Southern California Stormwater Monitoring Coalition: Five-Year Research Agenda 2024-2029

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Participants in the Expert Panel Workshop. From left to right: Dr. Marcus Beck, Dr. Allen P. Davis, Dr. Elizabeth Fassman-Beck (facilitator), Ivar Ridgeway, Dr. Rachel Noble, Dr. Joel Baker, Lauren Marshall, Dr. Bridget Wadzuck, Dr. Rich Ambrose, Dr. David Lopez-Carr, Dr. Brett Sanders, Ken Schiff (facilitator), Gerhardt Hubner (facilitator), Dr. John Izbicki, Grant Sharp

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EXECUTIVE SUMMARY

The Southern California Stormwater Monitoring Coalition (SMC) is a partnership of 18 stormwater management agencies spanning the regulatory and regulated sectors working to develop solutions to regional challenges in stormwater management. Since its founding in 2001, the SMC has been pooling its members' resources and expertise to collaboratively conceptualize, develop and co-fund stormwater research and monitoring initiatives across coastal southern California. This collaborative approach to stormwater management has influenced the development of NPDES permits, 303(d) listings and TMDLs, watershed management plans, basin plan amendments, water-quality objectives, and monitoring program designs.

To determine which research and monitoring projects to pursue, the SMC is guided by an overarching roadmap known as the SMC's Research Agenda. This research planning document is developed every five years by an independent panel of technical experts and thought leaders. The expert panel begins by listening to the priorities and perspectives of SMC member agencies, then develops a list of candidate projects that panelists believe will be optimally impactful, managerially relevant, and timely for the SMC to prioritize pursuing over the next five years. Using these Five-Year Research Agendas, the SMC has previously completed an expansive portfolio of projects totaling $46 million. A 2024 SMC survey found that all 12 of the SMC projects completed over the past decade have influenced or are expected to influence the development of a management decision or program within one or more SMC member agencies.

Following the SMC's June 2024 decision to renew its Master Agreement – the legal document that establishes the SMC's existence – the SMC convened a 12-member expert panel to develop the SMC's 2024-2029 Research Agenda. The panel was made up of experts in hydrology, chemistry/ toxicology, biology/ecology, public health, engineering (BMPs), climate change, data science, economics/social science, groundwater and environmental advocacy, plus one representative each from the stormwater regulated and regulatory communities and an NGO environmental advocate. The experts came from inside and outside California.

The blend of expertise, geography, and perspectives on the 2024 panel provided the raw ingredients for development of an ambitious, technically rigorous, multi-faceted 2024-2029 Research Agenda. The Expert Panel deliberated in person for three days during an in-person September 16-18, 2024 workshop in Costa Mesa, CA. The culmination of the workshop – this Research Agenda document – is intended to pick up where the SMC's prior Research Agenda left off, expanding investments in areas where the SMC has made key progress while simultaneously pushing the SMC into new frontiers. The 2024-2029 Research Agenda consists of 20 projects organized under six thematic research areas:

1. Contaminants
2. Biology

3. Data, New Technology and Communication
4. Best Management Practices (BMPs)
5. Modeling
6. Socio-economics and financing

Every priority project is designed to generate relevant, timely data and insights that can be integrated into management decision-making and planning processes by both regulated and regulatory agencies. Additionally, while each project can stand-alone, the Panel identified important synergies and opportunities that could be realized if the SMC decides to pursue some projects in tandem or sequentially. The 20 priority projects presented in this Research Agenda are intended to serve as a menu of options and a roadmap to guide the next five years of the SMC's research directions. The Research Agenda will ensure the SMC continues to deliver relevant, impactful data and insights when stormwater managers need this information most.

INTRODUCTION

Collaboration is a powerful vehicle for creating common understanding, and the Southern California Stormwater Monitoring Coalition (SMC) stands as a testament to the effectiveness of collaborative synergy. Since the SMC's original Master Agreement was signed in 2000, the coalition has been working to fill foundational gaps in knowledge about best practices for stormwater management. Through the SMC, the region's stormwater management community has developed monitoring infrastructure, deciphered stormwater mechanisms and processes, and assessed receiving water impacts. These projects have helped both dischargers and regulators make tremendous advancements in how they prioritize and address the challenges of wet- and dry-weather runoff.

The SMC was founded on the premise that the most pressing issues in stormwater management are not localized, but cut across watershed and jurisdictional boundaries. Thus, the SMC Master Agreement – which was initially signed in 2000 and renewed in 2009, 2015, 2019 and 2024 – serves as a cooperative agreement enabling SMC member agencies to develop, implement and co-fund a mutually agreed-upon set of research projects on an annual basis. Today, the SMC's 18 member agencies represent the region's largest stormwater management agencies and the regulatory agencies that oversee them:

- County of Orange
- Los Angeles County Flood Control District
- County of San Diego
- Ventura County Watershed Protection District
- Riverside County Flood Control and Water Conservation District
- San Bernardino County Flood Control District
- City of Long Beach
- City of Los Angeles
- City of San Diego
- City of Santa Barbara
- California Department of Transportation (Caltrans)
- Regional Water Quality Control Board - Los Angeles Region (Los Angeles Regional Board)
- Regional Water Quality Control Board - Santa Ana Region (Santa Ana Regional Board)
- Regional Water Quality Control Board - San Diego Region (San Diego Regional Board)
- Regional Water Quality Control Board – Central Coast (Central Board Regional Board)
- State Water Resources Control Board (State Water Board)
- Southern California Coastal Water Research Project (SCCWRP)
- United States Environmental Protection Agency (U.S. EPA)

Indirectly, SMC member agencies represent many additional stormwater co-permittees throughout Southern California.

Focus on regional challenges

Intense urbanization within the SMC Region of southern California brings significant adverse impacts to watershed hydrology, surface water quality, and natural habitats. Increased impervious surface area causes increased runoff volumes, higher peak runoff flow rates, and reduced infiltration volumes. In addition, anthropogenic pollutants accumulate on urban impervious surfaces and are transported by surface runoff to receiving waters (such contaminants include nutrients, heavy metals, bacteria, pesticides, and petroleum hydrocarbon, and others). These urban areas were historically developed proximate to natural stream and estuary systems and encroach substantially into riparian and floodplain areas. In the early- to mid-20th century natural drainage networks in urbanizing areas were incrementally and significantly modified with engineered runoff conveyance and storage facilities to reduce risk to life and property from increased flood flows. Government entities mandated the construction of flood control facilities designed to reduce flooding during large storm events by efficiently collecting and conveying stormwater flows to the ocean. However, these engineered systems can also disrupt or bypass the natural hydrological cycle, increase flow rates and bank erosion in stream channels, degrade or eliminate natural habitat, and reduce groundwater recharge pathways. These impacts of watershed urbanization and stream system modifications are under growing scrutiny by the public, environmental groups, and regulators. More recently, climate change, economic, social, and environmental equity, and groundwater impacts, have become emerging concerns demanding increased attention and consideration in stormwater management.

Over the past 25 years, stormwater science has evolved dramatically in Southern California as a result of regulatory pressure and intense urbanization, producing an array of tools ranging from advanced monitoring technologies to improved indicators and robust assessment tools and decision frameworks. One area of rapid scientific advancements has been water quality modeling to better simulate pollutant sources and sinks, and to develop watershed planning scenarios to most effectively achieve water quality compliance. Despite these significant advancements, there remains a considerable number of issues to solve and topics requiring regional attention and further investment.

Five-year SMC research planning cycles

Central to the SMC's success is its Five-Year Research Agenda. The SMC Research Agendas are Five-Year roadmaps that identify the issues that regulated and regulatory agencies need to address, and what projects are necessary to overcome these challenges in stormwater management. They demonstrate the SMC's commitment to being proactive rather than reactive to management and regulatory needs. Each year, the SMC Steering Committee decides which research and monitoring projects to fund from the Five-Year Research Agenda. Then, the Steering Committee works with the SMC Administrator and Budget Manager to conceptualize, develop, and oversee these projects. Because the SMC does not employ full-time technical staff, the SMC awards individual research contracts to various agencies and consulting firms. Each SMC Five-Year Research Agenda is published and made publicly available. The SMC Steering Committee is not required to implement all of the research projects outlined in the Research Agenda. For the projects that are selected, SMC non-members are encouraged to collaborate.

Virtually every project the SMC has undertaken has led to some change in stormwater management and/or policy (Table 1). For example, when the SMC addressed peak flow hydromodification, the outcome was interim peak flow criteria and the development of monitoring and management tools for identifying and minimizing hydromodification impacts in at-risk stream segments. Similarly, when the SMC addressed stream biological assessments, the outcome was an integrated, coordinated regionalized monitoring program that provides holistic views of ecosystem health and has become one of the foundations of California's forthcoming stream bio integrity program. Likewise, when the SMC addressed low impact development (LID), the outcome was a practitioners' manual and training program for LID designs.

Table 1. Example SMC research projects and their management outcomes.

PROJECT	MANAGEMENT OUTCOME
Development of the SMC Data Portal and Initial Population with Regional Monitoring Data	Integrates with the California Environmental Data Exchange Network used for 305(b) and 303(d) Assessments
Water Quality Index and Visualization	Will be used for assessing the next regional stream bioassessment program results, adopted Assessment Tool by the Statewide Perennial Stream Survey.
SMC CLEAN	Helped create the Statewide LID Manual and training program
Regional Freshwater Stream Bioassessment Monitoring Project	Technical foundation for the State's pending Biointegrity Policy, Regional benchmarks for Water Quality Improvement Plans, supports regional Biotic Ligand Model default values
Toxicity Testing Laboratory Intercalibration Study	Laboratory Guidance Manual named in some permits, used for shortlisting qualified contract laboratories, supported modifications to the State's Toxicity Implementation Plan
Standardized MS4 Monitoring Program	Developed the standardized monitoring designs used in nearly all member agency MS4 NPDES Permits
Stormwater Data Compilation Study	Relative nutrient loading from stormwater deemed small compared to POTWs, effectively removing stormwater as a source responsible for ocean eutrophication issues
Effects of Wildfires on Contaminant Runoff and Emissions	Created an emergency wildfire response monitoring program used by several member agencies
Regional Approaches to Trash Monitoring and Management	Created standardized methods for ongoing NPDES and TMDL trash monitoring in California
Chemistry Laboratory Intercalibration Study	Laboratory Guidance Manual named in some permits, used for shortlisting qualified contract laboratories
Bacterial Reference Watershed Study	Created the original reference condition for bacteria targets in TMDLs used throughout southern California
Laboratory Intercalibration Study	Laboratory Guidance Manual named in some permits, used for shortlisting qualified contract laboratories
Peak Flow Impacts	Developed hydromodification assessment tools at the core of most Hydromodification Management Plans
Microbial Source Tracking Method Comparison	Identified the primary methods that are the basis of the State's Microbial Source Tracking Manual

A 2024 SMC member survey found that all 12 of the SMC projects completed over the past decade have influenced or are expected to influence the development of a management decision or program within one or more SMC member agencies.

Approach to developing the 2024-2029 Research Agenda

For the development of the 2024 Research Agenda, the SMC used a similar approach utilized in the development of previous Research Agendas (2001, 2013, 2019). Rather than SMC member agencies developing the Five-Year Research Agendas themselves, the SMC unanimously decided to bring in outside experts to provide new perspectives and a variety of opinions on the challenges faced by the stormwater sector. In this way, the SMC did not focus solely on short-term needs nor constrain themselves to their existing knowledge base. As with previous research planning cycles, a panel of technical experts was convened for a facilitated three-day workshop that included in-depth discussion on SMC management issues.

To ensure the expert panel represented all areas of expertise relevant to SMC member agencies, the SMC identified experts from 12 different subject areas (Table 2). Then, the SMC identified a short-list of candidate panel members, comprised of regional to international experts, to provide direct and broad insight on these areas. The SMC selected its top preferences and then formally invited these members to participate in a three-day workshop. The 2024 Expert Panel consisted of nine technical experts – one from each of the nine technical fields – plus three additional members to represent regulated, regulatory, and non-governmental representatives (Table 2).

Table 2. List of subject matter experts on the SMC's 2024 Expert Panel.

NAME	AFFILIATION	SUBJECT MATTER EXPERTISE
Bridget Wadzuk	Villanova University	Hydrology
Joel Baker	University of Washington	Chemistry/Toxicology
Rich Ambrose	U.C.LA. (Retired)	Biology/Ecology
Rachel Noble	UNC Chapel Hill	Public Health/Environmental Microbiology
Allen P. Davis	University of Maryland	Engineering (BMPs)
Brett Sanders	U.C. Irvine	Climate Change
Marcus Beck	Tampa Bay Estuary Program	Data Science
David Lopez-Carr	U.C. Santa Barbara	Economics/Social Science
John Izbicki	U.S.G.S	Groundwater
Lauren Marshall	California Coastkeeper Alliance	Environmental Advocacy Community
Ivar Ridgeway	RWQCB-Los Angeles	Regulator Community
Grant Sharp	County of Orange	Regulated Community

The Panel was given the charge to:

- Develop a cohesive list of project concepts that will support stormwater management needs and address issues of concern
- Create a written summary of these project concepts for future use by the SMC

The Expert Panel was told that research should be regional in scale and not focused on site-specific or statewide concerns, albeit southern California region-wide issues are a reflection of site-specific and statewide problems. In addition, the Expert Panel was told that the Research Agenda should address medium- and long-term needs, not just short-term responses to immediate concerns.

On September 16, 2024, the Expert Panel initiated its three-day workshop with testimony from two SMC member agencies (the State Water Board and Orange County Public Works) who presented short descriptions of their Agency's programs and issues confronting them now and into the future. Additional testimony was given by public speakers wishing to address the Expert Panel. Then, the panel moved to closed session, where they brainstormed and identified 59 project ideas. During the second day, the Expert Panel focused on coalescing and refining the projects into 36 project concepts, then ultimately prioritized them into 20 stand-alone projects. The third day of the workshop focused on the finalization and formalization of each proposed project for the draft Research Agenda, with a summary presentation for report-out to the entire SMC membership.

Subsequently, the draft Research Agenda, and project write-ups were sent to the Expert Panel for final review and editing prior to an SMC vote to adopt the 2024-2029 Research Agenda. Upon adoption, the SMC is planning to rank the projects; these rankings will guide decision-making about SMC projects to implement throughout the course of the 2024-2029 Master Agreement.

2024-2029 Research Agenda projects

The SMC's 2024-2029 Research Agenda consists of 20 projects organized under six thematic research areas:

Contaminants: This theme consists of two projects on contaminant sources and two on contaminant risk assessment. The first contaminant source identification project focuses on quantifying the contribution of sanitary sewer exfiltration to bacterial contaminants in stormwater. The second focuses on developing updated event mean concentrations (EMCs) for a wide range of chemical and bacterial contaminants, which were originally generated over 20 years ago. The pair of risk assessment projects focus on generating improved estimates of microbial risk in wet weather discharges and prioritizing among the many constituents of emerging concern (CECs) that could be present in stormwater.

Biology: This theme consists of three projects, all focused on biological integrity. One project focuses on unique approaches to improving biological conditions in streams with modified physical habitat. A second project focuses on how biological conditions might change in estuaries as stormwater agencies capture freshwater flow upstream. The third project focuses on biological conditions s in ecological preserves – either fresh, estuarine, or marine habitats – resulting from State mandates for ecological protected areas.

Data, New Technology and Communication: This theme consists of five projects that fall into two categories: data mining or developing new technology. The data mining projects focus on increasing the effectiveness and efficiency of current monitoring programs and finding success stories from the large backlog of monitoring data collected by the SMC. The new technology projects include an artificial intelligence (AI) project assessing the potential advancement of stormwater management through the use of AI, as well as the potential false narratives of what AI can accomplish. The other new technology projects focus on advancement in real-time sensors for monitoring and identifying barriers to e-reporting.

Best Management Practices (BMPs): This theme consists of four projects, two of which represent extensions of work already being conducted by the SMC: quantifying the mechanisms and processes that remove pollutants within a BMP for improving confidence in BMP design and quantifying the pollutant load reduction from non-structural BMPs. The other two projects represent new frontiers for the SMC: exploring new and different BMP types specifically for southern California applications and creating a BMP operations and maintenance guidance for inspection and performance assessment.

Modeling: This theme includes two projects. The first critically assesses the performance of established, routinely used modeling tools. The second links upstream and downstream water management decisions – decisions that are typically made by different water management agencies that have different missions and decision criteria, and that infrequently communicate.

Socio-Economics and Financing: This theme consists of two projects, both designed to establish methods intended for use in similar future projects. The first project focuses on establishing a framework for overcoming a difficult challenge facing most stormwater agencies: how to optimize nature-based solutions in highly urban catchments where decisions rely on more than just science. The second project establishes a framework for assessing the socioeconomic benefits of stormwater capture and use.

For each project, the Panel developed a project description comprised of a problem statement, desired outcome (products), tasks, schedule, and necessary resources (expertise, costs, and potential collaborators). The sequence in which the projects are presented does not constitute any sort of prioritization.

Interrelationships among projects

Although this Research Agenda lists 20 stand-alone projects, the projects are not necessarily meant to be conducted independently. Many of the projects are interrelated and interdependent, and several build upon existing SMC work. Some projects can share data sets, and/or are dependent on a sequence while others can be parallel. Nearly all projects feed across themes. These interrelated projects can be more cost-effectively implemented by integrating and coordinating among multiple projects, leveraging efficiencies wherever possible. Four such synergistic projects in this Research Agenda are leveraging historical data mining to produce updated land use EMCs, identify efficiencies in monitoring programs, evaluate system-wide effectiveness, and critically assess existing modeling tools. Other candidate projects are intended to be done sequentially, such as the two economics and financing studies that focus on creating a pair of management frameworks for nature-based solutions and stormwater capture/use, respectively; once either one of these projects is completed, it will inform the other.

Through the development of this Research Agenda, the SMC Expert Panel came to fully appreciate the breadth and depth of stormwater research and monitoring projects that have been completed to date. The Expert Panel believes its proposed 2024-2029 projects will extend the SMC's legacy of research excellence, providing a menu for prioritizing and selecting from among numerous potential projects. This 2024-2029 Research Agenda will also serve as a beacon to non-member collaborators who are dealing with similar issues and interested in leveraged partnership. The Research Agenda also will help ensure the SMC continues to deliver relevant, impactful data and insights when stormwater managers need this information most.

Theme 1: CONTAMINANTS

Project 1.1: Exfiltration from sanitary sewage conveyance system

Problem Statement

The SMC has previously documented frequently elevated levels of human fecal contamination and human pathogens across all of the SMC member agency's MS4 systems during wet weather. Although it has long been assumed that underground sewer pipes do not experience exfiltration at large spatial scales, emerging evidence has found that sewage has the potential to be exfiltrated and then, when it rains, make its way into MS4 systems. However, the exact mechanisms, processes, and extent of leaking pipes for how the microbial and chemical contaminants from sewage exfiltration could be making their way through groundwater and into stormwater conveyances is largely unknown. Furthermore, the relative contribution that exfiltration plays to overall loading of microbial contaminants during storms is also unknown.

Purpose/Product

The purpose of this project is to confirm, and then quantify, how exfiltrated sewage moves through groundwater and into MS4 systems. This will require the continued development of sanitary sewer specific tracers, then applying these tracers in groundwater and MS4 systems. The effort to track these tracers in groundwater can involve a range of potential study designs, ranging from relatively basic to highly advanced, depending on level of effort and detail desired.

Tasks

Task 1: Development of sanitary sewer specific markers.

HF183 is a human specific marker, but it does not tell you which human source(s) it might come from. For this project, we need a marker specific to sanitary sewers. Two sanitary sewer specific markers have shown some success in limited applications from southern California: chemical analysis using non-targeted mass spectrometry (in Ventura) and microbial community sequencing (in San Diego). There may be other microbial markers that can be implemented that are also specific to human sewage sources. This task will continue to optimize these methods for all southern California applications including sampling a wide variety of sanitary sewer locations to ensure consistency in chemical and microbial source signatures, and also a wide variety of MS4 systems to ensure the characteristic signatures of MS4 are consistently different than sanitary sewer.

Task 2: Apply sanitary sewer specific markers in MS4 systems, soils, and groundwater.

Applying these sanitary sewer specific markers in MS4 systems will confirm that sanitary sewer contributions to stormwater are widespread or a localized phenomenon. Regardless, finding sanitary sewer specific markers in stormwater (in absence of a reported sanitary sewer overflow) will confirm exfiltration as a possible source of human waste to the separate MS4 system. Where sampling indicates exfiltration may be occurring, sampling of soils and groundwater near a suspected exfiltrating sanitary sewer will provide rationale for conducting the next task.

Task 3: Measuring subsurface transport of exfiltrated sewage.

This keystone task is the most difficult. Not all sewer lines contribute equally to receiving waters assuming leaks are present. Distance from receiving waters (and therefore travel time and microbial die off) will be important along with subsurface hydraulic conditions. To build confidence in subsurface transport estimates, a trio of approaches is recommended including: 1) field experiments designed to measure exfiltration at different pipe flows and pressures, 2) column experiments designed to measure the hydraulic properties of biofilms lining pipe walls and adjacent pipe bed materials, 3) modeling experiments designed to assess the potential range of pipe leakage and the movement of exfiltrated sewage given different engineered and hydraulic settings (including pipe bed properties, aquifer properties, and saturated versus unsaturated flow conditions).

Schedule

4-5 years for all tasks, especially since some of the work needs to be completed during wet weather events. Tasks 1 and 2 should be completed in series, each building off the other to ensure the work is necessary and for optimizing task scoping. Task 3 can be completed independently – especially if it remains focused on hydrogeology - but will benefit from Tasks 1 and 2.

Budget

$950K-2.5M, dependent on the number of systems that the exfiltration measurements are conducted and level of effort expended on subsurface transport.

Potential Collaborators

This project must be completed in collaboration with the sewage collection agencies involved. . Additional collaboration from State and Regional Water Boards who regulate both MS4 and sewage agencies will be important. An engineer with experience in sewage collection system design, construction, and maintenance should be recruited to participate.

Project 1.2: Improved estimates of microbial risk associated with stormwater impacts

Problem Statement

A recently completed SMC health risk modeling study found that exposure of swimmers to 100% stormwater generated a median risk profile of 190 gastrointestinal illnesses per 1,000 recreators – well above the USEPA threshold of 32 illnesses per 1,000 recreators. But like any model, there is some uncertainty in these QMRA (quantitative microbial risk assessment) estimates . This is because estimates were concentration-based, limited to relatively few storms, and did not take coastal receiving water dynamics into account. Additionally, insufficient effort was expended to translate QMRA model results into management actions that SMC member agencies may consider taking based on this new information.

Purpose/Product

The purpose of this study is to bolster and increase the accuracy and confidence of a wet weather runoff specific QMRA and develop appropriate management responses by SMC members.

Tasks

Task 1. Improve HF183 and pathogen data in wet weather.

While the SMC's previous study was the largest in California to measure HF183 contemporaneously with human pathogens in wet weather discharges, it still amounted to 31 sites and 70 total samples over two wet seasons. Sampling more sites over a wider range of storm conditions will enhance the characterization of HF183 and human pathogens in wet weather, which helps drive recreational exposure in the QMRA. In addition, capturing multiple samples over the duration of storms will permit management agencies to improve advisories. Pathogen data will be improved using a variety of recent microbial advances in droplet digital polymerase chain reaction (ddPCR) analysis such as additional concentration steps and hyperwelling to improve measurement sensitivity (lower detection limits). Additional steps should be taken to conduct shotgun sequencing to quantify pathogenic traits of specific bacterial and viral pathogen targets, thereby closing the gap between molecular detection and viability

Task 2. Improve QMRA model input using information about pathogenicity and estimates of exposure

Improve dose response estimates, possibly through assessment of pathogenicity, and revisiting swimmer demographics and behaviors will be valuable input to improve estimates for different recreational activities.

Task 3. Incorporate upcoast downcoast fate and transport characterization of bacterial and viral pathogens.

The previous SMC study examined recreational exposure to wet weather runoff, but recreators typically do not swim in flood control channels when it is raining. Thus, the previous SMC study quantified the recreational risk for varying dilutions of wet weather runoff with pathogen-free water. While helpful to determine what a minimal dilution would be to achieve an HF183 threshold, this dilution calculation does not take human behaviors into account. Some directed research with direct quantification of pathogen targets at locations upcoast, downcoast, and offshore from discharge points will improve the accuracy of risk characterization at specific swimming beaches.

Task 4: Mine available data on illness case, outbreak, and Emergency Room data from California Department of Health Services (CA DPH) for water recreators following storm events

It is important to place stormwater data generated using molecular tools for pathogen quantification into disease outcome context, so that management decisions and communication can match the magnitude of the problem. Some information may be gleaned about illness rates from CA DPH. Obtaining information on reported cases associated with swimming and surfing along coastal counties following wet weather may help support or oppose QMRA results. Examples such as ER records, publicly available International Classification of Diseases (ICD) codes, reported outbreaks associated with recreational water, or physicians notes along with stool samples could be useful for understanding exposure and specific pathogen infection rates.

Task 5. Management options for utilizing QMRA output.

While the previous SMC study estimated some risk-based thresholds for HF183 in wet weather discharges, it stopped short of developing the practical implementation of such a threshold. In order to make sure any risk-based threshold is utilized appropriately, the stormwater management community must decide how the QMRA model output should be applied. Challenging implementation issues are numerous such as: single samples vs geometric means, frequency vs locations of sampling, incorporating dry and wet weather vs wet weather only, action levels vs TMDL targets vs water quality objectives. Each of these can dramatically affect how managers may respond to a risk-based threshold.

Schedule

Three years depending on wet weather sampling, and the tasks can be selected independently.

Budget

$950,000-$1,200,000 especially depending on level of effort in Task 3. Individual tasks can be funded at a much lower cost.

Potential Collaborators

City and County monitoring programs for wet weather sample collection, highly qualified laboratory for microbial targets, regulators/regulated/public health agencies for Task 5.

Project 1.3: Updating Land Use Event Mean Concentrations

Problem Statement

Event Mean Concentrations (EMCs) – a foundational metric used by most SMC member agencies for watershed modeling, Water Quality Improvement Plans, Total Maximum Daily Loads, and BMP design, among others – were developed roughly 20 years ago. Since that time, land uses in southern California have changed, BMPs have been implemented at scale, building codes have morphed, and pollutant sources have evolved. Thus, it is necessary to update EMCs to ensure the most accurate information gets used across all relevant applications.

Purpose

The purpose of this project is to produce updated EMCs that will, in turn, more accurately and comprehensively inform stormwater management. The updated EMCs can be achieved through mining existing data and possibly new data collection where data gaps occur.

Tasks

Task 1. Gather existing data

Ideally, most of the necessary data already exists between: (i) SMC member agencies' regularly collected wet weather monitoring data, (ii) data from special studies, and (iii) non-SMC member monitoring data. Land use data from existing GIS and high-resolution satellite imagery (for more recent detailed information), rainfall, flow, pollutant concentrations, and metadata such as sampling design, laboratory methods, and quality assurance requirements, would all be necessary and useful data types.

Task 2. Review existing data for gaps

After compiling the regional data sets, the data should be examined for data gaps such as missing land uses or missing contaminants. Data gap examinations should be particularly focused on land use subcategories not previously well studied (i.e., schools or roadways/highways), equity / environmental justice considerations, and constituents of emerging concern (i.e., microplastics, 6PPD-Q, PFAS). Where data gaps exist, the SMC should consider collecting additional data to fill these gaps.

Task 3. Mine compiled dataset for patterns, trends, correlations, and anomalies.

The regional data set will be particularly useful for spatial and temporal analysis of patterns and trends. Examples of this analysis include: pollutant levels and land use distributions within each monitored catchment area, pollutant levels and precise land use categories and subcategories, pollutant levels in inland versus coastal areas, and identifying outlier data. De-trending data sets where explainable factors prevail will produce more accurate EMCs in the following tasks.

Task 4. Calculate updated EMCs for each pollutant / land use pair

The final task is to calculate the EMCs – including estimates of uncertainty - for each pollutant for each land use category. This data analysis may be straightforward if sampled catchments are comprised of a single predominant land use. But where mixed land uses occur, advanced statistical methods such as machine learning or regression classification trees might be necessary so mixed land uses can be separated *post hoc* to identify land use specific EMCs. Regardless if simple or advanced techniques are used, this task will require splitting the database into two parts: one for calibration and one for validation.

Schedule

2 - 4 years, depending on data availability and whether new data is required.

Budget

$400,000 - $1,500,000, depending on whether new data is required.

Potential collaborators

SMC members and other monitoring agencies to supply existing data sets.

Project 1.4: Develop risk-based approaches to contaminants of emerging concern

Problem Statement

Traditional risk assessment approaches for stormwater contaminants focus on individual chemicals – a management paradigm that is ill-suited for effectively characterizing and managing the complex pollutant mixtures found in stormwater. But emerging approaches have the potential to enable the discovery of thousands of anthropogenic chemicals in stormwater, including non-targeted approaches to mass spectrometry and artificial intelligence approaches that use large language models. These potential solutions offer a way out of the longstanding "needle in the haystack" problem.

Purpose

The purpose of this project is to provide stormwater managers with a rational risk-based way to deal with detection of complex mixtures of unregulated chemical pollutants in stormwater. This approach will guide responses (stormwater BMPs, waste disposal, consumer education, product substitution, etc.) that are prioritized and proportional to risk.

Tasks

Task 1. Non-targeted spectrometric analysis.

Augmentation of existing stormwater monitoring programs to include non-target mass spectrometric analysis designed to characterize the complex mixture of man-made chemicals in stormwater samples. This task does not require additional field sampling but will require modification of laboratory workflows to provide samples for non-target analysis, and to determine the sensitivity of new chemical target groups in stormwater. These data sets will then be analyzed using existing mass spectral databases to determine the predominant individual anthropogenic chemical components within the stormwater samples.

Task 2. Identify key species of concern.

This task will help the SMC identify what components of the ecosystem they are most interested in protecting. The aim will be to coordinate with natural resource scientists and programs to identify key species in stormwater-dominated systems (e.g., pollution sensitive species in the California Stream Condition Index, or CSCI , standard toxicity test organisms, etc.).

Task 3. Use AI to identify toxic chemicals to key species.

Combine existing ecotoxicological databases (such as EcoTox), molecular modeling, and large language models to determine the relative risk to key ecological species of the predominant individual chemicals detected in stormwater.

Task 4. Create a simplified toxicity assessment tool for assessment and communication.

While the technical elements of the previous three steps require extensive expertise, a simple straightforward way to assess and communicate the risk of the potentially hundreds to thousands of unknown chemicals in municipal stormwater is necessary. To achieve this goal, a weighted toxicity index for CECs in stormwater is recommended, providing a simple way to assess spatial and temporal trends in stormwater impacts and to evaluate the effectiveness of pollutant control strategies.

Schedule

2 – 3 years. This work should be done in sequential phases. Tasks 1 and 2 can be completed in the first one to two years. Years two and three can be used for Tasks 3 and 4.

Budget

$450,000 - $900,000, depending on availability/access to experienced mass spectrometry lab, plus an advanced data analyst.

Potential Collaborators

A qualified mass spectrometry laboratory experienced in characterizing wastewater and/or stormwater are relatively rare and often found at Universities. Additional collaborations with an ecotoxicological working group would be recommended.

Theme 2: BIOLOGY

Project 2.1: Meeting biological expectations in urban streams

Problem Statement

The San Diego Regional Water Quality Control Board recently became the first in California to propose a water-quality threshold for urban streams based on California Stream Condition Index (CSCI) scores – a biological scoring tool that may be applied to other regions in the future. As a result, there is growing interest in understanding the most effective management options that could be implemented to meet this threshold – either through water quality improvements alone, or in combination with stream restoration work.

Purpose

This project would address two questions: one focused on the potential for meeting the CSCI threshold by water quality improvements alone, and one focused on the potential for meeting the CSCI threshold by stream restoration. The product would be a final report with project findings and recommendations, which will help regulators and regulated communities understand how CSCI thresholds might be met.

Tasks

Question 1: Can CSCI thresholds in urban streams be met by water quality improvements alone?

This question can be answered using two different approaches. The first is to continue the methods currently being pursued by the SMC, namely comparing water quality measurements to CSCI scores across a range of stream conditions and stressors. Additional effort may be necessary to supplement the data set with new water quality data. The advantage of this approach is that the streams are in a realistic condition, but have so many co-stressors that the effect of water quality may be muted.

The second approach is to experimentally test effects of water quality on biological communities using mesocosms. This will require setting up an outdoor experimental stream mesocosm, which are not easy but have been used in research around the country, including California. Then, the effect of water quality can be directed tested by altering the water quality. While less realistic than actual streams, all other potential confounding factors are held steady and only the effect of water quality will be tested.

Question 2: How does restoring urban streams improve biological conditions in urban streams?

This question can also be answered using two different approaches. The first approach is to continue the methods currently being pursued by the SMC, namely analyzing the existing database on stream conditions and stressors to assess possible effects of restoration. The analysis could focus on streams with physical conditions representative of restored sites as a proxy for restoration sites.

The second approach is to sample restored streams before and after restoration to assess the effect(s) of restoration on stream condition. This approach will require identifying sites well ahead of restoration to quantify pre-restoration conditions, and then for several years post-restoration to see if/how stream conditions improve. This is a much more powerful approach compared to the first option but will take more time and coordination with Regional Boards and US Army Corps of Engineers (USACE) to identify upcoming restoration sites. A sample size of around ten sites would be appropriate. A control/reference site should be sampled at the same time as the restoration sites to account for regional temporal conditions (such as drought or high-rainfall years).

Schedule

Approximately two years for Question 1. Question 2 is roughly five-ten years, depending on when sufficient restoration sites can be identified and constructed.

Budget

The budget for Question 1 would be $150,000-$250,000 depending on how many microcosms are needed. The budget for Question 2 would be roughly $300,000.

Potential Collaborators

At a minimum, the restoration permitting agencies (RWQCBs and USACOE) and the restoration permittee will need to be collaborators.

Project 2.2: Ecohydrology in estuaries

Problem Statement

As stormwater capture and/or infiltration practices grow in southern California, stream flows into coastal estuaries will be reduced, potentially disrupting these critical, ecologically fragile habitats. Reduced stream flow, for example, affects estuarine salinity, which is a major driver of ecological diversity within these habitats. While the SMC has already invested in understanding the ecological effects of changing flow patterns on streams, little research has been conducted on the ecological consequences for estuaries.

Purpose

The purpose of this project is to understand the effects of reduced flow on estuary function and biodiversity. Because California has a wide variety of estuary types (i.e., closed vs open berms), with a wide variety of freshwater inputs, the study must include a range of estuary types. Moreover, because it's not possible to experimentally alter stream flows into estuaries, hydrological/hydrodynamic modeling will be used to project the changes in physico-chemical conditions in estuaries resulting from reduced freshwater input, and then the ecological effects inferred from the changes in physical conditions. The final product would be a report with recommendations, mainly to see if we should be concerned about the ecological effects of reducing flow into estuaries and providing recommendations of preferred flow conditions for different types of estuaries.

Tasks

Task 1. Estuary selection.

Because there are a variety of estuary types with a variety of stream flow inputs and habitats, the first task will be to select the estuaries to be modeled. A range of estuary types is recommended to ensure the magnitude and potential extent of ecohydrology impacts can be assessed.

Task 2. Collect data to create the estuarine hydrodynamic model.

Many estuaries have already been hydrodynamically modeled, so this task may not be too involved. But once the estuary(ies) has been selected, available data will need to be compiled for calibration and validation of estuarine model(s). If data does not exist, additional data collection may be required. Model upgrades may be necessary to ensure habitat delineation is captured and address climate change related sea level rise.

Task 3. Collect data to create the watershed hydrodynamic model.

Estuarine hydrodynamic models can be driven by empirical measurements of streamflow inputs, but if scenario planning is important such as stormwater capture, then a watershed hydrodynamic model will be necessary. This will be especially important for dry weather flows, which typically requires lots of data collection. Many watersheds have existing models, which may be sufficient. Model upgrades may be necessary to explore scenarios using planned runoff capture or flow modification due to future BMP implementation or watershed development/redevelopment.

Task 4. Hydrodynamic modeling for ecological consequences.

Build the hydrodynamic model of the estuary (and optional watershed) to see how changes of flow into the estuary would change; (1) physico-chemical conditions, particularly salinity, which would affect estuarine species such as cordgrass, and (2) berm dynamics (for intermittently open estuaries). The projected changes should be evaluated in the historical context of the estuary (especially berm dynamics for intermittently open estuaries). The model output should be evaluated for optimizing a variety of ecological niches and particularly for ecological tipping points. A range of different ecological tools and models are available for this task.

Schedule

2 years.

Budget

$100,000-$400,000 depending on the number of estuaries modeled, watershed models to be developed, and if hydrologic data collection is necessary.

Potential Collaborators

Southern California Wetlands Recovery Project, California Coastal Conservancy, Ocean Protection Council.

Project 2.3: SMC linkage to California's 30 x 30 goals

Problem Statement

The State of California's goal of protecting 30% of its area by the year 2030 – known as "30x30" – has the potential to significantly affect stormwater management, as pollutant input from upstream watershed areas cannot be minimized solely by management actions within 30x30 protected areas. Thus, there may be new attempts to reduce pollutant inputs, including by reducing and controlling stormwater inputs, in both inland areas and coastal areas. As the State rolls out its 30x30 plans in the coming years, the SMC should be kept up to date and stay connected and engaged in these planning processes.

Purpose

This project is meant to keep the SMC informed about the State's 30x30 process by producing periodic reports to the SMC about aspects of the 30x30 process that might concern them.

Tasks

Task 1. Inform the SMC about the 30x30 process, including goals, conservation criteria, and schedule.

The SMC will need to come up to speed on the 30x30 process, which can be accomplished through a series of activities including private briefings, inspecting planning documents, assessing current literature, legislative reviews, and guest speakers, amongst others.

Task 2. Participate in the State's 30x30 workshops, briefing, and working groups.

The State's 30x30 process is meant to be a fully transparent public process. Thus, there are many opportunities to get involved at any number of levels. To our knowledge, no other stormwater agency is actively involved in this process.

Task 3. Updates to the SMC Steering Committee

Updates to the SMC Steering Committee are the primary pathway for information transfer, especially as many milestones and decisions are in flux. Quarterly updates are recommended, especially at the beginning.

Schedule

The schedule depends on how quickly the State develops its 30x30 plan, but probably about one to two years.

Budget

$15-30K per year for tracking the 30x30 process.

Collaborators

CNRA, OPC, California Biodiversity Council, 30 x 30 Regional Working Group

Theme 3: DATA, NEW TECHNOLOGY, AND COMMUNICATION

Project 3.1: Identifying efficiencies for routine monitoring programs

Problem Statement

Stormwater monitoring programs are inefficient if the sampling frequency and the number of sampling sites are not optimized to answer the specific management questions the program is designed to answer. The key to being able to answer questions like "How many samples do I need per year to detect a trend?" or "How many samples do I need to determine if I am in compliance?" is to turn to statistical power analysis, a data analysis tool that can make explicit sampling design recommendations. However, stormwater managers have historically lacked the resources and expertise to conduct these analyses on their own.

Purpose

This project will develop a framework and series of web-based tools to provide quantitative recommendations for improving sampling efficiency and effectiveness so the SMC can modify their monitoring programs to robustly inform decision-making with optimal confidence.

Tasks

Task 1. Identify the common monitoring questions across SMC agencies including the questions that the monitoring should answer

NPDES-required monitoring and reporting programs vary from permit to permit, but there are some similarities across all of the SMC member agencies. This task will identify these similarities and most importantly define the management questions they have in common. These management questions will be the focus for the following tasks.

Task 2. Inventory existing monitoring data

Before statistical power analysis can be performed, the pertinent data associated with each management question needs to be compiled. These data can be compiled by each agency or by a single contractor.

Task 3. Run power analysis and generate recommendations for adjusting sampling effort

Power analysis is a well-established statistical tool for optimizing sampling effort in monitoring programs. Power analysis can determine the optimal sample sizes and frequency for a variety of commonly asked questions in NPDES programs such as detecting trends, determining the differences between two sites or watersheds, and whether a site is above/below a threshold of concern. Power analysis can be used for most any type of data including pollutant concentrations, bioassessment scores, trash, bacteria, volume capture, etc. Power analysis can account for potential confounding factors such as differences in rainfall, changes in land use, or implementation of management actions. The key to power analysis is using the data compiled in Task 2, so the sample size optimization is based on existing information.

Task 4. Create web-based tools to communicate results

Especially if users do not want to submit their data to a single unified database and prefer to run the power analysis from their own desktop, web-based tools are the way to go. These tools would ask users to upload their own data using a standardized data format and the web tool will automatically generate power curves quantifying sampling effort *vs* the ability to answer the management question of interest. The value of the web tool is the production of agreed upon data visualizations, allowing regulators and regulated to discuss sample size requirements based on the outcome of the power analysis as opposed to arguing about how the analysis should have been done and what does it mean. If this task is implemented, long term maintenance of the web-based tools should be incorporated.

Schedule

2-3 years depending on the number of management questions and data sets to compile.

Budget

$150,000 - $225,000

Collaborators

This project will require a skilled programmer and statistician. Examples of this work currently exists for North Orange County as preliminary example for further scope refinement.

Project 3.2: Identifying barriers to e-reporting

Problem Statement

SMC members – both regulated and regulatory – have repeatedly said that annual reporting is not efficient, effective, or inexpensive in its current form. However, the SMC's attempts to develop and implement e-reporting have been met with mixed success. Although the SMC's regional stream monitoring program is integrated with the SWRCB's SWAMP program, the SMC's recently completed streamlined annual reporting project did not meet everyone's needs, and future e-reporting requirements from EPA (via SMARTS) are expected. Developing consistent workflows or toolsets that meet the needs of multiple entities requires facilitated and proactive communication to identify common objectives that can be applied in workflows that facilitate e-reporting.

Purpose

The goal of this project is to facilitate communication among data providers and the agencies that receive the information. The outcome is to create a workplan for adapting or improving online tools to implement e-reporting, including the anticipated implementation of state-mandated reporting platforms such as SMARTs.

Tasks

Task 1. Convene a workshop of affected agencies and stakeholders

Communication starts with getting everyone facing e-reporting challenges in the same room. This project should aim to host a workshop of regulated and regulatory parties, which could extend beyond the SMC members. The workshop should identify current reporting challenges and anticipated future needs including identification of available data vs what is required for reporting. This workshop might last more than one day.

Task 2. Create a workplan with recommendations to overcome barriers to e-reporting.

The workshop output should be a set of guiding principles and specific recommendations on how to overcome the barriers to e-reporting. The workshop document should also include a workplan or strategy about how to overcome these barriers. The workplan content can address improving existing data tools, satisfying reporting needs, and providing analytics to support permittee decision-making.

Schedule

Approximately 1 year, including the review of the workplan by workshop participants.

Budget

$50,000-$100,000 depending on workshop length and honorariums/travel expenses.

Collaborators

At a minimum, this workshop should include decision-makers from the SMC regulated and regulatory members, and representatives from state waterboard and EPA e-reporting units.

Project 3.3: Evaluating system-wide effectiveness through data mining

Problem Statement

Progress toward improving water quality is often measured and reported at the permit level. However, the effectiveness of management actions is not necessarily detected at this level. For example, one-off activities may not produce a measurable impact for a permittee, while the collective benefit and cumulative effects of actions across a region might be detected at the receiving water scale. Similarly, reporting on structural BMPs that treat runoff from defined land areas typically takes place at the time scale of storm events, while public education programs may take years to change collective behaviors. SMC member agencies lack the tools and frameworks for taking on such investigations at insightful, relevant spatial and temporal scales.

Purpose

The project will produce a framework and tools for quantitative analysis of spatial and temporal trends in receiving water quality, based on the collective range of water quality-related activities implemented across the watershed or subwatershed scale. Collating information across member agencies is anticipated to enable comparisons of different approaches resulting from different permits, which should better inform future program implementation measures across the region.

Tasks

Task 1. Develop a spatial inventory of programmatic implementation activities.

The regulated SMC members conduct a tremendous amount of stormwater management activities such as the number and frequency of inspections, locations of public education campaigns, routes and frequency of street sweeping and catch basin cleaning, locations of structural BMP implementation, etc. The cumulative effect of these activities on water quality or runoff volume has not been well-documented. This task aims to compile all of the programmatic activities in a spatially defined database.

Task 2. Collate outfall and ambient monitoring data in the same spatial platform.

If the programmatic activities are the drivers of change, then outfall or receiving water data are the response factors of change. This task will collate outfall and receiving water data to see if implementation activities are related to changes in water quality and runoff volume in Task 3.

Task 3. Use advanced data analysis tools to relate changes in water quality or volume to implementation activities.

One reason changes in water quality or runoff volume have not been widely observed to date is because of small sample sizes, a large number of confounding factors, and the inherent variability of stormwater data. This task will use a combination of GIS and advanced statistical techniques (i.e., multiple linear regression, random forest, LASSO, etc.) to capture and remove the variability of confounding results, then clarify and quantify changes in water quality based on the implementation activities upstream. For example, advanced trend analysis might answer questions such as "is the number of inspections AND the miles of street sweeping in a catchment resulting in a detectable trend in water quality?"

Task 4. What have we learned?

This task will produce recommendations as to where changes in efforts in individual programmatic activities might provide the most benefit to SMC agencies. This task can also identify if/where inequity emerges in the resources allocated to water quality improvement initiatives across watersheds.

Schedule

4-5 years. It will take 2 years to compile all of the data, and another 2 years to analyze the data and inform the member agencies for generating the recommendations.

Budget

$250,000 - $400,000 depending upon how many watersheds and how many implementation activities are selected.

Collaborators

At a minimum, collaboration with the agencies conducting the implementation activities and the outfall monitoring will be required. GIS and advanced statistical skills will be required.

Project 3.4: Real-time monitoring and sensor technology

Problem Statement

Real time monitoring and sensor technology (i.e., sensors and communications) has evolved sufficiently to potentially increase the efficiency and effectiveness of costly, traditional data collection/surveillance monitoring (e.g., outfalls, ambient monitoring, illicit discharges). However, for SMC member agencies to make smart, strategic decisions about if and when to invest in advanced sensing technologies, there are substantial development needs ranging from data types to be monitored to data management and visualization, all in an effort to efficiently turn the firehose of data into easily digested information.

Purpose

The purpose of this project is to develop hardware and software solutions to streamline data collection and data processing for a range of SMC monitoring initiatives. The project ultimately aims to reduce the long-term costs of monitoring and data wrangling and use case studies to demonstrate the level of effort required to develop, deploy, and maintain these new technologies.

Tasks

Task 1. Identify opportunities

There are a lot of sensor types and potential applications. Priority will be placed on sensors built from open-source hardware, which can drastically reduce the cost of instruments. Likewise, sensors offering remote access and near-real-time communication capability will be prioritized to reduce the labor required to obtain data collected by the sensors.

Task 2. Automate raw data processing

Automated sensors typically generate large amounts of raw data. In some cases, only subsets of data are of interest, for example wet weather versus dry weather water quality. Continuous data often needs to be condensed into summary statistics for interpretation, such as average daily flow or proportion of time a water quality parameter exceeds a threshold. Translating raw data into useable information for decision-making is a challenge when done manually. This task will develop calculators to automate raw data processing into actionable information for the sensor applications prioritized in Task 1.

Task 3. Develop a workflow for data management and storage

This task will integrate raw data processing from Task 2 into a prototype information and data management system for storage, and will automate the data querying/interpretation for seamless interpretation. Open-source solutions that offer ability to integrate multiple data streams will be prioritized for adoption from available repositories or for development. Ultimately, SMC managers should expect dashboard alerts, alarms or warnings when sensor data is identifying conditions of concern for applications such as illicit discharge detection, and/or summary statistics for applications such as compliance reporting and trend tracking. Coordination with SMC member agencies' IT/IM teams is essential to ensure that the end product(s) are compatible with existing operational systems.

Task 4. Case studies.

Example implementation of sensors is the only way to determine if this new technology can actually save time and money, while delivering actionable information. A handful of sensor applications across a variety of conditions will accomplish this task, with the added benefit of providing more realistic level of effort and costs required to develop and deploy the infrastructure needed to automate sensing (i.e., sensor installation, communications protocols, sensor maintenance, power availability, etc.) and data processing.

Schedule

3-4 years, including background work on sensor selection, workflow development, and at least one case study.

Budget

$200,000-$400,000 depending upon the number of sensors, status of workflow development to date, and number of case studies.

Collaborators

SMC members with an interest in sensor technology, sensor vendors (i.e., BoSL, In-Situ, Campbell Scientific, etc.).

Project 3.5: Advantages, limitations, and unintended consequences of artificial intelligence

Problem Statement

Artificial intelligence (AI) methods for quantitative data exploration and analysis have evolved dramatically in recent years, demonstrating great potential for improving the distillation of information from complex data sets. However, misperceptions of the abilities of these tools and how they differ from more conventional AI methods have led to their misuse and over-application. Before managers consider using AI tools, they need to understand the potential advantages and limitations of these tools, as well as when these tools are appropriate or inappropriate, particularly as the technology continues to evolve.

Purpose

Increase awareness of SMC partners on the appropriate application and limitations of generative AI technologies. If successful, one outcome would be a follow-on project conducting an AI test application.

Tasks

Task 1. Convene a working group

The first step in this largely informational project is to convene a working group comprised of subject matter experts on AI methods and stormwater experts. This working group will be charged with identifying the opportunities and limitations of AI in stormwater applications. For example, the working group should create an inventory of existing tools, including generative AI, which could be applied to address challenges in SMC monitoring and assessment activities.

Task 2. Conduct a one-day seminar series

This seminar series will be used as an educational opportunity for SMC member agencies (opportunities for Professional Development Units should be explored). The SMC may also want to invite non-member agencies (which can also be used for cost recovery). The seminar series will present the background, methods, and potential opportunities of AI. The aim will be to ensure SMC member agencies can understand and responsibly choose AI in future activities. A workshop report will be produced for documentation and distribution.

Schedule

1 year, including multiple working group meetings to generate the workshop agenda and content.

Budget

$75,000-$100,000, depending on the size and make-up of the Working Group.

Collaborators

This project will require local and/or national academic experts on AI methods and SMC partner agencies with sufficient knowledge about IT resources to interact with AI experts.

Theme 4: BEST MANAGEMENT PRACTICES (BMPs)

Project 4.1: Expanding the BMP toolbox

Problem Statement

Managers rely on structural BMPs as a foundational solution for achieving water-quality improvement goals, but only a limited set of BMPs has been vetted and adapted for use in southern California. Additional BMP types could be adapted for use in this semi-arid climate, and new BMP types could be designed with the region's unique environment in mind. For example, managers could benefit from new treatment integrations (e.g., UV/LED treatment within existing BMP types), and designs capable of providing multiple benefits (e.g., stormwater management and energy generation, or pollutant management and ecosystem protection). Expanding the capacity of the BMP toolbox has the potential to enable southern California to better meet its water-quality targets while providing multiple benefits.

Purpose

This project will create a prioritized list of new, different, and/or redesigned BMPs for future exploration and assessment in southern California watersheds such as green roofs and permeable pavements. This list of new BMPs specific to southern California can be lab and/or field designed and tested in subsequent projects.

Tasks

Task 1. Investigate the suite of existing BMPs and demonstrate adaptation needs and effectiveness for Southern CA.

While southern California watersheds primarily use either biofiltration or infiltration BMPs, a wide variety of BMP designs are available that have not been rigorously evaluated or tested by SMC members. Most of these alternative BMPs have been developed primarily for the US East Coast environment, which does not have the same set of climate and regulatory conditions as southern California. This task will create a summary of existing BMPs in use globally , and what adaptations could be applied – including potential benefits/costs - for southern California.

Task 2. Ideate on new BMPs concepts specific to southern California.

This task aims to move beyond what has occurred elsewhere and develop alternative designs for new BMPs that focus on southern California's primary goals of climate resiliency, water quality treatment, and stormwater capture. Modeling efforts could support the early design phase of new BMP types and the potential for further investigation.

Task 3. Develop a process for BMP decision making.

This task aims to develop a decision analysis tool capable of selecting the new or modified technology for further investigation. Decision making criteria to help contextualize the utility of different BMPs can include pros/cons, constraints, climate, O&M needs, required space, and ability to integrate with other BMPs.

Task 4 (optional). Initiate a physical pilot program for new BMPs or monitoring study to quantify BMP benefits for decision support under Southern CA conditions, if needed.

Once this project is completed, a new project should be initiated to develop a physical pilot program for new BMPs or monitoring study to quantify BMP benefits for decision support under Southern CA conditions.

Schedule

1-2 years, depending on how many new BMPs are ideated and how much modeling they require.

Budget

$150-200k

Potential Collaborators

The selected contractor will need an expansive knowledge of BMP applications nationally to internationally.

Project 4.2: Quantify load reductions from non-structural BMPs

Problem Statement

The SMC recently invested in a foundational study to develop a standard procedure for quantifying the effectiveness of street sweeping in removing pollutants that would otherwise end up in storm drains. Preliminary results indicate that street sweeping's effectiveness can be quantified – a significant finding given that scientifically defensible data on how to award stormwater load reduction credits for street sweeping based on runoff concentrations have never been available in southern California.

Purpose/Product

This project would extend the existing non-structural project implemented by the SMC to include additional non-structural BMPs, additional pollutants, additional pollutant generation/sources, and additional climate characteristics. The product of this project is a document that provides quantitative pollutant load reductions based on specific non-structural BMP actions, with an initial project on street sweeping.

Tasks

Task 1. Measure street sweeper performance under different conditions.

Building on a prior SMC project constructing and validating a rainfall generator, this task would complete a rigorous testing program evaluating street sweeping effectiveness at multiple sites in SC. Sweeper performance would be based on differences in pollutant concentrations and/or loads between runoff generated by the rainfall generator (which is the unique aspect of this project) over swept areas compared to areas that are not swept. The study will address the parameters of interest, including sweeper type, time of year, number of sweepings, timing of sweeping based on rainfall, land use, traffic density, etc.

Task 2. Quantify load reductions based on street sweeping.

Based on the Task 1 studies, make recommendations on street sweeping numerical stormwater load reductions for various sweeping operations/management options.

Task 3. Design and recommend a follow up project quantifying the benefits of catch basin cleanout using the similar procedures with the rainfall generator.

Similar to the street sweeping study, use the rainfall generator to apply rain to areas near catch basins before and after catch basin cleanout. The amount and type of material removed during the cleanout would also be quantified. Effectiveness of clean out would be based on differences in pollutant concentrations and/or loads leaving the basin before and after the cleaning. The study will address parameters of interest, including catch basin type, time of year, mass and type of material removed from basin, timing of cleanout based on rainfall, etc.

Schedule

2 years, accounting for labor intensive sampling that is limited to certain times of year.

Budget

$400-500k depending on number of pollutants measured, and sweeping/catch basin and climate variables tested.

Potential Collaborators

Collaborating SMC member agencies are required for sampling sites and sweeping/clean out. Additional collaborators can include street sweeping manufacturers or service vendors.

Project 4.3: BMP operations and maintenance (O&M) guidance for inspection and performance assessment

Problem Statement

Managers lack comprehensive, rigorously vetted guidance for how to inspect, operate and maintain BMPs to optimize performance over time. However, knowledge has been growing in recent years, and municipalities are increasingly collecting BMP operations and maintenance (O&M) data sets. Thus, there is an opportunity to compile these insights and develop comprehensive regional studies shedding light on O&M best practices for BMPs across southern California.

Purpose/Product

Collated guidance document of collected best practices for inspection, operation, and maintenance that is then made specific to the Southern California environment . This guidance should include best practices of data collection for inspection and O&M programs to inform enforcement, future design/O&M practices, and provide indicators of performance failure and success. The creation of this guidance document may lead to recommendations for future study.

Tasks

Task 1. Prioritize a list of commonly used BMPs

The aim of this task is to develop a list of commonly used BMPs and prioritize BMPs for O&M review (including trash collection systems).

Task 2. Literature compilation

This task will build on existing local O&M knowledge for prioritized BMP types in Task 1 by conducting a literature review of international, national, and other state guidance on O&M with a focus on the impact of the O&M action and the transferability to the Southern CA environment. Identification of existing data sets that link inspection and maintenance activity to BMP performance will be specifically targeted. The Literature review should include a qualitative assessment of the benefits of O&M on extending the longevity and episodic performance of BMP systems.

Task 3. Develop a standardized inspection and inspection data collection system.

This task will identify key inspection elements for different types of BMPs based on case studies in other municipalities. The aim will be to develop an inspection protocol with informative and consistent scoring, notation, and data collection and management. Then, SMC agency staff will be trained on inspection procedures and data collection protocols.

Task 4. Recommendations on gaps in BMP type and O&M impact for future study

The literature review will likely lead to identifying data gaps between maintenance activity and actual performance. A metric quantifying BMP performance needs to be established, such as extending the time between major renovations/capital projects or lack of substantial failure.

Task 5. Assess the impact of O&M inspection on BMP performance

This task will use existing inspection data analysis structures, or modify for the Southern CA inspection plan, to assess the impact of inspection on BMP performance. This step will include statistical, regression, or AI data analytics to connect inspection ratings over time to performance. A semi-qualitative metric can be developed to indicate if an inspection and follow-up maintenance activity was successful, marginally successful, or a failure.

A companion project to the statistical analysis of linking inspection to performance would be to identify several example BMPs which are targeted for maintenance and to do a follow up post maintenance inspection and a quantitative assessment. This step would provide additional confidence in use of the semi-qualitative statistical inspection to predict performance. It is recommended to complete this effort on the three most commonly used BMPs.

Schedule

3 years, including the inspection data collection and analysis

Budget

$300-$400k dependent upon the level of effort for inspection data collection and analysis

Potential Collaborators

Possible pieces of this work would be attractive to other collaborators, including academics and other municipal agencies.

Project 4.4: BMP mechanisms and processes

Problem Statement

The SMC recently invested in an ongoing study that is working to open the “black box” around how BMPs perform, with a focus on understanding the effectiveness of different designs in removing different types of pollutants. While important progress has been made toward understanding BMP mechanisms and processes, this is a very complex topic and the initial SMC study will not be sufficient to develop comprehensive understanding of how to optimize the design and performance of all BMPs in southern California.

Purpose/Product

This project builds upon and expands an existing SMC project on BMP mechanisms and processes by including more pollutants, more BMP characteristics, and more BMP conditions. This project will provide science-based information on pollutant removal mechanisms in stormwater BMPs. The product from this project is a guidance document or decision support tool providing design and performance information on BMPs for SMC use.

Tasks

This is overall a major project. Several sub-projects are included to expand and broaden the scope and the final utility of the product.

Task 1. Literature review.

A literature review is needed to compile existing information on mechanisms of pollutant removals based on treatment systems in various types of waters (other than stormwater) and fundamental pollutant properties. From this information, a tool can be developed to guide the treatability of existing and emerging contaminants of concern using different BMPs based on information on correlating chemical structures/characteristics.

Task 2. Lab studies on treatment effectiveness.

Information gleaned in Task 1 will be used to design and implement lab studies on treatment effectiveness with a focus on understanding scientific mechanisms. A wide range of variables to test include: (A) different pollutants, but based on pollutant characteristics/properties (e.g., sorption potential, polarity, biodegradability, etc.) instead of a particular pollutant (e.g., metals, organics, nutrients, bacteria, CEC); (B) different BMP types – such as adsorption media, designs to promote biological processes, and; (C) different flow regimes (e.g., design events and antecedent dry times) and pollutant concentrations.

Task 3. Development of fundamental mechanistic models

Once the mechanisms and process are quantified, the next step is to develop fundamental mechanistic models to describe the treatment processes. These models will be used to be scale treatment up to the field. Variability will be included in the analysis and the output to account for variable hydrology and water quality experienced in field installations. One way to address this is the development of percent exceedance curves for suites of contaminants. This will be used to evaluate confidence in meeting specific water quality goals.

Task 4. Field monitoring/testing to confirm results obtained in lab studies.

Once the model is developed, it should be applied to BMPs in the field to validate the BMP mechanistic model in real-life scenarios.

Schedule

3-10 yrs, depending on number of pollutants and BMP types investigated

Budget

$300k-2.5M, depending on number of pollutants and BMP types investigated

Potential Collaborators

Possible pieces of this work would be attractive to other funding agencies, including EPA and NSF. Other possible collaborators include WERF or CASQA who have a need for this information. Partnership with SMC member agencies for field validation sampling will be necessary.

Theme 5: MODELING

Project 5.1: Critical assessment of stormwater model performance in a changing climate

Problem Statement

A wide range of hydrologic, hydraulic and transport models are used in stormwater management for needs such as documentation of permit compliance, design of stormwater infrastructure, and selection of best management practices (BMPs). Given the ubiquity of modeling in stormwater management, it is important to understand appropriate uses and limitations, especially when modeling is used as the basis for management actions. Managers need confidence in modeling predictions, and models also need to be evaluated to ensure that they are future-proofed in the face of changing environmental conditions.

Purpose

This project will produce a critical assessment of stormwater models to inform appropriate uses and limitations with respect to justifying stormwater management actions. This assessment will include both a quantitative evaluation of predictive capabilities and uncertainties across selected geographies for the southern California region, result in a summary assessment of the confidence with which management actions can be informed, and the data needed to achieve high confidence. This process can also be used to assess how well previously developed watershed models used for multi-decadal implementation strategies are performing after 5- to 10-years of actual implementation.

Tasks

Task 1. Identify the model(s) to be evaluated.

Review the models in use by stormwater management agencies across Southern California in each category of model type, summarize the most frequent use cases and scale of application, and identify a set of models for quantitative evaluation. Three general classes of models relevant to stormwater management can be considered:

(1) Watershed models that simulate rainfall runoff and transport of pollutants (e.g., SWMM, LSPC).
(2) Flood inundation models that simulate urban drainage and street flooding hazards in relation to landcover topography, urban stormwater infrastructure designs and operating conditions (e.g., HEC-RAS, TUFLOW).
(3) Surface-water/groundwater interaction (e.g., SWAT-MODFLOW, PARFLOW, GSFLOW) and transport models that simulate infiltration of rainwater and seepage of soil moisture either into deep aquifers or laterally into surface water bodies, while also tracking the transport and transformation of pollutants.

Task 2. Identify the locations and data to test the models.

Evaluate and identify a set of test sites to compare and test simulation results from each model, capturing representative geographies (e.g., topography, hydrology, land use, and urban development) of southern California. Organize calibration/validation datasets and collect additional data if needed.

Task 3. Evaluate model uncertainty

Evaluate model performance and uncertainties across sites and summarize results.

Critically examine suitability of models for decision-making needs based on model performance, data requirements, and predictive uncertainties. This will involve applications of models using the test sites described in Task 2, and analysis as to whether predictions made with models (e.g., in support of a permit application) can be later validated with measurements.

Task 4. Future proof the model

Examine model compatibility with California's 5th Climate Change Assessment data and projected demographic changes for making future predictions. This task aims to ensure that models being used for predicting future stormwater dynamics are appropriately sensitive to changing environmental conditions associated with a warming climate, such as changes in temperature and precipitation intensities.

Task 5. Recommendations for improving models moving forward.

Make recommendations for future model use, model development, and data collection needs. This task will draw upon the performance of models across geographies and use cases to identify the highest priorities for modeling improvements including standards of practice. The overarching goal of this task is to ensure that the stormwater management decisions that draw upon modeling results are justified given model limitations and uncertainties. But a secondary goal is to potentially highlight examples of modeling practices and use cases where the results are simply too uncertain to confidently justify management actions. Such cases will warrant discussion about potential alternatives.

Schedule

3-4 years, depending on the number of models, number of locations.

Budget

$200k/year/model type depending on data availability and number of scenarios to be modeled.

Potential Collaborators

SMC member agencies for existing models and data. Groundwater management agencies for surface-subsurface models, U.S. Army Corps of Engineers for flood models.

Project 5.2: Communicating upstream hydrology decisions to downstream municipalities

Problem Statement

SMC member agencies need regional information about ongoing stormflow management activities because stormwater management through both the wet season and dry season can be made more difficult and/or less effective when operators are surprised by real-time conditions, including unanticipated flows. Although communication occurs between dam operators, flood channel managers, and water managers to improve situational awareness, downstream municipalities' access to information about upstream hydrology decisions is often limited, and understanding of key dynamics may be incomplete across operators and managers. For example, dam releases due to fire debris may be good for reducing sedimentation, but may generate unanticipated water quality issues for SMC members downstream.

Purpose

The purpose of this project is to foster communication between upstream and downstream groups by enhancing communication and interaction amongst the flood control, water utility, and stormwater quality agencies within a watershed.

Tasks

Task 1. Organize and convene a workshop

Organize and convene a workshop aimed at water management agencies including SMC agencies to provide regional venue for communication and information about real-time decision making and plans for future stormwater management. The Workshop content can be flexible but may include presentations on the following:

1. Groundwater recharge facilities: where are they what are their operational parameters, who operates them and POCs
2. Stormwater detention basins: where are they, what are their operational parameters, who operates them and POCs
3. Decision rules for how recharge and detention facilities are operated (what facilities are at capacity or underused)
4. Future plans for operation of facilities (Infiltration of water other than stormflow, i.e., Imported water, treated municipal wastewater)
5. Dam operational, storage, and release parameters
6. Federal BAER (Burn Area Emergency Response) Teams (Remotely sensed data from burn areas and hazard assessment, landside potential and sediment loads, potential contaminants mobilized from wildlands and developed area)
7. Stream levee and flood control systems and design
8. Cloud seeding programs (timing and expected increase in precipitation)
9. Streamflow gaging and data availability (discussion of data needs, availability, and sharing)
10. Plans for projected weather patterns and climate change projections

Task 2. Create a workshop report

Create a workshop report capturing the lines of future communication, points of contact, possible decision criteria for initiating contact, and the potential for ongoing communication mechanisms

Schedule

< 1 year for a one-day workshop prior to the onset of the rainy season

Budget

$20-$40K

Potential collaborators/attendees/presenters

Groundwater management agencies, wastewater treatment operators, SMC members, U.S. Army Corps of Engineers, US Forest Service, U.S. Geological Survey. Federal BAER team representative, Flood control management agencies, Santa Ana Watershed Project Authority (SAWPA)

Theme 6: SOCIO-ECONOMICS AND FINANCING

Project 6.1: Spatial optimization of nature-based solutions in urban areas

Problem Statement

Highly urbanized areas are commonly priority areas for SMC member agencies to implement strategies to reduce pollutant loads in stormwater runoff and address hydrologic alteration – including nature-based solutions (NBS). Yet these areas also present the most challenges, partly because of lack of land availability and the cost of land. At the same time, these are often the locations that would benefit from NBS the most, especially if they are located in disadvantaged communities. This project is designed to assist member agencies in pursuing NBS opportunities in highly urbanized areas.

Purpose

The intent of this project is to assist SMC member agencies in pursuing NBS opportunities in highly urbanized areas. The primary product will be a methodology which member agencies can duplicate and implement within urbanized areas they would like to target.

Tasks

Task 1. Form a workgroup that would define the objectives of NBS opportunities analysis

This workgroup should include opportunities for groups that represent key stakeholders, including community leaders, NGOs, government agencies, and activist groups.

Task 2. Identify variables that limit opportunities for NBS.

There are a variety of factors that can limit NBS opportunities including real estate distribution and costs, land use management spatial arrangements, and grassroots and political resistance. This task could benefit from specifically identifying a GIS model development. The model could include layers describing stormflow infrastructure (including age and capacity), subsurface geology (i.e., forebay versus confining layers that limit subsurface movement of water,), economic value of real estate, wetlands or other areas that may receive nonmonetary benefits from shallow GW recharge, projections of RO under changing weather or climate patterns, areas that could use shallow GW (potentially non potable) as a source of supply. Other layers to assess monetary and nonmonetary benefits of storm flow capture, infrastructure changes, or other activities could be created as part of this task

Task 3. Use local knowledge to weight the most important variables

Not all limitations are created equal. Some are more sensitive in certain watersheds and less important in other watersheds based on different political-economic contexts, property arrangements, and stakeholder competing interests. Weighting the variables according to input from an expert team with knowledge of the project and the community would help towards identifying optimal location and sizing of NBS implementation.

Task 4. Run a spatial heat map model.

A heat map, produced by GIS output of the weighted variables will help target optimal locations for future NBS implementation. The hot spots will be the places to start seeking land purchase, redevelopment requirements, or public-private partnerships. A model of ''hot spots'' and ''cold spots'' could also be considered. If longitudinal data is available with at least 3 time periods, a more sophisticated ''increasing hot spots'' and ''decreasing cold spots'' model could provide more information for the end users.

Schedule

1-2 years, depending on the success of the workgroup and the number of variables to be considered.

Budget

$100-200K, depending on the number of locations to be modeled.

Collaborators

Potential collaborators include community based environmental justice groups, private property owners, NGOs, universities

Project 6.2: Socioeconomic benefits of stormwater capture and use

Problem Statement

SMC member agencies invest heavily in both non-structural and structural strategies to manage stormwater runoff. While work has been done to better understand the water quality and hydrologic benefits of these management actions, very little has been done to help agencies understand the economic and socioeconomic benefits of these actions.

Purpose

The purpose of this project is to help SMC member agencies better understand the economic and socioeconomic benefits of both non-structural and structural stormwater management actions. The primary product will be a methodology which member agencies can implement to assess the socio-economic and economic benefits of the management actions they are implementing or plan to implement in their communities (including stormwater capture projects).

Tasks

Task 1. Form an internal workgroup

Form an internal workgroup to define objectives of the project and inform the work.

Task 2. Inform key stakeholders

This task will convene key informant stakeholders to review and comment on the proposed objectives. Key informants will be selected to represent the local community impacted, regulatory agencies, and scientists.

Task 3. Brainstorm socio-economic benefits

Brainstorm collaboratively with key informants on socio-economic benefits that are impacted by stormwater management actions and how to quantify them. A final product for this step could be a hierarchy of top socio-economic benefits.

Task 4. Conduct literature review

Following the identification of potential socio-economic benefits, conduct a literature review on estimation on the identified potential socio-economic outcomes as well as other potential socio-economic outcomes that may be discovered in the literature review.

Task 5. Conduct a spatial hot spot analysis

Conduct a spatial hot spot analysis based on existing data defined in step 4. ArcGIS software is a common tool for this type of analysis. R and other software packages can potentially add additional analytical benefits.

Task 6. Conduct semi-structured interviews

Conduct semi-structured interviews with key community stakeholders identified by the key informant work group to probe potential (or experienced) costs and benefits of the project and analyze and interpret the data.

Task 7. Follow up surveys

To the extent time and resources are available, follow up with a quantitative analysis based on surveys of randomly selected households in the impacted community.

Schedule

2-3 years

Budget

$50-200K

Collaborators

Potential collaborators include community-based organizations, water and wastewater agencies, NGOs, universities, regulatory agencies

Important Projects that Did Not Get Prioritized

The Expert Panel developed additional project concepts that were highly recommended, but that the Panel did not prioritize for this Research Agenda. Consequently, they did not get the more in-depth scope development of the previous projects, but the Panel asked that these projects get listed for the SMC to consider:

- **Exploring a BMP credit/trading system**: This project would explore the needs and opportunities for creating a crediting system, which would be particularly useful in locations where BMP implementation is not feasible.
- **Analysis of funding opportunities**: This project would persistently scour for grants and other resources, then create a clearinghouse of funding opportunities for SMC member agencies. This project could also act as a hub for partnered proposals and grants increasing co-funding opportunities.
- **How to monitor for compliance with trash provisions**: Current compliance with the State's trash provisions is focused on implementation of trash devices. However, monitoring to assess compliance, or to assess effectiveness of compliance, is not well developed.
- **Updating the SWRCB's Microbial Source Tracking Manual**: The State's Microbial Source Tracking (MST) Manual is nearly 15 years old. There have been many new advances in MST and case studies where the MST has been applied; thus, an updated Manual is overdue. Pathogen quantification approaches have advanced substantially, potentially replacing some of the value of older MST tools, and making critical evaluation important.
- **Fate and transport of contaminants from stormwater in estuaries and near-coastal habitats**: Most SMC agencies have monitoring sites located at the end of major watersheds, oftentimes called mass emission stations. However, there is little to no monitoring or quantification of microbial and chemical targets once they are discharged from the end-of-watershed into the complex coastal system.
- **Re-evaluation of design storm standards**: Design storm standards have different meanings to different people, with different reactions based on their perspectives. A design storm standard, with applicability to different locations based on historical rainfall, was pursued as a regulatory objective in the early 2000s, but never moved into the regulatory realm. This project would revisit those early attempts at a design storm standard and see if this is a viable avenue, particularly with onset of climate change.
- **Harmful algal blooms**: Harmful algal blooms (HABs) seem to capture a lot of media headlines and are getting worse every year. This project would explore the relationship between stormwater discharges and nutrient loading and subsequent formation of HABs, predominantly in freshwater systems.