Appendix A – BMP Representation Summary

This appendix summarizes the assumptions regarding BMP implementation throughout the Tecolote watershed. It is important to note that this document provides details for future additional BMP implementation above and beyond current activities. The BMP Representation Memorandum which was previously submitted as part of the CLRP Phase II study provides a more robust summary of these activities.

1. Nonstructural BMPs

To assist in the phased reduction of pollutant loads, various nonstructural BMPs have been identified for implementation. These nonstructural BMPs include improvements to existing nonstructural BMP programs, as well as implementation of new nonstructural BMPs. LSPC watershed models were calibrated to in-stream monitoring data, which incorporates the effects of existing pollutant sources and current management actions upstream of the calibration points. Since the models are inclusive of current management practices, nonstructural BMPs will be modeled as additions to current nonstructural management programs. Estimated pollutant and flow reduction benefits from these current nonstructural BMPs will provide the baseline from which additional reductions will be achieved through implementation of structural and additional nonstructural BMPs to meet TMDL and CLRP requirements. In addition to those BMPs that are explicitly represented in the model, the effectiveness of many other nonstructural BMPs are not easily quantified and are therefore assigned a conservative pollutant load reduction value. A summary of nonstructural BMPs is provided in Table 1-1.

Table 1-1 Summary of nonstructural BMPs

Activity	Caltrans	City of San Diego
Nonstructural (Modeled)		
Enhance street sweeping through equipment replacement and route optimization	•	•
Expand residential BMP (irrigation, rainwater harvesting and turf conversion) rebate programs to multi-family housing in target areas		•
Initiate sweeping of medians on high-volume arterial roadways		•
Optimize catch basin cleaning to maximize pollutant removal		•
Reduction of over-irrigation		
Require sweeping of private roads & parking lots in targeted areas		•
Residential BMP Program: Downspout Disconnect		•
Residential BMP Program: Irrigation Control (Turf Conversion)	•	•
Residential BMP Program: Rain Barrels		•
Residential properties		
Nonstructural (Not Modeled)		
Amend zoning and other development regulations to facilitate LID implementation		
Animal-related facilities		•
Auto-related uses		•
Complete dry weather flow separation and treatment projects per capital improvement plans		•
Conduct trash clean-ups through community-based organizations involving target audiences		•
Continue to participate in source reduction initiatives		•
Design and implement property- and PGA-based inspections and accelerated enforcement		•

Develop outreach and training program for property managers responsible for HOAs and Maintenance Districts		•
Develop pilot project to identify and carry out site disconnections in targeted areas		•
Develop regional training for and focus locally on enforcement of water-using mobile businesses		•
Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements		•
Enhance LID implementation for new development and redevelopment through zoning amendments		•
Enhanced and expanded trash clean-up programs	•	
Enhanced IC/ID reporting and enforcement	•	
Erosion repair & slope stabilization - public property & right of way	•	
Expand outreach to HOA common lands and HOA rebates		•
Identify sewer leaks and areas for sewer pipe replacement prioritization		•
Improve consistency & content of websites to highlight enforceable conditions & reporting methods		•
Improved web/public resources on reporting enforceable discharges		
Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair		•
Increased channel cleaning and scour pond repair to improve MS4 function	•	
Increased sweeping frequency or routes		
Inspection/enforcement of power washing discharges		
Mitigation and conservation initiatives	•	
Nurseries and garden centers		•
Partnerships to address bacteria & trash impacts of homelessness		
Proactive MS4 repair and replacement	•	
Proactively monitor for erosion, and complete minor repair & slope stabilization		•
Property-based inspections	•	
Reducing groundwater infiltration		
Refocused or enhanced education & outreach to target audiences		
Sewer pipe replacement		
Support for Brake Pad Partnership	•	
Support partnership effort by social service providers to provide sanitation and trash management for persons experiencing homelessness		•
Train Development Services Department staff on LID regulatory changes and LID Design Manual		•
Train staff and boards to facilitate LID implementation and source control		
Training or certification requirements for mobile businesses		
Trash areas: require full four-sided enclosure, siting away from storm drains, cover; consider retrofit requirement		•
Update Minimum BMPs for existing residential, commercial & industrial development & enforce		•

Conceptual modeling approaches and BMP assumptions for each of the modeled nonstructural BMPs are detailed in this section.

1.1 Street Sweeping

Improved street and median sweeping technology enhances the potential for wet weather pollutant load reductions for bacteria, metals, non-metal toxics, and nutrients. Increasing the sweeping frequency, increasing the area of impervious cover swept, or upgrading the sweeping equipment can result in an increase in pollutant load removal. Note that while street sweeping can significantly reduce pollutant loads, the practice is not associated with runoff volume reduction.

1.1.1 Treatment Process Model Overview

The LSPC model's street sweeping BMP process for pollutant removal is illustrated in Figure 1-1. This BMP is explicitly represented in the model to simulate pollutant removal at the street level. Parameters of the street sweeping module can be adjusted to account for variable removal efficiencies (based on equipment type), sweeping frequency, and sweeping area coverage.

Ultimately, the total load of pollutants that are programmed to build up in the modeled watershed over time are re-programmed to be removed or reduced based on the assumed street sweeping practices occurring in the watershed. While the sweeping effectiveness parameters are best determined by scientific study, it is critical to document the following key variables relevant to street sweeping programs:

- Sweeping Equipment – Vacuum sweeping machines are generally more efficient than mechanical broom sweepers with regard to pollutant removal, especially in typical curb sweeping applications. Designed specifically to capture fine sediments in addition to coarse sediment and other solids, vacuum sweeping machines achieve greater sediment, nutrient, and metals removal as compared to mechanical broom sweepers, which are designed to capture coarse particles.
- Sweeping Frequency – More frequent sweeping activities can result in greater pollutant removal. Currently, sweeping routes are generally classified as High frequency (sweeping every 3 to 7 days), Medium frequency (monthly sweeping), or Low frequency (sweeping once every two months).
- Sweeping Routes – Increased treatment area can also result in greater pollutant removal.

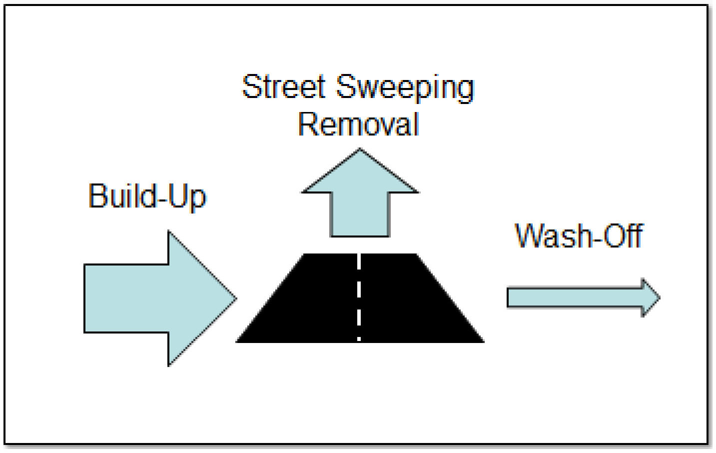


Figure 1-1 Street and Median Sweeping Treatment Process

1.1.2 Optimization Analysis

Street sweeping performance is a function of road area swept, the type of equipment used, and the frequency of sweeping. Recommendations for program enhancement could affect the selection of mechanical (broom) and enhanced (vacuum) sweeping of commercial and residential roads and medians at frequencies ranging from Bimonthly to twice a week. To develop a better understanding of the implications of assumptions associated with the proposed street sweeping program an optimization analysis was performed across all City of San Diego streets throughout Chollas, Scripps, Tecolote, and San Diego River watersheds. The optimization was set up to determine the optimal combination of enhancements to the street sweeping program to maximize sediment removal. Table 1-2 presents a summary of modeled street sweeping cost-benefit (in terms of sediment removal) across the four watersheds. Results from this optimization analysis are used to inform implementation decisions for individual watersheds.

Table 1-2. Summary of Street sweeping cost-effectiveness for sediment removal by type and frequency

Watershed	Subtotals (Variable Units)	Mechanical (Broom)					Enhanced (Vacuum)				
		BiMonthly	Monthly	BiWeekly	Weekly	2×Weekly	BiMonthly	Monthly	BiWeekly	Weekly	2×Weekly
Program Costs ($ Million)											
Chollas	$7.16	$0.61	$1.27	$0.00	$0.20	$0.12	$1.74	$2.45	$0.01	$0.46	$0.32
Scripps	$4.62	$0.79	$0.00	$0.23	$0.14	$0.05	$2.27	$0.00	$0.64	$0.37	$0.13
SDR	$9.93	$1.99	$0.22	$0.03	$0.30	$0.04	$5.70	$0.62	$0.09	$0.82	$0.12
Tecolote	$1.39	$0.34	$0.00	$0.00	$0.02	$0.00	$0.98	$0.00	$0.00	$0.05	$0.00
Program Sediment Removal (tons/year)											
Chollas	1,403	1.2	11.8	0.9	115.5	118.8	10.2	136.0	5.0	536	467
Scripps	834	11.6		50.2	60.6	30.8	62.3		243	252	123
SDR	2,743	119.0	17.4	9.5	314.7	53.0	539.6	92.2	51	1,340	205
Tecolote	648	69.3		1.3	53.0		313.0		5.6	206	
Program Cost-Effectiveness for Sediment ($/lb removed)											
Chollas	$2.55	$258	$53.52	$1.98	$0.86	$0.48	$84.88	$8.99	$1.01	$0.43	$0.34
Scripps	$2.77	$34		$2.30	$1.13	$0.79	$18.23		$1.31	$0.74	$0.54
SDR	$1.81	$8.34	$6.29	$1.74	$0.48	$0.42	$5.28	$3.34	$0.89	$0.31	$0.30
Tecolote	$1.07	$2.46		$0.28	$0.16		$1.56		$0.18	$0.11	

Color gradient indicates low to high cost effectiveness.

The results of this analysis suggest that increasing the frequency and/or using enhanced sweeping equipment is more cost effective for sediment removal, and that extremely infrequent sweeping (i.e. every other month) is the least cost-effective for reducing sediment delivery in runoff. The interaction between street sweeping and the other pollutants varies by pollutant, as summarized in Table 1-3.

Table 1-3. Summary of Street sweeping cost-effectiveness for copper, bacteria, and nutrients

Watershed	Subtotals	Mechanical (Broom)					Enhanced (Vacuum)				
		BiMonthly	Monthly	BiWeekly	Weekly	2×Weekly	BiMonthly	Monthly	BiWeekly	Weekly	2×Weekly
Program Cost-Effectiveness for Copper ($1,000/lb removed)											
Chollas	$1.13	$117	$23.8	$0.88	$0.38	$0.22	$37.72	$4.00	$0.45	$0.19	$0.15
Scripps	$1.23	$15		$1.02	$0.50	$0.35	$8.10		$0.58	$0.33	$0.24
SDR	$0.81	$3.71	$2.8	$0.77	$0.21	$0.19	$2.35	$1.48	$0.39	$0.14	$0.13
Tecolote	$0.48	$1.09		$0.12	$0.07		$0.70		$0.08	$0.05	
Program Cost-Effectiveness for Fecal Coliform ($1,000/Trillion removed)											
Chollas	$339	$41	$65	$516	$543	$631	$51	$158	$398	$434	$385
Scripps	$833	$488		$795	$743	$655	$370		$549	$455	$408
SDR	$303	$1,191	$532	$516	$878	$638	$767	$401	$398	$548	$384
Tecolote	$1,860	$1,594		$1,367	$1,044		$1,021		$850	$596	
Program Cost-Effectiveness for Nitrogen ($1,000/lb removed)											
Chollas	$16	$2	$3	$26	$26	$34	$2	$7	$20	$20	$19
Scripps	$41	$2		$1	$73	$129	$2		$1	$48	$73
SDR	$14	$1	$17	$2	$15	$77	$1	$27	$2	$10	$43
Tecolote	$86	$1		$48	$112		$1		$37	$74	

Color gradient indicates **low** to **high** cost effectiveness.

The modeled results suggest that:

- Street sweeping is cost effective for particulate matter like sediment and sediment-associated pollutants like metals, but not as cost effective for bacteria and nutrients. The metals removal cost-effectiveness gradient mirrors that of sediment removal.
- It is more cost-effective to sweep more frequently in watersheds with more rainfall.
- Because bacteria grow so quickly, increasing street-sweeping frequency provides little benefit for bacteria removal. In fact, the results suggest not sweeping as a means for controlling bacteria. Other BMPs may be more effective at bacteria management than sweeping, particularly those that are designed to reduce runoff volume.
- Similar to bacteria, more frequent street sweeping is also less cost-effective for nutrient removal. Direct source controls or practices that reduce runoff are likely more effective for nutrient removal than street sweeping.

Using the unit cost and performance information from modeling the proposed study, an optimization analysis was formulated to see if a more cost-effective management strategy could be derived to refine the proposed street sweeping program for the City of San Diego. The City provided a set of spatial and temporal constraints for each type of street sweeping, as defined in Table 1-4.

Table 1-4. Summary of Street sweeping cost-effectiveness for sediment removal by type and frequency

Legend: ● = 100% Maximum ◗ = 75% Maximum ○= Not applicable		**Frequency and Type**									
		Mechanical (Broom)					**Enhanced (Vacuum)**				
Land Use		**Bimonthly**	**Monthly**	**Biweekly**	**Weekly**	**2×Weekly**	**Bimonthly**	**Monthly**	**Biweekly**	**Weekly**	**2×Weekly**
Roads [a]	Commercial	●	●	●	●	●	◗	◗	◗	◗	◗
	Residential [c]	●	●	○	○	○	◗	◗	○	○	○
Medians [b]	Commercial	●	●	●	●	●	○	○	○	○	○
	Residential [c]	●	●	○	○	○	○	○	○	○	○

a. Candidate roads for sweeping exclude freeways and unimproved roads (without curb and gutter)
b. Only mechanical sweepers are used in medians/turn-lanes
c. The maximum sweeping frequency for residential roads and medians is bi-monthly

Because the proposed street sweeping program applies to all improved City of San Diego roads across watershed and jurisdictional boundaries, all roads with the potential for sweeping were evaluated in order to provide a direct comparison of optimization results against cost and benefit estimates for the proposed sweeping program. The constraints presented in Table 1-4 were applied spatially such that each of the 266 subwatersheds in the model (those having applicable city streets) had eleven possible options for sweeping—the ten combinations shown in Table 1-4, plus the option not to do street sweeping ($\sim 4 \times 10^{26}$ combinations). Figure 1-2 shows a near-optimal cost-effectiveness curve (derived after 10^{8} iterations). The red circle in Figure 1-2 shows the originally proposed solution, which was determined based on interviews with the City of San Diego staff, while the green diamond shows one near the knee of the cost-effectiveness curve, where the slope of the curve begins to flatten. This cost-effectiveness curve suggests that there are strategies available that are more cost-effective than the originally proposed strategy. For example, the recommended strategy at the knee of the curve (green diamond) is 50 percent of the cost of the proposed strategy and provides 350 percent more sediment removal. The reason for this savings is that it selectively targets certain areas (i.e. commercial roads in wetter areas of the study area) with more frequent and/or enhanced street sweeping than others.

It should be noted that this analysis was performed for a 10-year record of rainfall and included a representative range of wet and dry years. The pollutant removal effectiveness (i.e., percent removal) is likely to be muted when evaluating these optimized results in the context of a typical year as is done for the analysis for the CLPR model. As a result, the street sweeping removals summarized in the body of the CLRP Phase II report will not be as pronounced as those shown in Figure 1-2.

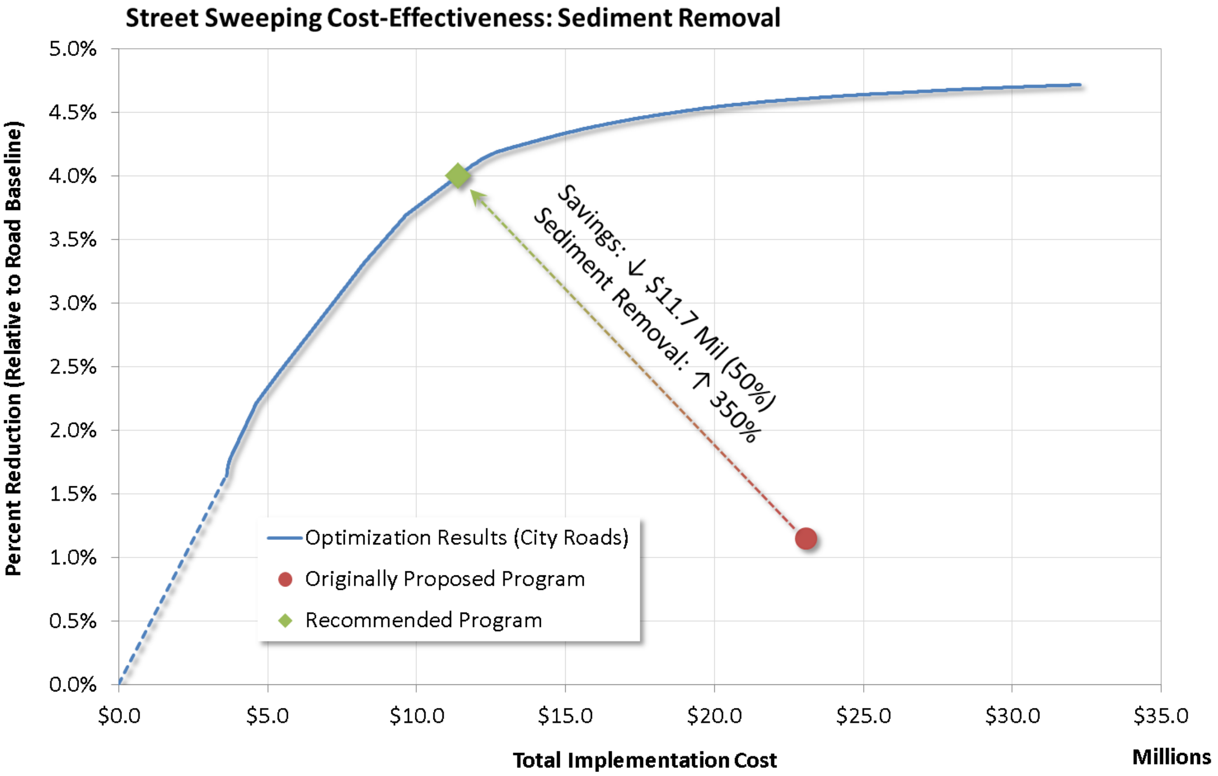


Figure 1-2. Near-optimal street sweeping cost-effectiveness curve versus originally proposed program.

The percent reductions presented from this analysis are diluted by loading from other areas which are not being swept. Furthermore, existing sweeping activity is also reflected in the modeled baseline. The results only show the change attributable to additional or enhanced sweeping on City streets. For these reasons, the values shown are single digit reductions relative to the existing condition as the baseline. Presenting the results this way also presents street sweeping benefits relative to other practices and relative to cumulative reduction requirements at downstream endpoints.

1.1.3 Proposed Program Enhancements

Program enhancements are recommended based on a combination of optimization analysis results and findings gleaned from interviews with individual RP representatives. The key findings of this analysis are:

- Enhancements of the street sweeping program should only be considered for those watersheds with metals load reduction requirements and not bacteria requirements.
- Sweeping of commercial areas should be performed at maximum frequency (2 times per week) with a regenerative air machine
- Converting to regenerative air sweeping in residential neighborhoods is not cost effective due to the limitations on sweeping frequency to bi-monthly
- Increasing frequency in residential neighborhoods being swept with mechanical brooms is not cost effective.

Because street sweeping is not effective for the critical pollutant, bacteria, no program enhancements were recommended for the City within Tecolote watershed. Implementation for the remaining RPs were based on interview results. Details regarding the interview process were presented in the BMP Representation Memorandum and recommended program enhancements are summarized in Table 1-5. Detailed model parameters are summarized in Table 1-6.

Table 1-5 Summary of Proposed Street Sweeping Program Enhancements

Sweeping Metric	Caltrans ****	City of San Diego
Current curb miles swept (miles per year)	80	3,156
Proposed enhanced equipment routes (miles)*	Not applicable	0
Proposed expanded sweeping routes (miles)**	Not applicable	0
Increased curb miles swept based on increased frequency (miles)	80	0
Proposed added private parking lot/road sweeping area (additional acres per year)***	Not applicable	0

Notes:

*	Conversion of routes from mechanical broom to vacuum sweeping machines
**	New medians to be swept with mechanical broom machines
***	Estimates based on GIS analysis and assumes monthly sweeping frequency
****	Caltrans program upgrades involve increased sweeping frequency. Caltrans sweeping frequency is assumed to increase from monthly (current program) to twice a month (proposed program).

Table 1-6 Summary of Model Parameters for Street Sweeping Program Enhancements

Parameter	Value	Source
Start month of sweeping practices	Continuous program	City of San Diego
End month of sweeping practices	Continuous program	City of San Diego
Typical days between HIGH frequency route sweeping	3-7	City of San Diego
Typical days between MEDIUM frequency route sweeping	30	City of San Diego
Typical days between LOW frequency route sweeping	60	City of San Diego
Fraction of land surface available for street sweeping	Provided at subwatershed level	GIS
Mechanical broom machine, weekly sweeping TS removal	13%	CWP 2008
Vacuum machine, weekly sweeping TS removal	31%	CWP 2008
Mechanical broom machine, monthly sweeping TS removal	9%	CWP 2008
Vacuum machine, monthly sweeping TS removal	22%	CWP 2008
Fraction of sand in solids storage available for removal by sweeping practices	78%	City of San Diego street sweeping pilot studies

Parameter	Value	Source
Fraction of silt/clay in solids storage available for removal by sweeping practices	6%	City of San Diego street sweeping pilot studies
Fraction of gravel in solids storage available for removal by sweeping practices	16%	City of San Diego street sweeping pilot studies
Concentration of copper in the removed sediment	93 mg/kg	City of San Diego street sweeping pilot studies
Concentration of zinc in the removed sediment	136 mg/kg	City of San Diego street sweeping pilot studies
Concentration of lead in the removed sediment	23 mg/kg	City of San Diego street sweeping pilot studies
Concentration of TKN in the removed sediment	495 mg/kg	City of San Diego street sweeping pilot studies
Concentration of total phosphorus in the removed sediment	199 mg/kg	City of San Diego street sweeping pilot studies
Concentration of bacteria in the removed sediment	0.00000521 x10^^{12} colonies per pound of street sediment	Pitt 1986

Notes:

- The location of existing sweeping activities will be used to spatially identify subwatersheds that will receive enhanced and expanded sweeping applications.
- Proposed levels of enhanced and expanded sweeping activities will be distributed to the subwatershed level of the LSPC model.

1.2 Catch Basin Cleaning

Enhanced catch basin cleaning activities will contribute to watershed-scale pollutant load reductions. Note that while enhanced catch basin cleaning can significantly reduce pollutant loads, this BMP is not associated with runoff volume reduction. This section summarizes the findings of a study focused on optimizing the City of San Diego's catch basin cleaning program and results of interviews with all other RPs.

1.2.1 Treatment Process Overview

A representation of the catch basin cleaning process and associated pollutant removal is provided in Figure 1-3. As the catch basin cleaning program improves effectiveness, pollutant loading to receiving waters through wash-off decreases. The primary method for improving pollutant reduction from catch basin cleaning activities is increased frequency of cleaning operations.

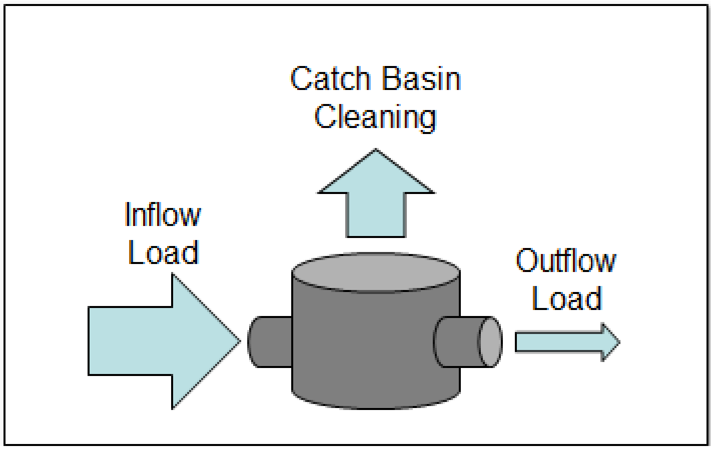


Figure 1-3 Catch Basin Cleaning Treatment Process

1.2.2 Optimization Analysis

To determine the maximum program enhancement scenario, manual clean-out data from 2009-2012 along with findings from Task Order 51 (The City of San Diego Catch Basin Cleaning Program Pilot Study) data was analyzed. As part of TO 51, a detailed assessment was performed to categorize catch basins according to their tendency to yield high, medium, or low debris weights per cleaning event. Previous studies also characterized typical pollutant loads per unit dry weight of debris. By combining these two pieces of information, estimates can be made regarding the effectiveness of the current program at reducing pollutant loads. In order to assess different possible scenarios for program enhancement, these data were used to perform an optimization analysis. Ultimately this information can be used to recommend the extent to which program enhancement is needed.

The TO 51 findings suggested that catch basins tend to fill up with debris quickly during storm events and remain at their capacity for debris storage until they are cleaned. Since current catch basin cleaning activities are typically performed only once annually, there is ample opportunity to substantially increase pollutant load removal by increasing the number of cleanings per basin. Several different scenarios were developed for possible future increases in catch basin cleanings (Table 1-7) and the associated pollutant load reductions were calculated based on concentrations of typical debris removal found in previous studies (Table 1-8). The results of this analysis are presented in Figure 1-4, which illustrates the cost-effectiveness of the increased cleaning activities relative to a 20-year implementation cost. As can be noted in Figure 1-4, enhanced catch basin cleaning activities (even for the most enhanced scenario 9) are not efficient for bacteria removal and result in zero percent reduction in fecal loads for all enhancement scenarios.

Table 1-7 Enhancement Scenarios

Enhancement Scenario	Number of Additional Cleanings per Year		
	High Yield Grids	Medium Yield Grids	Low Yield Grids
(1)	1	--	--
(2)	2	--	--
(3)	3	--	--
(4)	3	1	--
(5)	3	2	--
(6)	3	3	--
(7)	3	3	1

Enhancement Scenario	**Number of Additional Cleanings per Year**		
	High Yield Grids	**Medium Yield Grids**	**Low Yield Grids**
(8)	3	3	2
(9)	3	3	3

Table 1-8 Pollutant Concentrations Used to Calculate Reductions

Pollutant	**Concentration (per kg of dry debris)**	**Source**
Copper	75 mg/kg	City of San Diego TO 38
Zinc	232 mg/kg	City of San Diego TO 38
Lead	36 mg/kg	City of San Diego TO 38
Total Nitrogen	2,629 mg/kg	City of San Diego TO 38
Total Phosphorous	551 mg/kg	City of San Diego TO 38
Fecal Coliform	6.13 MPN/kg	City of San Diego TO 38

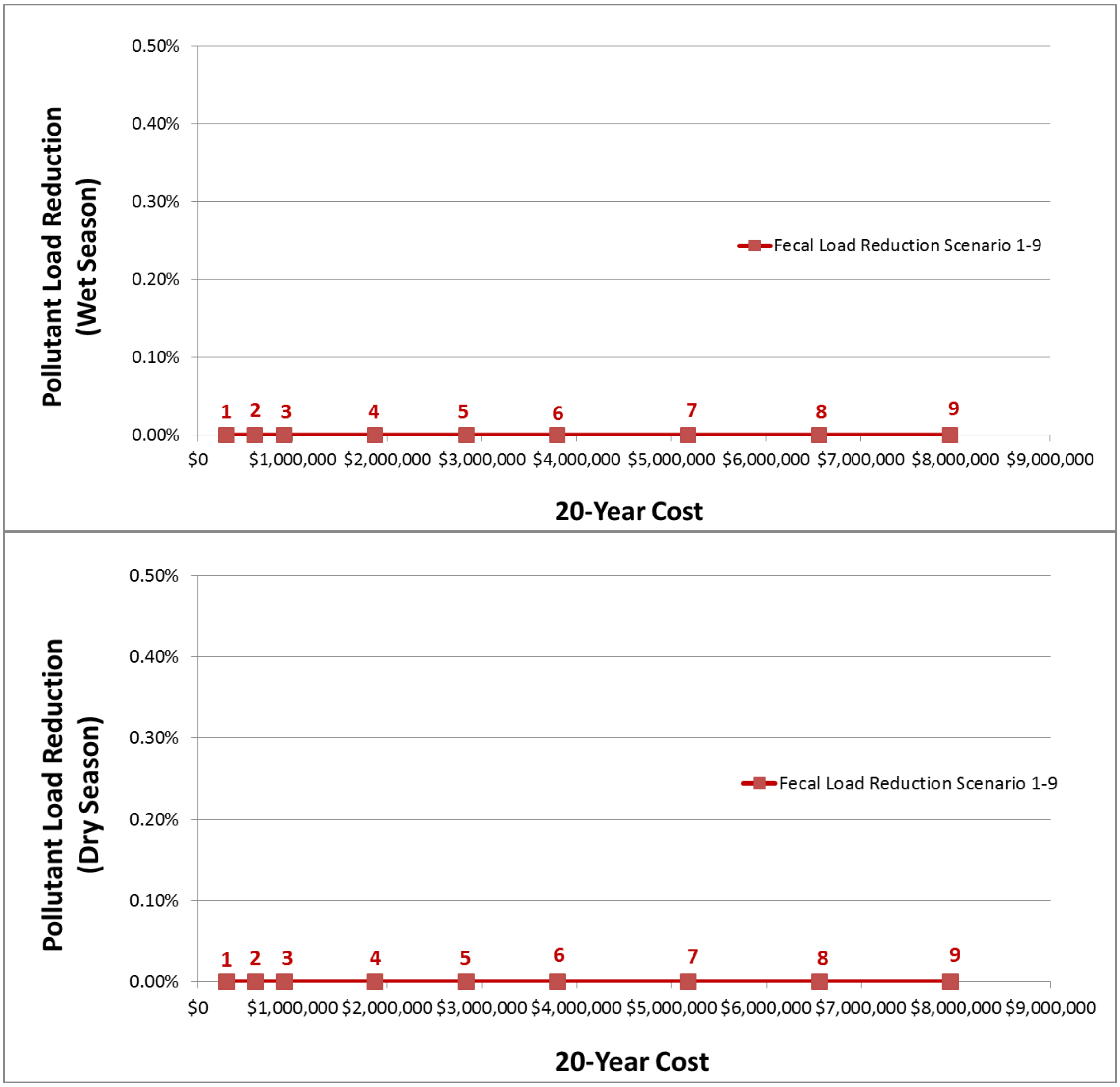


Figure 1-4 Catch Basin Cleaning Program Enhancement Scenarios (Wet and Dry Seasons)

1.2.3 Proposed Program Enhancements

Program enhancements are recommended based on a combination of optimization analysis results and findings gleaned from interviews with the City. Because the critical pollutant in the Tecolote watershed is bacteria, and because this BMP is not efficient in the reduction of bacteria loads (as displayed in Figure 1-4), no further catch basin cleaning program enhancements for the City of San Diego were recommended for this watershed.

1.3 Rain Barrels Incentive Program

Collection of rooftop runoff in rain barrel facilities can be part of a water conservation effort in which retained runoff is reused as irrigation. When reuse is not possible, the retained flows can be slowly released after a period of storage. To minimize the potential for dry weather flow generation and direct connection to impervious surfaces, any released flows can be routed through either landscaped areas, in which runoff load reduction can be attained through the processes of infiltration and evapotranspiration, or to bioretention BMPs as part of a longer treatment train approach.

1.3.1 Treatment Process Model Overview

The LSPC model's representation of rain barrel implementation for runoff volume reduction is provided in Figure 1-5. As the rain barrel program implementation increases, roof runoff is intercepted and temporarily stored in the barrel and the runoff volume (and associated pollutant load) to receiving waters decreases. Since the current rain barrel program implementation is relatively limited, methods for improving runoff volume reduction from rain barrel programs are primarily associated with additional rain barrel installations.

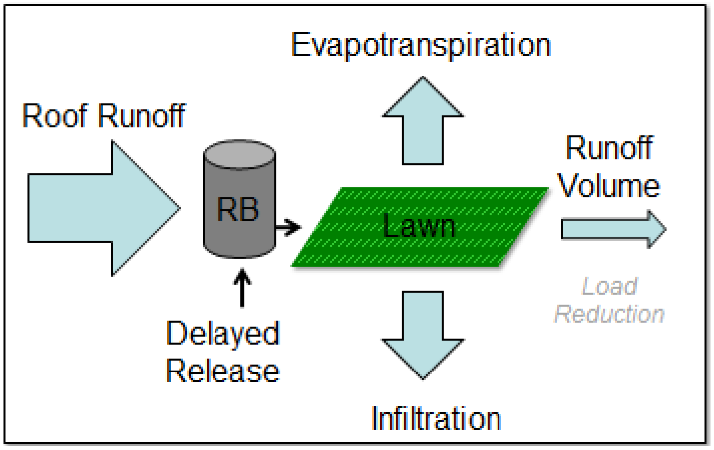


Figure 1-5 Rain Barrel Treatment Process

1.3.2 Proposed Program Enhancements

The City of San Diego Public Utilities Department currently operates a rebate program for rainwater harvesting practices, including rain barrels and cistern type devices. To date, the program has had limited implementation. Program enhancements are recommended based on findings gleaned from interviews with the City and other individual RP representatives. Future rain barrel implementation assumptions were based on historical rebate data. Details regarding the interview process and rebate assumptions were presented in the BMP Representation Memorandum. Assumptions regarding future implementation of the rain barrel program are summarized in Table 1-9 below.

Table 1-9 Summary of Rain Barrel Program Enhancements

Annual Rain Barrel Implementation Metric	Caltrans	City of San Diego
Single-family zoned parcels (SFZP)	Not applicable	15,759
SFZP percentage in watershed	Not applicable	5.14%
Rain barrel installations per year*	Not applicable	19

*This value reflects the number of rain barrels that the City has committed to installing, however does not reflect what was modeled. 5 rain barrel installations per year were modeled.

Simulation of long term rainfall and runoff processes within the BMP modeling software will assist in the determination of average rain barrel capture performance (runoff reduction) per rooftop drainage acre. Rain barrel modeling parameters are summarized in Table 1-10.

Table 1-10 Summary of Model Parameters for Rain Barrel Program Enhancements

Parameter	Value	Source
Contributing rooftop area to rain barrel	200 ft^2	City of San Diego
Rain barrel size (gallons - average)	65	City of San Diego
Primary outlet diameter	0.5 inch (minimum)	City of San Diego
Outlet pipe invert location	< 6 inches above bottom of barrel	City of San Diego
Overflow pipe diameter (inch)	2 inch (minimum)	City of San Diego
Maximum rain barrel outflow via 0.5 inch primary outlet	0.010 cfs	Orifice equation with depth = 2.5 feet
Rain barrel dewatering time	18 minutes	Typical value
Assumed soil infiltration rate at rain barrel discharge	0.03 in/hr	Type D soil infiltration parameter range
Assumed potential evapotranspiration rate	1.43 inches per month	Minimum monthly value in San Diego region in 2012
Assumed potential evapotranspiration rate	0.002 in/hr	Typical regional value
Assumed allowable ponding depth in landscaping area	0.75 inch	Typical regional value
Required landscaped area downstream of rain barrel discharge location to prevent rain barrel runoff	144 ft^2	Typical regional value

Parameter	Value	Source
Landscaped area dewatering time	23 hours	Typical regional value

1.4 Downspout Disconnection Incentive Program

Downspout disconnections provide a BMP alternative for runoff volume reduction in highly impervious watersheds. This cost-effective BMP, which provides for a disconnection of impervious surfaces between rooftops and sidewalks, driveways, or roads, can be modeled by routing runoff from impervious, directly connected rooftops over a segment of pervious land to simulate depression storage, infiltration processes, and overland flow routing on a typical lawn. This BMP is assumed for implementation only in single-family residential areas.

1.4.1 Treatment Process Model Overview

The LSPC model's downspout disconnection implementation for runoff volume reduction is provided in Figure 1-3. As the downspout disconnection program implementation increases, then the runoff volume and pollutant loads to receiving waters decreases. Since the downspout disconnection implementation program has recently initiated, methods for improving runoff volume reduction from downspout disconnections are primarily associated with additional facility installations.

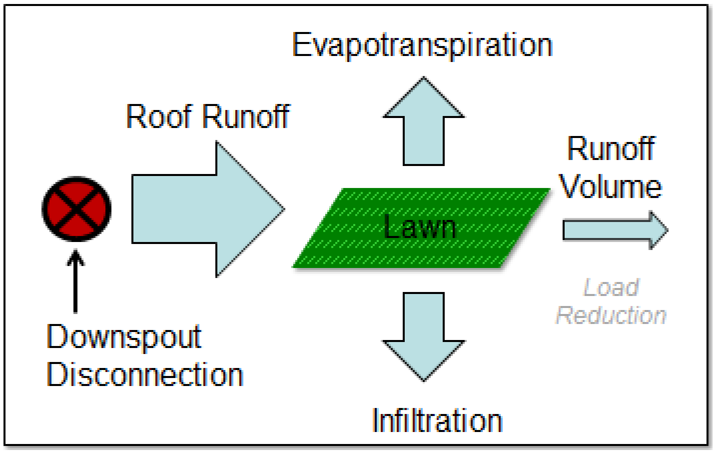


Figure 1-6 Downspout Disconnection Treatment Process

1.4.2 Proposed Program Enhancements

Program enhancements are recommended based on findings gleaned from interviews with the City and other individual RP representatives. Future rain barrel implementation assumptions were based on historical rebate data. Details regarding the interview process and model assumptions were presented in the BMP Representation Memorandum and recommended program enhancements are summarized in Table 1-11.

Table 1-11 Summary of Downspout Disconnection Program Enhancements

Annual Downspout Disconnection Implementation Metric	Tecolote Watershed
Single-family zoned parcels (SFZP)	15,759

Annual Downspout Disconnection Implementation Metric	Tecolote Watershed
SFZP percentage in City of San Diego	5.14%
Downspout disconnection installations per year	90

Assumptions regarding modeling parameters for downspout disconnections are summarized in Table 1-12.

Table 1-12 Summary of Model Parameters for Downspout Disconnection Program Enhancements

Parameter	Value	Source
Contributing rooftop area to rain barrel	200 ft^2	Typical area
85th percentile flow to disconnection	0.001 cfs	Rainfall intensity = 0.2 in/hr
85th percentile runoff volume to disconnections	10 ft^3	P = 0.6 inches
Assumed soil infiltration rate at rain barrel discharge	0.03 in/hr	Type D soil infiltration parameter range
Assumed potential evapotranspiration rate	1.43 inches per month	Minimum monthly value in San Diego region in 2012
Assumed potential evapotranspiration rate	0.002 in/hr	Typical regional value
Assumed allowable ponding depth in landscaping area	0.75 inch	Typical regional value
Required landscaped area downstream of discharge location	160 ft^2	Typical regional value
Landscaped area dewatering time	23 hours	Typical regional value

1.5 Irrigation Runoff Reduction

Reductions to irrigation runoff assist with runoff volume reduction goals and associated pollutant load reductions. This nonstructural BMP, which doubles as a water conservation initiative, incorporates good landscaping practices to limit irrigation runoff. Measures to reduce irrigation runoff can be implemented wherever landscapes are irrigated. Residential, commercial, recreational, and industrial land uses can be targeted by incentive policies and programs.

1.5.1 Treatment Process Model Overview

The LSPC model's representation of irrigation runoff reduction implementation is provided in Figure 1-4. As implementation of irrigation runoff reduction measures increases, then the runoff volume and associated pollutant loads to receiving waters decreases. Methods for implementing irrigation runoff reduction include the following.

- Turf conversion projects to reduce irrigation demand – Xeriscape conversion programs facilitate the transformation of residential lawns and gardens to low-irrigation landscapes using drought-tolerant plants and encouraging soil preparation, mulching, and zoned irrigation to reduce water use.
- Micro-irrigation practices – These measures are more efficient and use less water than conventional irrigation practices.
- Weather-based irrigation controllers – These devices reduce irrigation water use by meeting the actual needs of vegetation based on prevailing weather conditions, current and historic evapotranspiration soil moisture levels, and other factors relevant to adapt water application.

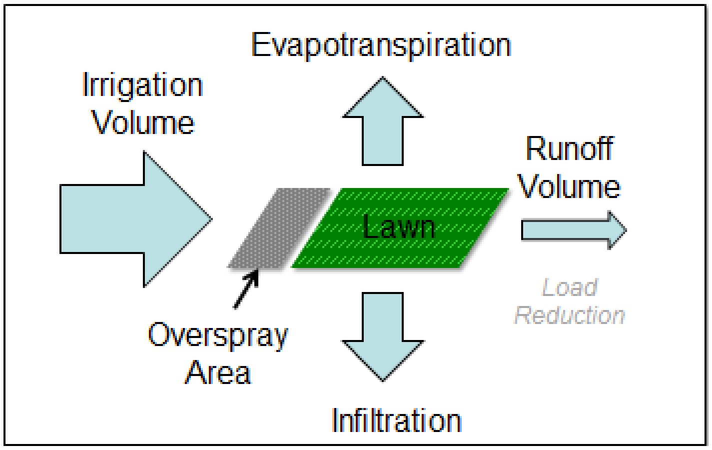


Figure 1-7 Irrigation Reduction Treatment Process

1.5.2 Proposed Program Enhancements

The City of San Diego Public Utilities Department currently operates a rebate program for irrigation runoff reduction practice. While combined with the City's rain barrel program from a budgetary and implementation standpoint, the irrigation reduction program will be modeled separately. Program enhancements are recommended based on findings gleaned from interviews with the City and other individual RP representatives. Future irrigation reduction implementation assumptions for the City of San Diego are based on targeted outcomes, rather than on the results of the existing program. The effects of the City of San Diego's irrigation runoff reduction program implementation were specifically modeled to result in:

1) elimination of all over-spray and

2) an overall 25% reduction in irrigation.

2. Structural BMPs

Structural BMPs provide the opportunity to intercept runoff and filtrate, infiltrate, or treat the stormwater. These structures tend to be more expensive than nonstructural BMPs, but they also tend to have predictable and reliable pollutant load removal effectiveness. Structural BMPs will be an important element of the overall CLRP compliance strategy. This section provides a summary of BMP representation information for the four different types of structural solutions evaluated as part of this analysis.

2.1 Centralized BMPs on Public Land

The construction of large centralized BMP facilities considered in this study focuses on surface BMPs that provide treatment via the processes of detention and infiltration. Specifically, these BMPs include infiltration basins and dry extended detention basins that are designed for extended residence times allowing water to infiltrate to native soils while accommodating for overflow and bypass during large storm events. The CLRP identified parcels that are likely suitable for locating centralized BMPs which can support watershed-scale implementation planning.

To better manage uncertainties associated with BMP placement and size, a standard centralized BMP representation was developed. Figure 2-1 presents a generalized schematic of a centralized, surface storage BMP that will be represented in the watershed model.

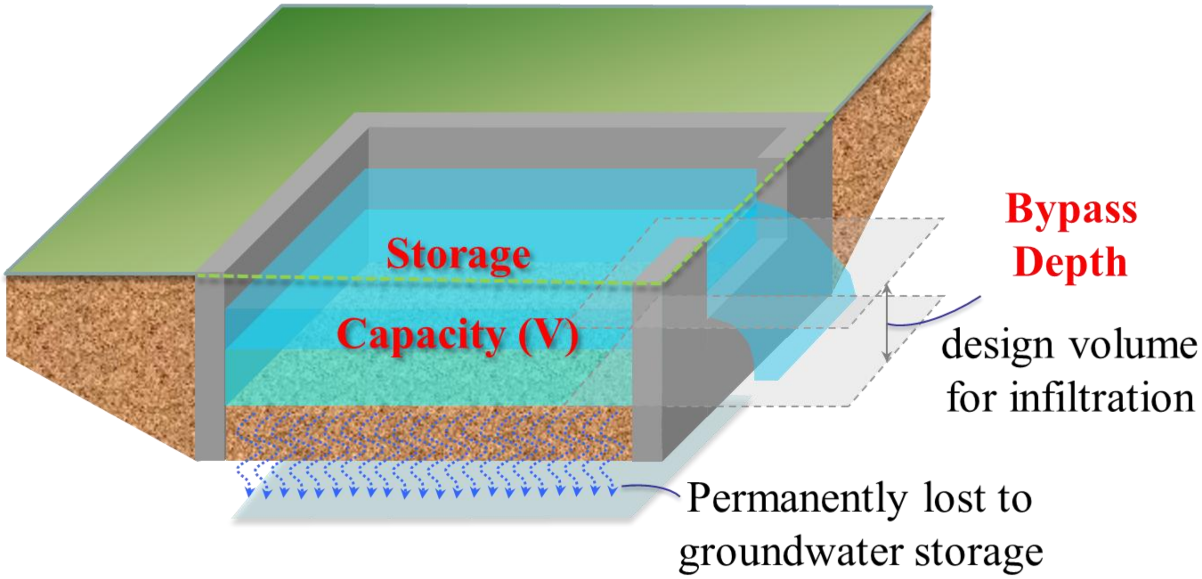


Figure 2-1 Centralized BMP representation.

Each of the centralized structural BMPs will be represented directly in the LSPC watershed model using a storage-discharge relationship to simulate outflow and a background infiltration rate reflective of the underlying soils. By incorporating these features directly into LSPC, the dynamic effect on volume and water quality incorporates all of the spatial variability (land use distribution and precipitation time series) within the watershed model. The static storage volume for each BMP facility will be calculated as the required volume corresponding to the 85th percentile rainfall depth based on the average percent imperviousness in the upstream contributing drainage area (City of San Diego 2008). The 85th percentile rainfall depth will be calculated uniquely for each centralized BMP using the weather station assigned to the model subwatershed that includes each BMP.

2.1.1 BMP Implementation in the Model

As part of CLRP Phase I, multiple desktop and field screening exercises were completed to develop a full understanding of the opportunities that exist for centralized BMP implementation in this watershed. The sites were pared down and prioritized based on feasibility, potential for pollutant load reduction, and other physical characteristics. The full list of BMP opportunities for this watershed is presented in Table 2-1.

Table 2-1 Centralized BMP opportunities in the Tecolote watershed

Candidate Opportunities				
APN	**Name**	**Jurisdiction**	**Drainage Area (ac)**	**Percent Impervious**
3612900400	John Muir School/Anderson School	City of San Diego	72	63
3620106900	James Madison High School	City of San Diego	97	60
4190200100	Mt. Everest Academy Elementary School	City of San Diego	21	74
4310700600	Sam Snead All American Golf Course	City of San Diego	5,642	55
4362612100	Tecolote Canyon Park	City of San Diego	6,032	55
Planned and Implemented Opportunities				
Status	**Description**	**Jurisdiction**	**Drainage Area (ac)**	**Percent Impervious**
Planned	A Low Flow Storm Drain Diversion Project is proposed to be installed at 4674 Tecolote Rd	City of San Diego	TBD	TBD
Planned	Bioinfiltration and biofiltration basins will be installed at Mt Abernathy to capture the first 0.25 inch of rain over the entire 18-acre drainage area and filter the water through plant material and layers of soil and base rock that will serve as the treatment. The three types of basins differ in the way the treated water is released. In one type, the treated water enters a perforated pipe which leads to the storm drain. In the second type, the treated water is collected in an underground storage tank and slowly allowed to infiltrate. In the third type of basin, the water is allowed to infiltrate directly from the basin.	City of San Diego	TBD	TBD
Implemented	A hydrodynamic separator (Baffle Box) was installed in Mt Ashmun Dr	City of San Diego	TBD	TBD
Planned	A hydrodynamic separator (Baffle Box) is proposed to be installed in Mt Ariane Dr	City of San Diego	TBD	TBD

Source: City of San Diego 2012b.

2.2 Distributed BMPs on Public Land

Distributed BMPs represent small-scale structures that capture and treat stormwater runoff at the source. They are typically integrated into site designs and oftentimes serve multiple uses, such as landscaping or driving surfaces while also acting to remove pollutants. Two primary distributed features are considered for implementation of distributed BMPs on public land: (1) bioretention, and (2) permeable pavement. Both bioretention and permeable pavement are represented with the modeling framework to quantify the dynamic effects they have on both flow and pollutant reduction across a range of storm conditions.

2.2.1 Bioretention

Bioretention generally refers to small, shallow vegetated features constructed in green spaces alongside roads, sidewalks, and other paved surfaces. Depending on site-specific opportunities and constraints, these features can be designed and implemented in a linear configuration as bioswales (City of San Diego 2011). Bioretention is designed to capture and treat runoff from impervious surfaces such as roads, parking lots, median strips, or the right-of-way along public roads. These features provide benefits in terms reducing volume from smaller storms and also improving water through physical and biological filtration. Figure 2-2 presents a conceptual diagram of the treatment pathways and processes for a typical bioretention BMP.

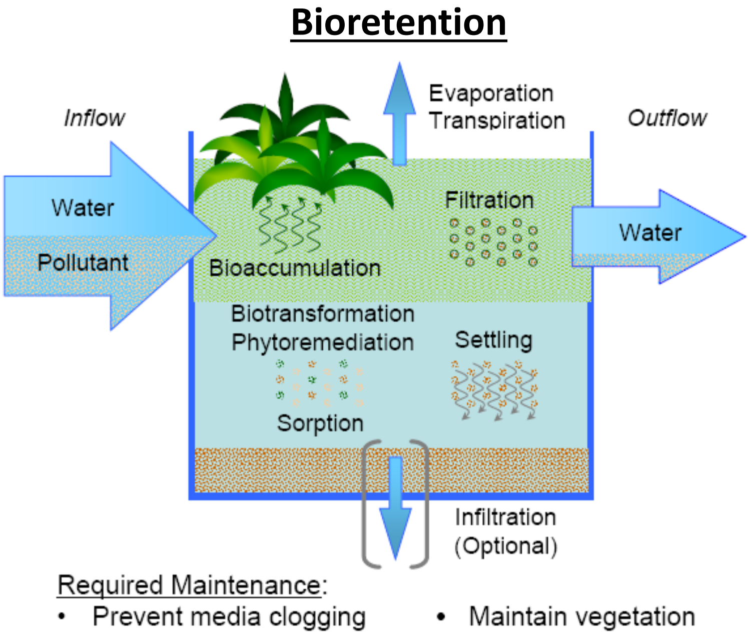


Figure 2-2 Conceptual diagram of typical bioretention BMP flow pathways and treatment mechanisms.

2.2.2 Permeable Pavement

Permeable pavement is typically used in place of traditional pavement to provide some infiltration capacity to native soils. In cases where the background infiltration capacity is poor, an underdrain may be included to convey stormwater to downstream treatment facilities. A number of variations exist which accommodate this infiltration function while maintaining the structural needs of the road surface. Common variations include permeable asphalt, pervious concrete, and concrete pavers. Permeable pavement receives direct inflow consisting of stormwater runoff and pollutant load from impervious road surfaces only. Effectively, each unit of modeled permeable pavement would replace an equal area unit of existing traditional pavement. Figure 2-3 presents a conceptual diagram of the treatment pathways and processes for a typical permeable pavement BMP.

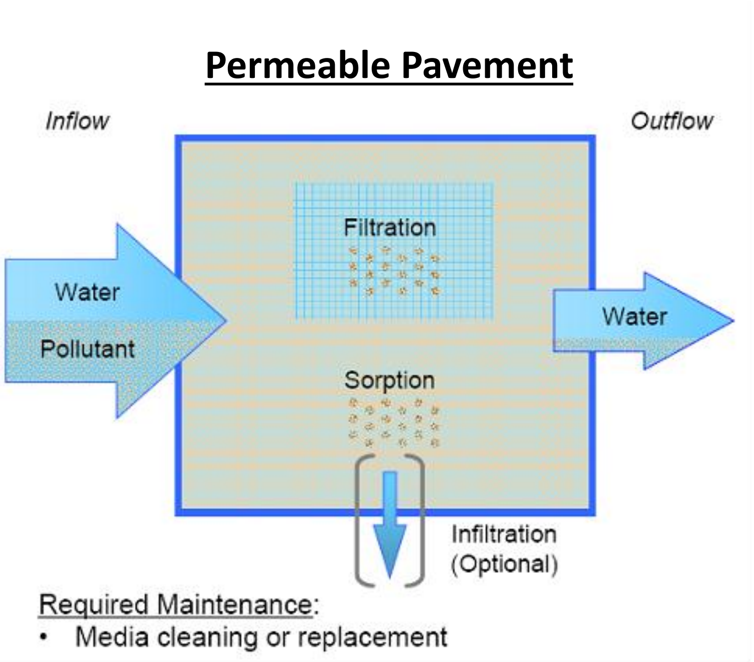
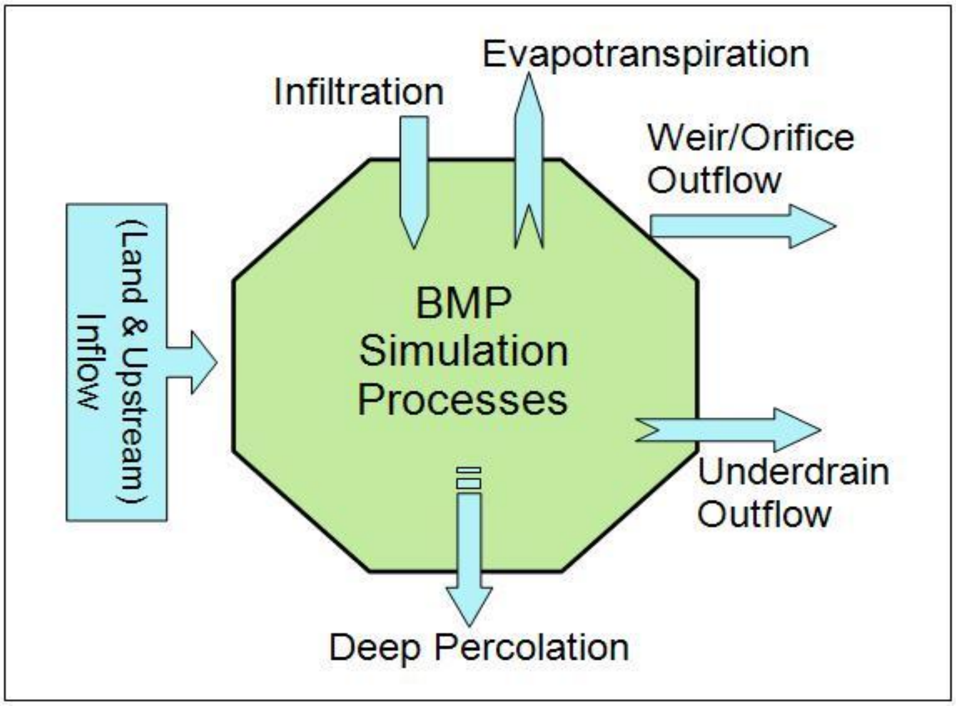


Figure 2-3. Conceptual diagram of typical permeable pavement BMP flow pathways and treatment mechanisms.

2.2.3 Model Representation

Bioretention and permeable pavement features will be evaluated using the modeling framework with runoff and pollutant loading boundary conditions generated using the LSPC watershed model. The model represents distributed BMPs using a set of (1) physical characteristics which describe the feature geometry, and (2) process-based parameters which describe the mechanisms related to flow and pollutant transport such as evapotranspiration, infiltration, and pollutant loss. Physically, both bioretention and pervious pavement can be conceptualized as having three compartments: (1) surface storage which provides volume for ponding (2) soil media or aggregate substrate, and (3) an optional underdrain reservoir when necessitated by background soil conditions.

The BMPs model incorporates a variety of pathways through which water and pollutants travel through the BMP (i.e. infiltration, evapotranspiration, weir overflow, and underdrain outflow). Figure 2-4 presents a schematic view of the soil media and underdrain components illustrating the related physical and process-based parameters. As discussed above, inflow from the land will be represented using the time series from the LSPC watershed model.



Source: Lee et al. 2012

Figure 2-4. Conceptual diagram of selected processes associated with structural BMPs.

While the model representation of permeable pavement is similar to bioretention, the two features are distinguished by a different set of physical and process-based parameters describing the function of infiltration both through the aggregate media and into background soils. For example, the ponding depth of pervious pavement is physically much smaller than that of bioretention, as stormwater would not be allowed to accumulate on the paved surface in practice. Also, because permeable pavement is not vegetated, the potential for evapotranspiration is also greatly diminished as compared to bioretention.

2.2.1 BMP Implementation in the Model

The CLRP Phase I identified public parcels that are likely suitable for distributed BMP development based on site characteristics and other important attributes. Selected sites were assessed using aerial imagery to estimate the typical area available for implementation of distributed BMPs throughout the watershed. A summary of BMP representation parameters is presented in Table 2-2.

Table 2-2 Summary of detailed model representation for distributed structural BMPs

	Bioretention	Permeable Pavement
Surface Parameters		
Unit size (sq ft.) *Varies with 85th percentile rainfall depth*	808 - 1,520	1,388 - 2,610
Design drainage area (acre)*	1	1
Substrate depth (ft)	3	2
Underdrain depth (ft)	None for B Soil 1.5 for C, D Soil;	None for B Soil 1.5 for C, D Soil;
Ponding depth (ft)	0.75	0.01
Subsurface Parameters		
Substrate layer porosity	0.4	0.4
Substrate layer field capacity	0.25	0.1
Substrate layer wilting point	0.1	0.05
Underdrain gravel layer porosity	0.4	0.4
Vegetative parameter, A	1	0
Monthly Growth Index	1	0
Background infiltration rate (in./hr), f_c	B - 0.8; C - 0.2; D - 0.01	B - 0.8; C - 0.2; D - 0.01
Media final constant infiltration rate (in./hr), f_c	2	2

2.3 Green Streets Alternative

Green streets provide an additional opportunity for locating BMPs in a publically owned location. To evaluate the extent to which green streets can help achieve compliance with WLA reduction targets, an assessment was performed to identify green streets opportunities on a watershed-wide basis. Available green street implementation and contributing areas were determined using available GIS information, sample roads, and existing project designs. The process began with identifying streets appropriate for green street retrofits and estimating the typical contributing area from surrounding parcels. Using the County roads information available on SANGIS, the roads were screened based on their functional class attribute so only roads with suitable characteristics were selected. The City of San Diego provided data that measures the street width from curb to curb and the right-of-way width allowing for a calculation of the space between the curb and edge of the right-of-way known as the parkway width. The parkway width information was combined with the selected function class roads and the median parkway width was identified for each of the function classes. An associated bioretention width was then assigned based on the available parkway width. The typical available length of BMP was estimated based on engineering judgment from designing green streets, such as the City of San Diego’s Bannock Avenue. The length of the bioretention cells was measured and compared to the length of each road segment to give an overall percentage of the roadway length that is available for BMP implementation. It was assumed that permeable parking lanes can also be installed in conjunction with each bioretention segment.

The contributing areas to the BMPs were found using random road sampling and identifying the surrounding drainage patterns. Using a random number generator, road segments of the identified function classes and surrounding land use were selected and the contributing area draining to the right-of-way was outlined based on a desktop analysis of topography, aerial imagery, and drainage infrastructure. Using the multiple samples for each function class and land use, the average contributing area of the surrounding parcels was identified. The roads deemed appropriate for BMP classification in the first step were tallied in each subwatershed and compared to the total roadway length within each subwatershed. This reduction percentage was assumed to be the available roads for BMP implementation across each subwatershed. The land uses in each subwatershed were multiplied by these two reducing factors to identify contributing areas to implementable roads. The areas were summed by subwatershed for the model input. Ultimately, the BMPs were represented in the modeling framework in the same way that they are described in Section 2.2 of this appendix.

2.4 Centralized BMPs on Private Land

In the event that the combination of structural and nonstructural BMPs listed above are not sufficient to meet WLA reduction targets, additional land will be needed to construct centralized BMPs to achieve sufficient load reductions. Modeling of centralized BMPs on private land was considered only at a conceptual level as it is not feasible to consider all factors needed to locate specific centralized BMPs due to unknown locations and land availability. Individual SUSTAIN models were developed for each subwatershed to characterize the unit response of a hypothetical BMP. Initially, each BMP was sized to capture the 85th percentile storm by fixing the depth at 4 feet and allowing the footprint to vary based on the required volume. Construction costs were incorporated as a function of BMP footprint and varied by watershed. A fixed land acquisition cost of $122/ft2 was also considered. Modeling each individual subwatershed separately allows quantification of a unique BMP response which is a function of both variation in precipitation and a unique land use distribution.

3. References

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Appendix B – Updated Costs

Table B-1 City of San Diego

Activity #	Activity	Quantity	Units	20-Year Cost (2013 dollars)
	Nonstructural (Not Modeled)			
1	Enhance LID implementation for new development and redevelopment through zoning amendments			$25,005
2	Train Development Services Department staff on LID regulatory changes and LID Design Manual			$201,964
3	Develop regional training for and focus locally on enforcement of water-using mobile businesses			$260,912
5	Design and implement property- and PGA-based inspections and accelerated enforcement			$2,329,223
6	Trash areas: require full four-sided enclosure, siting away from storm drains, cover; consider retrofit requirement			$15,003
7	Animal-related facilities			$15,003
8	Nurseries and garden centers			$15,003
9	Auto-related uses			$15,003
10	Update Minimum BMPs for existing residential, commercial & industrial development & enforce			$129,188
11	Support partnership effort by social service providers to provide sanitation and trash management for persons experiencing homelessness			$33,340
12	Develop pilot project to identify and carry out site disconnections in targeted areas			$494,967
13	Continue to participate in source reduction initiatives			$126,688
15	Expand outreach to HOA common lands and HOA rebates			$218,490
17	Develop outreach and training program for property managers responsible for HOAs and Maintenance Districts			$69,065
18	Conduct trash clean-ups through community-based organizations involving target audiences			$180,036
19	Enhance education and outreach based on results of effectiveness survey and changing			$1,512,110

	regulatory requirements			
20	Improve consistency & content of websites to highlight enforceable conditions & reporting methods			$27,626
25	Proactively monitor for erosion, and complete minor repair & slope stabilization			$1,059,952
26	Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair			$5,344,137
31	Identify sewer leaks and areas for sewer pipe replacement prioritization			$3,201
	Nonstructural (Modeled)			
14a	Expand residential BMP (irrigation, rainwater harvesting and turf conversion) rebate programs to multi-family housing in target areas			$162,526
14b	Residential BMP Program: Rain Barrels			$36,338
14c	Residential BMP Program: Irrigation Control (Turf Conversion)			$103,838
14d	Residential BMP Program: Downspout Disconnect			$92,588
	Structural (Modeled)			
32	32. Centralized on Public			
	Centralized - Mt Everest Academy	0.2	ac	$6,152,929
	Centralized - Sam Snead Golf Course	11.4	ac	$10,825,560
	Centralized - John Muir School	1.0	ac	$1,973,872
	Centralized - Tecolote Canyon Park	6.0	ac	$5,187,661
	Centralized - James Madison High School	1.4	ac	$5,200,337
	Centralized BMP Design Support			$159,171
	Centralized BMP O&M Supervision			$697,310
33	33. Distributed on Public			
	Distributed - Bioretention	5.8	ac	$28,836,040
	Distributed - Permeable Pavement	1.4	ac	
34	34. Green Streets			
	Distributed - Bioretention	0.94	ac	$8,319,264
	Distributed - Permeable Pavement	0.02	ac	
36	36. Planned BMPs			
	Planned	2	BMPs	$239,222

Appendix C – Updated Schedule

Table C-1 Tecolote Watershed Nonstructural BMP Implementation Schedule

🟦	CLRP Implementation Schedule
░	O&M

	RP		TECOLOTE – IMPLEMENTATION YEAR																		
Management actions	**CSD**	**CTRANS**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**[1]
CLRP IMPLEMENTATION PROGRAM ACTIONS																					
Initial structural and nonstructural BMP analysis	√	√	🟦																		
CLRP modifications and improvements	√	√	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
CLRP reporting	√	√	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
NONSTRUCTURAL																					
DEVELOPMENT REVIEW PROCESS																					
Amend regulations to facilitate LID implementation	√			🟦	🟦	🟦	🟦	🟦	░	░	░	░	░	░	░	░	░	░	░	░	░
Train staff and boards	√			🟦	🟦	🟦	🟦	🟦	░	░	░	░	░	░	░	░	░	░	░	░	░
ENHANCED INSPECTIONS and ENFORCEMENT																					
Mobile business training requirements	√			🟦	🟦	🟦	🟦	🟦	░	░	░	░	░	░	░	░	░	░	░	░	░

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[1] The load reduction analysis and scheduling of BMPs was performed for final targets only. Interim targets and associated schedules will be further evaluated through an adaptive process as BMPs are implemented and their effectiveness is assessed.

	RP		TECOLOTE – IMPLEMENTATION YEAR																		
Management actions	**CSD**	**CTRANS**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**[1]
Power washing discharges inspection/ enforcement	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Enhanced IC/ID reporting and enforcement		√		■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Property based inspections	√	√		■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
SUSMP and REGULATORY ENHANCEMENT[2]																					
Amend SUSMP, other code and zoning requirements, including adding retrofit requirements, to reduce pollutants from:																					
Trash enclosure & storage areas	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Animal-related facilities	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Nurseries and garden centers	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Auto-related uses	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Update minimum BMPs	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
NEW/EXPANDED INITIATIVES																					
Address bacteria & trash impacts of homelessness	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Pilot projects to disconnecting impervious surfaces	√			■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Support for brake pad partnership (source reduction initiatives)	√	√		■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒

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[2] Adoption of revised standards and use in development review at the end of the implementation period

	RP		TECOLOTE – IMPLEMENTATION YEAR																		
Management actions	**CSD**	**CTRANS**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**[1]
LANDSCAPE PRACTICES																					
Landscape BMP incentives, rebates, and training:																					
Residential properties	√			■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Homeowners' associations/property managers	√			■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Non-residential properties	√			■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Reduction of over-irrigation	√			■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Irrigation, pesticide & fertilizer reduction		√		■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
EDUCATION AND OUTREACH																					
Develop outreach and training program for property managers responsible for HOAs and Maintenance Districts	√			■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Enhanced and expanded trash clean-up programs	√	√		■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Enhance education and outreach based on results of effectiveness survey and changing regulatory requirement	√			■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Improve web resources on reporting	√			■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
MS4 MAINTENANCE																					

Management actions	RP		TECOLOTE – IMPLEMENTATION YEAR																		
	CSD	CTRANS	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031[1]
Proactive MS4 repair & replacement	√	√		■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Increased channel cleaning & scour pond repair	√	√		■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Erosion repair and slope stabilization:																					
Public property & right of way	√	√		■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Enforcement on private properties	√				■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
CAPITAL IMPROVEMENT PROJECTS																					
Dry weather flow separation	√				■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Sewer pipe replacement	√			■																	
Mitigation and conservation initiatives		√		■	■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

Table C-2 Tecolote Watershed Structural BMP Implementation Schedule

■	Implementation Schedule
▒	O&M

	BMPS PER RP		TECOLOTE – IMPLEMENTATION YEAR																		
Management actions	**CSD**	**CTRANS**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
STRUCTURAL																					
STRUCTURAL: PLANNED AND IMPLEMENTED																					
PLANNED AND IMPLEMENTED BMPS: DISTRIBUTED																					
Planned - Distributed	1		■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
	1				■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
STRUCTURAL: NEW BMPS ON PUBLIC PARCELS																					
NEW BMPS: Centralized																					
Centralized - BMP	1					■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
	1						■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
	1							■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
	1								■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒
	1									■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒
NEW BMPS: DISTRIBUTED[3]																					
Distributed - BMP	**11%**					■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
	11%						■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
	11%							■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒

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[3] New identified distributed BMPs were uniformly distributed over the period of implementation

Management actions	**BMPS PER RP**		**TECOLOTE – IMPLEMENTATION YEAR**																		
	CSD	**CTRANS**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
	11%								■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨
	11%									■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨
	11%										■	■	■	■	▨	▨	▨	▨	▨	▨	▨
	11%											■	■	■	■	▨	▨	▨	▨	▨	▨
	11%												■	■	■	■	▨	▨	▨	▨	▨
	11%													■	■	■	■	▨	▨	▨	▨
NEW BMPS: GREEN STREETS[4]																					
Green Streets	**11%**					■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	11%						■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	11%							■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	11%								■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨
	11%									■	■	■	■	▨	▨	▨	▨	▨	▨	▨	▨
	11%										■	■	■	■	▨	▨	▨	▨	▨	▨	▨
	11%											■	■	■	■	▨	▨	▨	▨	▨	▨
	11%												■	■	■	■	▨	▨	▨	▨	▨
	11%													■	■	■	■	▨	▨	▨	▨

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[4] New green street opportunities were distributed by area over the period of implementation

Appendix D – Water Quality Composite Scores

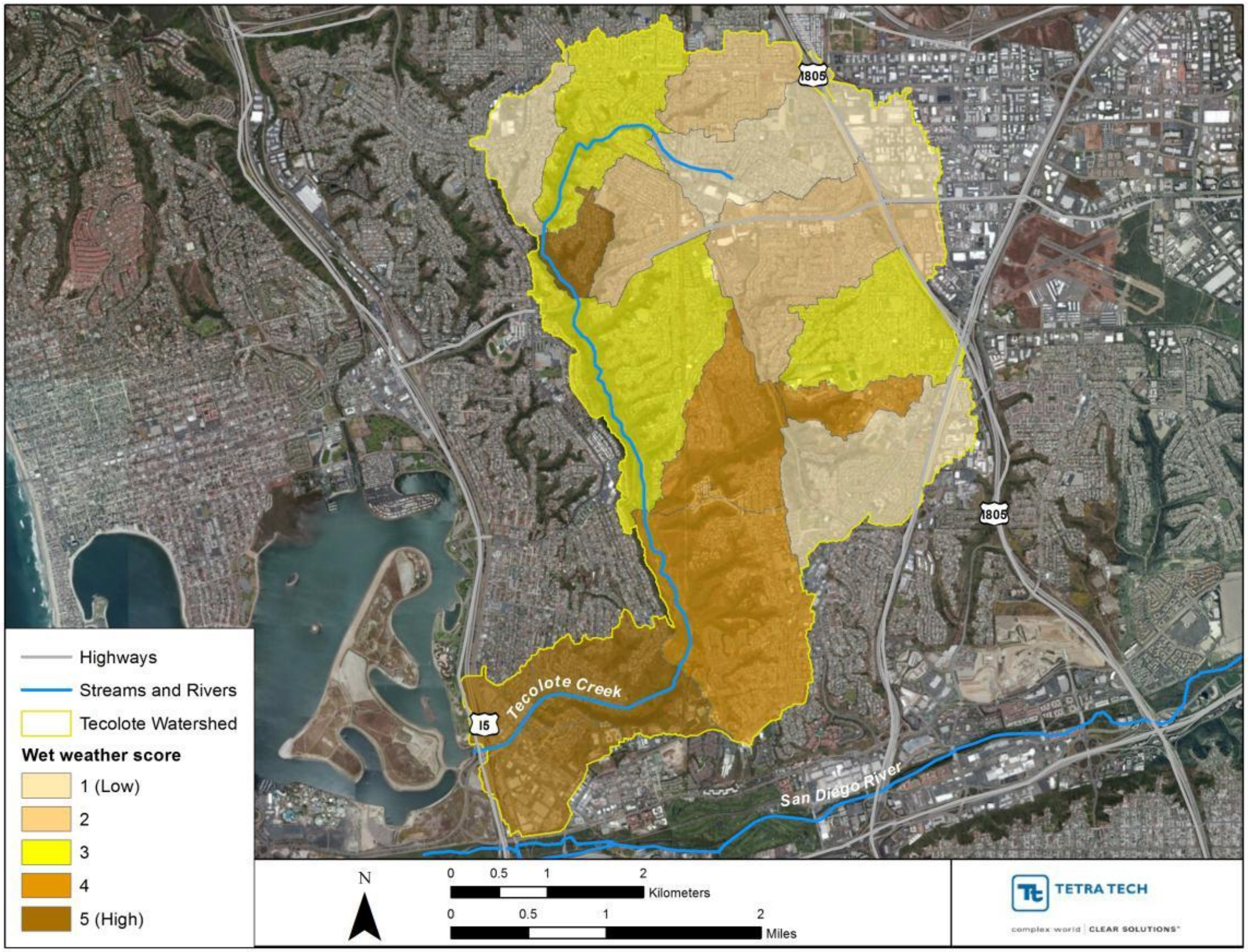

Figure D-1 Tecolote Watershed Wet Weather Composite Score (Bacteria)

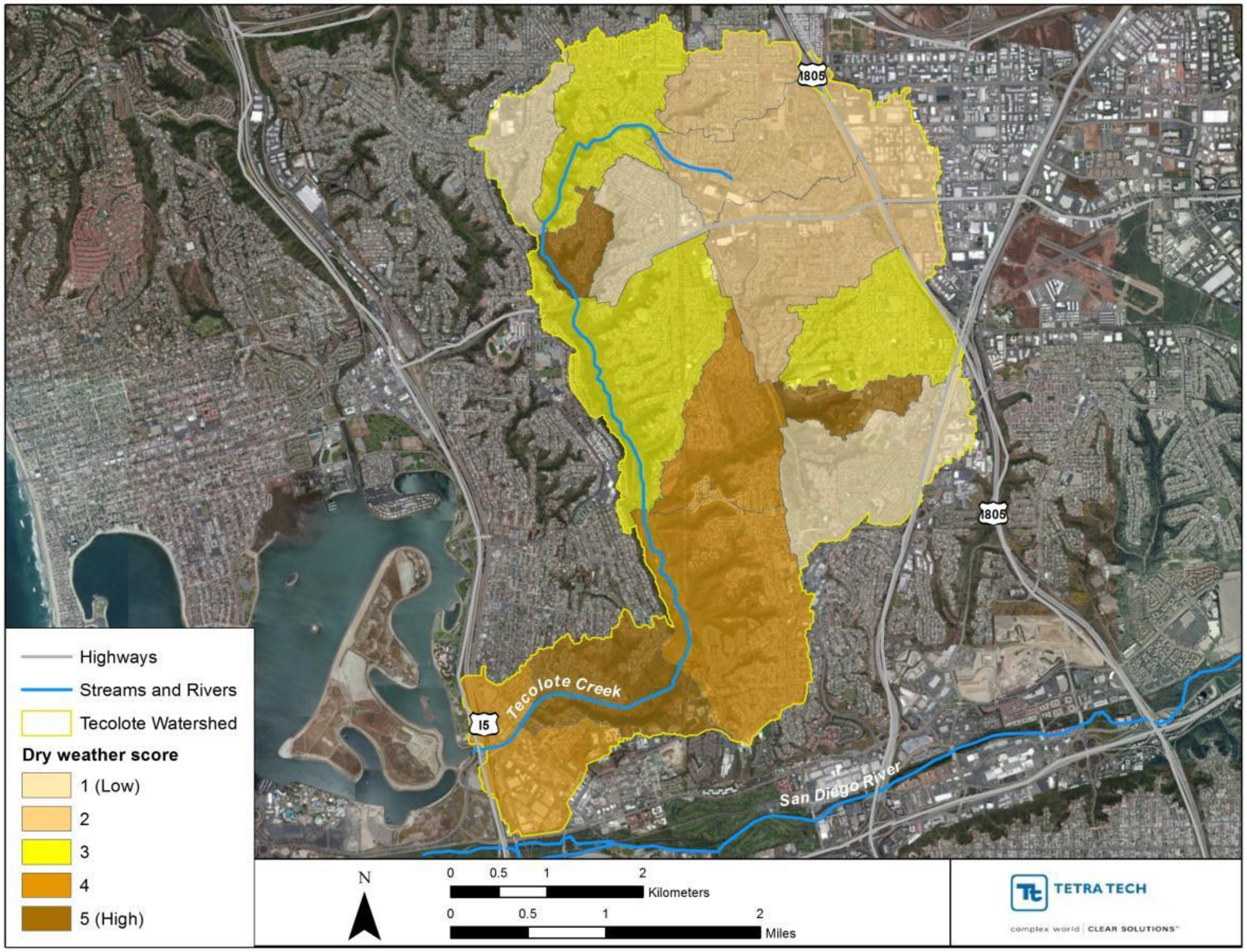

Figure D-2 Tecolote Watershed Dry Weather Composite Score (Bacteria)

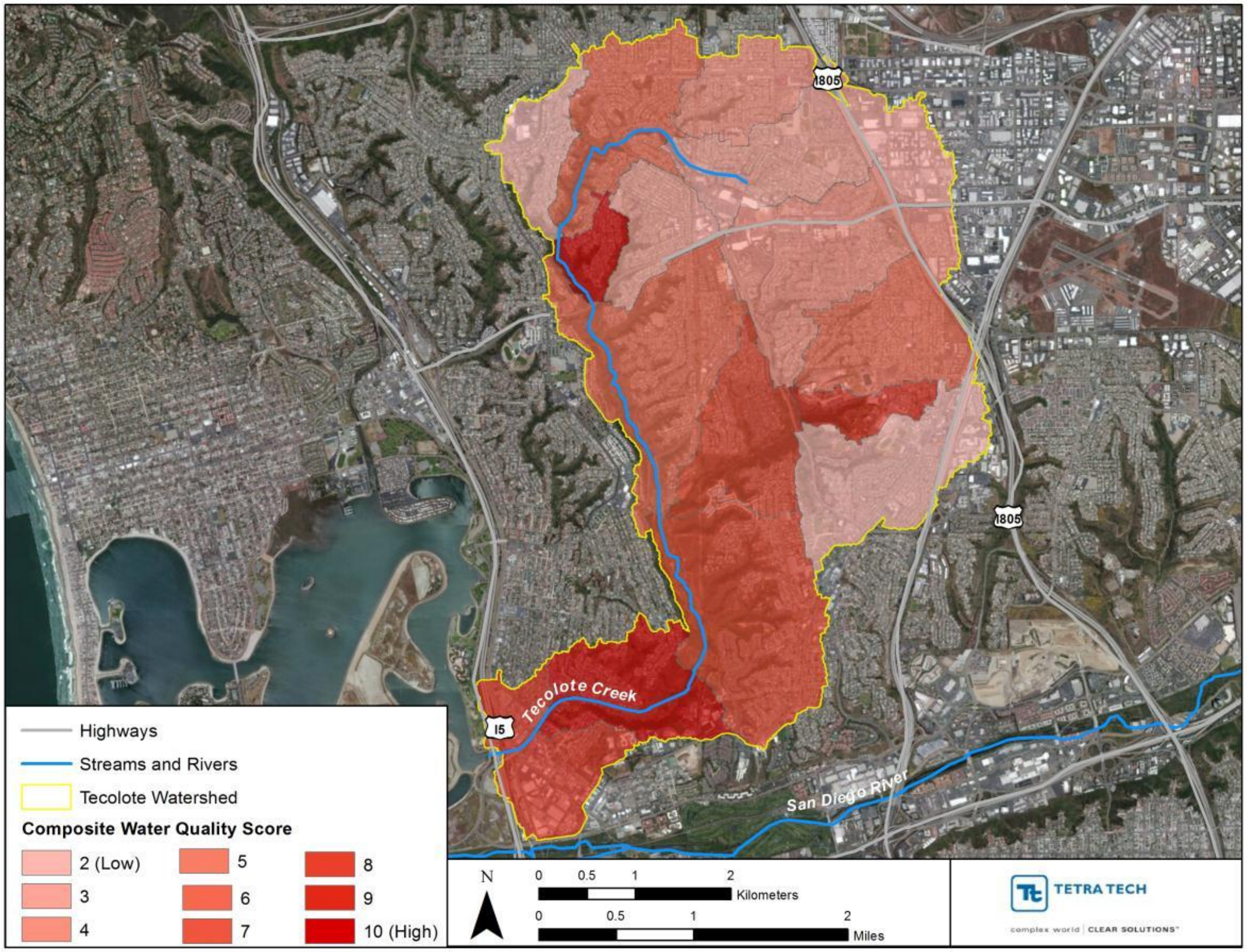

Figure D-3 Tecolote Watershed Water Quality Composite Score (Bacteria)

Appendix E. BMP Fact Sheets

Fact sheets for the centralized BMPs are presented below. These include:

Mt. Everest Academy Elementary School Centralized BMP Fact Sheet

Site Overview

Mt. Everest Academy Elementary School (Site) catchment is located in the northern portion of the Tecolote Watershed, just north of Balboa Avenue and west of Genesee Avenue. The 21-acre drainage area is primarily single-family residential with one shopping plaza in addition to the school campus. Based on NRCS data, the predominant soil type of the Site is HSG D. A subsurface detention basin (Figure 1) would be appropriate to treat the drainage area. The available BMP area is outlined in Figure 2.

Figure 1. Example of a Subsurface Detention Basin

Photo Source: http://www.conteches.com/Products/Stormwater-Management/Detention-and-Infiltration.aspx

Figure 2. Available BMP area

BMP Design Considerations – Subsurface Detention Basin

BMP design information for Mt. Everest Academy Elementary School is summarized in Table 1. This BMP type constructed beneath the field will allow for continued use of the fields and will not rely on infiltration. Because the catchment drains via overland flow to the school, the need to pump stormwater to the BMP is unlikely; although depending on the depth of a subsurface detention basin, it may be necessary to pump stormwater up to a discharge point. The stormwater runoff could enter the centralized BMP via storm inlet and pipe extending from the corner of Mt. Etna Dr. and Mt. Everest Blvd on the northeast corner of the school property. There are no apparent environmental concerns in the area.

Table 1. BMP Design Information Summary

Subsurface Detention Basin	
BMP Drainage Area (Acres)	21
Available BMP Area (Acres)	7.4
Treatment Volume Capacity (Ac-Ft)	0.7
BMP Surface Area (Acres)	0.2
Recommended Ponding Depth (Ft)	3.0

(Note: BMP surface area and depth are recommendations only)

The available BMP area is proposed on public property, and therefore legal maintenance access is not an issue.

BMP Performance and Costs

Expected Pollutant Reductions

Table 2. Expected Pollutant Reductions

Pollutant	Watershed Load (lb, counts, or ft3/yr)	Percent Load Reduction
Enterococcus	1.42E+04	87.1%
Fecal Coliform	1.34E+03	83.1%
Total Coliform	3.71E+04	85.0%
Nitrogen	100.74	72.4%
Phosphorus	16.80	70.3%
Cu	1.2	57.0%
Pb	1.1	55.3%
Zn	7.4	57.8%
Sediment	1,555.1	56.7%
Flow Volume	377,483	54.1%

Estimated Costs

Table 3. Implementation Costs

Cost Estimate	
Planning	$62,000
Design	$248,000
Permits/Studies	$15,000
Construction	$620,114
Annual Operation & Maintenance	$19,396
Total	$964,509

Costs are provided in 2013 dollars based on planning level estimates. Assumptions were derived from field visits and previous costing efforts for similar BMPs. Actual cost will vary depending on site conditions and utilities, final design components, and actual sediment/debris loading.

James Madison High School
Centralized BMP Fact Sheet

Site Overview

James Madison High School (Site) catchment is located in the upper northeast portion of the Tecolote Watershed, south and west of the juncture of Interstate-805 and Clairemont Mesa Blvd. The 97-acre drainage area is a mixture of single-family residential, the James Madison High School, and various other businesses. The area is largely impervious. The only green space is the athletic fields at the high school and the residential yards. Based on NRCS data, the predominant soil type of the Site is HSG D. A dry extended detention basin (Figure 1) would be appropriate to treat the drainage area. The available BMP area is outlined in Figure 2.

Figure 1. Example of a Dry Extended Detention Basin

Photo Source:
http://www.fxbrowne.com/html/newsletters/July_2010/news_jul10_st.htm

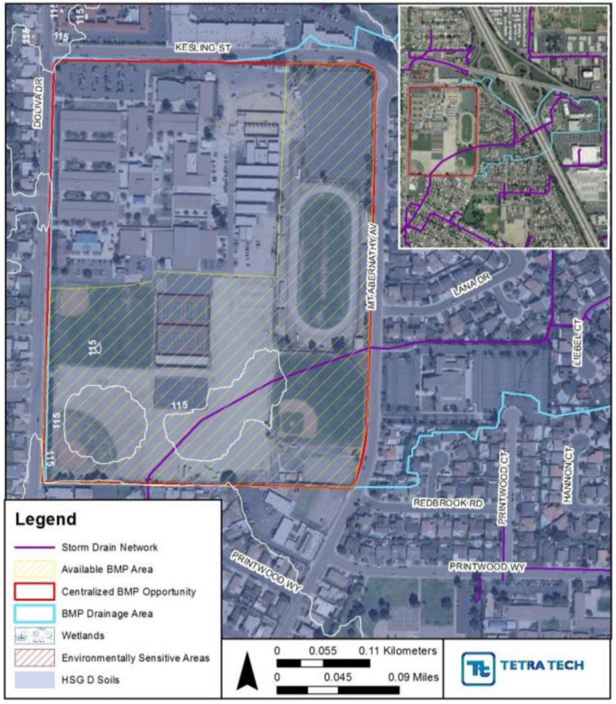

Figure 2. Available BMP area

BMP Design Considerations – Dry Extended Detention Basin

BMP design information for James Madison High School is summarized in Table 1. The school has large open areas between its fields, which could be used for a basin. With stormwater collecting in the storm sewer buried 6 feet deep under the school fields, the stormwater will need to be pumped up to the BMP, which adds cost for materials, installation, electricity, and maintenance. There are no apparent environmental concerns in the area, although soil contamination potential should be investigated based on the history of the site and surrounding land uses.

Table 1. BMP Design Information Summary

Dry Extended Detention Basin	
BMP Drainage Area (Acres)	97
Available BMP Area (Acres)	30
Treatment Volume Capacity (Ac-Ft)	2.7
BMP Surface Area (Acres)	1.4
Recommended Ponding Depth (Ft)	2.0

(Note: BMP surface area and depth are recommendations only)

The available BMP area is proposed on public property, and therefore legal maintenance access is not an issue.

BMP Performance and Costs

Expected Pollutant Reductions

Table 2. Expected Pollutant Reductions

Pollutant	Watershed Load (lb, counts, or ft3/yr)	Percent Load Reduction
Enterococcus	6.36E+04	72.9%
Fecal Coliform	9.25E+03	69.3%
Total Coliform	1.68E+05	69.4%
Nitrogen	689.42	56.5%
Phosphorus	128.56	54.9%
Cu	9.0	45.0%
Pb	7.1	44.3%
Zn	60.8	45.3%
Sediment	8,721.7	48.5%
Flow Volume	2,945,574	45.5%

Estimated Costs

Table 3. Implementation Costs

Cost Estimate	
Planning	$90,900
Design	$363,700
Permits/Studies	$15,000
Construction	$909,336
Annual Operation & Maintenance	$117,761
Total	$1,496,698

Costs are provided in 2013 dollars based on planning level estimates. Assumptions were derived from field visits and previous costing efforts for similar BMPs. Actual cost will vary depending on site conditions and utilities, final design components, and actual sediment/debris loading.

John Muir School and Mount Etna Neighborhood Park Centralized BMP Fact Sheet

Site Overview

John Muir School and Mount Etna Neighborhood Park (Site) catchment is located in the northern portion of the Tecolote Watershed approximately ½-mile north of Balboa Avenue and west of Genesee Avenue. The 72-acre drainage area is predominately single-family residential. The area is largely impervious. Based on NRCS data, the predominant soil type of the Site is HSG D. A dry extended detention basin (Figure 1) would be appropriate to treat the drainage area. The available BMP area is outlined in Figure 2.

Figure 1. Example of a Dry Extended Detention Basin

Photo Source:
http://www.fxbrowne.com/html/newsletters/July_2010/news_jul10_st.htm

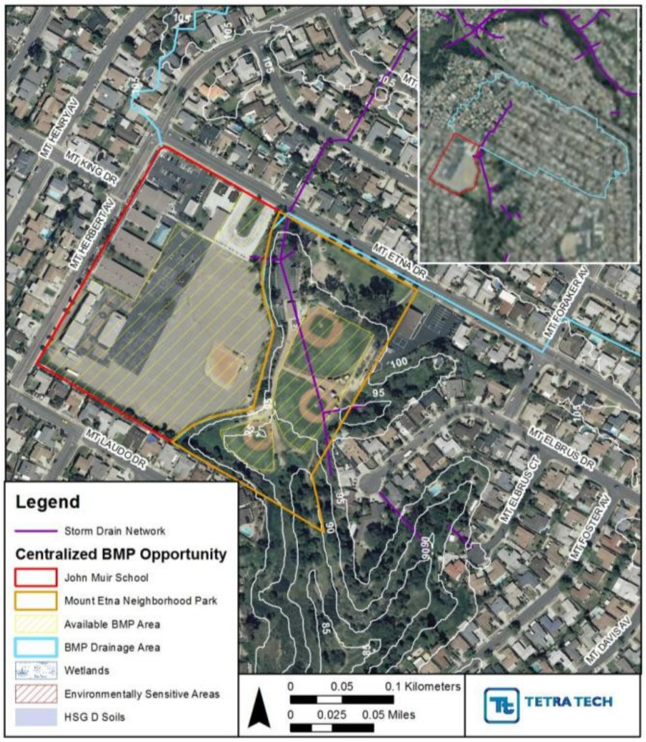

Figure 2. Available BMP area

BMP Design Considerations – Dry Extended Detention Basin

BMP design information for John Muir School and Mount Etna Neighborhood Park is summarized in Table 1. The school has a large open area around its baseball diamond, which could be used for a basin. With stormwater collecting in the storm sewer buried 8 feet deep under the school parking lot, the stormwater will need to be pumped up to the BMP, which adds cost for materials, installation, electricity, and maintenance. There are no apparent environmental concerns in the area, although soil contamination potential should be investigated based on the history of the site and surrounding land uses.

Table 1. BMP Design Information Summary

Dry Extended Detention Basin	
BMP Drainage Area (Acres)	72
Available BMP Area (Acres)	10.2
Treatment Volume Capacity (Ac-Ft)	2.0
BMP Surface Area (Acres)	1.0
Recommended Ponding Depth (Ft)	2.0

(Note: BMP surface area and depth are recommendations only)

The available BMP area is proposed on public property, and therefore legal maintenance access is not an issue.

BMP Performance and Costs

Expected Pollutant Reductions

Table 2. Expected Pollutant Reductions

Pollutant	Watershed Load (lb, counts, or ft3/yr)	Percent Load Reduction
Enterococcus	4.88E+04	84.2%
Fecal Coliform	4.59E+03	79.8%
Total Coliform	1.27E+05	81.7%
Nitrogen	345.51	67.8%
Phosphorus	57.61	65.4%
Cu	4.2	50.2%
Pb	3.9	48.4%
Zn	25.3	51.0%
Sediment	5,333.4	49.5%
Flow Volume	1,294,669	51.5%

Estimated Costs

Table 3. Implementation Costs

Cost Estimate	
Planning	$83,900
Design	$335,600
Permits/Studies	$15,000
Construction	$838,945
Annual Operation & Maintenance	$84,923
Total	$1,358,367

Costs are provided in 2013 dollars based on planning level estimates. Assumptions were derived from field visits and previous costing efforts for similar BMPs. Actual cost will vary depending on site conditions and utilities, final design components, and actual sediment/debris loading.

Sam Snead All American Golf Course
Centralized BMP Fact Sheet

Site Overview

The Sam Snead All American Golf Course (Site) catchment is located in the southwest portion of the Tecolote Watershed. It is bordered by State Road 52 on the north, Interstate 5 on the west, Interstate 805 on the east, and culminates at Sam Snead All American Golf Course to the south. The 5,642-acre drainage area is primarily single-family residential. Based on NRCS data, the predominant soil type of the Site is HSG B. The Site is located within the floodplain of a waterway, which makes a constructed wetland system (Figure 1) appropriate to treat the drainage area. The available BMP area is outlined in Figure 2.

Figure 1. Example of a Constructed Wetland System

Photo Source: http://www.iees.ch/EcoEng071/EcoEng071_Turon.html

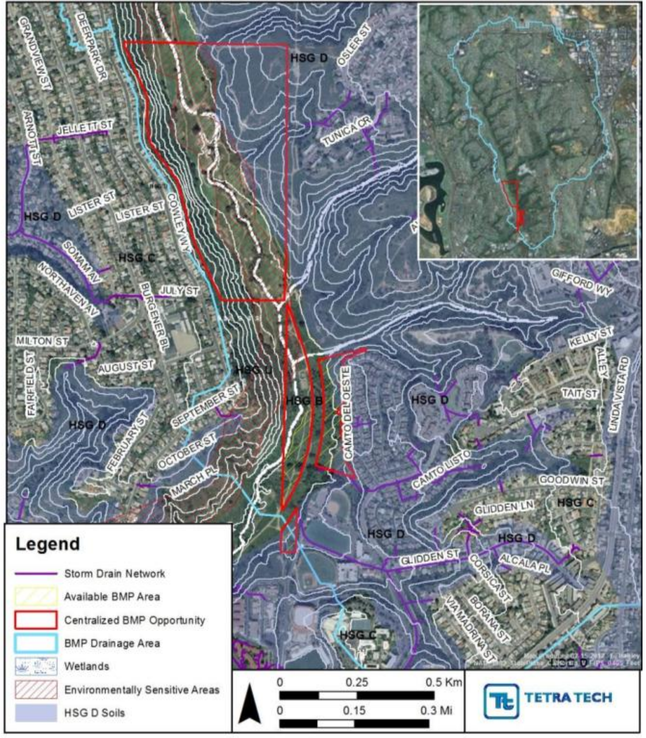

Figure 2. Available BMP area

BMP Design Considerations – Constructed Wetland System

BMP design information for the Golf Course is summarized in Table 1. This Site is located within the floodplain of a waterway. Implementing an off-line wetland system would allow low flows from the waterway to be diverted for treatment into the wetland. The treated water would then be released back into the waterway or would infiltrate to the groundwater. There are environmentally sensitive areas within the canyon, but not directly in the proposed BMP area.

Table 1. BMP Design Information Summary

Constructed Wetland System	
BMP Drainage Area (Acres)	5642
Available BMP Area (Acres)	11.4
Treatment Volume Capacity (Ac-Ft)	34.2
BMP Surface Area (Acres)	11.4
Recommended Ponding Depth (Ft)	3.0

(Note: BMP surface area and depth are recommendations only)

Legal maintenance access is not an issue. The site can be accessed by an unpaved road from Toreno Way or Tecolote Road.

BMP Performance and Costs

Expected Pollutant Reductions

Table 2. Expected Pollutant Reduction

Pollutant	Watershed Load (lb, counts, or ft3/yr)	Percent Load Reduction
Enterococcus	2.86E+06	68.6%
Fecal Coliform	2.68E+05	62.0%
Total Coliform	7.54E+06	63.1%
Nitrogen	18,644.07	39.0%
Phosphorus	3,308.83	37.3%
Cu	221.3	28.8%
Pb	227.9	28.1%
Zn	1,360.3	29.3%
Sediment	330,862.4	43.9%
Flow Volume	76,089,402	19.0%

Estimated Costs

Table 3. Implementation Costs

Cost Estimate	
Planning	$711,700
Design	$2,846,900
Permits/Studies	$15,000
Construction	$7,117,338
Annual Operation & Maintenance	$985,056
Total	$11,675,994

Costs are provided in 2013 dollars based on planning level estimates. Assumptions were derived from field visits and previous costing efforts for similar BMPs. Actual cost will vary depending on site conditions and utilities, final design components, and actual sediment/debris loading.

Tecolote Canyon Park
Centralized BMP Fact Sheet

Site Overview

Tecolote Canyon Park (Site) catchment is located in the southwest portion of the Tecolote Watershed. It is bordered by State Road 52 on the north, Interstate 5 on the west, Interstate 805 on the east, and culminates at The Tecolote Canyon Park. The 6,032-acre drainage area is predominantly single-family residential. Based on NRCS data, the predominant soil type of the Site is unclassified urban soils (HSG U); therefore, pending a geotechnical investigation by a licensed geotechnical engineer, a subsurface detention gallery (Figure 1) would be appropriate to treat the drainage area. The available BMP area is outlined in Figure 2.

Figure 1. Example of a Subsurface Detention Gallery

Photo Source: http://www.conteches.com/Products/Stormwater-Management/Detention-and-Infiltration.aspx

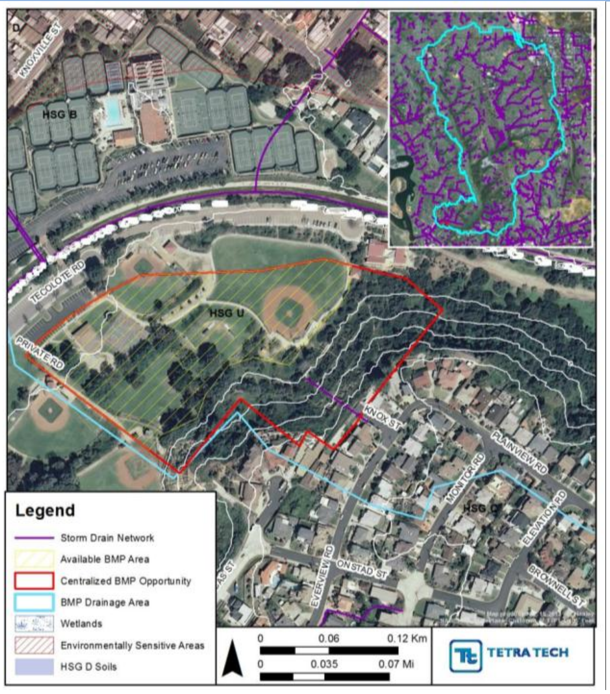

Figure 2. Available BMP area

BMP Design Considerations – Subsurface Detention Gallery

BMP design information for Tecolote Canyon Park is summarized in Table 1. This BMP type constructed beneath a field will allow for continued use of the space and will not rely on infiltration. Stormwater will need to be pumped at least 20 feet vertically to the BMP following collection within the waterway, which adds cost for materials, installation, electricity, and maintenance. There are no apparent environmental concerns in the area, although soil contamination potential should be investigated based on the history of the site and surrounding land uses.

Table 1. BMP Design Information Summary

Subsurface Detention Gallery	
BMP Drainage Area (Acres)	6032
Available BMP Area (Acres)	6.0
Treatment Volume Capacity (Ac-Ft)	18.0
BMP Surface Area (Acres)	6.0
Recommended Ponding Depth (Ft)	3.0

(Note: BMP surface area and depth are recommendations only)

The available BMP area is proposed on public property, and therefore legal maintenance access is not an issue.

BMP Performance and Costs

Expected Pollutant Reductions

Table 2. Expected Pollutant Reductions

Pollutant	Watershed Load (lb, counts, or ft3/yr)	Percent Load Reduction
Enterococcus	2.36E+06	68.6%
Fecal Coliform	2.29E+05	62.1%
Total Coliform	6.19E+06	63.3%
Nitrogen	16,269.58	39.4%
Phosphorus	2,922.85	37.3%
Cu	199.0	28.9%
Pb	198.4	27.9%
Zn	1,200.1	29.4%
Sediment	298,143.9	43.0%
Flow Volume	67,142,316	19.4%

Estimated Costs

Table 3. Implementation Costs

Cost Estimate	
Planning	$1,054,300
Design	$4,217,200
Permits/Studies	$15,000
Construction	$10,543,009
Annual Operation & Maintenance	$518,450
Total	$16,347,959

Costs are provided in 2013 dollars based on planning level estimates. Assumptions were derived from field visits and previous costing efforts for similar BMPs. Actual cost will vary depending on site conditions and utilities, final design components, and actual sediment/debris loading.