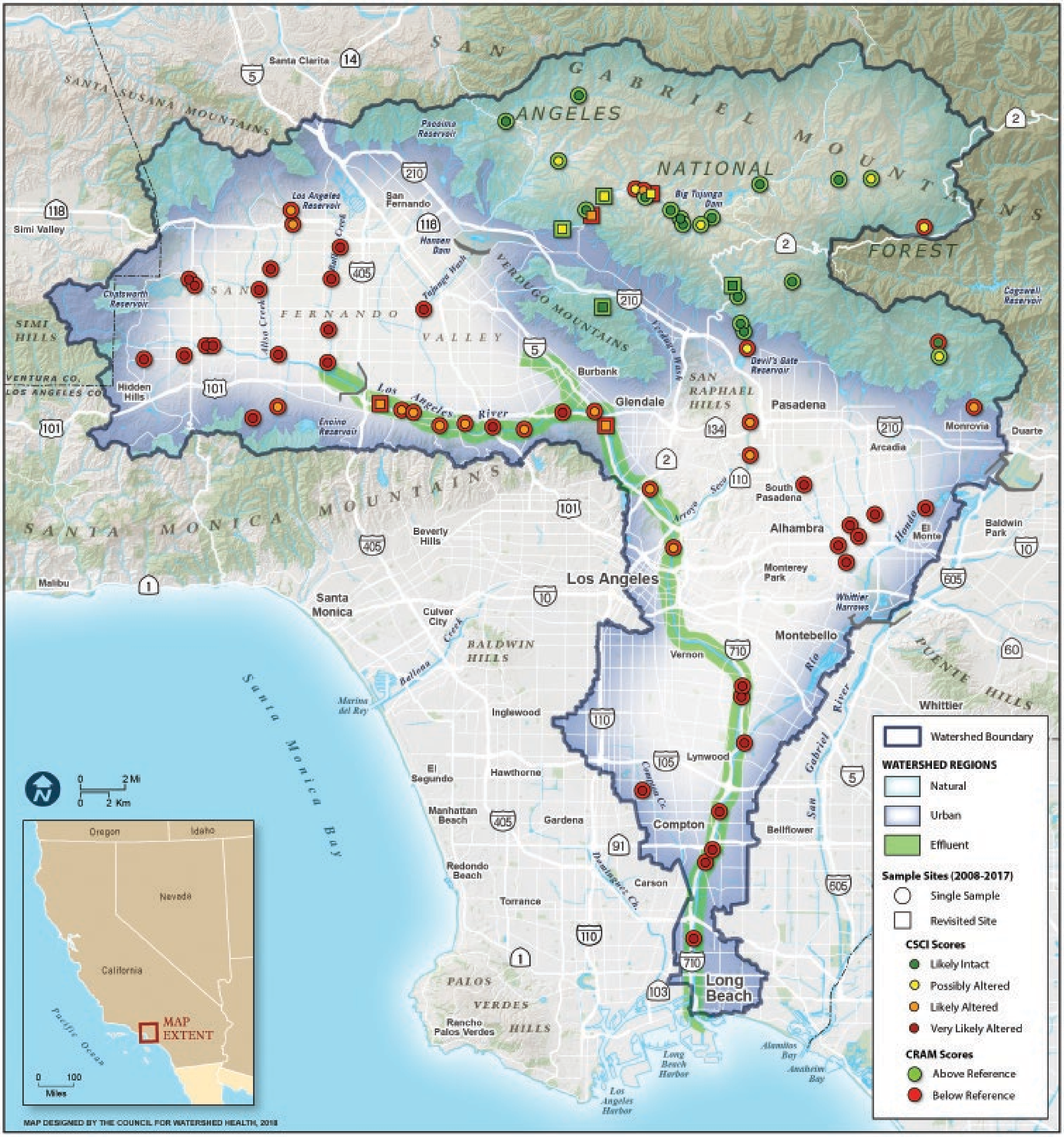

TABLE 11. Water quality within the different watershed subregions of the LA River for the period 2008-2017. Asterisks reflect values that exceed WQOs (nitrate concentrations>10 mg/L, temperature > 26 °C, pH outside the 6.5-8.5 range, dissolved oxygen < 5 mg/L). Dissolved metal concentrations, adjusted for hardness, were compared to California's Toxic Rule (CTR) thresholds. Note ammonia exceeded WQOs for a single sample from 2008-2017.

	EFFLUENT		URBAN		NATURAL	
MEASURED VARIABLES	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*
General Chemistry						
Dissolved Oxygen (mg/L)	10.19	4.89*-17.45	10.32	5.30-16.81	8.08	6.00-10.48
pH	8.45	7.42-9.38*	8.74*	7.34-10.80*	7.9	6.99-8.51
Specific Conductivity (uS/cm)	1096	797-1355	1400	8.0-3681	481	245-762
Temperature (°C)	23.41	13.3-32.8*	24.56	13.8-36.7*	17.11	11.0-25.0
Mean Slope (%)	1.05	0.05-5.02	1.1	0.11-5.20	2.96	0.85-8.87
Alkalinity as $CaCO_3$ (mg/L)	140	100-206	308	40-4520	214	119-276
Total Suspended Solids (mg/L)	24.61	8.2-93.6	114.76	2.00-1330	3.13	0.01-1.33
Dissolved Organic Carbon (mg/L)	6.95	6.12-8.19	11.32	1.79-37.62	2.96	1.20-6.83
Total Organic Carbon (mg/L)	7.96	6.79-10.82	12.95	2.50-42.00	5.8	0.18-102.22
Nutrients (mg/L)						
Ammonia	0.12	0.02-0.35	0.39	0.02-9.95*	0.04	0.02-0.15
Nitrate as N	3.95	0.98-5.87	1.29	0.01-6.48	0.07	0.01-0.53
Total Kjeldahl Nitrogen	2.01	1.23-2.80	3.28	0.14-18.37	0.3	0.00-1.73
Orthophosphate as P	0.12	0.02-0.34	0.15	0.02-0.77	0.08	0.02-1.06
Phosphorus	0.24	0.13-0.37	0.43	0.01-2.19	0.1	0.01-1.33
Dissolved Metals (ug/L)*						
Arsenic	1.7	0.3-3.1	2.4	0.1-6.5	1.3	0.0-5.4
Cadmium	0.2	0.0-0.4	0.1	0.0-0.3	0	0
Chromium	1.6	0.5-2.5	2	0.2-7.5	1.5	0.1-7.3
Copper	5.9	1.5-9.0	11	0.6-30.6*	1.2	0.0-2.9
Iron	43	12.2-156.0	69.9	2.5-253.0	52.3	2.6-337.0
Lead	0.3	0.1-0.5	0.3	0.0-1.3	0.1	0.0-0.2
Mercury	0	0	0	0	0	0
Nickel	5.4	1.7-7.8	8.8	0.7-78.0	1.5	0.5-3.9
Selenium	1.2	0.2-1.6	1.8	0.1-11.5	0.1	0.1-0.3
Zinc	25.7	8.4-42.2	9.4	1.5-24.2	3.2	0.7-13.2

2.3.2 AQUATIC CHEMISTRY

A comparison of water quality parameters among the three watershed subregions from 2008 through 2017 demonstrates the spatial differences in water quality *(Table 11)*.

- Exceedances of the Basin Plan WQOs over the nine-year period included pH and temperature in the channelized lower watershed and copper in the urban subregion.
- Nutrients were consistently lower at natural sites in the upper watershed compared to the lower tributaries and the mainstem. Although nitrogenous compounds were higher in the effluent-dominated and urban reaches, they generally did not exceed regulatory water quality standards (though water quality thresholds are protective of human health and not necessarily aquatic health).

- Metals were also higher in the lower watershed, but did not exceed regulatory thresholds with the exception of copper, which exceeded the California Toxics Rule (CTR) chronic thresholds, in a handful of urban sites.

2.4 SUMMARY AND NEXT STEPS

Over nine years of monitoring, we found a strong positive relationship between the condition of the biological communities and physical habitat conditions in the Los Angeles River watershed. Temperature and pH exceeded regulatory thresholds at lower watershed sites. While nutrients and metals were elevated in lower watershed sites, they generally did not exceed WQOs with the exception of copper. Sites in the upper watershed are in better condition than lower watershed sites across various metrics of stream health.

Nutrients, habitat degradation, metals, sulfate, and chloride had a negative relationship with biological condition of streams in the watershed. Degraded biological conditions are not surprising considering the Los Angeles River watershed is one of the most extensively urbanized areas in the world. The LARWMP is designed to continue measuring the effects of these stressors and to provide managers the context necessary to make decisions regarding the ambient condition of the watershed.

In efforts to better understand the condition of streams and prioritize management activities, there remains incredible opportunity to coordinate with citizen science efforts and grow the body of data that can help us to better understand the ecological health of the watershed, especially as revitalization efforts begin.

Over the next few years, the LARWMP will continue to support and coordinate with larger regional monitoring efforts such as the Stormwater Monitoring Coalition (SMC) Program and the State Water Board's Surface Water Ambient Monitoring Program (SWAMP). Recently, the SMC Program has begun to assess the extent of nonperennial streams and to explore the use of cellular bioassays to detect impacts of chemicals of emerging concern. The LARWMP will adjust relevant monitoring program components accordingly. For example, LARWMP added trash assessments to stream condition monitoring in 2018, in coordination with the SMC's 2018 Bight Monitoring Program. The data will help us to gain a better understanding of trash extent and the impact of trash management actions in the region. In 2011, LARWMP conducted trash assessments at targeted and random sites throughout the watershed to assist the SMC region-wide trash assessment study. The monitoring data assisted City Council in the decision to ban plastic grocery bags in Los Angeles.

2.5 REFERENCES

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FIGURE 13. Estuary, Confluence, and High-Value Habitat Sites monitored by LARWMP.

Chapter 3

Are Conditions at Locations of Unique Interest Getting Better or Worse?

Compton Creek confluence/Los Angeles River confluence (facing southwest).

3.1 BACKGROUND

LARWMP assessed how conditions might be changing over time in habitats of unique interest. The fourteen designated sites were assessed annually: four confluences representing the major subwatersheds, the Los Angeles River estuary, and nine wetland habitats *(Figure 13)*. Aquatic chemistry, biota, and physical habitat data were collected regularly from 2009-2017. The primary goal of this component of the program is to track trends over time and provide early warning of potential degradation so that management action can be taken.

- Four of the targeted watershed sites were established upstream of confluence points in the upper and lower watershed to provide information regarding water quality trends over time. These four sites differ from the random sites in the previous chapter because their locations are fixed and are sampled annually. These data are being used to assess temporal trends in stream condition and if changes in these trends can be attributed to natural, anthropogenic, or watershed management changes.

- The LARWMP collects samples at the mouth of the Los Angeles River estuary near Queensway Bridge using data assessment tools specific to the State's sediment quality objectives (SQOs) (SCCWRP, 2014).

- Working group members identified nine unique habitats of high value. They provide a measure of natural background or provide context against which trends in other portions of the watershed can be evaluated.

3.2 CONFLUENCE SITES

There were no significant temporal trends in biological condition and riparian habitat condition across confluence sites during the eight years of monitoring *(Figure 14)*. Though, habitat condition (CRAM) scores at Rio Hondo and CSCI scores have shown slight improvements. Both biotic and riparian habitat condition at confluence sites were below reference condition, and in the "likely altered" or "very likely altered" categories, for the eight years of monitoring. Measurements varied considerably from year to year and trends moved, at times, in opposite directions, depending on the site. Though some weak trends did emerge in water chemistry. Ammonia, cadmium, selenium, and specific conductivity concentrations showed weakly increasing patterns, though concentrations were below water quality thresholds *(Figure 15; Table 12)*. The concentrations of these constituents were generally highest at the Tujunga Wash confluence site. The most consistently increasing trends were ammonia at the Arroyo Seco and Compton Creek sites and specific conductivity at the Arroyo Seco site.

Chloride concentrations at the Tujunga Wash confluence are also elevated in comparison to all other sites *(Figure 16)*, are above WQOs, and have increased through time ($p = 0.08$, $tau = 0.50$, $n = 9$). The increasing trend in chloride concentrations at the Tujunga Wash is of concern, given the potential impact to benthic macroinvertebrate communities (Kaushal et al., 2005).

THE CALIFORNIA RAPID ASSESSMENT METHOD (CRAM)

The California Rapid Assessment Method (CRAM) was developed to provide biologists and ecologists a quick way to evaluate the complex ecological condition of wetlands and riverine systems using a finite set of observable field indicators, such as plant community composition and structure, hydrology, physical structure, and buffers (Stein, et al. 2009). CRAM assesses and scores wetland condition with respect to four overarching attributes: Buffer/ Landscape Context, Hydrology, Physical Structure, and Biotic Structure. *http://www.cramwetlands.org*

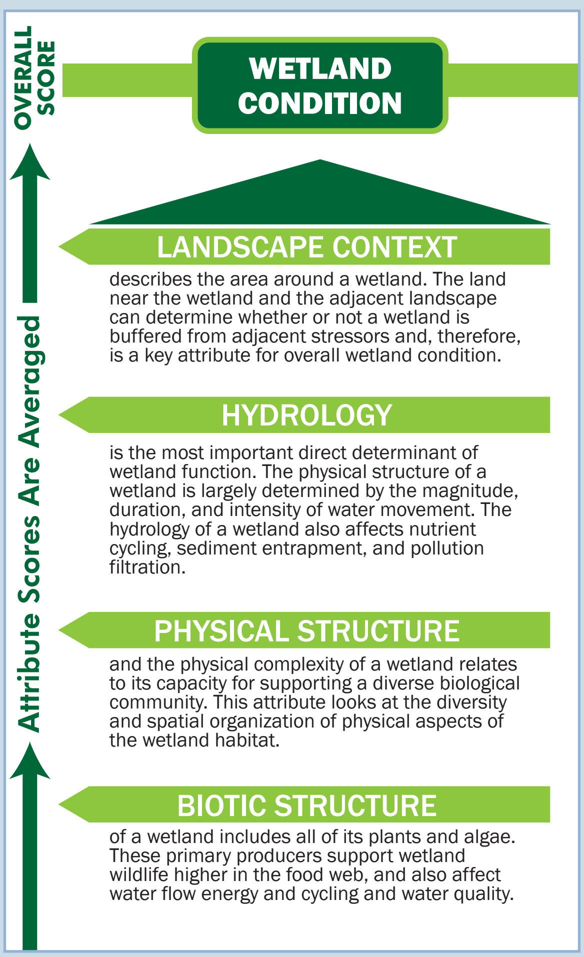


FIGURE 14. CSCI and CRAM scores at confluence sites from 2009-2017. The red dotted line indicates CRAM threshold, above which sites are considered to be in reference condition (CRAM>72). The orange dotted line refers to the CSCI threshold above which sites are considered “intact” or “possibly altered” (CSCI>0.79).

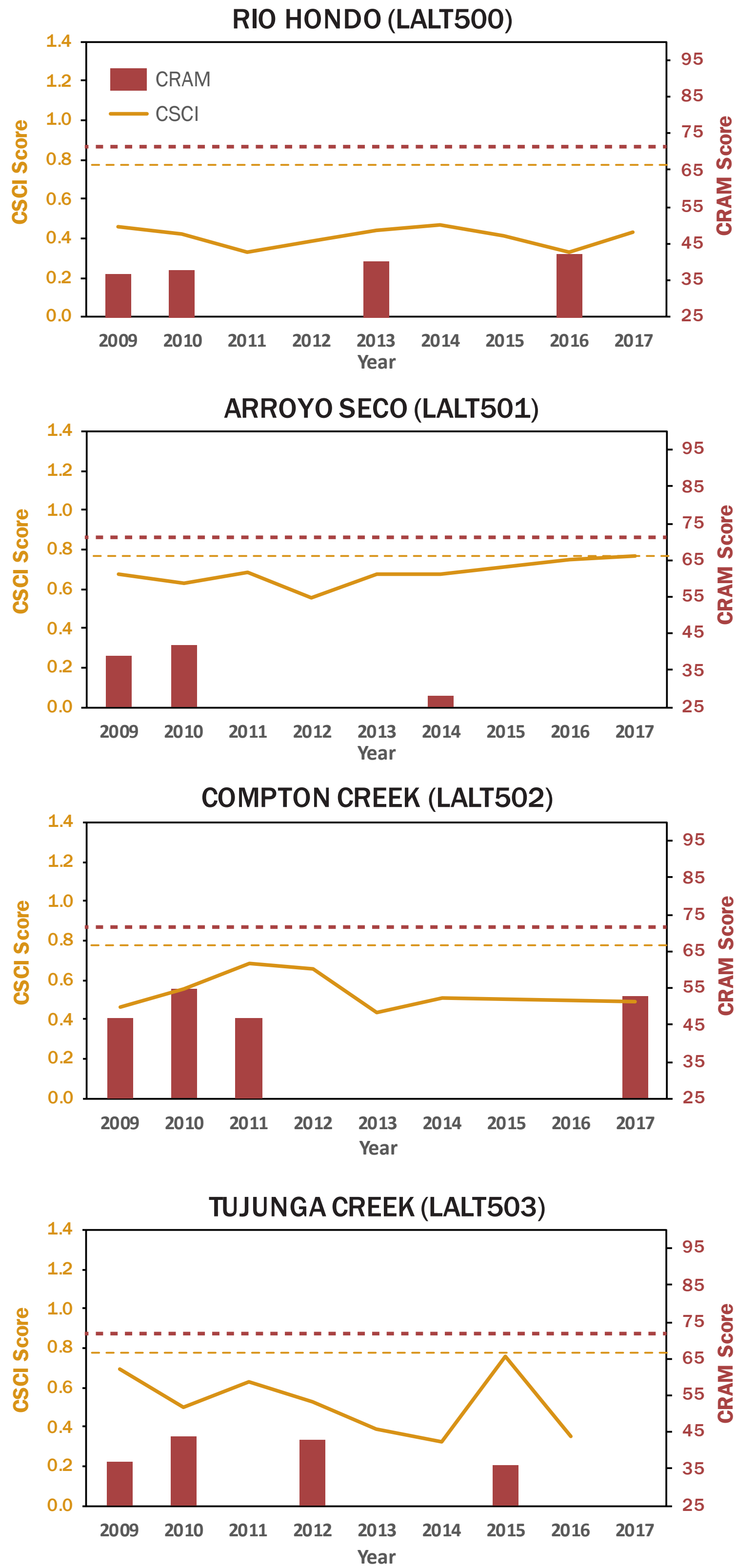


FIGURE 15. Specific conductivity, ammonia, cadmium, and selenium concentrations from 2009-2017.

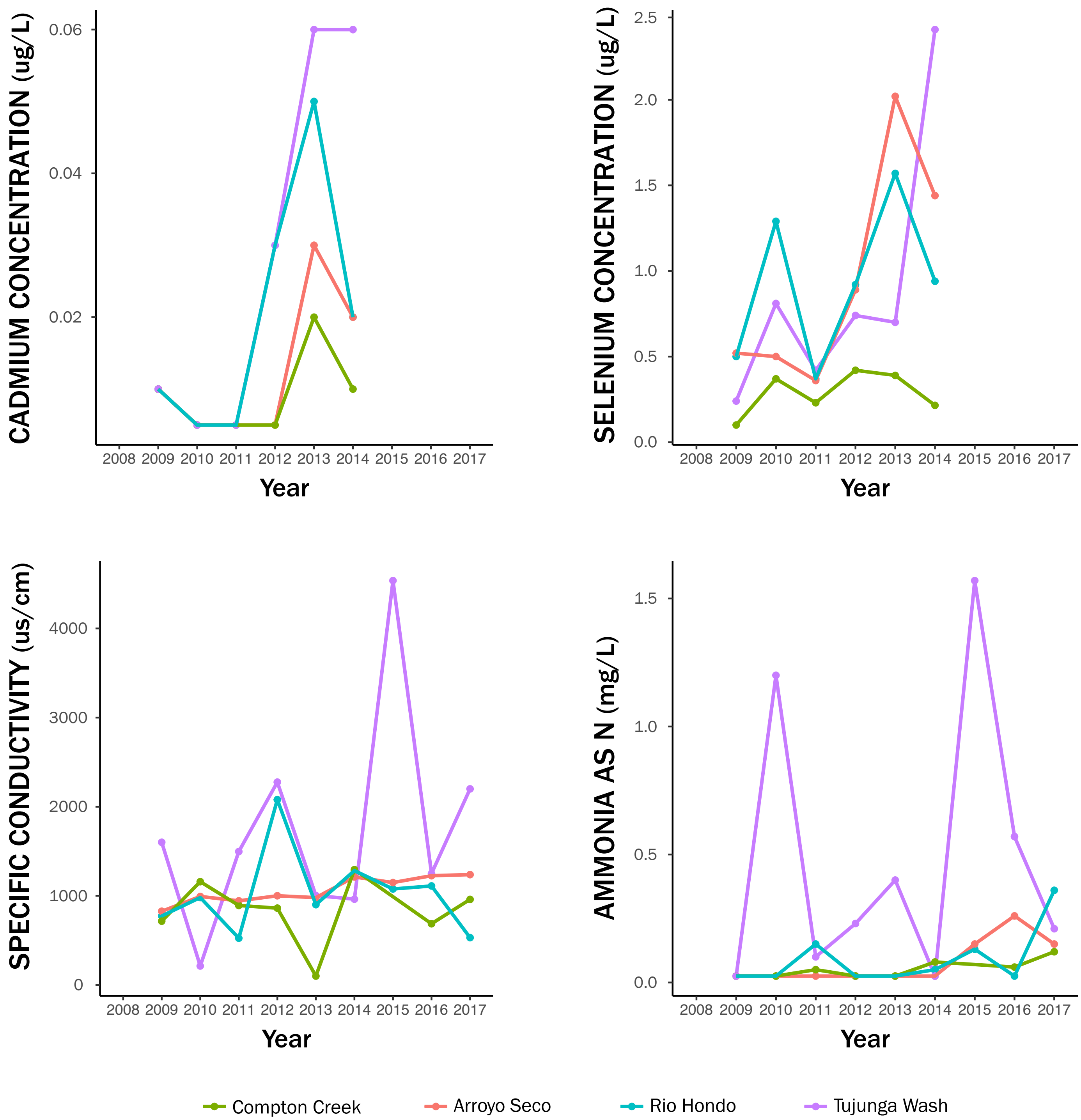
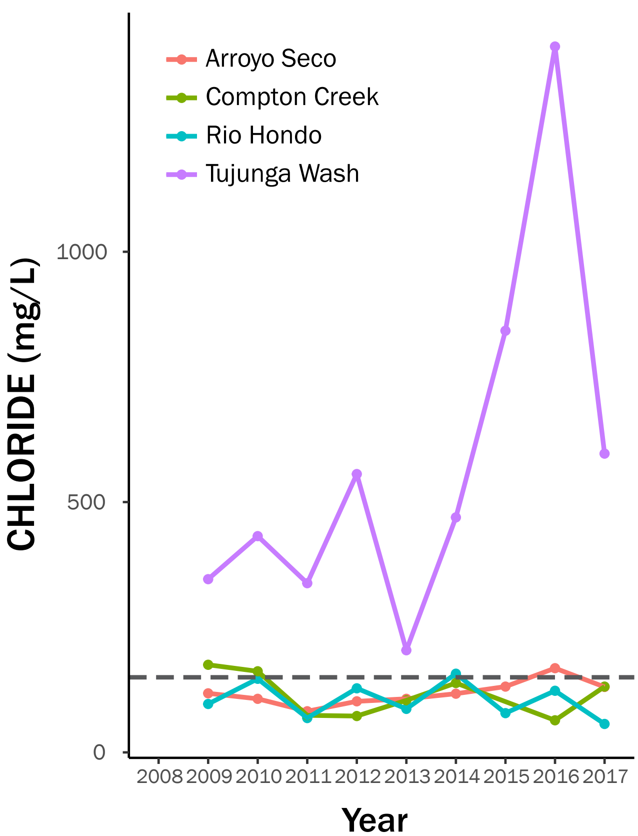


TABLE 12. Aquatic chemistry trends in ammonia as N, cadmium, selenium, and specific conductivity at confluence sites sampled from 2009-2017, n = 66. Arrows represent the direction of the trend, trend color represent the strength of the relationship between variable concentration and time (tau < 0.65 = green or weak trend; no strong increasing trends). Significance denotes the statistical strength of the relationship ($p<0.05$ = red or a strong relationship; $0.05 < p < 0.10$ = green, moderate to weak relationship; $p > 0.10$ = gray, no relationship). Individual sites with strong increasing trends are listed.

CONSTITUENT	TREND	SIGNIFICANCE
Ammonia	↗	• Arroyo Seco • Compton Creek
Cadmium	↗	
Specific conductivity	↗	• Arroyo Seco
Selenium	↗	

FIGURE 16. Chloride concentrations at confluence sites from 2009-2017. Dashed line represents Basin Plan WQOs for LA River tributaries, 150 mg/L.



3.3 LOS ANGELES RIVER ESTUARY

At the Los Angeles River Estuary, the LARWMP monitored sediment contamination levels. The State of California Sediment Quality Objectives (SQOs) is a Multiple Lines of Evidence (MLOE) approach for assessing the exposure of organisms to sediment contamination. Three assessments provide evidence that a site is impacted: sediment chemistry, sediment toxicity, and the condition of resident infauna species. Assessment results are integrated into a rank score providing insight into whether an embayment habitat is similar to reference conditions or has been degraded as a result of sediment contamination (SCCWRP, 2009).

The integrated scores for sediment chemical exposure, toxicity, and benthic disturbance were calculated at the estuary from 2009-2017 *(Table 13)*. Sediment quality was highly variable across the eight-year period ranging from ‘clearly impacted’ to ‘unimpacted’. The estuary is located at the most downstream portion of the watershed and receives contaminants associated with point and nonpoint source discharges from the watershed. These contaminants are received mainly during storms from November through March, which can be highly episodic and, depending on their intensity, can either scour the bottom or allow contaminants to deposit in the sediments.

Benthic infauna and toxicity were highly variable over the eight-year period. Benthic infauna was particularly variable with scores ranging from ‘highly disturbed’ in 2016 to ‘minimum disturbance’ the following year. These results reflect the fact that this is a highly modified estuary with little protection from scouring after storm events and daily tidal flushing. These natural events transport contaminants both to and from the estuary, constantly changing the habitat conditions for benthic infauna. As a result, this habitat is highly unstable and in a constant state of flux.

3.4 HIGH-VALUE SITES OF UNIQUE CONCERN: RIVERINE AND ESTUARINE WETLANDS

Wetland habitats are particularly important for their relatively natural state in an otherwise heavily urbanized areas of the watershed. The LARWMP assesses the condition of nine sites over time to provide information that can result in the development of either restorative or protective management decisions. Specific areas of value and/or at-risk habitats that are monitored for the LARWMP Program are Sepulveda Basin, Glendale

TABLE 13. Sediment quality objectives for the LA River Estuary from 2009 through 2017. Category scores range from: (1) reference; (2) minimal disturbance; (3) moderate disturbance; and (4) high disturbance.

Metric	2009	2010	2011	2012	2013	2014	2015	2016	2017
CHEMISTRY									
CA LRM	4	3	4	4	Not Analyzed	Not Analyzed	4	4	4
CSI	3	2	2	2	Not Analyzed	Not Analyzed	2	3	1
Integrated Chemistry Score	4	3	3	3	Not Analyzed	Not Analyzed	3	4	3
TOXICITY									
Eohaustorius estuarius	3	Not Analyzed	1	4	2	4	1	1	3
Mytilus galloprovincialis	3	3	1	1	1	2	1	3	1
Integrated Toxicity Score	3	3	1	3	2	3	1	2	2
INFAUNA									
BRI	2	1	2	4	1	3	2	4	1
IBI	3	2	1	4	3	3	2	4	2
RBI	4	1	2	4	3	3	3	1	3
RIVPACS	2	2	1	4	4	2	3	4	2
Integrated Infauna Score	3	2	2	4	3	3	3	4	2
SITE ASSESMENT	Clearly Impacted	NA	Unimpacted	Likely Impacted	NA	NA	Possibly Impacted	Likely Impacted	Possibly Impacted

Narrows, the upper portion of Tujunga Wash, the upper portion of Arroyo Seco, Eaton Wash, and Golden Shores Wetland at the estuary. Over the eight-year monitoring period, these sites have been below reference condition but stable *(Figure 17; Table 14)*. Minimally impacted sites that provide a measure of natural background for context are USGS gauging station in Arroyo Seco, Alder Creek and Haines Creek Pools. These sites are relatively accessible by road and have late-season flows. Over the eight-year monitoring period, these sites have generally been in reference condition and stable or improving.

A description of each site is provided on the following page using most recent CRAM scores and multi-year trend analysis. Initially, CRAM assessments were conducted annually. More recently, conditions are being assessed on a three-year cycle acknowledging the inherently slow rate of change in the component indicators, though fewer site visits have reduced the sample size and limited the strength of trend analysis.

3.5 SUMMARY AND NEXT STEPS

Confluence sites throughout the watershed had poor biological community condition, reflecting the nature of urbanized sites where riparian habitat has been highly modified. Temporal trends in water chemistry after eight years of monitoring the Los Angeles River Watershed are weak or absent, though several water quality constituents, including ammonium, cadmium, selenium, and specific conductivity, show vaguely increasing but statistically significant trends. These trends are stronger at some sites than others. For example, ammonia at the Arroyo Seco and Compton Creek sites and specific conductivity at Arroyo Seco showed a consistently increasing trend. The rate of change at these sites has been small and the concentrations of these constituents have remained below water quality thresholds. Constituent concentrations were the highest at the Tujunga Creek confluence site. However, only chloride concentrations were above WQOs and showed an increasing trend.

Glendale Narrows (LALT400)

The Glendale Narrows is an approximately seven-mile long section of the Los Angeles River adjacent to Griffith Park, Los Feliz, Atwater Village, and Elysian Valley. It is earthen bottom as a result of the high-water table; however, the banks are shored with concrete. The earthen bottom provides a complex streambed composed of cobble, boulders, and sand, which support diverse plant, bird, and fish communities. Frontage roads along both banks serve as walking and cycling paths for the public. This section of the river was opened to non-motorized boating in 2013.

The Golden Shores Wetland (LALT404)

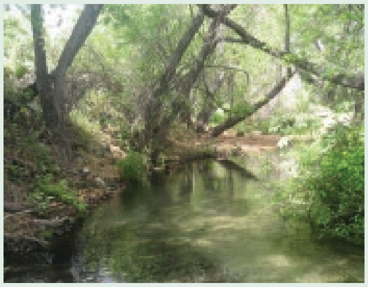
Golden Shores Wetland was constructed in 1997 as part of mitigation for wetlands that were destroyed in Long Beach Harbor. The 6.4-acre wetland at the mouth of the Los Angeles River includes both intertidal and subtidal habitats. The site is one of the few tidally influenced wetlands in Southern California. These habitats are important to the coastal ecosystem because they serve as highly productive habitats for fish, waterfowl, and plants. The entire perimeter of the wetland is protected by riprap levees with a single southern inlet connected to the Los Angeles River estuary.

Sepulveda Basin (LALT405)

Sepulveda Basin, upstream of Sepulveda Dam, is a site that is largely operated under lease by the City of Los Angeles Department of Recreation and Parks. The 225-acre area includes sports fields, agriculture, golf courses, a fishing lake, parklands, a water reclamation facility, and a wildlife refuge. The 3-mile reach of river upstream of the dam is unlined with relatively natural riparian zones. The water source for this reach is nearly 100% tertiary-treated effluent from the D.C. Tillman Water Reclamation Plant during the dry season.

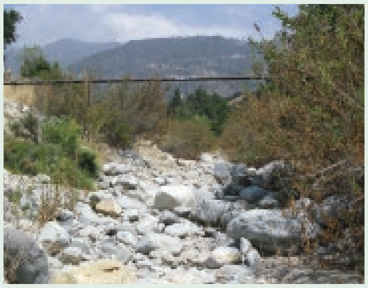
Haines Creek Pools and Stream (LALT407)

The 13-acre Tujunga Ponds Wildlife Sanctuary in Sunland is a Caltrans mitigation project constructed following completion of the 210-Foothill Freeway. The site was acquired by Los Angeles County Parks and Recreation Department in 1978 and contains two small lakes and surrounding dense willow riparian and cottonwood riparian woodlands. Visitors use the natural areas and existing trails around the ponds for nature study, photography, and similar passive recreation under permit from LACDPW.



Eaton Wash (LALT406)

Eaton Canyon begins at the Eaton Saddle near Mount Markham and San Gabriel Peak in the San Gabriel Mountains. Its drainage flows into the Rio Hondo to the Los Angeles River. The Eaton Canyon Natural Area Park covers 190-acres where Eaton Creek forms a 50-foot waterfall from the mountains to the foothill wash at the base of the San Gabriel Mountains. Several more secluded waterfalls also exist above Eaton Falls. This area is very popular with the public, especially during the summer months for hiking and swimming.



Arroyo Seco (LALT450)

The Arroyo Seco site is located downstream of Devil's Gate Dam. The Arroyo Chub, a locally extirpated native fish, was recently re-introduced to this section of the Arroyo Seco following habitat restoration. The site was downstream of the recent 2009 Station Fire and was scoured during heavy rainstorms following the fire.

Tujunga Sensitive Habitat (LAUT401)

The Tujunga Sensitive Habitat site is located downstream of the Big Tujunga Dam in a relatively undisturbed, upper watershed riparian zone. Big Tujunga Canyon is high in species richness, including 38 recorded threatened and endangered species of amphibians, reptiles, fish, and birds and twenty-four plants. This area burned during the 2009 Station Fire and, therefore, provides an opportunity to assess the post-fire recovery process along the riparian corridor and the surrounding buffer zones. Since this site is difficult to access, the site is not heavily used for recreation.

Alder Creek (LAUT403)

Alder Creek is located in the upper reaches of the Los Angeles Watershed and is the highest elevation of the unique habitat sites. Due to the remoteness, it provides a sentinel for conditions in the relatively undisturbed upper watershed. The site burned during the 2009 Station Fire.

Upper Arroyo Seco (LAUT402)

The Arroyo Seco Watershed begins at Red Box Saddle in the Angeles National Forest near Mount Wilson in the San Gabriel Mountains. Much of the watershed contains nearly pristine habitat area and as a result, the hiking trails running along its length are very popular with the public for hiking and cycling. The biological condition score at this site (as measured by the CSCI) is one of the highest in southern California, particularly for a lower watershed site. This site was devastated by the 2009 Station Fire and has been the location for an ongoing post-fire recovery study.

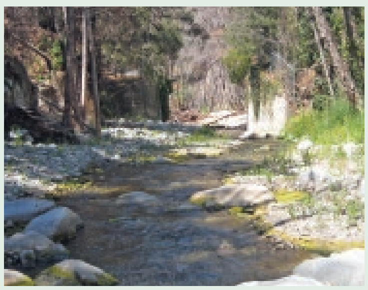


FIGURE 17. CRAM scores for high-value habitat sites monitored from 2009-2017. The grey dotted line indicates CRAM threshold, above which sites are considered to be in reference condition (CRAM>72).

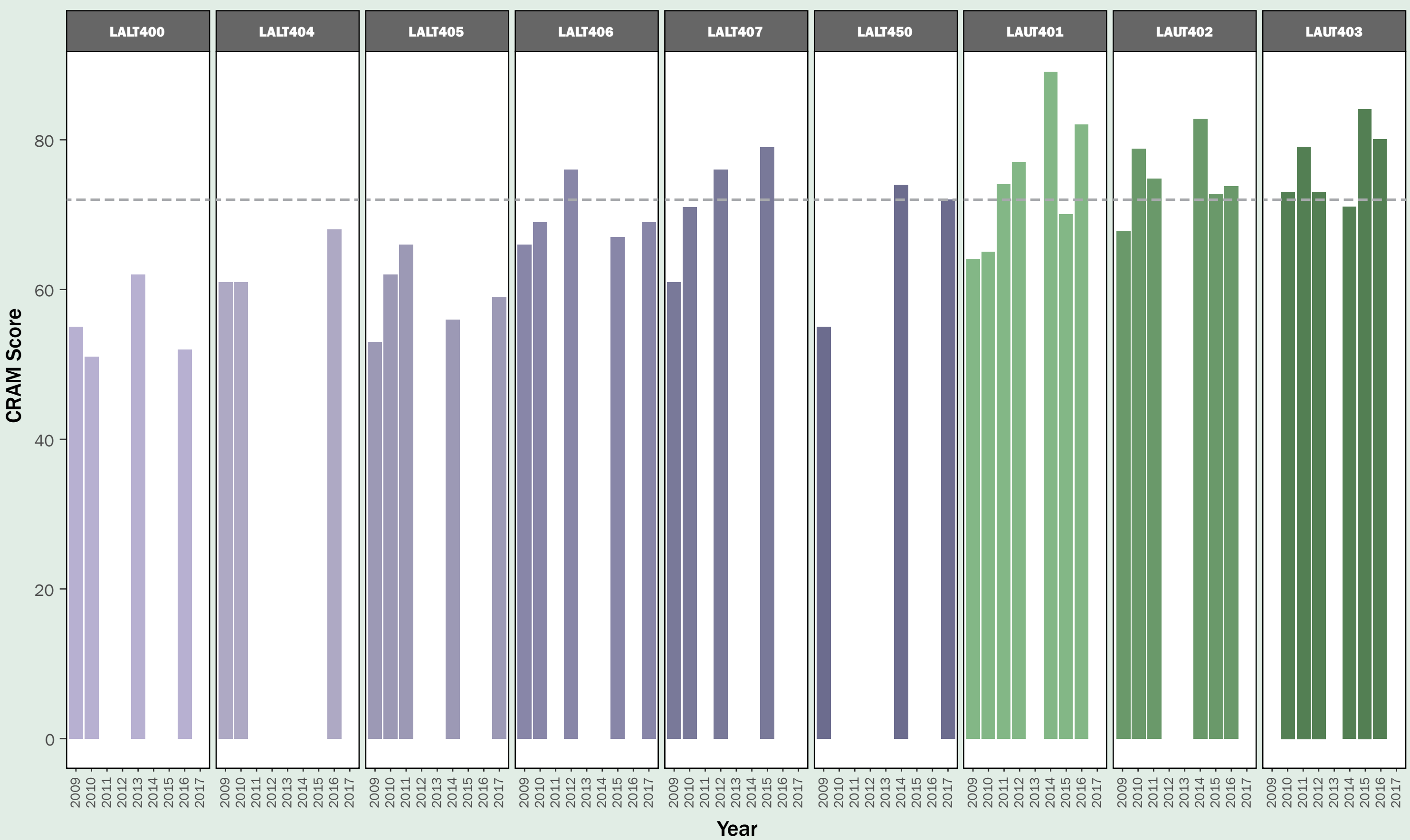


TABLE 14. Summary of trends and findings for high value habitat sites. CRAM Score status is based on scores from the most recent monitoring period. Trend status is based on Mann Kendall significance test, which test for consistent improving or degrading trends.

Location	Site	CRAM	Trend	Notes
LOWER WATERSHED	**Golden Shore Wetlands** (LALT 404)	Impaired	Stable	The average CRAM score (63) for this wetland was below reference condition (72) for estuarine wetlands that were surveyed for a statewide calibration study conducted by SCCWRP. Scores have stayed steady during the 9-year monitoring period. The habitat complexity typical of a perennial wetland has been lost; the limited freshwater flow into the wetland consists mostly of urban runoff including runoff from the port. Conversely, the biotic structure of the wetland is relatively good, with several native plant species present.
	Arroyo Seco (LALT 450)	Impaired	Stable	The CRAM score at this site was 67 on average between 2009 and 2017. Riparian habitat condition appears to be improving, though not significantly, since monitoring began. This reach has a relatively good riparian zone and moderate streambed complexity; however, surrounding residential development and heavy recreational-use has adversely impacted the site.
	Glendale Narrows (LALT 400)	Impaired	Stable	CRAM scores at this site averaged 55 from 2009 and 2017 owing to its poor physical structure, lack of buffer zones, and highly modified hydrology. The plant community is a mix of native riparian plant species and invasive species, notably Arundo donax. CRAM scores at this site are below reference condition, but have not had a significant increasing or decreasing trend, holding steady over the past 9 years of monitoring.
	Sepulveda Basin (LALT 405)	Impaired	Stable	CRAM scores at this site averaged 59.2 from 2009 to 2017 and the trends have not significantly improved or worsened, despite recent dips in CRAM score. This site is below reference condition. The buffer zones on this reach of the Los Angeles River are wide and relatively undisturbed. However, the physical structure of the stream bottom and banks are highly modified and lack complexity.
	Eaton Wash (LALT 406)	Impaired	Stable	CRAM scores averaged 69.4 at Eaton Canyon from 2009 to 2017 and have held steady over the past 10 years. Riparian habitat condition is impaired. The buffer zones on this reach are relatively undisturbed and continuous and the hydrology upstream and downstream of the site is natural. The low structural diversity of the plant community, as well as a large number of the invasive plant species has contributed to lower scores.
	Haines Creek Pools and Streams (LALT 407)	Reference Condition	Slight Improvement	CRAM scores averaged 71.8 from 2009 to 2017 and there is a moderately improving trend in riparian condition at the site. The buffer zones surrounding the pools are in excellent condition, while their physical structure is not ideal owing to a lack of complexity. The hydrology of the pools is highly modified, albeit functional considering this is a remediated site. The biotic structure of the site is relatively good with several endemic species and good zonation.
UPPER WATERSHED	**Tujunga Sensitive Habitat** (LAUT 401)	Reference Condition	Improvement	The average CRAM score at this site is 74.5. Scores at this site have been variable, but improving from 2009 (CRAM score = 64) through 2017 (CRAM score = 82) (p=0.07). Improved scores are mainly due to improved biotic structure of the plant communities, recovery of the physical structure following the heavy scouring that occurred from post-fire winter storms in 2010, and continued improvement in the hydrology of the site. The buffers surrounding the site have been in excellent condition throughout the period.
	Upper Arroyo Seco (LALT 402)	Reference Condition	Stable	The CRAM scores at this site have ranged from 68 to 83, with an average of 75 from 2009 to 2017. We have seen a slight, though not statistically significant, improvement since the Station Fire. The consequences of the fire, which modified the physical structure of the streambed and surrounding riparian zone, included loss of complexity and erosion. The buffer zones and hydrology of the site has changed slightly during the recent monitoring in the post-fire period.
	Alder Creek (LAUT 403)	Reference Condition	Stable	CRAM scores at this site were stable over the period from 2009 to 2017 (average 76.6). The buffer zones at this upper watershed site were in excellent condition with essentially no human influence. The site is a wash and, therefore, the physical structure of the streambed and banks scored lower than the other attributes. The biotic structure scores were also lower owing to a lack of vegetative layering and sparse vegetative density.

MONITORING STREAM RECOVERY FOLLOWING THE 2009 STATION FIRE

The September 2009 Station Fire was the largest wildfire in Los Angeles County's history, burning 161,189 acres or 252 square miles of upper watershed mountainous terrain in the Los Angeles and San Gabriel River watersheds. The areas affected by the fire had not burned for decades, resulting in an extremely hot burn that devastated the riparian zones of streams throughout the upper watersheds. The fire burned for 49 days, from August 29th until October 16th, and cost an estimated $95,300,000 to fully contain.

The following winter, several heavy rainstorms caused widespread erosion from the burn areas. The fire, coupled with erosion from the rainstorms, degraded the conditions in the riparian zones of streams throughout the watershed.

Image courtesy JPL Photojournal.

Big Tujunga Canyon post-fire.

Prior to the fire, the Los Angeles River Watershed Monitoring Program (LARWMP) and San Gabriel River Regional Monitoring Program (SGRRMP) had initiated ambient water quality monitoring programs using randomly selected sites where a suite of indicators, including water chemistry and toxicity, bioassessment and physical habitat conditions, were collected annually during the summer. Several of the sites burned during the Station Fire, providing an opportunity for the SGRRMP and LARWMP to establish long term trend monitoring programs at these sites to detect the rate and quality of their recovery. Three sites in the Los Angeles River Watershed were revisited three times from 2010 to 2013.

Stream biological conditions decreased immediately following the fire to levels below the impairment threshold at some sites and then gradually began to improve. Sampling at these sites occurred in the summer as part of the larger ambient monitoring program and concentrations of nutrients and metals were similar between pre- and post-fire sampling, probably due to lack of runoff. In contrast, measures of the riparian habitat condition using the California Rapid Assessment Method (CRAM), showed clear decreases in riparian zone biotic structure, increases in eroded and vulnerable banks, and decreased streambed complexity and structure. The populations of aquatic macroinvertebrates in these streams recovered to pre-burn composition within three to four years. It is hoped that these results will help forest service managers to understand the impact of fires on the riparian zones in the watershed and to efficiently manage their recovery in the future.

The majority of high-value sites that have been actively managed for restoration or recently burned, have steadily improved since monitoring began. Two sites that burned during the 2009 Station Fire, the Upper Arroyo Seco and Tujunga Sensitive Habitat sites, rebounded post fire, but have dipped below reference condition more recently due to drought conditions. The Alder Creek Site is the only post-fire site that has not shown an improving trend, though average CRAM scores are above the reference condition and steady over the eight-year monitoring period. The Haines Creek and Pools Site is the only lower watershed site that has a consistent improving trend in riparian habitat condition. The site overlaps with a Caltrans mitigation project.

Large investment in urban restoration is occurring globally, despite being poorly understood. Long-term monitoring data is rarely available to track the progress and efficacy of restoration projects. Given the focus on restoration activities in streams throughout the watershed and multi-benefit restoration along the channelized portions of the Los Angeles River, there is an opportunity to coordinate with ongoing and future projects to track restoration efficacy. Meanwhile, the impact of ongoing management activities, such as dredging and invasive eradication, on aquatic communities remains poorly quantified. Data on habitat condition, water chemistry, and biological condition, along with more targeted species monitoring, can help build our understanding of project performance and can inform best practices for urban rivers.

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Are Receiving Waters Near Discharges Meeting Water Quality Objectives?

Reclaimed water from Tillman plant discharging to Lake Balboa (Photo courtesy of John Schramm).

4.1 BACKGROUND

The type and magnitude of pollutants that enter the Los Angeles River is determined by discharge sources and season. During the dry season, the Los Angeles River is primarily sustained by wastewater from reclamation plants (point sources), treated to reduce or eliminate nutrients, pathogens, and organic matter *(Figure 18)*, and to a lesser degree, urban runoff and groundwater seepage (nonpoint sources). In contrast, stormwater runoff (nonpoint source) contributes the largest volumes during the rainy season.

The goal of this question is to assess the impact of known point source discharges on receiving water quality in the Los Angeles River *(Figure 19)*. The LARWMP focused on effluents from three publicly-owned treatment

WATER QUALITY OBJECTIVES FOR RECEIVING WATERS

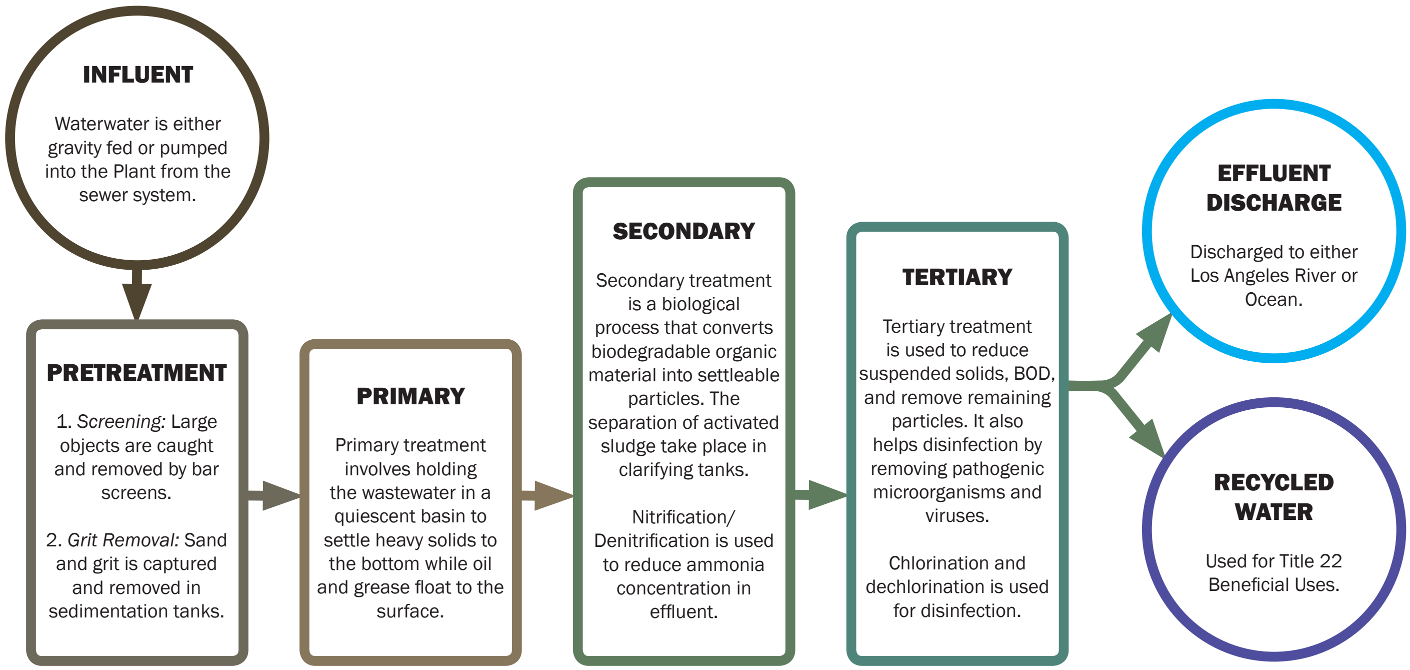
Nutrients, metals, and *E. coli* were compared against the objectives described in the Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties. Metals were compared to the State of California Toxics Rule (CTR) to determine if they were above either the acute or chronic thresholds. For some of these constituents, objectives are adjusted according to other measured parameters such as hardness for metals and pH and temperature for ammonia. Acute thresholds represent maximum 1-hr concentrations protective of aquatic life uses and the chronic thresholds represent maximum 30-day average concentrations protective of aquatic life uses.

Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties:

www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/

CA CTR:
www.epa.gov/wqs-tech/water-quality-standards-establishment-numeric-criteria-priority-toxic-pollutants-state

FIGURE 18. Generalized wastewater reclamation plant (WRP) treatment process.



works (POTWs) that discharge tertiary-treated effluents to the Los Angeles River, above the confluence with the Arroyo Seco:

- City of Burbank Water Reclamation Plant (BWRP),
- City of Los Angeles Glendale Water Reclamation Plant (LAGWRP)
- City of Los Angeles D.C. Tillman Water Reclamation Plant (DCTWRP)

The treatment capacities of these WRPs range from 9 million gallons per day (MGD) for the Burbank WRP to 20 MGD and 80 MGD for the Glendale and Tillman WRPs, respectively. Las Virgenes Municipal Water District (LVMWDs) Tapia Plant is also permitted to discharge 2 MGD to the Los Angeles River at certain times of year. However, discharges are typically much less than this (see *Table 8*).

National Pollution Discharge Elimination System (NPDES) permits require these POTWs to monitor water quality upstream and downstream of the point of discharge to demonstrate that they attain certain water quality standards. As part of this report, LARWMP consolidated these data from 2013 to 2017 and compared them to the State of California threshold values considered to be protective of aquatic life.

4.2 WATER QUALITY OF RECEIVING WATERS (2013-2017)

Receiving waters near the treatment plant discharges are meeting WQOs except for copper and bacteria.

Generally, the concentrations of heavy metals are below acute and chronic regulatory CTR thresholds at both upstream and downstream sites. Heavy metal concentrations appear to be diluted by POTWs effluents as the concentration of copper ($p = 0.07$) and selenium ($p=0.003$) were significantly reduced downstream of the POTWs over the monitoring period (*Figure 20*). Though copper concentrations have exceeded chronic thresholds both upstream and downstream of POTW effluents.

E.coli concentrations are above regulatory thresholds in about half of the water quality samples in both upstream and downstream samples. POTW effluent, however, does not appear to be contributing to elevated bacteria levels (effluents themselves are monitored and have low levels of *E. coli*). Upstream and in channels sources, urban runoff, homeless populations, and wildlife, may all be possible sources of *E. coli*. Though upstream and downstream concentrations do not differ across POTWs ($p = 0.57$, *Figure 21*), at Los Angeles-Glendale and Burbank Water Reclamation Plants, effluent improves water quality by diluting upstream bacteria concentrations.

FIGURE 19. Location of water reclamation plants in the Los Angeles River Watershed.

FIGURE 20. Heavy metal concentrations upstream and downstream of POTW effluents. Red (chronic) and black (acute) lines denote regulatory thresholds.

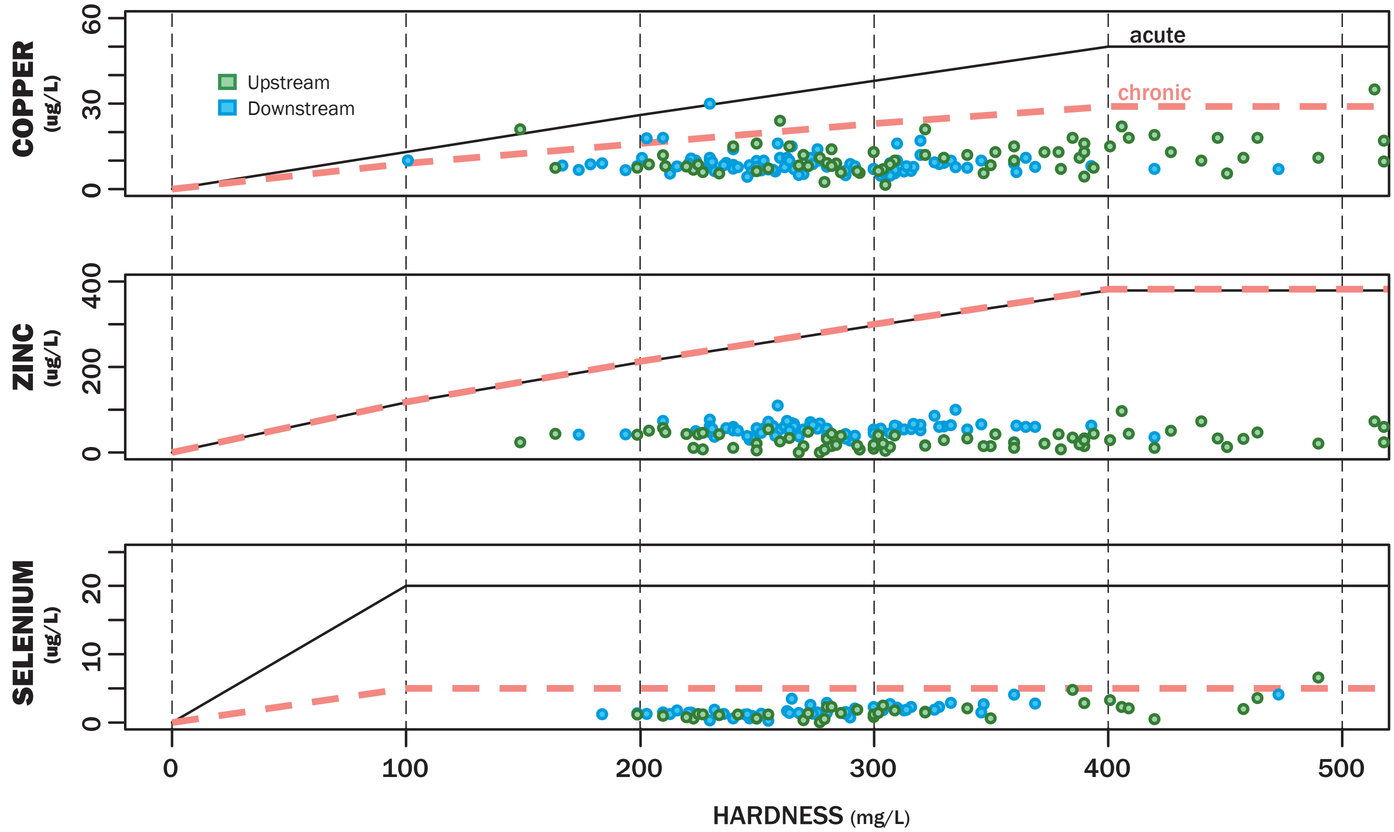


FIGURE 21. *E.coli* concentrations (log transformed) upstream and downstream of POTW effluents. Horizontal lines denote regulatory thresholds.

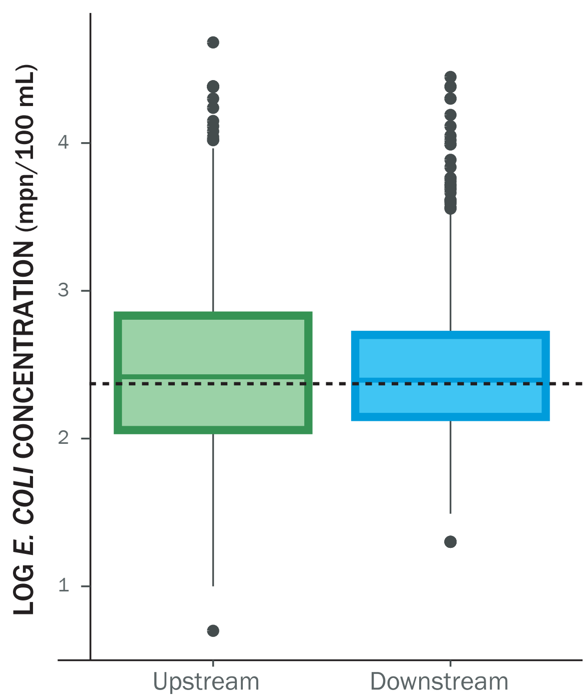


FIGURE 22. Ammonia and nitrate concentrations upstream and downstream of POTWs. Horizontal lines denote regulatory thresholds.

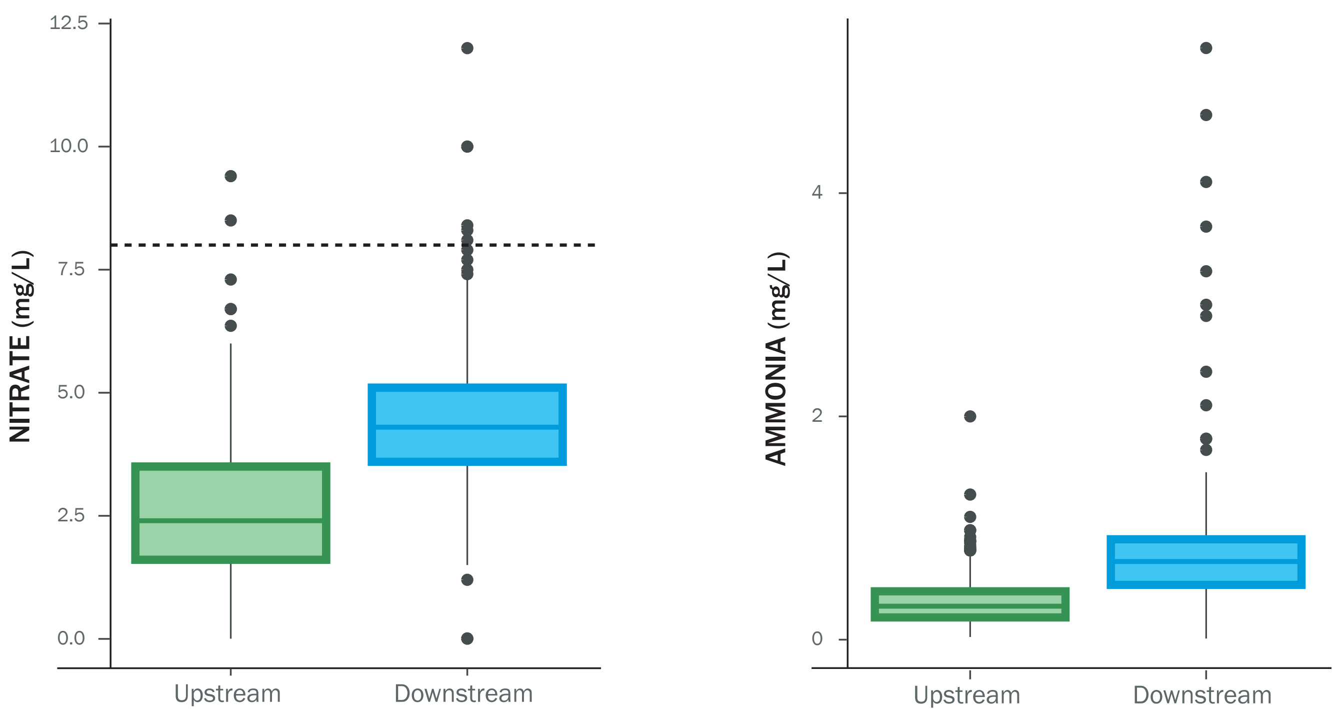


TABLE 15. POTW receiving water concentrations of nutrients.

	Range (n)			
	Donald C. Tillman WRP	LA-Glendale WRP	Burbank WRP	Threshold Value
Nitrate-Nitrogen (mg/L)	0.5-5.39 (93)	3.03-6.84 (204)	0.004-12 (260)	8.0
Ammonia-Nitrogen (mg/L)	0.1-1.61 (130)	0.1-3.62 (190)	0.01-5.3 (261)	*

*: calculated based on temperature and pH

In contrast, the effluents from these facilities contain higher concentrations of nutrients (e.g., ammonia and nitrate) than receiving waters. These nutrients increase downstream of the POTWs *(Figure 22)*. However, the majority of samples that were assessed against relevant water quality standards during the five-year period were still within thresholds regarded as safe for humans *(Table 15)*.

4.3 SUMMARY AND NEXT STEPS

Effluents from POTWs within the LA River Watershed have a variable impact on water quality. Effluents dilute the concentration of heavy metal contaminants and do not significantly contribute to the high levels of bacteria that occur upstream. The effluents themselves have low *E. coli* concentrations, signaling that nearby wildlife, homeless populations, or urban runoff are contributing to elevated *E. coli* levels. POTWs are, however, a source of ammonia and nitrates to receiving waters, as concentrations are higher downstream of the discharges, although both upstream and downstream concentrations are generally below WQOs.

The Cities of Burbank and Los Angeles will continue to monitor receiving waters to determine if they are meeting the WQOs for their beneficial uses. Recently, Salt and Nutrient Management Plans were developed to improve the quality of water used in groundwater basins receiving

LOS ANGELES RIVER WATERSHED PUBLICLY OWNED TREATMENT WORKS (POTWs)

BURBANK WATER RECLAMATION PLANT

The City of Burbank Water Reclamation Plant (BWRP) was built in 1966 and currently treats 9 million gallons of sewage per day (MGD). Before the BWRP was built, the City of Burbank sent all of its wastewater to the City of Los Angeles for treatment and disposal.

The plant was upgraded in 2000 to ensure that it could meet the new stringent treatment regulations mandated by the Los Angeles Regional Water Quality Control Board (LARWQCB). The plant was upgraded again in 2002 to convert ammonia to nitrogen using the nitrification/denitrification treatment process. Today BWRP and the City of Burbank are rapidly expanding their use of recycled water.

Burbank Water Reclamation Plant. Photo courtesy of City of Burbank Public Works Department.

LOS ANGELES-GLENDALE WATER RECLAMATION PLANT

Los Angeles-Glendale Water Reclamation Plant Water Reclamation Plant commenced operations in 1976 as the first water reclamation plant in the city. The cities of Los Angeles and Glendale co-own the plant and the LA Sanitation operates and maintains it. Each city pays 50% of the costs and receives an equal share of the recycled water. In 2007, the City added nitrification/denitrification upgrades to secondary treatment to reduce nitrogen in effluent. The plant processes around 20 MGD of wastewater and produces recycled water that exceeds WQOs for industrial and irrigation uses. Recycled water production saves 1 billion gallons of potable water/year.

Los Angeles-Glendale Water Reclamation Plant. Photo courtesy of City of Los Angeles Bureau of Sanitation.

DONALD C. TILLMAN WATER RECLAMATION PLANT

The Donald C. Tillman Water Reclamation Plant (DCTWRP) began continuous operation in 1985. A major construction project that doubled the capacity of DCT was completed in 1991 – expanding the plant from 40 MGD to 80 MGD. The plant was upgraded again in 2007 to convert ammonia to nitrogen using the nitrification/denitrification treatment process.

The DCTWRP, together with the Los Angeles-Glendale Water Reclamation Plant, is the leading producer of reclaimed water in the San Fernando Valley. By reclaiming a significant portion of wastewater, these treatment facilities have provided critical hydraulic relief to the City's downstream sewage lines and have helped augment local water supplies.

Donald C. Tillman Water Reclamation Plant. Photo courtesy of John Schramm.

recycled water from POTWs (SNMP, 2016). This monitoring will determine changes in the concentration and presence of constituents as new chemicals are introduced, advance treatment processes are implemented, the use of recycled water increases, and policies restricting the use of various substances are enacted.

4.4 REFERENCES

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Is it Safe to Recreate in the LA River and its Tributaries?

5.1 BACKGROUND

When the public imagines the Los Angeles River and its watershed, they commonly visualize the wide concrete-lined channels of the lower watershed. This image overshadows the abundant recreational opportunities provided by the soft-bottom portions of the river and the nearby freshwater lakes and streams, particularly the headwater streams in the Angeles National Forest. During the warm spring and summer months, thousands of locals and visitors enjoy swimming in cool waters of these relatively natural streams. Despite this popularity, prior to LARWMP, little was known about the safety of swimming at popular swimming sites throughout the watershed.

To determine the human health safety of swimming in these waters, LARWMP began measuring *E. coli*, a type of Fecal Indicator Bacteria (FIB). The presence of *E. coli* in recreational waters indicates fecal contamination by humans or animals and acts as a freshwater diagnostic tool for the presence of other more harmful pathogens, such as *Salmonella* and *Giardia*.

In California, the State Water Resources Control Board and Regional Water Quality Control Water Boards determine waters that are suitable for swimming (REC-1) and describe Water Quality Objectives (WQOs) to protect these waters (AB 411). At locations where people are in direct contact with the water, such as when swimming and wading, FIB should not exceed WQOs. The Los Angeles Basin Plan *E. coli* water quality objective for freshwater recreational swimming is 235 per 100 mL based on a Most Probable Number (MPN) per single sample analysis (LARWQCB 2014). This standard was developed based on the relationship between bacteria levels, human health effects, and “historically acceptable illness rates,” which for freshwater bodies has been designated as eight illnesses per 1,000 swimmers (US EPA, 1986).

Photo: (right) Within the Angeles National Forest at Switzer Falls, a visitor studies the insects in water.

In 2010, Los Angeles Conservation Corps (LACC) along with its partners formed Paddle the LA River Pilot program. This was the first non-motorized boating pilot program on the Los Angeles River at Sepulveda Recreation Basin. The program organizers thought that by paddling this scenic stretch, people experience first-hand that the Los Angeles River is part of an ecosystem that is both beautiful and significant to Los Angeles’ past and future. This program operated for two years.

In 2013, The Mountains Recreation and Conservation Authority (MRCA), in cooperation with the City and County of Los Angeles, the Los Angeles County Flood Control District, and the Army Corps of Engineers, administered the Los Angeles River Recreation pilot program to increase safe public access to the L.A. River and to promote the goal of river revitalization.

Since 2013, the Los Angeles River Recreation Zone has provided an opportunity for any member of the public to walk, fish, and kayak on a 2.5-mile portion of the L.A. River in Elysian Valley and the Sepulveda Basin from Memorial Day through September and from sunrise to sunset daily, during safe conditions.

WATER QUALITY NOTIFICATIONS IN THE LOS ANGELES RIVER

Due to water quality concerns, in 2018 the City of Los Angeles increased monitoring efforts in the Los Angeles River recreational zones to twice a week. Results are posted on the LA Sanitation website. When bacteria levels are exceedingly high at two or more sites a closure advisory is issued.

OPEN

Water quality is suitable for recreational activities, but swimming in the river is still prohibited. Test results indicate bacteria levels lower than 235 MPN, the limit for REC-1.

CAUTION

Users should exercise increased caution. Test results indicate bacteria levels between 235 MPN (REC-1) and 576 (Limited REC-1) at one or more of the sampling sites located in the recreation zone or above 576 at only one of the sites.

CLOSED

This LA River Recreation Zone is not suitable for recreational activities. Test results indicate levels exceeding 576 MPN (Limited REC-1) at two or more of the sampling sites located in the recreation zone. A Closure Advisory will be issued by the City of Los Angeles and the MRCA will close the recreation zone and post closed signs. The recreation zone will stay closed until further bacteria testing show that the zone is once again suitable for recreational activities.

5.2 SAMPLING AND SITE SELECTION

Weekly sampling for *E. coli* commences in the summer from May to September at high-use recreational swimming sites. Sixteen recreational swimming sites were monitored from 2013 through 2017, including streams in the Angeles National Forest, sites in the Los Angeles River, and streams in the lower watershed *(Figure 23)*. In 2016, five kayak sites within the recreational zone in the Los Angeles River were added to the LARWMP monitoring program *(Table 16)*. Initially, sites were selected based on the collective knowledge of the workgroup of popular swimming locations. Sites were then added or excluded as LARWMP improved its understanding of the recreational use of streams, as well as depending on drought condition and the accessibility of the site to visitors and monitoring teams.

To capture site conditions during heavy use and elucidate the relationships between heavy recreational use and *E. coli* concentrations, sampling was concentrated around weekends and holidays when the swimming intensity is greatest. Depending on the site, sources of FIB could include visitors, dogs, wildlife, urban runoff, homeless populations, and trash (for example: diapers, toilet paper).

5.3 RESULTS

Recreational sites in the Angeles National Forest are very popular with the public during the warm summer months. These sites are readily accessible to the 10 million residents (Census Bureau, 2017) of Los Angeles County and provide an opportunity to explore unique habitats in an otherwise highly urbanized watershed. Sites vary in condition, use, and in the average number of visitors. Many of the sites in the natural regions of the watershed are popular swimming holes accessible via a short hike. In the urbanized portions of the watershed, kayaking, hiking, and fishing are popular.

During the summer months of 2013 through 2017, a total of 955 samples were collected from swimming sites and analyzed for *E. coli*. A total of 27% of the samples collected exceeded the REC-1 standard for a single sample for *E. coli* (235 MPN/100 mL). This is an increase of 6% compared to 2009-2012 and is higher than in the neighboring San Gabriel River watershed, where only 4% of samples exceeded the REC-1 standard during 2007 through 2009.

FIGURE 23. Exceedance of REC-1 standards at swimming sites from 2009-2017 (Note: figure includes data from 2009-2012 for sites that continued to be part of the monitoring program in 2013-2017).

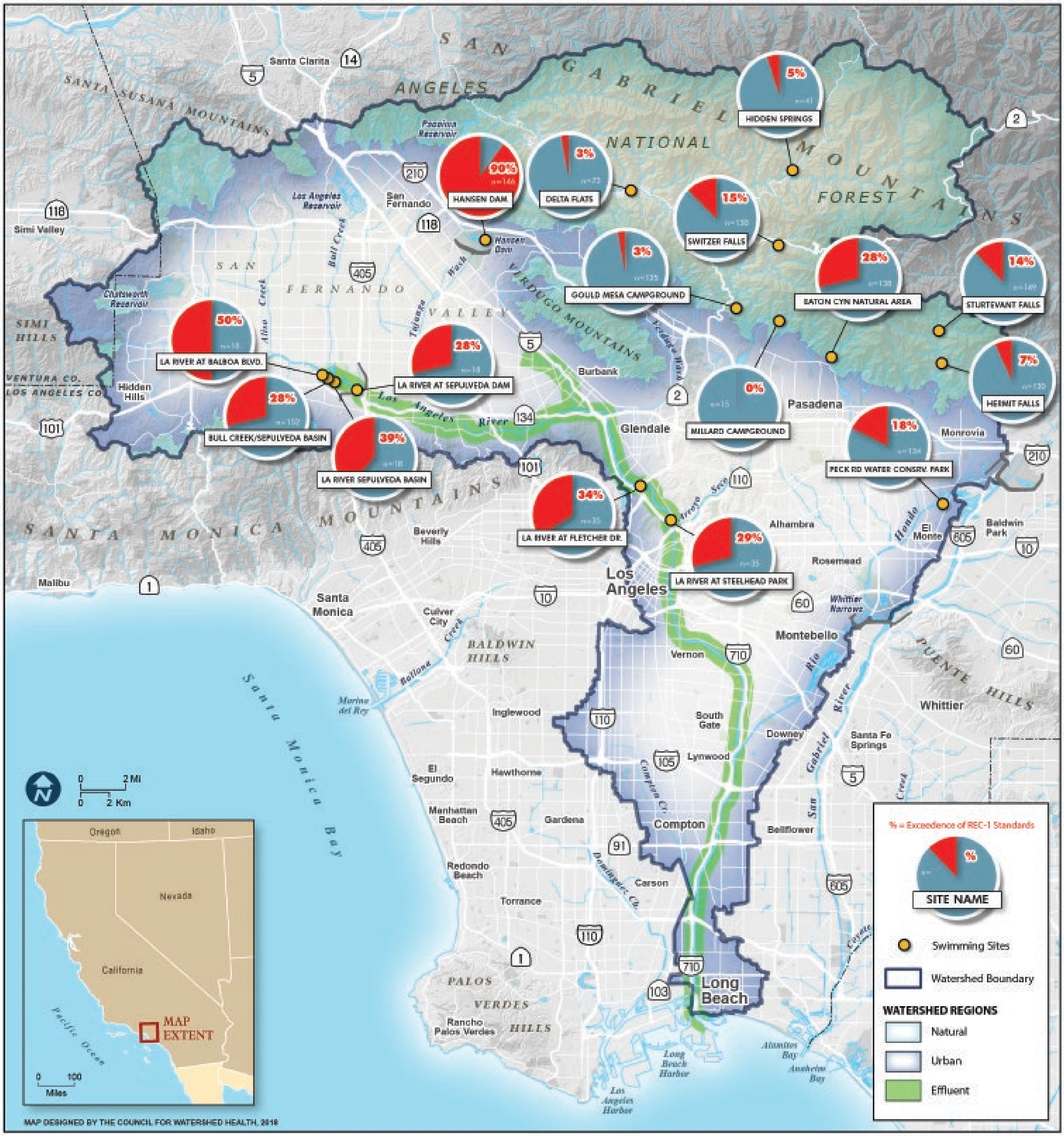


TABLE 16. Recreational swimming sites within the Los Angeles River Watershed.

SWIMMING SITES	SITE CODES	NOTES
Big Tujunga	LAUT 206	Fire closure due to Station fire. Reopened in 2014.
Switzer Falls	LAUT 208	
Gould Mesa Campground	LAUT 209	
Sturtevant Falls	LAUT 210	
Hidden Springs	LAUT 211	Fire closure due to Station fire. Reopened in 2015. Dropped in 2017 due to limited recreational use.
Hermit Falls	LAUT 213	
Millard Campground	LALT 203	
Eaton Canyon	LALT 204	
Bull Creek, Sepulveda Basin	LALT 200	
Peck Road Park	LALT 212	
Hansen Dam	LALT 214	
Sepulveda Basin at Balboa Blvd	LALT 215	Recreational zone and kayak site added in 2016.
LA River Sepulveda Basin	LALT 216	Recreational zone and kayak site added in 2016.
LA River at Sepulveda Dam	LALT 217	Recreational zone and kayak site added in 2016.
LA River, Fletcher Drive	LALT 218	Recreational zone and kayak site added in 2016.
Steelhead Park	LALT 219	Recreational zone and kayak site added in 2016.

The greatest frequency of REC-1 exceedances occurred at the two sites: Hansen Dam, where 90% of samples exceeded the REC-1 WQOs, and the Sepulveda Basin at Balboa Blvd, where 50% of samples exceeded WQOs. The sources of bacteria at these sites are unknown, but because both sites are large open spaces within the urbanized portions of the watershed, they may have heightened bacteria levels originating from wildlife, recreational activities (Hansen Dam is used by the equestrian community and horse waste is often found on trails and near streams), and human sources.

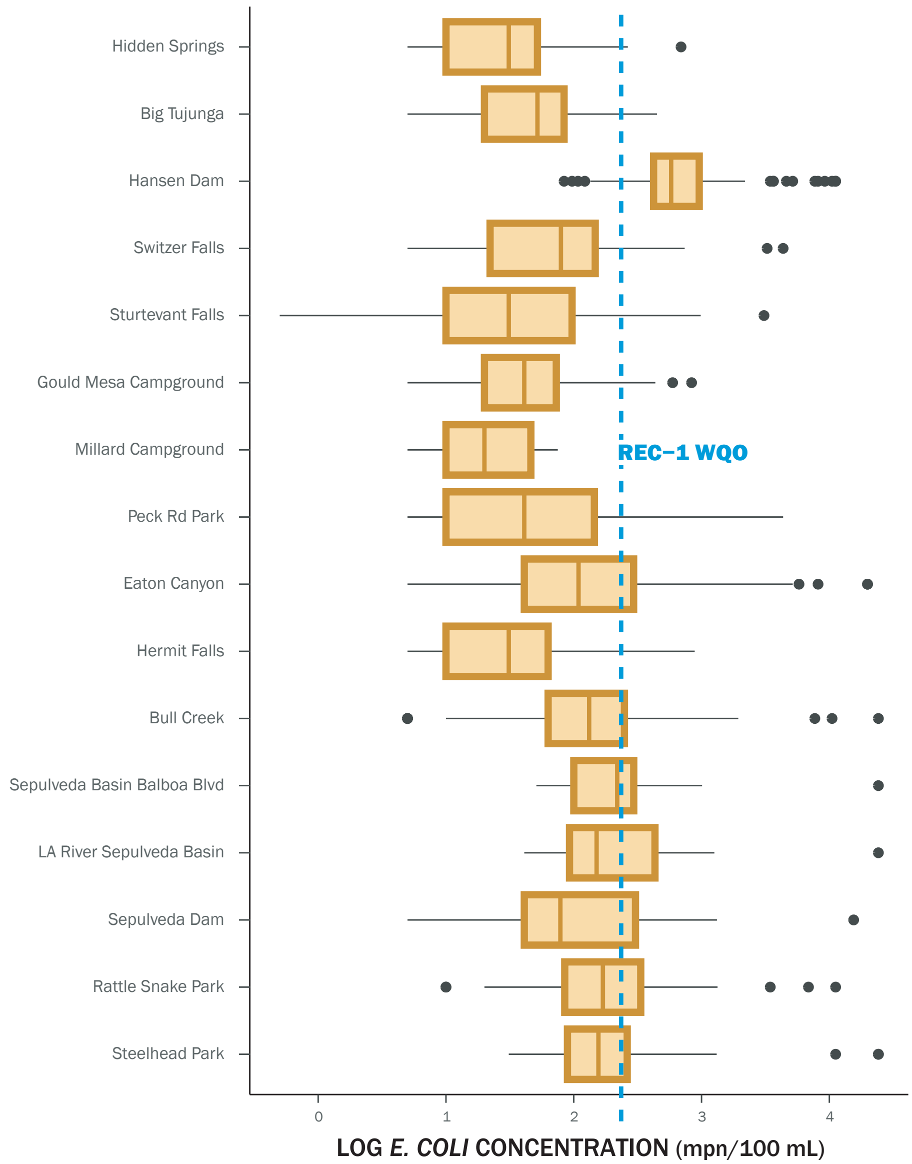
Apart from the Sepulveda Basin, other sites within the recreational zone had recurring and high *E. coli* levels. These sites are soft-bottom vegetated sites in the channelized portion of the river. Fecal bacteria inputs at these sites can include wildlife and both upstream and in-channel human activities. However, exposure at these sites to elevated bacteria levels is likely lower because of reduced risk of swallowing water during non-motorized boating activities (such as kayaking), the only sanctioned water contact recreational activity in this section of the river. Full body immersion at these sites is also minimal, according to observational data taken during monitoring trips, though sites were sampled between 7 a.m. and 2 p.m. and sampling times may not overlap with peak recreation times.

At the most popular swimming sites in the Angeles National Forest, Hermit Falls, Eaton Canyon, and Sturtevant Falls, the frequency of single-sample REC-1 exceedance ranged between 7% and 28%. These sites show signs of heavy recreational use; sites and trails leading to swimming holes are often littered with trash on holidays and weekends. Despite the presumed relationship between *E. coli* levels and number of visitors, there is not a strong relationship between the two at recreational sites (r = -0.22). This is less surprising at lower watershed sites that may receive FIB inputs from dry-weather runoff and a variety of upstream human activities.

In an attempt to discern possible sources of *E. coli* at swimming sites, LARWMP records numbers of humans, dogs, and birds at each site during sample collection. Although these counts represent only a snapshot of recreational activity during a sampling event, eventually they can suggest relationships between *E. coli* concentrations and use. Turbidity, water temperature, air temperature, pH, and conductivity are also recorded during sample collection.

We compared *E. coli* counts to these above-mentioned parameters. The strongest correlation was between turbidity and *E. coli* (r = 0.455). This may indicate that

FIGURE 24. Range in *E. coli* concentrations at popular recreational sites from 2009-2017. Bacterial concentrations are compared to the single sample REC-1 water quality objective. Dots represent outliers, values that are abnormally outside the range of values observed. The vertical line on each bar represents the median or midpoint in the dataset.



bacteria may reside in bottom sediments and are stirred up in the water column by wading and swimming activity. Sediments can serve as a reservoir and growth media for bacteria, including pathogenic strains (Alm and Burke, 2003). Fecal indicator bacteria can be orders of magnitude higher in sediments and wet sand than in the water column and can suspend after perturbation (Jamieson *et al.*, 2005). A favorable environment for bacteria is created in sediments due to the availability of organic matter and nutrients, protection from predators, such as protozoa, and shielding from exposure to the UV sunlight (Kim *et al.*, 2010). These results also show that there is a large amount of variation inherent in bacteria data sets *(Figure 24)* (EPA, 2010). Tracking potential sources would require molecular techniques and sanitary surveys at sites with elevated bacteria concentrations.

5.4 SUMMARY AND NEXT STEPS

Swimming and wading at freshwater sites in the Los Angeles River watershed is popular, particularly during the summer months and on holiday weekends. Sites in the lower watershed have a higher percentage of recurring exceedances than upper watershed sites. There was no relationship between the number of people at a site, during monitoring, and *E. coli* levels. Instead, turbidity has the strongest relationship with FIB levels. Wading and swimming activities stir up sediments and disturb the stream banks, which can increase the amount of sediment and suspend bacteria in the water. The sampling and analytical methods currently used by the LARWMP program do not allow for confirmation of potential sources for bacterial contamination. As a result,

TESTING THE WATERS: MICROBIAL METHODS

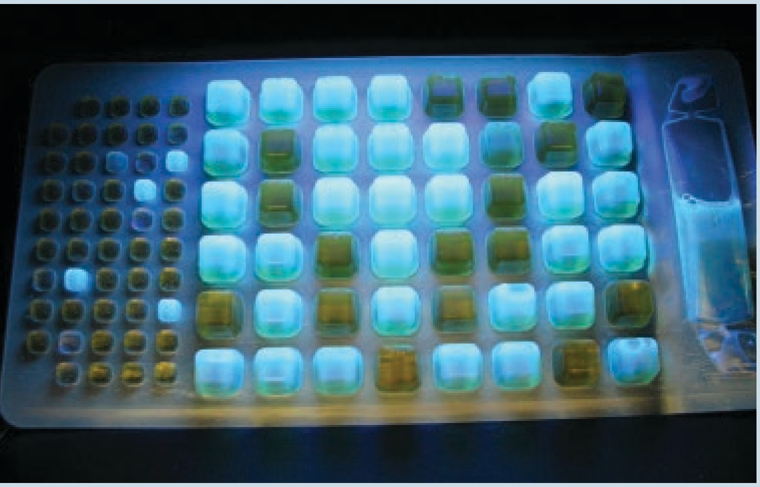


FIGURE 25. IDEXX Method (upper left) Sample and reagent mix are poured into an IDEXX tray; (lower left) wells that fluoresce are positive for *E. coli*. Image sources: LA Sanitation.

Since the LARWMP program began, methods to quantify indicators of fecal pathogens, and the pathogens themselves, and identify their sources have grown and evolved. Regulatory agencies have been cautious in updating regulatory criteria based on new methods because newer methods may be cost prohibitive and perform inconsistently. In addition, there are a smaller number of proficient lab personnel and epidemiological studies to support rigorous criteria setting. Instead agencies like the EPA have advocated a toolbox approach, made protection consistent in both marine and fresh water environments, and issued tools to support notification programs and management of recreational waters. The tools to quantify fecal indicator bacteria and fecal pathogens include:

IDEXX: The IDEXX Colilert test is the current method used by LARWMP to quantify the concentrations of FIB in water samples. This method is the most accepted for use by state and federal agencies. It is very easy to use and does not require special skills to perform. The test uses a nutrient indicator, which fluoresces when metabolized by *E. coli*. Based on the number of tray cells fluorescing *(Figure 25)*, signaling a cell positive for *E. coli*, the count of bacteria is determined using a Most Probable Number (MPN) statistical table. The drawback for this method is there is a 24-hours period before results are available.

qPCR: Short for quantitative polymerase chain reaction, is derived from the same field of molecular biology as is microbial source tracking (MST). This rapid method uses chemical or thermal reactions to breakdown the bacteria and then works to isolate DNA sequences unique to *Enterococcus* spp. and *E. coli*. The method quantifies the amount of the DNA, from which the relative quantity of bacteria can be determined. Advantages of this method include its timeliness, results are available in 2 hours, and it is more predictive of the presence of swimming-associated GI illness-causing pathogens than other methods (EPA, 2012). Wider application of this method requires greater distribution of qPCR-capable laboratories with experienced personnel to ensure quality performance and, in some instances, site-specific criteria due to matrix interference. In 2012, the EPA issued revised water quality criteria based on this method.

MST: Microbial Source Tracking (MST) targets intestinal microbial species closely associated with the gut of a particular animal group. The technology differentiates the source of *E. coli* from human sewage, wildlife, agriculture and other sources, improving chances for effective remediation. By employing this technology, it is possible to identify non-point sources of human fecal pollution in a large watershed (Peed, 2011). This is especially meaningful for water quality in recreational settings because human fecal contamination poses a greater risk for public health. While this technology is promising, it is technically demanding and requires specialized equipment, detailed procedures, and specialized training (EPA, 2017). The advancement of this technology is dependent on its level of transferability and the development of standardized method. Much like the qPCR method, this method cannot differentiate between viable and non-viable genetic material (both live and dead pathogens are detected and cannot be differentiated).

Transcription-Mediated Amplification Method: Similar to qPCR, nucleic acid sequences are isolated, replicated, and analyzed, but instead of using DNA, the process uses bacterial RNA. This method takes two hours for results, requires simple equipment, which can be developed for the field and can be performed by technicians with little to no prior experience with molecular methods. However, this technology still requires more testing and research to reduce false negatives (Griffith et al., 2007).

an additional study identifying sources of bacteria is recommended in order to strengthen recommendations on best management practices to reduce bacterial contamination at recreational swim sites. Microbial source tracking, recommended for sites not receiving effluents from water reclamation plants, can provide insight as to sources of fecal contamination at sites that are frequented by the public and often have elevated bacterial levels like Hansen Dam.

An additional area for further investment is in educational outreach. Human sources, from recreational activities, 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. Additionally, education and engagement can be key in improving site condition. Trash is often visible on trails and at swim sites. Some trash, like pet waste and diapers, poses a threat to public health. Visitor surveys can be a key tool for identifying gaps in understanding and pinpointing the most appropriate tools for better communicating monitoring data.

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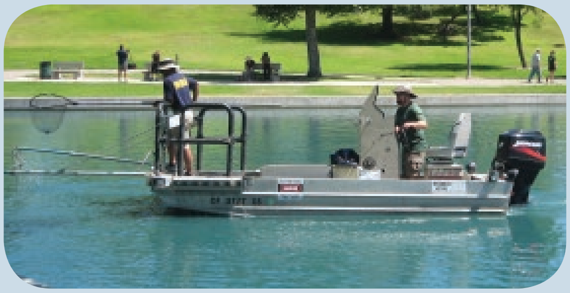
CHAPTER 6

ARE FISH SAFE TO EAT?

Fishing on the Los Angeles River (Photo courtesy of William Preston Bowling).



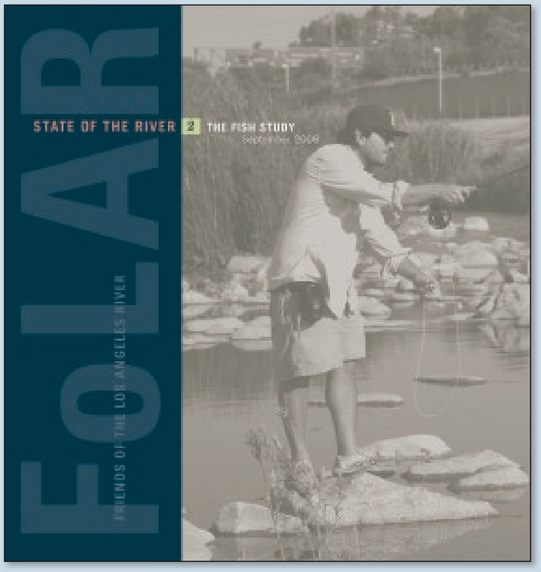
Fish tissues were collected following guidelines established by OEHHA (2005) using a combination of techniques depending on the water body and included boat drawn seines, hand seines, hook and line, and electro shocking.

http://oehha.ca.gov/fish/pdf/fishsampling121406.pdf

6.1 BACKGROUND

Certain contaminants in the environment can accumulate in fish tissue. This bioaccumulation of contaminants poses a health risk to those that eat fish from local water bodies. The contaminants that bioaccumulate, or accumulate in living organisms, are hydrophobic (or water fearing) compounds that adhere to small particles and accumulate in the fatty tissue of fish. These particles are eaten by small organisms and move up the food chain, becoming more concentrated. Contaminants that bioaccumulate include DDT, mercury, selenium, and PCBs. These contaminants have been introduced into the watershed from insecticide application, natural processes, and industrial activities. While contaminants like DDT and PCBs have been banned for decades, they do not degrade easily and are still commonly detected in fish tissues (EPA, 2009)*(Figure 26)*.

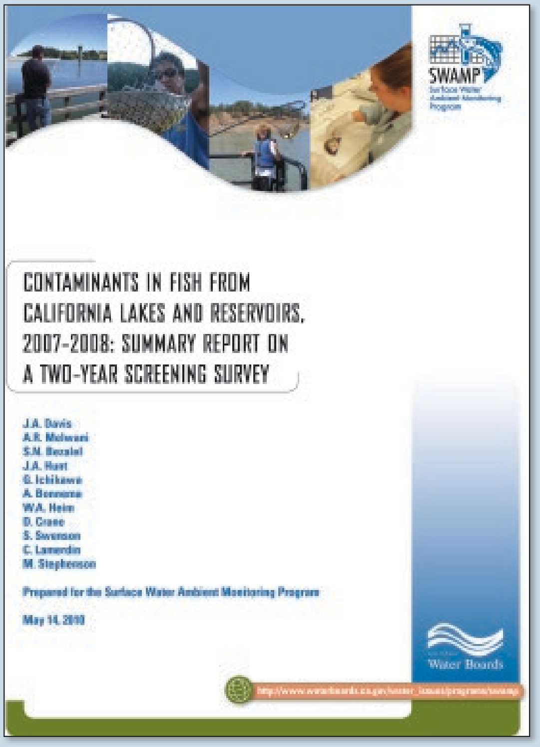
FOLAR FISH STUDY



In 2007, the Friends of the Los Angeles River surveyed fish populations in the Glendale Narrows area, an approximate eight-mile stretch of natural bottom river that extends from Riverside Drive near Griffith Park to the Figueroa Bridge in Cypress Park. The levels of mercury and PCB of four composite samples of bullhead catfish, carp, sunfish and tilapia were well below the three servings per week consumption guidelines described by OEHHA. The results showed that fish tissues collected along the Glendale Narrows had lower concentrations of contaminants than found in many lakes and stream sites monitored across the nation. Eight species of fish were collected, none of the them native. Species included the fathead minnow, carp, black bullhead, Amazon sailfin catfish, mosquitofish, green sunfish, largemouth bass, and tilapia. Mosquitofish and tilapia were the most abundant species.

In 2016, FOLAR sampled the brackish estuary near the mouth of the Los Angeles River. The estuary is home to a mix of native and non-native fish species. Natives included California killifish, Northern anchovy, and topsmelt. Non-native species like asian carp and mosquitofish were also common in this section of the river.

SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP) STUDIES



The SWAMP report, *Contaminants in Fish from California Lakes and Reservoirs, 2007-2008*, summarizes the results of a 2-year screening study of 272 of California's more than 9,000 lakes and reservoirs. This represents the beginning of a long-term, statewide, comprehensive bioaccumulation-monitoring program for California surface waters.

The survey identified problems in certain areas of the state, with methylmercury and polychlorinated biphenyls (PCBs) being the contaminants of greatest concern. Methylmercury poses the most widespread potential health risk, 21% of the lakes surveyed had at least one fish species with an average methylmercury level high enough (> 0.44 ppm) that OEHHA would consider recommending no consumption.*

Despite this, the degree of methylmercury contamination in the state's lakes is not unusual and is comparable to the average condition observed across the U.S. in a 2008 national lakes survey.

The study provides information that will be valuable in prioritizing lakes in need of further study to support development of consumption guidelines and cleanup plans.

*For women between 18 and 45 years of age and children between 1 and 17 years of age

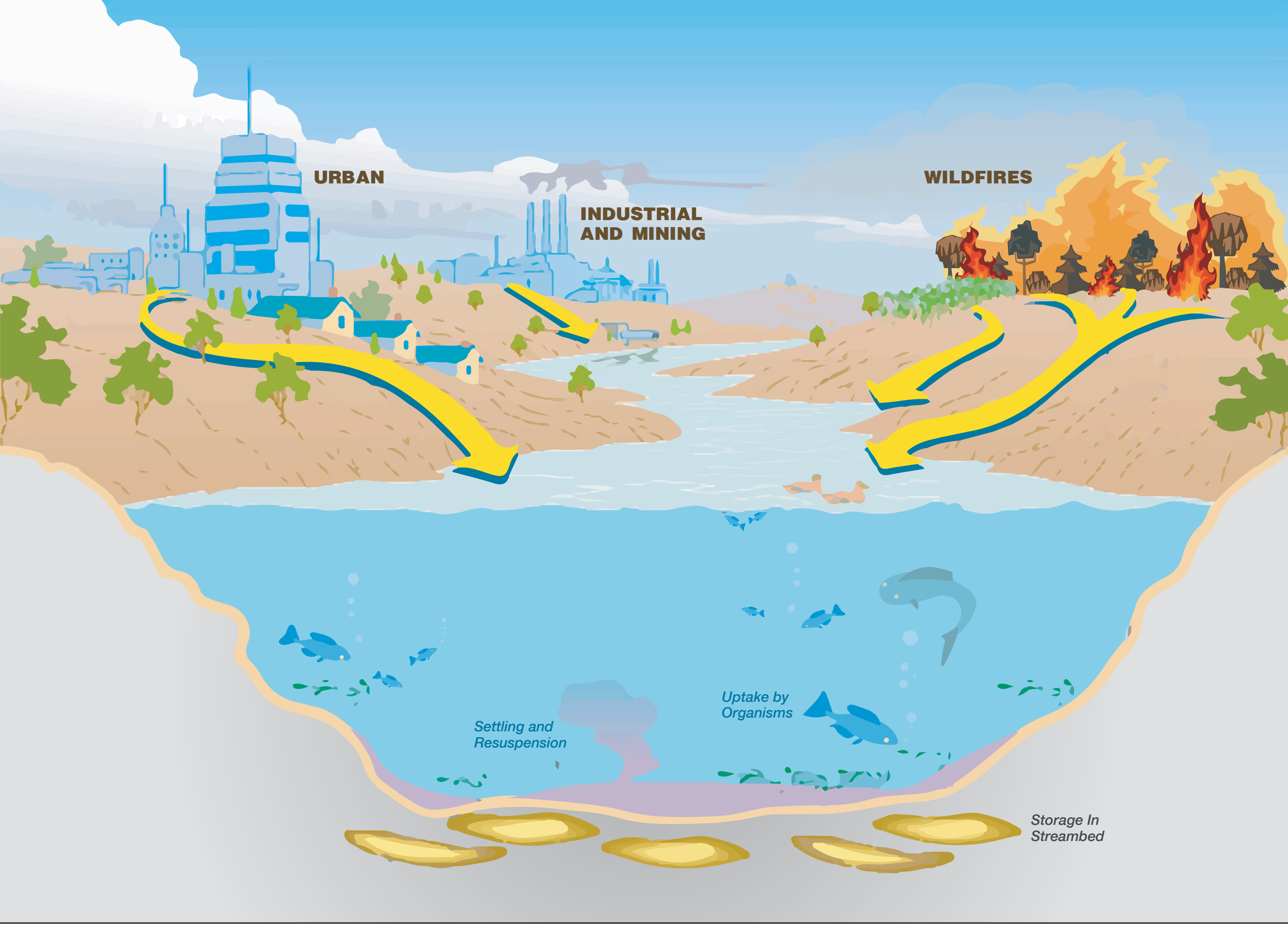


FIGURE 26. Sources of contaminants in the watershed that accumulate in fish tissues *(adapted from USGS)*.

Prior to the start of LARWMP fish tissue sampling, little was known regarding the safety of eating fish caught in the watershed's estuary, creeks, and lakes. Designed to leverage and complement fish tissue monitoring studies by California's Surface Water Ambient Monitoring Program (SWAMP) and the Friends of the Los Angeles River (FOLAR), the LARWMP program began monitoring sites popular among the angling community in 2008. A regional survey of anglers helped in selecting target species and fishing locations where fish are most likely being consumed (Allen *et al.*, 2008), along with the input of the LARWMP technical stakeholder group *(Figure 27)*. Largemouth bass and common carp are the most prevalent fish species and the most commonly caught at monitoring sites. Blue gill, channel catfish, and redear sunfish were later targeted since they are more frequently eaten and little or no data was available for these fish *(Table 17)*.

Four contaminants were selected for analysis based on their contribution to human health risk in California's coastal and estuarine fishes: mercury, selenium, total DDTs, and total PCBs. Fish tissue concentrations were evaluated using thresholds developed by the California Office of Environmental Health Hazard Assessment (OEHHA) for methylmercury, PCBs, DDTs, and selenium *(Table 18)*(OEHHA, 2008).

6.2 CONCENTRATION OF CONTAMINANTS IN FISH TISSUES

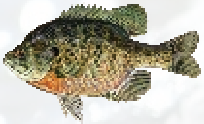
Analysis of fish tissue indicated that, in general, fish that are commonly caught and consumed from lakes in the watershed are likely to be safe to eat in moderate amounts *(Figures 28-29)*. The concentrations of harmful contaminants generally depend on size and trophic position; larger fish higher in the food chain generally

FIGURE 27. Fish tissue bioaccumulation sampling locations for 2013-2017.

TABLE 17. Species of fish collected from the LA River Watershed during 2013-2017. Total lengths are the range of lengths observed from 2013-2017. Life history and distributions are from Moyle (2002).

BLUE GILL (*Lepomis macrochirus*)

Non-native species that is widespread in their distribution and can live and survive in wide temperature ranges and under conditions of low oxygen. Prefer shallow warm waters. Hide in rooted plants. Bottom feeders, consume all available food including largemouth bass eggs. Their diet also includes aquatic insects and their larvae.



LENGTH OBSERVED: 13-18 CM

REDEAR SUNFISH (*Lepomis microlophus*)

Non-native species that was introduced into warm regions of the U.S. from the Southeastern U.S. Prefer warm, deep, quiet water bodies and backwater habitats that are not too turbid. Feed on snails and clams and the bottom dwelling larval stages of aquatic insects.

LENGTH OBSERVED: 13-22 CM

TILAPIA (*Oreochromis* sp.)

Non-native species that is widespread in their distribution. Prefer warm waters and river backwaters. Feed on phytoplankton, aquatic plants, and detritus.

LENGTH OBSERVED: 15-28 CM

LARGEMOUTH BASS (*Micropterus salmoides*)

Non-native species that is widespread in their distribution and prefer shallow waters with moderate clarity. Cover in aquatic vegetation and submerged trees. Largemouth bass has a diverse range of prey, ranging from benthic macroinvertebrates and zooplankton to amphibians and fish fry.

LENGTH OBSERVED: 31-51 CM

CHANNEL CATFISH (*Ictalurus punctatus*)

Non-native species. Omnivorous and opportunistic diet, feeds on fish and plant material, crustaceans, aquatic insects and clams (Marsh 1981).

LENGTH OBSERVED: 49-74 CM

COMMON CARP (*Cyprinus carpio*)

Non-native species that is widespread in their distribution and are resilient to high levels of turbidity, low oxygen levels, and high temperature found in urbanized streams. Omnivorous bottom feeding diet that includes aquatic plants, plankton, and benthic macroinvertebrate.

LENGTH OBSERVED: 20-84 CM

Fish are proportionately scaled by average size.

Illustrations:
Duane Raver, USFWS (bluegill, carp, bass, sunfish)
Joe Tomeilleri (catfish)
Jón Baldur Hlíðberg (tilapia)

OEHHA ADVISORY TISSUE LEVELS

The OEHHA Advisory Tissue Levels (ATLs) 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 in order 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.

http://www.oehha.ca.gov/fish/so_cal/index.html

TABLE 18. OEHHA Advisory Tissue Levels (ATLs) *(parts per billion)* (OEHHA, 2008).

CONTAMINANT	THREE 8-OUNCE SERVINGS* A WEEK	TWO 8-OUNCE SERVINGS* A WEEK	ONE 8-OUNCE SERVINGS* A WEEK	NO CONSUMPTION
DDTs[1]**	≤520	>520-1,000	>1,000-2,100	>2,100
Methylmercury (Women aged 18-45 years and children aged 1-17 years)[1]	≤70	>70-150	>150-440	>440
Methylmercury (Women over 45 years and men)[1]	≤220	>220-440	>440-1,310	>1,310
PCBs[1]	≤21	>21-42	>42-120	>120
Selenium[2]	≤2500	>2500-4,900	>4,900-15,000	>15,000

[1]ATLs are based on non-cancer risk

[2]ATLs are based on cancer risk

*Serving sizes are based on an average 160-pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts (for example, individuals weighing 80 pounds should eat one 4-ounce serving a week when the table recommends eating 8-ounces).

**ATLS for DDTs are based on non-cancer risk for two and three servings per week and cancer risk for one serving per week.

FIGURE 28. Maximum mercury level in fish tissues by lake and species for lakes monitored from 2013-2017. Vertical lines represent thresholds for consumption frequency.

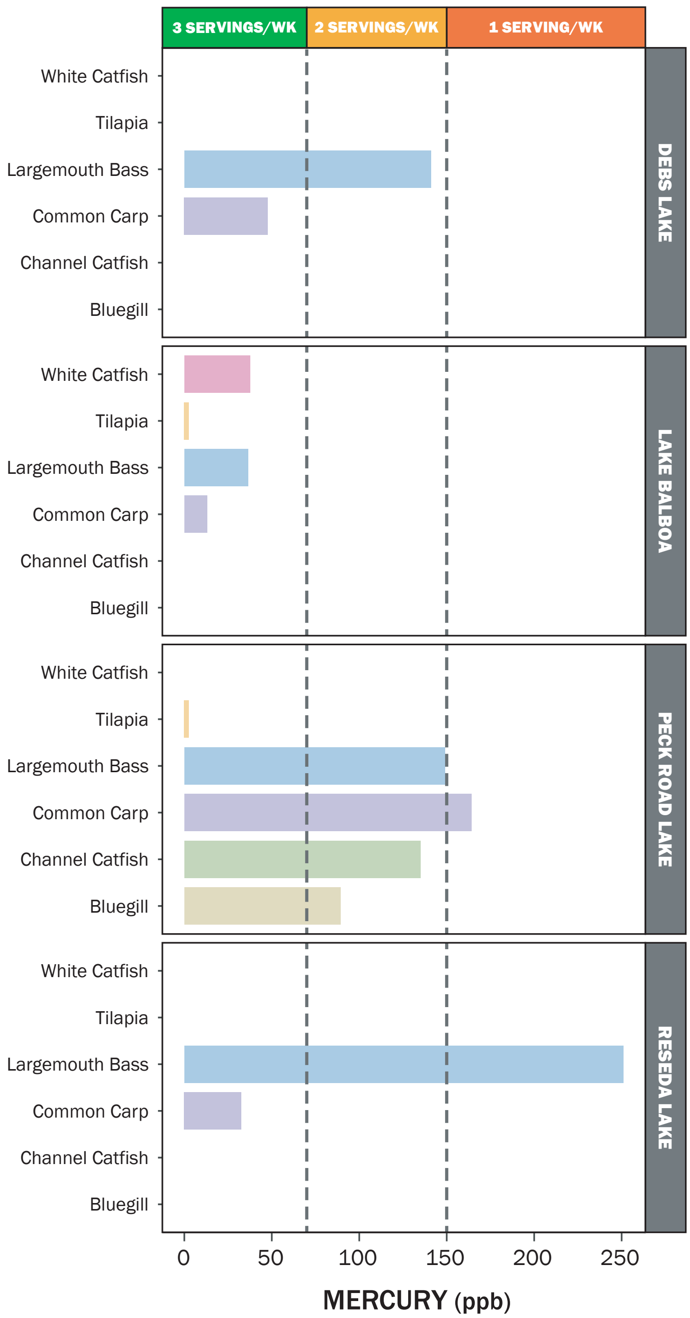
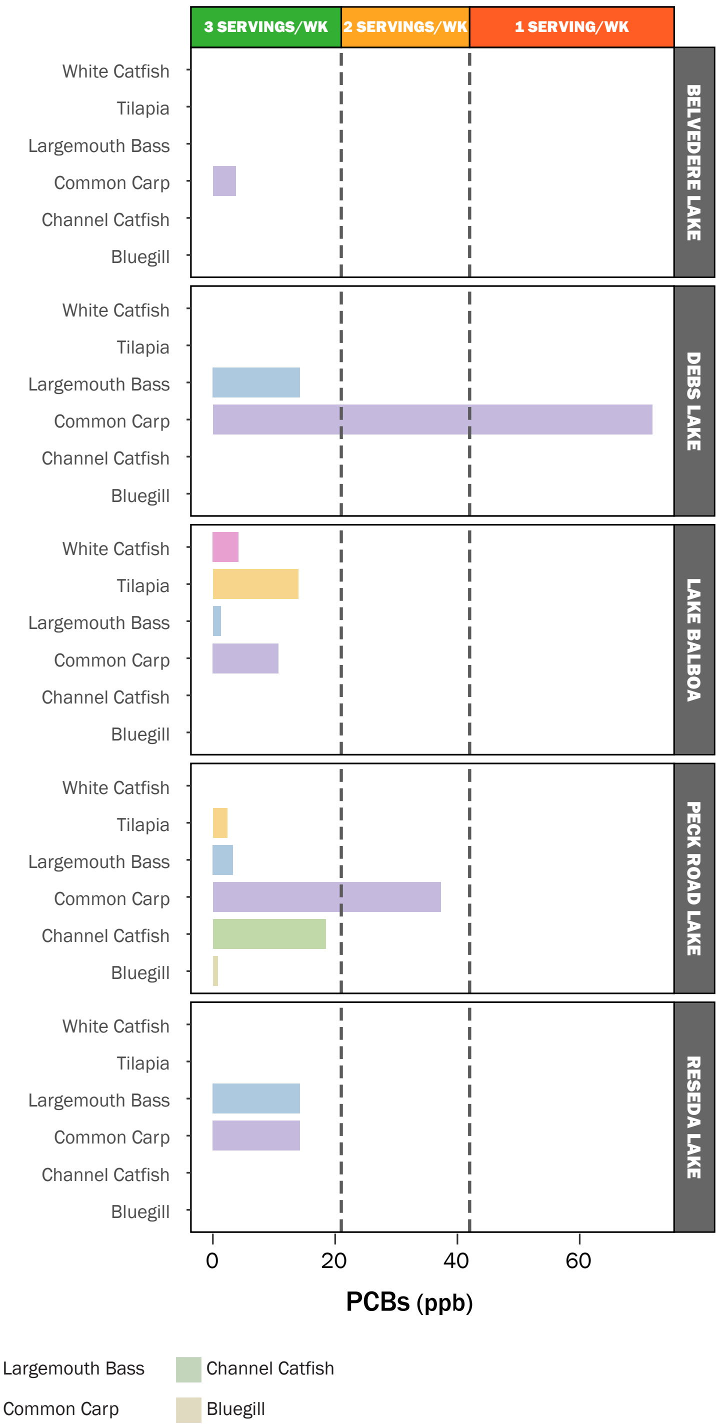


FIGURE 29. Maximum PCB level in fish tissue by lake and fish species sampled from 2013-2017. Vertical lines represent thresholds for consumption frequency.



LOS ANGELES RIVER FISHING

Fishermen are a frequent sight along the banks of the Los Angeles River, where they use canned corn, tortillas, and commercial bait to catch fish, mostly carp. Even the occasional fly fisherman can be seen casting along the river.

Historically, the Los Angeles River supported a seasonal recreational fishery, with an annual winter run of steelhead trout. Following its channelization, the trout disappeared, replaced by carp, tilapia, and other non-native species.

Fishing is now allowed in the river along the recreational zone, located in the Glendale Narrows and Sepulveda Basin. Along the other sections of the river, it is not an officially-sanctioned activity, and it is currently illegal to walk in the river channel below the bike paths.

Photo (left): Fly fishing on the Los Angeles River near Atwater Village.
(Courtesy of William Preston Bowling)

MERCURY'S RISK TO WILDLIFE IN CALIFORNIA

Fish tissue monitoring efforts across the state have been focused on the human health impacts due to the consumption of sportfish from impaired bodies of water. However, wildlife is also exposed to high mercury concentrations from the fish in their diet and the impacts are of particular concern for rare, threatened, and endangered species. SWAMP began to monitor prey fish and birds, along with continued sportfish monitoring, to build predictive tools (Ackerman et al., 2015) and to determine a biomagnification factor to estimate wildlife risks.

In 2016, LARWMP monitored prey fish species in the watershed. In the two lakes that were monitored prey fish mercury concentrations were high, or above wildlife habitat thresholds, at Peck Road Lake.

PREY FISH

Year	Common Name	Comp #	Mercury (ppb)	Selenium (ppb)	DDTs (ppb)	PCBs (ppb)
2016: *Peck Road Park Lake*	bluegill	1	76	360	ND	20
	largemouth bass	1	59	320	ND	9
2017: *Lake Balboa*	convict fish	1	8	360	286	4.06
	inland silverside	1	13	380	211	7.12
	largemouth bass	1	4	290	93	1.34
	largemouth bass	2	4	320	130	4.21
	largemouth bass	3	4	320	139.6	2.12

Wildlife Habitat Methylmercury Threshold: 50 PPB wet weight for fish 50-150mm (Palumbo and Iverson, 2017) have higher contaminant levels. No species or location had fish contaminant levels that were close to the “No Consumption” advisory for the lakes sampled from 2013-2017 (this was not true for water bodies monitored from 2008-2012, please refer to Morris *et al.*, 2013). In all instances when tilapia was monitored, the concentrations of mercury and PCBs were below detection. This species is generally safe to eat.

Only two fish species exceeded the OEHHA consumption thresholds limiting recommended consumption to one 8-ounce serving a week (OEHHA 2008, note this ATL is for women of childbearing age or children) during the five-year period. This included common carp at Peck Road Lake and largemouth bass at Reseda Lake, both for mercury, and common carp at Debs Lake for PCBs. Selenium and DDTs did not exceed consumption thresholds in any fish species monitored by the LARWMP.

Species that are more commonly consumed such as bluegill and catfish were only found at a subset of sites and were within the two 8-ounce serving/week consumption thresholds.

6.3 SUMMARY AND NEXT STEPS

In general, fish from lakes in the Los Angeles River Watershed are safe to eat in moderate amounts; the recommended serving size will vary depending on lake and fish species. Of all the species sampled, tilapia is generally the safest to eat. Fish sampled from 2013-2017 have mercury and DDT concentrations that are lower than the national average (EPA, 2013). Compared to fish from other parts of California, fish in the watershed have lower concentrations of mercury and PCBs and comparable concentrations of selenium and DDT (Davis, *et al.*, 2010). Mercury concentrations in largemouth bass collected from streams nationwide (Scudder, *et al.*, 2009), for example, far exceeded those of bass measured in the Los Angeles River Watershed.

To improve our understanding of the safe to eat program, we recommend:

- An updated survey of anglers throughout the watershed. These detailed angler surveys will provide valuable information to watershed managers on which species of fish are commonly caught and eaten, which locations are anglers frequenting, the frequency and quantity of consumption, and who is eating the fish. Since the contaminant level varies based on preparation and the specific tissues that are consumed, we recommend the survey incorporate questions to determine whether advisory levels for cooked fish fillet are appropriate.
- Resampling of sites in the River, specifically in the recently formalized recreational zone, to determine how contaminant levels have changed.
- Improved education and outreach to the angling community through ranger programs and community science efforts.

6.3 REFERENCES

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