Bioassessment Survey of the Stormwater Monitoring Coalition

Workplan for Years 2021 through 2025
Version 1.0

Raphael D. Mazor

Southern California Coastal Water Research Project

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INTRODUCTION

Southern California's coastal watersheds contain important aquatic resources that support a variety of ecological functions and environmental values, but results of the Stormwater Monitoring Coalition's (SMC's) five-year survey ending in 2013 suggest that less than half of southern California's perennial, wadeable streams are in good biological condition—mostly in headwaters and undeveloped portions of the region (Mazor 2015). A second five-year cycle, beginning in 2015, showed that conditions were largely stable, with only a small number of streams showing improving or degrading trends. For its third cycle, the SMC will expand on assessments of status and trends, while including modifications to address knowledge gaps, such as how development affects the ecological potential of streams.

Comprising over 7,000 stream-kilometers, southern California's coastal watersheds are crucial for both humans and wildlife's habitat, drinking water, agriculture, and industrial uses. In order to assess the health of streams in these watersheds, the Stormwater Monitoring Coalition (SMC), a coalition of multiple state, federal, and local agencies, began monitoring stream condition in 2009 using multiple indicators of ecological health. This survey documented the condition of presumed perennial wadeable streams in the region and set a baseline for monitoring regional trends. In 2015, a new five-year program built on the initial survey to focus on trend detection. In 2021, a third five-year survey will go further, expanding coverage in under-sampled areas, conducting causal assessments at sites in poor condition, and getting a better understanding of the extent of perennial, intermittent, and ephemeral streams in the region.

The SMC stream survey is a collaborative effort of leading stormwater and regulatory agencies in southern California. Through a re-allocation of permit-required monitoring efforts, this survey is intended to provide valuable data about the condition of Southern California coastal streams in a cost-effective way. Additionally, the SMC's stream survey serves as the southern California component of the statewide stream condition survey (i.e., the Perennial Stream Assessment, PSA).

The goal of this document is to guide implementation of a collaborative large-scale, regional monitoring program of southern California's coastal streams. It describes sample draw parameters, analytes that will be assessed, quality assurance requirements, standard protocols, and other information needed to ensure comparability across different programs. While the details concerning implementation (such as specific labs and contractors) will vary among participants, each agency can use this document to create consistent sampling programs within their regions that will contribute to an assessment of the entire region.

The SMC is a coalition of multiple state, federal, and local agencies that works collaboratively to improve the management of stormwater in southern California. SMC members include regulatory agencies, flood control districts, and research agencies: County of Los Angeles Department of Public Works, County of Orange Public Works, County of San Diego Department of Public Works, Riverside County Flood Control and Water Conservation District, San Bernardino County Flood Control District, Ventura County Watershed Protection District, City of Long Beach Public Works Department, City of Los Angeles Department of Public Works, California Regional Water Quality Control Board—Santa Ana Region, Los Angeles Region, and San Diego Region, State Water Resources Control Boards, California Department of Transportation, and the Southern California Coastal Water Research Project (SCCWRP). In addition, the SMC collaborates with the U.S. Environmental Protection Agency Office of Research and Development. For more information, visit the SMC webpage at http://socalsmc.org/.

KEY MONITORING QUESTIONS AND APPROACH

The Southern California Stream Survey was originally designed to generate data to answer three key management questions.

1. What is the condition of streams in Southern California?
2. What stressors are associated with poor condition?
3. Are conditions changing over time?

The survey will continue to provide data to address these questions but will be modified to address new questions as part of special studies:

1. What are conditions at under-sampled areas of interest, such as restored sites, soft-bottom channels, small urban streams, and headwaters?
2. What are likely causes of poor conditions at selected low-scoring sites?
3. Where do streams support flows sufficient for assessing conditions with benthic macroinvertebrates?

Each of these questions will be addressed through new special studies included within the survey.

KEY PARTNERS

Several SMC member and non-member agencies or programs directly contribute to the SMC stream survey (Table 1). Contribution levels of stormwater agencies are determined by monitoring requirements in their permits, whereas the contributions of regulatory agencies are based on discretionary funding or funding from the Surface Water Ambient Monitoring Program. Contributions from permittees may change if their permit requirements are modified over the course of the survey.

Table 1. Agencies contributing to the SMC stream survey.

Agency	Expected contribution over 5 years (# sampling events)
Stormwater agencies	
Ventura County Watershed Protection District	75
Los Angeles County Flood Control District	35
Los Angeles River Watershed Monitoring Program	30
San Gabriel River Regional Monitoring Program	30
Orange County Public Works	40
Riverside County Flood Control and Water Conservation District	30
San Diego county Co-Permittees (combined)	80
Regulatory agencies	
Regional Water Quality Control Board – Los Angeles	60
Regional Water Quality Control Board – Santa Ana	65
Regional Water Quality Control Board – San Diego	30
Surface Water Ambient Monitoring Program	Direct support for algal taxonomic analysis and quality assurance
Total	**475**

SURVEY ELEMENTS

There are five major elements to this cycle of the SMC stream survey:

1. Condition estimates of stream condition, made at one-time visits to probabilistic sites
2. Trend estimates, made at revisits to a set of previously sampled probabilistic sites
3. Estimates at under-sampled areas of interest, made at sites located in areas that have little data about stream condition
4. Causal assessments at sites in poor condition
5. Wet-dry mapping in catchments with poorly characterized hydrologic regimes

Each element is described below.

Committed and uncommitted elements

This workplan describes the elements of a regional stream survey that SMC members have identified as priority needs. However, these priorities outstrip available resources, and in some cases go beyond permit requirements of some participants. Therefore, the SMC commits to collecting data for some of these elements, identified as **committed elements** below. In contrast, **uncommitted elements** may be implemented if additional resources become available, or non-SMC partners wish to contribute to the program.

Each SMC participant commits to one or more survey elements, based on agency priorities and permit requirements. Because these priorities and requirements may change, the SMC will re-evaluate these commitments on an annual basis. Table 2 summarizes the expected contribution each program element. Participants may alter their allocations on an annual basis (e.g., shifting sites from one study to another, or one watershed to another), with the approval of the SMC technical workgroup.

Table 2. Expected number of samples contributed to each survey elements by participant and watershed over 5 years. Targ: Target under-sampled areas or stream types. Causal: Causal assessment. Wet-Dry: Wet-dry mapping. Watershed abbreviations are presented in Table 3. LARWMP: Los Angeles River Watershed Monitoring Program. SGRRMP: San Gabriel River Regional Monitoring Program. RB4: Regional Water Quality Control Board – Los Angeles. RB8: Regional Water Quality Control Board – Santa Ana. RB9: Regional Water Quality Control Board – San Diego.

Participant	Watershed	Survey element					Participant total
		Cond.	Trend	Causal	Targ	Wet-Dry	
Ventura	VEN	7	12	18	0	0	75
	SCL	5	9	0	0	0	
	CAL	7	13	0	0	0	
	SMB	0	4	0	0	0	
Los Angeles	SCL	5	9	0	0	0	35
	SMB	4	9	0	0	0	
	LAR	0	0	8	0	0	

Participant	Watershed	Survey element Cond.	Trend	Causal	Targ	Wet-Dry	Participant total
LARWMP[1]	LAR	8	15	7	0	0	30*
SGRRMP[1]	SGR	8	15	7	0	0	30*
Orange	LSA	8	9	0	5	0	40
	SJU	7	6	0	0	5	
Riverside	MSA	2[2]	4	1	2	1	30
	USA	2[2]	0	0	0	0	
	SJC	2[2]	5	0	0	0	
	NSD	2	5	1	1	2	
San Diego	NSD	5	10	3	2	0	80
	CSD	5	10	3	2	0	
	MBSD	5	10	3	2	0	
	SSD	5	10	3	2	0	
RB4	VEN	4	8	2	1	0	60
	SCL	4	11	0	1	1	
	CAL	4	8	0	1	0	
	SMB	4	6	0	1	0	
	LAR	0	0	2	1	0	
	SGR	0	0	1	0	0	
RB8	LSA	0	5	0	0	0	65
	MSA	9[2]	6	20	0	0	
	USA	9[2]	11	0	0	0	
	SJC	0	5	0	0	0	
RB9	SJU	0	0	0	5	0	30
	NSD	0	0	0	9	0	
	CSD	0	0	0	4	0	
	MBSD	0	0	0	8	0	
	SSD	0	0	0	4	0	

[1] The LARWMP and SGRRMP programs typically collect data from additional sites that are not formally part of the SMC survey. These contributions usually amount to an additional 20 sampling events per program over 5 years. These programs are supported by SMC members (e.g., Orange County Public Works, Los Angeles County Flood Control District), and non-SMC dischargers (e.g., Los Angeles County Sanitation District). 2 Sample draws for these groups do not stratify by watershed within the Santa Ana region. Therefore, the numbers in this table are an approximation of the expected distribution of samples.

Condition estimates

Condition estimates are made by collecting bioassessment samples at probabilistically selected sites from a sample frame representing streams in the region.

Sampling frame

The sampling frame is the stream network represented by the National Hydrography Dataset (NHD Plus) within the three Southern Californian regional boards, as modified for use by the Perennial Stream Assessment. Streams on the Channel Islands, on Camp Pendleton, and on Miramar military lands excluded because of limited access.

The sampling frame was divided into strata based on agency jurisdictions, as well as other units of interest. Watersheds and land use classifications follow the designations used by the Perennial Stream Assessment.

Sample Draw

For the 2021-2025 cycle, the SMC will continue to use the sample draw it created for the previous survey (Mazor 2015). For the condition estimate, sites are selected from the sample frame using a spatially balanced design (Stevens and Olsen 2004). Each agency will have its own sample draw, and most agencies will have multiple strata, each with their own list of sites to evaluate. Every stratum will also have an extensive oversample to allow replacement of unsampleable sites. These sample draws will implement multi-density intensifications for certain stream types; specifically, higher order streams and agricultural streams will be weighted to improve representation of these scarce and/or frequently rejected stream types. These sampling strata are shown in the map below (Figure 1, Table 3). The final distribution of sites will depend on the sampling success rate, but is expected to range from 5 to 12 per watershed over the course of 5 years. In previous efforts, the SMC survey sought to collect data from 30 sites in each watershed over 5 years; this survey reflects a reduction in a commitment to that effort in order to direct resources towards other survey elements. Thus, a number of condition sites in each watershed are **uncommitted** elements.

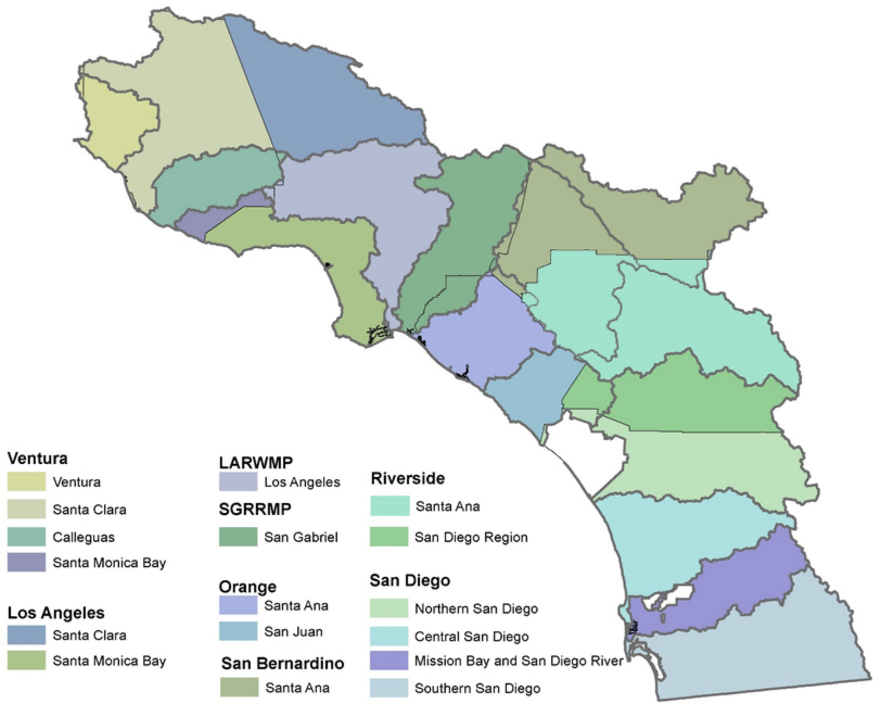

Figure 1. Sampling strata for participating SMC agencies. White spaces correspond to military land excluded from condition estimates of the survey.

Table 3. Watersheds of the SMC survey.

Watershed			Counties
Los Angeles Region			
	VEN	Ventura River	Ventura County
	SCL	Santa Clara River	Ventura and Los Angeles Counties
	CAL	Calleguas Creek	Ventura County
	SMB	Santa Monica Bay	Ventura and Los Angeles Counties
	LAR	Los Angeles River	Los Angeles County
	SGR	San Gabriel River	Los Angeles and Orange Counties
Santa Ana			
	LSA	Lower Santa Ana	Orange and Riverside Counties
	MSA	Middle Santa Ana	Riverside and San Bernardino Counties
	USA	Upper Santa Ana	Riverside and San Bernardino Counties
	SJC	San Jacinto River	Riverside County
San Diego			
	SJU	San Juan Creek	Orange, Riverside and San Diego Counties
	NSD	Northern San Diego	Riverside and San Diego Counties
	CSD	Central San Diego	San Diego County
	MBSD	Mission Bay and San Diego River	San Diego County
	SSD	Southern San Diego	San Diego County

The condition site sample draw is included in Appendix A.

Selecting sites from the sample draw

The sample draws are sorted into draws for each agency, subdivided into watersheds. Participants shall evaluate each site in numerical order, from smallest to largest, evaluating sites for the following factors:

- Stream status: Is the target location on or near a stream channel? Exclude tidal creeks, reservoirs, pipelines, and other non-stream habitats. Agricultural canals and conveyances that exhibit signs of bidirectional flow may be excluded as non-streams.
- Flow status: Is the stream perennial or intermittent? Is it sufficient to conduct sampling?
- Wadeability status: Is the stream wadeable?
- Physical access status: Can the reach be safely accessed by a field crew?
- Landowner permission status: Has the landowner granted permission for access?

Results of these evaluations are submitted on an annual basis at the end of the sampling season. Participants go down the list of sites as far as needed to obtain the intended number of condition sites. The following year, participants continue at the same point on the list they stopped at the previous year.

The intended number of condition sites in each watershed is provided to each participant along with the sample draw. These numbers reflect five-year total numbers of intended condition sites; participants are advised to sample a consistent number of condition sites in each year.

Fully hardened channels

There are no categorical exemptions for fully hardened (concrete) channels from condition assessments. However, once a participant has sampled **one** condition site in a concrete channel in a watershed, subsequent condition sites in the sample draw falling in concrete channels in that watershed may be skipped; site evaluation data (e.g., indications of whether a site is wadeable, flowing, accessible, etc.) for these "skipped" sites is still required. These will be treated as "target not sampled" sites in ambient assessments.

Sampling period

Condition sites (and all sites with bioassessment sampling) shall be sampled within the appropriate index period for southern California, in accordance with the SWAMP bioassessment protocol (Ode et al. 2016). In a year with typical precipitation, sampling should take place between April 15 and July 15. The sampling period may be delayed and extended in wet years with late rainfall, or moved earlier in dry years. Ideally, samples are collected at least 4 weeks after the most recent storm event that elevates flows sufficient to cause streambed scour. Samples should not be collected from reaches where flows are insufficient to follow the standard SOP (e.g., reaches that are partially dry, or entirely stagnant).

Participants will determine whether they wish to sample all condition sites in a single year, or to distribute them across the 5 years of the survey.

Analytes measured at condition sites

Sampled parameters are described in this section. Details about methods, protocols, and quality assurance are provided in the appendix. At the Executive Committee's discretion, this list of recommended parameters may be modified if they believe it is appropriate. Except where indicated, all SMC participants are expected to sample all parameters. Table 4 summarizes commitments to sample analytes at condition sites. Table 5 and Table 6 summarize sample handling guidelines and relevant reporting limits. Unless otherwise indicated, the SMC commits to measuring these analytes at all condition sites.

Table 4. Analytes and commitments to collect or analyze samples at condition sites.

Analyte		Requirement at condition sites
Biological indicators		
	Benthic macroinvertebrate taxonomy	Collect and analyze samples at every site-visit
	Diatom taxonomy	Collect and analyze samples at every site-visit
	Soft-bodied algae taxonomy	Collect samples and archive at SCCWRP
	Benthic algae samples for molecular analysis	Collect samples and archive at SCCWRP
	Vertebrate observations	Record data at every site-visit
	eDNA water samples	Uncommitted
Habitat		
	Full Physical Habitat protocol	Conduct protocol at every site-visit
	Hydromodification screening protocol	Conduct protocol at every site-visit
	California Rapid Assessment Method	Conduct protocol at every site-visit
	Channel engineering	Conduct protocol at every site-visit
	Hydrologic state	Conduct protocol at every site-visit
	Water presence loggers	Uncommitted
Sediment chemistry		
	Grain size	Uncommitted
	Total organic content	Uncommitted
	Pyrethroid pesticides	Uncommitted
	Cyanotoxins	Uncommitted
	Nutrients	Uncommitted
	Other constituents of emerging concern (CECs)	Uncommitted
Water chemistry		
	Conventional analytes and major ions	Collect and analyze samples at every site-visit
	Total suspended solids	Collect and analyze samples at every site-visit
	Nutrients	Collect and analyze samples at every site-visit
	Cyanotoxins	Uncommitted
Benthic algae biomass		
	Chlorophyll-a	Collect and analyze samples at every site-visit
	Ash-free dry mass	Collect and analyze samples at every site-visit
	Cyanotoxins	Uncommitted
Geospatial information		
	Watershed delineations, points	Generate for every site

Biological indicators

Benthic macroinvertebrates shall be sampled using standard SWAMP protocols (i.e., Ode et al. 2016). The reach-wide method shall be used in all cases; in low-gradient (< ~1% slope), sandy streams the margin-center-margin modification may be used at the discretion of the field crew. Replicate samples are collected at 10% of sites. Data shall be submitted using standard SMC taxonomic data formats. All samples shall be identified to SAFIT Level 2, with a target count of 600 organisms.

Benthic diatoms and soft algae shall be sampled using standard SWAMP protocols (i.e., Ode et al. 2016). Qualitative samples are not required. Replicate samples are collected at 10% of sites. Data shall be submitted using standard SWAMP taxonomic data formats. Diatom samples shall be subject to taxonomic analysis and identified to the level specified in the diatom standardized taxonomic effort (Theroux et al. 2019). Samples for soft-bodied algal taxonomic analysis and for molecular analysis shall be collected and archived at SCCWRP; there is **no commitment** to lab analyses of these samples.

Benthic algae biomass (both ash-free dry mass and chlorophyll a) shall be sampled using standard SWAMP protocols (Ode et al. 2016). Replicates shall be collected at 10% of sites; field blanks are also recommended. These data shall be submitted (in units of mass per area) using standard SMC chemistry data formats.

Molecular analysis of benthic algal biofilm. An aliquot of the composite algae sample may be saved for molecular analysis. Samples will undergo DNA extraction and will be analyzed with a DNA metabarcode sequencing approach that targets up to three DNA barcode regions (e.g., 16S, 18S, and rbcL). These three barcode regions allow for the identification of both prokaryotes and eukaryotes, including cyanobacteria, soft-bodied algae, diatoms, and metazoa. The raw DNA sequence data will be processed through bioinformatic workflows and compared against DNA reference libraries for taxonomic assignment. These data will be used to support the development of a molecular ASCI and other bioassessment tools. The SMC will **commit** to collect these samples and archive them at SCCWRP. There is **no commitment** to analyze these samples. Arrangements for archiving samples at SCCWRP may be made by contacting Jeff Brown (jeffb@sccwrp.org) or Susanna Theroux (susannat@sccwrp.org).

Molecular analysis of eDNA samples. Water column environmental DNA (eDNA) samples may be collected at any sites for future DNA metabarcode sequencing or quantitative PCR (qPCR) analysis of target taxa including invasive, endangered, or rare species. Water samples should be collected following the California Molecular Methods Workgroup water eDNA protocol (LINK). Samples will undergo DNA extraction and will be analyzed with either a DNA metabarcode sequencing approach (similar to the analysis of benthic algal biofilms, described above), or a targeted analysis such as quantitative PCR (qPCR) using species-specific probes (e.g., for native fish and amphibians, or invasive species). These data will be used to assess distributions of species of interest, to better understand the propagation of eDNA in the environment, and to explore the value of eDNA methods as a complement to traditional bioassessment sampling. There is **no commitment** to collect or analyze these samples. Participants may wish to collect these samples and archive them at SCCWRP by contacting Jeff Brown (jeffb@sccwrp.org) or Susanna Theroux (susannat@sccwrp.org).

Vertebrate observations are made opportunistically at every field visit where time allows. Vertebrates (invasive species in particular) observed during sampling or reconnaissance operations are reported using the SMC standard reporting form.

Habitat

Physical habitat (PHAB) shall be assessed using the standard SWAMP protocol (Ode et al. 2016). The "full" suite of PHAB parameters shall be measured at every sampling event. Data shall be submitted using the SWAMP PHAB Data entry tool.

CRAM assessments shall be conducted using standard CRAM protocols (Riverine Field Book version 6.1, www.cramwetlands.org). Replication is not required. Data shall be submitted to eCRAM.

Water presence loggers are not required at condition sites because they require more visits than is normally planned in the course of bioassessment sampling. Various types of loggers may be used to assess streamflow duration: pressure transducers, wildlife cameras, and stream temperature, intermittency and conductance (STIC) loggers, have all been effectively used to determine the presence or absence of surface flow. Costs range from < $100 (for STIC loggers) to $1,000 (for paired pressure transducers, used to assess water level). Loggers should not be deployed in unsuitable locations (e.g., high traffic areas, or areas prone to extreme scour during winter storms).

Trash monitoring shall be assessed using the standard trash submission guidance document. Data can be submitted using the trash submission template.

Hydromodification data are collected according to the hydromod submission guide, and reported using the hydromod data submission template.

Hydrologic state shall be collected opportunistically, on every field visit (recon and sample collection of other analytes), where practical, using the SMC standard reporting form.

Channel engineering shall be collected at every site visit where it has not been previously assessed. Data shall be reported using the SMC standard reporting form.

Water chemistry

Core *water chemistry* analytes include nutrients, major ions, solids, and conventional analytes. Nutrients include total N, total P, ammonia-N, nitrate-N, nitrite-N, and orthophosphate-P. Major ions and conventional analytes include total suspended solids, alkalinity as $CaCO_3$, hardness as $CaCO_3$, chloride, sulfate, sodium, calcium, magnesium, chemical oxygen demand, turbidity, specific conductance, dissolved oxygen, pH, and temperature. Specific analytes and recommended reporting limits for the parameters listed above are presented in the tables below.

Cyanotoxins

Samples may be collected for the analysis of cyanotoxins, which can be measured in water, benthic algae, and sediments. Priority cyanotoxins are microcystins, cylindrospermopsin, and anatoxin-a, which currently have recreational guidance thresholds in California. The collection of water samples, surface scums and algal mats should follow the protocols outlined in the

SWAMP HAB Field Guide for Sample Collection for Toxin Analysis. The collection of sediments should follow the sediment chemistry guidance below. Water and benthic algae (i.e., algal mats) samples can be analyzed with ELISA or LC-MS/MS, as long as target reporting levels are achieved (Table 5); sediment samples should be analyzed with LC-MS/MS.

Time-integrated concentrations of cyanotoxins can also be evaluated using *in situ* passive samplers. Solid phase adsorption toxin testing (SPATT) and organic diffusive gradients in thin films (o-DGT) samplers can be deployed for periods of 1-4 weeks to provide semi-quantitative, time-integrated estimations of microcystins, cylindrospermopsin, and/or anatoxin-a. Deployment and handling of SPATT samplers are outlined in Howard et al. 2018. Deployment and handling of o-DGT samplers are outlined in Du et al. (2020). Passive sampler extracts should be analyzed with LC-MS/MS.

There is **no commitment** to collecting or analyzing cyanotoxin samples at this time.

Sediment chemistry and toxicity

Sediments may be collected at sites where sufficient fine-grained sediment (i.e., silts and clays) are present. In general, labs require at least 750 mL of sediments for analysis; if only a small volume of sediment can be collected, analyses should prioritize chemistry over toxicity. Crews should collect sediment within the reach, but if necessary, may be collected up to 10 m up- or down-stream of the bioassessment reach. Each sample should be analyzed for grain size, total organic carbon, pyrethroid pesticides. If appropriate, sediment samples can also be analyzed for more CECs such as cyanotoxins, fipronil, and toxicity with *Hyallela azteca* (15°C or 23°C) or *Chironomus dilutus* (23°C). In addition, sediment samples can also be performed suspect screening and non-targeted analysis (NTA) for novel organic contaminants or causal chemicals to biological impacts. Bioavailable fraction (i.e., freely dissolved concentration) of CECs can be measured with *ex situ* passive sampling method in the laboratory. The extract of the *ex situ* passive samplers can be further used in suspect screening/NTA and cell assay tests. There is **no commitment** to collect or analyze sediment samples at this time.

Geospatial information

Participants shall generate shapefiles consisting of *watershed delineations* and sampling locations at every site where bioassessment samples are collected, following the steps in Boyle et al. 2020.

Table 5. Sample holding guidelines for major analytes. These guidelines are not intended to supersede laboratory recommendations. Max RL Maximum reporting limits.

Table 5a. Water and sediment chemistry analytes. Asterisks indicate analytes that may be measured in the field, as well as in the lab.

Analyte	Max RL	Container type	Holding time	Holding conditions
Water chemistry				
Conventional analytes and major ions				
Suspended solids	1 mg/L	Polyethylene	7 days	Cool to ≤ 6°C
Alkalinity as $CaCO^{3}$*	5 mg/L	Polyethylene	14 days	Cool to ≤ 6°C
Hardness as $CaCO^{3}$	5 mg/L	Polyethylene	6 months	Cool to ≤ 6°C; HNO_3 or H_2SO_4 to pH < 2
Chloride	1 mg/L	Polyethylene	28 days	Room temperature OK
Sulfate	1 mg/L	Polyethylene	28 days	Cool to ≤ 6°C
Magnesium	0.1 mg/L	Polyethylene	28 days	Room temperature OK
Sodium	10 mg/L	Polyethylene	28 days	Room temperature OK
Calcium	0.1 mg/L	Polyethylene	28 days	Room temperature OK
Chemical oxygen demand	10 mg/L	Glass	28 days	H_2SO_4 to pH ≤ 2, cool to 4°C
Turbidity*	1 NTU	Polyethylene	48 hours	Cool to ≤ 6°C
Specific conductance*	1 uS/cm	Polyethylene	48 hours	Room temperature OK
Dissolved oxygen	0.1 mg/L	NA	NA	Measured in field
Temperature	0.1 °C	NA	NA	Measured in field
pH*	0.1 units	Polyethylene	48 hours	Cool to ≤ 6°C
Nutrients				
Ammonia as N	0.1 mg/L	Polyethylene	48 hours; 28 days if acidified	Cool to ≤ 6°C; H_2SO_4 to pH < 2
Nitrogen, Total	0.2 mg/L	Polyethylene	28 days	Cool to ≤ 6°C; H_2SO_4 to pH < 2
Nitrate + Nitrite as N	0.1 mg/L	Polyethylene	48 hours; 28 days if acidified	Cool to ≤ 6°C; H_2SO_4 to pH < 2
Phosphorus as P	0.05 mg/L	Polyethylene	28 days	Cool to ≤ 6°C; H_2SO_4 to pH < 2
OrthoPhosphate as P	0.05 mg/L	Polyethylene	48 hours	Cool to ≤ 6°C
Nitrite as N	0.1 mg/L	Polyethylene	48 hours; 28 days if acidified	Cool to ≤ 6°C; H_2SO_4 to pH < 2

Analyte	Max RL	Container type	Holding time	Holding conditions
Nitrogen, Total Kjeldahl	0.1 mg/L	Polyethylene	7 days; 28 days if acidified	Cool to $\leq$ 6°C; H_2SO_4 to pH < 2
Benthic algae biomass				
Ash-free dry mass	1 g/m^2	Glass-fiber filter within petri dish, wrapped in aluminum foil	28 days	Freeze to -20°C
Chlorophyll-a	10 mg/m^2		28 days	Freeze to -20°C
Cyanotoxins				
In water				
Microcystins	0.1 µg/L	Amber glass or dark HDPE	48 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
Cylindrospermopsin	0.05 µg/L	Amber glass or dark HDPE	48 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
Anatoxin-a	0.1 µg/L	Amber glass or dark HDPE	48 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
In sediment				
Microcystins	0.1 ng/g	250-mL Chem 300-series amber glass jars with Teflon lid-liner; pre-cleaned	48 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
Cylindrospermopsin	0.05 ng/g	250-mL Chem 300-series amber glass jars with Teflon lid-liner; pre-cleaned	48 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
Anatoxin-a	0.1 ng/g	250-mL Chem 300-series amber glass jars with Teflon lid-liner; pre-cleaned	48 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
In benthic algae				
Microcystins	0.1 ng/g	Amber glass or dark HDPE	24 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
Cylindrospermopsin	0.05 ng/g	Amber glass or dark HDPE	24 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C
Anatoxin-a	0.1 ng/g	Amber glass or dark HDPE	24 hours at 4°C; 6 months of -20°C; long term if -80°C	Freeze to -20°C

Analyte	Max RL	Container type	Holding time	Holding conditions
In passive samplers				
Microcystins	0.1 µg/L	Dry in ziplock bag or whirlpak	48 hours at 4°C; long term if <-20°C	Freeze to -20°C
Cylindrospermopsin	0.05 µg/L	Dry in ziplock bag or whirlpak	48 hours at 4°C; long term if <-20°C	Freeze to -20°C
Anatoxin-a	0.1 µg/L	Dry in ziplock bag or whirlpak	48 hours at 4°C; long term if <-20°C	Freeze to -20°C
Sediment chemistry				
Total organic content (TOC)	See Table 6	250-mL glass jar	28 days at 4°C or 12 months at -20°C	Cool to 4°C or freeze to -20°C; dark
Grain size		250-mL glass jar (may be same as for TOC)	28 days at 4°C	Cool to 4°C; dark. Do not freeze.
Organics (e.g., CECs)		Two 250-mL Chem 300-series amber glass jars with Teflon lid-liner; pre-cleaned	14 days at 4°C or 12 months at -20°C	Cool to 4°C, or freeze to -20°C; dark

Table 5b. Field measurements

Parameter	Resolution	Calibration or check frequency
Dissolved oxygen	0.01 mg/L	Daily, or change in 500 m elevation
pH	0.01 pH units	2-point calibration, per manufacturer
Specific conductance	1 uS/cm	Per manufacturer
Temperature	0.1°C	Per manufacturer
Turbidity	0.1 NTU	2-point calibration, per manufacturer
Velocity (flow meter)	0.1 ft/s	Per manufacturer

Table 6. Analyte methods and reporting limits for sediment analysis

Analyte	Method	Modification for methods?	Reporting Level
TOC	EPA 9060am	Yes – Uses TCD	NA
Grain size	Plumb, 1981 or SM 2560 D	None	1%
% Solids	EPA 1684		
Pyrethroids	EPA 3540C followed by EPA 8270D by NCI-GCMS	Yes – Uses NCI and calibration checks differ	
Bifenthrin			0.25 ng/g
Cyfluthrin, total			1.25 ng/g
Cypermethrin, total			1.25 ng/g
Deltamethrin/ Tralomethrin			1.00 ng/g
Esfenvalerate/ Fenvalerate, total			0.50 ng/g
Fenpropathrin			0.25 ng/g
Permethrin, cis-			1.25 ng/g
Permethrin, trans-			2.5 ng/g
Cyhalothrin, lambda, total			0.50 ng/g
Fipronil			0.50 ng/g
CECs (screening)	Low- or High-Mass Resolution Mass Spectrometry		Varies
Toxicity			
Hyalella azteca (23°C)	US EPA (2000) 600/R-99/064		
Hyalella azteca (15°C)	US EPA (2000) 600/R-99/064	Yes, temperature	
Chironomus (23°C)	Granite Canyon-MPSL *Chironomus dilutus* sediment test SOP 2.1		

Trend sites

Trend sites are a subset of probabilistic sites that are revisited several times to determine if conditions are improving, degrading or stable. A probabilistic site must be visited over 3 separate years to be considered a trend site. For the SMC survey purposes, sites selected from targeted (rather than probabilistic) designs are not used for regional trend estimates.

The SMC survey will use a "panel" approach to sampling trend sites:

- Panel One: These probabilistic sites were visited three or more times as of 2020. A number of these sites (specified in Table 7) will be visited once over the 5 years of the present cycle (generally, in 2025). Sites that were determined to be in stable condition may be excluded from Panel One, if agreed to by the SMC workgroup as a whole.
- Panel Two: These probabilistic sites have been visited no more than twice as of 2020. Over the next 5-year cycle, a number of these sites (specified in Table 7) will be visited up to 4 more times (generally in 2021 to 2024).

For each sampling agency, a list of potential trend sites will be generated for each panel. Each list shall be evaluated in numeric order, which will preserve the spatial balance of the original sample draws.

For the trend estimates, the goal of having 30 sites sampled a minimum of 3 times in each watershed requires more sampling effort than the SMC is able to commit to. Therefore, a large number of trend sites are **uncommitted**.

Selecting trend sites from the sample draw

The sample draws are sorted into draws for each agency, subdivided into lists called Panel 1 or Panel 2. Panel 1 sites are those that have been sampled in 3 or more years, and need only be sampled once more over the 5-year course of the survey. Panel 2 sites are those that have been sampled less frequently, and should be visited up to 4 more times to improve trend estimates.

Participants shall evaluate each list in order. In most years, they evaluate Panel 2 list, evaluating sites in order to identify the intended number of sampleable sites. In subsequent years, these sites should be revisited; if that site becomes unavailable and a replacement is needed, re-evaluate sites on the sample draw, beginning again at the top of the list.

In a year of the participant's choosing, they shall evaluate the Panel 1 list. In general, Panel 1 sites should be evaluated in the final year of the survey (i.e., 2025). If a list is depleted (that is, all sites are rejected) prior to achieving the intended number of samples, an alternative site may be identified by consulting Raphael Mazor (raphaelm@sccwrp.org).

The intended number of trend sites is provided to each participant along with the sample draw. These numbers reflect five-year total numbers of intended trend sites; participants are advised to sample a consistent number of trend sites in each year. The trend sampling effort is summarized in Table 7.

Fully hardened channels

There are no categorical exemptions for fully hardened (concrete) channels from trend assessments. Trend sites that were previously identified to be stable (hardened or otherwise) may be skipped at the participant's discretion if another trend site on the sample draw is available for sampling. Participants may also cease sampling a concrete channel in Panel 2 once a third sample has been obtained.

Table 7. Summary of trend sampling effort. Watershed abbreviations are explained in Table 3. LARWMP: Los Angeles River Watershed Monitoring Program. SGRRMP: San Gabriel River Regional Monitoring Program. RB4: Regional Water Quality Control Board – Los Angeles. RB8: Regional Water Quality Control Board – Santa Ana.

Participant	Panel	Watershed	Sites available	Targeted number of sites	Visits per site	5-year allocation (Number of samples)	Guidance
Los Angeles	1	SMB	4	1	1	1	Sample 1 site once
Los Angeles	1	SCL	1	1	1	1	Sample 1 site once
Los Angeles	2	SMB	11	2	4	8	Sample 2 sites 4 times each
Los Angeles	2	SCL	10	2	4	8	Sample 2 sites 4 times each
Ventura	1	CAL	3	1	1	1	Sample 1 site once
Ventura	2	CAL	8	3	4	12	Sample 3 sites 4 times each
Ventura	1	SCL	1	1	1	1	Sample 1 site once
Ventura	2	SCL	13	2	4	8	Sample 2 sites 4 times each
Ventura	2	SMB	5	1	4	4	Sample 1 sites 4 times each
Ventura	2	VEN	9	3	4	12	Sample 3 sites 4 times each
LARWMP	1	LAR	8	3	1	3	Sample 3 sites once each
LARWMP	2	LAR	24	3	4	12	Sample 3 sites 4 times each
SGRRMP	1	SGR	8	2	1	2	Sample 2 sites once each
SGRRMP	2	SGR	24	3	4	12	Sample 3 sites 4 times each
Orange	1	LSA	1	1	1	1	Sample 1 site once
Orange	2	LSA	31	2	4	8	Sample 2 sites 4 times each
Orange	1	SJU	2	2	1	2	Sample 2 sites once each
Orange	2	SJU	20	1	4	4	Sample 1 sites 4 times each
Riverside	1	MSA	1	1	1	1	Sample 1 site once
Riverside	2	MSA	11	1	3	3	Sample 1 sites 3 times each
Riverside	1	SJC	1	1	1	1	Sample 1 site once
Riverside	2	SJC	13	1	4	4	Sample 1 sites 4 times each
Riverside	1	NSD	1	1	1	1	Sample 1 site once
Riverside	2	NSD	5	1	4	4	Sample 1 sites 4 times each
San Diego	1	NSD	3	2	1	2	Sample 2 sites once each
San Diego	2	NSD	12	2	4	8	Sample 2 sites 4 times each
San Diego	1	CSD	3	2	1	2	Sample 2 sites once each
San Diego	2	CSD	17	2	4	8	Sample 2 sites 4 times each
San Diego	2	MBSD	11	2	5	10	Sample 2 sites 5 times each

San Diego	1	SSD	3	2	1	2	Sample 2 sites once each
San Diego	2	SSD	11	2	4	8	Sample 2 sites 4 times each
RB8	1	USA	2	2	1	2	Sample 2 sites once each
RB8	2	USA	11	2	5	10	Sample 2 sites 5 times each
RB8	1	MSA	1	1	1	1	Sample 1 site once
RB8	2	MSA	2	2	5	10	Sample 2 sites 5 times each
RB8	2	SJC	0	2	5	10	Sample 2 sites 5 times each
RB4	2	CAL	2	2	4	8	Sample 2 sites 4 times each
RB4	1	SCL	11	3	1	3	Sample 3 sites once each
RB4	2	SCL	10	2	4	8	Sample 2 sites 4 times each
RB4	1	SMB	2	2	1	2	Sample 2 sites once each
RB4	2	SMB	2	1	4	4	Sample 1 sites 4 times each
RB4	2	VEN	3	2	4	8	Sample 2 sites 4 times each

Sampling period

Trend sites have the same sampling period as condition sites.

Analytes

With the following exceptions and modifications, the analytes measured at sampling events at trend sites shall be the same as analytes measured at condition sites:

CRAM shall be measured at every trend site visit. It may be skipped if the trend site was visited in the previous year, and there have been no major changes in site conditions (e.g., no major channel-altering storms or wildfires in the watershed). Typically, CRAM is needed only once in fully hardened channels.

Hydromodification screening shall be measured at every trend site visit. It may be skipped if the trend site was visited in the previous year, and there have been no major changes in site conditions (e.g., no major channel-altering storms or wildfires in the watershed). Typically, hydromodification screening assessment is needed only once in fully hardened channels.

Channel engineering data typically does not change from year to year, and therefore need not be assessed at trend sites if previously collected data are available.

Water presence loggers are required at trend sites that meet the reference criteria described in Ode et al. (2016), as identified in the trend site sample draw. Loggers are not needed at “Panel 1” sites, because multiple visits aren’t anticipated at these sites. Sites that lack suitable locations for deployment or have alternative sources of hydrologic data (e.g., a nearby USGS gauge) do not need to have loggers deployed.

Geospatial information is generally not needed for trend sites, as this information should already be available at all condition sites.

SPECIAL STUDIES

Target under-sampled areas or stream types

Why is this a priority study?

Although the survey has covered extensive areas in the South Coast region through probabilistic sampling, some areas remain under-sampled. Some regions (such as high-elevation headwaters) are under-sampled due to difficult access and scarcity of intermittent or perennial streams. Other regions, such as Chollas Creek, are relatively small first-order streams that have high social importance, yet represent only a small portion of the South Coast, and thus rarely come up on probabilistic sample draws. Targeting under-sampled regions can improve coverage and extend our understanding of the conditions of streams in the region.

Collecting data in certain stream-types (rather than regions) may also have particular value to managers, and may be included in this study. Examples of these stream types include soft-bottom engineered channels, and channels that have been subject to restoration or other rehabilitation efforts (such as low-impact development or stormwater best management practices). The former will help identify ranges of bioassessment index scores associated with modified channels, and the latter may help identify potential for improvements.

Some sites of interest (e.g., reference sites) were sampled for a limited number of analytes under other programs (e.g., sites that were sampled for benthic invertebrates but not algae or water chemistry). Targeting them for sampling under the SMC Survey will result in a more complete data set. Other targeted sites have no data collection within the past 10 years. These sites may also be included in this study.

How sites are selected

SMC participants identified sites of interest through discussions with colleagues within their agencies, and by consulting studies that identify regions with well- or poorly characterized biological conditions (e.g., Mazor et al. 2020). Sites shown in Appendix C may or may not be accessible and sampleable, and field reconnaissance prior to the sampling season will be needed to determine whether these sites may be included in the study. Coordinates indicate approximate locations, with specific locations to be determined through field reconnaissance.

More than 100 regions or sites have been identified as under-sampled areas, and sampling them all requires more resources than the SMC is able to commit. Therefore, a large number of under-sampled regions or sites are **uncommitted** elements of the survey.

Frequency of sampling

In general, sites targeted for sampling under this study will be sampled once over the 5 years of the survey.

Sampling period

This study has the same sampling period as condition sites.

Analytes to be measured

Sites sampled under this special study will have the same as condition sites, described above (Table 4).

Tradeoffs

One site sampled under this study is equivalent to sampling one condition site.

Analysis

To the extent practical, targeted sites will be included in estimates of regional condition by using spatial statistical networks (e.g., Mazor et al. 2020).

Causal assessment

Why is this a priority study?

Previous SMC surveys have indicated that poor biological conditions are widespread, affecting the majority of stream-miles in most of the South Coast region. Causal assessments are a direct way to identify the stressors potentially causing poor conditions at specific sites so that managers can determine appropriate actions for improving conditions.

The goal of a causal assessment is not to characterize general stressors to biology (e.g., elevated conductivity can create a reduction in BMI diversity). The goal of the assessment is to identify the specific stressors that are likely impacting the resident biota of a specific waterbody (e.g., excessive amounts of fine sediment in a reach are linked to the low CSCI scores observed there).

To better inform the management of California's aquatic resources and to take advantage of the large amounts of high quality monitoring data, a three-tiered causal assessment framework – based upon the US EPA Causal Analysis Diagnosis Decision Information System (CADDIS, http://epa.gov/caddis) framework – has been developed and will be applied within the SMC program:

> **Rapid Screening Causal Assessment (RSCA)**: An evaluation configured to provide a rapid, overview assessment and summary of the stressors impacting a system using a standard set of potential stressors and analytical techniques to interpret the relationship between stressor exposure and biological response. Given its ease of use and relatively quick turnaround time, screening-level assessment can be applied at a large number of monitoring sites as soon as standardized monitoring data are collected and analyzed. This level of causal assessment could therefore be used to help managers prioritize remediation efforts within their region of responsibility. This tier produces an assessment of the causality for the most common stressors to a waterbody to better inform and streamline any more detailed follow-on analyses. The RSCA workflow is generically applicable to any site with poor CSCI scores, but can only derive certain types of evidence (e.g., spatial co-occurrence, or comparison to thresholds) for a limited number of stressors that are widely measured (e.g., nutrients, solids, or habitat degradation).
>
> **Detailed Causal Assessment**: A moderately intensive and site-specific assessment configured to provide an additional investigation of the "standard" stressors identified as

likely causes during a screening casual assessment, as well as stressors and environmental characteristics unique to a given location. This level of causal assessment is a stakeholder informed process that uses site-specific data and analyses, with the goal of providing greater confidence on the likelihood of a stressor as a cause and provide some insight into potential sources of that stressor. This tier produces a detailed, rigorous investigation of select stressors impacting a waterbody, providing insight into sources and potential management actions to improve waterbody conditions. Unlike RSCA, detailed causal assessment allows consideration of stressors that may not be widely measured (e.g., long-term hydrologic records), and can consider lines of evidence not included in the RSCA workflow (e.g., temporal co-occurrence).

Confirmatory Causal Assessment: An assessment configured to provide the stakeholder and management community with confidence that remediating a given stressor will have a good likelihood of improving the condition of the resident biota in specific system. This level of causal assessment is a very situation -dependent process. It involves experimental manipulations and modelling to demonstrate the effectiveness of potential management actions to improve biotic conditions at a location, as well as set expectations for improvement before large-scale implementation. This tier produces a demonstration of how specific stressors are impacting the biota of a specific waterbody and how their amelioration may be expected to improve conditions there.

Within this three-tiered framework, stream locations with degraded biological condition are referred to as test sites. The underpinnings of the causal assessment are a variety of comparative analyses that contrast biotic data, abiotic data, and combinations of the two from the test site and from other ecologically similar sites that are referred to as comparator sites.

As part of this special study, a combination of rapid screening and detailed causal assessments will be conducted at a series of test sites within the region where poor biotic conditions have been observed and managers wish to identify stressors causing those conditions. Confirmatory causal assessment is not proposed as part of the SMC survey. Each causal assessment will be led by participants sharing jurisdiction over the test site, providing data, local knowledge, or technical review throughout the survey.

How test sites are selected

Ideally, causal assessment will be performed at every site with low bioassessment index scores or other indicators of poor biological condition (e.g., fish kills, harmful algae blooms, etc.). For this survey, a small number of potential test sites have been prioritized by SMC participants based on their agency's priorities (Table 8). In general, test sites where the suspected causes are related to degraded water quality —as opposed to habitat alteration—will be selected. These sites were identified based on one or more of the following criteria:

- Low CSCI scores (e.g., less than 0.79, or less than predicted from landscape model of Beck et al. 2019a)
- Stresses are likely associated with water quality (vs. habitat) degradation. For example:
    - Identified as likely water quality stress in Stream Quality Index (Beck et al. 2019b)
    - IPI and CRAM scores indicate good habitat quality

    - Soft-bottom or natural channel structure in urban or agricultural settings
    - Landscape model predicts high scores (Beck et al. 2019a)
- Study outcomes are likely to inform management decisions affecting the site

Based on these criteria, the SMC technical workgroup has identified 14 test sites as high priority for causal assessment. However, the SMC is only able to allocate resources for 5 test sites (to be determined by the SMC bioassessment workgroup). Therefore, the remaining test sites are **uncommitted** elements of the survey. Conducting causal assessments at biologically degraded sites not listed in Table 8 are also considered **uncommitted** elements.

Table 8. Potential causal assessment test sites. See Table 3 for watershed abbreviations.

County	Watershed	Site(s)	Reach or site name	Latitude	Longitude	Mean CSCI score
San Diego	SSD	911M24913	Campo Creek	32.590	-116.515	0.72
San Diego	CSD	SMC00710	Carrol Canyon	32.889	-117.200	0.66
San Diego	SSD	910OTJMC4	Jamul Creek	32.637	-116.884	0.55
Los Angeles	LAR	SMC01096, SMC01320	Big Tujunga	34.285	-118.293	0.60 - 0.67
Los Angeles	SGR	SMC00428	Shortcut Canyon	34.247	-118.049	0.70 - 0.79
Los Angeles	SGR	SMC00144	Graveyard Canyon	34.245	-17.795	0.82
Los Angeles	SGR	405CE00280, SMC00480, SMC04000, SGUT502	Cattle Canyon	34.232	-117.748	0.51 - 0.91
Los Angeles	SGR	SMC00544	Marshall Canyon	34.146	-117.741	0.96-1.09 (protective)
Ventura	VEN	402M00015, SMC04047, 402M00100, 402BA0031	Ventura River near Meiners Oaks	34.475	-119.292	0.64 - 0.75
Ventura	CAL	408M03119, SMC02884	Conejo Creek	34.228	-118.972	0.37 – 0.58
Ventura	SCL	403CE0156	Santa Paula Creek	34.377	-119.060	0.62
Ventura	SCL	403S01784	Santa Clara River	34.402	-118.747	0.72
Ventura	CAL	ME-CC	Calleguas Creek Mass Emissions	34.179	-119.040	0.56
Riverside	MSA	801M16861	Goldenstar Creek	33.897	-117.361	0.64

Approach

The SMC will combine elements of rapid screening causal assessment followed by detailed causal assessments to provide a cost effective, thorough analysis of selected test sites over the 5-year course of the survey. The rapid screening analyses will be used to provide an initial, baseline assessment for the test site, provide a prioritized list of stressors to be investigated in the follow-up detailed assessments, and provide summaries of biotic and abiotic data collected over the ensuing 5 years. The detailed analyses will provide supporting evidence for the screening results by incorporating temporal patterns in stressors/responses, as well as by considering site-specific stressors excluded from rapid causal assessment workflows (e.g., long-term flow data).

By the nature of these assessments, where one set of analyses informs the next, we will take an adaptive approach, updating the monitoring plan each year to determine the appropriate steps to take in the upcoming sampling season. These modifications must be agreed to by the SMC workgroup as a whole. The steps described below may not apply to all test sites, as some may have more information available at the outset of the study than others and will most likely have different stressors impacting them.

1. Conduct rapid-screening causal assessment (RSCA) to determine support for stressors that are incorporated into existing rapid workflows (e.g., nutrient concentrations, water temperature, ions).
2. Identify data gaps in standard stressor data at the test site and its comparator sites, ideally finding 30 comparator sites with complete data for each test site.
3. Review RSCA results and identify potential sources of those stressors characterized as Likely or as Indeterminant causes in the assessment.
4. Identify additional site-specific stressors potentially affecting the test site (i.e., those not considered in the rapid screening assessment) and their sources within the test site's catchment based upon land use or local knowledge (e.g., dam operations, urban runoff, proximity to a farm, wildfire, etc.).
5. Identify appropriate analytes to characterize the additional stressors identified in Step 4 or to better characterize the Likely/Indeterminate stressors from Step 3. For example, if a site is located near an agricultural area, pesticides and nutrient concentrations may be appropriate analytes to measure. These analytes may already be included in the standard suite of analytes measured at condition sites (Table 4), or may include additional analytes, some of which may require more intensive sampling strategies to measure (e.g., diel flux of dissolved oxygen). Some analytes in Table 4 may be pre-emptively ruled out if they are not linked to one of the potential sources that have been identified; for example, if the test site has excellent habitat quality, additional CRAM measurements may not be necessary for causal assessment.
6. Collect new data at test and comparator sites. Confirm that poor conditions occur at the test site by sampling the indicators listed in Table 4. This list may be adjusted to add analytes identified in Step 5 and by dropping analytes that have been pre-emptively ruled out in Step 3. Identify stressors with major data gaps as detailed in Step 2 and fill those data gaps at comparator sites within the participants' jurisdictions as needed.
7. Seek out additional data from other programs that may improve confidence or modify support for additional stressors at the test site (e.g., CEDEN, Healthy Watersheds portal, California Integrated Water Quality System Project [CIWQS], USGS stream gauges, groundwater monitoring, and other water quality databases).
8. Repeat the data gap and causal assessment analyses each year within the five-year period as needed to fill the data gaps and sufficiently evaluate each potential stressor identified at each test site.

Upon completion of the study, we should have produced a report for each test site that summarizes the results of the causal assessment at the site, cataloging each of the standard and site-specific stressors as either a Likely Cause, Unlikely Cause, or Indeterminate Cause of the observed low CSCI scores. At this point, the SMC participants will determine whether more intensive causal assessment is warranted (e.g., confirmatory causal assessment), and whether fixes for the identified stressors fall within their agency's capabilities or authority.

Analytes to be measured

At the outset of the study, the standard suite of biotic (BMI and Algae) and abiotic analytes (Table 3) will be measured at each test site. However, the results of the initial screening causal assessments and the local knowledge of each test site project group will be used to modify the suite of analytes to be measured at their respective test sites. It is to be expected that some of the standard biotic and abiotic measures will be reduced and replaced on a test-site-by-test-site basis with different test site- and comparator site-specific analytes to better inform and customize the causal assessment at each test site.

Tradeoffs

In general, one test or comparator site sampled under this study shall be considered the equivalent of one condition site. However, costs of sampling one site in this study may vary if additional expensive analytes are measured. These expenses may be mitigated in one of two ways, both of which require approval by the SMC workgroup. First, analytes may be dropped from test or comparator sites to maintain cost neutrality with new analytes. Second, if new analytes are particularly expensive, an entire condition site may be dropped.

Sampling period

This study has the same sampling period as condition sites, unless otherwise dictated by the needs of the investigation of the test site. For example, if hydromodification is a candidate cause, assessment of winter stormflows may be necessary.

Wet-dry mapping

Why is this a priority study?

Previous surveys have shown that intermittent and ephemeral streams dominate the South Coast region, comprising between 50 and 95% of the stream-miles in different watersheds (Mazor 2015). Sites presumed to be perennial are sometimes determined to be intermittent, and sites presumed to be ephemeral may sometimes be sampleable in wetter years. Unfortunately, currently available maps and hydrologic models lack the precision and resolution to accurately display where perennial, intermittent, and ephemeral streams are located in some areas. Although the SMC survey has provided a snapshot of flow conditions at large numbers of sites, more intensive data collection is needed to determine which sites are perennial, intermittent, or ephemeral. As a result, managers have an insufficient understanding of their aquatic resources. For a bioassessment program, this uncertainty can increase costs of field reconnaissance to identify which streams are likely to be sampleable during the sampling period. Furthermore, knowledge of flow duration would give managers more understanding of which regulatory programs or water quality objectives apply to a given stream.

How sites are selected

SMC participants identified a number of catchments where improved understanding of streamflow duration is desired (Appendix D). Many of these areas have rarely, if ever, been sampled, often due to a presumption of insufficient flow or due to interpretation of limited data sources and field observations. These locations generally correspond to HUC12 catchments. However, the specific stream reaches included in the study (e.g., mainstems vs. tributaries) will be determined based on participant interest, access, and other factors. The total length of a stream assessment shall be limited to the length field crews can assess in a single day, including any study enhancements described below. In general, this is presumed to be around 10 km per catchment.

More than 100 regions or sites have been identified as requiring wet-dry mapping, and mapping them all requires more resources than the SMC is able to commit. Therefore, a large number of catchments are **uncommitted** elements of the survey.

Approach

The first step in the study is to conduct a desktop analysis to compile available data on flow duration in the catchment. Participants shall review data sources of aquatic monitoring data to determine what, if any, aquatic sampling has previously occurred (e.g., The SMC Data Portal or CEDEN for bioassessment and other water quality monitoring data; the California Natural Diversity Database for aquatic species observations). Historical imagery (e.g., Google Earth) shall be reviewed to determine places and times where surface water is visible. Social media resources (e.g., iNaturalist, Instagram) with time and geospatial information may also be used to assess flow conditions. The StreamTracker database shall be consulted to see if there is any available information in the catchment. Hydrologic models, if available, shall be identified and reviewed to determine if flow metrics relevant to flow duration (e.g., hydroperiod) have been calculated for reaches of interest. Based on this data review, participants shall prepare a short narrative statement describing data availability and likely flow duration conditions in the catchment submitted to SCCWRP (raphaelm@sccwrp.org or jeffb@sccwrp.org) at least one week prior to the field data collection event. This data review may result in modifications to the time or location of field data collection, or even a change in the selected catchment.

Once this desktop analysis is complete, field data collection can begin. This study consists of five possible data collection elements. The first element is required for the study; other elements may be added, generally at the cost of reducing the overall length of stream assessed or other tradeoffs determined by the SMC technical workgroup.

1. Baseline stream-walking
   Field crews shall conduct a stream-walking expedition along a stream corridor, recording hydrologic state at regular intervals (e.g., every ***~200 m***), and at points where hydrologic conditions change. Hydrologic state is determined by visual observation, and shall follow the categories identified in Gallart et al. (2016):
   - Hyperrheic: (flood conditions)
   - Eurheic (baseflow)
   - Oligorheic (trickling flow)
   - Arheic (stagnant surface water)

- Hyporheic (subsurface flow, saturated sediment)
- Edpahic (unsaturated sediment)

Photo-documentation is also required at each location.

Inaccessible reaches that cannot be visually observed shall be skipped from stream-walking. No sample collection or direct hydrological measurements (e.g., streamflow) are required. Additional information (e.g., channel engineering state, changes in channel morphology) may be recorded, as determined by the workgroup and participant interest.

Expeditions shall be conducted at least ***two*** times per year for at least ***two*** years. Thus, every catchment in the study shall receive at least 4 visits over the course of the study. One visit shall occur in early Spring or late Winter (i.e., between February and April), when flows are presumed to be highest. Another visit shall occur in late Summer or early Fall (i.e., between August and November), when flows are presumed to be lowest.

The timing of the two expeditions may be modified to address questions related to seasonality and applicability of biological objectives. For example, the two expeditions may be timed 4 weeks apart to determine if a stream has at least 4 weeks of sustained flow.

2. Higher frequency of stream-walking
   Higher frequency of visits may be desirable in certain cases. For example, planning two visits in early spring, one month apart, would be sufficient to determine if a stream meets the definition of *seasonal* in proposed biological objectives in the San Diego Basin Plan. Revisits over three or more years will provide better insight into interannual variability in streamflow. High frequency of visits (e.g., 12 or more) may allow the develop of dynamic, animated maps that visualize changes in flow conditions.

   Higher frequency of stream-walking may require tradeoffs in numbers of condition sites or other study elements, at a rate of 4 additional day-long expeditions for one condition site.

3. Streamflow Duration Assessment
   The EPA has recently developed a streamflow duration assessment method (SDAM) for the Arid West (Mazor et al. in prep). Participants may implement this method at one or more locations on one or more visits. The protocol consists of rapid measurement of 5 indicators:
   - Number of hydrophytic plant species (e.g., willows, cattails, alders; (US Army Corps of Engineers 2018)) in or near the channel: None, 1 to 2, or 3+
   - Number of aquatic invertebrates (live specimens, cases, shells, or exuviae) found within the reach: None, 1 to 19, or 20+
   - Mayflies, stoneflies, or caddisflies: Presence or absence of live specimens, cases, or exuviae
   - Extent of live or dead algae cover on the streambed: None, < 10%, or ≥ 10%
   - Live fish: Presence or absence

The protocol requires no sample collection, and typically takes about 30 minutes to conduct on a 40 m to 200 m reach, and results in a classification of streamflow duration: ephemeral, intermittent, perennial, at least intermittent, or need more information.

If this is enhancement is included, it is recommended that ***four*** locations are assessed per catchment, per expedition, and that different locations are assessed upon repeat visits. This way, a larger number of locations (16 expected) are assessed.

If this enhancement is included in the study, the overall length of an assessed catchment shall be reduced to ensure that an expedition can be completed in a single day.

4. Water presence logger deployment
   Various types of water presence loggers have been used to assess streamflow duration: water level loggers, wildlife cameras, and stream temperature, intermittency and conductance (STIC) loggers, have all been effectively used to determine the presence or absence of surface flow. Costs range from <\$100 (for STIC loggers) to \$1000 (for paired pressure transducers, used to assess water level). Participants may deploy loggers at a number of suitable locations within the study area. It is recommended that at least one logger be deployed within each catchment. Loggers should not be deployed in unsuitable locations (e.g., high traffic areas, or areas prone to scour during winter storms). Loggers should remain deployed year-round where practical, but they may be temporarily removed during winter storms to prevent equipment loss.

   If this enhancement is included in the study, the costs of acquiring new equipment may result in a tradeoff by dropping selected analytes from other study sites. These tradeoffs require approval of the entire SMC technical workgroup.

5. Drone deployment
   Drones may provide a rapid way of assessing surface water presence over a large area. Although drone use is only suitable in certain areas, and may not provide the same precision as direct visual observation in differentiating hydrologic states, they may provide a great enhancement to the study.

   If this enhancement is included in the study, the overall length of an assessed catchment shall be reduced to ensure that an expedition can be completed in a single day. Costs of acquiring a drone or procuring services may require tradeoffs in numbers of condition sites or analytes measured in other study sites; these tradeoffs require approval of the SMC technical workgroup.

UPDATING THE WORKPLAN

In contrast to previous workplans, the current workplan offers greater flexibility to SMC participants in determining how to pursue different survey elements. Therefore, the survey will require annual review and reappraisal to ensure that the participants' contributions fulfill the major goals of the SMC.

Every year, the SMC bioassessment workgroup shall reconvene to review potential updates to the workplan, such as reallocation of efforts among elements, modifications to measured analytes, and tradeoffs to maintain cost neutrality. For example, a participant may propose adding toxicity analysis at a causal assessment site, and dropping CRAM assessment that site to maintain cost neutrality. Another participant may propose eliminating a condition site altogether to cover the costs of sediment analysis at a number of other sites they are sampling. These updates require approval from the SMC bioassessment workgroup. Major modifications (determined by the SMC survey coordinator, Raphael Mazor [raphaelm@sccwrp.org]) may require approval from the SMC steering committee.

These modifications should be approved in the Fall or Winter prior to the sampling season.

Tracking contributions from each agency

Prior to every sampling season, each participant shall submit to SCCWRP a report summarizing the intended contributions to each survey element. Within a month of the completion of a sampling season, participants shall submit a post-sampling report, identifying sites that were sampled under each survey element. Formats for these reports are currently in development.

DATA SUBMISSION AND ACCESS

SMC data portal

Submitting data

Data shall be submitted according to the schedule below:

- Taxonomy data: *February 28* after sample collection
- All other data types: *October 31* after sample collection

CRAM data shall be submitted to eCRAM (https://www.cramwetlands.org/) by *October 31* after sample collection.

Prior to every sampling season, each participating agency shall identify a single contact person responsible for all data submission from that agency (multiple contacts may be identified if appropriate). Most data should be submitted by the end of November of the year of sampling; taxonomic data should be submitted by the end of February the year following sampling. Most data types are submitted through the SCCWRP data portal (http://smc.sccwrp.org/), where data submission guides may be found.

Data type	What is submitted?	How is it submitted?	Typical deadline
Site evaluation data	1 Excel template	Data portal	Oct
Chemistry	2 Excel templates	Data portal	Oct
Toxicity	3 Excel templates	Data portal	Oct
Bug taxonomy	2 Excel templates	Data portal	Feb
Algae taxonomy	2 Excel templates	Data portal	Feb
PHAB	Access shell database	Data portal	Oct
CRAM	eCRAM forms	eCRAM	Oct
Hydromod PHAB module	1 Excel template	Email	Oct
Channel engineering	1 Excel template	Email	Oct

Vertebrate observations	1 Excel template	Email	Oct
Trash	1 Excel template	Email	Oct
Time series data	1 to 3 Excel templates	Email	Oct
Site photos	JPEG file	Email	Oct
Geospatial data*	2 shapefiles (points and polygons)	Email	Oct

*Only for new sites that have not been sampled in previous years

Receipts for data submission, if not provided by the data portal, may be requested from SCCWRP (Jeff Brown: jeffb@sccwrp.org). Submitting correct data is the responsibility of each participating agency. If problems are discovered with submitted data, the participating agency shall resubmit corrected data. Although formal training for data submission will not be provided, SCCWRP will support the data submission process on an individual basis.

Data submission for discontinued parameters (such as water column toxicity) will be supported for participants who wish to continue sampling them.

Accessing data

All SMC data may be accessed through the SMC data portal (http://smc.sccwrp.org/). Data in the portal are considered public after the SMC has published a report to summarize the data (typically one year after sample collection).

The SMC portal aggregates all data submitted to the portal, as well as all public bioassessment data submitted to CEDEN in the South Coast region, plus all public SMC and SWAMP data submitted to CRAM.

CEDEN

To the extent possible, all data submitted to the SMC data portal shall be submitted to CEDEN. At the time of this workplan, CEDEN can accept these data types:

- Benthic macroinvertebrate taxonomy
- Benthic algae taxonomy
- Water chemistry
- Sediment chemistry
- Field water quality
- Physical habitat

In addition, it is expected that CEDEN will soon be able to accept CSCI, ASCI, and IPI scores (as "habitat" data). It is not expected that CEDEN will accept other data types collected by the SMC.

Schedule of CEDEN data submissions

The transfer of data from the SMC to CEDEN will be scheduled to support development of the Water Board's Integrated Report to the EPA on the condition of California's surface waters. Therefore, SMC data will be transferred to CEDEN by the appropriate deadlines in years that the Integrated Report covers the Los Angeles, Santa Ana, and San Diego regions.

Reporting

The SMC uses two primary mechanisms to report data collected under the stream survey: Dashboards and written reports. Other mechanisms (e.g., peer-reviewed journal articles, fact sheets, presentations at conference, etc.) may also be used as determined by the SMC steering committee or workgroup.

Dashboards

The SMC has developed a prototype dashboard to present and synthesize bioassessment data collected in the region (Figure 2). This dashboard is based on the Stream Quality Index (SQI), which brings together biological response data (i.e., CSCI and ASCI scores), habitat data (i.e., CRAM and the IPI), and water chemistry data (i.e., total nitrogen, total phosphorus, and specific conductivity). The current dashboard is based on a limited, static dataset, and cannot accommodate new data.

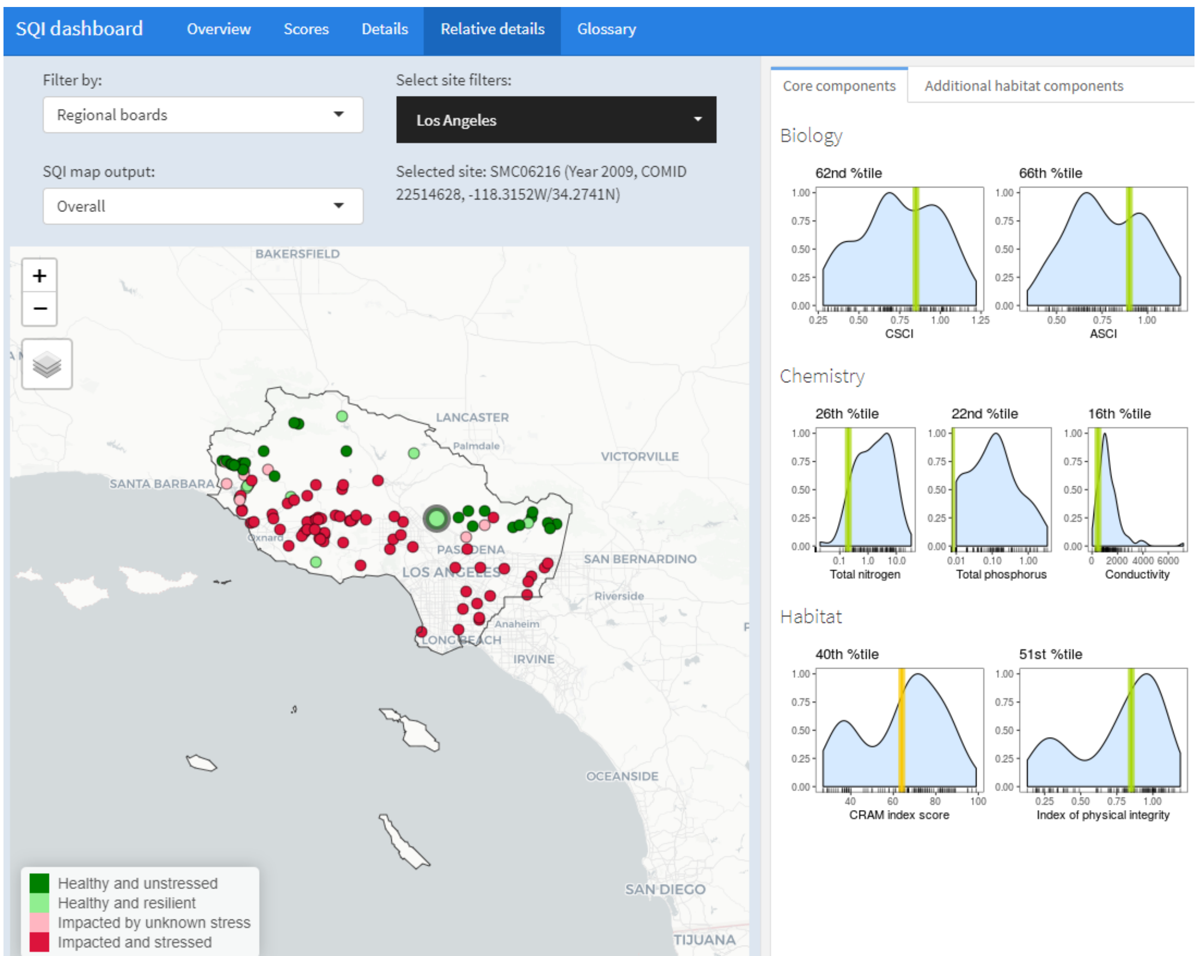

Figure 2. Dashboard for the SMC's Stream Quality Index (https://sccwrp.shinyapps.io/sqi_shiny).

The SMC will link the dashboard to the SMC data portal so that it can be dynamically updated with the most recently available data. This is a **committed element**.

The SMC will expand the dashboard to include new components identified by the SMC workgroup. These components include:

- Instant report generation for subregions (e.g., watersheds, counties) or sites of interest (**uncommitted element**)
- A user interface for rapid screening causal assessment (**uncommitted element**)
- Addition of data types not incorporated into the SQI (**uncommitted element**)
- Improved data access tools (**uncommitted element**)

Written reports

The SMC publishes technical reports at least once every other year. These reports are typically written in a "feature" style format, highlighting key messages for non-technical audiences. Feature subjects are determined by the SMC workgroup or steering committee. Past topics have included biological conditions in engineered channels, assessments with algal indices, and a regional analysis of hydromodification susceptibility. In general, these features are accompanied by shorter articles on a wide range of topics, both technical (e.g., extent of pyrethroid contamination in sediments) and non-technical (e.g., use of SMC data in developing water quality improvement plans). Production of three reports during the workplan period is a **committed element**.

Priority topics and data mining efforts

The SMC workgroup had tentatively identified a wide range of priority topics to address in technical reports. Although these topics will form part of the written reports described above, they are by and large **uncommitted efforts** requiring additional support to complete publication.

- Biological conditions in soft-bottom modified channels
- Trends in constrained streams
- Impacts of climate change on biological reference conditions in Southern California
- Relationships between biological conditions and restoration efforts
- Relationships between biological conditions and stormwater BMP or green infrastructure implementation
- Regional causal assessments
- Relationships between algal composition and physical habitat, flow alteration, and background water chemistry

QA REQUIREMENTS

Field replicates are collected as required by the SWAMP QAPrP: 10%, or one per participant: benthic macroinvertebrates, diatoms, and benthic algae biomass, and 5% for sediment toxicity, bioanalytic screens, and all water and sediment chemistry analytes. This requirement may be reduced or waived by the SWAMP Bioassessment Coordinator. No duplicates are required for CRAM, vertebrates, phab, hydromod, trash assessments, channel engineering, and hydrology.

Field or travel blanks are collected as required by the SWAMP QAPrP (i.e., one per method): bioanalytic screens, and all water chemistry analytes. Field blanks are also recommended for sediment chemistry and toxicity samples. Not required: benthic macroinvertebrates, diatoms, soft algae, benthic algae biomass, CRAM, vertebrates, phab, hydromod, channel engineering, and hydrology.

Matrix spikes are required by the SWAMP QAPrP: 5% or one per batch for water chemistry and sediment chemistry samples (pyrethroids). Matrix spikes are not required for algae biomass, or suspended solids.

Toxicity tests shall be consistent with requirements of the SWAMP QAPrP. Sediment toxicity control consistent with Section 7 of the appropriate EPA method/manual must be tested with each analytical batch of sediment toxicity tests. Reference toxicant tests must be conducted monthly for species that are raised within a laboratory, or per analytical batch for commercially-supplied or field-collected species.

Training and auditing

For the first year of the survey, field crews should expect to participate in 1 to 2 days of training. In subsequent years, crews should participate in 1 to 2 days of training and intercalibration events. Training will be provided by SCCWRP staff or by the UC Davis Training Academy.

For the first year of the survey, all field crews will be audited, with repeat audits conducted as needed. Thereafter, crews will be audited every other year. The SMC survey coordinator may require additional audits as he or she sees fit.

Total training/auditing costs per agency (expected; additional training or audits may be required for individual crews as determined by the SMC survey coordinator):

- Field methods intercalibration, training: 1 day
- Auditing: 1-2 days. Audits may be waived if a crew has received a satisfactory audit in the previous year.

SUMMARY OF UNCOMMITTED PROGRAM ELEMENTS

To facilitate collaboration with partners outside the SMC program, this workplan identifies a number of uncommitted elements that can be supported by interested parties. This section of the workplan summarizes uncommitted elements, and describes how these parties (SMC members themselves, or outside collaborators) may contribute to the SMC survey.

Collect data at additional sites

Every element of the program needs greater sampling effort than the SMC is currently able to provide. These outstanding needs are summarized in Table 9. SMC members or outside collaborators may collect and submit data at sites that fulfill SMC program needs, in accordance with the element designs described above. These sites will be selected by the SMC survey coordinator in consultation with participants who share jurisdiction over the region in question. Estimated costs are summarized in Table 10.

Table 9. Needs for each survey element of the SMC survey. Table 2 summarizes current levels of commitment to meet these needs.

Survey element	Survey need

Condition assessment	30 sites per watershed
Trend assessment	30 sites per watershed
Targeted sites in under-sampled regions	Sites listed in Appendix C
Causal assessment sites	30 samples per test site (including samples at comparator sites) • Highest need: Test sites identified in Table 8 • Additional need: All sites with CSCI scores < 0.79
Wet-dry mapping	Catchments listed in Appendix D

Cost estimate: $8,000 and $12,000 per site, including site reconnaissance, field sampling, and lab analysis.

Unmeasured analytes at survey sites

Some analytes identified as a need for the SMC survey do not have commitments to sample. Collaborators may support lab analysis of samples collected by SMC member field crews, or collect and analyze the samples themselves.

Cyanotoxins

Sites sampled by the SMC may be revisited by collaborators to collect additional cyanotoxin data (or analyze archived samples, if available). These collections may include water column grabs, sediment, algal mats, benthic algal biofilm, or time-integrated passive samplers deployed for an appropriate length of time. Analyses should cover the analytes listed in Table 5 and/or Table 6.

Cost estimate: $400 to $600 per site (does not include sample collection).

Water presence loggers

Water presence information from data loggers may be collected at trend sites, or any other site where long-term monitoring is expected. Water level loggers (i.e., paired pressure transducers) or wildlife cameras will be used.

Cost estimate: $750 for loggers/camera (does not include deployment or retrieval)

Sediment chemistry and toxicity

Sediment samples may be collected concurrently with bioassessment, or by revisiting assessed sites, and analyzed for the analytes identified in Table 5 and Table 6, such as pyrethroid and cyanotoxin concentrations, novel CEC screening and identification, or used in toxicity assays.

Cost estimate: $250 to $300 per sample for sediment grain size and total organic carbon, $800 to $1,000 per sample for pyrethroids and fipronil, $1,000 to $1,200 per sample for non-target analysis, and $1200 to $1600 for sediment toxicity. Costs do not include sample collection

Molecular analysis of eDNA or benthic biofilm samples

Samples collected and archived at SCCWRP may be analyzed by extracting DNA, and subjected to metabarcode sequencing, or qPCR, as described above.

Cost estimate: $200 to $300 per sample for metabarcoding, sample-and-target species for qPCR. Costs do not include sample collection.

Conduct additional causal assessments

Collaborators able to make large contributions to the SMC survey may conduct causal assessments focusing on test sites where SMC participants are unable to make a commitment. These test sites may include some of the candidates listed in Table 8, or at other biologically degraded sites identified in consultation with the SMC technical workgroup.

Cost estimate: $35,000 to $45,000 with no additional data collection. If data collection is necessary, costs are an additional $10,000 to $12,000 per sample.

Improve the SMC survey dashboard to aid access to and interpretation of survey data

The SMC dashboard requires the development components identified by the SMC workgroup. These components include:

Small modifications (cost estimate: $10,000 to $15,000)

- Addition of data types not incorporated into the SQI
- Improvements to facilitate data access (e.g., map-based querying tools, query tools linked to the SQI dashboard, automated generation of data dictionaries, etc.)

Moderate modifications (cost estimate: $20,000 to $25,000)

- Instant report generation for subregions (e.g., watersheds, counties) or sites of interest

Major modifications (cost estimate: $60,000 to $80,000)

- A user interface for rapid screening causal assessment

Support analysis and reporting of data on topics of interest to the SMC

The SMC workgroup had tentatively identified a wide range of priority topics to address in technical reports:

- Biological conditions in soft-bottom modified channels
- Trends in constrained streams
- Impacts of climate change on biological reference conditions in Southern California
- Relationships between biological conditions and restoration efforts
- Relationships between biological conditions and stormwater BMP or green infrastructure implementation
- Regional causal assessments

Cost estimates: $30,000 to $40,000 each report, covering all data available to date.

Table 10. Summary of costs of uncommitted elements of the SMC survey.

Item	Estimated cost
Full data collection	$8,000 to $12,000 per site
Cyanotoxin analysis	$400 to $600 per sample
Water presence loggers	$750 per site
Sediment analysis	
- Grain size and TOC	$250 to $300 per sample
- Pyrethroids and fipronil	$800 to $1,000 per sample
- Non-target analysis	$1,000 to $1,200 per sample
- Toxicity (*Hyalella azteca*)	$1,200 to $1,600 per sample
Molecular analysis	
- Metabarcoding	$200 to $300 per sample
- Quantitative PCR	$200 to $300 per sample and target species
Causal assessments	
- Analysis of existing data	$35,000 to $40,000 per test site
- Collection of new data	$10,000 to $12,000 per site
Updates to SMC dashboard	
- Minor modifications	$10,000 to $15,000
- Moderate modifications	$20,000 to $25,000
- Major modifications	$60,000 to $80,000
Additional reports on selected subjects	$30,000 to $40,000 per report

References

Beck, M., R.D. Mazor, S. Johnson, K. Wisenbaker, J. Westfall, P.R. Ode, R. Hill, C. Loflen, M. Sutula, E.D. Stein. 2019a. Prioritizing Management Goals for Stream Biological Integrity Within the Developed Landscape Context. Freshwater Science DOI:10.1086/705996.

Beck, M., R.D. Mazor, S. Theroux, K.C. Schiff. 2019b. The Stream Quality Index: A multi-indicator tool for enhancing environmental management. Environmental and Sustainability Indicators DOI:10.1016/j.indic.2019.100004.

Boyle, T., R. Mazor, A.C. Rehn, S. Theroux, M. Beck, M. Sigala, C. Yang, S. Rastergarpour, and P.R. Ode. 2020. Instructions for calculating bioassessment indices and other tools for evaluating wadeable streams in California. SWAMP=SOP-2020-0001. Available from https://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/docs/20201030_consolidated_sop.pdf

Du, B., J. Smith, K. Maruya, C.S. Wong. 2020. Comparison of Novel Passive Sampling Methods to Identify Cyanotoxins and their Sources. Technical Report 1123. Southern California Coastal Water Research Project. Costa Mesa, CA.

Gallart, P. Llorens, J. Latron, N. Cid, M. Rieradevall, and N. Pratt. 2016. Validating alternative methodologies to estimate the regime of temporary rivers when flow data are unavailable. Science of the Total Environment 565: 1001-1010. doi.org/10.1016/j.scitotenv.2016.05.116

Howard, M.A., K. Hayashi, J. Smith, R. Kudela, and D. Caron. 2018. Standard operating procedures for Solid Phase Adsorption Toxin Testing (SPATT) assemblage and extraction of HAB toxins. University of California at Santa Cruz. Santa Cruz, CA. http://oceandatacenter.ucsc.edu/home/Misc/SPATT%20SOP%20All%20Toxins.pdf

Mazor, R.D. 2015. Bioassessment of perennial streams in southern California: A report on the first five years of the Stormwater Monitoring Coalition's regional stream survey. SCCWRP Technical Report #844. http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/844_SoCalStrmAssess.pdf

Mazor, R.D., A. Santana, C. Endris, and K. O'Connor. 2020. Assessing the representativeness of bioassessment samples using spatial statistical networks for watersheds in California: A guide for aquatic resource managers. SCCWRP Technical Report 1143. Costa Mesa, CA. https://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1143_SpatialStatisticalNetworks.pdf

Mazor, R.D., Mazor, R.D., Topping, B., Nadeau, T.-L., Fritz, K.M., Kelso, J., Harrington, R., Beck, W., McCune, K., Lowman, H., Allen, A., Leidy, R., Robb, J.T., and David, G.C.L. In prep. A beta Streamflow Duration Assessment Method for the Arid West of the United States. Version 1.0.

Ode, P.R., A.E., Fetscher, and L.B. Busse. 2016. Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 004

Stevens, D.L. and A.R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Theroux, S., R. Stancheva, and R. Sheath. 2019. A standardized Taxonomic Effort (STE) for California Stream Algae. Available from https://sccwrp-my.sharepoint.com/:w:/g/personal/susannat_sccwrp_org/EbtbrQReeuBNvXCNvMaafWcBBfGvYKn9lHN9AdRLUrnyCA?rtime=R9rIAteQ2Eg

US Army Corps of Engineers. 2018. National Wetland Plant List, version 3.4: Arid West. Available from: http://wetland-plants.usace.army.mil/nwpl_static/data/DOC/lists_2018/Regions/pdf/reg_AW_2018v1.pdf

Appendix A. Condition sites sample draw

A spreadsheet with the condition site sample draw may be downloaded here:

ftp://ftp.sccwrp.org/pub/download/PROJECTS/SMCConditionSites2021.zip

Appendix B. Trend sites sample draw

A spreadsheet with the trend site sample draw may be downloaded here:

ftp://ftp.sccwrp.org/pub/download/PROJECTS/SMCTrendSites2021sampledraw_12232020.zip

APPENDIX C. LIST OF CANDIDATE SITES FOR TARGETING UNDER-SAMPLED AREAS

These sites are located in areas or stream-types that require additional data. Sites on this list may or may not have sufficient flow for sampling, and may or may not be accessible. Field and desktop reconnaissance each sampling season is required to determine which, if any, of these sites are sampleable.

Table C-1. Sites in under-sampled regions in Ventura County. Coordinates indicate approximate locations.

Watershed	Site or reach name	Latitude	Longitude	Notes
LAR	Bell Canyon	34.20479	-118.68159	Urban
SCL	Upper Fish Creek	34.60927	-118.80213	Open
SCL	Upper Piedra Blanca Creek	34.60063	-119.17952	Open
SCL	Hot Springs Canyon	34.57845	-118.98933	Open
SCL	Alder Creek	34.57301	-118.95263	Open
SCL	Upper Agua Blanca Creek	34.56804	-118.84233	Open
SCL	Upper Sespe	34.56561	-119.04880	Open
SCL	Trout Creek	34.56174	-119.14244	Open
SCL	Middle Sespe	34.55682	-118.94349	Open
SCL	Timber Creek	34.55041	-119.06956	Open
SCL	West Fork Sespe	34.50594	-118.97033	Open
SCL	Middle Sespe	34.45847	-118.93396	Open
SCL	403BA0015	34.53173	-119.18367	Reference site
SCL	403BA0171	34.58579	-119.28339	Reference site
SCL	403STC024	34.44967	-119.05647	Reference site
SCL	403STC026	34.55916	-119.26916	Reference site
SCL	403STC085	34.64270	-119.07834	Reference site
SCL	403WE0795	34.64087	-119.08205	Reference site
SCL	403WE0891	34.65923	-119.14343	Reference site
SMB	Upper Big Sycamore Canyon	34.12017	-119.00212	Open
VEN	Abadi Creek	34.60340	-119.39804	Open
VEN	Cañada Larga	34.34450	-119.26647	Open
VEN	402BA0095	34.46260	-119.34602	Reference site
VEN	402BA0287	34.50284	-119.36579	Reference site
VEN	402PS0048	34.51967	-119.40631	Reference site
VEN	402WE0536	34.51967	-119.40631	Reference site
VEN	402WE0803	34.42130	-119.38173	Reference site
VEN	VENTURA13	34.50144	-119.34800	Reference site

Table C-2. Sites in under-sampled regions in Los Angeles County. Coordinates indicate approximate locations.

Watershed	Site or reach name	Latitude	Longitude	Notes
LAR	Little Tujunga	34.37754	-118.26888	Open
LAR	Little Tujunga	34.36083	-118.33917	Open
LAR	Fox Creek	34.30760	-118.17749	Open
LAR	Pacoima Wash	34.31309	-118.40800	Urban natural channel
SCL	Fish Creek	34.64501	-118.52618	Open
SCL	San Francisquito Trib	34.62191	-118.44295	Open
SCL	San Francisquito	34.61077	-118.43591	Open
SCL	Soledad Canyon	34.43964	-118.26804	Open
SCL	Soledad Canyon	34.43902	-118.21468	Open
SCL	Aliso Canyon	34.43681	-118.13657	Open
SCL	Soledad Canyon	34.43452	-118.36547	Open
SCL	Aliso Canyon	34.42961	-118.11451	Open
SCL	Aliso Canyon Tributary	34.42698	-118.15028	Open
SCL	Aliso Canyon Tributary	34.40244	-118.12750	Open
SCL	South Fork Santa Clara	34.38526	-118.54965	Soft-bottom engineered
SCL	South Fork Santa Clara	34.37162	-118.51142	Soft-bottom engineered
SCL	Bouquet Canyon	34.45006	-118.50412	Soft-bottom engineered
SCL	403STC066	34.58488	-119.16533	Reference site
SGR	Upper East Fork	34.34337	-117.70222	Open
SGR	Fish Fork	34.30788	-117.72819	Open
SGR	Cattle Canyon	34.23150	-117.71542	Open
SGR	San Dimas Canyon	34.16880	-117.76776	Open
SGR	Tonner Canyon	33.95122	-117.83787	Open
SGR	RBBIO-304	34.27211	-117.89234	Reference site
SGR	405SGB003	34.27283	-117.88967	Reference site
SGR	405SGB006	34.25082	-117.82265	Reference site
SMB	Ramirez Canyon	34.05951	-118.79747	Open
SMB	Temescal Canyon	34.05597	-118.52904	Open
SMB	Corrall Canyon	34.04477	-118.73334	Open
SMB	Zuma Canyon	34.04031	-118.81449	Open
SMB	Zuma Canyon	34.02500	-118.81431	Urban natural channel
SMB	Ramirez Canyon	34.03620	-118.79320	Urban natural channel
SMB	Dume Canyon	34.01498	-118.79939	Urban natural channel

Table C-3. Sites in under-sampled regions in San Bernardino County. Coordinates indicate approximate locations.

Watershed	Site or reach name	Latitude	Longitude	Notes
MSA	San Antonio Creek	34.27413	-117.63507	Open
MSA	Day Canyon	34.19540	-117.54610	Open
MSA	801WE1020	34.25224	-117.53177	Reference site
USA	WF City Creek	34.20695	-117.18930	Open
USA	WF City Creek	34.20646	-117.20768	Open
USA	WF City Creek	34.20620	-117.20118	Open
USA	EF City Creek	34.18639	-117.17748	Open
USA	Keller Creek	34.16912	-117.04490	Open
USA	Plunge Creek	34.16674	-117.12302	Open
USA	Grout Creek	34.27207	-116.95095	Open
USA	Big Bear tributary	34.29128	-116.88442	Open
USA	Green Canyon	34.22313	-116.80612	Open
USA	801CE0152	34.18870	-117.18186	Reference site
USA	801WE0787	34.14541	-116.87918	Reference site
USA	801WE0806	34.15014	-117.13425	Reference site
USA	801SBCATC	34.20161	-117.22852	Reference site
USA	R5BIO-304	34.16405	-116.83301	Reference site

Table C-4. Sites in under-sampled regions in Orange County. Coordinates indicate approximate locations.

Watershed	Site or reach name	Latitude	Longitude	Notes
LSA	Modjeska Canyon, Santiago side	33.70822	-117.61214	Open
LSA	Modjeska Canyon, Modjeska side	33.71450	-117.62404	Open
LSA	Gypsum Canyon	33.83926	-117.70899	Open
LSA	Black Star Canyon	33.77890	-117.67413	Open
LSA	Silverado Canyon d/s town at turnout	33.74790	-117.64100	Open
LSA	Silverado Canyon u/s of site SMC00105	33.75109	-117.57871	Open
LSA	Weir Canyon	33.81072	-117.75676	Open
LSA	Bolsa Chica Channel u/s Westminster Blvd.	33.75998	-118.04298	Earthen rip rap channel u/s BCC02
LSA	Greenville Banning Channel u/s I-405	33.69138	-117.92347	Earthen rip rap channel
LSA	Pelanconi Park Anaheim Hills	33.84838	-117.79511	Natural watercourse from dissipator
LSA	Santiago Creek (E08) around Maybury Ranch	33.81489	-117.79460	Urban
LSA	Oak Canyon Nature Center	33.84105	-117.75888	Developed
LSA	Serrano Creek u/s Trabuco Rd.	33.65326	-117.68108	Developed, restored
LSA	Buck Gully d/s of 2018 site	33.59674	-117.86262	Developed
LSA	Upper Brea Canyon Channel	33.94432	-117.87174	Developed
SJU	Holy Jim u/s community	33.68460	-117.51500	Natural

SJU	Upper Trabuco, u/s Holy Jim parking lot	33.68175	-117.50680	Natural
SJU	Falls Canyon at REF-TCAS	33.67768	-117.53628	Natural
SJU	Trabuco Canyon at Arizona crossing	33.66687	-117.56739	Natural
SJU	Trabuco Creek u/s 241	33.65000	-117.60014	Developed
SJU	English Channel d/s Entidad	33.64488	-117.65652	Developed, never sampled
SJU	901BELOLV	33.64154	-117.55300	Open
SJU	Aliso Creek u/s Creekside	33.63943	-117.67003	Developed
SJU	Bell Creek outfalls	33.62046	-117.56459	Developed, never sampled
SJU	Trabuco Creek, 901M14118	33.60980	-117.62700	Urban, needs resampling
SJU	Oso Creek d/s Jeronimo	33.60445	-117.65022	Developed
SJU	Hot Springs Canyon, SMC01705	33.60370	-117.51000	Natural
SJU	Lower Tijeras, 901M14134	33.59230	-117.63300	Urban, needs resampling
SJU	Upper Laguna Canyon, I02S01	33.59194	-117.75009	Developed
SJU	San Juan Creek u/s Lucas Canyon Road	33.58805	-117.51659	Natural
SJU	San Juan Creek u/s #7	33.57966	-117.52834	Natural
SJU	Middle Bell Canyon	33.57509	-117.56664	Natural
SJU	San Juan Creek u/s Caspers	33.57368	-117.54098	Natural
SJU	Prima Deshecha d/s PDCM01	33.44397	-117.64372	Developed, never sampled

Table C-5. Sites in under-sampled regions in Riverside County. Coordinates indicate approximate locations.

Watershed	Site or reach name	Latitude	Longitude	Notes
NSD	Upper De Luz	33.48441	-117.30638	Open, State Lands
NSD	902ASTRLC	33.44330	-116.98800	Open
NSD	Los Alamos Canyon	33.54715	-117.35615	Open
SJC	Poppet Creek	33.83106	-116.86719	Open
SJC	SF San Jacinto	33.68178	-116.75635	Open
SJC	802WE0658	33.72932	-116.67480	Reference site
SJC	RB8_172	33.78419	-116.83941	Reference site
SJC	RB8_543	33.80340	-116.73136	Reference site
SJC	RB_070	33.77175	-116.76756	
SJU	901NP9BWR	33.53047	-117.42858	Open
SJU	901NP9TNC	33.52740	-117.40706	Open
SJU	Nickel Canyon	33.50850	-117.44898	Open, Wilderness

Table C-6. Sites in under-sampled regions in San Diego County. Coordinates indicate approximate locations.

Watershed	Site or reach name	Latitude	Longitude	Notes
SJU	901DCCDCx	33.47286	-117.46576	Reference site
NSD	Upper Long Canyon	33.41067	-116.90271	Open, USGS Site
NSD	Rainbow Creek	33.40906	-117.18733	Transition between high and low scoring reaches
NSD	Upper Long Canyon Trib	33.39440	-116.87880	Open, USGS Site
NSD	Santa Margarita	33.36691	-117.31808	Transition between high and low scoring reaches
NSD	903FCPSPx	33.35170	-116.91389	Open
NSD	903R9PPCD	33.33980	-116.95700	Open
NSD	903NP9UAC	33.32036	-116.62265	Open
NSD	903ACPCT1	33.29606	-116.63860	Open
NSD	902NP9CWC	33.41925	-116.86102	Open
CSD	905DGCC1x	33.15997	-116.84040	Open
CSD	905WE0679	33.13395	-116.65636	Open
CSD	Guejito Creek	33.12016	-116.94721	Natural
CSD	Bear Valley	33.08635	-117.05672	Natural urban channel
CSD	San Bernardo Valley	33.07560	-117.06402	Natural urban channel
CSD	Poway Creek	32.95711	-117.00602	Transition between high and low scoring reaches
CSD	Poway Creek	32.95253	-117.02731	Transition between high and low scoring reaches
CSD	909SWCASR	32.94193	-116.55349	Open
CSD	Sycamore Creek	32.89714	-116.99130	Natural
CSD	Sycamore Creek	32.89714	-116.99130	Transition between high and low scoring reaches
CSD	Sycamore Creek	32.88117	-116.99957	Transition between high and low scoring reaches
CSD	905CE0512	33.11107	-116.74311	Reference site
MBSD	907NP9SVC	32.99037	-116.85274	Open, State Lands
MBSD	907CSVDFW	32.98390	-116.86700	Open, State Lands
MBSD	San Vicente Creek	32.95219	-116.90638	Natural
MBSD	West Branch San Vicente Creek	32.94645	-116.91312	Natural
MBSD	Padre Barona Creek	32.93191	-116.87616	Natural
MBSD	San Diego River near Lakeside	32.87176	-116.91118	Transition between high and low scoring reaches
MBSD	Peutz Creek	32.85590	-116.79230	Open, SDRPF
MBSD	907NP9OSD	32.84794	-117.04997	Open, State Lands
MBSD	Forester Creek	32.80574	-116.74400	Restored soft-bottom channel
SSD	909HPCASR	32.93310	-116.54600	Open, State Lands
SSD	911FCCPCT	32.76440	-116.43900	Open
SSD	911TJKC1x	32.75980	-116.45078	Open
SSD	911PVCAEC	32.74530	-116.65100	Open
SSD	911NP9EPC	32.74481	-116.64880	Open
SSD	910NP9CCN	32.64150	-116.83600	Open, Wilderness
SSD	910NP9ARP	32.62880	-116.88200	Open, State Lands

Appendix D. List of candidate catchments of wet-dry mapping

List of catchments recommended for wet-dry mapping.

Table D-1. Catchments selected for potential inclusion in wet-dry mapping in Ventura County. Coordinates indicate approximate downstream end of catchment.

Watershed	Catchment	Latitude	Longitude	Notes
CAL	Happy Camp Canyon	34.293635	-118.860489	Never sampled
CAL	Chivos - Las Llajas Canyons	34.282371	-118.699580	Never sampled
CAL	Tapo Canyon	34.267726	-118.743492	Sparsely sampled
CAL	South Branch Arroyo Conejo	34.184624	-118.915002	Never sampled
CAL	Alamos Canyon	34.181152	-118.874032	Sparsely sampled
CAL	Arroyo Conejo	34.171890	-118.822537	Never sampled
SCL	Seymour Creek	34.734010	-119.042291	Never sampled
SCL	Hungry Valley	34.721981	-118.851873	Never sampled
SCL	Lockwood Creek	34.702141	-119.000661	Sparsely sampled
SCL	Matau Creek	34.677411	-119.018292	Sparsely sampled
SCL	Piedra Blanca Creek	34.59937	-119.152869	Eastern portion
SCL	Agua Blanca Creek	34.539977	-118.766759	Sparsely sampled
SCL	Lake Piru	34.469247	-118.752689	Sparsely sampled
SCL	Pole Creek	34.401070	-118.904200	Sparsely sampled
SCL	Adams Canyon	34.346318	-119.102994	Never sampled
SCL	Fagan Canyon	34.340538	-119.074463	Never sampled
SCL	Wheeler-Hampton Canyon	34.303915	-119.110775	Never sampled
SCL	Hall Canyon	34.278306	-119.264469	Never sampled
SMB	Potrero Valley Creek	34.144918	-118.836519	Sparsely sampled
SMB	Big Sycamore Canyon	34.074549	-119.014183	Sparsely sampled
VEN	Upper Sespe Creek	34.604850	-119.368366	Never sampled
VEN	Thacher Creek	34.443449	-119.228712	Sparsely sampled
VEN	Los Sauces Creek	34.348983	-119.422027	Never sampled

Table D-2. Catchments selected for potential inclusion in wet-dry mapping in Los Angeles County. Coordinates indicate approximate downstream end of catchment.

Watershed	Catchment	Latitude	Longitude	Notes
LAR	Upper Pacoima Wash	34.341623	-118.393935	Sparsely sampled
LAR	Mill Creek	34.310498	-118.142656	Never sampled
LAR	Alder Creek	34.310228	-118.071915	Sparsely sampled
LAR	Fox Creek	34.302392	-118.176890	Never sampled
LAR	Little Tujunga Creek	34.273004	-118.371362	Sparsely sampled
SCL	Hungry Valley	34.702963	-118.804083	Never sampled
SCL	Gorman Creek	34.683604	-118.786052	Sparsely sampled
SCL	Liebre Gulch	34.661982	-118.755294	Never sampled
SCL	Upper Castaic	34.611177	-118.663968	Never sampled

SCL	Fish Canyon	34.610429	-118.654764	Never sampled
SCL	Middle Castaic Creek	34.547329	-118.618087	Never sampled
SCL	Lake Piru	34.491811	-118.731557	Never sampled
SCL	Kentucky Springs Canyon	34.474676	-118.158125	Never sampled
SCL	Aliso Canyon	34.469066	-118.160269	Never sampled
SCL	Acton Canyon	34.467328	-118.198150	Never sampled
SCL	Agua Dulce Canyon	34.441365	-118.333343	Never sampled
SCL	Lower Castaic Creek	34.436679	-118.625127	Sparsely sampled
SCL	Arrastre Canyon	34.436347	-118.327533	Never sampled
SCL	Sand Canyon	34.424124	-118.536915	Sparsely sampled
SCL	Mint Canyon	34.421013	-118.452296	Never sampled
SGR	Iron Fork	34.298871	-117.744628	Never sampled
SGR	Devil's Canyon	34.246715	-117.974659	Never sampled
SGR	Devil's Canyon	32.247050	-117.975223	Never sampled
SGR	Upper Cattle Canyon	34.232804	-117.724994	Never sampled
SGR	Roberts Canyon	34.164674	-117.907668	Never sampled
SGR	Fish Canyon	34.157313	-117.925591	Never sampled
SGR	San Dimas Wash	34.136335	-117.776236	Never sampled
SMB	Rustic Canyon	34.034422	-118.517612	Sparsely sampled
SMB	Sullivan Canyon	34.031701	-118.512455	Sparsely sampled
SMB	Mandeville Canyon	34.030989	-118.516666	Sparsely sampled
SMB	Palos Verdes canyons	33.749541	-118.341337	Never sampled

Table D-3. Catchments selected for potential inclusion in wet-dry mapping in San Bernardino County. Coordinates indicate approximate downstream end of catchment.

Watershed	Catchment	Latitude	Longitude	Notes
MSA	East Etiwanda Creek	34.039331	-117.513050	Sparsely sampled
USA	Baldwin Lake	34.264971	-116.859901	Never sampled
USA	Big Bear Lake	34.244515	-116.970243	Sparsely sampled
USA	Mission Zanja	34.071615	-117.265189	Never sampled
USA	Warm Creek	34.064853	-117.305453	Sparsely sampled
USA	Reche Canyon	34.053702	-117.289144	Never sampled
USA	Yucaipa Creek	34.005029	-117.120854	Never sampled

Table D-4. Catchments selected for potential inclusion in wet-dry mapping in Orange County. Coordinates indicate approximate downstream end of catchment.

Watershed	Catchment	Latitude	Longitude	Notes
LSA	Upper Santiago Creek	33.745946	-117.672855	Sparsely sampled
LSA	Los Trancos Creek	33.577558	-118.839314	Sparsely sampled
SJU	Upper Aliso Creek	33.619416	-117.688204	Never sampled
SJU	Moro Canyon	33.561921	-117.819983	Never sampled
SJU	Emerald Canyon	33.555785	-117.804784	Never sampled

SJU	Laguna Canyon	33.543447	-117.784040	Sparsely sampled
SJU	Middle San Juan Creek	33.531514	-117.553985	Sparsely sampled
SJU	Salt Creek	33.482001	-117.721483	Sparsely sampled
SJU	Lower San Mateo Creek	33.454255	-117.569564	Sparsely sampled

Table D-5. Catchments selected for potential inclusion in wet-dry mapping in Riverside County. Coordinates indicate approximate downstream end of catchment.

Watershed	Catchment	Latitude	Longitude	Notes
LSA	Carbon Creek	33.937567	-117.768722	Never sampled
LSA	Alsio Creek - Santa Ana River	33.871959	-117.672218	Never sampled
MSA	Reche Canyon	34.017212	-117.272262	Never sampled
MSA	Upper Chino Creek	34.011203	-117.728660	Sparsely sampled
MSA	Lake Norconian - Temescal Wash	33.889757	-117.576758	Tributaries never sampled
MSA	Moreno Valley	33.876123	-117.210299	Sparsely sampled
MSA	Lake Mathews	33.837712	-117.394603	Sparsely sampled
MSA	Arroyo Del Torro - Temescal Wash	33.725301	-117.378200	Never sampled
MSA	Goldenstar Canyon	33.924096	-117.417283	Sparsely sampled. Causal assessment site
NSD	Warm Springs Creek	33.687646	-117.072782	Sparsely sampled
NSD	Rawson Canyon	33.605233	-117.022998	Never sampled
NSD	Upper Tucalota Creek	33.591898	-117.028774	Never sampled
NSD	Lower Tucalota	33.548450	-117.454640	Sparsely sampled
NSD	Upper Cahuilla Creek	33.536774	-116.755345	Vail Lake tributary
NSD	Santa Gertudis Creek	33.523871	-117.169769	Never sampled
NSD	Upper Wilson Creek	33.505071	-116.859791	Vail Lake tributary
NSD	Lower Cahuilla Creek	33.501422	-116.853618	Vail Lake tributary
NSD	Lower Wilson Creek	33.492371	-116.956214	Vail Lake tributary
NSD	Arroyo Seco Creek	33.484792	-116.977863	Has had loggers at some points at 902ASTRLC and 902SMAS1x
NSD	Long Canyon Murrieta	33.483878	-117.144620	Sparsely sampled
NSD	Cottonwood Creek - Temecula Creek	33.481483	-116.962809	Vail Lake tributary. Has a long-term logger already at 902NP9CWC
NSD	Pechanga Creek	33.474570	-117.128129	Sparsely sampled
NSD	Tule Creek	33.440322	-116.861428	Vail Lake tributary
NSD	Chihuahua Creek	33.398340	-116.799511	Vail Lake tributary
NSD	Rattlesnake Creek - Temecula Creek	33.394500	-116.807360	Vail Lake tributary
SJC	Laborde Canyon-San Jacinto River	33.847290	-117.055081	Never sampled
SJC	Potrero Creek	33.846497	-116.991979	Never sampled
SJC	Mount Rudolph-San Jacinto River	33.845244	-117.131036	Never sampled
SJC	Poppet Creek - San Jacinto River	33.766863	-116.906204	Never sampled
SJC	Perris Valley - San Jacinto River	33.736918	-117.248360	Never sampled

SJC	Lower South Fork San Jacinto River	33.727520	-116.810632	Sparsely sampled
SJC	Sant Johns Canyon	33.712635	-116.985654	Never sampled
SJC	Bautista Creek	33.709789	-116.868585	Sparsely sampled
SJC	San Jacinto Valley	33.687074	-117.163539	Never sampled
SJC	Menifee Valley	33.675529	-117.229935	Never sampled
SJC	Upper South Fork San Jacinto River (Hemet Valley)	33.661815	-116.664595	Northern portion well sampled, but southern portion not sampled at all
SJC	Lake Elsinore	33.644478	-117.327544	Sparsely sampled
SJU	Lower San Mateo Creek	33.522036	-117.504749	Never sampled
USA	Little San Gorgonio Creek	33.940332	-117.038076	Never sampled

Table D-6. Catchments selected for potential inclusion in wet-dry mapping in San Diego County. Coordinates indicate approximate downstream end of catchment.

Watershed	Catchment	Latitude	Longitude	Notes
CSD	Temescal Creek	33.121810	-116.851717	Sparsely sampled
CSD	Upper Santa Maria Creek	33.027561	-116.910706	Never sampled
MBSD	Ritchie Creek	32.991203	-116.740739	Sparsely sampled
MBSD	Upper San Vicente Creek	32.934535	-116.907080	Sparsely sampled
MBSD	Conejos Creek	32.891213	-116.763953	Sparsely sampled
MBSD	Lower San Vicente Creek	32.875054	-116.921043	Never sampled
MBSD	Rose Canyon	32.851092	-117.229588	Never sampled
MBSD	Sycamore Canyon	32.846376	-117.006572	Sparsely sampled
MBSD	San Clemente Canyon	32.837956	-117.228809	Sparsely sampled
NSD	San Onofre Creek	33.385477	-117.556930	Never sampled
NSD	Pauma Creek	33.342528	-117.020559	Sparsely sampled
NSD	Las Pulgas Canyon	33.293461	-117.459940	Never sampled
NSD	Aliso Canyon	33.269937	-117.439337	Never sampled
NSD	Paradise Creek	33.263652	-116.952060	Sparsely sampled
NSD	Pilgrim Creek	33.249233	-117.331298	Never sampled
NSD	Loma Alta Creek	33.188509	-117.359553	Sparsely sampled
SJU	Lower San Mateo Creek	33.392477	-117.589746	Sparsely sampled
SSD	Taylor Creek	32.791702	-116.743169	Never sampled
SSD	Loveland Reservoir	32.754797	-116.851407	Sparsely sampled
SSD	La Posta Creek	32.713178	-116.493995	Sparsely sampled
SSD	Powerhouse Canyon	32.710740	-117.143896	Never sampled
SSD	Lower Pine Valley Creek	32.701247	-116.677290	Sparsely sampled
SSD	Chollas Creek	32.691272	-117.121164	Sparsely sampled
SSD	Sweetwater Reservoir	32.690645	-117.004184	Sparsely sampled
SSD	Morena Reservoir	32.681393	-116.178680	Sparsely sampled
SSD	Paradise Valley	32.676188	-117.084235	Never sampled
SSD	Jamul Creek	32.652119	-116.870737	Never sampled
SSD	Dulzura Creek	32.651321	-116.862631	Sparsely sampled

SSD	Miller Creek - Campo Creek	32.641591	-116.420291	Never sampled
SSD	Telegraph Canyon	32.613519	-117.089858	Never sampled
SSD	Lower Otay Reservoir	32.613116	-116.930123	Tribs never sampled
SSD	McAlmond Canyon	32.612864	-116.700019	Sparsely sampled
SSD	Campo Valley	32.608213	-116.477400	Never sampled
SSD	Potrero Creek	32.607019	-116.693930	Sparsely sampled
SSD	Poggi Canyon	32.589320	-117.086370	Sparsely sampled
SSD	Bell Valley - Campo Creek	32.582754	-116.564026	Sparsely sampled
SSD	Lower Tecate Creek	32.578588	-116.617246	Never sampled
SSD	Bee Canyon	32.570116	-116.760133	Never sampled
SSD	Otay Mesa	32.562040	-116.828919	Sparsely sampled
SSD	Mine Canyon	32.561935	-116.805672	Sparsely sampled
SSD	Tijuana River mainstem	32.550740	-117.081752	Sparsely sampled