Appendix D: Modeled Benefits for New Wet Weather Structural BMPs

APPENDIX D: MODELED BENEFITS FOR NEW WET WEATHER STRUCTURAL BMPS

D.1 Introduction

The purpose of this appendix is to document the methodology used to

(1) Estimate baseline Fecal Coliform loads by HSA,
(2) Quantify estimates structural BMP performance per unit of developed acre treated based on the representative catchment approach, and
(3) Apply the results of these analysis to estimate load reductions by HSA associated with structural BMP implementation (FC load reduction for WY1993 and average annual load reduction other pollutants).

Wet weather load estimates for the South Orange County (SOC) WQIP were determined using the Structural BMP Prioritization and Analysis Tool (SBPAT), which is a publicly available, Geographical Information System (GIS)-based model used to quantify benefits, costs, uncertainties and potential risks associated with storm water quality projects. SBPAT has already been developed for the South Orange County region: OCTA-SBPAT.[1]

D.2 Model Methodology

D.2.1 Overview

Each model simulation integrates continuous modeling estimates of watershed hydrology and BMP hydrologic and hydraulic performance combined with Monte Carlo analysis of water quality that rely on repeated random sampling to obtain numerical results. Model simulations are run 40,000 times to calculate a distribution of outcomes that can support the definition of confidence levels and quantify variability. Consistent with the SBPAT usage, Monte Carlo methods are used in physical and mathematical problems when it is difficult to obtain a closed-form expression, when a deterministic algorithm is not desired, and/or when expected output ranges (or quantified uncertainty) are desired. A schematic of SBPAT's Monte Carlo process is provided in Figure 1. Model documentation, as well as links to related technical articles and presentations, is provided at www.sbpat.net.

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[1] The Orange County Transportation Authority (OCTA) version of the Structural BMP Prioritization and Analysis Tool (OCTA-SBPAT) was developed as part of the Measure M2, Tier 2 Environmental Cleanup Allocation effort.

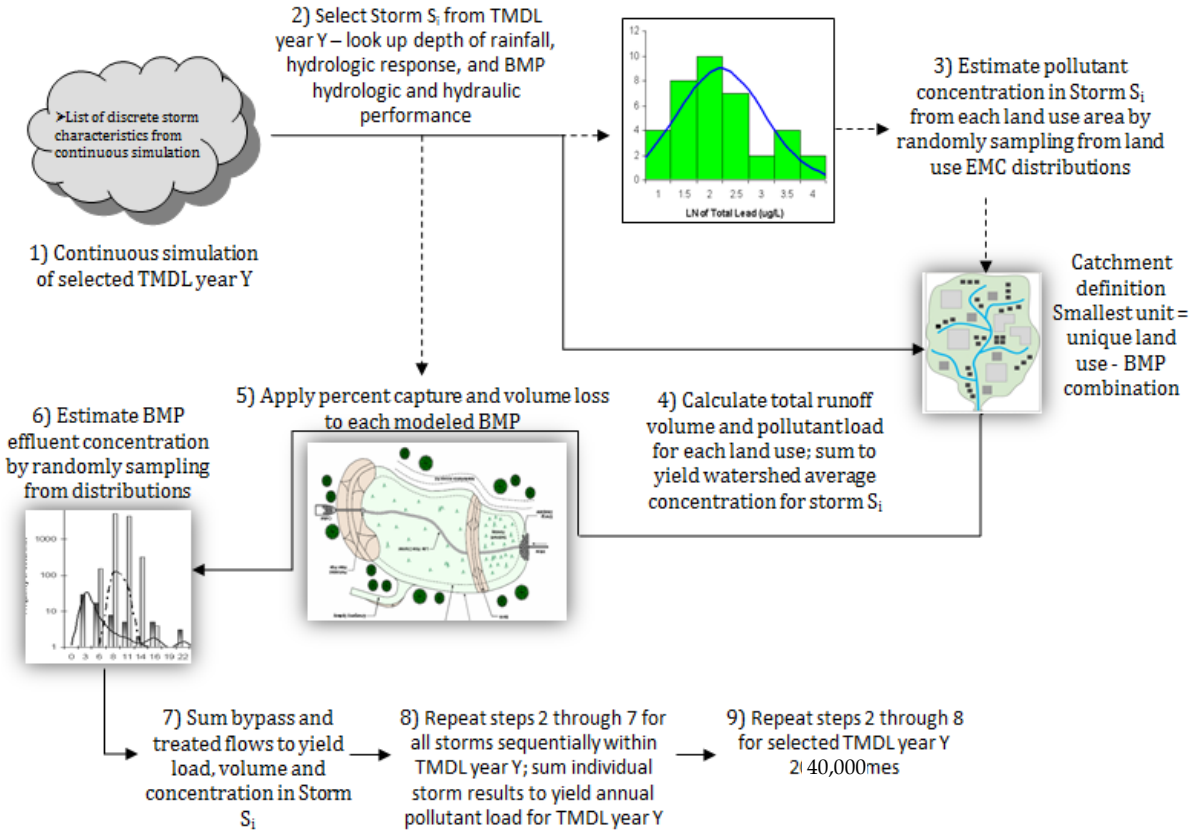


Figure 1. SBPAT Monte Carlo Method Components

Data used for the quantification/analysis module include both fixed and stochastic parameters. The model utilizes land use-based event mean concentrations (EMCs), USEPA SWMM, USEPA/American Society of Civil Engineers/Water Environment Research Foundation (USEPA/ASCE/WERF) International BMP Database (IBD) water quality concentrations, watershed/GIS data, and a Monte Carlo approach to quantify water quality benefits and uncertainties. Model data flow is provided below in Figure 2.

GIS layers used in SBPAT included, but were not limited to, the following:

- Receiving water bodies
- Soils
- Rain gage polygons
- Parcels
- Land use

- Catchments

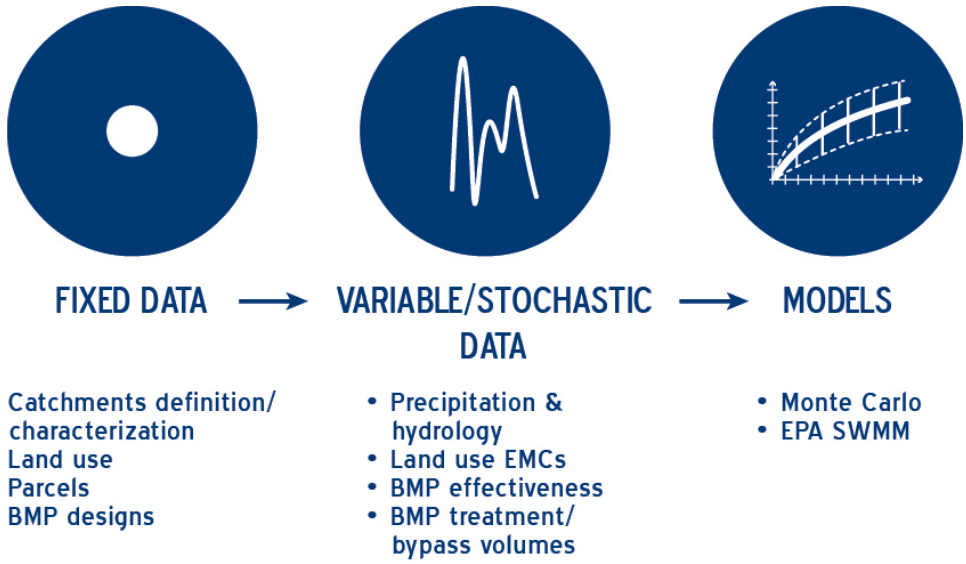


Figure 2. SBPAT Model Data Flow

D.2.2 Hydrology

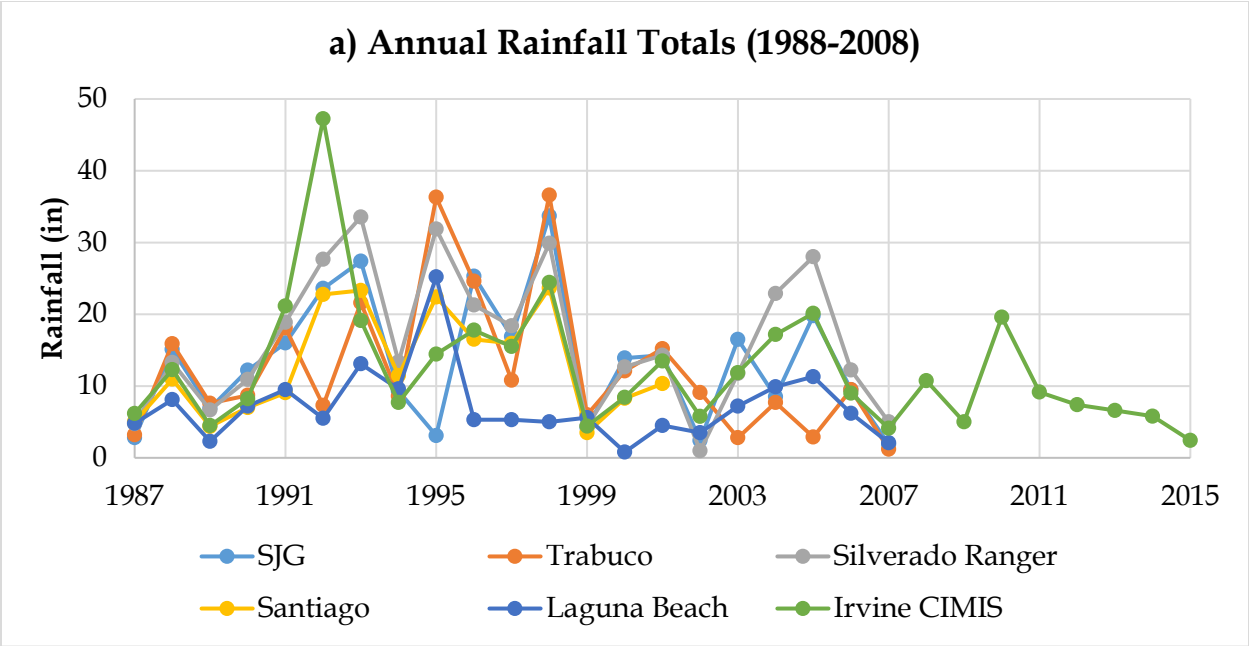
SBPAT utilizes a customized version of SWMM for continuously simulating study area hydrology (i.e., runoff time series) and BMP hydrology and hydraulics (i.e., capture efficiency and volume reduction). Long-term, hourly rainfall data and average monthly evapotranspiration values are used along with land use-based catchment imperviousness and soil properties to calculate runoff volumes. Storm events are individually tracked for the entire simulation so that the volumes of runoff infiltrated, evapotranspired, captured, and released (if applicable) by BMPs are calculated for every storm event.

Rain Gauge Selection

Annual rainfall and historical monthly rainfall at various gauges from California Irrigation Management Information System (CIMIS), and NOAA National Climate Data Center (NCDC) in the Orange County area were evaluated to select a rain gauge that could best represent rainfall data for WQIP study area and provide reliable data quality (i.e., limited missing data). Figure 3 shows a map of rain gauge locations in the area that were considered. For rain gauges with available rainfall data, Figure 4 demonstrates long term annual and monthly rainfall data, respectively. Some gages exhibited significant missing data in some years (for example, Trabuco gage in 2003-2007; the Santiago Guard Station gage in 1995). The Irvine rain gauge data from the CIMIS network was found to have the most reliable rainfall data among other stations and represents a reasonable

midpoint between higher elevation gages that have greater typical rainfall and the lower elevation Laguna gauge which has lower typical rainfall. Therefore, the Irvine CIMIS data was used for all watersheds/catchments in SBPAT for this analysis. The same rainfall record was used to establish baseline loads as well as load reductions, therefore any errors introduced as part of rain gage selection tend to offset in the application of the model for this purpose.

Figure 3. SBPAT Model Data Flow



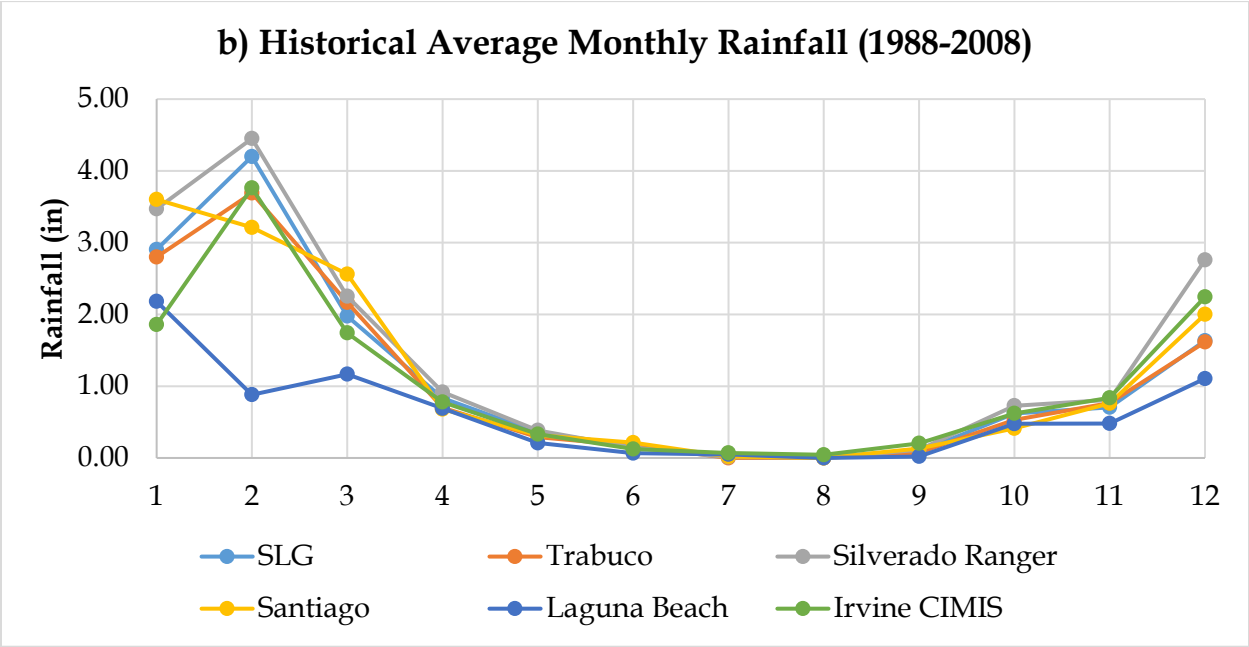


Figure 4. a) Annual Rainfall Totals, and b) Monthly Rainfall Totals

H.2.3 Spatial Data

Land uses and catchment data used in this WQIP were based on OCTA SBPAT geodatabase, since this was the most current land use data available and most representative of current conditions.

The baseline load analysis for fecal coliform was performed for each watershed in the South Orange County area. The area consists of Laguna Coastal Streams, Aliso Creek, Dana Point Coastal Streams, San Juan Creek, and San Clemente Streams, as shown in Figure 5.

A representative catchment approach was used to estimate the load reductions that would result from implementation of various types and sizes of wet weather . The representative area was defined based on land use analysis, and includes a set of selected catchments that have similar land use distribution to the overall developed/urban areas in the South Orange County. Figure 6 shows land use characteristics comparison between the representative area and the South Orange County urban areas.

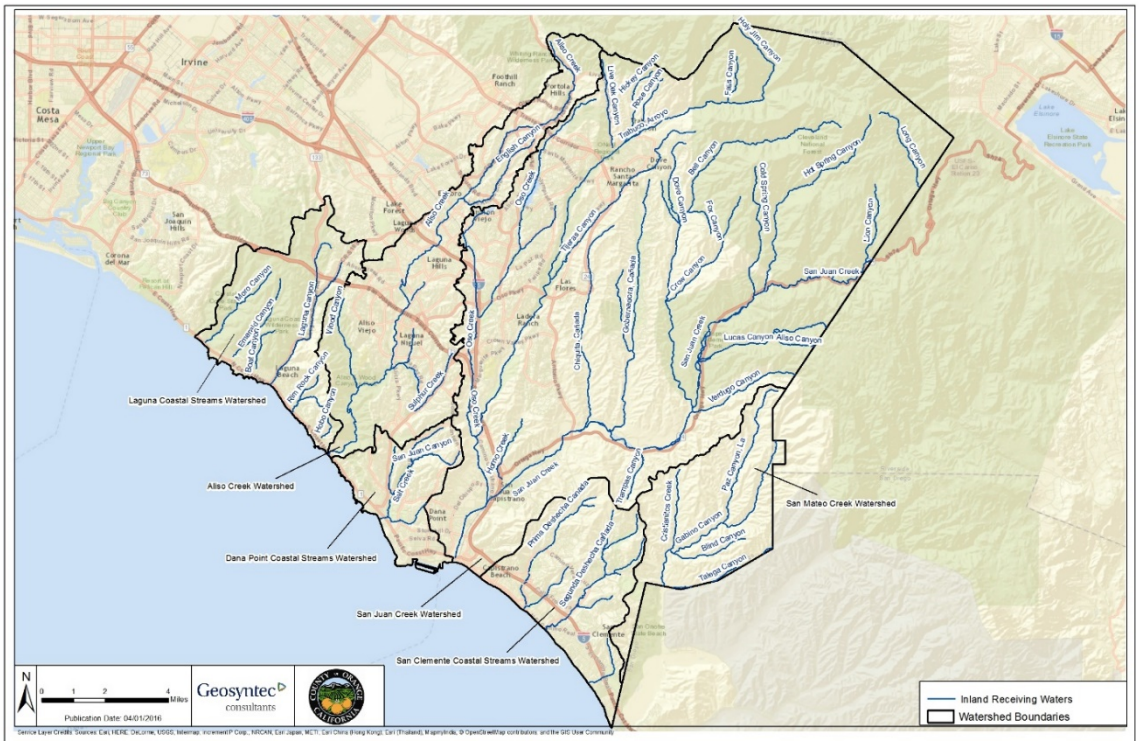


Figure 5. Map of Watersheds in South Orange County Area

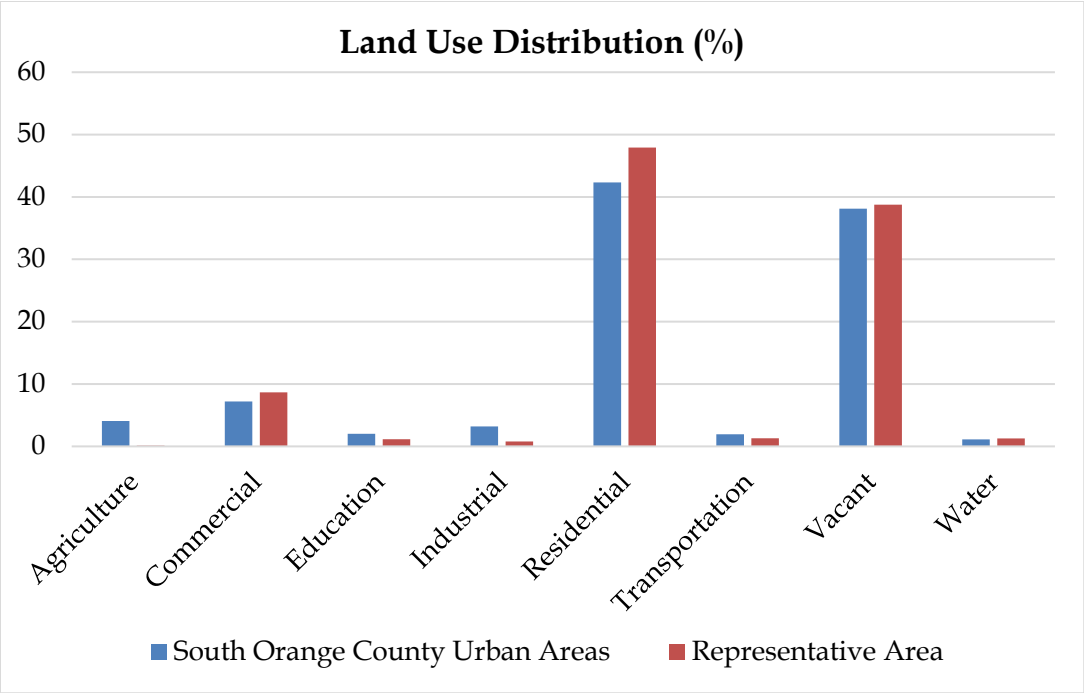


Figure 6. Land Use Distribution in the Representative Area Compared to the South Orange County Urban/Developed Areas

H.2.4 Water Quality Data

As previously described, SBPAT links the long-term hydrologic output from EPA SWMM to a stochastic Monte Carlo water quality model to develop statistical descriptions of stormwater quantity and quality. Through this approach, the predicted runoff volumes for each storm were randomly sampled from the long-term storm event runoff volume record produced by SWMM. The water quality parameters analyzed in SBPAT includes total suspended solids (TSS), total phosphorus (TP), dissolved phosphorus as P (DP), ammonia as N (NH3), nitrate as N (NO3), total Kjeldahl nitrogen as N (TKN), dissolved copper (DCu), total copper (TCu), total lead (TPb), dissolved zinc (DZn), total zinc (TZn), and fecal coliform (FC). Fecal coliform was used instead of other indicator bacteria as the BMP performance datasets for this parameter are more robust than other indicator bacteria at this time.

Land use-based wet weather pollutant EMC values (summarized in Table 1) and BMP effluent concentrations (see Table 2, and Table 3 for summary statistics) for each storm were then randomly sampled from their log-normal statistical distributions. Land use EMCs for modeled pollutants selected for WQIP analysis were originally developed for Orange County Transportation Authority SBPAT models. EMC statistics are calculated based on 1996-2000 data for Los Angeles County land use sites except for agriculture which are based on Ventura County MS4 EMCs, and fecal coliform which are based on 2000-2005 SCCWRP Los Angeles region land use data. The runoff volumes (including

volumes treated, reduced, and bypassed by BMPs), land use EMCs, and BMP effluent concentrations were combined to determine the total pollutant loads and load reductions (i.e., difference between existing and post-BMP load calculations) for each randomly sampled storm event. This procedure was then repeated thousands of times, each time recording the volume, pollutant concentrations, loads, and load reductions for each randomly selected storm event. The statistics of these recorded results were then used to characterize the average (mean) values for the annual volume, pollutant loads, and pollutant concentrations in stormwater runoff from the modeled area, with and without BMPs implemented.

Table 1. Proposed SBPAT EMCs for SOC WQIP Watersheds – Arithmetic Estimates of the Lognormal Summary Statistics (means with standard deviations in parentheses)

Land Use	TSS	TP	DP	NH3	NO3	TKN	Diss Cu	Tot Cu	Tot Pb	Diss Zn	Tot Zn	Fecal Col.
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	#/100 mL
Single Family Residential	124.20 (184.88)	0.40 (0.30)	0.32 (0.21)	0.49 (0.64)	0.78 (1.77)	2.96 (2.74)	9.36 (9.02)	18.70 (13.37)	11.27 (16.56)	27.46 (56.19)	71.89 (62.35)	31,508 (94,213)
Commercial	66.99 (47.09)	0.40 (0.33)	0.29 (0.25)	1.21 (4.18)	0.55 (0.55)	3.44 (4.78)	12.33 (10.22)	31.36 (25.65)	12.44 (34.21)	153.38 (96.05)	237.08 (150.34)	51,634 (1,485,805)
Industrial	219.19 (206.90)	0.39 (0.41)	0.26 (0.25)	0.6 (0.95)	0.87 (0.96)	2.87 (2.33)	15.20 (14.84)	34.53 (36.70)	16.37 (47.05)	422.09 (534.00)	537.39 (487.81)	3,763 (4,858)
Education (Municipal)	99.61 (122.71)	0.30 (0.17)	0.26 (0.20)	0.40 (0.99)	0.61 (0.67)	1.71 (1.13)	12.15 (10.99)	19.87 (13.65)	3.64 (4.94)	75.38 (52.26)	117.6 (83.15)	51,634 (1,485,805)
Transportation	77.78 (83.77)	0.68 (0.94)	0.56 (0.82)	0.37 (0.68)	0.74 (1.05)	1.84 (1.44)	32.40 (25.47)	52.22 (37.52)	9.21 (14.50)	221.96 (201.67)	292.90 (215.83)	1,680 (456)
Multi-family Residential	39.87 (51.27)	0.23 (0.21)	0.20 (0.19)	0.50 (0.74)	1.51 (3.06)	1.80 (1.24)	7.37 (5.72)	12.13 (5.56)	4.54 (7.77)	77.52 (84.08)	125.06 (101.15)	11,823 (23,710)
Agriculture (row crop)	999.25 (648.18)	3.34 (1.53)	1.41 (1.04)	1.65 (1.67)	34.40 (116.32)	7.32 (3.44)	22.48 (17.53)	100.13 (74.79)	30.20 (34.32)	40.14 (49.06)	274.80 (147.27)	60,328 (152,690)
Vacant / Open Space	216.60 (1,483)	0.12 (0.31)	0.09 (0.27)	0.11 (0.25)	1.17 (0.79)	0.96 (0.9)	0.57 (1.91)	10.55 (24.4)	3.04 (13.11)	28.06 (12.89)	26.32 (69.51)	6,312 (1,310)

Table 2. IBD Arithmetic Mean Estimates of BMP Effluent Concentrations

BMP	TSS	TP	DP	NH3	NO3	TKN	DCu	TCu	TPb	DZn	TZn	FC
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	#/100 mL
Constructed Wetland / Retention Pond (with Extended Detention)	38.3	0.19	0.11	0.18	0.42	1.20	5.3	6.7	7.2	22.1	35.3	1.01E+04
Constructed Wetland / Retention Pond (without Extended Detention)	32.9	0.17	0.09	0.17	0.38	1.20	5.3	6.2	12.0	22.6	38.0	9.89E+03
Dry Extended Detention Basin	42.3	0.37	0.26	0.16	0.61	2.40	6.5	11.4	14.4	33.7	78.4	1.41E+04
Hydrodynamic Separator	98.1	0.50	0.06	0.30	0.67	2.07	13.1	16.7	12.7	78.4	107.4	2.68E+04
Media Filter	22.3	0.14	0.07	0.18	0.74	0.98	8.3	11.0	4.6	34.7	37.6	5.89E+03
Sub-surface Flow Wetland	18.1	0.06	0.06	0.09	0.27	0.87	4.6	4.6	0.7	20.9	25.8	PR=90%
Treatment Plant	2.0	0.00	0.00	0.00	0.27	0.01	1.0	1.0	4.4	5.0	5.0	2.00E+00
Vegetated Swale (Bioswale)	27.1	0.28	0.17	0.09	0.43	0.87	9.6	10.1	6.4	33.3	33.3	8.00E+04
Bioretention with Underdrains (biofiltration)	18.1	0.14	0.07	0.18	0.37	0.98	8.3	8.8	4.2	34.7	37.6	5.89E+03
Bioretention w/o underdrain	Volume reductions only											
Cistern	Volume reductions only											
Green Roof	Volume reductions only											
Porous Pavement	Volume reductions only											
Infiltration Basin	Volume reductions only											

Table 3. IBD Arithmetic Standard Deviations of BMP Effluent Concentrations

BMP	TSS	TP	DP	NH3	NO3	TKN	DCu	TCu	TPb	DZn	TZn	FC
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	#/100 mL
Constructed Wetland / Wetpond (with Extended Detention)	76.80	0.253	0.357	0.234	0.787	0.688	4.288	9.710	12.96	42.46	61.96	3.23E+04
Constructed Wetland / Wetpond (without Extended Detention)	71.14	0.228	0.313	0.375	0.750	0.848	4.196	8.849	123.0	41.88	85.57	3.08E+04
Dry Extended Detention Basin	87.36	0.673	0.439	0.183	1.173	5.029	6.656	19.96	56.01	64.68	137.9	4.15E+04
Hydrodynamic Separator	236.5	1.237	0.093	0.880	1.198	3.737	11.98	11.98	25.70	137.4	137.4	2.16E+05
Media Filter	40.73	0.168	0.099	0.382	0.852	1.213	13.75	17.20	10.02	142.2	100.3	1.27E+04
Sub-surface Flow Wetland	30.66	0.145	0.088	0.145	0.552	0.594	3.504	3.504	1.845	12.84	17.16	5.37E+02
Treatment Plant	2.00	0.003	0.003	0.006	0.552	0.030	3.000	3.000	10.97	15.00	15.00	1.00E+00
Vegetated Swale (Bioswale)	35.12	0.311	0.239	0.145	0.905	0.872	7.749	9.429	15.36	28.49	34.86	1.19E+06
Bioretention with Underdrains (biofiltration)	30.66	0.168	0.099	0.382	0.552	1.213	13.75	11.12	4.84	100.3	100.3	1.27E+04
Bioretention w/o underdrain	Volume reductions only											
Cistern	Volume reductions only											
Green Roof	Volume reductions only											
Porous Pavement	Volume reductions only											
Infiltration Basin	Volume reductions only											

H.3 Calculation of Baseline Loads and Target Load Reductions

In order to have a comparison between current bacteria loads and future reductions (to meet the TMDL requirements), wet weather baseline bacteria loads were calculated for each two-digit HSA watershed within the South Orange County area, using SBPAT. In order to maintain consistency with the Permit, which bases load reduction calculations on Water Year (WY) 1993, baseline loads for the WQIP analysis were also calculated based on rainfall from WY 1993. Target load reductions (TLRs) for wet weather fecal coliform loading were calculated based on load-based effluent limitations (expressed as percent load reductions) in the Permit. Table 4 summarizes wet weather baseline loads and TLRs for SOC watersheds.

Table 4. Baseline Loads and Target Load Reductions for SOC Watersheds, Water Year 1993

Watershed	Baseline Loads for WY 1993 (MPN*10^12)	Percent Load Reductions - Fecal Coliform1	Target Load Reductions (MPN*10^12)
Dana Point Coastal	1543	14.86	229
Laguna Coastal	1115	52.07	580
San Clemente	2553	24.58	628
San Juan Creek	11191	12.82	1435
Aliso Creek	4765	26.62	1268

[1] Source: 2015 Regional MS4 Permit, Attachment E, Table 6.3

H.4 Representative Wet Weather Load Reductions from Structural BMPs

Structural BMPs are engineered systems designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media absorption, or any other physical, biological, or chemical process. Two general types of structural BMPs were modeled in this WQIP; regional, and distributed BMPs.

“Regional” structural BMPs are treatment or volume mitigation BMPs implemented to treat larger subwatershed or catchment scale drainage areas. Three representative types of regional structural BMP technologies were evaluated to assess representative pollutant load reduction:

- Subsurface Flow (SSF) Wetlands
- Infiltration Basins and Underground Infiltration Galleries

- Wet Ponds

"Distributed" structural BMPs are treatment or volume mitigation BMPs implemented at the neighborhood, parcel or site scale. Distributed structural BMPs include green streets, rainwater harvesting, and other Low Impact Development-type solutions. Three representative types of distributed structural BMP technologies were evaluated to assess representative pollutant load reduction:

- Bioretention without underdrains (infiltration)
- Biofiltration with elevated underdrains (partial infiltration, partial biofiltration)
- Media Filter (no infiltration)

Table 5 summarizes the water quality performance assumptions for each of the BMPs that were modeled in WQIP.

Table 5. Assumptions and Source Data for BMP Performance

BMP	Source Data and Assumptions
Biofiltration with elevated underdrain	Better of media filtration and bioretention categories in the IBD, plus volume reduction
Bioretention w/o underdrain	No treated effluent; volume reductions only
Media Filter	Media filter category from the IBD; includes non-bio media filters (e.g., sand filters)
Subsurface Flow Wetland	Better of all IBD categories; except for Fecal Coliform where 90% removal is used a
Constructed Wetland / Retention Pond (w/o Extended Detention)	Based on combined wetland basin and retention pond IBD categories
Infiltration Basin	No treated effluent; volume reductions only

[a] SSF (subsurface flow) wetlands provide multiple unit treatment processes provided by other BMPs (e.g., sedimentation, filtration, biochemical, etc.). The 90% removal is based on USEPA, 1993[2], which states that SSF wetlands are generally capable of a 1 to 2 log reduction in fecal coliforms.

The performance of representative regional and distributed BMPs in the South Orange County watersheds were evaluated in terms of load reductions per unit of developed area treated. BMPs were of each type were applied to the selected representative area (discussed in "Spatial Data" Section. Each BMP type was modeled for several design storm scenarios, ranging from 10% to 100% of design capture volume (DCV), which was

[2] United States Environmental Protection Agency (USEPA), 1993. Subsurface Flow Wetlands for Wastewater Treatment, A Technology Assessment. July.

1 inch for the CIMIS Irvine Rain Gauge. Tables 6 through 11 summarize structural BMP performance results for regional and distributed BMPs (expressed as load reductions per developed area per year), and for various design storm sizing factors.

Fecal coliform load reductions were calculated based on WY 1993 rainfall data for consistency with the year used in setting the baseline load and target load reduction. The results for other constituents are expressed as average annual load reductions calculated using long-term rainfall data (1990-2014).

Table 6. Representative Normalized Pollutant Load Reduction Results for Regional Infiltration Basin

Design Storm (% of DCV)	FC	DCu	DP	DZn	NH3	NO3	TCu	TKN	TP	TPb	TSS	TZn
	WY1993 load reduction (MPNx10^12/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)
10	0.0231	0.0019	0.0535	0.0150	0.1174	0.1798	0.0040	0.5046	0.0687	0.0018	19.6750	0.0251
20	0.0486	0.0038	0.1068	0.0300	0.2363	0.3619	0.0081	1.0167	0.1375	0.0036	39.8534	0.0502
30	0.0735	0.0053	0.1506	0.0422	0.3318	0.5120	0.0113	1.4156	0.1937	0.0051	56.3804	0.0705
40	0.0994	0.0065	0.1829	0.0515	0.4019	0.6297	0.0138	1.7272	0.2355	0.0063	69.6028	0.0858
50	0.0958	0.0074	0.2082	0.0584	0.4507	0.7160	0.0157	1.9647	0.2674	0.0071	78.9364	0.0971
60	0.1001	0.0080	0.2287	0.0638	0.5001	0.7960	0.0173	2.1581	0.2951	0.0077	87.7400	0.1068
70	0.1131	0.0086	0.2474	0.0687	0.5376	0.8497	0.0186	2.3181	0.3157	0.0083	97.8761	0.1139
80	0.1120	0.0091	0.2613	0.0723	0.5592	0.9018	0.0196	2.4537	0.3352	0.0089	102.1297	0.1206
90	0.1109	0.0095	0.2716	0.0754	0.5987	0.9406	0.0204	2.5566	0.3515	0.0093	107.6473	0.1257
100	0.1434	0.0098	0.2815	0.0782	0.6126	0.9764	0.0212	2.6657	0.3618	0.0095	111.9422	0.1300

Table 7. Representative Normalized Pollutant Load Reduction Results for Regional Wet Pond

Design Storm (% of DCV)	FC	DCu	DP	DZn	NH3	NO3	TCu	TKN	TP	TPb	TSS	TZn
	WY1993 load reduction (MPNx10^12/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)
10	0.0086	0.0003	0.0144	0.0039	0.0324	0.0445	0.0010	0.0941	0.0139	0.0004	4.9743	0.0065
20	0.0212	0.0008	0.0330	0.0089	0.0727	0.0995	0.0022	0.2120	0.0313	0.0008	11.5882	0.0147
30	0.0269	0.0012	0.0496	0.0135	0.1077	0.1508	0.0033	0.3222	0.0476	0.0013	17.5877	0.0223
40	0.0376	0.0015	0.0646	0.0176	0.1430	0.2036	0.0043	0.4197	0.0619	0.0017	22.9557	0.0290
50	0.0423	0.0018	0.0786	0.0213	0.1737	0.2434	0.0052	0.5038	0.0753	0.0020	28.4364	0.0350
60	0.0483	0.0021	0.0916	0.0247	0.1981	0.2859	0.0061	0.5971	0.0874	0.0024	33.5869	0.0409
70	0.0597	0.0024	0.1030	0.0281	0.2259	0.3273	0.0069	0.6681	0.0987	0.0027	40.4828	0.0457
80	0.0720	0.0026	0.1133	0.0306	0.2567	0.3513	0.0075	0.7316	0.1092	0.0029	41.8484	0.0502
90	0.1073	0.0028	0.1228	0.0333	0.2734	0.3872	0.0082	0.7904	0.1175	0.0032	46.0285	0.0549
100	0.0843	0.0030	0.1311	0.0356	0.2903	0.4212	0.0088	0.8476	0.1258	0.0033	48.6330	0.0586

Table 8. Representative Normalized Pollutant Load Reduction Results for Regional SSF Wetland

Design Storm (% of DCV)	FC	DCu	DP	DZn	NH3	NO3	TCu	TKN	TP	TPb	TSS	TZn
	WY1993 load reduction (MPNx10^12/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)
10	0.0280	0.0011	0.0457	0.0114	0.1071	0.1543	0.0033	0.3636	0.0615	0.0018	17.4260	0.0204
20	0.0551	0.0021	0.0915	0.0226	0.2099	0.3068	0.0066	0.7178	0.1222	0.0035	35.4041	0.0406
30	0.0854	0.0030	0.1277	0.0315	0.2923	0.4315	0.0093	1.0137	0.1707	0.0049	49.0078	0.0569
40	0.1014	0.0036	0.1554	0.0383	0.3627	0.5293	0.0112	1.2163	0.2080	0.0060	59.8321	0.0689
50	0.1181	0.0040	0.1753	0.0432	0.4104	0.5931	0.0128	1.3766	0.2365	0.0067	68.2488	0.0781
60	0.1434	0.0044	0.1928	0.0470	0.4479	0.6649	0.0140	1.5188	0.2574	0.0074	77.9852	0.0857
70	0.1553	0.0047	0.2065	0.0505	0.4814	0.7127	0.0151	1.6170	0.2785	0.0079	82.3773	0.0910
80	0.1653	0.0050	0.2176	0.0534	0.5057	0.7487	0.0159	1.7325	0.2930	0.0084	87.6724	0.0953
90	0.1855	0.0052	0.2272	0.0554	0.5193	0.7946	0.0165	1.7850	0.3048	0.0087	93.1443	0.0998
100	0.1987	0.0053	0.2363	0.0572	0.5436	0.8320	0.0172	1.8422	0.3148	0.0090	96.8245	0.1033

Table 9. Representative Normalized Pollutant Load Reduction Results for Distributed Bioretention

Design Storm (% of DCV)	FC	DCu	DP	DZn	NH3	NO3	TCu	TKN	TP	TPb	TSS	TZn
	WY1993 load reduction (MPNx10^12/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)
10	0.0381	0.0021	0.0588	0.0168	0.1318	0.1792	0.0044	0.5530	0.0749	0.0020	18.8064	0.0282
20	0.0729	0.0043	0.1172	0.0335	0.2615	0.3487	0.0087	1.1009	0.1497	0.0040	37.2929	0.0563
30	0.1039	0.0059	0.1627	0.0467	0.3671	0.4880	0.0121	1.5403	0.2091	0.0056	51.6980	0.0782
40	0.1374	0.0071	0.1972	0.0567	0.4441	0.5949	0.0147	1.8610	0.2531	0.0067	62.5057	0.0943
50	0.2117	0.0081	0.2233	0.0641	0.4976	0.6778	0.0167	2.1188	0.2872	0.0077	72.2354	0.1074
60	0.2066	0.0089	0.2447	0.0697	0.5495	0.7351	0.0182	2.3200	0.3126	0.0083	77.7647	0.1174
70	0.2427	0.0095	0.2597	0.0745	0.5830	0.7830	0.0194	2.4691	0.3329	0.0087	83.4845	0.1253
80	0.2279	0.0099	0.2725	0.0781	0.6170	0.8227	0.0204	2.5961	0.3487	0.0093	86.9783	0.1311
90	0.2000	0.0104	0.2837	0.0813	0.6275	0.8503	0.0213	2.6711	0.3623	0.0097	91.9496	0.1370
100	0.2636	0.0107	0.2932	0.0841	0.6600	0.8870	0.0219	2.7896	0.3758	0.0101	93.0324	0.1413

Table 10. Representative Normalized Pollutant Load Reduction Results for Distributed Media Filter

Design Storm (% of DCV)	FC	DCu	DP	DZn	NH3	NO3	TCu	TKN	TP	TPb	TSS	TZn
	WY1993 load reduction (MPNx10^12/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)
10	0.0418	0.0013	0.0625	0.0159	0.1386	0.1102	0.0034	0.5016	0.0645	0.0019	20.0967	0.0288
20	0.0817	0.0024	0.1100	0.0277	0.2445	0.2030	0.0060	0.8562	0.1137	0.0033	34.5631	0.0502
30	0.1658	0.0031	0.1429	0.0365	0.3216	0.2687	0.0079	1.1489	0.1497	0.0043	46.3764	0.0663
40	0.1131	0.0037	0.1703	0.0429	0.3777	0.3234	0.0094	1.3457	0.1792	0.0051	54.5466	0.0784
50	0.1430	0.0043	0.1911	0.0487	0.4313	0.3570	0.0106	1.5253	0.2009	0.0057	61.5800	0.0883
60	0.3703	0.0047	0.2094	0.0525	0.4546	0.4004	0.0116	1.6617	0.2207	0.0062	67.6869	0.0957
70	0.1808	0.0050	0.2218	0.0563	0.4997	0.4381	0.0125	1.7917	0.2312	0.0067	73.0172	0.1027
80	0.2339	0.0052	0.2323	0.0593	0.5118	0.4270	0.0129	1.8833	0.2464	0.0070	75.1257	0.1079
90	0.2109	0.0053	0.2455	0.0616	0.5206	0.4571	0.0134	1.9462	0.2559	0.0074	77.6039	0.1128
100	0.2864	0.0056	0.2505	0.0632	0.5524	0.4946	0.0139	1.9923	0.2669	0.0075	80.8457	0.1157

Table 11. Representative Normalized Pollutant Load Reduction Results for Distributed Biofiltration

Design Storm (% of DCV)	FC	DCu	DP	DZn	NH3	NO3	TCu	TKN	TP	TPb	TSS	TZn
	WY1993 load reduction (MPNx10^12/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)	Average annual load reduction (lbs/ year/ developed acre treated)
10	0.0531	0.0019	0.0759	0.0200	0.1711	0.2033	0.0048	0.6301	0.0834	0.0023	24.8899	0.0354
20	0.0821	0.0033	0.1293	0.0342	0.2897	0.3432	0.0082	1.0993	0.1440	0.0040	42.3677	0.0606
30	0.1253	0.0045	0.1695	0.0443	0.3722	0.4517	0.0108	1.4319	0.1874	0.0053	55.5484	0.0789
40	0.1532	0.0053	0.2008	0.0527	0.4451	0.5414	0.0129	1.6979	0.2241	0.0062	66.1521	0.0930
50	0.1562	0.0060	0.2250	0.0590	0.4968	0.6010	0.0144	1.9104	0.2525	0.0070	73.9095	0.1043
60	0.2341	0.0067	0.2449	0.0640	0.5406	0.6542	0.0159	2.1009	0.2763	0.0076	80.4919	0.1133
70	0.1916	0.0073	0.2583	0.0687	0.5719	0.7101	0.0169	2.2435	0.2976	0.0081	85.9341	0.1207
80	0.2409	0.0077	0.2733	0.0717	0.6070	0.7515	0.0180	2.3625	0.3137	0.0088	91.4636	0.1268
90	0.2214	0.0082	0.2856	0.0750	0.6244	0.7766	0.0187	2.5086	0.3284	0.0089	94.1084	0.1313
100	0.2578	0.0085	0.2927	0.0766	0.6472	0.8030	0.0194	2.5479	0.3408	0.0094	97.0548	0.1356

H.5 Application of Representative Load Reductions to Watershed-scale BMP Implementation Scenarios

Calculated base line fecal coliform loads for each watershed (see section H.3), along with calculated load reductions from structural BMPs (see section H.4) were applied in a spreadsheet-based calculator to estimate load reductions for each watershed. The load reduction spreadsheet:

- Allows the user to input:
  1) percent of developed land treated in each watershed.
  2) distribution of BMP types (expressed as percentage). A single BMP type or any combination of the six BMP types specifies in this WQIP can be selected to calculate average annual average annual load reductions.
  3) sizing factor; ranging from 10% to 100% of design capture volume (DCV), which was 1 inch for the CIMIS Irvine Rain Gauge.
- Estimates fecal coliform load reduction from assumed mix of structural BMPs for each watershed (expressed as percentage of baseline loads and range to be used for planning/reporting)
- Estimates average annual load reductions achieved by assumed combination of structural BMPs implementation, as mass/count per year for the water quality parameters analyzed in SBPAT, in each watershed

Table 12 and Table 13 illustrate structural control implementation assumptions in this WQIP. 15% of developed land uses areas in each watershed assumed to be treated by BMPs, except for Laguna Coastal Streams watershed (with 75% developed land use treatment). Once the percent of treated developed land areas in each watershed is determined, treated acreage areas are calculated to be multiplied by unit load reductions. BMP distribution in this WQIP consists of even split between infiltration, biofiltration, media filtration, and subsurface flow wetlands. Average sizing factor of 50% of the 85th percentile, 24-hour design storm (0.5 in based on CIMIS Irvine Rain Gauge data). Tables 14 and 15 summarize load reductions based on implementation assumptions.

Table 12. Percent of Developed Land Treated in WQIP (Input Data)

Watershed	Percent of developed land treated (%)
Aliso Creek	15
Dana Point Coastal Streams	15
Laguna Coastal Streams	75
San Clemente	15
San Juan Creek	15

Table 13. Distribution of Assumed BMPs and Sizing Factor (Input Data)

BMP Type	Distribution of BMP types (%)	Sizing factor (% of DCV)
Regional Infiltration Basin	0.00	50
Regional Wet Pond	0.00	50
Regional SSF Wetland	25.00	50
Distributed Bioretention	25.00	50
Distributed Media Filter	25.00	50
Distributed Biofilter	25.00	50

Table 14. Fecal Coliform Load Reduction from Assumed Mix of Structural Controls (Output Data)

Watershed	Baseline FC Load, MPN*10^12	TLR (%)	TLR, MPN*10^12	Load Reduction from Assumed Mix of Structural Controls		
				As MPN*10^12	As % of Baseline	Range to Use for Planning/Reporting
Aliso Creek	4,765	26.6%	1,268	293	6.2%	4% to 9%
Dana Point	1,542	14.9%	229	98	6.3%	4% to 9%
San Joaquin Hills, Laguna Hills	1,115	52.1%	581	301	27.0%	18% to 41%
San Clemente	2,553	24.6%	628	154	6.0%	4% to 9%
San Juan Creek	11,191	12.8%	1,435	516	4.6%	3% to 7%

Table 15. Average Annual Load Reductions from Assumed Mix of Structural Controls (Output Data)

Watershed	FC	DCu	DP	DZn	NH3	NO3	TCu	TKN	TP	TPb	TSS	TZn
	Average annual load reduction (MPNx10^12/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)	Average annual load reduction (lbs/year)
Aliso Creek	293	10	380	100	856	1039	25	3230	455	13	128,617	176
Dana Point Coastal Streams	98	3	126	33	285	346	8	1075	151	4	42,789	59
Laguna Coastal Streams	301	11	390	103	879	1068	26	3320	468	13	132,181	181
San Clemente	154	6	200	53	450	547	13	1700	240	7	67,695	93
San Juan Creek	516	18	668	176	1505	1827	45	5682	801	22	226,247	310