Annual Water Quality Report

Fiscal Year
2018

Report on data collected between July 1, 2017 and June 30, 2018, according to the FY 2018 Water Quality Research and Monitoring Plan.

City of Santa Barbara Creeks Division

Contents

Introduction

The following report describes sampling and results that were based on the Fiscal Year 2018 Research and Monitoring Plan (Research Plan; Appendix A). The Research Plan is organized around program elements and research questions that have been reviewed by the Creeks Advisory Committee (CAC). The Research and Monitoring Program is adaptive, and as questions are answered or modified, sampling strategies change as well. The program elements and research questions are provided below. Where possible, the report is organized around the research questions. ***The primary purpose of this report is to serve as an internal record of data collection and analysis. Please see the Creeks Division 2001-2006 report for a discussion of methods, information on water quality criteria, and a glossary of monitoring terms.***

The **goals** of the monitoring program are to:

1. Quantify the levels (concentration, flux, or load) of microbial contamination and chemical pollution in watersheds throughout the city.
2. Evaluate impacts of pollution on beneficial uses of creeks and beaches, including recreation and habitat for aquatic organisms.
3. Evaluate the effectiveness of the City's restoration and water quality treatment projects, which includes collecting baseline data for future projects.
4. Identify sources of contaminants and pollution in creeks and storm drains.
5. Evaluate long-term trends in water quality.
6. Meet monitoring requirements for grants.
7. Meet General Permit monitoring requirements.
8. Investigate 303(d)-listed waterbody impairments.

The **underlying motivation** behind the monitoring program is to obtain information that the City can use to:

1. Develop strategies for water quality improvement, including prioritization of capital projects and outreach/education programs.
2. Communicate effectively with the public about water quality.

In support of the program goals, the Research Plan consists of **six key elements** and associated research questions:

1. Grant Project Requirements
2. General Permit Requirements
3. Watershed Assessment (including Creek Walks and Bioassessment)
4. Storm Monitoring
5. Restoration and Water Quality Project Assessment
6. Source Tracking

The FY18 Research Plan contains the program elements, associated research questions, and approach to obtaining answers. Many minor changes were made for FY 17. In FY 18, Creeks staff continued to focus monitoring and research efforts primarily on the following seven projects, which are shaded in the attached Research Plan. Additional sample collection to address ongoing research questions is also noted in the Research Plan.

1. Neonicotinoid Pesticides: The "Impact of Neonicotinoid Pesticides on Estuaries and Coastal Streams Project" is a collaborative effort among the Creeks Division, the University of California, Santa Barbara (UCSB) and the United States Geological Survey (USGS). The project was designed to understand the potential ecological impacts of neonicotinoid pesticides (neonics) in local creeks and estuaries and is comprised of three integrated elements: 1) field testing to measure the concentrations of neonics in creeks and estuaries, 2) laboratory toxicity tests to understand the impact of neonics on aquatic insects, and 3) modeling to project the laboratory results to broader

ecological impacts in creeks. The project is funded largely by a grant from the National Oceanic and Atmospheric Administration's California SeaGrant Grant Program to Principal Investigator Dr. Hunter Lenihan (UCSB), with additional Measure B funding for laboratory testing by USGS. Toxicity testing and mathematical modeling will be completed by UCSB. Field sampling has been conducted over multiple storms by the Creeks Division, with laboratory testing of field samples to be completed by Dr. Michele Hladik (USGS Pesticide Fate and Transport Group) in fulfillment of a contract funded by the Creeks Division.

2. Pollutant Load Model Selection: The Phase II General Permit contains a requirement to quantify pollutant loads and pollutant load reductions achieved by the program as a whole. The Central Coast Regional Water Quality Control Board ("Regional Board") has stated in recent memos to Permittees that it expects catchment-scale spatial modeling and prioritization for BMP-associated improvements in the present permit cycle. The Creeks Division was a stakeholder in the development of a Regional Board-supported model (Total Estimation of Load Reduction, or TELR) produced by 2nd Nature Consultants. The TELR model is a proprietary software platform with an annual license fee and it does not allow for modification of the model. The Creeks Division seeks a lower-cost, simplified, and adaptable alternative and will therefore compare the TELR model results to an in-house approach performed by a GIS intern. Output from both models (ranking of catchment by pollutant load and loading rate) will be compared to a simple ranking by catchment imperviousness.

3. Low Dissolved Oxygen and Impact on Bioassessment Scores: Several creek sites in Santa Barbara have low bioassessment scores (Index of Biological Integrity, or IBI) due to development in the surrounding watersheds. Low dissolved oxygen is known to be one of many interacting variables related to watershed impairment, but it is not known as the main proximate driver of low bioassessment scores in Santa Barbara. The Creeks Division will work with Ecology Consultants and others in the coming year to examine if low dissolved oxygen is the mechanistic reason for the lack of "pollution-sensitive" insects recorded in low-scoring creek sites in Santa Barbara. Dissolved oxygen loggers will be installed for two weeks at a time at multiple locations, e.g. riffles and pools, within several creek sites where bioassessment will also be conducted. Input will continue to be solicited from UCSB and the Department of Fish and Wildlife. This work addresses overall bioassessment scores in the City and the specific Clean Water Act listing for low dissolved oxygen impairment on Mission Creek.

4. Andreé Clark Bird Refuge Studies: The Creeks Division will continue to monitor the Bird Refuge weekly, collect storm monitoring data, and assess the scientific merit of treatment options at the Bird Refuge.

5. Microbial Source Tracking at Leadbetter and Sycamore Creek Watersheds: The Creeks Division will assist UCSB with sampling and serve as a stakeholder in the UCSB-led project.

6. Microbial Source Tracking for Identification and Elimination of New Leaks: In past research, microbial source tracking has identified sewage leaks that were quickly repaired by the City. Research has also ruled out numerous areas throughout the City where storm drains are not contaminated by sewage. Due to the aging nature of infrastructure, the Creeks Division has awarded a contract with UCSB to develop a plan to monitor for potential future sewage leaks that may reach storm drains and/or creeks.

7. Outfall Monitoring and Source Tracking Follow Up: The Permit-required outfall monitoring and the Microbial Source Tracking at Leadbetter Beach and Sycamore Creek Project have generated a list of four storm drains that should be investigated for potential illicit discharge contamination. Each of the four locations will need to be investigated by closed circuit television in storm drains or other methods to determine sources of flow during dry weather.

8. Historical Fecal Indicator Bacteria Analysis: This project is in partnership with Dr. Holden and will include an update to previous statistical analysis conducted by the Creeks Division, and additional work in order to gain insight about results obtained thus far by UCSB in their current Microbial Source Tracking work (to be presented to the Committee as a separate agenda item).

Grant Project Requirements

Neonicotinoid Pesticides

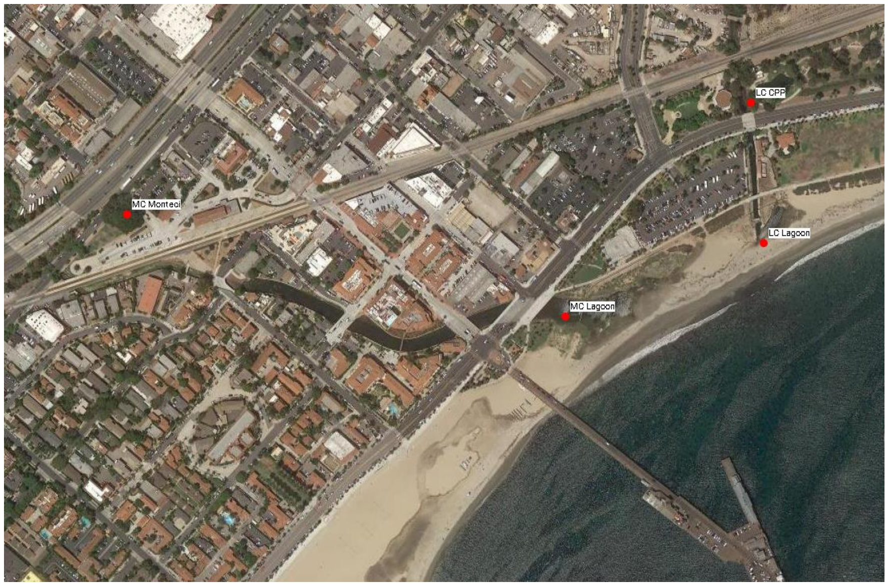
The following section includes material that was submitted for grant requirements. The section on bioassessment is new to FY 18.

Meeting Objective 1:

Objective 1 was completed. As detailed below, neonicotinoid pesticides and fipronil and its degradates were pervasive in Santa Barbara creeks and estuaries during dry and wet weather. In addition, imidacloprid and fipronil were found frequently above established chronic toxicity thresholds, raising concerns about ecological impacts of the widespread use of systemic pesticides.

Samples were collected from Mission Creek at Montecito Street (MC Monteci), Laguna Channel at Chase Palm Park (LC CPP), and Mission Lagoon (MC Lagoon) and Laguna Channel Lagoon (LC Lagoon, Figure 1). During the drought conditions of this study, the estuaries of Mission Creek and Laguna Channel drained separately to the ocean. Samples were collected during storm events, to determine peak concentrations, and following storm events, to assess how long aquatic organisms are exposed to lower concentrations of pesticides (**Error! Reference source not found.**). As planned, samples were collected during a small, early storm, a medium, “design storm” (~1”/24 hrs), and a large storm (>2”/24 hrs). During storm events, samples were collected using an ISCO autosampler and clean tubing collecting into 1-L amber glass bottles and chilled at 4°C. Samples were shipped to USGS overnight to ensure maintenance of proper temperatures.

Samples were processed in the laboratory of Dr. Michelle Hladik (USGS). Samples were maintained at 4°C until extraction. Samples ertr then filtered with a 0.7-mm glass-fiber filter, spiked with a surrogate (imidacloprid-d4), and passed through an Oasis HLB solid-phase extraction (SPE) cartridge (6 cc, 500 mg). The cartridges were eluted with 10 mL of 50:50 dichloromethane: acetone, reduced under nitrogen and an internal standard, 13C3-caffeine, is added. Extracts were analyzed for the following six neonicotinoids with associated detections limits (ng/L): acetamiprid (3.5), clothianidin (6.2), dinotefuran (5.5), imidacloprid (4.9), thiacloprid (3.8), and thiamethoxam (3.9) on an Agilent 1260 bio-inert liquid chromatograph (LC) coupled to an Agilent 6430 tandem mass spectrometer (MS/MS). Further details of the neonicotinoid method can be found in Hladik and Calhoun, 2012. Fipronil and four of its major degradates were analyzed using an Agilent 7890 gas chromatograph coupled to an Agilent 5975 mass spectrometer and further method details can found in Hladik et al., 2008. Compounds and detection limits (ng/L) are as follows: fipronil (2.9), fipronil desulfinyl (1.6), fipronil desulfinyl amide (3.2), fipronil sulfide (1.8), fipronil sulfone (3.5).



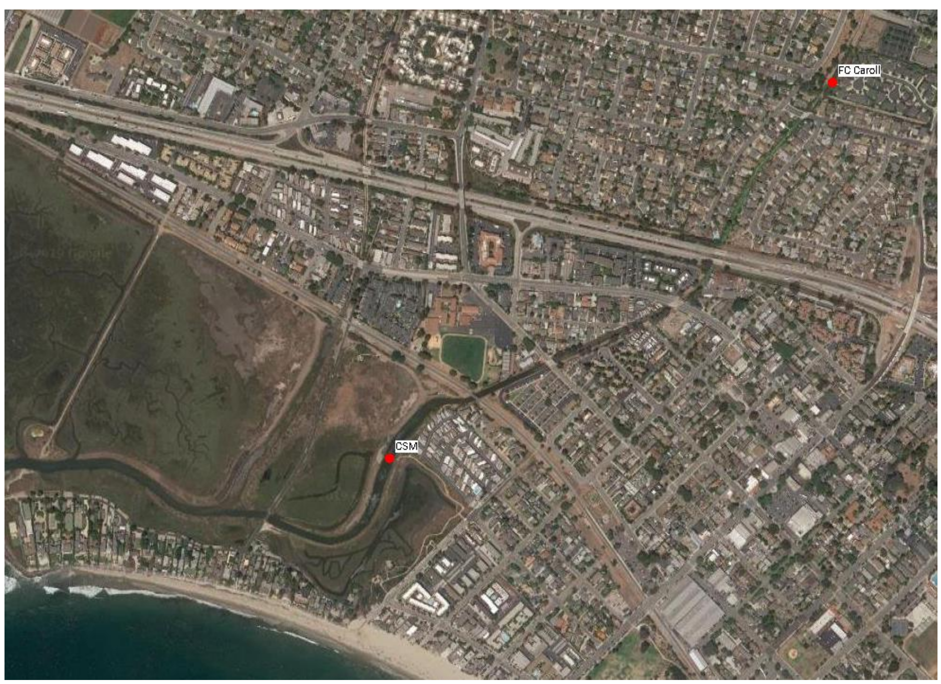


Figure 1. Map of sampling locations. Upper panel, urban sites and estuaries in Santa Barbara, CA. Lower panel, agricultural site and estuary in Carpinteria, CA.

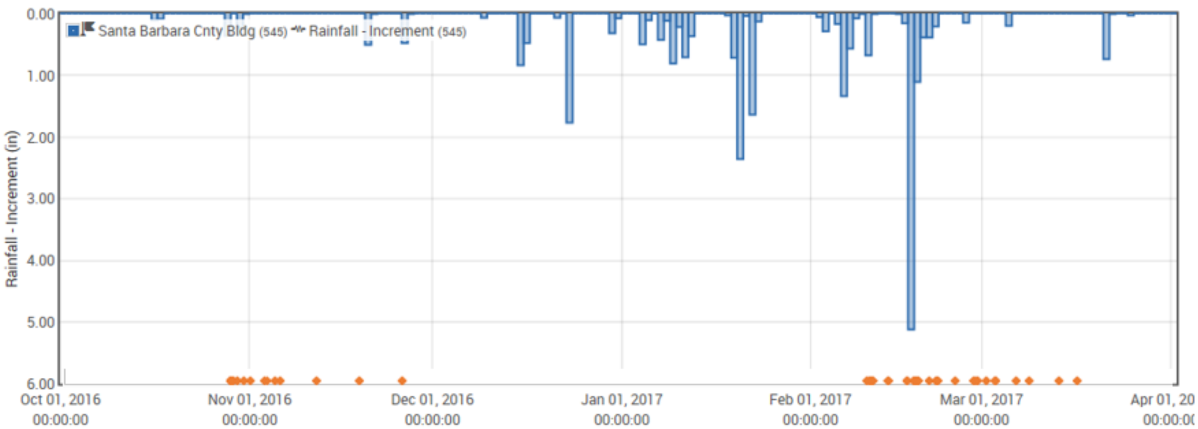


FIGURE 2. RAINFALL (BLUE BARS, INVERSE AXIS) AND SAMPLING TIME POINTS (ORANGE SYMBOLS) DURING WINTER 2016-2017.

AS EXPECTED, IMIDACLOPRID WAS DETECTED IN EVERY WET WEATHER SAMPLE COLLECTED (

Table 1 and Figure 3). More surprising was that imidacloprid was also detected in every dry weather sample, i.e. the concentration never dropped below detection in samples collected in days to weeks after storm events. Previous sampling by the City found non-detectable levels of imidacloprid in creek samples collected in summer. Two neonicotinoid pesticides, clothianidin and thiacloprid, were not detected in any samples. Acetamiprid, which had not been tested previously by the City, was found in 50% of dry weather and 74% of wet weather samples. Two other neonicotinoid pesticides, dinotefuran and thiamethoxam, were found only in runoff from agricultural areas (see Objective 2).

Fipronil and/or at least one of its degradates was found in 91% of samples overall (**Error! Reference source not found.**). Fipronil was detected in 93% of wet weather and 80% of dry weather samples and fipronil sulfone was detected in 88% and 77% of wet and dry weather samples, respectively. Other degradates were detected less frequently.

TABLE 1. FIELD SAMPLING RESULTS. BLANK CELLS INDICATE RESULTS BELOW LEVELS OF DETE TION (SEE TEXT FOR DETECTION LIMITS). RESULTS SUPPORT OBJECTIVES 1-4. CLOTHIANIDIN AND THIACLOPRID WERE TESTED BUT NOT DETECTED IN ANY SAMPLES.

Neonicotinoids(ng/L)	Fipronil + degradates(ng/L)

Site	Date	Time	Type	Volume (L)	Aceta-miprid	Dinote-furan	Imida-cloprid	Thiameth-oxam	Fipro-nil	Fipro-nil desul-finyl	Fipro-nil sulfide	Fipro-nil desul-finyl amide	Fipro-nil sulfone
LC CPP	10/28/2016	4:46	Env	0.969			19.1		19.0	7.1			5.3
LC CPP	10/28/2016	4:47	Rep	1.000			19.9		19.4	7.9			5.5
LC CPP	10/28/2016	5:10	Env	0.860	7.9		25.7		21.0	7.9			5.1
LC CPP	10/28/2016	6:10	Env	0.905	22.9		35.0		33.9	9.0			6.5
LC CPP	10/28/2016	7:10	Env	0.870	37.9		57.5		27.9	10.8			6.9
LC CPP	10/28/2016	8:10	Env	0.900	44.8		79.0		31.9	8.8			6.8
LC CPP	10/28/2016	9:10	Env	0.910	30.4		65.9		33.7	9.0			6.8
LC CPP 17	10/29/2016	10:36	Env	1.000	18.9		62.4		26.1	7.4			6.2
LC CPP 20	10/30/2016	10:03	Env	0.960	25.6		83.7		26.7	7.3			5.9
LC CPP 21	10/31/2016	8:55	Env	0.990	13.2		73.6		16.1	5.8			6.4
LC CPP	11/2/2016	17:45	Env	0.960	14.0		64.8		28.8	14.4			12.7
LC CPP	11/3/2016	8:25	Env	0.980	12.3		65.2		29.6	14.6			11.9
LC CPP	11/4/2016	10:20	Env	1.000	12.0		58.0		31.6	16.4			13.7
LC CPP	11/5/2016	9:40	Env	1.000	11.0		51.7		26.6	13.5			11.3
LC CPP #31	11/11/2016	9:10	Env	1.000	6.6		29.4		14.4	10.6			8.9
LC CPP	11/18/2016	9:10	Env	0.990	4.6		19.0		9.6	7.2			6.2
LC CPP	11/25/2016	9:40	Env	0.980	7.7		70.9		22.9	9.8			9.8
LC CPP	2/10/2017	3:00	Env	0.810	2.0		16.5		20.8				11.1
LC CPP	2/10/2017	11:00	Env	0.815	3.8		12.8		17.5				9.1
LC CPP	2/10/2017	13:00	Env	0.810	3.4		16.7		14.0				5.6
LC CPP	2/10/2017	15:00	Env	0.835	5.1		22.4		20.2				7.7
LC CPP	2/10/2017	17:00	Env	0.830	3.4		14.8		23.6				7.7
LC CPP	2/17/2017	16:00	Env	0.840	1.8		23.4		26.7			3.3	9.9
LC CPP	2/17/2017	19:00	Env	0.840	2.0		24.1		31.0			5.1	15.0
LC CPP	2/17/2017	22:00	Env	0.835	2.1		22.9		20.3			2.0	8.0
LC CPP	2/18/2017	1:00	Env	0.870	1.6		51.3		30.5	1.7		5.9	13.7
LC CPP	2/17/2017	15:18	Env	0.965	1.5		27.1		33.0	1.9		4.6	13.8
LC CPP	3/13/2017	10:30	Env	1.000			5.3		9.2	3.4	4.0	4.4	12.0
LC Lagoon	2/13/2017	7:10	Env	0.990	1.4		10.7		20.7			3.6	8.6
LC Lagoon	2/16/2017	8:40	Env	0.970			5.4		10.1				7.4
LC Lagoon	2/16/2017	8:40	Rep	0.980			5.8		10.6				8.1
LC Lagoon	2/21/2017	9:00	Env	1.000			19.2		18.2	1.3		1.2	9.4
LC Lagoon	2/24/2017	8:30	Env	0.990			8.4		10.3				9.8

LC Lagoon	2/27/2017	9:38	Env	0.980			19.3		10.8				7.8
LC Lagoon	3/1/2017	8:45	Env	0.855			7.7		6.8				4.4
LC Lagoon	3/6/2017	8:05	Env	1.000			15.3		17.4	3.3	2.3		8.0
LC Lagoon	3/8/2017	8:30	Env	0.950			7.3		15.4	2.8	2.9		13.1
LC Lagoon	3/16/2017	8:50	Env	0.970			4.6		4.5	2.1	2.3		6.3
MC Monteci	10/28/2016	5:38	Env	1.000	17.4		109.8		42.6	11.4			10.1
MC Monteci	10/28/2016	5:39	Rep	1.000	19.1		109.6		48.3	12.8			11.0
MC Monteci	10/28/2016	6:26	Env	0.890	16.8		65.1		39.7	15.4			12.1
MC Monteci	10/28/2016	7:26	Env	0.890	20.0		66.4		44.8	11.8			10.5
MC Monteci	10/28/2016	8:26	Env	0.855	9.0		43.6		38.3	14.9			11.2
MC Monteci	10/28/2016	9:26	Env	0.890	16.0		72.0		45.6	11.8			11.4
MC Monteci 14	10/28/2016	10:26	Env	0.860	20.3		89.1		38.8	9.9			9.8
MC Monteci 18	10/29/2016	10:26	Env	0.990	19.0		93.0		35.6	13.5			10.4
MC Monteci	2/17/2017	16:00	Env	0.760			25.8		15.6			3.6	2.8
MC Monteci	2/17/2017	19:00	Env	0.730			30.2		18.2			5.0	4.2
MC Monteci	2/17/2017	22:00	Env	0.720			31.7		10.1				
MC Monteci	2/18/2017	1:00	Env	0.620			37.8		20.9			6.9	5.8
MC Monteci	2/18/2017	7:00	Env	0.800			18.3		12.0			2.2	2.5
MC Lagoon 19	10/30/2016	9:51	Env	0.920	24.2		85.1		36.9	14.7			9.7
MC Lagoon 22	10/31/2016	9:29	Env	0.960	24.0		82.4		36.7	16.0			9.5
MC Lagoon	11/2/2016	17:55	Env	0.990	20.1		28.2		48.3	26.9			16.7
MC Lagoon	11/4/2016	10:30	Env	1.025	21.2		38.2		51.3	27.8			16.6
MC Lagoon	11/5/2016	9:50	Env	1.000	21.5		30.6		43.8	27.1			15.4
MC Lagoon #32	11/11/2016	9:25	Env	1.000	19.4		25.1		35.9	21.8			11.9
MC Lagoon	11/18/2016	9:25	Env	0.990	18.0		23.8		35.5	25.2			13.4
MC Lagoon	11/25/2016	9:50	Env	1.000	11.7		31.3		25.6	16.1			10.0
FC Carrol Ln	2/10/2017	3:43	Env	0.810		103.7	40.5						
FC Carrol Ln	2/10/2017	7:43	Env	0.805		127.1	47.5						
FC Carrol Ln	2/10/2017	9:43	Env	0.785		103.8	68.4						
FC Carrol Ln	2/10/2017	11:43	Env	0.690	19.3	436.5	158.3	23.0	92.4	6.2	2.9		4.4
FC Carrol Ln	2/10/2017	13:43	Env	0.750	7.9	440.6	94.7	21.9	36.4	2.7			3.5
FC Carrol Ln	2/10/2017	15:43	Env	0.890	6.1	249.8	86.7	6.9	37.4	2.7			3.7
FC Carrol Ln	2/10/2017	19:43	Env	0.745	4.3	1017.7	124.5	8.7	17.5				
FC Carrol Ln	2/13/2017	8:15	Env	1.000		60.1	40.5						
FC Carrol Ln	2/16/2017	8:00	Env	0.980		7.2	35.2	2.9					
FC Carrol Ln	2/16/2017	8:00	Rep	0.970		11.4	36.8	3.7					
FC Carrol Ln	2/27/2017	9:05	Env	1.000		9.5	48.8						

FC Carrol Ln	3/13/2017	9:18	Env	1.000		13.1	29.7						
CSM FC	2/21/2017	9:30	Env	0.980	2.2	9.0	20.7		12.7	1.3		2.5	6.8
CSM FC	2/24/2017	9:15	Env	0.970		3.3	16.1		4.3				2.9
CSM FC	3/1/2017	9:30	Env	1.000		7.4	21.2		2.3				
CSM FC	3/6/2017	8:50	Env	1.000		13.0	18.9		3.4				2.8
CSM FC	3/8/2017	9:05	Env	1.000		6.0	9.7						
CSM FC	3/16/2017	9:45	Env	0.860		8.1	16.1						
Rain	2/17/2017	12:00	Env	1.000									
Rain	2/17/2017	12:00	Env	0.990									
Anapamu/Salsipuelar (pollen)	6/19/2017	16:43	Env	0.610									
Dwight Murphy Park (mulch)	6/19/2017	16:46	Env	0.600									
Sweeper (66)	6/19/2017	15:26	Env	1.000			42.0						
63	6/19/2017	16:27	Field Blank	1.062									

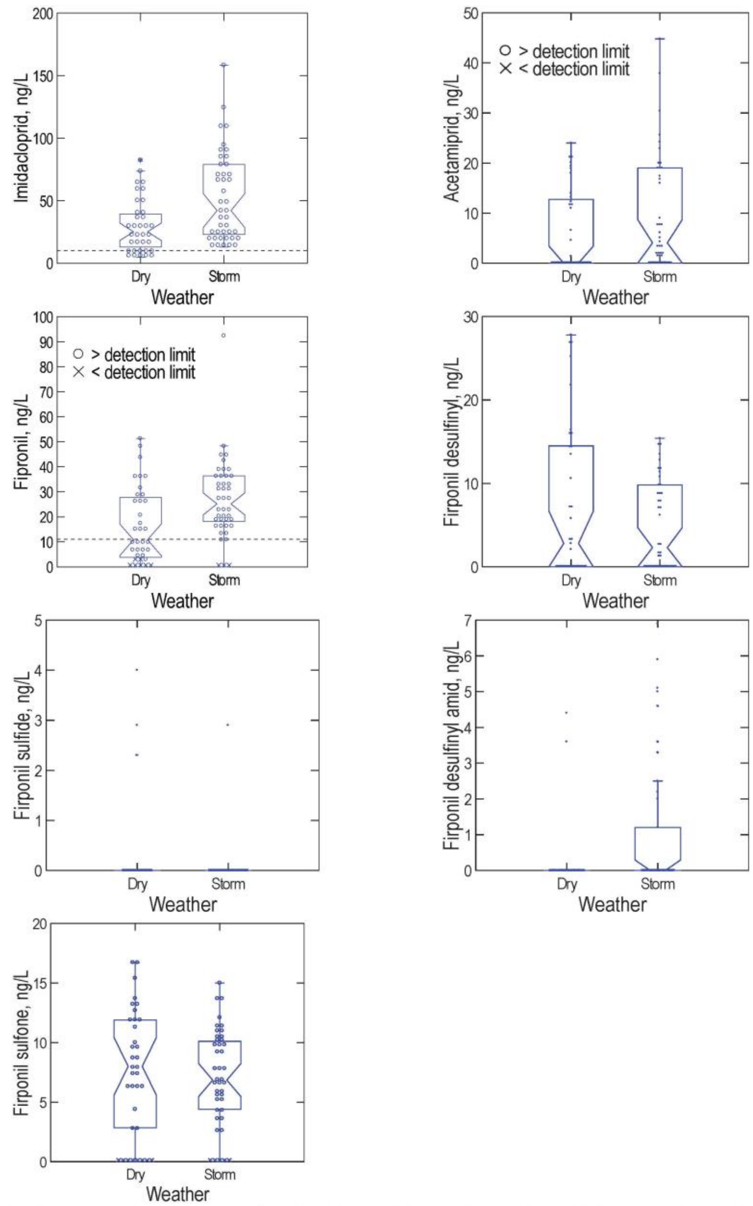


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FIGURE 3. CONCENTRATIONS OF NEONICOTINOID PESTICIDES AND FIPRONIL AND FIPRONIL DEGRADATES DURING DRY AND WET WEATHER. SAMPLES BELOW DETECTIONS LEVELS WERE PLOTTED AS ZERO FOR THE PURPOSE OF RANKING AND NONPARAMETRIC STATISTICS. BOXES SHOW THE MEDIAN (NOTCH) AND INTERQUARTILE RANGE. EXTANT OF NOTCHES REPRESENT NONPARAMETRIC CONFIDENCE INTERVALS (SYSTAT 11). DASHED LINES REPRESENT US EPA BENCHMARKS FOR CHRONIC TOXICITY TO AQUATIC INVERTEBRATES.

Imidacloprid and fipronil were frequently above new US EPA Aquatic Life Benchmarks for chronic invertebrate toxicity in fresh water (**Error! Reference source not found.**; US EPA 2017). Imidacloprid was found above the chronic benchmark in 90% of samples and fipronil exceeded the benchmark in 72 % of samples. All results were below acute benchmarks. Imidacloprid benchmarks were updated in 2017 and are now much lower than when this research began. Fipronil benchmarks were updated in 2016, but there is concern that chronic benchmarks are not sufficiently protective (US EPA 2017). All other pesticides were below chronic benchmarks at sites and time points, with the exception of thiamethoxam, for which no chronic benchmark exists.

During the post-storm sampling, no surface runoff was observed in the watersheds sampled, whereas flow continued to discharge from storm drain outlets. We suspect that imidacloprid-contaminated shallow groundwater (also called interflow) infiltrates into storm drains. The solubility of systemic pesticides leads longer discharges of contaminated water, compared to older pesticides with high adsorption coefficients.

Results generated under Objective 1 will provided ample data for modelers to simulate winter exposure scenarios of imidacloprid and fipronil in coastal streams and estuaries. These results are among the first for surface waters following storm events and for California estuaries.

<u>Meeting Objective 2</u>:

Objective 2 was completed. Samples were collected from Laguna Channel, Laguna Lagoon, Franklin Creek, and Carpinteria Salt Marsh (Figure 1). Samples were collected and processed as in Objective 1.

Imidacloprid was detected in both urban and agricultural runoff. During the storm event of 2/10/17, which was the fourth storm of the season, imidacloprid values were higher in agricultural runoff compared to urban runoff (**Error! Reference source not found.**). During the weeks afterward, which was punctuated by a large storm event on 2/18/17, values remained higher in the Carpinteria Salt Marsh (Franklin Creek input, also receives urban runoff) compared to Laguna Channel Lagoon (receives only urban runoff). In the post-storm samples, values remained close to or above the US EPA chronic toxicity threshold.

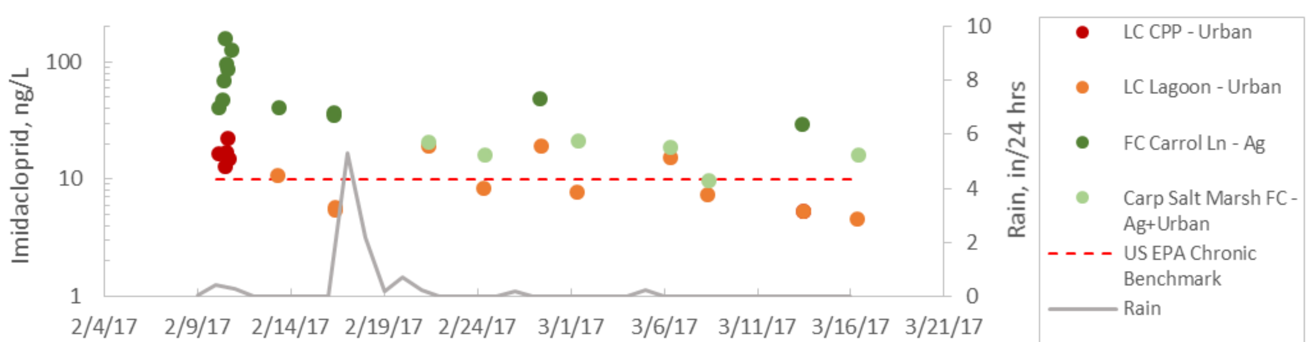


FIGURE 4. IMIDACLOPRID IN RUNOFF FROM URBAN (RED AND ORANGE SYMBOLS) AND AGRICULTURAL (GREEN SYMBOLS) DRAINAGES. DASHED LINE SHOWS US EPA BENCHMARK FOR CHRONIC TOXICITY OF AQUATIC INVERTEBRATES.

One reason that the agricultural area discharged higher concentrations may be more frequent applications of pesticides, compared to homeowners who may treat for ants and termites in summer months. In addition, the ratio of pesticide-treated area to total area may be higher in the agricultural drainage.

In addition to imidacloprid, two pesticides were detected in agricultural runoff that were not found in the urban area. Dinotefuran and thiamethoxam were detected frequently in storm runoff at FC Carroll Ln, but were not found in the urban sites of Santa Barbara.

Meeting Objective 3:

This objective was not completed as planned and was expanded on to address concerns. As described below, challenges with toxicity tests prevented an accurate test of chronic toxicity of creek water. Using short-term tests, creek water was deemed to have no toxicity even when imidacloprid was present. Because the literature continued to show toxicity to some aquatic insects at low concentrations of imidacloprid, and this project demonstrated long-term exposure to imidacloprid, the City sought to examine whether changes have been seen in previously-collected bioassessment data. Despite high variability in temporal patterns, the results showed a decline in sensitive insects from 2000-2012, as explained below. Because no neonicotinoid samples were collected with the aquatic insect data, the result does not demonstrate a conclusive connection between systemic pesticides and declines of non-target organisms, but it does sound a call for additional analysis of existing datasets.

The City of Santa Barbara was not able to obtain reliable results of long-term chronic toxicity tests using Chironomus with raw stormwater, despite multiple attempts. The laboratory that the City often contracts with was not able to complete the test successfully, due to cannabilism of the test organism. An alternative laboratory was contracted for limited Chironomus testing, but samples were collected without simultaneous neonicotinoid testing. Furthermore, only 5-day tests, rather than long-term chronic toxicity tests, were available.

Toxicity results, using ceriodaphia, hyalella (5-day tests) in creek storm flow, showed 95-100% survival, even when imidacloprid and fipronil were elevated (Table 2). Chironomus tests also showed 90-100% survival. Only one toxicity result from creek water was significantly different from the laboratory control sample, and the results showed higher growth in creek water than in the control sample. Toxicity testing results confirms the need for sensitive test species for neonicotinoid research.

TABLE 2. CREEK SAMPLE TOXICITY TESTS CONDUCTED BY OUTSOURCED LABORATORIES.

StationID	Date	Time	Result	Units	AnalysisMethod	Comments
LC CPP	05-Jan-16	5:46:00 AM	138	% Reprod	Ceriodaphnia Toxicity	Not sig. different from control.
LC CPP	05-Jan-16	5:46:00 AM	90	% Survival	Ceriodaphnia Toxicity	Not sig. different from control.
LC CPP	06-Mar-16	1:40:00 AM	100	% Survival	Ceriodaphnia Toxicity	Not sig. different from control.
LC CPP	06-Mar-16	1:40:00 AM	149	% Reprod	Chironimus Toxicity	Flagged as suspect by laboratory.
LC CPP	06-Mar-16	1:40:00 AM	103	% Survival	Chironimus Toxicity	Flagged as suspect by laboratory.
LC CPP	06-Mar-16	1:40:00 AM	211	% Reprod	Ceriodaphnia Toxicity	Signifcantly different from control.
FC Carroln	10-Feb-17	12:50:00 PM	95	% Survival	Hyalella Toxicity	Not sig. different from control.
LC CPP	10-Feb-17	12:20:00 PM	100	% Survival	Hyalella Toxicity	Not sig. different from control.
LC CPP	17-Feb-17	10:00:00 AM	100	% Survival	Hyalella Toxicity	Not sig. different from control.
LC CPP	17-Feb-17	10:00:00 AM	100	% Survival	Ceriodaphnia Toxicity	Not sig. different from control.
MC Monteci	18-Jan-18	12:34:00 PM	100	% Survival	Chironimus Toxicity	Not sig. different from control.
MC Monteci	18-Jan-18	4:00:00 PM	90	% Survival	Chironimus Toxicity	Not sig. different from control.
MC Monteci	19-Jan-18	1:00:00 PM	97	% Survival	Chironimus Toxicity	Not sig. different from control.

Owing to literature results demonstrating field toxicity of imidacloprid at low concentrations, the City sought an alternative approach to examining potential impacts of systemic pesticides. First, mayfly nymphs were found to be especially sensitivity to imidacloprid, and second, extensive losses of winged insects have been shown in the past 30 years in European nature reserves (Hallman et al 2017). The City used previously collected bioassessment data to query if mayflies and/or total aquatic insects have declined in Santa Barbara creeks.

For the analysis of benthic invertebrates (BMI), a data set was used that had been collected by Jeff Brinkman of Ecology Consultants and funded by the City and the County of Santa Barbara. The dataset consists of samples collected yearly from 2000-2019. There are a total of 53 creek sites ranging from fully developed to reference (undisturbed) watershed locations. Approximately 25 sites are visited per year. Samples are collected once per year, in late spring, and the entire benthic macroinvertebrate community is collected and identified to family. Methods, locations, and results are available on the City's website at sbcreeks.com. Results are used to calculate an index of biological integrity and track responses to watershed disturbance, fire, flood, drought, and restoration projects.

A subset of the data was examined for the potential impact of systemic pesticides. Data were limited to the years 2000-2012 in order to exclude the effect of drought. Only sites with at least 8 years of data were included, which resulted in 16 creek locations in Santa Barbara County with a range of urban, agricultural, and mixed use watersheds. Prior to analysis, the year following any wildfire in a drainage was eliminated from the dataset.

A mutiple regression analysis using ordinary least squares was conducted on transformed data (Table 3). Standardized regression coeffecients are reported in order to compare effect sizes.

Regressions were conducted for the following dependent variables: total benthic macroinvertebrate abundance, sensitive mayfly abundance (not Baetids), insect richness, Ephemeroptera-Plecoptera-Trichopteraephemoptera (EPT) richness, % sensitive BMI, % shredders, and average tolerance value.The following independent variables were included in the models: Year (variable of interest), % of watershed developed, yearly rainfall, and spring temp.

After controlling for the effects of land use and annual rainfall using multiple regression analysis, we found a significant decline from 2000 to 2012 for several invertebrate metrics (standardized regression coefficient, p value), including log[invertebrate abundance] (-0.35, <0.0001), log[non-Baetid mayfly abundance] (-0.24, <0.0001), insect taxonomic richness (-0.19, 0.001), logit[proportion shredders] (-0.13, 0.05), and EPT richness (-0.12, 0.03).

TABLE 3. MULTIPLE REGRESSION RESULTS.

Independent Variables→ Dependent Variable	Year	% of Watershed Developed (Urban + Ag)	Rain per Year	Spring Temp	Adjusted Squared Multiple R
Log(BMI Abundance)*	-0.36 ****	0.037 *	-0.37 ****	-0.067	0.24
Log(Mayfly Abundance+1)*	-0.24 ****	-0.75 ***	-0.18 ****	-0.01	0.65
Insect Diversity (# Fam)	-0.19 ***	-0.69 ****	-0.16 **	-0.02	0.53
Logit(% Shredders)	-0.13 *	-0.60 ****	-0.14 *	-0.028	0.39

Logit(% Mayfly)	-0.098 *	-0.79 ****	-0.12 **	-0.047	0.65
EPT Diversity (# Fam)	-0.12 ****	-0.74 ****	-0.078 *	-0.064	0.56
Logit(% Sensitive BMI)	-0.096	-0.76 ****	-0.19 ****	-0.029	0.62

P: * <0.05, **, <0.01, *** <0.001, ****<0.0001

Declines were detected in streams across the land use spectrum (moderately to heavily impacted by urban and/or agricultural development, as well as reference locations). Invertebrate metrics were not related to regional mean air temperature (previous year or previous spring). Metric values at references sites may have declined owing to pollutant impacts (e.g., broad scale pesticide dispersion, lack of adult invertebrate dispersal from impacted sites, pesticides leached from dogs along hiking trails) or to direct (temperature, but see above) and indirect (dissolved oxygen) factors related to climatic cycles and trends. These results do not provide a direct connection between systemic pesticides and invertebrate metrics or discount other long-term drivers of invertebrate change; however, to date, the only pattern we have found suggests an association between invertebrate declines and increasing neonicotinoid use, emphasizing the importance of expanded research on this topic.

Meeting Objective 4:

Objective 4 has been completed. Pilot scale testing was completed for neonicotinoids and fipronil in various environmental samples. None of the measured pesticides were detected in pure rainwater. Samples of tree pollen, mulch in a City park, and street sweeper material was used to leach pesticides prior to analysis. Of all of the pesticides tested, only imidacloprid was found, and only in the sample of street sweeper material.

TABLE 4. PESTICIDES CONCENTRATIONS IN ENVIRONMENTAL SAMPLES THAT WERE LEACHED PRIOR TO ANALYSIS. BLANK CELLS INDICATE NO SAMPLE WAS TESTED, ND SIGNIFIES RESULTS BELOW DETECTION LIMITS.

Site	Imidacloprid, ng/L	All other neonicotinoids, ng/L	Fipronil and degradates, ng/L	Hyalella Toxicity-96 hr, % survival	Ceriodaphnia Toxicity-96 hr, % survival
Rain	nd	nd	nd		
Rain	nd	nd	nd		
Stone Pine Polllen	nd	nd	nd	5	80
Mulch in City Park	nd	nd	nd	0	0
Street Sweeper Material	42.0	nd	nd	95	100
Field Blank	nd	nd	nd		

These results provide a mechanism for understanding previous results obtained in City testing, i.e. imidacloprid was found in runoff from a park that was not treated with pesticides. It is likely that dust, such as that found in street

sweeping material, is wind-blown throughout the urban environment. In addition, this result suggests that a more detailed study would be required to develop a detailed model of fate and transport of imidacloprid.
Toxicity tests were also conducted on leached material, with very concerning results (**Error! Reference source not found.**). For the mulch leachate, 0% survival was found for both test species, and for the pollen, only 5% survival was found with hyalella. This is among the most problematic result obtained in years of testing by the City. The City will pursue additional studies of mulch, pollen, and street sweeper spoils in coming years.

Based on results described here, additional samples will be collected in FY 19 to test for imidacloprid and fipronil at locations included in the bioassessment analysis. Samples will also be collected from street sweeping debris, pollen, and mulch to expand the pilot study. Last, additional statistical tests will be carried out on bioassessment data.

General Permit Modeling

The following section was completed as a General Permit modeling requirement.

Simple Santa Barbara Model Overview

The Simple Santa Barbara Model is a spatially explicit, reproducible, and objective approach to meeting the requirements of the Central Coast Regional Water Quality Control Board (Regional Board) letter dated June 13, 2016 (13267 Letter), as detailed in Attachment 1 of the 13627 Letter. The Regional Board approved the City's modeling approach in a letter dated August 29, 2017.

In accordance with the intent of the Permit, the goals of the model are 1) to assess program effectiveness by demonstrating volume and pollutant load reductions resulting from implementation of the Stormwater Program and 2) prioritize areas within the City that are predicted to generate high volume and pollutant loading rates. The model demonstrates program effectiveness in a spatially explicit manner based on three broad categories of BMPs: street sweeping, private distributed BMPs, and public centralized BMPs. The model is not designed to demonstrate the effectiveness of particular types of distributed BMPs throughout the City. In other words, the model can estimate answers to the following questions:

- Which land uses contribute the most to runoff and pollutant loads, in absolute amounts and rates/acre?
- Which receiving waters receive the greatest runoff volume and pollutant loads?
- Which neighborhoods (~140 acre) have the highest potential to pollute receiving waters?
- How much has water quality improved due to street sweeping?
- How much has water quality improved due to public permeable paver projects?
- How much has the Tier 3 guidance for re/developed properties improved water quality?
- How has the City's stormwater program all together improved water quality?

However, it cannot answer these types of question:

- Has water quality improved more due to private permeable paver projects or private bioretention installations on private property?
- What type of BMPs should be prioritized in each location?

The following sections follow the format of Attachment 1: Fundamental Components of Municipal Catchment Scale Stormwater Volume and Pollutant Loading Analysis to the 13267 Letter. Additional details are provided in the Model Guidance sections for the unmitigated and mitigated conditions. Finally, results are presented for the unmitigated and mitigated conditions.

1. The Spatial Framework

a. Catchment Boundaries

A grid system using the City's existing Storm Drain and Sewer Atlas scheme is used in place of hydrologically determined catchments (Figure 5). Each grid block, or page in the atlas, is ~137 acres. Using this approach, it is easy to identify relevant infrastructure, such as storm drains and wastewater pipes, within each catchment because the naming scheme of the City's infrastructure includes the grid number. For example, Outfall N-E11-10 is a node in grid E11 of the City's Storm Drain Atlas. The City's Storm Drain atlas provides a wealth of information for stormwater work, e.g. it contains flow lines for each gutter. Subcatchments are determined for each receiving water and land use (LU) within each catchment, e.g. E11-LHC-SFR, E11-HVC-OP, etc. (Figure 6, Table 5). The benefit of the grid system is that it is reproducible and "pages" can aligned with the existing storm drain and wastewater infrastructure documents. After all runoff and load calculations are completed for each subcatchment (see below), results are summed by catchment, land use, receiving water, or any combination thereof. There are 861 subcatchments (unique map grid, receiving water, and land use) with an average size of

14 acres. Calculations conducted over time can be used to model runoff and load reductions to specific receiving waters.

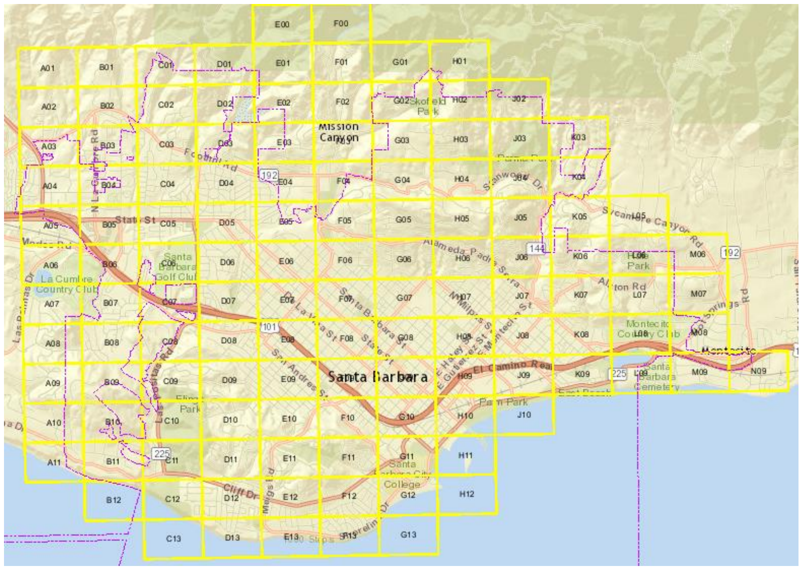


Figure 5. Proposed catchment (Catch) boundaries for the City's spatially explicit model.

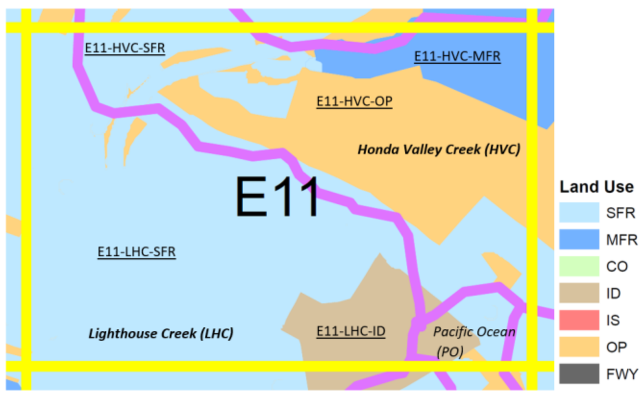


Figure 6. Example catchment division by receiving and land use (Catch-Rec-LU). Yellow lines mark Map Grid Boundaries (Catchments), pinks lines mark receiving water boundaries, and fill color denotes land use. Underlined text shows example subcatchment IDs. See text below for land use designations and abbreviations.

Table 5. Example catchment and division into Catch-Rec-LUs[1].

OBJECT ID	LU	Name_Abb	GRIDNO	SubCatchID	Shape_Length	Shape_Area	Acres	Imp	UnmitRunRate FtPerYear	UnmitRunVol CfPerYear	UnmitTSS LbPerYear	UnmitTssRateLb PerYearPerAcre
1	CO	WBD	F11	F11-WBD-CO	467.64	8954.64	0.21	0.03	0.11	957.73	3.05	14.83
2	CO	WBD	F10	F10-WBD-CO	1672.23	89367.40	2.05	0.05	0.13	11420.08	36.36	17.72
3	CO	WBD	G11	G11-WBD-CO	4023.85	109579.52	2.52	0.41	0.58	63872.14	203.36	80.84
4	CO	WBD	G10	G10-WBD-CO	1013.91	12074.95	0.28	0.38	0.54	6499.19	20.69	74.65
5	CO	RD	G07	G07-RD-CO	450.73	5566.50	0.13	0.53	0.73	4074.69	12.97	101.52
6	CO	RD	G06	G06-RD-CO	4743.71	366629.28	8.42	0.15	0.25	92263.02	293.75	34.90
7	CO	RD	H07	H07-RD-CO	7864.13	193870.46	4.45	0.63	0.86	167268.08	532.55	119.66

8	CO	RD	H06	H06-RD-CO	4149.89	394339.97	9.05	0.12	0.22	86416.24	275.13	30.39
9	CO	RD	J10	J10-RD-CO	3542.80	161098.93	3.70	0.11	0.20	32811.22	104.47	28.25
10	CO	RD	J09	J09-RD-CO	18246.42	1504280.86	34.53	0.50	0.70	1052558.48	3351.16	97.04
11	CO	RD	J08	J08-RD-CO	13085.95	467627.45	10.74	0.54	0.74	346606.33	1103.53	102.80
12	CO	RD	J07	J07-RD-CO	1351.83	52937.46	1.22	0.51	0.71	37675.00	119.95	98.70
13	CO	SC	H05	H05-SC-CO	572.03	14845.80	0.34	0.16	0.26	3907.65	12.44	36.50
14	CO	SC	H04	H04-SC-CO	1397.85	90652.07	2.08	0.02	0.09	8310.44	26.46	12.71
15	CO	SC	K09	K09-SC-CO	5856.57	259299.79	5.95	0.47	0.66	171091.13	544.72	91.51
16	CO	SC	K08	K08-SC-CO	4676.71	79966.56	1.84	0.59	0.81	64533.73	205.46	111.92
17	CO	MD	J09	J09-MD-CO	7864.35	445331.17	10.22	0.63	0.86	383119.62	1219.79	119.31
18	CO	MD	J08	J08-MD-CO	9148.38	189579.84	4.35	0.54	0.74	139957.98	445.60	102.39
19	CO	MD	J07	J07-MD-CO	412.58	5044.71	0.12	0.25	0.07	350.35	1.12	9.63
20	CO	MD	K09	K09-MD-CO	3627.93	158911.34	3.65	0.58	0.79	125726.58	400.29	109.73

[1]A note about units: throughout this document and the model itself, units are included in every column and/or field name.

b. Catchment outfalls and receiving water.

Subcatchments are delineated by watershed and receiving water. All outfalls are noted. See section a, above.

c. Hydrologic connectivity

Connectivity is assumed to be 100% for all catchments. The City is thoroughly storm drained, and open channels are generally short and steep, providing 100% conveyance of all but the smallest storms through all channels.

d. Land Use Designations

Land use designations are:

- Single family residential (SFR)
- Multi-family residential (MFR)
- Industrial (ID)
- Commercial (CO)
- Institutional (IS)
- Freeway/High Traffic (FWY)
- Open Space (OP)

The land uses are the same as those of the National Stormwater Quality Database (NSQD), with the exception that residential (RE) is divided into SFR and MFR. Using the NSQD divisions facilitates use of NSQD data for generating EMCs. Incorporation of roads into the land use also make it easier to use measured PIA, rather than modeled PIA, as in the 2nd Nature LLC's (2nd Nature) Total Estimate of Load Reduction (TELR) model and Geosyntec's Pollutant Load Reduction Model (PLRM).

2. Runoff Characteristics

a. Precipitation

The average annual precipitation for Santa Barbara is used (18.52 in yr^{-1} or 1.54 ft yr^{-1}). This will be used for comparison purposes even if average annual rainfall changes over time due to climate change.

b. Imperviousness and soil permeability

Percent impervious area (PIA) is determined for each subcatchment (Table 5). PIA is taken from the National Land Cover Database. The PIA is averaged for each subcatchment using GIS.

Soil permeability is excluded from the model as national guidance suggests omitting hydrologic soil groups from urban watershed modeling. Furthermore, soil mapping has not proven to correlate with infiltration test results conducted in the City.

c. Pollutant types for evaluation

Total suspended sediment is modeled as the pollutant of concern, following 2nd Nature's guidance. Additional pollutants, such as pesticides and nutrients, may be modeled in the future if valid concentration data become available.

d. Urban runoff pollutant data

The City uses the NSQD data to calculate event mean concentrations for each land use (EMC-LU) for total suspended solids (TSS). The NSQD data set has been culled to include only data points that are identified as a single dominant land use, reducing the data set from approximately 7,000 data points to approximately 4,000 data points. Median concentrations are used for each EMC-LU (Table 6). Note that the City prefers to omit land-use specific EMCs, based on an extensive review of various model guidance documents, literature, and NSQD results, but has proceeded due to guidance from the Regional Board.

TABLE 6. LU-EMCS FOR MODEL.

Land Use	EMC-mg/L	EMC lb/cf
CO	51	0.003183826
FWY	74.5	0.004650883
ID	71	0.004432385
IS	67	0.004182673
OP	38	0.002372263
SFR	57	0.003558394
MFR	57	0.003558394

e. Pollutant reduction estimates resulting from stormwater program actions.

Several categories are used to estimate the effectiveness of stormwater program actions (BMPs) in reducing volume and pollutant loads. Volume reduction and pollutant removal for each BMP category are determined for each subcatchment. The BMP removals (volume and pollutant load) are subtracted from the unmitigated model to determine the mitigated results. The mitigated results are an estimated measure of overall program effectiveness.

Streetsweeping: The intention was to use the City's Streets Division estimate of the tons of street dirt removed annually per neighborhood to model the amount of TSS removed per catchment due to street sweeping. However, the City records the total debris volume removed per year, and even using conservative conversion factors, the estimate of TSS mass removal across the entire was greater than amount of modeled TSS in runoff from the unmitigated condition. This result is likely due to large amounts of trash and leafy debris removed by street sweeping in heavily landscaped Santa Barbara. Therefore, the model relies on estimates from the Expert Panel literature review to assign percentages of TSS removal based on street sweeping frequency, presented in

Table 7 (Schueler, T., Giese, E., Hanson, J., Wood, D. 2016. Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Chesapeake Stormwater Network, Ellicott City, MD). The City uses advanced sweeping technologies (AST) and sweeps anywhere from weekly to four times per week.

TABLE 7. STREET SWEEPING SCENARIOS AND PERCENT REMOVAL OF TSS USED IN SBSM

Sweeping Frequency, Times per Month	Percent of Unmitigated TSS (lbs/yr) Removed per Year
1	6%
2	11%
4	16%
8	21%
12	21%
16	21%

i. Distributed BMPs: Parcels that been developed or redeveloped under Tier 3 are estimated to have a 50% reduction in runoff volume and 50% reduction in TSS concentration in the remaining runoff compared to the model unmitigated (baseline) values. These reductions were determined from a qualitative assessment of hundreds of projected implemented under the City's Tier 3 requirements and the effectiveness of BMPs summarized by the International Stormwater Database. Given the number of projects and the number of elements included with project, it is not expected that a more precise estimate could or should be obtained using City resources. The acreage of each parcel is included in the pollutant reduction model. The reduction for each parcel is subtracted from the runoff volume and pollutant load for the associated subcatchment (Table 11).

i. Decentralized public BMPs are addressed individually. In most cases, 100% runoff reduction and 100% pollutant removal is modeled, due to the preponderance of infiltration projects in the City's portfolio.
ii. Centralized BMPs are assessed individually. Centralized BMPs have areas of run-on incorporated. The volume reduction and treatment is estimated for each project using monitoring and/or observations.
iii. Additional BMPs categories can be added if necessary.
iv. Combined effectiveness of BMPS. Volume Reduction and TSS removal are be summed for the three BMP categories across each subcatchment.
v. The totals are subtracted from unmitigated rates for each subcatchment (unmitigated rates from Table 1 above).
vi. Totals for catchments, receiving waters, and land uses can be summed as described in the Unmitigated Guidance section.

3. Computational Requirements

a. Annual stormwater volume and pollutant loads delivered from each catchment.

The volume and pollutant load estimates are reliable, repeatable, and comparable among catchments. The Simple Method (Schueler 1987) is used to calculate annual stormwater volume and pollutant load for each subcatchment. The EMCs for each land use are used in the calculations. The runoff and pollutant loads for subcatchments are summed to determine the runoff volume and pollutant load per catchment. The results can also be summed by land use and by receiving water.

The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (Rv). Runoff volume is calculated as:

$$\mathbf{R = P * P_j * Rv}$$

Where:
- R = Annual runoff (inches)
- P = Annual rainfall (inches)
- P_j = Fraction of annual rainfall events that produce runoff (usually 0.9)
- Rv = Runoff coefficient

In the Simple Method, the runoff coefficient is calculated based on impervious cover in the subwatershed. This relationship is shown in Figure A.1. Although there is some scatter in the data, watershed imperviousness does appear to be a reasonable predictor of Rv.

The following equation represents the best fit line the dataset (N=47, R^2=0.71).

$$\mathbf{Rv=0.05+0.9Ia}$$

Where: Ia = Impervious fraction

FIGURE 7. FROM THE NEW YORK STATE STORMWATER MANAGEMENT DESIGN MANUAL (HTTPS://WWW.HYDROCAD.NET/PDF/NY-SIMPLE-METHOD.PDF)

b. BMP incorporation

BMPs are incorporated as described above. A spreadsheet file of each parcel, subcatchment ID, acreage, land use, impervious fraction (derived from the LU-Imp, not measured by parcel), year (if any) it was re/developed under Tier 3 is maintained. A dataset of public BMPs is also maintained, including the acreage of run on. For each BMP, the reduction in runoff and pollutant load over the baseline modeled value is calculated as above. The reductions for each parcel and/or project will be summed by subcatchment, and this total is subtracted from the baseline value for each catchment.

c. Spatial and temporal comparisons.

The City maintain a GIS "project" for mapping the spatial data. The data are available in charts for temporal comparison.

d. Reporting formats

The City will provide data in desired reporting formats.

4. Standardized Protocols

a. Consistency

A consistent methodology is applied within and across each catchment to estimate annual volume and pollutant load reductions. For example, even if average annual rainfall changes over time due to climate change, the City will continue to use the same annual rainfall value for the model.

b. Normalization.

Stormwater volume and pollutant load are also converted to rates per unit area for purpose of comparison among catchments. Catchment rankings are based on normalized rates so that the catchments with the greatest risk to receiving waters per acre can be identified.

Model Guidance-Unmitigated (Baseline) Conditions

Overall Approach: This project uses GIS mapping (and some ArcMap statistical tools) and Excel spreadsheets to calculate and track runoff and pollutant loads for subcatchments throughout the MS4. For the most part, the project involves nothing more than simple arithmetic. However, there are several different units used for the same dimension. Therefore, all field (GIS) and column (Excel) names contain the units in the field name to avoid confusion. Careful consideration of units must be maintained at every step of this project. In addition, care is taken to keep the methods as simple as possible, so that future years can be updated by personnel with basic GIS and advanced Excel skills.

This section should only be completed one time, but instructions are provided here to re-create the process if necessary. GIS tools and tips are highlighted in side bars.

1. File organization
   Organize sub-folders in Simple Santa Barbara Model folder:
   a. Docs
   b. GIS Projects
   c. Excel Files
   d. PDF Maps and Tables
2. Prepare Event Mean Concentration (EMC) data from National Stormwater Quality Database (NSQD).
   a. Download dataset, Save as “yyyy.mm.dd” NSQD for EMC, save worksheet as “AllData”
   b. Copy worksheet, name “OneLU”
   c. Sort by Principal Landuses.
   d. Delete all with “Mix” in Principal Landuse.
   e. Calculate Median TSS for each landuse type. For RE, create two rows,
      SFR and MFR, with the same results. If we get a better dataset in the future
      We may have two different values.
   f. Save table in new worksheet “EMCs”
   g. Complete unit conversion using this formula (don’t include terms in brackets).

	A	B	C
1	**Land Use**	**EMC-mg/L**	**EMC lb/cf**
2	CO	51	=**b2** [mg L^{-1}] * 0.000062427961[(lb cf^{-1})/ (mg L^{-1})]
3	FWY	74.5	
4	ID	71	
5	IS	67	
6	OP	38	
7	SFR	57	
8	MFR	57	

How to Save an Editable Layer.
- Import from GIS server.
-Right click, Export.
-Save in Project Folder

How to Delete Fields. *With Editing OFF, right click and Delete Field.*

How to Add Fields. *With Editing OFF, click Table Options (left button on attribute table window). Click add field. Use Double for most number purposes.*

How to Update Tables*. Turn Editing On. Copy column data in Excel and put cursor in top cell and Paste.*

1. GIS Setup
   Create Project (PermitModelUnmit) add City GIS Layers
   a. Reference→ Map Grid
   b. Base Layer

c. Parcel Layer
d. Zoning Layer

2. GIS Processes

   Import or create additional layers and attributes

   a. Land Use

      The land use layer was created from an existing land use layer provided by the county. A clip operation was performed to isolate all land use parcels within our MS4 area. The parcels and adjacent roads were then classified based on a description field provided in the original data.

   b. Imperviousness

      A raster from the National Land Cover Database was used to determine the impervious values. Impervious values were obtained through the "Zonal Statistics as a Table" tool in ArcMap. The proportion impervious in an area is abbreviated as Imp. The percent impervious (PIA) is Imp*100. More detailed instructions can be found in 2nd Nature's guidance documentation.

   c. Receiving Waters

      Receiving water (watershed) boundaries were determined by iterative DEM processing and review of the storm drain GIS layer and staff knowledge. Some receiving waters are actually storm drain networks that discharge on the beach. The larger of these are named, whereas the smaller beach drainages are all labeled Pacific Ocean. The watershed boundaries for the airport area were created manually through review of all receiving waters and drainage points.

   d. Grid Layer

      Copy of the Map Grid layer. Airport map grids were added for consistency but are not included in the City's Storm Drain Atlas.

   e. SubCatchments

      Divide the Catchments by Receiving Waters and Land Use. Starting with the "Land Use" (LU) layer, a dissolve was performed to get 7 polygons, one for each LU, within each map grid. An "Intersect" operation was performed with the "Receiving Waters" (RW) layer with the "Map Grid" layer. The resulting layer was then intersected with the LU layer to get the LU for each RW within each catchment. The "SubCatchID" field was then populated with the associated map grid, receiving water (Rec), and landuse (LU) values.

Table 8. Updated fields for subcatchment attribute table.

Field	Example
SubCatchID	E11-LHC-SFR
Catchment	E11
ReceivingWater	LHC
LandUse	SFR
Acres	4.2
PIA	0.55
UnmitRunRateFtPerYear	
UnmitRunVolCfPerYear	
UnmitTSSLbPerYear	
UnmitTSSRateLbPerYearPerAcre	

3. Excel Processes
   a. Copy Attribute Table to Excel (see sidebar above), add formulae.
   b. Paste in EMC table also.
   c. The formula for runoff is the Simple Method (see above section for details):

Table 9. Example runoff and pollutant load calculations[1,2].

	A	B	C	D	E	F	G	H	I	J
1	KSubCatchID	Catchment	Receiving Water	LandUse	Acres	Ia	UnmitRunRateFtPerYear [ft yr^{-1}]	UnmitRunVolCfPerYear [ft^3 yr^{-1}]	UnmitTSSLbPerYear [lb^3 yr^{-1}]	UnmitTSSRateLbPerYearPerAcre
2	E11-LHC-SFR	E11	LHC	SFR	4.2	0.55	=(18.52[in yr^{-1}]*0.9* (0.05+0.9*Ia)) / 12[in ft^{-1}]	= **UnmitRunRateFtPerYear** [ft yr^{-1}] *** Acres** [acres] *** 43,560** [ft^2 $acre^{-1}$]	= **UnmitRunVolCfPerYear** [ft^3 yr^{-1}] *** EMC** [lb cf^{-3}]	= **UnmitTSSLbPerYear** [lb^3 yr^{-1}] **/ Acres** [acres]

[1]Do not include terms in brackets.

[2] EMC refers to this lookup formula: vlookup(d2,l2:n8, 3,true), with this table:

	L	M	N
1	**Land Use**	**EMCmgPerL**	**EMCLbPerCf**
2	CO	51	0.003183826
3	FWY	74.5	0.004650883
4	ID	71	0.004432385
5	IS	67	0.004182673
6	OP	38	0.002372263
7	SFR	57	0.003558394
8	MFR	57	0.003558394

   d. Paste results back into GIS attribute table (see sidebar above).

4. Maps
   Create maps of RunoffRate (blue dark to light) and TSSRate (red dark to light). Add Catchment outlines (yellow) and labels and Receiving Water outlines and labels.

5. Rankings

   In Excel, copy and "paste as values." Use Pivot Tables to (make sure to "Copy and Paste Values" so rankings are not lost):

   a. Sum by Catchment and the sort results.
      i. Runoff Volume by Catchment: Sum UnmitRunoffVolumeCfPerYr for each Catchment, sort results, assign ranking.
      ii. Runoff Rate by Catchment: Divide Volume by Catchment by Catchment SqFt, sort results, assign ranking.
      iii. Pollutant load by Catchment: Sum UnmitTSSLbPerYr for each Catchment, sort results, assign ranking.
      iv. Pollutant Rate by Catchment: Divide UnmitTSSLbPerYr by Catchment Acres, sort results, assign ranking.
   b. Sum by Receiving water
      i. Volume by Receiving Water: Sum UnmitRunoffVolume for each Receiving Water, sort results, assign ranking.
      ii. Volume Rate by Receiving Water: Divide Volume by Receiving Water by Receiving Water SqFt, sort results, assign ranking.
      iii. Pollutant load by Receiving Water: Sum UnmitTSSLbPerYr for each Receiving Water, sort results, assign ranking.
      iv. Pollutant Rate by Receiving Water: Divide Pollutant Load by Receiving Water by Receiving Water Acres, sort results, assign ranking.
   c. Sum by Land Use
      i. Volume by Land Use: Sum UnmitRunoffVolume for each Land Use, sort results, assign ranking.
      ii. Volume Rate by Land Use: Divide Volume by Land Use by Land Use SqFt, sort results, assign ranking.
      iii. Pollutant load by Land Use: Sum UnmitTSSLbPerYr for each Land Use, sort results, assign ranking.
      iv. Pollutant Rate by Land Use: Divide Pollutant Load by Land Use by Land Use Acres, sort results, assign ranking.

   d. Create 12 tables in Word, save as PDF, with ID, rankings, and totals.

Model Guidance-Mitigated Conditions

1. GIS Processes
    a. Copy Unmitigated Project and rename it – CityMit2018. Rename all relevant layers and fields MitYear in place of Unmit.
    b. Add copy of parcel layer (see sidebar above).
        i. For attribute table, delete most fields.
        ii. Add fields for Acres, LandUse, PIA, MitYear, PrivOrPub, MitRunVolCfPerYear, MitTSSLbPerYear
    c. Add copy of sweet sweeping map if available.
    d. Copy and rename Unmitigated Excel file to Mit2018. Add these fields/columns:

StSwTSS Removal LbPerYr	T3Vol RedCfPerYr	T3TSSRemoval LbPerYear	PubBMP VolRedCf PerYr	PubBMP TSSRem LbPerYr	TotalRunVol RedCfPerYr	TotalTSS Red LbPerYr

And

MitRunRate FtPerYr	MitRunVol CfPerYr	MitTSS LbPerYr	MitTssRateLb PerYrPerAcre

2. BMP Reductions
    a. StreetSweeping. There is no volume reduction due to street sweeping. Determine TSS removal per subcatchment.
        i. Create a GIS layer for Street Swept Streets.
        ii. For each subcatchment, obtain the acres of streets.
        iii. Calculate the unmitigated TSS load of the streets based on the LU and an assigned PIA of 100.
        iv. Calculate the mitigated TSS load of the streets by multiplying the reduction from Table.

TABLE 10. EXAMPLE CALCULATION OF TSS REMOVED BY STREET SWEEPING NEEDS FIXING

SubCatchID	acres	Acres of roads	UnmitTSS LbPerYearSts	UnmitTssRateLb PerYearPerAcreSts	TSSRemovalStSwFreq	StSwTSSRemoval LbPerYr	StSwTSSRemoval LbPerYrPerAcreSt
J09-MD-CO	10.22		1220	119	0.21	1220*0.21=	119*0.21=25

    b. Private (Tier3) / Distributed BMPs. Parcels that been developed or redeveloped under Tier 3 are estimated to have a 50% reduction in runoff volume and 50% reduction in TSS concentration in the remaining runoff compared to the model unmitigated (baseline) values. These reductions were determined from a qualitative assessment of hundreds of projected implemented under the City's Tier 3 requirements and the effectiveness of BMPs summarized by the International Stormwater Database. Given the number of projects and the number of elements included with project, it is not expected that a more precise estimate could or should be obtained using City resources. The acreage of each parcel is included in the pollutant reduction model. The reduction for each parcel is subtracted from the runoff volume and pollutant load for the associated subcatchment (Table 11).

TABLE 11. CONTRIVED EXAMPLE OF TIER 3 REDUCTIONS IN RUNOFF VOLUME AND POLLUTANT LOADING.

Example APNs	SubCatch ID	acres	Imp	UnmitRun Rate FtPerYear	UnmitTssRate LbPerYear PerAcre	Tier3 RunRate FtPerYr	T3VolRed CfPerYear	T3TSSRem RateLbPerYear PerAcre[1]	Tier3TSSRem LbPerYear
COM-1	J09-MD-CO	0.25	0.63	0.86	119.31	0.5*0.86= 0.43	0.43*0.25(43,560) =4683	0.75*119.31= 89.48	89.48*0.25= 22.37

COM-2	J09-MD-CO	0.17	0.63	0.86	119.31	0.5*0.86= 0.43	0.43*0.17(43,560) =3184	0.75*119.31= 89.48	89.48*0.17= 15.21
COM-3	J09-MD-CO	0.17	0.63	0.86	119.31	0.5*0.86= 0.43	0.43*0.17(43,560) =3184	0.75*119.31= 89.48	89.48*0.17= 15.21
TOTAL	J09-MD-CO						11051		52.79

[1]The 0.75 arises from 25% of the pollutant load remaining after 50% of the volume is reduced and 50% of the pollutants are removed from the remaining runoff (1-0.5*0.5).

c. Public BMPs
   i. Use procedure described above, after conducting BMP Assessment. Note that for 2018, the BMP assessment showed that all projects were fully infiltrating.

d. Sum the BMP reductions for each subcatchment (Table 13).

Table 12. Example summation of BMP effectiveness.

SubCatch ID	StSwTSS Removal LbPerYr	Tier3Vol RedCfPer Year	Tier3TSS Removal LbPerYear	CenBMP VolRedCfPer Year	CenBMP TSSRemoval LbPerYear	TotalRun VolRedCf PerYear	TotalTSS RemovalLb PerYear
J09-MD-CO	27.38	11051	52.79	0	0	11051	27.38+52.79=80.17

e. Calculate the mitigated values for each subcatchment.

Table 13. Example mitigated results for one subcatchement.

SubCatch ID	AreaSqFt	Acres	TotalRunVol RedCfPerYear	TotalTSS Removal LbPerYear	MitRunVol CfPerYear	UnmitRunRateFtPerYear	MitTSS LbPerYear	MitTssRateLb PerYearPerAcre
J09-MD-CO	445331	10.22	11051	80.17	383119.62-11051= 372068	372068 /445331.17 =0.84	1219.79-80.17= 1139.62	1139.62/10.22= 111.5

3. Mitigated values. For each catchment, subtract the reductions from each subcatchment as shown above. Totals for catchments, receiving waters, and land uses can be summed as described in the Unmitigated Guidance section.

4. Maps
   Create maps of MitRunRate (blue dark to light) and MitTSSRate (red dark to light). Add Catchment outlines (yellow).

5. Ranking
   In Excel, copy and “paste as values.” Use Pivot Tables to (make sure to “Copy and Paste Values” so rankings are not lost):
   a. Sum by Catchment and the sort results.
      i. Volume by Catchment: Sum MitRunoffVolume for each Catchment, sort results, assign ranking.
      ii. Volume Rate by Catchment: Divide Volume by Catchment by Catchment Acres, sort results, assign ranking.
      iii. Pollutant load by Catchment: Sum MitTSSLbPerYear for each Catchment, sort results, assign ranking.
      iv. Pollutant Rate by Catchment: Divide Pollutant Load by Catchment by Catchment Acres, sort results, assign ranking.
   b. Sum by Receiving water
      i. Volume by Receiving Water: Sum MitRunoffVolume for each Receiving Water, sort results, assign ranking.
      ii. Volume Rate by Receiving Water: Divide Volume by Receiving Water Acres by Receiving Water Acres, sort results, assign ranking.
      iii. Pollutant load by Receiving Water: Sum MitTSSLbPerYear for each Receiving Water, sort results, assign ranking.
      iv. Pollutant Rate by Receiving Water: Divide Pollutant Load by Receiving Water by Receiving Water Acres, sort results, assign ranking.
   c. Sum by Land Use
      i. Volume by Land Use: Sum MitRunoffVolume for each Land Use, sort results, assign ranking.
      ii. Volume Rate by Land Use: Divide Volume by Land Use by Land Use Acres, sort results, assign ranking.
      iii. Pollutant load by Land Use: Sum MitTSSLbPerYear for each Land Use, sort results, assign ranking.
      iv. Pollutant Rate by Land Use: Divide Pollutant Load by Land Use by Land Use Acres, sort results, assign ranking.

   d. Create 12 tables in Word, save as PDF, with ID, rankings, and totals.

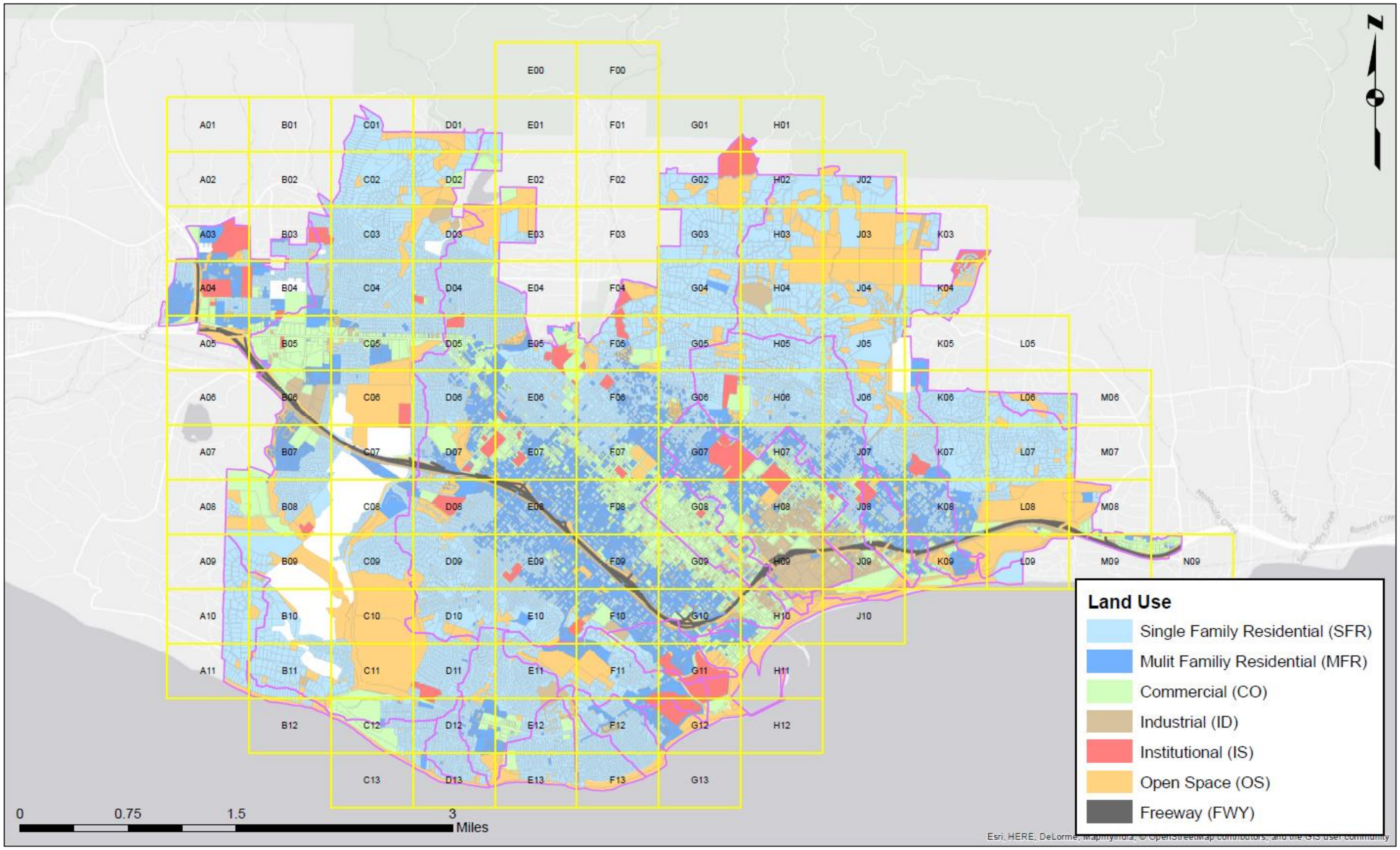
Results-Unmitigated Conditions

The following maps and ranking tables show the results of the Santa Barbara Simple Model for the unmitigated, or baseline, condition. This refers to post-development, pre-stormwater program conditions. Background information (raw imperviousness, receiving waters, catchment boundaries), model input (land use, averaged impervious), and model output (runoff rate, pollutant loading rates) are shown for the main MS4 and the outlying Airport MS4.

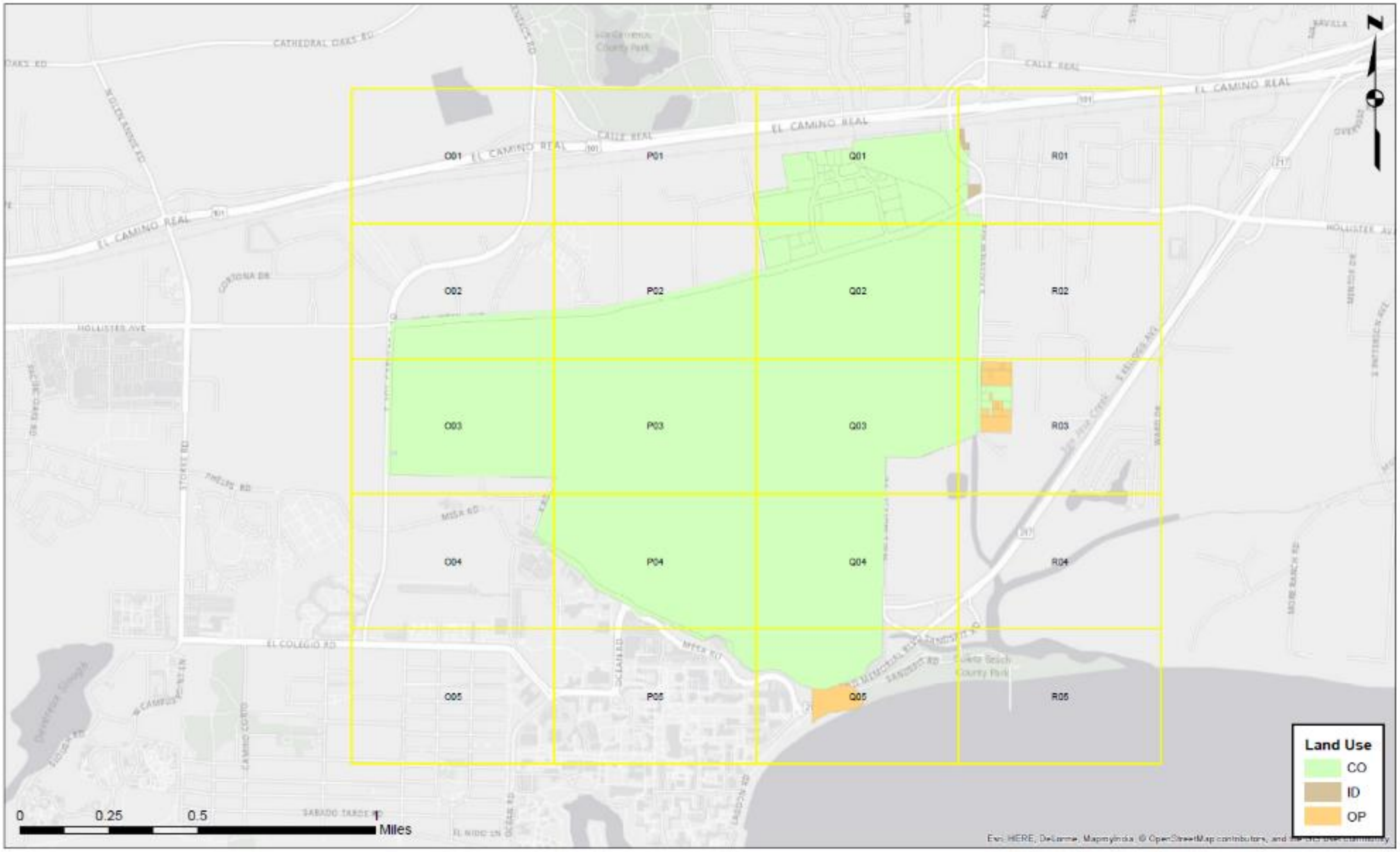
Model Input

The following plates show inputs to the SBSS, including catchments (grid spaces), land uses, receiving waters, and MS4 outfalls, for both the main MS4 area and the non-adjacent airport section of MS4. It should be noted that the color scales are identical for each pair of maps, but the distance scales are not.

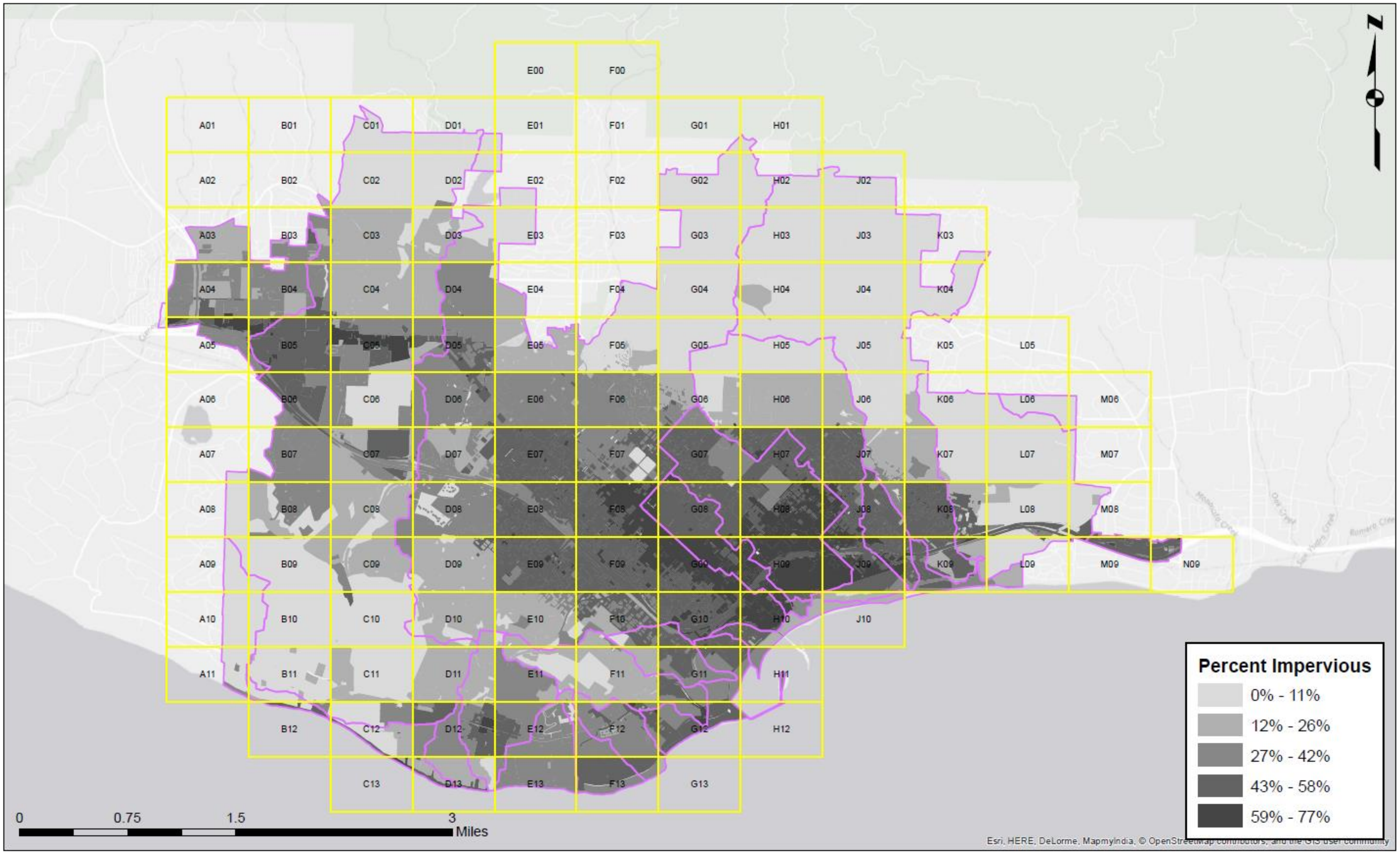
City of Santa Barbara: Land Use



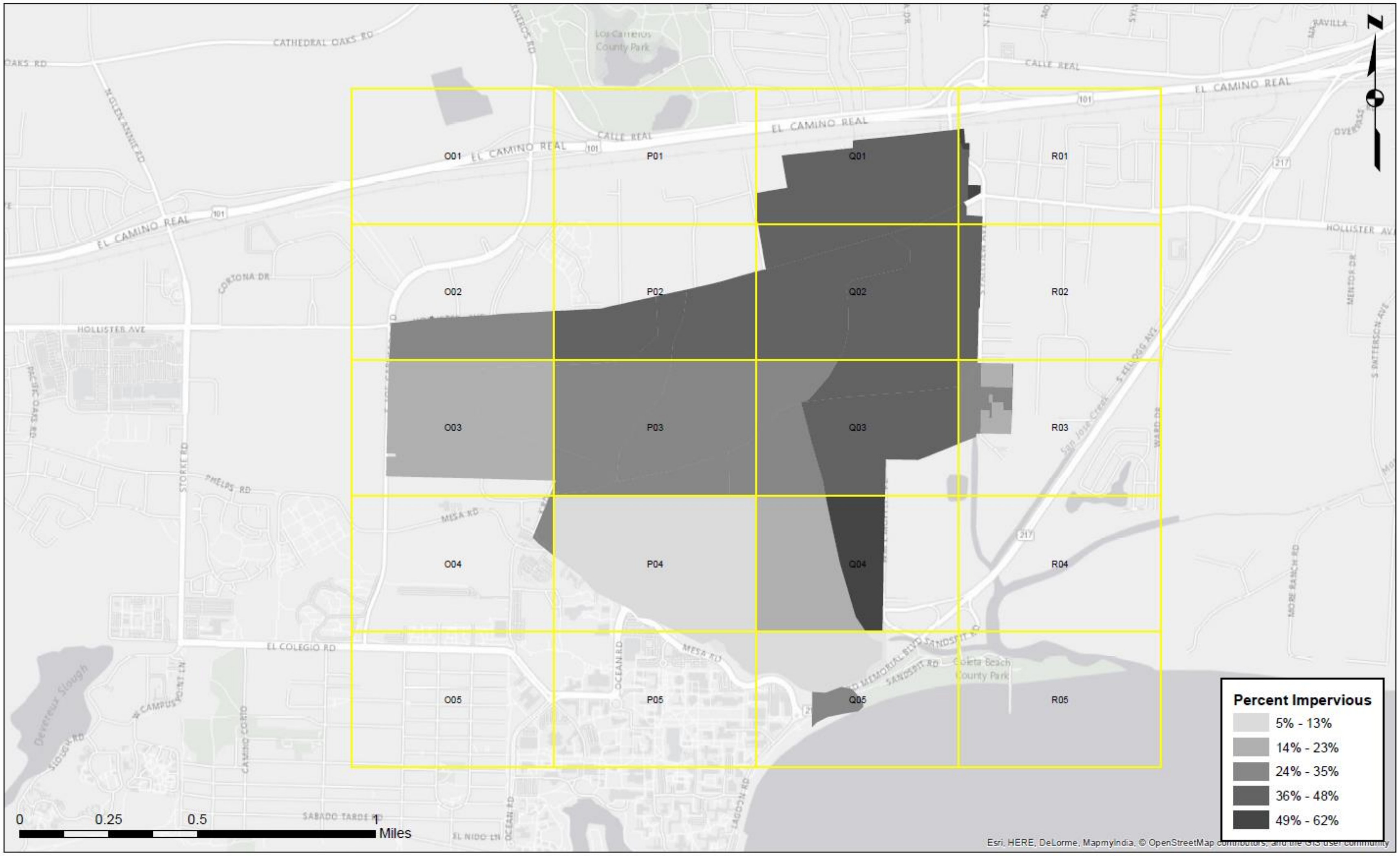
City of Santa Barbara: Land Use

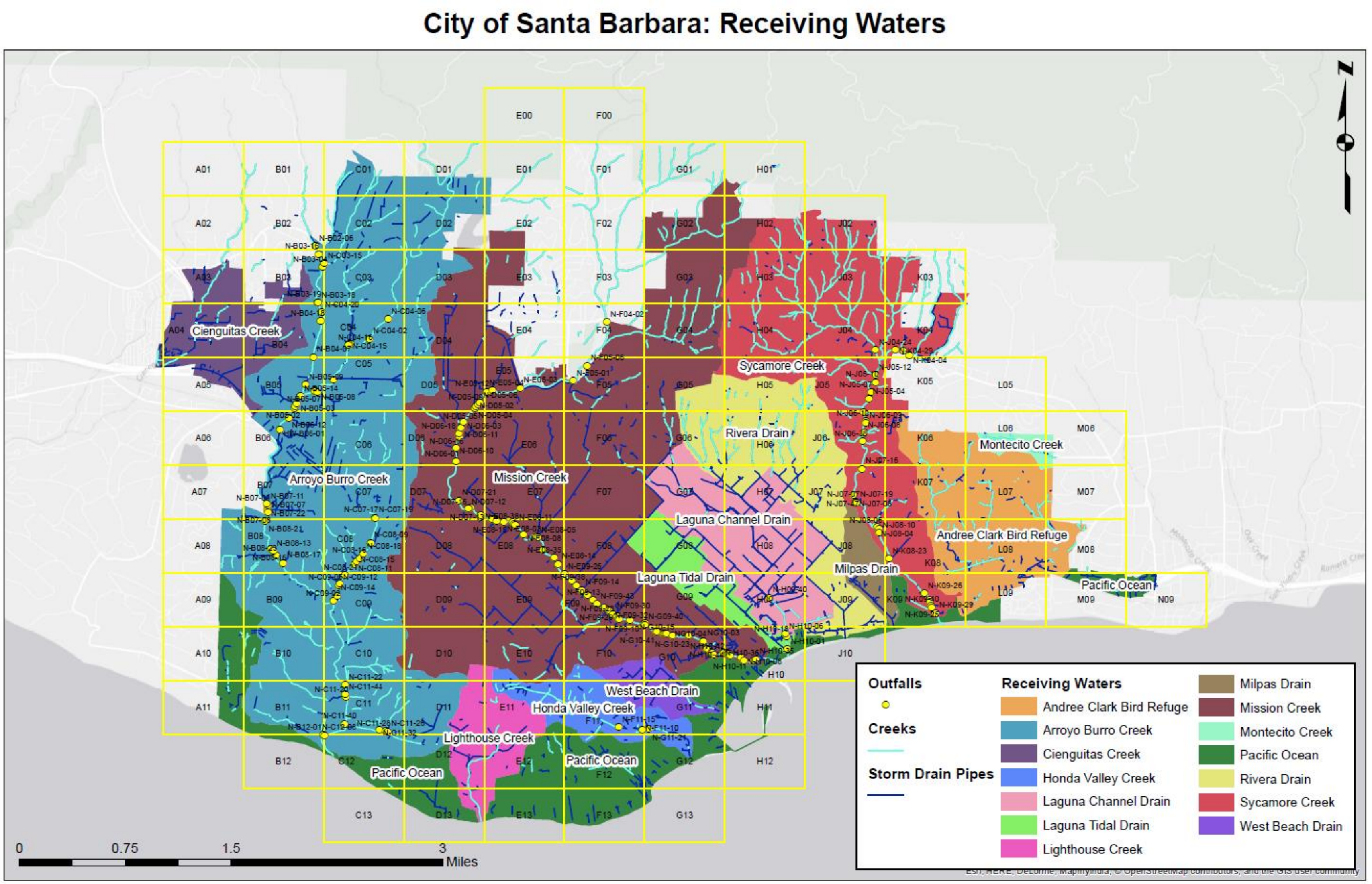


City of Santa Barbara: Imperviousness

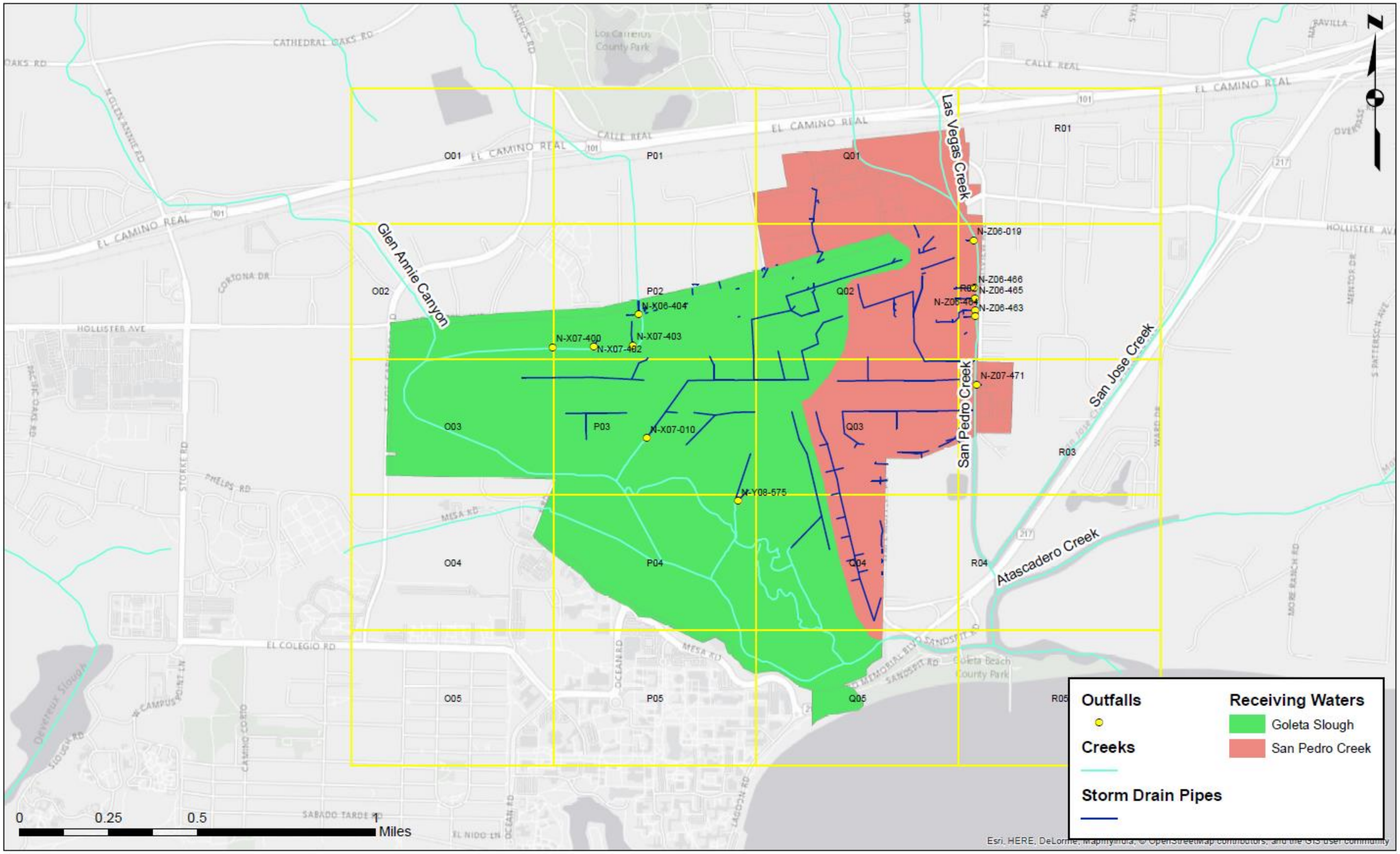


City of Santa Babara: Imperviousness




City of Santa Barbara: Receiving Waters
Cienguitas Creek
Arroyo Burro Creek
Mission Creek
Sycamore Creek
Rivera Drain
Montecito Creek
Laguna Channel Drain
Andree Clark Bird Refuge
Laguna Tidal Drain
Milpas Drain
Pacific Ocean
West Beach Drain
Honda Valley Creek
Lighthouse Creek
Pacific Ocean
Pacific Ocean
Outfalls
Creeks
Storm Drain Pipes
Receiving Waters
Andree Clark Bird Refuge
Arroyo Burro Creek
Cienguitas Creek
Honda Valley Creek
Laguna Channel Drain
Laguna Tidal Drain
Lighthouse Creek
Milpas Drain
Mission Creek
Montecito Creek
Pacific Ocean
Rivera Drain
Sycamore Creek
West Beach Drain
0 0.75 1.5 3 Miles
N

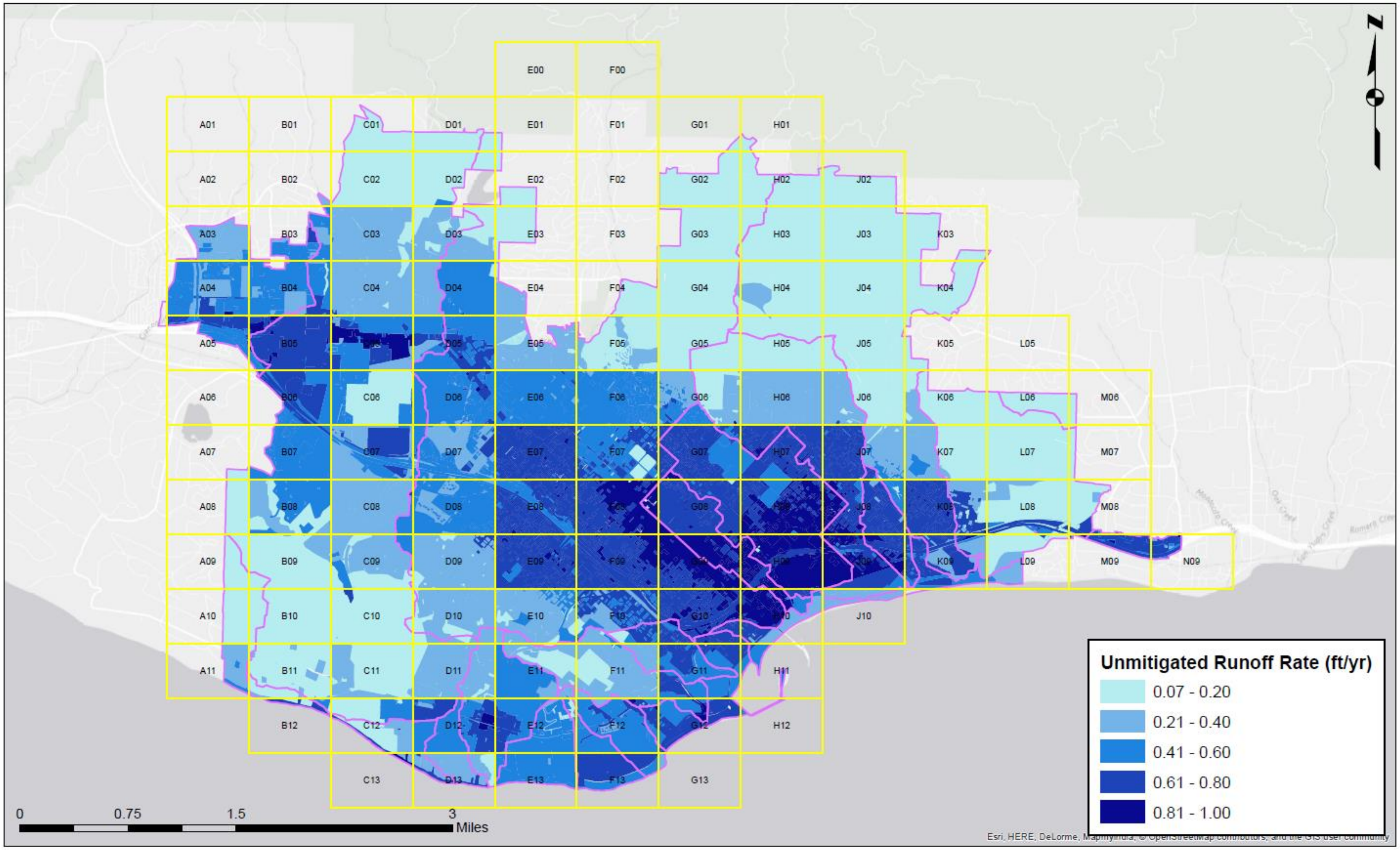
City of Santa Barbara Report #1: Catchment, Outfalls, and Receiving Waters



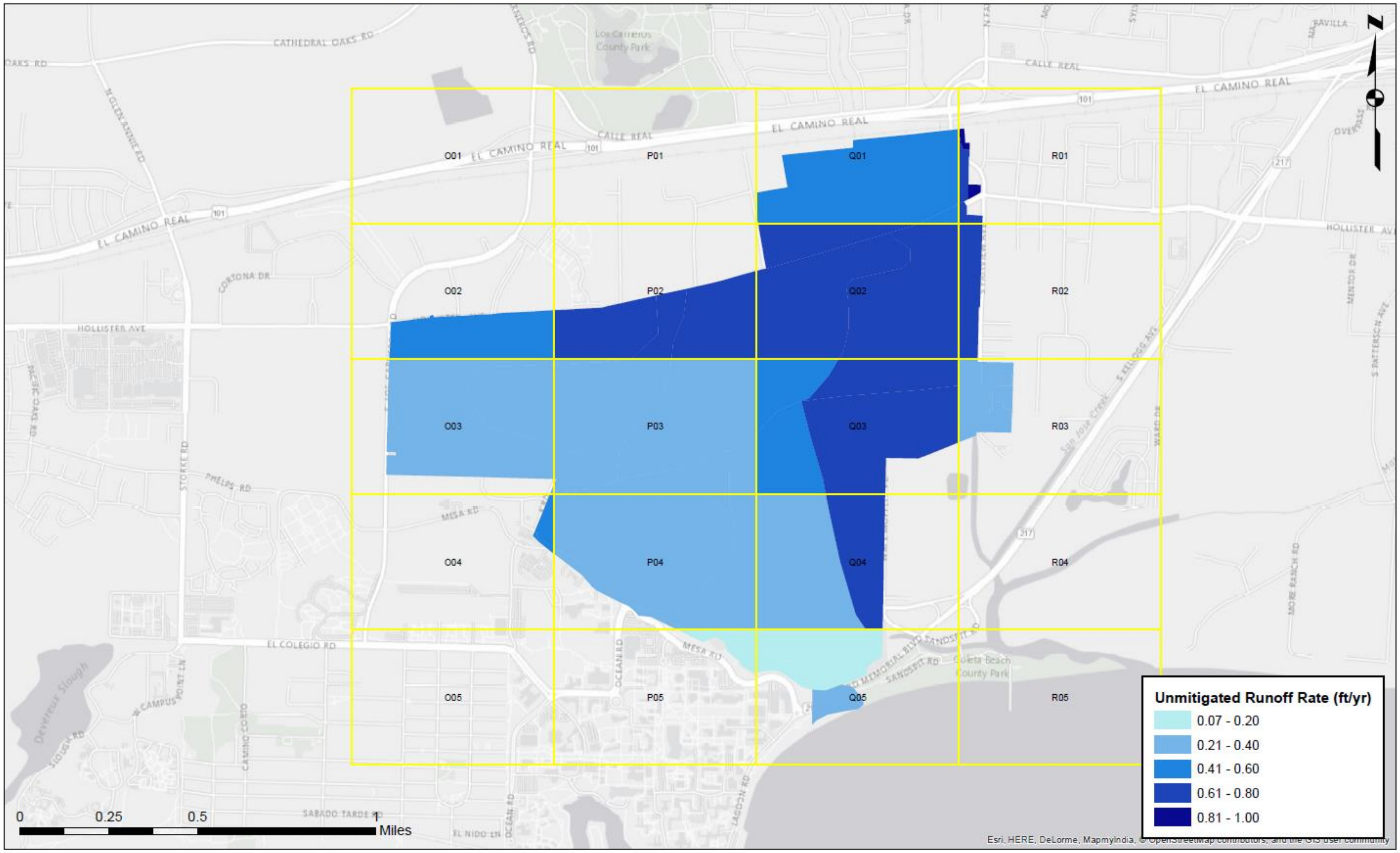
Unmitigated Model Output

The following plates show the maps of runoff rate and TSS loading rate based on SBSM calculations for both the main MS4 area and the non-adjacent airport section of MS4. The maps were submitted in partial fulfillment for Report #2. It should be noted that the color scales are identical for each pair of maps, but the distance scales are not.

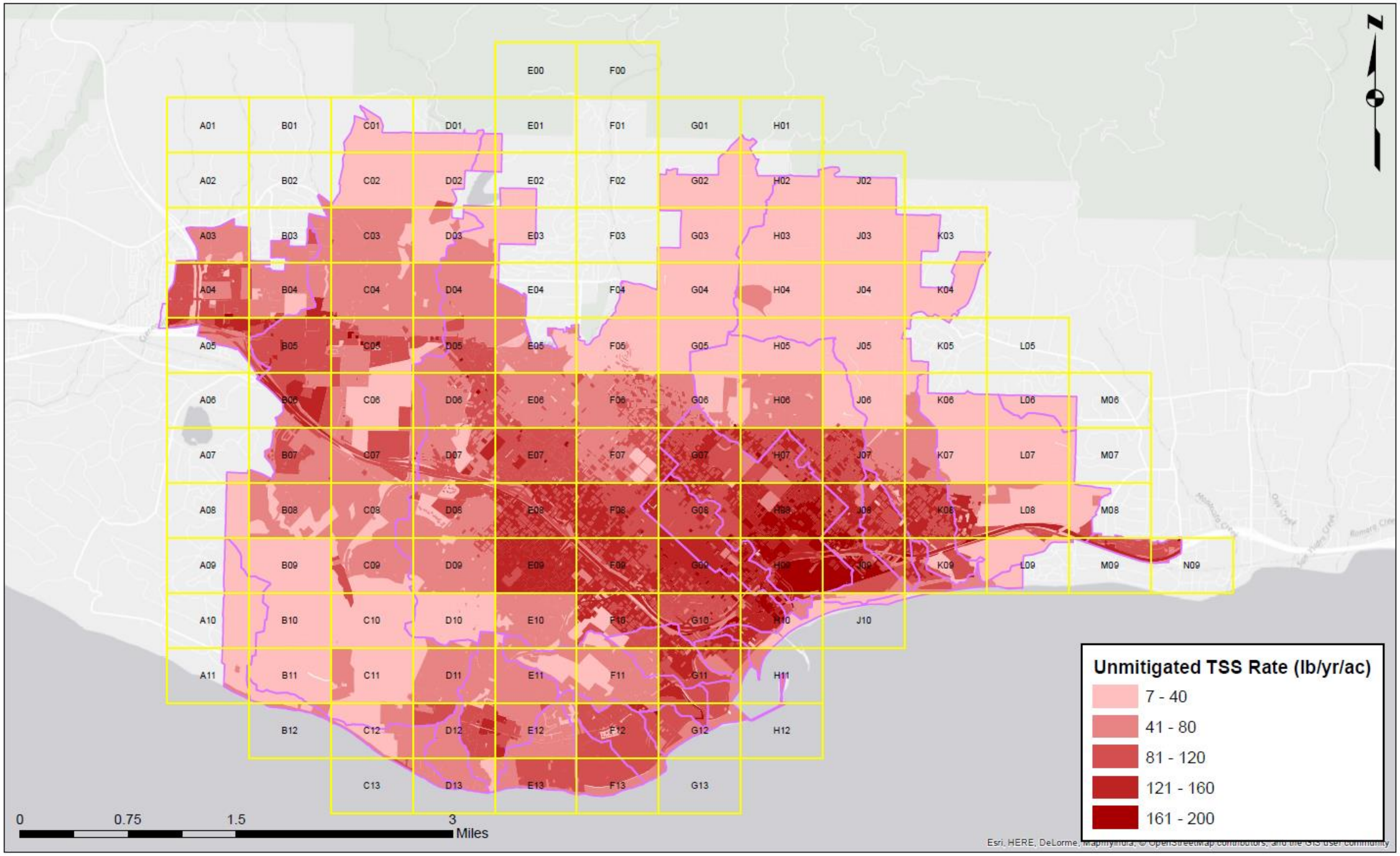
City of Santa Barbara: Unmitigated Runoff Rate (ft/yr)



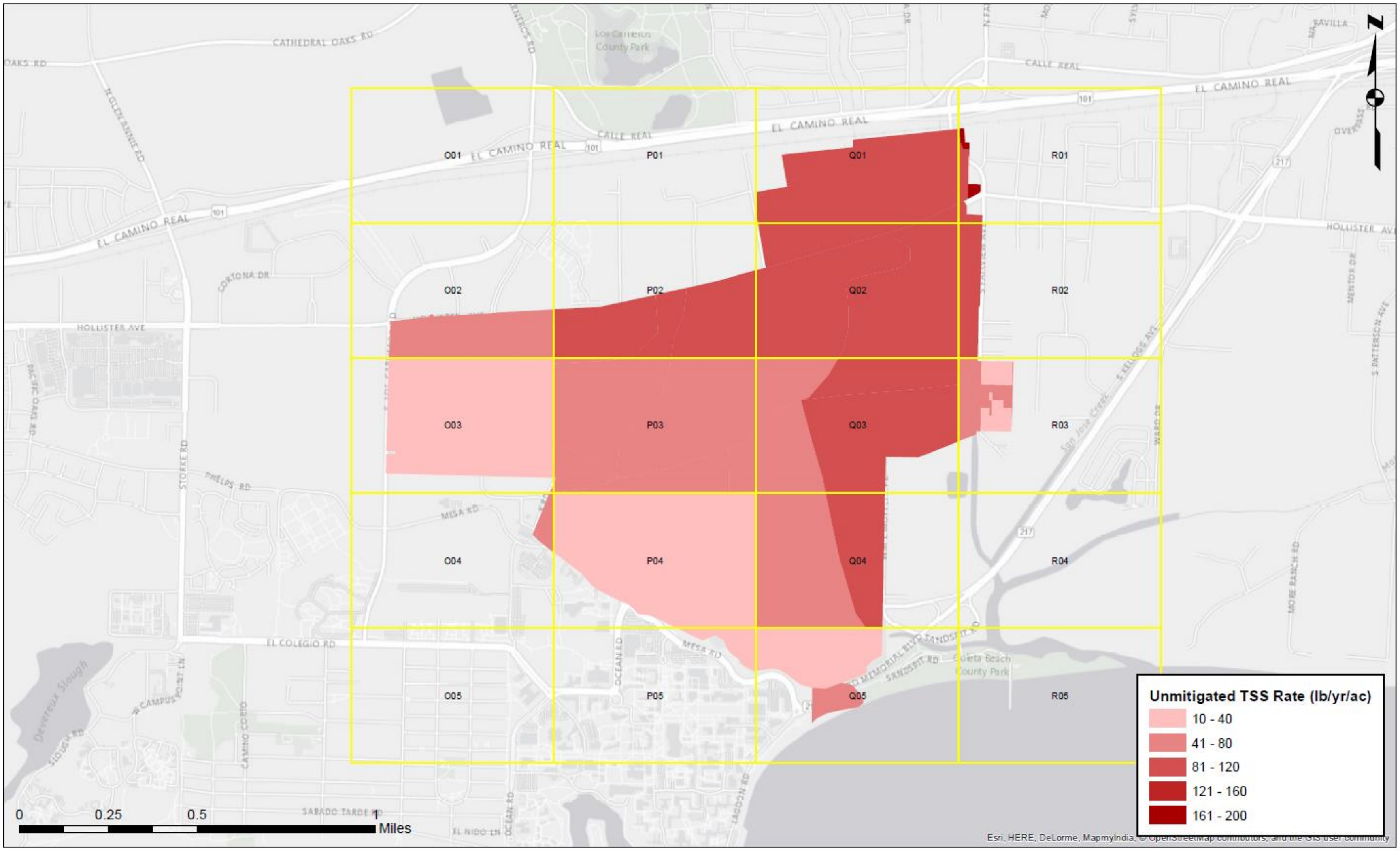
City of Santa Barbara: Unmitigated Runoff Rate (ft/yr)



City of Santa Barbara: Unmitigated TSS Rate (lb/yr/ac)



City of Santa Barbara: Unmitigated TSS Rate (lb/yr/ac)



The following table provides catchment rankings for the unmitigated condition as calculated by the SBSM. This table was previously submitted in partial fulfillment of Report #2. As can be seen in Table 14, eight catchments are included in the top ten rankings of each measure. These catchments are highly impervious and contain a high proportion of land uses that are modelled with relatively high concentrations of TSS in runoff.

Table 14. Updated Report #2, Catchment Rankings by Runoff Volume and Pollutant Load (submitted 10/26/2017). Shading marks the eight catchments that are included in the top ten rankings for each measure.

Catchment/ Grid ID	Acres	Unmitigated Runoff Volume, cf	Rank	Unmitigated Runoff Rate, ft per yr	Rank	Unmitigated TSS Load, lb per yr	Rank	Unmitigated TSS Rate, lb per year per acre	Rank
H09	144	5,535,222	1	0.88	1	22158	1	154	1
H08	141	5,213,933	3	0.85	3	20245	2	143	2
J09	144	4,924,091	4	0.78	5	18959	3	131	3
G09	140	5,225,209	2	0.86	2	17802	4	127	4
E09	142	4,657,963	6	0.75	7	17784	5	125	5
F08	139	4,763,268	5	0.79	4	16940	7	122	6
F09	139	4,374,059	9	0.72	9	16822	8	121	7
G10	142	4,425,887	8	0.72	10	17098	6	121	8
E08	139	4,118,579	14	0.68	17	16428	9	118	9
J08	142	4,325,800	11	0.70	12	16306	10	115	10
B06	100	2,860,543	31	0.66	19	11330	28	114	11
G08	139	4,595,372	7	0.76	6	15664	13	112	12
G07	140	3,974,747	15	0.65	20	15679	12	112	13
H07	141	4,281,229	12	0.70	14	15774	11	112	14
M09	33	994,905	75	0.70	13	3653	74	112	15
E07	140	4,212,146	13	0.69	16	15620	14	111	16
R01	5	167,490	119	0.71	11	592	117	110	17
B05	137	4,368,837	10	0.73	8	14754	15	108	18
K08	141	3,798,259	16	0.62	24	14748	16	105	19
H10	111	3,352,904	23	0.69	15	11433	27	103	20
N09	20	571,062	91	0.67	18	1988	88	102	21
A05	56	1,561,898	60	0.64	22	5534	56	99	22
G11	137	3,512,011	18	0.59	29	13011	17	95	23
D12	139	3,465,102	20	0.57	30	12678	19	91	24
R02	14	400,577	102	0.65	21	1275	99	90	25
J07	142	3,373,447	22	0.55	36	12689	18	90	26
G12	82	2,211,334	41	0.62	23	7325	43	90	27
F10	138	3,040,145	27	0.50	42	12011	21	87	28
F13	79	2,082,176	44	0.61	26	6853	46	87	29
F12	139	3,264,502	25	0.54	38	12037	20	86	30
C05	140	3,485,002	19	0.57	31	12005	22	86	31
Q02	136	3,668,638	17	0.62	25	11681	24	86	32
A04	136	3,009,103	29	0.51	40	11584	25	85	33
K09	135	3,266,641	24	0.56	34	11454	26	85	34
D05	140	3,427,650	21	0.56	33	11807	23	84	35
P02	66	1,726,123	52	0.60	27	5496	58	84	36
Q01	77	2,005,066	45	0.60	28	6384	50	83	37
B07	108	2,380,216	38	0.51	41	8724	38	81	38
F07	140	3,048,418	26	0.50	43	11051	29	79	39
Q03	123	3,025,406	28	0.57	32	9632	35	78	40
D06	139	2,955,777	30	0.49	44	10814	30	78	41
E13	80	1,868,669	50	0.54	37	6102	52	77	42
D07	141	2,822,843	33	0.46	47	10556	31	75	43

Catchment/ Grid ID	Acres	Unmitigated Runoff Volume, cf	Rank	Unmitigated Runoff Rate, ft per yr	Rank	Unmitigated TSS Load, lb per yr	Rank	Unmitigated TSS Rate, lb per year per acre	Rank
B04	118	2,295,262	40	0.45	50	8525	39	72	44
E12	139	2,844,178	32	0.47	46	9966	33	72	45
F06	140	2,673,180	35	0.44	51	9967	32	71	46
E06	140	2,758,584	34	0.45	49	9890	34	70	47
C07	65	1,198,576	65	0.42	58	4606	63	70	48
B03	56	1,071,077	72	0.44	52	3928	67	70	49
D04	138	2,627,233	36	0.44	53	9373	37	68	50
D08	139	2,572,766	37	0.42	56	9474	36	68	51
C13	5	131,464	120	0.55	35	346	120	63	52
O04	4	73,735	123	0.45	48	235	122	63	53
A03	61	976,270	76	0.37	64	3845	69	63	54
Q04	87	1,645,733	56	0.44	54	5239	60	61	55
B02	3	48,834	127	0.39	60	174	125	60	56
O02	36	680,963	86	0.43	55	2168	85	60	57
H11	20	452,410	99	0.52	39	1195	101	60	58
C08	74	1,185,619	67	0.37	63	4186	64	56	59
D09	138	2,131,924	42	0.35	66	7648	40	55	60
E04	30	464,041	97	0.35	67	1646	97	54	61
P03	138	2,338,451	39	0.39	61	7446	42	54	62
C04	138	2,098,083	43	0.35	68	7460	41	54	63
D13	72	1,186,975	66	0.38	62	3809	71	53	64
B12	18	361,095	104	0.47	45	909	109	52	65
B08	126	1,943,324	47	0.35	65	6480	49	51	66
E11	138	1,945,780	46	0.32	70	6917	44	50	67
E10	139	1,843,856	51	0.31	74	6818	47	49	68
D11	138	1,902,362	49	0.32	71	6747	48	49	69
G06	141	1,904,658	48	0.31	73	6898	45	49	70
K07	138	1,673,366	54	0.28	78	6165	51	45	71
C09	122	1,616,358	58	0.30	75	5418	59	44	72
H06	138	1,718,735	53	0.29	76	6054	53	44	73
H12	3	56,315	124	0.42	57	134	128	44	74
E05	111	1,337,368	62	0.28	79	4796	61	43	75
R03	20	287,292	110	0.34	69	833	113	42	76
C03	138	1,623,156	57	0.27	81	5733	55	42	77
F11	139	1,587,118	59	0.26	83	5749	54	41	78
G13	3	54,738	125	0.39	59	130	129	41	79
O03	99	1,223,811	64	0.28	77	3897	68	39	80
L08	140	1,646,651	55	0.27	80	5506	57	39	81
M08	49	577,545	89	0.27	82	1813	92	37	82
C12	105	1,132,337	69	0.25	85	3744	72	36	83
J10	33	453,193	98	0.31	72	1160	103	35	84
A11	35	380,876	103	0.25	84	1221	100	35	85
D10	138	1,379,262	61	0.23	87	4694	62	34	86
C06	124	1,273,791	63	0.24	86	4136	65	33	87
D03	128	1,152,704	68	0.21	90	4028	66	32	88
K06	97	838,817	80	0.20	93	2986	80	31	89
B11	123	1,105,930	70	0.21	91	3741	73	30	90
P04	118	1,045,851	74	0.20	92	3330	75	28	91
L07	138	1,089,190	71	0.18	94	3832	70	28	92
Q05	37	346,165	106	0.21	89	1016	108	27	93
F05	123	971,577	77	0.18	95	3318	76	27	94
L09	70	660,914	87	0.22	88	1879	89	27	95

Catchment/ Grid ID	Acres	Unmitigated Runoff Volume, cf	Rank	Unmitigated Runoff Rate, ft per yr	Rank	Unmitigated TSS Load, lb per yr	Rank	Unmitigated TSS Rate, lb per year per acre	Rank
M06	7	52,241	126	0.17	98	185	124	26	96
M07	11	79,880	122	0.17	97	274	121	25	97
J06	129	933,040	79	0.17	99	3208	78	25	98
A10	43	301,270	109	0.16	101	1071	107	25	99
G05	138	961,715	78	0.16	100	3295	77	24	100
B10	79	531,680	96	0.16	102	1859	90	24	101
G01	4	23,437	130	0.13	109	98	130	23	102
C02	123	816,284	82	0.15	103	2870	82	23	103
C11	134	1,055,965	73	0.18	96	3087	79	23	104
H04	138	824,501	81	0.14	107	2954	81	21	105
K04	84	540,277	94	0.15	104	1802	94	21	106
A09	41	247,719	113	0.14	105	876	112	21	107
H05	138	781,658	83	0.13	108	2745	83	20	108
P05	7	42,900	128	0.14	106	137	127	19	109
G04	137	712,484	85	0.12	113	2554	84	19	110
H01	5	23,171	131	0.10	119	97	131	18	111
D02	100	533,822	95	0.12	111	1812	93	18	112
G03	113	576,300	90	0.12	116	2032	87	18	113
L06	81	413,948	101	0.12	115	1392	98	17	114
J05	126	654,755	88	0.12	114	2165	86	17	115
F04	42	222,668	114	0.12	112	684	114	16	116
K05	9	39,776	129	0.10	120	150	126	16	117
C01	57	256,358	112	0.10	117	885	111	16	118
A08	39	169,429	118	0.10	118	524	119	13	119
H03	138	558,812	92	0.09	122	1845	91	13	120
C10	129	714,568	84	0.13	110	1718	95	13	121
B09	85	356,642	105	0.10	121	1125	105	13	122
E01	4	15,118	133	0.08	128	54	133	13	123
D01	50	201,841	116	0.09	123	637	116	13	124
K03	53	202,279	115	0.09	126	671	115	13	125
H02	92	333,796	107	0.08	129	1138	104	12	126
J02	73	270,494	111	0.09	127	890	110	12	127
J04	137	549,347	93	0.09	124	1648	96	12	128
E03	48	187,355	117	0.09	125	575	118	12	129
F03	0	1,506	134	0.07	132	5	134	11	130
G02	99	326,609	108	0.08	130	1077	106	11	131
A07	7	22,267	132	0.07	133	71	132	10	132
E02	26	83,430	121	0.07	131	230	123	9	133
J03	136	425,886	100	0.07	134	1181	102	9	134

The following tables provide additional demarcation of volume and pollutant loading by land use and receiving water. As shown in Table 15, industrial land use has the high rate of volume and TSS loading, due to the high associated EMC and the high PIA of industrial areas. On the other hand, single family residential areas comprise the greatest runoff volume and TSS load to surface waters due to their widespread prevalence in the City.

TABLE 15

Rankings by Land Use for Runoff Volume and Pollutant Load (10/26/2017)

Land Use	Acres	Unmittigated Runoff Volume, cf per year	Rank	Unmittigated Runoff Rate, ft per yr	Rank	Unmittigated TSS Load, lb per yr	Rank	Unmittigated TSS Rate, lb per year per acre	Rank
ID	410	12,936,922	5	0.72	1	57341	4	140	1
FWY	180	5,139,384	7	0.66	2	23903	7	133	2
MFR	1559	41,566,736	3	0.61	3	173860	3	112	3
CO	2375	58,654,192	2	0.57	4	186745	2	79	4
IS	400	7,013,909	6	0.40	5	29337	6	73	5
SFR	5705	78,238,784	1	0.31	6	278404	1	49	6
OP	2054	18,427,048	4	0.21	7	43713	5	21	7

TABLE 16

Rankings by Receiving Water for Runoff Volume and Pollutant Load (10/26/2017)

Receiving Water	Acres	Unmittigated Runoff Volume, cf per year	Rank	Unmittigated Runoff Rate, ft per yr	Rank	Unmittigated TSS Load, lb per yr	Ran k	Unmittigated TSS Rate, lb per year per acre	Rank
Laguna Channel Drain	566	18,901,644	4	0.77	2	73402	3	130	1
Laguna Tidal Drain	194	6,816,387	11	0.81	1	23118	11	119	2
Milpas Drain	114	3,553,493	13	0.72	3	13292	13	117	3
West Beach Drain	119	2,734,079	15	0.53	5	10791	15	91	4
San Pedro Creek	308	8,119,164	9	0.61	4	25827	9	84	5
Cienguitas Creek	385	8,373,179	8	0.50	6	31422	8	82	6
Mission Creek	3447	66,346,393	1	0.44	9	243892	1	71	7
Lighthouse Creek	271	5,321,210	12	0.45	8	19011	12	70	8
Pacific Ocean	1041	21,256,916	3	0.47	7	71505	4	69	9
Rivera Drain	700	12,829,250	5	0.42	10	47239	5	67	10
Honda Valley Creek	253	3,514,404	14	0.32	12	12954	14	51	11
Goleta Slough	659	10,559,038	7	0.37	11	33534	7	51	12
Arroyo Burro Creek	2566	35,325,781	2	0.32	13	122694	2	48	13
Andree Clark Bird Refuge	667	6,928,782	10	0.24	14	23975	10	36	14
Sycamore Creek	1343	11,119,618	6	0.19	15	39719	6	30	15
Montecito Creek	51	277,637	16	0.13	16	930	16	18	16

As shown in Table 16, the Mission Creek watershed produces the greatest volume of runoff and mass of TSS due to the large watershed. Laguna Channel and the Laguna Tidal Drain watersheds produce the highest rates of volume runoff and pollutant loading.

Results-Mitigated Conditions 2018

BMPAssessment

TABLE 17. CITY OF SANTA BARBARA, BMP ASSESSMENT FOR REPORT #3

BMP Assessment**Location***	**Identifier***	**Type**	**Current BMP Condition (ability to function relative to design)**	**Assessment Method and Empirical Data**
MacKenzie Park Parking Lot	051-112-018	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past seven years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Oak Park Main Parking Lot and Stage Area	051-330-002	Permeable Pavers, new landscape	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past five years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Oak Park BBQ Area	051-340-001	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past five years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.

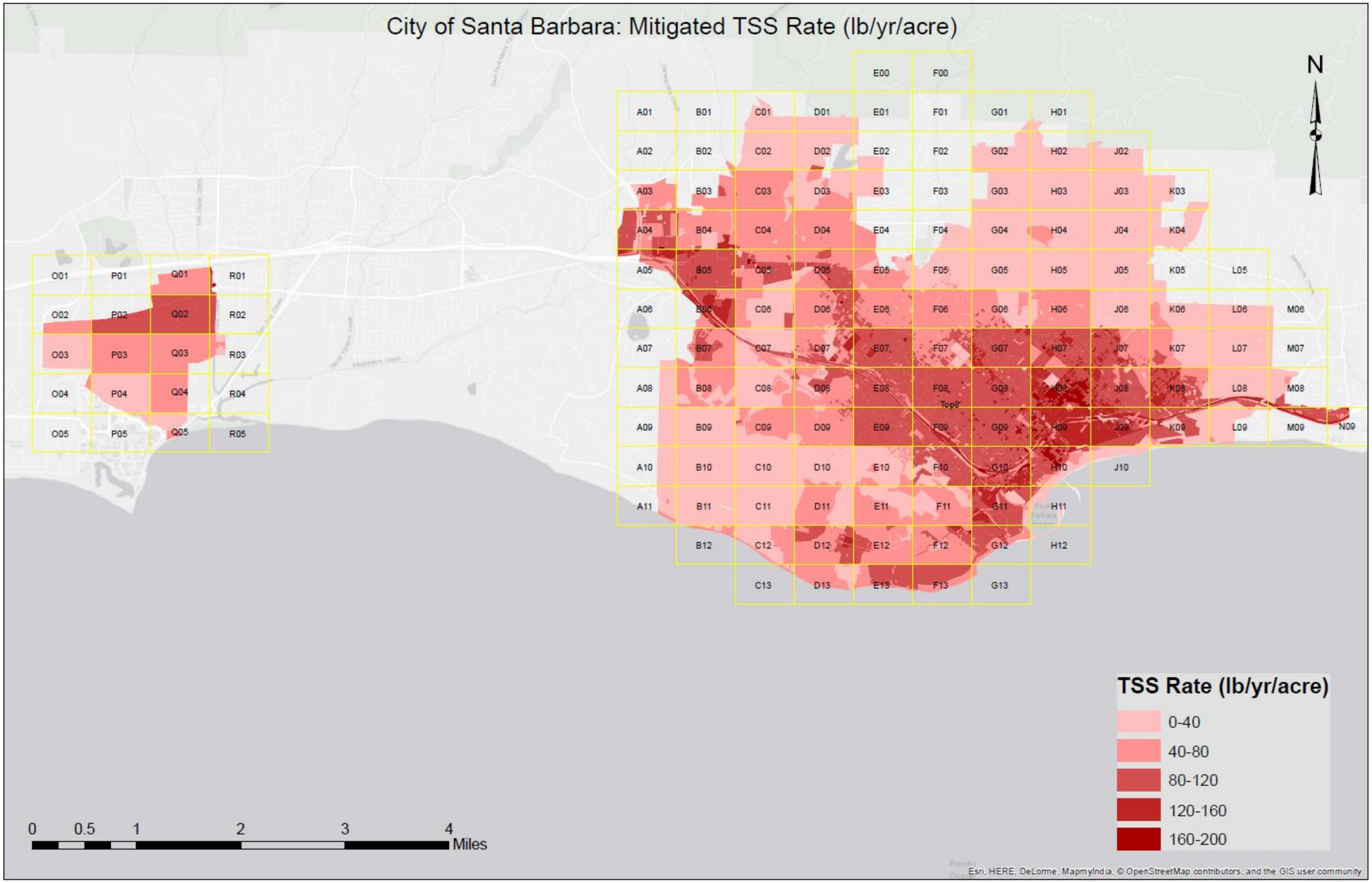
BMP Assessment**Location***	**Identifier***	**Type**	**Current BMP Condition (ability to function relative to design)**	**Assessment Method and Empirical Data**
Oak Park Tennis Court Lot	051-330-002	Permeable Pavers, new landscape	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past five years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Stevens Park Lot	053-032-001	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past five years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Westside Neighborhood Center	039-161-014	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past five years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Plaza de Vera Cruz	031-201-004	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past two years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.

BMP Assessment**Location***	**Identifier***	**Type**	**Current BMP Condition (ability to function relative to design)**	**Assessment Method and Empirical Data**
Alice Keck Park Surrounding Sidewalks	Public Right-of-Way	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past two years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Quarantina Street 700 block	Public Right-of-Way	Permeable Pavers, new landscape	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past two years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Quarantina Street 800 block	Public Right-of-Way	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past two years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Laguna Lot	031-160-016	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past two years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.

BMP AssessmentLocation*	Identifier*	Type	Current BMP Condition (ability to function relative to design)	Assessment Method and Empirical Data
Parks Yard	031-160-016	Permeable Pavers	BMP retains full capacity relative to design.	Depth loggers in monitoring wells show no overtopping of vault during the past two years for design storms. Visual observations of pavers show no overtopping during design storms (select data available in Special Studies Montoring Report). Visual inspection during dry weather shows minor clogging of paver gaps; these are regularly treated by blowing and vacuuming the pavers.
Las Positas/Cliff Dr Roundabout	Public Right-of-Way	Swale and bioretention basins	BMP retains full capacity relative to design.	Visual observations on Feb 22, 2018 during dry weather indicate swale and bioretention basins have sufficient ponding area and will function efficiently. Visual observations on March 13, 2018 during wet weather indicate the same.

Mitigated Maps and Catchment Rankings

The following maps and ranking tables show the results of the Santa Barbara Simple Model for the mitigated condition in 2018. This refers to post-development, stormwater program conditions.


City of Santa Barbara: Mitigated TSS Rate (lb/yr/acre)
N
TSS Rate (lb/yr/acre)
0-40
40-80
80-120
120-160
160-200
0 0.5 1 2 3 4
Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

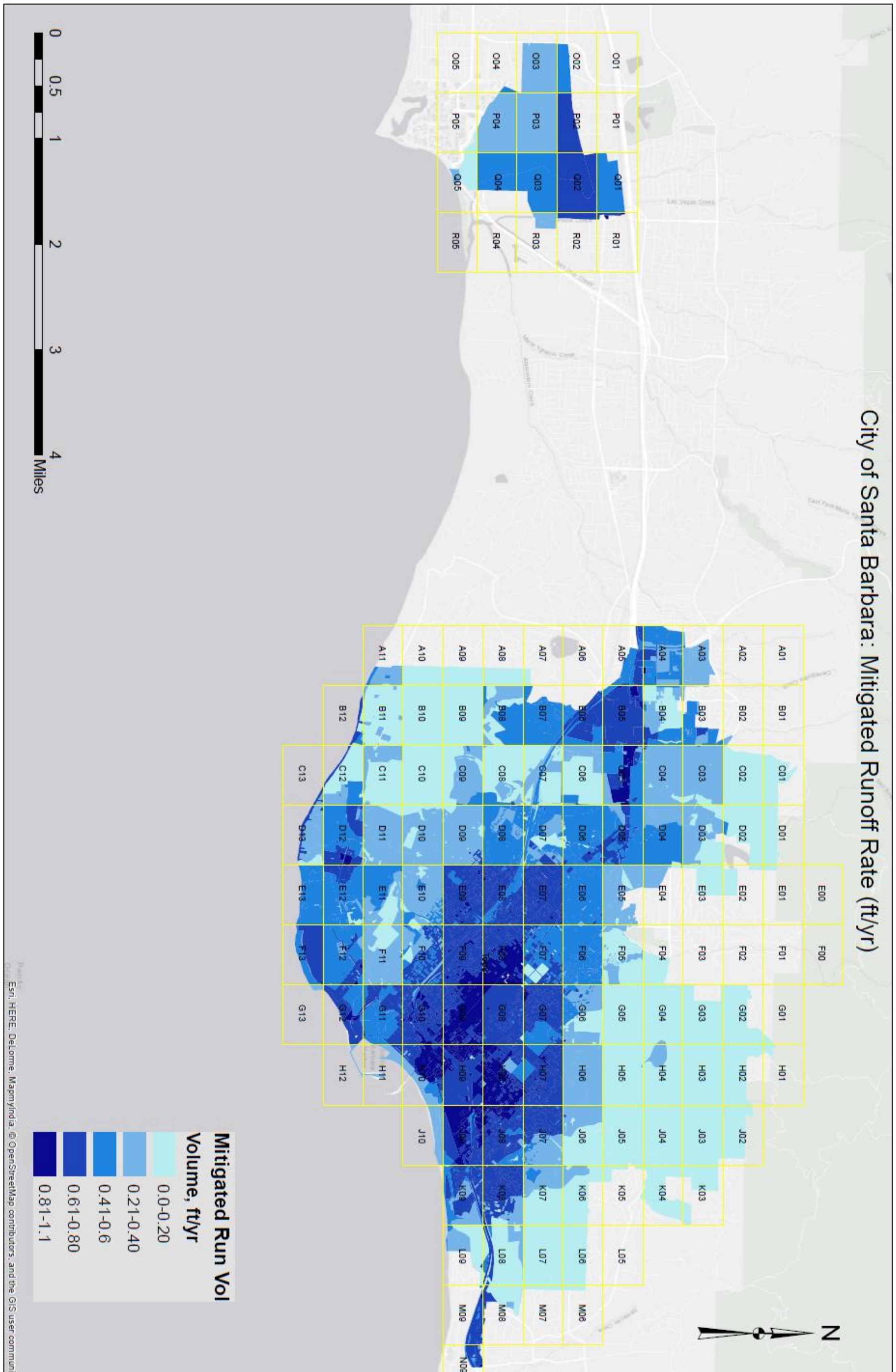


TABLE 18. REPORT #3, CATCHMENT RANKINGS BY MITIGATED RUNOFF VOLUME AND MITIGATED POLLUTANT LOAD (SUBMITTED 10/26/2017). SHADING MARKS THE EIGHT CATCHMENTS THAT ARE INCLUDED IN THE TOP TEN RANKINGS FOR EACH MEASURE.

City of Santa Barbara: Report #3, Mitigated Catchment Rankings

Catch-	Acres	Mitigated	Rank	Mitigated	Rank	Mitigated	Rank	Mitigated	Rank
H09	143.6	5156152	2	0.82	3	18848	1	131	1
H08	141.3	5132475	3	0.83	2	18093	2	128	2
J09	144.2	4861707	4	0.77	5	17664	3	122	3
G09	140.1	5178282	1	0.85	1	16111	4	115	4
E09	141.9	4657963	6	0.75	6	15987	5	113	5
F09	138.9	4374059	9	0.72	8	15454	7	111	6
B06	100.1	2860543	31	0.66	19	11100	24	111	7
G10	141.7	4404623	8	0.71	11	15678	6	111	8
F08	139.1	4733245	5	0.78	4	15364	8	110	9
R01	5.4	167490	119	0.71	10	593	117	110	10
E08	138.7	4118579	14	0.68	16	15186	9	109	11
E07	140.3	4189546	13	0.69	15	14601	10	104	12
M09	32.7	984120	75	0.69	14	3368	73	103	13
J08	142.0	4310397	10	0.70	12	14574	11	103	14
H07	141.3	4281229	12	0.70	13	14483	12	103	15
B05	137.2	4290254	11	0.72	9	14065	14	102	16
G07	140.4	3974710	15	0.65	20	14336	13	102	17
G08	139.3	4528189	7	0.75	7	13892	15	100	18
A05	55.7	1561898	59	0.64	22	5460	55	98	19
N09	19.5	565008	91	0.66	18	1869	88	96	20
K08	140.9	3798259	16	0.62	24	13484	16	96	21
H10	111.1	3287558	23	0.68	17	10184	28	92	22
R02	14.2	400577	101	0.65	21	1275	99	90	23
G11	137.0	3422136	20	0.57	28	12286	17	90	24
G12	81.8	2206296	40	0.62	23	7108	41	87	25
D12	138.7	3453219	19	0.57	30	11995	18	86	26
Q02	136.5	3625654	17	0.61	25	11475	20	84	27
P02	65.8	1726123	51	0.60	27	5496	54	84	28
F13	79.0	2081121	43	0.61	26	6515	44	83	29
J07	141.5	3353604	22	0.54	35	11563	19	82	30
F12	139.4	3261067	25	0.54	36	11372	21	82	31
C05	140.0	3485002	18	0.57	29	11331	22	81	32
F10	138.3	3037961	27	0.50	39	11185	23	81	33
A04	135.8	3009103	29	0.51	38	10948	26	81	34
K09	135.0	3262358	24	0.55	34	10726	27	79	35
D05	140.1	3418049	21	0.56	33	11016	25	79	36
Q03	122.8	3022233	28	0.57	31	9622	32	78	37
Q01	77.1	1899103	46	0.57	32	5878	52	76	38
B07	108.9	2380216	38	0.50	40	8226	38	76	39
D06	139.5	2951380	30	0.49	43	10164	29	73	40
E13	79.6	1854797	49	0.53	37	5753	53	72	41
D07	141.2	2790879	33	0.45	46	9990	30	71	42
F07	139.9	3038631	26	0.50	42	9683	31	69	43
E12	138.9	2839959	32	0.47	45	9458	33	68	44
B03	57.3	1071077	72	0.43	53	3710	69	65	45
D04	137.8	2627233	36	0.44	50	8749	34	63	46
D08	139.5	2572766	37	0.42	54	8691	35	62	47
O04	3.7	72584	123	0.45	48	231	122	62	48
E06	140.3	2758584	34	0.45	47	8690	36	62	49
Q04	86.5	1635706	55	0.43	51	5208	59	60	50
O02	36.1	680963	86	0.43	52	2168	85	60	51
B04	134.0	1418478	60	0.24	83	7990	39	60	52
F06	140.1	2673180	35	0.44	49	8349	37	60	53
B02	2.9	48834	126	0.39	56	170	125	59	54
A03	64.1	945772	77	0.34	63	3661	70	57	55
C13	5.4	118886	120	0.50	41	296	120	54	56
P03	137.7	2338451	39	0.39	57	7445	40	54	57
B12	17.5	361095	103	0.47	44	902	108	52	58
E04	30.4	464041	97	0.35	61	1538	97	51	59
D09	138.3	2127200	41	0.35	60	6953	42	50	60
C04	138.1	2098083	42	0.35	62	6843	43	50	61

Catch-	Acres	Mitigated	Rank	Mitigated	Rank	Mitigated	Rank	Mitigated	Rank
D13	72.5	1169608	67	0.37	59	3559	71	49	62
E11	138.1	1934406	45	0.32	67	6329	45	46	63
D11	137.8	1892502	47	0.32	68	6207	46	45	64
B08	138.2	1943324	44	0.32	66	6152	47	45	65
K07	138.1	1662139	54	0.28	75	6073	49	44	66
G06	141.0	1881423	48	0.31	70	6108	48	43	67
H06	138.0	1703612	52	0.28	73	5927	51	43	68
E10	138.8	1836978	50	0.30	71	5954	50	43	69
R03	19.6	287292	110	0.34	64	834	111	43	70
G13	3.2	54738	124	0.39	55	130	128	41	71
E05	111.2	1337368	62	0.28	76	4489	61	40	72
O03	98.8	1223811	64	0.28	72	3896	67	39	73
C03	137.9	1605304	57	0.27	79	5389	57	39	74
F11	138.5	1587118	58	0.26	80	5405	56	39	75
C09	138.2	1677359	53	0.28	74	5329	58	39	76
L08	139.9	1635250	56	0.27	78	5178	60	37	77
M08	49.1	577545	89	0.27	77	1694	94	34	78
C12	105.4	1127381	69	0.25	82	3548	72	34	79
H11	20.1	324210	107	0.37	58	655	115	33	80
A11	35.2	378942	102	0.25	81	1139	101	32	81
D10	137.8	1364737	61	0.23	84	4302	62	31	82
C07	140.1	1198576	66	0.20	91	4296	63	31	83
J10	33.4	453193	98	0.31	69	1006	105	30	84
D03	134.1	1152704	68	0.20	90	4009	65	30	85
K06	100.9	835808	80	0.19	92	2970	79	29	86
H12	3.1	43786	127	0.33	65	89	131	29	87
C08	139.4	1214314	65	0.20	89	4043	64	29	88
C06	138.3	1273791	63	0.21	87	3999	66	29	89
P04	117.6	1045856	73	0.20	88	3330	74	28	90
L07	137.5	1085220	70	0.18	93	3815	68	28	91
Q05	37.2	345971	105	0.21	86	1016	104	27	92
M06	7.1	52216	125	0.17	98	185	124	26	93
M07	10.8	79880	122	0.17	97	274	121	25	94
F05	122.8	953302	76	0.18	95	3048	78	25	95
L09	69.7	654743	87	0.22	85	1706	93	24	96
B11	135.9	1071717	71	0.18	94	3312	75	24	97
G01	4.2	23437	130	0.13	108	98	129	23	98
J06	137.1	933040	78	0.16	100	3193	76	23	99
G05	138.0	929883	79	0.15	101	3133	77	23	100
A10	43.4	296638	109	0.16	99	980	107	23	101
C02	123.2	799281	82	0.15	102	2780	82	23	102
H04	137.8	824501	81	0.14	105	2954	80	21	103
K04	84.4	539140	94	0.15	103	1796	91	21	104
C11	137.9	1042652	74	0.17	96	2828	81	21	105
H05	137.8	775300	83	0.13	107	2711	83	20	106
A09	41.2	244581	113	0.14	106	804	112	19	107
P05	7.2	42851	128	0.14	104	136	127	19	108
H01	5.3	23171	131	0.10	118	97	130	18	109
G04	137.4	699604	85	0.12	113	2486	84	18	110
G03	113.0	576300	90	0.12	112	2032	87	18	111
D02	100.4	532387	95	0.12	109	1804	89	18	112
L06	80.8	404622	100	0.11	114	1349	98	17	113
F04	42.4	222668	114	0.12	110	684	113	16	114
J05	136.7	650953	88	0.11	115	2145	86	16	115
C01	57.0	256358	112	0.10	116	885	109	16	116
A08	38.8	169429	118	0.10	117	512	119	13	117
E01	4.1	15118	133	0.08	125	54	133	13	118
H03	137.8	550310	92	0.09	121	1800	90	13	119
B10	137.8	528809	96	0.09	123	1785	92	13	120
D01	50.1	201841	116	0.09	119	637	116	13	121
K03	53.4	202279	115	0.09	124	671	114	13	122
C10	137.8	714568	84	0.12	111	1676	95	12	123

Catch-	Acres	Mitigated	Rank	Mitigated	Rank	Mitigated	Rank	Mitigated	Rank
J04	137.4	549347	93	0.09	120	1648	96	12	124
E03	48.0	187355	117	0.09	122	575	118	12	125
J02	72.7	265486	111	0.08	126	863	110	12	126
F03	0.5	1506	134	0.07	130	5	134	11	127
G02	99.2	326609	106	0.08	128	1077	102	11	128
H02	91.9	305547	108	0.08	127	987	106	11	129
A07	7.0	22267	132	0.07	131	71	132	10	130
K05	15.4	39776	129	0.06	133	150	126	10	131
E02	25.6	83430	121	0.07	129	230	123	9	132
J03	136.0	425886	99	0.07	132	1181	100	9	133
B09	137.7	351635	104	0.06	134	1067	103	8	134

Total Load Reductions

The Santa Barbara Simple Model estimates a 1.2% reduction in runoff volume, from 221,976,975 cf yr^{-1} in the unmitigated condition to 219,374,039 cf yr^{-1} of runoff in the mitigated condition. The model also estimates a 6.9% reduction in TSS load, from 793,303 lb yr^{-1} to 738,330 lb yr^{-1}. The higher relative reduction in TSS load compared to volume is due to the substantial impact of street sweeping on TSS loading. For the Top 8 catchments described in the unmitigated section above, the model estimates a 9.9% reduction in TSS (lb yr^{-1}) and a 1.6% reduction in volume. These catchments have a relatively high frequency of street sweeping.

General Permit Monitoring-303(d) and Special Studies

The following section was completed as a General Permit monitoring requirement.

Introduction

During Permit Year 5, the City carried out monitoring for Special Studies and 303(d) Monitoring under Regional-Board Approved Monitoring Plan/QAPPs. The City also carried out extensive monitoring and research under the Creeks Advisory Committee-approved Water Quality Research and Monitoring Plan (not included here). This report includes the required sections for Special Studies monitoring, as shown in

(iii) **Reporting –** By the second year Annual Report, the Permittee shall complete and have available a report (50 page maximum) that includes a summary of baseline data collections and discussion of monitoring program results.

By the fifth year Annual Report, the Permittee shall complete and have available a report (50 page maximum) that includes a comparison of data collection to baseline data, and discussion of monitoring program results.

At a minimum, the second and fifth year Annual Reports shall include the following information:

(a) The purpose of the monitoring, contextual background and a description of the study design and rationale.
(b) Sampling site(s) locations, including latitude and longitude coordinates, water body name and water body segment if applicable. Sampling design, including sampling protocol, time of year, sampling frequency and length of sampling.
(c) Methods used for sample collection: list methods used for sample collection, sample or data collection identification, collection date, and media if applicable.
(d) Results of data collection, including concentration detected, measurement units, and detection limits if applicable.
(e) Quantifiable assessment analysis and interpretation of data for each monitoring parameter or other data type.
(f) Comparison to reference sites (if applicable), guidelines or targets
(g) Discussion of whether data collected addresses the objective(s) or question(s) in the study plan
(h) Quantifiable discussion of program/study pollutant reduction effectiveness.

FIGURE 8. REQUIREMENTS FOR YEAR 5 SPECIAL STUDIES REPORTING, COPIED FROM THE GENERAL PERMIT.

There are no specific reporting requirements for 303(d) Monitoring.

Special Studies Monitoring

Special Studies Monitoring was carried out according to the approved Monitoring Plan/QAPP with the following exceptions: the Haley Drain was not sampled due to lack of flow during the drought. The Hope Drain and Westside Drain were not sampled due to lack of operation.

Purpose of Monitoring

On July 1, 2013 the California State Waterboard's Phase II Small MS4 General Permit (General Permit) became effective (Order No. 2013-0001 DWQ). Section E. 13 of the General Permit, Water Quality Monitoring, contains monitoring requirements that vary based on a jurisdiction's population size, geographical location, and existing water quality impairments. This Special Studies Plan describes in part activities that the City of Santa Barbara (City) will conduct in order to meet the monitoring requirements of the Permit. Results from monitoring described here will also support the City's Program Effectiveness Assessment and Improvement Plan, as required in Section E. 14, particularly the requirements to assess pollutant load reductions for specific best management practices (BMPs) and for the storm water program as a whole.

Underlying the purpose of meeting the Permit requirements is the City's continued desire to improve water quality in surface and marine waters. The monitoring described here is a subset of a larger Water Quality Monitoring and Research Program conducted by the City's Creeks Division. The Water Quality Monitoring and Research Program is designed to identify water quality impairments, prioritize potential solutions, e.g. source identification and BMPs, and gauge the effectiveness of BMPs implemented by the City. For additional information about the City's Monitoring Program, see the Creeks Division website (www.sbcreeks.com).

Contextual Background

The Water Quality Monitoring (E.13) section of the General Permit provides a flow chart and narrative description of monitoring requirements. According to the General Permit language and a Regional Board Consultation conducted on April 16, 2014, the City is required to conduct 303(d) Monitoring (E.13.c) and Special Studies (E.13.d.2). As agreed to by Regional Board staff, a separate Monitoring Plan for 303(d) monitoring was submitted during the second year of the Permit.

Rationale

On April 16, 2014 the City consulted with the Central Coast Regional Board as required by E.13.d.2.(i). At the meeting, it was discussed that the rationale for selecting Special Studies, in lieu of Receiving Water Monitoring, is two-fold. First, the Regional Board prefers that the City focus on quantifying pollutant load reduction, rather than measure concentrations in receiving water. Second, the City could not identify sampling sites that would meet the site selection criteria for receiving water monitoring as specified in E.13.d.1. Both parties reached agreement that an appropriate Special Studies focus should be the quantification of load reduction for previously-installed infrastructure projects designed to reduce pollutant loads to impaired water bodies, including low impact development (LID) projects. The projects should address impairments in which urban runoff is specifically listed as a potential source. The following table shows the projects that will be studied, as described in detail in later sections of this document, in order to achieve compliance with E. 13 of the Permit. Some of the data used in the proposed Special Studies were collected prior to the 2013 renewel of the Permit. The City added LID Streets, Sidewalks, and Alleys Project to Special Studies monitoring in Year 2 of the Permit.

TABLE 19. 303(D) IMPAIRMENTS ADDRESSED BY PROJECTS

Project Name (Installation Date)	Project Description	Water Body Name	Pollutant(s)	Potential Source
Hope Drain Diversion (installed 3/15/07)	Low-flow diversion of urban runoff to sanitary sewer during dry weather	Arroyo Burro Creek	E. coli, Fecal coliform	Urban Runoff/Storm Sewers
Haley Drain	Low-flow diversion of urban runoff to sanitary	Mission Creek	E. coli	Urban Runoff/Storm Sewers

(installed 7/22/06))	sewer during dry weather	Pacific Ocean at East Beach-Mission Ck.	Total coliform	Urban Runoff/Storm Sewers
Westside Summer Urban Runoff Facility (SURF) (installed 12/4/2006)	Ultraviolet disinfection of discharge from the Westside Storm Drain	Mission Creek	E. coli	Urban Runoff/Storm Sewers
		Pacific Ocean at East Beach-Mission Ck.	Total coliform	Urban Runoff/Storm Sewers
Parking Lot LID Demonstration (installed 12/26/2013)	Permeable pavers installed at six sites to increase infiltration and eliminate pollutant runoff	Arroyo Burro Creek	E. coli, Fecal coliform	Urban Runoff/Storm Sewers
		Mission Creek	E. coli	Urban Runoff/Storm Sewers
		Pacific Ocean at East Beach-Mission Ck.	Total coliform	Urban Runoff/Storm Sewers
Streets, Sidewalk, and Alleys Project	Permeable pavers installed at four sites to increase infiltration and eliminate pollutant runoff	Mission Creek	E. coli	Urban Runoff/Storm Sewers
		Pacific Ocean at East Beach-Mission Ck.	Total coliform	Urban Runoff/Storm Sewers

Appendices contain additional background information. Because there are three very different types of projects being studied as part of this Plan, the material is not repeated in this section (Table 20).

TABLE 20. BACKGROUND INFORMATION FOR PROJECTS

Appendix and Project	Project Background	Study Design/Load Reduction Quantification Approach	Reference Data	Surrounding Land Use
Appendix A – Hope Drain Diversion	Final Report, p. 3-7	Monitoring Plan, p. 3	Final Report, p.16	Commercial, Final Report p. 21
Appendix A – Haley Diversion	Final Report, p. 3-7	Monitoring Plan, p. 3 Final Report, p. 13	Final Report, p. 17	Residential and Commercial, Final Report p. 22
Appendix B- Westside Summer Urban Runoff Facility	Final Report, p. 2-4	Final Report, p. 17	Final Report, p. 18	Residential, Open, and limited Commercial, Final Report p. 5
Appendix C – Parking Lot LID Demonstration Project	MP/QAPP, p. 1-3	MP/QAPP, p. 2	N/A	These projects do not treat runon, therefore surrounding land use is not presented.
Appendix D- Street, Sidewalks, and Alleyways LID Project	MP/QAPP p. 1-3	MAP/QAPP p. 2	N/A	These projects do not treat runon, therefore surrounding land use is not presented.

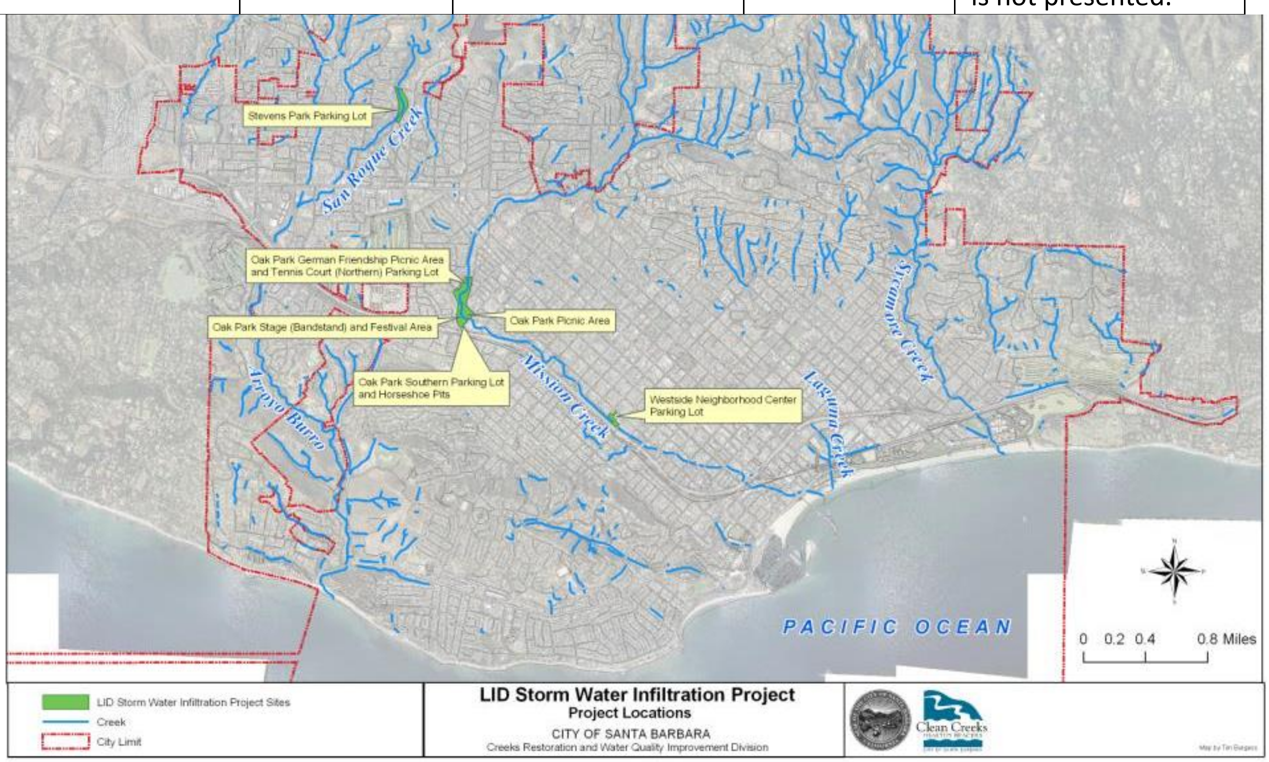


FIGURE 9. MAP OF SANTA BARBARA AND PARKING LOT LID DEMONSTRATION PROJECT LOCATIONS

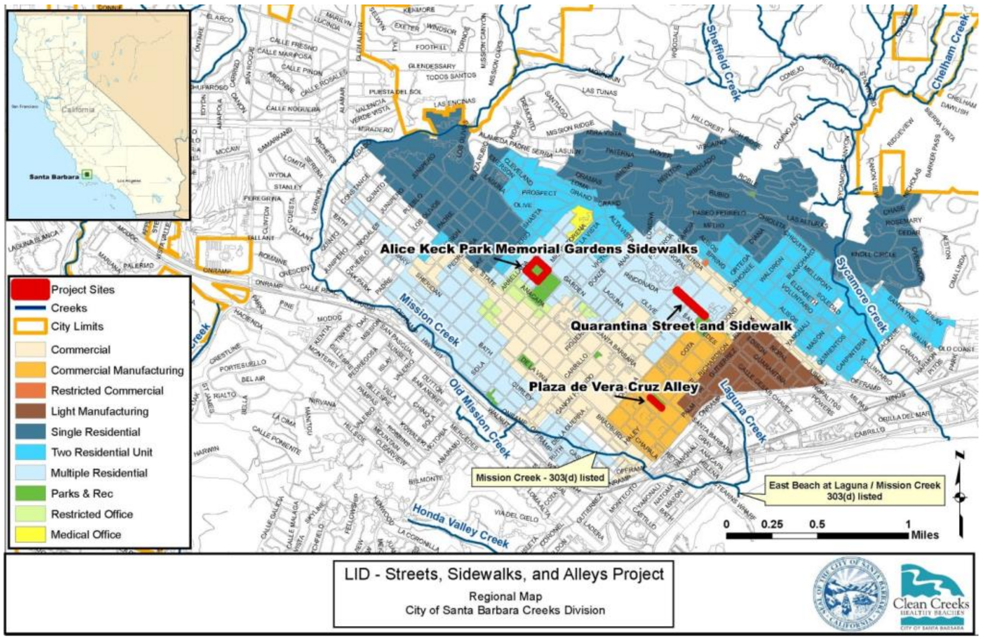


FIGURE 10. MAP OF STREETS, SIDEWALKS, AND ALLEYWAYS PROJECTS.

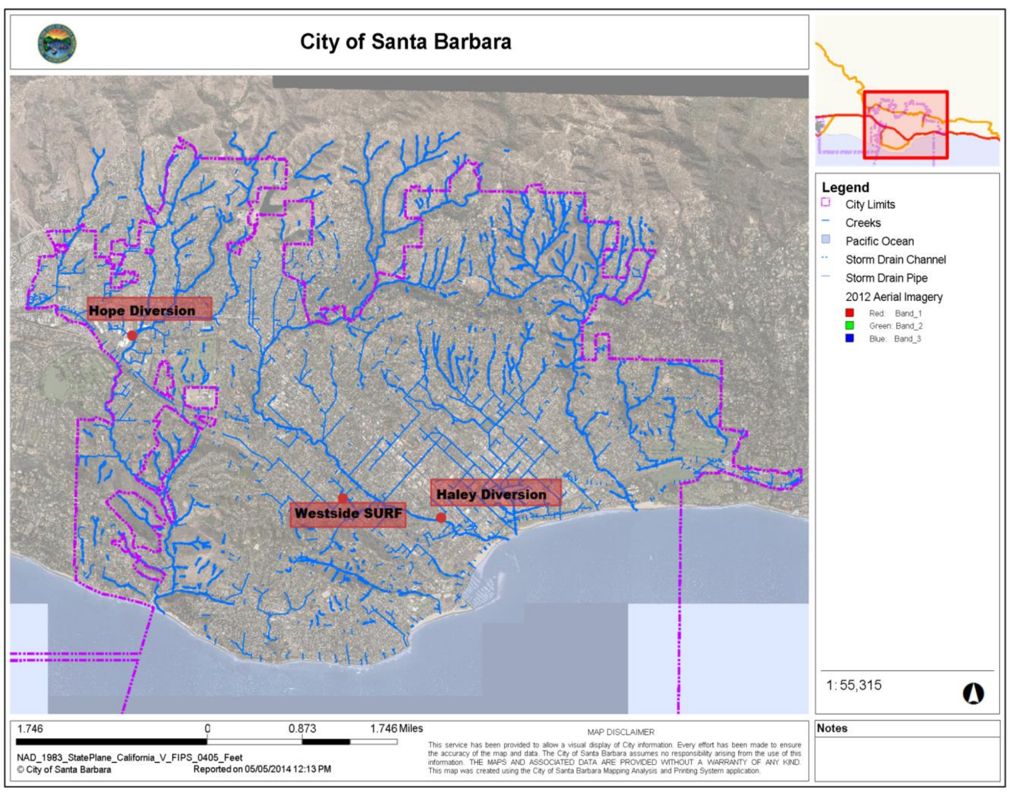


FIGURE 11. MAP OF DIVERSION AND DISINFECTION PROJECTS.

Study Design

Because this report addresses different types of projects, there is not a single study design. Study designs for each project can be found in the appendices, as described in Table 20.

Sampling site(s) locations and Sampling Design

Details for each sampling site, including maps and latitude and longitude coordinate, are provided in the appendices (Table 20). The sampling sites have the same water body name and water body segment if applicable as the project locations (Table 19). Sampling design, including sampling protocol, time of year, sampling frequency and length of sampling are summarized in Table 21.

Table 21 summarizes the sampling design for each project. See Appendices for details and rationale for parameter selection.

TABLE 21. SUMMARY OF SAMPLING DESIGN

Project	Sites	Parameters	Frequency
Hope Diversion	Hope Drain Manhole (see Appendix A)	Total coliform, fecal coliform (*E. coli*), enterococcus	Quarterly
Haley Diversion	Haley Drain Pump (see Appendix A)	Total coliform, fecal coliform (*E. coli*), enterococcus	Quarterly
Westside Summer Urban Runoff Facility	SURF up (inlet) and SURF down (outlet) (see Appendix B)	Total coliform, fecal coliform (*E. coli*), enterococcus	Weekly during facility operation (April 1 – October 31 per AB411 guidelines)
Parking Lot LID Demonstration	Runoff location at each site (See Appendix C)	Total coliform, fecal coliform (*E. coli*), Enterococcus, Toxicity, Nutrients, Metals, Surfactants, Total Suspended Solids (see Appendix C)	Up to three timepoints during three pre-project storms (see Appendix C)
Streets, Sidewalks and Alleyways	Runoff location at each site (See Appendix D)	Total coliform, fecal coliform (*E. coli*), Enterococcus, Toxicity, Nutrients, Metals, Surfactants, Total Suspended Solids (see Appendix D)	Up to three timepoints during three pre-project storms (see Appendix C)

Methods

Methods, including sample collection, sample or data collection identification, collection date, and media if applicable are provided in the appendices, as described in Table 20.

Results

Results of data collection, including concentration detected, measurement units, and detection limits if applicable are provided in the appendices, as described in Table 20.

Quantifiable assessment

Load reduction is the primary quantifiable assessment for each project.

BECAUSE THE PRIMARY IMPAIRMENTS ADDRESSED ARE FECAL INDICATOR BACTERIA (FIB) GROUPS, THE FIB LOAD REDUCTIONS ARE SUMMARIZED FOR ALL PROJECTS IN

Table 22.

TABLE 22. FIB LOAD REDUCTION FOR ALL PROJECTS. FOR ALL YEARS AND PROJECTS, NUMBERS LISTED ARE LISTED IN THE ORDER TOTAL COLIFORM, FECAL COLIFORM, AND ENTEROCOCCUS. ALL UNITS ARE MPN.

Permit Year, Dates, and Rainfall	Hope and Haley Low Flow Diversions	Parking Lot LID	Streets, Sidewalks, Alleyways LID
Permit Year 1, Jan 2013-June 2014 10.67 in.	8.9E+12, 8.9E+11, 8.9E+11	4.97E+09, 2.18E+07, 2.00+E08	Not yet installed.
2, July 2014-June 2015 9.73 in.	n/a	4.53E+09, 1.98E+07, 1.82+E08	9.2E+08, 4.03E+06, 370E+07
3, July 2015-June 2016 10.57 in.	n/a	4.92E+09, 2.16E+07, 1.98+E08	1E+09, 4.38E+06, 4.02+E07
4, July 2016-June 2017 27.25 in	n/a	1.27E+10, 5.56E+07, 5.10+E08	2.58E+09, 1.13E+07, 1.04E+08
5, July 2017-June 2018 9.89	n/a	4.60E+09, 20.02E+07, 1.85+E08	9.36E+08, 4.10E+06, 3.76E+-7
Total Load reduction	8.9E+12, 8.9E+11, 8.9E+11	3.17E+10, 1.39E+08, 1.28+E09	5.43E+09, 2.38E+07, 5.43E+09

Load reductions were not calculated for the Hope and Haley Diversions after March 24, 2014 because they were not in operation. Due to limited sampling, load calculations were based on average load reduction per day obtained from the Final Report in the appendix. For load reductions from Jan. 1, 2013 to March 24, 2014, Load reductions were not calculated for the SURF facility because it was not in operation due to maintenance issues.

TABLE 23. POLLUTANT LOAD REDUCTIONS FOR PUBLIC PERMEABLE PAVER PROJECTS.

	Load reduction, Permit cycle, kg		
Pollutant	**Parking Lot Project (68.1 in rain infiltrated)**	**Streets Sidewalks and Alleyways Project (57.4 in rain infiltrated)**	**Combined Projects Load Reduction**
Organic Carbon, Dissolved	463.1	33.3	496.5
Nitrate (as N)	10.9	30.4	41.3
Total Kjeldahl Nitrogen	109.0	212.5	321.5
Total Nitrogen	115.8	247.0	362.8
Total Phosphorus	17.7	54.6	72.3
Hydrocarbons-EFH (C13 - C40)	42.9	103.4	146.3
Total Suspended solids	5040.1	6318.4	11358.5
Chromium	0.1	0.2	0.4
Copper	0.5	1.3	1.8
Iron	95.4	132.1	227.5
Lead	0.2	0.4	0.6
Manganese	3.5	54.6	58.0
Nickel	0.1	0.2	0.3
Sodium	63.9	183.8	247.7
Zinc	4.2	5.5	9.7
Surfactants	8.7	6.9	15.6
Imidacloprid	**n/a**	0.006	0.006
Pendimethalin	n/a	0.0	0.048

Comparison to reference sites (if applicable), guidelines or targets, COMPARE TO BASELINE

For the projects studied here, the appendices contain comparisons of measure concentrations to Basin Plan water quality objectives and other criteria. For all load reduction calculations, the comparison is to zero load reduction.

Discussion – Objectives

The data collected and presented in this report meets the objective of the Special Studies study plan. The objectives are to calculate the loads of pollutants prevented from reaching receiving waters. These objectives have been met as shown in the data presented above.

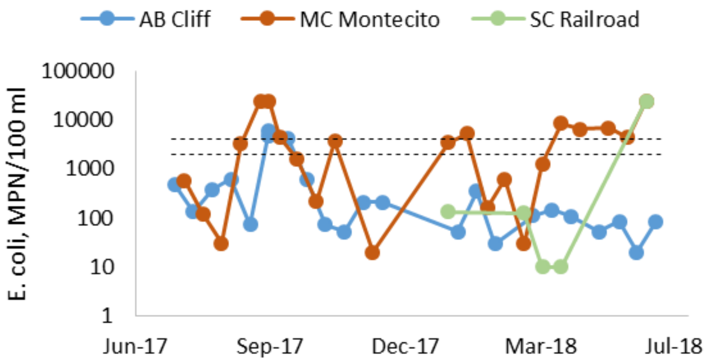
Discussion – Pollutant Reduction

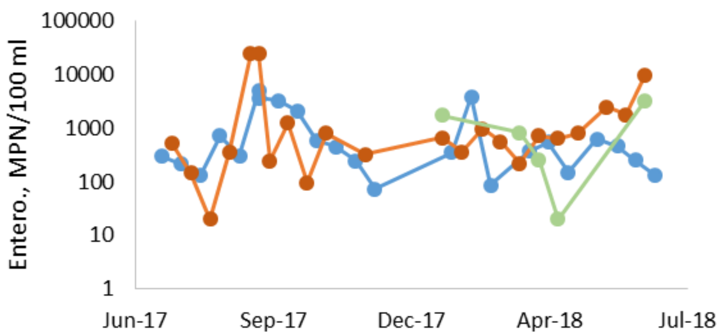
Pollutant reductions were achieved by the projects studied here. Total pollutant reductions of fecal indicator bacteria were shown for low-flow diversion projects and permeable paver infiltration projects for the duration of the Permit cycle. Interestingly, despite periods of non-operation during the drought, the low-flow diversions were achieved greater load reductions than the permeable paver projects. This is due to the continuous nature of the BMPs, and this provides incentive to continue additional dry-weather projects if the total load (rather than concentration) is the ultimate goal. Conversely, the permeable paver projects achieved greater load reductions for many other pollutants that would likely be below detection limits in dry weather sampling of the diversions.

303(d) Monitoring

303(d) Monitoring was carried out according to the approved Monitoring Plan/QAPP with the following exceptions: Sycamore Creek was not sampled on 21 sample dates due to non-existent flow in the creek. Mission Creek was not sampled on two samples dates, and Arroyo Burro was not sampled on three sample dates due to holiday closures of City offices and staff illness. Fecal indicator bacteria results are shown in Figure 1. Project Action Limits are shown for visual comparison; however additional calculations are required to demonstrate exeedances. Table 1 shows the samples which exceed Project Action Limits; note, however, that the water quality objectives underlying the Project Action Limits were developed mostly for beach environments and are not typically applied to freshwater. For comparison purposes, beach water quality exceedances are summarized in Table 2 (these data were acquired from the County of Santa Barbara and were not sampled by the City).

Toxicity testing was partially completed during Permit Year 5 due to difficulty finding appropriate laboratory testing for the Chironomus test and delayed reporting from the identified laboratory. Because results were received very recently, City staff will complete toxicity reporting and CEDEN uploads during Permit Year 6.





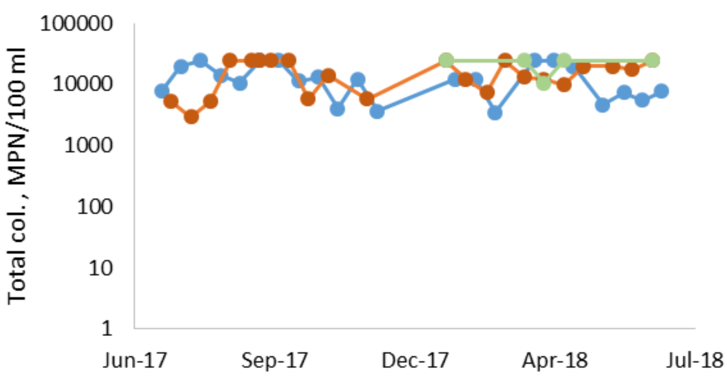


FIGURE 12. FECAL INDICATOR BACTERIA RESULTS DURING PERMIT YEAR 5. MISSING DATA POINTS REPRESENT DATES WHEN CREEK WAS NOT FLOWING DUE TO DROUGHT. HORIZONTAL LINES REPRESENT OR PARTIALLY REPRESENT PROJECT ACTION LIMITS AS FOLLOWS: FECAL COLIFORM/E. COLI, 10% OF SAMPLES SHOULD NOT EXCEED 4,000 MPN/100 ML (UPPER LINE) DURING ANY 30 DAY PERIOD AND 5-SAMPLE/30 DAY GEOMEAN SHOULD NOT EXCEED 2,000 MPN/100 ML (LOWER LINE); NOTE THAT DUE TO ONLY TWO SAMPLES COLLECTED PER 30-DAY.

TABLE 24. 303(D) FECAL INDICATOR BACTERIA MONITORING RESULTS, PERMIT YEAR 5. SHADING REPRESENTS EXCEEDANCES. SEE FIGURE 12 HEADING FOR STANDARDS.

StationID	Date		Ec oli		Enterococcus		Total coliform	Ratio of Fecal:Total Coliform
AB Cliff	7/3/2017		495		295		7701	0.064

StationID	Date		Ec oli		Enterococcus		Total coliform	Ratio of Fecal:Total Coliform
AB Cliff	7/17/2017		134		213		19863	0.007
AB Cliff	7/31/2017		379		135		24192	0.016
AB Cliff	8/14/2017		620		712		14136	0.044
AB Cliff	8/28/2017		73		305		10462	0.007
AB Cliff	9/11/2017		6131		4884	>	24192	
AB Cliff	9/25/2017		4106		3255	>	24192	
AB Cliff	10/9/2017		620		2098		11199	0.055
AB Cliff	10/23/2017		74		598		12997	0.006
AB Cliff	11/6/2017		52		448		3968	0.013
AB Cliff	11/20/2017		211		246		12033	0.018
AB Cliff	12/4/2017		213		74		3654	0.058
AB Cliff	1/29/2018		52		350		12033	0.004
AB Cliff	2/12/2018		354		3873		12033	0.029
AB Cliff	2/26/2018		30		86		3448	0.009
AB Cliff	3/26/2018		110		369		24192	0.005
AB Cliff	4/9/2018		146		546	>	24192	0.006
AB Cliff	4/23/2018		109		148		19863	0.005
AB Cliff	5/14/2018		52		617		4611	0.011
AB Cliff	5/29/2018		86		457		7270	0.012
AB Cliff	6/11/2018		20		250		5475	0.004
AB Cliff	6/25/2018		86		134		7701	0.011
MC Monteci	7/10/2017		594		529		5172	0.115
MC Monteci	7/24/2017		122		145		2909	0.042
MC Monteci	8/7/2017		31		20		5172	0.006
MC Monteci	8/21/2017		3255		350	>	24192	
MC Monteci	9/5/2017	>	24192	>	24192	>	24192	
MC Monteci	9/11/2017	>	24192		24192	>	24192	
MC Monteci	9/19/2017		4611		243	>	24192	
MC Monteci	10/2/2017		1576		1236	>	24192	
MC Monteci	10/16/2017		218		97		5794	0.038
MC Monteci	10/30/2017		3654		789		14136	0.258
MC Monteci	11/27/2017		20		323		5794	0.003
MC Monteci	1/22/2018		3448		657	>	24192	
MC Monteci	2/5/2018		5298		364		12033	0.440
MC Monteci	2/20/2018		161		959		7270	0.022
MC Monteci	3/5/2018		631		565	>	24192	0.026
MC Monteci	3/19/2018		30		218		12997	0.002
MC Monteci	4/2/2018		1266		717		12033	0.105
MC Monteci	4/16/2018		8664		644		9804	0.884
MC Monteci	4/30/2018		6586		809		19863	0.332
MC Monteci	5/21/2018		6867		2481		19863	0.346
MC Monteci	6/4/2018		4352		1789		17329	0.251
MC Monteci	6/18/2018	>	24192		9804	>	24192	
SC Railroa	1/22/2018		135		1723	>	24192	0.006
SC Railroa	3/19/2018		125		816		24192	0.005
SC Railroa	4/2/2018		10		259		10462	0.001
SC Railroa	4/16/2018	<	10		20		24192	0.000

StationID	Date		Ec oli		Enterococcus		Total coliform	Ratio of Fecal:Total Coliform
SC Railroa	6/18/2018	>	24192		3255	>	24192	
Exceedances			12					8

Appendix A FY 18 Research and Monitoring Plan

City of Santa Barbara Creeks Division

Water Quality Monitoring Program

The goals of the monitoring program are to:

9. Quantify the levels (concentration, flux, or load) of microbial contamination and chemical pollution in watersheds throughout the city.
10. Evaluate impacts of pollution on beneficial uses of creeks and beaches, including recreation and habitat for aquatic organisms.
11. Evaluate the effectiveness of the City's restoration and water quality treatment projects, which includes collecting baseline data for future projects.
12. Identify sources of contaminants and pollution in creeks and storm drains.
13. Evaluate long-term trends in water quality.
14. Meet monitoring requirements for grants.
15. Meet General Permit monitoring requirements.

The underlying motivation behind the monitoring program is to obtain information that the City can use to:

3. Develop strategies for water quality improvement, including prioritization of capital projects and outreach/education programs.
4. Communicate effectively with the public about water quality.

Program Elements with Associated REQUIREMENTSand/or Research QUESTIONS

A. Grant Project Monitoring Requirements

1. **LID Streets, Sidewalks, and Alleys**
   a. Maintain HOBO data loggers and graph results.
2. **Neonicotinoid Pesticides in Santa Barbara** -Partnering with UCSB and USGS to study neonicotinoid pesticides in SB.
   a. Assist in data analysis and publication

B. NPDES Permit Requirements: Phase II Small MS4 General Permit.

1. **Illicit discharge, detection and elimination.**

E.9.a. Outfall Mapping

(i) **Task Description** – Within the second year of the effective date of the permit, the Permittee shall create and maintain an up-to-date and accurate outfall map[15]. The map may be in hard copy and/or electronic form or within a geographic information system (GIS) the development of the outfall map shall include a visual outfall inventory involving a site visit to each outfall. Renewal Permittees that have an existing up-to-date outfall map that includes the minimum requirements specified in Section E.9.a.(ii)(a-e) are not required to re-create the outfall map. This does not exempt Renewal Permittees with an existing outfall map from conducting the field sampling specified in Section E.9.c.

(ii) **Implementation Level** - The outfall map shall at a minimum show:

(a) The location of all outfalls[16] that are operated by the Permittee within the urbanized area, drainage areas, and land use(s) contributing to those outfalls that are operated by the Permittee, and that discharge within the Permittee's jurisdiction to a receiving water. Each mapped outfall shall be located using coordinates obtained from a global positioning system (GPS) and given an individual alphanumeric identifier, which shall be noted on the map. Photographs or an electronic database shall be utilized to provide baseline information and track operation and maintenance needs over time.

(b) The location (and name, where known to the Permittee) of all water bodies receiving direct discharges from those outfall pipes.

(c) Priority areas, including, but not limited to the following:

1) Areas with older infrastructure that are more likely to have illegal connections and a history of sewer overflows or cross-connections
2) Industrial, commercial, or mixed use areas;
3) Areas with a history of past illicit discharges;
4) Areas with a history of illegal dumping;
5) Areas with onsite sewage disposal systems;
6) Areas upstream of sensitive water bodies;
7) Areas that drain to outfalls greater than 36 inches that directly discharge to the ocean; and
8) Other areas that are likely to have illicit discharges

The priority area list shall be updated annually.

(d) Field sampling stations

(e) The permit boundary

Submerged outfalls or other outfalls that may pose a threat to public safety and/or that are inaccessible are not required to be inventoried.

E.9.c. Field Sampling to Detect Illicit Discharges

(i) **Task Description –** Within the second year of the effective date of the permit (e.g. while conducting the outfall inventory under Section E.9.a.), the Permittee shall sample any outfalls that are flowing or ponding more than 72 hours after the last rain event. The Permittee shall also conduct dry weather sampling (more than 72 hours since the last rain event) of outfalls annually identified as priority areas.

(ii) **Implementation Level** – The Permittee shall:

(a) Conduct monitoring[17] for the following indicator parameters identified in Table 1 to help determine the source of the discharge. Alternatively, the Permittee may select parameters based on local knowledge of pollutants of concern in lieu of sampling for the parameters listed in Table 1. Modifications and associated justifications shall be identified within SMARTS prior to conducting field sampling as specified in Section E.9.c.(i).

Table 1. Indicator Parameters

Indicator Parameters Used to Detect Illicit Discharges					
Parameter	Discharge Types It Can Detect				Laboratory/Analytical Challenges
	Sewage	Washwater	Tap Water	Industrial or Commercial Liquid Wastes	
Ammonia	●	⦿	○	⦿	Can change into other nitrogen forms as the flow travels to the outfall
Color	⦿	⦿	○	⦿	
Conductivity	⦿	⦿	○	⦿	Ineffective in saline waters
Detergents – Surfactants	●	●	○	⦿	Reagent is a hazardous waste
Fluoride*	○	○	●	⦿	Reagent is a hazardous waste Exception for communities that do not fluoridate their tap water
Hardness	⦿	⦿	⦿	⦿	
pH	○	⦿	○	⦿	
Potassium	⦿	○	○	●	May need to use two separate analytical techniques, depending on the concentration
Turbidity	⦿	⦿	○	⦿	

● Can almost always (>80% of samples) distinguish this discharge from clean flow types (e.g., tap water or natural water). For tap water, can distinguish from natural water.
⦿ Can sometimes (>50% of samples) distinguish this discharge from clean flow types depending on regional characteristics, or can be helpful in combination with another parameter
○ Poor indicator. Cannot reliably detect illicit discharges, or cannot detect tap water
N/A: Data are not available to assess the utility of this parameter for this purpose.
Data sources: Pitt (
*Fluoride is a poor indicator when used as a single parameter, but when combined with additional parameters (such as detergents, ammonia and potassium), it can almost always distinguish between sewage and wash water.

(b) Verify that indicator parameters, as specified in Table 2. Action Level Concentrations for Indicator Parameters are not exceeded. Alternatively, the Permittee may tailor Table 2 to align with parameters based on local knowledge of pollutants of concern. Modifications and associated justifications shall be identified within SMARTS prior to conducting field sampling as specified in Section E.9.c.(i).

Table 2. Action Level Concentrations for Indicator Parameters

Indicator Parameter	Action Level Concentration
Ammonia	>= 50 mg/L
Color	>= 500 units
Conductivity	>= 2,000 µS/cm
Hardness	<= 10 mg/L as CaCO3 or >= 2,000 mg/L as CaCO3
pH	<= 5 or >=9
Potassium	>= 20 mg/L
Turbidity	>= 1,000 NTU

(c) Conduct follow up investigations per Section E.9.d. if the action level concentrations are exceeded.

[14] The Permittee shall use the Center for Watershed Protection's guide on Illicit Discharge Detection and Elimination (IDDE): A Guidance Manual for Program Development and Technical Assistance (available at www.cwp.org) or equivalent when developing an IDDE program. Guidance can also be found at: http://cfpub.epa.gov/npdes/stormwater/idde.cfm.
[15] The Permittee may utilize existing forms such as the CWP Outfall Reconnaissance Inventory/Sample Collection Field Sheet while conducting the mapping inventory and Field Sampling as specified below, in Section E.9.c.(http://cfpub.epa.gov/npdes/stormwater/idde.cfm).
[16] Submerged outfalls or other outfalls that may pose a threat to public safety and/or that are inaccessible are not required to be inventoried.

[17] A description of indicator parameter sampling equipment is described in Chapter 12: Indicator Monitoring in the CWP IDDE: Guidance Manual found at: http://www.epa.gov/npdes/pubs/idde_manualwithappendices.pdf. Sampling may be conducted using field test kits.

2. General Permit Monitoring.

a. Special Studies.

E.13.d. Receiving Water Monitoring and Special Studies

Traditional Small MS4 Permittees with a population greater than 50,000 listed in Attachment A that are not already conducting ASBS, TMDL or 303(d) monitoring efforts shall participate in one of the following monitoring programs, subject to Regional Water Board Executive Officer approval:

- E.13.d.1. Receiving Water Monitoring
- E.13.d.2. Special Studies

Conduct monitoring according to Special Studies Plan. Plan includes load reduction monitoring for FIB reduction projects, including:

- Hope Diversion
- Haley Diversion
- SURF Project
- Parking Lot LID
- Streets, Alley, and Sidewalks LID

Quality Assurance Project Plan (approved by Regional Board)

Where applicable, the Permittee shall prepare, maintain, and implement a Quality Assurance Project Plan (QAPP) in accordance with the Surface Water Ambient Monitoring Program. All monitoring samples shall be collected and analyzed according to the Program QAPP developed for the purpose of compliance with this Order. SWAMP Quality Assurance Program Plan (2008) is available at:

http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/qaprp082209.pdf

A formatted Microsoft Word document that includes guidelines and boilerplate language for developing the permit QAPP is available at:

http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa

Water quality data shall be uploaded to SMARTS and must conform to California Environmental Data Exchange Network (CEDEN) Minimum Data Templates format. CEDEN Minimum Data Templates are also available at: http://ceden.org/

- **Reporting**

(iii) **Reporting** – By the second year Annual Report, the Permittee shall complete and have available a report (50 page maximum) that includes a summary of baseline data collections and discussion of monitoring program results;

By the fifth year Annual Report, the Permittee shall complete and have available a report (50 page maximum) that includes a comparison of data collection to baseline data, and discussion of monitoring program results.

At a minimum, the second and fifth year Annual Reports shall include the following information:

(a) The purpose of the monitoring, brief contextual background and a brief description of the study design and rationale.
(b) Sampling site(s) locations, including latitude and longitude coordinates, water body name and water body segment if applicable. Sampling design, including sampling protocol, time of year, sampling frequency and length of sampling.
(c) Methods used for sample collection: list methods used for sample collection, sample or data collection identification, collection date, and media if applicable.
(d) Results of data collection, including concentration detected, measurement units, and detection limits if applicable.
(e) Quantifiable assessment, analysis and interpretation of data for each monitoring parameter.
(f) Comparison to reference sites (if applicable), guidelines or targets
(g) Discussion of whether data collected addresses the objective(s) or question(s) of study design
(h) Quantifiable discussion of program/study pollutant reduction effectiveness.

- Water quality data submittal.

Water quality data shall be uploaded to SMARTS and must conform to California Environmental Data Exchange Network (CEDEN) Minimum Data Templates format. CEDEN Minimum Data Templates are also available at: http://ceden.org/

- For the Special Studies Plan, the Regional Board agreed that submittal to CEDEN is not necessary.

b. 303(d) Monitoring.

E.13.c. 303(d) Monitoring

All Permittees that discharge to waterbodies listed as impaired on the 303(d)[28] list where urban runoff is listed as the source, shall consult with the Regional Water Board within one year of the effective date of the permit to assess whether monitoring is necessary and if so, determine the monitoring study design and a monitoring implementation schedule. Permittees shall implement monitoring of 303(d) impaired water bodies as specified by the Regional Water Board Executive Officer.

2010 303(d) listings with Urban Runoff as a Source

WATER BODY NAME	POLLUTANT	POLLUTANT CATEGORY	POTENTIAL SOURCES
Arroyo Burro Creek	Escherichia coli (E. coli)	Pathogens	Urban Runoff/Storm Sewers
Arroyo Burro Creek	Fecal Coliform	Pathogens	Urban Runoff/Storm Sewers
Mission Creek (Santa Barbara County)	Escherichia coli (E. coli)	Pathogens	Urban Runoff/Storm Sewers
Mission Creek (Santa Barbara County)	Fecal Coliform	Pathogens	Urban Runoff/Storm Sewers
Mission Creek (Santa Barbara County)	Unknown Toxicity	Toxicity	Urban Runoff/Storm Sewers
Pacific Ocean at East Beach – Mission Ck.	Total Coliform	Pathogens	Urban Runoff/Storm Sewers
Sycamore Creek	Fecal Coliform	Pathogens	Urban Runoff/Storm Sewers

The US EPA approved 2012 list of 303(d) impaired water bodies do not include any in the City of Santa Barbara with Urban Runoff listed as a Potential Source. The City will communicate with the Regional Board about this change.

c. Program Evaluation, Assessment, and Identification Plan. According to the Regional Board, the following text from section E.14 dictates modeling and monitoring to assess pollutant load reductions.

d.

> 6) Quantification of pollutant loads and pollutant load reductions achieved by the program as a whole

> (d) The Program Effectiveness Assessment and Improvement Plan shall identify assessment methods the Permittee will use to quantitatively assess BMP performance at reducing pollutant loads wherever feasible, using the following or equivalent methods:
> 1) Direct quantitative measurement of pollutant load removal for BMPs that lend themselves to such measurement (e.g., measuring sediment collected through street-sweeping activities);
> 2) Science-based estimates of pollutant load removal for BMPs where direct measurement of pollutant removal is overly challenging (e.g., removal of heavy metals through a bioswale);
> 3) Direct quantitative measurement of behaviors that serve as proxies of pollutant removal or reduction (e.g., the percentage of construction sites demonstrated by inspection to be in compliance with permit conditions); or
> 4) Visual comparison (e.g., using photographs to compare the amount of trash in a creek between one year and the next).

C. Watershed Assessment

Research questions:

1. Is overall water quality, in terms of indicator bacteria and field properties, getting better over time?
2. What is the impact of sustained drought on water quality, habitat, and stream communities?
3. Are pharmaceutical and personal care products (PPCPs) reaching creeks via irrigation runoff and reclaimed water main breaks? *On hold until reclaimed water system is upgraded.*
4. What are the background daily cycles of water flow in Santa Barbara creeks? Is there a daily pumping in or removal of water from Arroyo Burro?
5. Are new or emerging contaminants detected in dry weather conditions? *No new contaminants to test have been identified.*
6. Are low dissolved oxygen concentrations responsible for some low bioassessment scores in Santa Barbara? What are nighttime DO concentrations throughout Mission Creek?

D. Storm Monitoring

Research Questions:

1. Is there toxicity in Mission Creek during storm events?
2. Neonicotinoid Pesticides (Partnership with UCSB and USGS)
   a. What is the spatial and temporal variability of neonics concentrations?
   b. What are the sources in the urban environment?
   c. What is the ecological impact of neonics at low concentrations?

3. Is runoff from coal tar sealed parking lots and slurry sealed roads more toxic than untreated surfaces? *On hold for FY 17.*
4. How to Water Quality Improvement Projects function during rain events?
    a. Upper Las Positas (Golf Course) (Infiltration via level loggers)
    b. MacKenzie LID (Infiltration)
    c. Parking Lot Storm Water Treatment Demonstration Project
    d. Streets, Sidewalks and Alleys LID
    e. Fish Passage Projects
    f. Permit PEAIP – Private BMPs
    g. Are human waste markers present in creek flow during wet weather? This is being addressed in UCSB Leadbetter and SC MST Project (see below).

E. Restoration and Water Quality Project Assessment

Overall Research Questions:

1. What is the baseline water quality at future restoration, LID, and/or treatment sites, particularly as they relate to project design and assessment of project performance?
2. Do Creeks Division treatment projects result in improved water quality, as reflected in pre- and post-project, and/or, upstream to downstream, conditions?
3. Do Low Impact Development (LID)/infiltration projects result in pre-development runoff patterns? What are the loads of pollutants prevented from entering surface water from LID projects?
4. What are the mechanisms of project success?
5. Are installed projects continuing to function correctly?

Projects and Specific Questions

1. **Westside SURF and Old Mission Creek Restoration**
    a. Have habitat scores and index of biological integrity (IBI) scores in Bohnett Park improved?
2. **Arroyo Burro Restoration, including Mesa Creek Daylighting**
    a. How does Arroyo Burro Estuary biological integrity compare to other estuaries in the area?
3. **Hope and Haley Diversions-***See Permit Monitoring*
4. **Upper Las Positas Creek Project Performance**
    a. What is the infiltration rate of stormwater in the basins?
5. **McKenzie Park Storm Water Treatment Retrofit (Storm)**
    a. Are basins functioning correctly?
    b. Is the design storm fully infiltrated?
    c. What are rainfall, storage, and draw down patterns?
6. **Storm Water Infiltration Demonstration Project**
    a. Are basins functioning correctly?
    b. Is the design storm fully infiltrated?
    c. What are rainfall, storage, and draw down patterns?
7. **Streets, Sidewalk, and Alleys LID – See Permit Monitoring**
8. **Debris Screens**
    a. Has the installation of catch basin screens lead to decreased trash observed in creeks? *Also addressed with photography of catch basins.*
9. **Mission Creek Fish Passage (Dissolved Oxygen)**
    a. What are the conditions in creek segments where fish spend time waiting for passage conditions (above or below passages)?
10. **Laguna Channel Disinfection**
    a. Are there human markers in scavenger pump discharge? *See Microbial Source Tracking*
11. **Andre Clark Bird Refuge**
    a. What is the cause of stink events?
    b. How is the pilot project performing? Does bioaugmentation help?
    c. What are the sources of nutrients during dry and wet weather?
    d. What is the scientific merit of proposed improvement projects?

12. **Las Positas Creek Restoration Project**
    a. What are the flow patterns in dry and wet weather?
13. **Upper Arroyo Burro (Barger) Restoration**
    a. Is water being pumped from creek or adjacent groundwater?
    b. What is the historical water quality?
    c. Identify any data gaps.
14. **Arroyo Burro Open Space**
    a. What is the baseline bioassessment?
15. **Trash Capture**
    a. What is the baseline for future Trash Capture devices? *Methods TBD.*

F. Source Tracking/Illicit Discharge Detection

Research questions:

1. Conduct IDDE investigation per General Permit (Section B).
2. What are the causes of persistent beach warnings that occur?
3. How do FIB, host-specific markers and pathogens decay in lagoons? *UCSB Project, results to be published soon.*
4. Is RV dumping a consistent problem in Santa Barbara?
5. What is the risk to human health from recreation in creeks and beaches in Santa Barbara? This quesi
6. Are human waste markers present and associated with beach warnings at Leadbetter Beach and E. Beach at Sycamore?
7. Are human waste markers present in creek flows during wet weather?
8. Historical FIB Data Analysis

Sampling Table for FY 18 Research Plan.

Sampling Table for Proposed FY 18 Research Plan. Shaded rows mark areas of primary focus and staff time during FY 18, as described in the May 2017 Staff Report.

PROGRAM ELEMENT and QUESTIONS	**APPROACH/METHODS**	**SAMPLING SITES, PARAMETERS, FREQUENCY**	**RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES**
A. Grant Project Monitoring Requirements			
1. Neonicotinoid Pesticides in Santa Barbara	a. Partnership with UCSB and USGS to study neonicotinoid pesticides in SB. b. Three components: a. Field work (City/USGS) b. Laboratory toxicology studies (UCSB) c. Modeling studies (UCSB)		1. Field work complete. 2. Jill meet weekly with UCSB (Lenihan, Means, Mueller).
B. General Permit Requirements			
1. IDDE	Conduct sampling for chemical indicators at any flowing drain in Priority Areas.	**Sites**: All flowing outfalls in priority areas. **Parameters:** Ammonia, color, conductivity, surfactants, fluoride, hardness, pH, potassium, and turbidity. Add FIB. **Frequency:** Annually	3. Chris, with watershed Stewards to assist with sampling.
2. Monitoring-Special Studies	Conduct monitoring according to Special Studies Plan. Plan includes load reduction monitoring for FIB reduction projects, including: a. Hope Diviersion b. Haley Diversion	**Sites:** Hope Diversion, Haley Diversion, Westside Drain, OMC W. Anapamu. **Parameters:** FIB	4. Calculate load reductions for Year 3 Report (10/15/16).

PROGRAM ELEMENT and QUESTIONS	**APPROACH/METHODS**	**SAMPLING SITES,** **PARAMETERS,** **FREQUENCY**	**RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES**
	c. SURF Project d. Parking Lot LID e. Streets, Alley, and Sidewalks LID		
3. Monitoring-303(d)	Biweekly FIB sampling as in C.1 and toxicity sampling as in C.8 and D.1.	Parameters: FIB Frequency: biweekly Parameter: toxicity Frequency:	5. Submit data to CEDEN and report to SMARTS by 10/15/16.
4. Performance Evaluation, Assessment, and Identification Plan	General Permit requires quantification of pollutant load reduction by entire stormwater permit. Model choice has yet to be finalized. Creeks Division is on Technical Advisory Committee for Total Evaluation of Load Reduction model (TELR).	Creeks Division to choose between two pollutant models by testing performance, costs, and benefits of both. Model output (catchment ranking) will also be compared to simple ranking by % Impervious and Impervious Acres.	6. WQ Interns to conduct mapping and modeling under Creeks supervision.
C. Watershed Assessment			
1. Is overall water quality, in terms of indicator bacteria, field properties, and bioassessment getting better over time?	Long term sampling of integrator sites. Long term bioassessment at select sites.	**Sites:** Integrator Sites (3), Honda and Lighthouse **Parameters:** FIB, field parameters, flow. **Frequency:** Biweekly for integrators, quarterly for Honda and Lighthouse.	7. Inform El Estero of sampling schedule for FY 17. 8. Review 2016 Bioassessment Report when available.
2. Are pharmaceutical and personal care products (PPCPs) reaching creeks?	Sample discharge from recycled water spigots.	On hold. See SCCWRP list for parameters.	

PROGRAM ELEMENT and QUESTIONS	**APPROACH/METHODS**	**SAMPLING SITES,** **PARAMETERS,** **FREQUENCY**	**RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES**
3. What are the background daily cycles of water flow in Santa Barbara creeks? Is there a daily pumping in or removal of water from Arroyo Burro, including San Roque Creek	HOBO level loggers, creek walks, no sampling required.	None. San Roque Creek is dry now.	9. Internal deadline: Install level logger by 8/1/2016.
4. Are new and emerging contaminants detected in dry weather?	Integrator sites tested one time for pyrethroids and neonics, all ND. However, sumithrin and dichloran not included. Focus now on neonics in irrigation runoff.	**Sites:** Dry weather outfall sampling where we know irrigation runoff to occur (TBD). **Parameters:** Sumithrin, dichloran, neonics. **Frequency:** one time, dry weather.	10. Keep abreast of new pesticides, etc.
5. Are low dissolved oxygen concentrations responsible for some low bioassessment scores in Santa Barbara? What are nighttime DO concentrations throughout Mission Creek?	Use data loggers to record DO levels in pools and riffles.	**Sites:** Rattlesnake, Mission Canyon, Bioassessment Sites. **Parameters:** DO, temperature, **Frequency:** Two week installations, log every 5 minutes.	11. Formalize technical advisory input from UCSB.
D. Storm Monitoring			
1. Is there toxicity in Mission Creek during storm events?	Two storms, per 303(d) Monitoring Plan to be approved by Regional Board.	**Sites:** Mission Creek at Montecito. **Parameters:** Selenastrum toxicity, other spp. **Frequency:** Two storms, may be first flush.	
2. New and Emerging Contaminants: Neonicotinoid Pesticides		??	

PROGRAM ELEMENT and QUESTIONS	**APPROACH/METHODS**	**SAMPLING SITES,** **PARAMETERS,** **FREQUENCY**	**RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES**
a. What is the spatial and temporal variability of neonics concentrations? b. What are the sources in the urban environment? **c.** What is the ecological impact of neonics at low concentrations?			
1. Is runoff from coal tar sealed parking lots and slurry sealed roads more toxic than untreated surfaces?	On hold for FY 17.		Inquire with UCSB (Means) about partnership.
2. Upper Las Positas (Golf Course)	Measure infiltration rate of basins.	HOBO loggers installed in FY 16. Review data.	
3. MacKenzie LID	Maintain HOBO data loggers and graph results.	None.	
4. Parking Lot Storm Water Treatment Demonstration Project.	Maintain HOBO data loggers and graph results.	None.	
5. Streets, Sidewalks and Alleys LID	See A.2.		12. Tim Burgess
6. Fish Passage Projects	Flow measurements		13. George Johnson, Watershed Stewards
7. Permit PAEIP – Private BMPs	See B. 4	**Sites:** 5 private BMPs (TBD), upstream & downstream, 10 total. **Parameters:** Hydrocarbons, trash, nutrients, bacteria, TSS, pesticides, herbicides **Frequency:** 3 time points (same or different storms).	14. On hold.
8. Bird Refuge – What are source of nutrients in storm events?			15.

PROGRAM ELEMENT and QUESTIONS	**APPROACH/METHODS**	**SAMPLING SITES,** **PARAMETERS,** **FREQUENCY**	**RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES**
9. Are human waste markers present in creek flow during wet weather?	See Source Tracking below.	None.	
E. Restoration and Water Quality Project Assessment			
1. Westside SURF and Old Mission Creek Restoration (see annual report for details)		**Sites:** SURF up, SURF down, Westside Drain, OMC at W. Anapamu, **Parameters:** FIB, field. **Frequency:** Weekly for SURF operation, biweekly for downstream impacts when SURF in operation.	
2. Arroyo Burro Restoration.	Suspension of quarterly testing until results from biweekly testing warrant a change.	**Sites:** AB at Cliff, AB Estuary upper, AB Estuary Mouth **Parameters:** FIB, field. **Frequency:** biweekly.	Include results in FY16 WQ Report.
3. Hope and Haley Diversions	See B.2.	**Sites:** Hope Diversions, Haley Pump **Parameters:** FIB, field **Frequency:** Quarterly	
4. Upper Las Positas Restoration	See storm monitoring.		
5. MacKenzie Park Storm Water Treatment Retrofit	See storm monitoring.		
6. Storm Water Infiltration Demonstration Project (Parking Lot LID)	See storm monitoring		
7. Streets, Alleys, and Sidewalks LID	See Permit monitoring		

PROGRAM ELEMENT and QUESTIONS	APPROACH/METHODS	SAMPLING SITES, PARAMETERS, FREQUENCY	RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES
8. Debris Screens (Creek Walks)	Conduct thorough analysis of FIB data to test role of debris screens and leaf litter reduction.		
9. Mission Creek Fish Passage (Eutrophication/Dissolved Oxygen)	Dissolved Oxygen, pH, temperature, conductivity (nutrients as part of above study)	MC Lagoon, MC upper reaches	Analyze for summer months, collect data continuously.
10. Laguna Channel Disinfection	Include site in contract with UCSB.	Sample scavenger pump discharge for human waste markers.	
11. Bird Refuge	a. Continue monitoring aeration pilot project and annual cycles. b. Conduct sampling for potential project analysis as needed.	**Sites:** Aeration and open sites. **Parameters:** field **Frequency:** Weekly.	
12. Las Positas Creek Restoration Project. What are the flow patterns in dry weather?	Measure flow in channel and test for temperature increases along concrete channel.	**Sites:** Every 25' along concrete reach **Parameters:** Temperature **Frequency:** Quarterly	16. Manage HOBO logger in lower end of concrete reach
13. Upper Arroyo Burro Restoration (Barger) a. Is water being pumped from creek or adjacent groundwater? b. What is the historical water quality? c. Identify any data gaps. 10.	c.	**Sites:** Upper and lower end of project. **Parameter:** FIB, nutrients, field. **Frequency:** Quarterly	Purchase and install HOBO in lower end of concrete reach

PROGRAM ELEMENT and QUESTIONS	**APPROACH/METHODS**	**SAMPLING SITES,** **PARAMETERS,** **FREQUENCY**	**RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES**
14. Arroyo Burro Open Space	Conduct ongoing bioassessment for baseline measurements. WQ sampling to be determined.		
15. Trash Capture Devices	Develop monitoring plan to collect baseline data for trash capture.	No sampling in FY 17.	
F. Source Tracking			17.
1. Conduct IDDE investigation per General Permit (Section B).	See above.		18.
2. What are the causes of persistent beach warnings that occur?	Conduct additional surveillance and sampling (indicator bacteria and/or DNA techniques) up creek and within estuaries when persistent warnings occur.		As needed (none in FY 16)
3. Are there pathogens present in Santa Barbara creeks? Are SB beaches suitable for Quantitative Microbial Risk Assessment (QMRA)?	Hold for FY 17, except as included in UCSB MST project.		
4. How do FIB, host-specific markers and pathogens decay in lagoons?			UCSB Project; results to be released soon.
5. Is RV dumping a problem in Santa Barbara?	Observation.	Situational.	
6. What is the risk to human health from recreation in creeks and beaches in Santa Barbara?	Use new epidemiology studies in Southern California to conduct simple model of illness rates at Santa Barbara beaches. No sampling required.		

PROGRAM ELEMENT and QUESTIONS	**APPROACH/METHODS**	**SAMPLING SITES,** **PARAMETERS,** **FREQUENCY**	**RESPONSIBLE PARTY IF NOT CREEKS/DEADLINES**
7. Are human waste markers present and associated with beach warnings at Leadbetter Beach and E. Beach at Sycamore?	Clean Beaches Initiative Grant to fund microbial source tracking at Leadbetter and E. Beach at Sycamore.		UCSB and Geosyntec.
11. Are human waste markers present in creek flows during wet weather?	Grant in F.8 includes wet weather sampling.		UCSB sampling as part of MST project.
12. Historical FIB Data Analysis	Update previous historical analysis conducted in 2009 and submit to peer reviewed journal.		Partnership with UCSB.