APPENDIX H

Identification of Goals

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Table of Contents

H.1 Identification of Sediment Numeric Goals H-3
H.1.1 Sediment TMDL Targets H-3
H.1.2 Sediment Goals Expressed as Sediment Load Reduction H-5
H.1.3 Compliance Pathways to Meet the Sediment TMDL H-8
H.2 Identification of Bacteria Numeric Goals H-8
H.2.1 Receiving Water Limitations H-9
H.2.2 Effluent Limitations H-11
H.2.3 Interim Goals and Existing Conditions H-12
H.2.4 Compliance Pathways H-15
H.3 Freshwater Discharge Numeric Goals H-15

List of Tables

Table H-1 Sediment TMDL Interim and Final Milestones H-4
Table H-2 Sediment Numeric Goals by Subwatershed H-6
Table H-3 Jurisdictional Sediment Goals for Los Peñasquitos WMA H-7
Table H-4 Final Receiving Water Numeric Goals within Los Peñasquitos WMA..... H-10
Table H-5 Final Effluent Limitations Expressed as an Exceedance Frequency for Los Peñasquitos River WMA..... H-11
Table H-6 Final Effluent Limitations Expressed as an Exceedance Frequency for Los Peñasquitos WMA H-12
Table H-7 Existing Conditions and Interim TMDL Targets for Los Peñasquitos WMA H-14

APPENDIX H. IDENTIFICATION OF GOALS

Numeric goals must be developed to support Water Quality Improvement Plan implementation and are used to measure progress toward addressing the highest priority water quality conditions. Numeric goals may take a variety of forms, but must be quantifiable so that progress toward and achievement of the goals are measurable. Applicable Total Maximum Daily Load (TMDL) targets are required to be incorporated as Water Quality Improvement Plan goals. As these conditions are TMDL derived, each highest priority water quality condition may include multiple criteria or indicators. In accordance with the MS4 Permit and applicable regulatory drivers, final goals and reasonable interim goals for each five-year period from Water Quality Improvement Plan approval to the anticipated final goal compliance date (including an interim goal for this permit term) have been developed.

Within the Los Peñasquitos WMA, the Sediment TMDL dictates the sediment final and interim goals, applicable during wet weather. The Bacteria TMDL is the driver for bacteria final and interim goals, which are applicable during both dry and wet weather. A TMDL represents the maximum amount of a pollutant of concern that a water body can receive and still attain water quality standards. TMDLs can take a variety of forms, including concentration-based TMDLs, which focus on reducing pollutant sources to achieve a maximum pollutant concentration consistent with existing water quality objectives (WQOs), and load-based TMDLs, which focus on reducing sources to achieve a watershed-specific maximum load that is protective of beneficial uses. Reduction of freshwater discharges during dry weather will assist in compliance with both TMDLs.

Although the Pacific Ocean shoreline segment was removed from the 303d list for Recreational Water Contact (REC-1) impairment in 2010, calculation of the Bacteria TMDL had already begun and the segment remained in the TMDL through adoption in 2011. The Los Peñasquitos shoreline segment was then incorporated into the Bacteria TMDL requirements within the MS4 Permit in 2013. Therefore, the Bacteria TMDL targets are required to be incorporated into the Water Quality Improvement Plan goals.

Responsible Agencies must meet the wet weather Sediment TMDL targets within 20 years of TMDL adoption (Fiscal Year [FY] 2035), the Bacteria TMDL targets within 20 years of TMDL adoption (FY 2031) and dry weather Bacteria TMDL targets within 10 years (FY 2021). The reduction of freshwater discharges will assist in compliance with both TMDLs, but the dry weather bacteria targets will be the driver for addressing freshwater discharges by FY 2021.

Both TMDLs identify receiving water and watershed targets, providing multiple compliance pathways to meet TMDL interim and final targets. Language to incorporate the Sediment TMDL into the MS4 Permit is currently being drafted. Water Quality Improvement Plan goals will be updated as the TMDL is incorporated.

This appendix presents the Sediment TMDL and Bacteria TMDL numeric targets, how the targets were derived, and how the targets were translated into Water Quality

Improvement Plan numeric goals. Section H.1 presents the interim and final Water Quality Improvement Plan sediment numeric goals. Section H.2 presents the interim and final Water Quality Improvement Plan bacteria numeric goals. Section H.3 presents the Water Quality Improvement Plan interim and final freshwater discharge numeric goals.

H.1 Identification of Sediment Numeric Goals

The Sediment TMDL addresses the Los Peñasquitos Lagoon impairment due to sedimentation and siltation based on an exceedance of the narrative water quality objectives. Because the water quality objective (WQO) for sediment is narrative, the Basin Plan does not explicitly state a numeric target that must be reached, but requires the TMDL to set numeric targets specific to the Los Peñasquitos WMA to evaluate the attainment of objectives. The narrative states, "The suspending sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses" (Regional Board, 1994).

The beneficial uses that are most sensitive to increased sedimentation are estuarine habitat and preservation of biological habitats of special significance. Deposition of watershed sediment contributes to elevation increases within the Lagoon, which is a critical variable that determines the productivity and stability of these uses. Current watershed sediment loads and legacy impacts from urbanization (e.g., land development resulting in increased runoff and erosion rates and physical impacts of construction of the railway berms, Highway 101, and access roads affecting hydrologic exchanges) have been identified as contributors to the Lagoon's sedimentation impairment (Regional Board, 2012).

The TMDL calculated a Lagoon numeric target and a watershed numeric target. Both were based on a "reference condition" identified within the Lagoon itself. Considering various lines of evidence, the TMDL estimated that the Lagoon was likely achieving the water quality standard for sediment in the mid-1970s. The numeric targets used the Lagoon and watershed conditions present during the mid-1970s as the reference condition for each target.

H.1.1 Sediment TMDL Targets

Lagoon mapping was used to establish the Lagoon numeric target, which is expressed as an increasing trend in the total area of tidal saltmarsh and non-tidal saltmarsh toward 346 acres. This target acreage represents 80% of the total acreage of tidal and non-tidal saltmarsh present in 1973. As of 2010, 262 acres of tidal saltmarsh and non-tidal saltmarsh are present in the Lagoon. The calculation and interpretation of the numeric target as an increasing trend in acreage takes into account other factors impacting the salt marsh habitat in the lagoon, as well as the length of time necessary to successfully restore the biological, physical, chemical, and hydrological structural characteristics of saltmarsh habitat. The final lagoon numeric target requires the successful restoration of tidal and non-tidal salt marsh to achieve a lagoon total of 346 acres. This can either mean:

1. Successful restoration of 80% of the 1973 acreage of lagoon saltmarsh habitat (346 acres); or
2. Demonstrate that implementation actions are active on and/or affecting 346 acres with continued monitoring to ensure 80% target achievement.

The watershed numeric target is expressed as mass of sediment per wet period (211 days from October 1st through April 30th of each year). The historical land use (mid-1970s) distribution compared to Year 2000 was used to calculate the targets of 12,360 tons per wet period. Two broad categories of sediment sources were identified: 1) Pacific Ocean and 2) watershed sources which consist of all point and nonpoint sources of sediment in the watershed draining to the lagoon. Sediment contributions from the Pacific Ocean are considered a nonpoint, natural background source of sediment. The remainder of the estimated load, 2,580 tons/year, was assigned to the collective Sediment TMDL responsible parties. The parties identified by the TMDL include the Responsible Agencies for this Water Quality Improvement Plan, in addition to Phase II MS4 permittees, general construction storm water NPDES permittees, and general industrial storm water NPDES permittees. This reduction is a 67% sediment load reduction from Year 2000 load to the historical (mid-1970s) load by the collective TMDL responsible parties.

Ultimately, the final TMDL Lagoon numeric target must be achieved within 20 years of the approved TMDL. Interim milestones in the TMDL Staff Report, attached to the Sediment TMDL Resolution, require incremental watershed sediment load reductions during the 20 year period. The interim TMDL milestones were the basis for the interim numeric goals for Water Quality Improvement Plan development and are presented in Table H-1.

Table H-1
Sediment TMDL Interim and Final Milestones

Compliance Year	5 years	9 years	13 years	15 years	20 years
	FY20	FY24	FY28	FY30	FY35
Compliance with TMDL Interim and Final Milestones					
Lagoon Target (Restoration of Saltmarsh Habitat)	Increasing trend towards 346 acres of saltmarsh habitat				Successful restoration of salt marsh habitat to total 346 acres[1]
OR					
Watershed Target (% Load Reduction)	20%	40%	60%	80%	

Note:
1. This can either mean:
   - Successful restoration of 80% of the 1973 acreage of lagoon saltmarsh habitat (346 acres); or
   - Demonstrate that implementation actions are active on and/or affecting 346 acres with continued monitoring to ensure 80% target achievement.

% = percent

As stated in the TMDL, current sediment loading is not the only cause of the Lagoon impairment. Historical loading, including activities within the Lagoon, contributed to the impairment. While the TMDL assigned sediment load reductions to the TMDL responsible parties, additional measures were also suggested, including the reduction of freshwater discharges and Lagoon restoration. All three strategies will contribute to the increase in saltmarsh habitat. Thus the strategies selected in the Water Quality Improvement Plan will target both sediment and freshwater reduction within their jurisdiction, in addition to collaboration with WMA stakeholders and TMDL responsible parties in potential restoration activities.

The TMDL receiving water goal is successful restoration of salt marsh habitat, as defined above. Restoration strategies taken in the Lagoon require collaboration with all other parties, including but not limited to the Responsible Agencies listed in this Water Quality Improvement Plan, watershed and Lagoon stakeholders, and other agencies that have jurisdiction in or regulatory control over the Lagoon. Therefore, the final receiving water goal for this Water Quality Improvement Plan is successful restoration of 346 acres of salt marsh habitat, achieved by a collaborative effort among Responsible Agencies and other TMDL responsible parties.

H.1.2 Sediment Goals Expressed as Sediment Load Reduction

To translate TMDL watershed goals to the Responsible Agencies for implementation planning, the TMDL watershed models were updated to better reflect current conditions and improve the accuracy of load estimates for Water Quality Improvement Plan development. The land use distribution was updated to compare Year 2009 land use to the historical land use conditions. One representative water year (water year 2003) was selected to simulate wet weather conditions during both time periods. Water Year 2003 represents typical wet and dry weather conditions within the subwatershed, based on an analysis of rainfall data over a 20-year time period. Because the Water Quality Improvement Plan focuses on implementation planning through an adaptive management framework, using a representative water year will more accurately assist the Responsible Agencies in designing programs and BMPs to reach the targets.

In addition, the updated model was used to calculate load reductions by subwatershed. Four subwatersheds are defined for the Water Quality Improvement Plan: 1) Carmel Valley Creek, 2) Los Peñasquitos Creek, 3) Carroll Canyon Creek, and 4) the area draining directly to the Lagoon. The reference load, the current load, and load reduction required was estimated for each subwatershed and is presented in Table H-2. Because the mass of sediment reduction is, in part, related to rainfall, which varies by year, the percent load reduction required was selected as the sediment numeric goal for the Water Quality Improvement Plan. This reflects the varying weather conditions from year to year and still allows for implementation planning to provide assurance that the programs and BMPs selected will attain the goals.

Table H-2
Sediment Numeric Goals by Subwatershed

Subwatershed	Reference[1] Sediment Load (Tons/Wet Period)	Current[2] Sediment Load (Tons/Wet Period)	Sediment Reduction Required (Tons/Wet Period)	Sediment Reduction Required (% Load Reduction)	Final Compliance Date
	Estimated Using WY 2003[3] Rainfall Data				
Wet Period (Oct 1 – April 30)					
Carmel Valley Creek	99	475	376	79.2%	2035
Los Peñasquitos Creek	861	1631	771	47.2%	
Carroll Canyon Creek	521	1004	484	48.2%	
Direct Drainage to Los Peñasquitos Lagoon	82	126	44	34.8%	

Note:
1. The Reference modeled load was estimated using mid-1970s land use information.
2. The Current model load was estimated using 2009 land use.
3. Sediment loading for both the reference and current wet period used rainfall data from WY2003, and average rainfall year.

% = percent

Because of the collaborative nature of meeting the TMDL Lagoon and watershed numeric targets, jurisdictional goals have been assigned to each Responsible Agency named in this Water Quality Improvement Plan to provide a method to assess Responsible Agency progress toward achieving goals on an individual basis. The updated model results from the Water Quality Improvement Plan modeling effort were used to allocate jurisdictional responsibility by subwatershed. The current load (in tons/wet period) for WY 2003 by subwatershed (Table H-1) was multiplied by the percentage of land area of each jurisdiction. The result, in tons/year, was then multiplied by the appropriate subwatershed percent load reduction required. Two jurisdictions, the City of San Diego and the County of San Diego, are located in multiple subwatersheds. For those jurisdictions, the sum of the load reductions required are presented along with a WMA percent load reduction. This allows those jurisdictions the greatest flexibility in implementation across subwatersheds to support the beneficial uses of the lagoon. This method also retains jurisdictional equitability by first assigning load reductions on a subwatershed scale and then summing to the WMA scale. Again, because the mass of sediment reduction is, in part, related to rainfall, which varies by year, the percent load reduction required was selected as the sediment numeric goal for

the Water Quality Improvement Plan. Table H-3 presents the jurisdictional goals by subwatershed[1].

Table H-3
Jurisdictional Sediment Goals for Los Peñasquitos WMA

Subwatershed	City of Del Mar	City of Poway	City of San Diego	San Diego County
Current Sediment Load by Jurisdiction (tons/ wet period)				
Carmel Valley Creek			455	
Los Peñasquitos Creek		677	848	76
Carroll Canyon Creek			962	7.6
Direct Drainage to Lagoon	1.6		121	
Percent Load Reduction Required (%)				
Carmel Valley Creek			79.2%	
Los Peñasquitos Creek		47.2%	47.2%	47.2%
Carroll Canyon Creek			48.2%	48.2%
Direct Drainage to Lagoon	34.8%		34.8%	
Load Reduction Required (tons/ wet period)				
Carmel Valley Creek			360	
Los Peñasquitos Creek		320	401	36
Carroll Canyon Creek			463	3.7
Direct Drainage to Lagoon	0.6		42.0	
Jurisdictional Sum for Los Peñasquitos WMA	0.6 (34.8%)	320 (47.2%)	1266 (53.1%)	40 (47.6%)

% = percent

Interim goals, identified in Table H-1, were applied equally to each jurisdiction. Increasing incremental reductions are required during the 20 years after TMDL approval. For example, in FY2020, each jurisdiction is required to reduce their sediment load by 20%. Therefore, the City of Del Mar must reduce their sediment load by 7.0% (20% of 34.8%) by FY2020. The City of Poway must reduce their sediment load by 9.4% (20% of 47.2%) by FY2020. The City of San Diego must reduce their sediment load by 10.6% (20% of 53.1%) by FY2020. The County of San Diego must reduce their sediment load by 9.5% (20% of 47.6%) by FY2020. Jurisdictional goals are presented in Section 4.1 of this Water Quality Improvement Plan.

[1] Caltrans has jurisdiction in all four subwatersheds. Caltrans' sediment load was calculated, but is not included in Table H-2. Caltrans MS4 Permit does not identify a sediment load reduction required for the Sediment TMDL and is therefore not included within this Water Quality Improvement Plan.

H.1.3 Compliance Pathways to Meet the Sediment TMDL

Language to incorporate the Sediment TMDL into the MS4 Permit is currently being drafted. Water Quality Improvement Plan goals and this Appendix will be updated as the TMDL is incorporated.

Final compliance with the Sediment TMDL, as incorporated into the MS4 Permit, may be demonstrated by the Responsible Agencies using one of the following methods:

Placeholder

H.2 Identification of Bacteria Numeric Goals

The final and interim bacteria numeric goals were derived from water quality-based effluent limitations (WQBELs) identified in the Bacteria TMDL and incorporated into the MS4 Permit. Bacteria TMDL WQBELs include receiving water limitations and effluent limitations, presented in multiple formats. The receiving water limitations and effluent limitations are discussed in detail in Section H.2.1 and Section H.2.2, respectively. Attachment E.4 of the Municipal Permit provides the following options to meet numeric goals and to demonstrate final compliance with the Bacteria TMDL:

(1) There is no direct or indirect discharge from the Responsible Agency's municipal separate storm sewer systems (MS4s) to the receiving water; OR

(2) There are no exceedances of the final receiving water limitations in the receiving water at, or downstream of, the Responsible Agency's MS4 outfalls; OR

(3) There are no exceedances of the final effluent limitations at the Responsible Agency's MS4 outfalls; OR

(4) The pollutant load reductions for discharges from the Responsible Agencies' MS4 outfalls are greater than or equal to the final effluent limitations; OR

(5) The Responsible Agencies can demonstrate that exceedances of the final receiving water limitations in the receiving water are due to loads from natural sources, AND pollutant loads from the Responsible Agencies'' MS4 are not causing or contributing to the exceedances; OR

(6) The Responsible Agencies develop and implement the Water Quality Improvement Plan as follows:

   (a) The Responsible Agencies incorporate best management practices (BMPs) to achieve the receiving water limitations and/or the effluent limitations,

   (b) The Responsible Agencies include an analysis in the Water Quality Improvement Plan, utilizing a watershed model or other watershed analytical tools, to demonstrate that the implementation of the BMPs

achieves compliance with the final receiving water and/or effluent limitations,

(c) The results of the analysis must be accepted by the San Diego Water Board as part of the Water Quality Improvement Plan,

(d) The Responsible Agencies continue to implement the BMPs, and

(e) The Responsible Agencies continue to perform the specific monitoring and assessment specified to demonstrate compliance with the receiving water and effluent limitations (RWQCB, 2013a).

H.2.1 Receiving Water Limitations

Bacteria TMDL receiving water limitations are expressed as concentrations and as an allowable exceedance frequency. The limitations vary depending on the weather condition. The Bacteria TMDL identified WQBELs based on precipitation: wet weather (one day of 0.2 inches of rainfall or more plus three days) and dry weather (all other days, including those in the winter season). For each condition, receiving water targets were identified based on WQOs (Table H-4). WQOs are concentrations of bacteria indicators identified as acceptable levels for recreational contact (REC-1). Wet weather conditions are episodic and short in duration; therefore, single sample maximum WQOs apply. Geometric mean WQOs apply during dry weather when monitoring results over a longer duration are averaged and assessed. The WQOs do not account for a natural increase in bacteria loads during storm events. To account for background bacteria concentrations during wet weather, the Bacteria TMDL incorporated an allowable exceedance frequency of the WQO based on a reference (mostly undeveloped) watershed.

The TMDL targets are directly incorporated as Water Quality Improvement Plan numeric goals. Table H-4 presents the TMDL receiving water limitations, and thus the Water Quality Improvement Plan numeric goals for the Pacific Ocean shoreline at the Los Peñasquitos lagoon mouth and the final compliance date.

Table H-4
Final Receiving Water Numeric Goals within Los Peñasquitos WMA

Indicator Bacteria	Shoreline WQO (MPN/100mL)	Shoreline Allowable Exceedance Frequency[1]	Shoreline WQO (MPN/100mL)	Shoreline Allowable Exceedance Frequency
	Wet Weather (Single Sample Maximum)[2]		Dry Weather (30-day Geometric Mean)[3]	
	Final Compliance: April 4, 2031		Final Compliance: April 4, 2021	
Fecal coliform	400	22%	200	0%
Enterococcus	104	22%	35	0%
Total coliform	10,000	22%	1,000	0%

Note:
1. The 22% allowable exceedance frequency only applies to wet weather days. For dry weather days, the dry weather bacteria densities must be consistent with the single sample maximum REC-1 water quality objects in the Ocean Plan.
2. During wet weather days, only the single sample maximum receiving water limitations are required to be achieved.
3. During dry weather days, the single sample maximum and 30-day geometric mean receiving water limitations are required to be achieved.

mL = milliliters; MPN = most probable number; WQO = water quality objective

The Bacteria TMDL specifies a final receiving water limitation allowable exceedance frequency of 22 percent during wet weather periods based on reference conditions, but allows no exceedances during dry weather. To assess compliance, the Bacteria TMDL expressed exceedances of WQOs as the percentage of days that the appropriate WQO was allowed to exceed per year. The TMDL calculated this value using a mass-based conversion based on bacteria loading, as required by federal regulations (Bacteria TMDL, 2010). The TMDL load was calculated by multiplying the WQOs by the daily modeled stream flow. Modeled daily loads greater than this threshold were flagged as an exceedance. Modeled daily loads were classified as occurring on either wet days or dry days to determine compliance with the different weather-based requirements. For wet weather, the Bacteria TMDL specifies a final allowable exceedance frequency of 22 percent based on reference conditions, while no exceedances are allowed during dry weather. For wet weather, the daily load from wet days greater than the TMDL load and the calculated allowable exceedance load (load from the 22 percent of the allowable days) were flagged as exceedances. For dry days, the daily load from dry days greater than the TMDL load were flagged as exceedances.

The number of total wet and dry weather days will change by year, but the percentage of exceedance days is the compliance point. For example, the TMDL calculated the number of allowable exceedance days for the critical, or wettest, year within the model period, water year 1993. The number of wet weather days was 98; therefore, the final number of allowable wet weather exceedance days for the critical year would have been 22 (rounded expression of 22 percent of 98 days). The final allowable number of dry

weather exceedance days for the critical year is zero, because a reference condition was not applied to dry weather days in the TMDL. Final compliance with wet weather WQBELs is required in FY 31. Final compliance with dry weather WQBELs is required in FY21.

H.2.2 Effluent Limitations

The Bacteria TMDL provides two expressions of effluent limitations. The first expression is equivalent to the receiving water limitations, but is assessed at MS4 outfalls (Table H-5). The second expression is a mass-based load reduction from the subwatersheds discussed below.

Table H-5
Final Effluent Limitations Expressed as an Exceedance Frequency for Los Peñasquitos River WMA

Indicator Bacteria	WQO (MPN/100mL)	MS4 Outfall Allowable Exceedance Frequency[1]	WQO (MPN/100mL)	MS4 Outfall Allowable Exceedance Frequency
	Wet Weather (Single Sample Maximum)[2]		Dry Weather (30-day Geometric Mean)[3]	
	Final Compliance: April 4, 2031		Final Compliance: April 4, 2021	
Fecal coliform	400	22%	200	0%
Enterococcus	104	22%	35	0%
Total Coliform	10,000	22%	1,000	0%

Note:
1. The 22% allowable exceedance frequency only applies to wet weather days. For dry weather days, the dry weather bacteria densities must be consistent with the single sample maximum REC-1 water quality objects in the Ocean Plan.
2. During wet weather days, only the single sample maximum receiving water limitations are required to be achieved.
3. During dry weather days, the single sample maximum and 30-day geometric mean receiving water limitations are required to be achieved.

% = percent; mL = milliliters; MPN = most probable number; WQO = water quality objective

Another expression of WQBELs is the percent bacteria load reduction required from the watershed to meet the WQOs expressed as an allowable exceedance frequency. The TMDL was calculated by multiplying the WQOs by the average daily modeled stream flow. Modeled daily loads greater than this threshold were flagged as an exceedance. The allowable exceedance load for wet weather was calculated by summing the top 22 days (22 percent of the 98 wet weather days in the critical year) with the highest modeled daily loads. This load was then subtracted from the modeled wet weather total for the year. The difference between the remaining modeled load and the TMDL load represents the load reduction required for wet weather. The percent load reduction is calculated by dividing the exceedance load by the total annual load for the critical year.

The final load reductions estimated to meet receiving water goals are presented in Table H-6.

Table H-6
Final Effluent Limitations Expressed as an Exceedance Frequency for Los Peñasquitos WMA

Indicator Bacteria	Percent Watershed Load Reduction Required	
	Wet Weather	Dry Weather
	Final Compliance: April 4, 2031	Final Compliance: April 4, 2021
Fecal coliform	2.0%	96.6%
Enterococcus	1.9%	99.4%
Total coliform	1.6%	96.5%

Dry weather WQBELs, expressed as percent watershed load reduction, were calculated using the same formula, but daily loads were calculated using a slightly different model (steady-state plug-flow reactor model) in the Bacterial TMDL. Two variations in the calculation are that (1) an allowable load using the reference watershed approach was not applied for dry weather, per the TMDL, and (2) the percent load reductions were calculated based on a 30-day period for comparison with the 30-day geometric mean WQO. Otherwise, the TMDL load was calculated in the same manner as that for the wet weather load and the difference between the remaining modeled load and the TMDL load is the load reduction required for dry weather. The percent load reduction is calculated by dividing the exceedance load by the total monthly load for the critical year.

H.2.3 Interim Goals and Existing Conditions

The first five TMDL interim compliance pathways are the same as the final compliance pathways. In addition, two compliance pathways (6 and 7 below) provide interim compliance calculated using a midpoint between existing conditions and final targets. Finally, compliance pathway 8 provides interim compliance with the TMDL if the Responsible Agencies are implementing strategies selected and included in a watershed model or other analytical tool to demonstrate that the interim TMDL compliance requirements will be met. Attachment E.4 of the Municipal Permit provides the following options to meet interim numeric goals and to demonstrate interim compliance with the Bacteria TMDL:

(1) There is no direct or indirect discharge from the Responsible Agency's municipal separate storm sewer systems (MS4s) to the receiving water; OR

(2) There are no exceedances of the final receiving water limitations in the receiving water at, or downstream of, the Responsible Agency's MS4 outfalls; OR

(3) There are no exceedances of the final effluent limitations at the Responsible Agency's MS4 outfalls; OR

(4) The pollutant load reductions for discharges from the Responsible Agencies' MS4 outfalls are greater than or equal to the final effluent limitations; OR

(5) The Responsible Agencies can demonstrate that exceedances of the final receiving water limitations in the receiving water are due to loads from natural sources, AND pollutant loads from the Responsible Agencies'' MS4 are not causing or contributing to the exceedances; OR

(6) There are no exceedances of the interim receiving water limitations in the receiving water at, or downstream of, the Responsible Agency's MS4 outfalls; OR

(7) The pollutant load reductions for discharges from the Responsible Agencies' MS4 outfalls are greater than or equal to the interim effluent limitations; OR

(8) The Responsible Agencies submit and are fully implementing a Water Quality Improvement Plan, accepted by the San Diego Water Board, which provides reasonable assurance that the interim TMDL compliance requirements will be achieved by the interim compliance dates.

Interim goals are identified for each expression of WQBELs and each weather condition. Bacteria TMDL wet and dry weather interim compliance is calculated as the halfway point between the existing, 2002 conditions and the final TMDL target. The MS4 Permit allows an alternative interim compliance date from the original Bacteria TMDL compliance date (MS4 Permit, Attachment E). Interim compliance of receiving water or effluent limitations is most reasonably attained in FY24 for wet weather and FY19 for dry weather. Updates to existing programs, changes in municipal ordinances, and collaboration within jurisdictions, WMAs, and the region have been occurring since the Bacteria TMDL and the 2013 MS4 Permit were adopted and are ongoing. Through CLRP and Water Quality Improvement Plan development, planning efforts are underway, including measures to secure funding and increase general momentum to implement and expand storm water and water conservation measures. The alternative compliance dates allow for the success of the monitoring, assessment, and goal and strategy adaptation process detailed within this Water Quality Improvement Plan.

The TMDL model used data through 2002, which is why 2002 is considered the existing condition. The existing condition does not necessarily reflect current conditions, nor is it the Water Quality Improvement Plan baseline for all goals. The existing condition for load reductions is assumed to be 0% in 2002, as that was the beginning of implementation planning. The Bacteria TMDL estimated the 2002 existing exceedance frequency for wet weather since wet weather data was not available. The MS4 permit requires the dry weather exceedance frequency to be calculated and presented in the Water Quality Improvement Plans. For each indicator bacteria, available monitoring data collected between January 1, 1996 and December 31, 2002 was assessed and compared to 30-day geometric mean WQOs.

Table H-7 presents the existing condition for the receiving water and effluent limitations and the interim TMDL compliance target for Los Peñasquitos River. The Bacteria TMDL estimates that the 2002 wet weather exceedance frequency for fecal coliforms, *Enterococcus*, and total coliforms were 30 percent for all indicator bacteria species based on modeling results. To calculate dry weather exceedance frequencies, 138 results were available for *Enterococcus*, 145 results for fecal coliforms, and 146 results for total coliforms between 1996 and 2002. The exceedance frequency using geomeans (percent of dry weather days with a geomean exceeding the geomean WQO) was 19% for *Enterococcus*, 4% for fecal coliforms, and 1% for total coliforms. Interim compliance is 50% of the existing condition.

Table H-7
Existing Conditions and Interim TMDL Targets for Los Peñasquitos WMA

Bacteria Indicator	Receiving Water Exceedance Frequency		Effluent Load Reduction		Interim Compliance Date
	Existing 2002 Condition	Interim Compliance[1]	Existing 2002 Condition	Interim Compliance[1]	
Wet Weather					
Fecal coliform	30%[2]	26%	0%	1.0%[2]	April 4, 2024
Enterococcus	30%[2]	26%	0%	1.0%[2]	
Total coliform	30%[2]	26%	0%	0.8%[2]	
Dry Weather					
Fecal coliform	4%[3]	2.0%[2]	0%	48.3%[2]	April 4, 2019
Enterococcus	19%[3]	9.5%[2]	0%	49.7%[2]	
Total coliform	1%[3]	0.5%[2]	0%	48.3%[2]	

Note:
1. Interim compliance is calculated as 50% between the existing condition and the final TMDL target.
2. Source: Bacteria TMDL
3. Source: Monitoring data

% = percent; N/A = not applicable

The difference between the existing dry weather exceedance frequency and the dry weather load reduction highlights the shortcomings of dry weather modeling based on limited observed data. Uncertainties in the model may result in a potential disconnect between receiving water quality and watershed loading estimates. An exceedance frequency of less than 20% based on monitoring data would seem to require a lower load reduction from the watershed than 99%; however this highlights the difference between concentration and load-based information which incorporates potential uncertainties in modeling dry weather flows. A 99% watershed load reduction likely overstates the actual load reduction required to meet final compliance. Regardless of the load reduction required, the primary strategy during dry weather is to eliminate dry weather flows, which will, in turn, reduce and eliminate pollutant loading. In the Water

Quality Improvement Plan, dry weather reduction strategies and progress towards meeting them are more frequently discussed in terms of flow reduction, rather than load reduction. This acknowledges the related benefit to load reductions, but highlights the source or transport mechanism for dry weather implementation.

H.2.4 Compliance Pathways

Interim and final compliance with the Bacteria TMDL, as incorporated into the MS4 Permit, may be demonstrated by the Responsible Agencies using any one of the methods presented in the previous sections. Section 5 of the Water Quality Improvement Plan provides additional information on the monitoring that will be completed for assessment. The compliance analysis, modeling conducted to provide assurance that interim and final goals will be met, is discussed in more detail in Appendix J and Section 4.3 of the Water Quality Improvement Plan.

H.3 Freshwater Discharge Numeric Goals

Neither the Sediment TMDL nor the Bacteria TMDL identified the reduction of freshwater discharge required to assist in meeting TMDL targets. The Sediment TMDL Technical Report cites studies and monitoring data that demonstrate an increase in flow associated with urbanization, however not all of that flow is a result of direct discharge from the MS4. The geology of the watershed particularly in the lower watershed allows infiltrated water, including irrigation water, to percolate directly to the creeks.

For the purpose of Water Quality Improvement Plan numeric goals, freshwater discharges from the MS4s throughout the watershed will be assessed. Irrigation runoff is the predominant source of freshwater discharges, and indicator bacteria, during dry weather from the MS4. Modeling within the San Diego region, including in Los Peñasquitos WMA, indicates that a 25% reduction in irrigation (modeled as a reduction in irrigated land by 25% and the reduction of overspray by 35%) results in an average 80% reduction in fecal coliforms and an average 85% reduction in surface flows (flows through an MS4). These results combined with the estimated 10% load reduction gained by other nonstructural activities, reaches or nearly reaches the load reductions estimated to be required to be in compliance with Bacteria TMDL targets, particularly considering the limitations of the dry weather modeling discussed in Section H.2.3.

The 25% reduction in irrigation is inline and slightly more aggressive than California's statewide 20x2020 Water Conservation Plan (20x2020 Plan) which aims to reduce the urban water demand by 20% per capita by 2020. In California, outdoor water consumption exceeds 40% of overall urban water use (DWR, 2010). The reduction of irrigation (or outdoor water) demand not only benefits receiving water conditions, including the restoration of saltmarsh habitat, but also reduces costs of new water infrastructure and reduces water-related energy among other benefits discussed in the 20x2020 Plan.

The strategies used to reduce and eliminate dry weather flows will be encouraged and implemented throughout the watershed, not only reducing freshwater discharges directly to the lagoon through MS4 outfalls but to tributaries upstream through MS4

discharges, surface runoff, and percolation through groundwater seeps. By targeting a reduction in irrigation, both irrigation runoff and overall anthropogenic contributions to a rising groundwater table will be addressed.

REFERENCES

California Department of Water Resources (DWR). 20x2020 Water Conservation Plan. February, 2010. http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/docs/20x2020plan.pdf

San Diego Regional Water Quality Control Board (Regional Board). 2010. *Revised TMDL for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (including Tecolote Creek)*. Resolution No. R9-2010-0001. Approved February 10, 2010. http://www.waterboards.ca.gov/sandiego/water_issues/programs/tmdls/docs/bacteria/updates_022410/2010-0210_BactiI_Resolution&BPA_FINAL.pdf.

San Diego Regional Water Quality Control Board (Regional Board). 2012. Order Number R9-2012-0033, *Total Maximum Daily Load for Sedimentation in Los Peñasquitos Lagoon*.

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APPENDIX I

Jurisdictional Strategies and Schedules

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TABLE OF CONTENTS

I.1 Caltrans Strategies I-2
I.2 City of Del Mar Strategies I-7
I.3 City of Poway Strategies I-13
I.4 City of San Diego Strategies I-21
I.5 County of San Diego Strategies I-53

LIST OF TABLES

Table I-1 Caltrans Jurisdictional Strategies I-3
Table I-2 City of Del Mar Jurisdictional Strategies I-9
Table I-3 City of Poway Jurisdictional Strategies I-15
Table I-4 City of San Diego Jurisdictional Strategies I-23
Table I-5 City of San Diego Annual Schedule I-43
Table I-6 County of San Diego Jurisdictional Strategies I-55

APPENDIX I. JURISDICTIONAL STRATEGY SELECTION BY RESPONSIBLE AGENCY

Strategy selection within the Los Peñasquitos WMA is discussed in Section 4.2.1 and Appendix J. This appendix provides the selected strategies for each Responsible Agency including the implementation approach and level of effort required. The corresponding implementation year and duration provide context for when the strategy will be implemented. Strategies not being implemented upon approval of the Water Quality Improvement Plan provide a future date for implementation or a trigger for implementation in the future. Responsible Agencies are continually collaborating with internal jurisdictional departments, other Responsible Agencies, stakeholders, and watershed groups and non-profit organizations, and these collaborating entities are presented in the jurisdictional strategies tables as well. The strategies are subject to change and will be modified through the adaptive management process, as needed.

I.1 Caltrans Strategies

Caltrans' jurisdiction areas include roadways, land adjacent to roadways, and facilities; Caltrans' jurisdictional strategies specifically focus on BMP implementation to reduce known pollutants within these areas. Caltrans is not permitted within the MS4 Permit; however, Caltrans is subject to similar requirements through its MS4 Permit (SWRCB, 2013). Though not permitted within the MS4 permit, Caltrans has voluntarily contributed to the Water Quality Improvement Plan effort to provide a consistent and subwatershed-wide approach to meeting applicable TMDL requirements. Caltrans voluntary contributions include a detailed list of strategies developed and provided in Table I-1 below. The strategies and schedules presented in Table I-1 are subject to change and are contingent upon annual budget approvals and funding availability. They will be modified through the adaptive management process as needed.

Table I-1 Caltrans Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Responsible City Department and Other Collaborating Departments or Agencies
Jurisdictional Strategies					
Design Stormwater Program					
CT-1	Update and implement design BMPs.	Office of Stormwater Management Design (OSWMD) develops, evaluates, and enhances guidance documents and tools. Refer to Landscape Architecture Program (LAP).	Jurisdiction-wide	FY16	HQ (OSWMD)
CT-1.1	Update and implement Landscape Architecture Program (LAP).	LAP provides technical assistance on new and ongoing research related to permanent erosion control and permanent BMPs. In addition, the LAP develops methods to enhance roadside vegetation, which protects slopes from erosion and sediment loss, and may remove pollutants from stormwater runoff.	Jurisdiction-wide	FY16	HQ (OSWMD)
CT-1.2	Implement native landscape/LID Design Guide Strategy.	Require native landscaping/LID in stormwater data report and project plan design guide. Done as part of erosion control. The Project Planning and Design Guide (PPDG) includes an online training program. Projects go through the same review process for native landscape reviews. If project is greater than an acre, subject to a stormwater data report. Minor projects are not subject to as extensive reviews. Try to treat 100% of roadway.	Jurisdiction-wide	FY16	District 11 with HQ (OSWMD)
CT-2	Train staff on Design Stormwater Program.	Train staff on Design Stormwater Program. Curriculum updated to reflect the latest strategies.	Jurisdiction-wide	FY16	District 11
CT-3	Plan and implement treatment BMPs as appropriate.	Treatment BMPs are planned and implemented to comply with Caltrans NPDES Permit project development requirements, TMDL waste load allocations, location specific requirements, and the requirements in the Project Planning and Design Guide (PPDG) according to the Targeted Design Constituent (TDC) approach. The treatment BMP consideration process favors infiltration of stormwater and directs staff to evaluate LID strategies first.	Jurisdiction-wide	FY16	District 11 NPDES and Design with HQ (OSWMD)
CT-4	Develop procedures to encourage mitigation for projects within the same watershed.	Caltrans will investigate procedures to mitigate within the same watershed as new projects.	Jurisdiction-wide	FY16	District 11 NPDES and Stewardship
CT-5	Implement a self-audit program to ensure BMPs are designed, implemented, and maintained.	Design Compliance Monitoring Program is a self-audit program that uses the SWDR (Stormwater Data Report) as a tool for documenting compliance with the design pollution prevention and treatment BMP requirements of the 1999 NPDES Permit, 2012 NPDES Permit, and the Caltrans' 2003 Statewide SWMP. The SWDR and its checklists are reviewed by District staff to ensure that BMPs are being considered and appropriately incorporated into Caltrans' projects. This review also ensures stormwater compliance throughout the project planning and design phases.	Jurisdiction-wide	FY16	District 11 NPDES
Construction Management					
CT-6	Administer a program to oversee implementation of BMPs during the construction phase of Caltrans projects. Includes inspections at an appropriate frequency and enforcement of requirements.	Caltrans complies with the statewide Construction General Permit. The district holds pre-construction meetings for all projects that require a SWPPP. For larger projects, there are year-round, weekly inspections.	Jurisdiction-wide	FY16	District 11 with the Division of Construction
CT-7	Construction stormwater training for District staff.	Continue implementation of the construction stormwater classes offered throughout the Caltrans districts by the Division of Construction. Classes updated to reflect latest permit requirements.	Jurisdiction-wide	FY16	District 11 with the Division of Construction
CT-8	Implement a self-audit program to ensure compliance with water quality requirements.	Continue implementation of the Construction Compliance Evaluation Plan. Evaluates contractor's SWPPP or WPCP implementation and assesses compliance with water quality requirements, evaluates stormwater contract administration, and incorporates quality control, quality assurance, and independent assurance elements.	Jurisdiction-wide	FY16	District 11 NPDES

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Responsible City Department and Other Collaborating Departments or Agencies
CT-9	Maintenance training for employees.	The Division of Maintenance has formal stormwater management training sessions for new employees and refresher training for existing staff. Both types of courses are scheduled from one to 15 hours in length. In addition to formal training, Division of Maintenance policy is that Supervisors conduct stormwater BMP tailgate meetings a minimum of every 10 working days or when there is a change in the type of work activity. These meetings are to review BMPs prior to conducting roadside maintenance activities.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
Maintenance					
CT-10	Administer a program to require implementation of minimum BMPs for facilities and leased space (air space leases).	Refer to SWMP. Leased space is required to meet current stormwater regulations.	Jurisdiction-wide	FY16	District 11 with ROW Department
CT-11	Inspection of facilities and leased areas.	The Department will continue to reduce the potential for storm water pollution by the development and implementation of Facility Pollution Prevention Plans (FPPPs), which specify controls to minimize contact between storm water and the various substances at highway maintenance facilities. Per Maintenance Manual Vol.2 under F Family, periodic inspections are conducted to evaluate whether the BMPs are adequate and properly implemented. The SWMP states this provision regarding FPPP. *Maintenance Facility Pollution Prevention Plans. Facility Pollution Prevention Plans (FPPP) has been developed for each maintenance facility owned or operated by the Department. The FPPPs describe the activities conducted at the facility and the BMPs to be implemented to reduce the discharge of pollutants in storm water runoff from these facilities. Supervisors inspect their maintenance facilities monthly to monitor the implementation and adequacy of the BMPs. A report that includes the date of the inspection, the name of the inspector, observations, and recommended corrective actions is prepared by the Supervisor. All inspection records will be maintained for a period of 3 years. Any observed instances of non-compliance will be reported to the District Maintenance.*	Jurisdiction-wide	FY16	District 11 with ROW Department
CT-12	Implement BMPs targeting reduction of over-irrigation.	Reduce over irrigation by requiring native, drought tolerant plants and irrigation system improvements.	Jurisdiction-wide	FY16	District 11 Landscape and Stewardship
CT-13	Proactively monitor for erosion, and complete repair and slope stabilization.	Division of Maintenance conducts inspections on a five-year cycle. Program includes self-imposed goal to annually inspect approximately 20% of slopes in each District and includes investigating public complaints and widely understood problem areas (WUPAs).	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
MS4 Infrastructure					
CT-14	Inspect and clean catch basins and conduct source investigations to identify upstream source of materials.	Inspect catch basins once every three years with 1/3 inspected per year. If needed, catch basins are cleaned. If a catch basin is cleaned, a source inspection is conducted to identify source of sediment or other material.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
CT-15	Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.	Prioritize MS4 repairs. Funding for repairs based on size of project. Districts are able to conduct small repairs immediately, while larger projects are prioritized for repair out of annual budget.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
Roads and Streets					
CT-16	Implement operation and maintenance activities on streets and roadways.	Refer to Work Plan.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
CT-16.1	Implement street sweeping.	Every road swept once a month. To meet performance schedule, street sweepers are replaced on a four-year cycle.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
CT-16.2	Perform sweeping of medians on high-volume arterial roadways.	Medians with shoulders are swept approximately once per month.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Responsible City Department and Other Collaborating Departments or Agencies
CT-17	Implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers.	Refer to Vegetation Control Plan. Caltrans is actively reducing fertilizer/pesticide application and only applies to targeted areas. All pesticide use is reported to the California Department of Pesticide Regulation.	Jurisdiction-wide	FY16	District 11 with Roadside Maintenance Office and California DPR
Illicit Connections/Illegal Discharges					
CT-18	Identify and resolve potential illicit connections/illegal discharges (IC/IDs).	Continue maintaining a hotline for reporting of illicit discharges. Majority of calls come from contractors and construction and maintenance staff. Continue coordination with other jurisdictions to address IC/IDs and provide written notification of potential IC/IDs associated with a municipality's jurisdiction.	Jurisdiction-wide	FY16	District 11 with other jurisdictions
CT-19	Identify erosion and slope stabilization issues on private or municipal property and inform the source for repair.	When Caltrans staff or contractors identify erosion or slopes in need of repair, it is treated as an IC/ID and the property owner is notified.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
Public Education and Participation					
CT-20	Implement a public education and participation program to raise awareness of stormwater pollution and prevention on California's freeways and highways.	Continue to implement the "Don't Trash California" Campaign, Adopt-A-Highway program, and partner with local organizations.	Jurisdiction-wide	FY16	District 11 with HQ (OSWMD)
CT-20.1	Conduct trash cleanups.	Conduct trash cleanups through local probation and adopt-a-highway programs. Encourage prevention through "Don't Trash California" campaign.	Jurisdiction-wide	FY16	District 11 Division of Maintenance
CT-20.2	Target school-based education and outreach.	Provide outreach to schools raising awareness of stormwater pollution through watershed model demonstrations. Hold bring-your-child-to-work days with watershed model.	Jurisdiction-wide	FY16	District 11 with HQ (OSWMD)
Other Nonstructural Strategies					
CT-21	To provide sanitation and trash management, implement access control in targeted areas.	As necessary, implement methods such as rip-rap, chain link fences, and remove low-lying brush to discourage use of right-of-way areas.	Jurisdiction-wide	FY16	District 11 NPDES, Design and Maintenance
CT-22	Continue participating in source reduction initiatives.	Continue participation in Brake Pad Partnership through work with California Stormwater Quality Association.	Jurisdiction-wide	FY16	HQ with CASQA
CT-23	Removal of invasive plants.	Removal of invasive plants through maintenance and construction programs.	Jurisdiction-wide	FY16	District 11 with Division of Maintenance
CT-24	Protect areas that are functioning naturally.	Required as part of the stormwater data report (SWDR), the Project Planning and Design Guide (PPDG), and the Natural Environment as Treatment (NEAT) programs, Caltrans minimizes disturbance of exiting vegetation and avoids hardscapes.	Jurisdiction-wide	TBD	District 11 with HQ (OSWMD)
CT-25	Collaborate with Responsible Agencies on Water Quality Improvement Plans.	Voluntarily participate in the development of the Water Quality Improvement Plan and continue to collaborate with RAs on water quality planning and implementation projects.	Jurisdiction-wide	FY16	District 11
Green Infrastructure					
CT-26	Caltrans Construction (#172824)	Bioswales were installed in 2005 along Route 56.	Los Peñasquitos Creek Subwatershed	In place	District 11
CT-27	Caltrans Construction (#EA-2T0934)	Bioswales were installed in 2011 along Route 15.	Los Peñasquitos Creek & Carroll Canyon Creek Subwatersheds	In place	District 11
CT-28	Construct Managed Lanes (HOV/BRT Lanes) (#2T2004)	1 bioswale is under construction along Route 805 to treat about 7.75 acres.	Carroll Canyon Creek Subwatershed	2012	District 11

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Responsible City Department and Other Collaborating Departments or Agencies
CT-29	Direct Access Ramp (#2T0951)	3 Bioretention filtration units and 4 flogard screen filters along Route 15 will be used to treat 5.4 acres.	Los Peñasquitos Creek Subwatershed	2014	District 11
Multiuse Treatment Areas					
CT-30	Caltrans Construction (#080934)	1 detention basin was constructed in 2005 at the intersection of route 15 and route 56. The basin is 213 SF and treats 4.9 acres.	Los Peñasquitos Creek Subwatershed	In place	District 11
CT-31	Construct Managed Lanes (HOV/BRT Lanes) (#2T2004)	Installation of 1 detention basin in 2012. The basin is 30,350 SF and will treat 15.5 acres.	Carroll Canyon Creek Subwatershed	2012	District 11

I.2 City of Del Mar Strategies

The City of Del Mar has selected jurisdictional strategies that best suit the topography and characteristics of its jurisdiction to comply with Permit requirements. Del Mar's land use primarily consists of low-density residential and commercial areas, so the strategies address problematic areas associated with these characteristics. Del Mar has an irrigation control program in place to address runoff associated with residential and commercial properties; other residential BMP rebate programs such as rain barrels and downspout disconnections are not identified at this time. Despite stringent planning requirements, the jurisdiction is highly developed, and many roads have not only limited right-of-way, but also physical space for green street implementation. While green streets will be considered, options may be limited due to right-of-way constraints and bluff stabilization concerns in many parts of the City of Del Mar. The Del Mar City Council requires approval of costs before their presentation, which occurs every two years. For the purpose of this draft version of the Water Quality Improvement Plan, only costs that have been Council-approved will be presented. The City of Del Mar has identified the jurisdictional strategies in Table I-2 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

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Table I-2 City of Del Mar Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
Jurisdictional Strategies					
Development Planning					
All Development Projects					
DM-1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-2	Train staff on LID regulatory changes during annual stormwater training.	Formal staff training implemented annually during stormwater training.	City-wide	FY16	Ongoing
DM-3	Maintain existing floor area ratio requirements to limit impervious surface areas.		City-wide	FY16	Ongoing
DM-4	Continue retention of native vegetation - New or redevelopment projects within the Lagoon Overlay Zone shall include the retention of the maximum amount of native vegetation on the site. Revegetation or landscaping of sites within the Lagoon Overlay Zone shall include the use of non-invasive, drought tolerant species native to the San Diego coastal region and which are compatible with adjacent wetland habitat species.	Refer to Municipal Code.	City-wide	FY16	Ongoing
Priority Development Projects (PDPs)					
DM-5	For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-6	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP.	City-wide	FY15	Ongoing
Construction Management					
DM-7	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Refer to JRMP; Construction site inventory updated monthly and inspections of prioritized sites are conducted biweekly year round.	City-wide	FY16	Ongoing
Existing Development					
Commercial, Industrial, Municipal, and Residential Facilities and Areas					
DM-8	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP; Programmatic inspection/maintenance frequency included in JRMP update.	City-wide	FY16	Ongoing
DM-8.1	Update minimum BMPs for commercial, industrial, and municipal existing development and enforce. Includes BMPs for water-using mobile businesses.	Refer to JRMP; minimum BMPs updated within JRMP update.	City-wide	FY16	As-needed
DM-8.2	Provide BMP factsheet to water-using mobile businesses when business license is granted.	To ensure implementation of minimum BMPs for water -using mobile businesses, when a business license is granted for a water-using mobile business, a BMP factsheet is provided.	City-wide	FY16	Ongoing
DM-8.3	Conduct property-based commercial, industrial, municipal, and residential inspections. Includes identification and addressing unmitigated incidents of power washing discharges.	Refer to JRMP. Inspections of commercial, industrial, municipal, and multi-family residential areas conducted a minimum of six times per year.	City-wide	FY16	Ongoing
DM-8.4	Update municipal swimming pool discharge ordinance to ensure discharges from swimming pools meet permit requirements.	Refer to JRMP.	City-wide	Before FY16	As needed

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
DM-9	Implement pet waste program.	Implement education and prevention program. Pet waste bag dispensers and trash bins provided in public areas. Pet waste removal occurs as part of Dog Beach maintenance.	City-wide	FY16	Ongoing
DM-10	Promote and encourage implementation of designated BMPs at residential areas.		City-wide	FY16	Ongoing
DM-10.1	Promote and collaborate with water agencies and other groups to encourage implementation of water conservation programs that improve water quality by reducing over-irrigation with smart products or turf replacement and capturing rain water in residential areas.	Collaborate with MWD and promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal. Collaborate with San Diego County Water Authority (SDCWA) and promote their Water Smart irrigation system checkups and turf replacement incentives.	City-wide	FY16	Ongoing
DM-11	Promote and encourage implementation of designated BMPs in commercial areas.	Collaborate with MWD and promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal.	City-wide	FY16	Ongoing
MS4 Infrastructure					
DM-12	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Refer to JRMP.	City-wide	FY16	Ongoing
DM-12.1	Perform catch basin cleaning.	Inspect and clean catch basins annually.	City-wide	FY16	Ongoing
DM-12.2	Repair and replace MS4 components as needed to provide source control from MS4 infrastructure.		City-wide	FY16	Ongoing
DM-13	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers and identify sewer leaks and areas for sewer pipe replacement.	Refer to Sanitary Sewer Management Plan.	City-wide	FY16	Ongoing
Roads, Street, and Parking Lots					
DM-14	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Refer to JRMP	City-wide	FY16	Ongoing
DM-14.1	Enhanced street sweeping by use of regenerative air vacuum sweepers.	Enhanced sweeping implemented by using regenerative air vacuum sweepers. Residential areas are swept 2x per year; primary roads (Camino Del Mar) and business district are swept 2x per month. Collection and bike lanes and medians are swept 2x per month.	City-wide	FY16	Ongoing
DM-14.2	Perform sweeping of medians on high-volume arterial roadways.	Primary roads and business district medians are swept 2x per month.	Primary roads & business district	FY16	Ongoing
Pesticide, Herbicides, and Fertilizer BMP Program					
DM-15	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Refer to JRMP.	City-wide	FY16	Ongoing
Retrofit and Rehabilitation in Areas of Existing Development					
DM-16	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-17	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Refer to JRMP	City-wide	FY16	Ongoing

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
Illicit Discharge, Detection, and Elimination (IDDE) Program					
DM-18	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-19	Conduct frequent visual outfall monitoring to identify and eliminate illicit discharges.	As part of the patrol-based program for the construction, existing development, and outfall inventories, visit outfalls a minimum of six times per year to identify and eliminate potential illicit discharges.	City-wide	FY16	Ongoing
Public Education and Participation					
DM-20	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP.	City-wide	FY16	Ongoing
DM-20.1	Continue outreach to property managers responsible for HOAs and Maintenance Districts.	As part of the patrol-based program for the residential existing development inventory, provide frequent education and contact to HOAs and maintenance districts targeting outdoor activities and trash areas.	TBD	FY16	Ongoing
DM-20.2	Continue education and outreach to reduce over-irrigation through patrol program.	Once per year outside of business hours, patrol jurisdiction for incidents of over-irrigation and leave door-hangers identifying problem areas and appropriate corrective actions.	TBD	FY16	Ongoing
DM-20.3	Conduct trash cleanups through community-based organizations involving target audiences.	In partnership with I Love a Clean San Diego, host a site in Del Mar during two beach clean-ups per year.	TBD	FY16	Ongoing
DM-20.4	Review City storm water website and identify and implement required updates to reflect WQIP and JRMP revisions.	Update City Clean Water Program website with WQIP and JRMP information and highlight what the community can do for water quality.	City-wide	FY16	As needed
DM-20.5	Collaborate with regional education and outreach efforts.	Participate in Regional Think Blue campaign and collaborate with other regional efforts to provide consistent message or efficiency in training for targeted audiences.	City-wide	FY16	Ongoing
Enforcement Response Plan					
DM-21	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Refer to JRMP.	City-wide	FY16	Ongoing
Additional Nonstructural Strategies					
DM-22	Continue participating in source reduction initiatives.	Continue implementation of cigarette ban on beaches, parks and in commercial areas.	City-wide	FY16	Ongoing
DM-23	Proactively monitor for erosion and complete minor repair and slope stabilization as needed.	Post-storm monitoring is conducted to identify slope and bluff erosion in priority areas. As-needed, repairs and slop stabilization are completed.	City-wide	FY16	Ongoing
DM-24	Protect areas that are functioning naturally.	As opportunities arise, where feasible, the City will protect areas that are functioning naturally. This may include avoiding hardscape development and degradation in unpaved open space areas and creating permanent open space protections to undeveloped city-owned land.	TBD	TBD	As available
DM-25	City will consider alternative compliance program on a case by case basis.	Refer to JRMP.	TBD	Optional	TBD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation
DM-26	If a regional education group for the equestrian community and property owners is developed by the County of San Diego, contribute to the effort through outreach, education, and policy measures.		TBD	Optional	TBD
DM-27	If a regional outreach program for the development community is created, provide technical education and outreach support on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	Participate in the development of a regional outreach program to the development community if it occurs.	TBD	Optional	TBD
DM-28	Conduct special studies	San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for "natural sources" to establish the concentrations or loads from streams in a minimally disturbed or "reference" condition. Refer to Section 5.1 for further details.	Los Peñasquitos WMA Subwatershed	Optional	TBD
DM-28.1	Reference watershed study	Los Peñasquitos WMA special study will assess sediment loads in the watersheds upstream of the Draft Sediment TMDL compliance monitoring locations. Includes the analysis of sediment water column loads, stream bedload, and air monitoring. Implemented in a phased approach. Monitoring will occur first in the Carroll Canyon subwatershed. The Los Peñasquitos Creek and Carmel Valley Creek subwatersheds will be monitored in subsequent phases. Refer to Section 5.1 for further details.	Los Peñasquitos WMA Subwatershed	Optional	TBD
Green Infrastructure					
DM-29	If interim load reduction goals are not met, potential opportunities for green infrastructure will be considered.	Adaptive management process.	Los Peñasquitos Lagoon Subwatershed	FY22	Ongoing
Green Streets					
DM-30[1]	0.06 acres of green streets (0.03 acres of permeable pavement and 0.03 acres of bioretention) have been identified as potential opportunities for green street projects to treat a drainage area of 2.59 acres.	Construction, operation and maintenance of 0.06 acres of green streets (0.03 acres of permeable pavement and 0.03 acres of bioretention) to treat a drainage area of 2.59 acres.	Los Peñasquitos Lagoon Subwatershed	FY22	Ongoing
DM-31	If interim load reduction goals are not met, potential opportunities for green streets will be considered.	Adaptive management process.	TBD	Optional	TBD
Multiuse Treatment Areas					
Other Opportunities					
DM-32[1]	Implement 0.18 acres with a total storage volume of 0.35 ac-ft. of multiuse treatment area projects on private parcels and/or through public-private partnerships.	Construction, operation and maintenance of multiuse treatment area projects on private parcels and/or through public-private partnerships.	Los Peñasquitos Lagoon Subwatershed	FY26, FY33	Ongoing
Dry Weather Flow Separation and Treatment Projects					
DM-33	If interim load reduction goals are not met, dry weather flow separation and treatment projects may be considered.	Adaptive management process.	TBD	Optional	TBD

Notes: 22nd DAA = 22nd District Agricultural Association; CWP = Clean Water Program; MWD = Metropolitan Water District; SDCWA = San Diego County Water Authority

1. Strategy has been identified as potential based on results of a model that may not be reflective of the small drainage area that leads from Del Mar to the lagoon. The strategy is presented until further analysis (including monitoring data) can confirm or revise the needs and strategies.

I.3 City of Poway Strategies

The City of Poway, located in the middle of the watershed, tends to have larger lot sizes and more pervious surfaces. In addition to administrative JRMP strategies, the focus is on source control, such as open trash enclosures and a public waste yard, through monitoring and reducing the pollutant source exposure and storm water runoff,. Strategies and implementation details are presented below. The City of Poway has identified the jurisdictional strategies in Table I-3 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

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Table I-3 City of Poway Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Jurisdictional Strategies						
Development Planning						
All Development Projects						
PW-1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Priority Development Projects (PDPs)						
PW-2	For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
PW-3	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP.	City-wide	FY16	As needed	DSD
PW-3.1	Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover.	Implemented through the Minor Development Review process and the plan check process.	City-wide	FY16	As needed	DSD
PW-4	Administer an alternative compliance program to on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5. and Appendix N for further details.	Refer to JRMP.	City-wide	FY16	As needed	DSD
Construction Management						
PW-5	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Refer to JRMP; Perform daily inspections during construction.	City-wide	FY16	Ongoing	DSD
Existing Development						
Commercial, Industrial, Municipal, and Residential Facilities and Areas						
PW-6	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP; Commercial/industrial/municipal are inspected annually, with municipal receiving more frequent inspections by staff.	City-wide	FY16	Ongoing	DSD
PW-6.1	Review policies and procedures to ensure discharges from swimming pools meet permit requirements.	Annually review policies and procedures.	City-wide	Prior to FY16	As needed (Annually)	DSD
PW-6.2	Track stationary and mobile businesses through communication with Business Licensing Division.	Maintain through the City's Commercial/Industrial program.	City-wide	FY16	Ongoing	DSD with Administrative Services
PW-7	Promote and encourage implementation of designated BMPs with all new construction.		City-wide	FY16	Ongoing	DSD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
PW-7.1	Promote MWD and other groups to encourage implementation of water conservation programs that improve water quality by reducing over-irrigation with smart products or turf replacement and capturing rain water in residential areas.	Collaborate with MWD to promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal. Collaborate with San Diego County Water Authority (SDCWA) to promote their Water Smart irrigation system checkups and turf replacement incentives.	City-wide	FY16	Ongoing	DSD with MWD and SDCWA
PW-8	Promote and encourage implementation of designated BMPs in commercial areas.	Collaborate with MWD and promote their SoCal Water$mart rebates and products such as weather based irrigation controllers, rotating sprinkler nozzles, soil moisture sensor system, rain barrels, and turf removal.	City-wide	FY16	Ongoing	DSD with MWD
PW-9	Implement program to investigate illegal grading on private property.	Program to investigate reports of illegal grading. Maintain records of reported illegal gradings and immediately investigate. If activity violates grading or stormwater regulation, issued a "Stop Work" notice and must obtain grading permit and correct stormwater violations. Reports are tracked in "Trackit" software as a code violation and bi-monthly meetings to discuss the status of reports. Grading cases are subject to a strict timeline of action, and enforcement is upped until either compliance, or a Notice of Violation is filed against the property. If it is a stormwater issue, the City's on-call stormwater contractor corrects the issue and City liens the property for payment.	City-wide	FY16	Ongoing	DSD
MS4 Infrastructure						
PW-10	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Refer to JRMP.	City-wide	FY16	Ongoing	DSD with DPW
PW-10.1	Perform catch basin cleaning.	Inspect and clean catch basins annually.	City-wide	FY16	Ongoing	DPW
PW-10.2	Clean open-channels and repair scour ponds to reduce pollutant loads and invasive plants and animals.	Inspect and clean open channels and scour ponds.	City-wide	FY16	Ongoing	DPW
PW-10.3	Proactively repair and replace corrugated metal pipe (CMP) MS4 components to provide source control from MS4 infrastructure.	Implement CMP replacement program with an emphasis on pipes in open canyons.	City-wide	FY16	Ongoing	DSD with DPW
PW-11	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers and identify sewer leaks and areas for sewer pipe replacement.	Program implemented through sewer maintenance and inspection program.	City-wide	FY16	Ongoing	DSD with DPW
Roads, Street, and Parking Lots						
PW-12	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Refer to JRMP; The City of Poway is divided into 7 zones for road operation and maintenance activities; rotational cycle: one zone inspected each year	City-wide	FY16	Ongoing	DSD with DPW
PW-12.1	Implement street sweeping.	Refer to JRMP; all areas swept twice per month.	City-wide	FY16	Ongoing	DPW
PW-12.2	Increase maintenance on access roads by proactively monitoring for erosion and completing minor repair and slope stabilization.		City-wide	FY16	Ongoing	DSD with DPW

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
PW-12.3	Increase maintenance on access trails by proactively monitoring for erosion and completing minor repair and slope stabilization.		City-wide	FY16	Ongoing	DSD with DPW
PW-13	Enhance street sweeping through route optimization (sweep all routes twice per month).			FY18		
Pesticide, Herbicides, and Fertilizer BMP Program						
PW-14	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Retrofit and Rehabilitation in Areas of Existing Development						
PW-15	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.		City-wide	TBD	Ongoing	DSD
PW-16	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.		City-wide	TBD	Ongoing	DSD
Illicit Discharge, Detection, and Elimination (IDDE) Program						
PW-17	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Public Education and Participation						
PW-18	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
PW-18.1	Target school-based education and outreach.	Through "I Love a Clean San Diego," give school presentations to fourth-graders eight times per year.	City-wide	FY16	Ongoing	DSD with I Love a Clean San Diego
PW-18.2	Conduct education through community-based organizations.	Through "I Love a Clean San Diego," staff street fair booths twice per year.	City-wide	FY16	Ongoing	DSD with I Love a Clean San Diego
PW-18.3	Review City storm water website and identify and implement required updates to reflect WQIP and JRMP revisions.	Review City storm water website, identify and implement required updates to reflect WQIP and JRMP revisions.	City-wide	Prior to FY16	As needed	DSD
PW-18.4	Target human behavior in parks and other public areas including trash reduction or other high impact behavior to habitat, wildlife, and water quality.	Implement trash reduction programs by increasing the number of trash and recycling bins during high-traffic public events and in public parks.	City-wide	FY16	Ongoing	DSD
PW-18.5	Collaborate with regional education and outreach efforts.	Participate in Regional Think Blue campaign and collaborate with other regional efforts to provide consistent message or efficiency in training for targeted audiences.	City-wide	FY16	Ongoing	DSD with regional education and outreach campaigns

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Enforcement Response Plan						
PW-19	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Refer to JRMP.	City-wide	FY16	Ongoing	DSD
Additional Nonstructural Strategies						
PW-20	Conduct special studies.	San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for "natural sources" to establish the concentrations or loads from streams in a minimally disturbed or "reference" condition. Refer to Section 5.1 for further details.	City-wide	TBD	TBD	DSD
PW-20.1	Reference watershed study.	Los Peñasquitos WMA special study will assess sediment loads in the watersheds upstream of the Draft Sediment TMDL compliance monitoring locations. Includes the analysis of sediment water column loads, stream bedload, and air monitoring. Implemented in a phased approach. Monitoring will occur first in the Carroll Canyon subwatershed. The Los Peñasquitos Creek and Carmel Valley Creek subwatersheds will be monitored in subsequent phases. Refer to Section 5.1 for further details.	City-wide	FY16	Ongoing	DSD
PW-21	As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and acquiring privately-owned undeveloped open areas.	As opportunities arise, where feasible, avoid hardscape development and degradation in unpaved open space areas, create permanent open space protections to undeveloped city-owned land, and acquire privately owned undeveloped parcels of land.	TBD	Optional	As available	DSD
Green Infrastructure						
PW-22	0.26 ac have been identified as potential opportunities for green infrastructure implementation on public parcels.	Construction, operation, and maintenance of 0.26 ac of bioretention and permeable pavement.	Los Peñasquitos Creek Subwatershed	FY22	Ongoing	DSD
Green Streets						
PW-23	32.42 acres of permeable pavement and 32.47 acres of bioretention have been identified as potential opportunities for green street projects.	Construction, operation and maintenance of 32.42 acres of permeable pavement and 32.47 acres of bioretention for green streets.	Los Peñasquitos Creek Subwatershed	FY22	Ongoing	DSD
Multiuse Treatment Areas						
Infiltration and Detention Basins						
PW-24	Community Detention Basin	Community Detention Basin is already in place.	Community Rd.	In place	Ongoing	DSD
PW-25	Gate Detention Basin	Gate Detention Basin is already in place.	Gate Dr.	In place	Ongoing	DSD
PW-26	Kirkham Detention Basin	Kirkham Detention Basin is already in place.	Kirkham Way	In place	Ongoing	DSD
PW-27	Stotler Detention Basin	Stotler Detention Basin is already in place.	Stotler Ct.	In place	Ongoing	DSD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
PW-28	Stowe Detention Basin	Stowe Detention Basin is already in place.	Stowe Dr.	In place	Ongoing	DSD
PW-29	If interim load reduction goals are not met and additional multiuse treatment areas are required, a constructed wetland system can be implemented in the open space adjacent to Carriage Road.	Construction, operation and maintenance of a Constructed Wetland System that would treat approximately 9567 acres of drainage area on 1.7 acres of available space (APN 3175012400).	Open space adjacent to Carriage Rd.	FY22	Ongoing	DSD
PW-30	If interim load reduction goals are not met and additional multiuse treatment areas are required, a dry extended detention basin can be implemented in Hilleary Park.	Construction, operation and maintenance of a Dry Extended Detention Basin that would treat approximately 138 acres of drainage area on 1.6 acres of available space (APN 3171020700).	Hilleary Park	FY22	Ongoing	DSD
Additional Watershed Opportunities						
PW-31	Through adaptive management and additional analysis in the future, the City will identify and implement one or more of the following opportunities to meet numeric goals: 1) new strategies not yet identified, 2) implement 28.8 acres with a total storage volume of 57.7 ac-ft. of multiuse treatment area projects on private parcels and/or through public-private partnerships, 3) MS4 outfall repair and relocation, 4) slope stabilization, 5) stream restoration, or 6) increased implementation of nonstructural or/and green infrastructure BMPs.	Through adaptive management and additional analysis in the future, the City will identify and implement one or more of the following opportunities to meet numeric goals: 1) new strategies not yet identified, 2) implement 28.8 acres with a total storage volume of 57.7 ac-ft. of multiuse treatment area projects on private parcels and/or through public-private partnerships, 3) MS4 outfall repair and relocation, 4) slope stabilization, 5) stream restoration, or 6) increased implementation of nonstructural or/and green infrastructure BMPs.	Los Peñasquitos Creek Subwatershed	FY26, FY33	Ongoing	DSD
PW-32	If interim load reduction goals are not met and additional multiuse treatment area projects are required, implement, as needed, on private parcels and/or through public-private partnerships.	Construction, operation and maintenance of multiuse treatment area projects on private parcels and/or through public-private partnerships.	Los Peñasquitos Creek Subwatershed	Optional	FY27	DSD
Stream, Channel, and Habitat Rehabilitation Projects						
PW-33	Rattlesnake Creek Project (stabilization of ephemeral tributary segment to Rattlesnake Creek)	This project involves the stabilization of a section of an ephemeral tributary to Rattlesnake Creek, which is located west of Midland Road, between Kentfield Drive and Norwalk Street. The project will involve grading in order to widen the channel bottom and contour the banks. It will include installation of rip rap, turf reinforcement matting, concrete pillow blocks, and a headwall, landscape removal and replacement, temporary BMPs, a temporary diversion system, and temporary irrigation.	West of Midland Rd, between Kentfield Dr. and Norwalk St.	2016 (estimated)	TBD	DSD

Notes: DSD = Development Services Department; DPW = Department of Public Works; MWD = Metropolitan Water District; SDWCA = San Diego County Water Authority

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I.4 City of San Diego Strategies

The City has identified water quality improvement strategies that are expected to provide the greatest benefits to the watershed and its residents, businesses, communities within the City's jurisdictional boundaries.

Strategies were selected by evaluating the following considerations, in descending priority:

- Potential to reduce pollutant loads for the highest priority condition condition(s)
- Potential to reduce loads for other pollutants (including priority water quality conditions)
- Cost effectiveness,
- Feasibility and ease of implementation
- Social impacts and benefits
- Other[1] impacts and benefits

The strategies that provide the best value, most return on investment, and greatest range of benefits will be recommended, as needed, as the City moves forward in its water quality improvement efforts. The recommended strategies chosen will be consistent with those already identified in the Comprehensive Load Reduction Plans (CLRPs) for various TMDLs in the San Diego Region.

The City is currently developing a framework to evaluate potential other benefits the recommended strategies may provide beyond improved water quality. These additional benefits may be financial, environmental, or societal. The recommended strategies will be scored based on the number of other benefits they provide, and may guide future updates to the Water Quality Improvement Plan (Appendix L).

The cumulative storm water quality benefits of the Recommended Strategies identified in this Plan are needed to achieve the level of effort needed to demonstrate progress toward achieving the Water Quality Improvement Plan's (Plan) interim and final numeric goals. It is important to note that these strategies are subject to change through the iterative, adaptive management process set forth in this Water Quality Improvement Plan. Through the adaptive management process the Responsible Agencies will be able to implement strategies and assess their impact to water quality and use new available information to refine, modify, remove, replace, or add strategies which will ensure the most effective suite of strategies are being implemented. Therefore, actual implementation of strategies is dependent upon both approval of funding in future annual budgets and adjustments that may occur as part of the iterative process.

[1] Other benefits refer to outcomes of a strategy beyond water quality improvements. Other benefits can include reduced air pollution, increased water conservation, watershed protection, public open space, aesthetics-induced property value increases, and increased business investments.

The recommended strategies selected are presented in Table I-4. These strategies will be implemented by the City; they are not intended to be implemented by private entities (e.g., development, business, industry, etc.). Some of the City's strategies, such as development planning, may have implications for private entities. The City has also developed a schedule as a best estimate of the shortest amount of time required to plan and implement the strategies. The City's schedule table is found in Table I-5. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

Optional strategies are activities that may be implemented by the Responsible Agencies at their discretion through the iterative approach. Unlike the recommended strategies, optional strategies have not been determined to be necessary in order to achieve the Plan's interim and final numeric goals. However, the Responsible Agencies may select from the optional strategies if the current suite of recommended strategies is not demonstrating sufficient progress toward achieving interim or final numeric goals, and if other identified triggers are met.

Table I-4 City of San Diego Jurisdictional Strategies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Jurisdictional Strategies						
Development Planning						
All Development Projects						
CSD-1	Establish guidelines and standards for all development projects; provide technical support related to implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area or implement easements to protect water quality, where applicable and feasible. Includes internal coordination and collaboration between City departments (DSD, PWD, and Engineering) to improve success and long-term benefits of BMPs.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-1.1	Investigation and research of emerging technology.	Annually the Construction & Development Standards Group identifies new tasks to conduct literature review, communication with researchers outside of the City, physical testing and experimentation of new or emerging technologies, and other research with the goal of updating tools available for reducing pollutant loads from development and redevelopment sites.	City-wide	Prior to FY16	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-1.2	Approve and implement a green infrastructure policy.	The City will begin developing a policy in FY16 that will increase the green infrastructure requirements for City CIP projects. This policy will be coordinated with ongoing efforts to update City design manuals and LID design standards for public LID BMPs.	City-wide on public parcels	FY16 (Begin)	As needed	T&SW with DSD and PWD
CSD-1.3	Develop Design Standards for Public LID BMPs.	Improve quality of design to ensure efficiency and reliability in public designs.	City-wide	FY14-FY15	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-1.4	Outreach to impacted industry regarding minimum BMP requirement updates.	Affects commercial, industrial, and residential development.	City-wide	FY15	As needed	TBD
CSD-2	Train staff on LID regulatory changes and LID practices.	Formal training is required for all staff involved in development plan review to increase knowledge of LID BMPs. Goal of training associated with LID practices and regulations is to promote LID implementation and to avoid adverse conditions such as trees planted within swales, or planned drainage patterns which obstruct or inhibit LID performance.	City-wide	FY16	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-3	Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities to support compliance with the MS4 Permit and TMDLs in a reasonable manner. Ensure consistency with the City of San Diego's BMP Design Manual. Update the Storm Water Standards Manual accordingly.	Municipal codes and ordinances will be brought to City Council for consideration to encourage LID implementation (e.g., runoff detention and filtration using natural filters and stormwater retention for reuse). LID stormwater management will be encouraged in proposed codes and ordinances associated with development and redevelopment projects, which are brought to City Council for consideration.	City-wide	FY15	As needed	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-4	Create a manual that outlines right-of-way design standards.	Create a manual that includes flood control performance standards, permanent BMP elements design standards, design standards for green streets and other BMPs, and maintenance access. Provides drainage and streets design standards. Opportunity to merge various existing manuals and provide consistency.	City-wide	FY15	One time	T&SW with DSD and PWD
CSD-5	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	Technical education and outreach to the development community includes outreach on design standards, City design manuals, and the WMAA.	City-wide	Prior to FY16	Ongoing	T&SW with DSD
Priority Development Projects (PDPs)						
CSD-6	For PDPs, provide technical support to other City departments to ensure implementation of on-site structural BMPs to control pollutants and manage hydromodification by developing City wide storm water development standards and design guidelines.	Coordinate with other City departments to promote and confirm a thorough understanding of requirements for implementing structural BMPs that control pollutants and manage hydromodification. Included in that understanding are requirements to confirm proper design and construction through processes controlled by other City departments.	City-wide	FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-6.1	Institute a program to verify and enforce maintenance and performance of treatment control BMPs.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Refer to JRMP (currently under development).	City-wide	FY15	Every 5 years/ permit cycle	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7.1	Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.	Amend BMP Design Manual and zoning standards/requirements which address reduction of pollutants for common areas of trash build-up (e.g. restaurants, supermarkets, "big box" retail stores with food, pet stores). Most effective method for source control of bacteria and trash is to employ four-sized trash enclosures with a cover over trash areas.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7.2	Amend BMP Design Manual for animal-related facilities, such as such as animal shelters, "doggie day care" facilities, veterinary clinics, breeding, boarding and training facilities, groomers, and pet care stores.	Amend BMP Design Manual and zoning requirements (including retrofits) to provide supplemental standards for animal facilities (including animal shelters, dog daycares, veterinary clinics, groomers, pet car stores, and breeding, boarding, and training facilities). Supplemental standards may include requiring covered trash enclosures, identification of landscaped relief areas on site plans, ensuring drainage connections and treatment swales for areas that will not drain to the sanitary sewer, as well as inspection of grading, drainage, and landscaping for outdoor exercise areas.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-7.3	Amend BMP Design Manual for nurseries and garden centers.	Amend BMP Design Manual to provide supplemental standards for plant nurseries and garden centers. Standards will focus on reducing irrigation runoff, and loading of sediment, pesticides, and nutrients. Measures may include: covered outdoor storage, green waste management BMPs, improved irrigation efficiency to reduce dry-weather runoff, and containment of runoff from impervious areas where plants and materials are stored.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-7.4	Amend BMP Design Manual for auto-related uses.	Amend BMP Design Manual to provide supplemental standards for automotive-related uses to reduce loading of metals, oils, grease, and trash. Measures may include: four-sized covered trash enclosures, and careful review of auto-related usage areas (e.g. garage bays at repair shops) for grading, drainage, and drain connections to sanitary sewer systems.	City-wide	FY15	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-8	Develop and administer an alternative compliance program for on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5.	Refer to JRMP (currently under development).	City-wide	FY15	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-8.1	Create a fund that allows habitat acquisition, protection enhancement, and restoration in conjunction with other cooperating entities including community groups, academic institutions, state county, and federal agencies, etc.	This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, 4) partners have been identified and formal MOUs have been developed, and 5) consensus and community support has been achieved.	City-wide	Optional	TBD	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
Construction Management						
CSD-9	Coordinate with other City departments to promote and confirm a thorough understanding of requirements for implementing temporary BMPs that control sediment and other pollutants during the construction phase of projects. Included in that understanding are requirements to inspect at appropriate frequencies and effectively enforce requirements through process controlled by other City departments.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
Existing Development						
Commercial, Industrial, Municipal, and Residential Facilities and Areas						
CSD-10	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with DSD, PUD, & PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-10.1	Update minimum BMPs for existing residential, commercial, and industrial development. Specific updates to BMPs include required street sweeping, catch basin cleaning, and maintenance of private roads and parking lots in targeted areas.	Refer to JRMP (currently under development).	City-wide	FY15	Every 5 years	T&SW
CSD-10.2	Outreach to property managers and trash haulers to elevate the emphasis of power washing as a pollutant source.	Emphasis will be placed on non-compliant washing as an enforceable violation.	City-wide Residential, commercial and industrial areas	FY15	Ongoing	T&SW
CSD-10.3	Implement property based inspections.	Property-based inspections increase awareness and responsibility for individual properties to tackle issues associated with trash, landscapes, and parking areas. Expanding beyond the business-level inspections will achieve different and more effective opportunities for education, outreach, inspection, and enforcement to encourage water conservation strategies.	City-wide	Prior to FY16	Ongoing	T&SW
CSD-10.4	Review policies and procedures to ensure discharges from swimming pools meet permit requirements.	Verify and bring to City Council for consideration an update (as needed) for the City's Municipal Code (43.0301) to meet new permit requirements for swimming pool discharges.	City-wide	FY15	As needed	T&SW, City Attorney (Civil & Criminal)
CSD-11	Promote and encourage implementation of designated BMPs for residential and non-residential areas.	Landscape-based rebates are a "gateway" for adoption of other beneficial practices and are one of the nonstructural methods which address impacts from single-family residential areas (City of San Diego 2011 program development background study). Residential incentives can include: education and training (neighborhood watershed field days), and aggressive subsidies or rebates for grass replacement and rainwater harvesting. Existing programs will be expanded overall, and also have targeted expansion within specific subwatershed, particularly with highest water quality priority conditions.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, MWD, CWA & local water agencies
CSD-11.1	Residential and Commercial BMP: Rain Barrel	The existing PUD rebate program will continue for residential properties and expand for commercial properties for water collection, conservation, and reuse with rain barrels.	City-wide Residential Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
CSD-11.2	Residential and Commercial BMP: Grass Replacement	The existing PUD grass replacement cash rebate program will continue and expand for residential and commercial properties. Program encourages a reduction in water use through the conversion of non-artificial grass to water wise plant material, while maintaining a high level of living landscape to benefit the environment.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
CSD-11.3	Residential and Commercial BMP: Downspout Disconnect	Disconnecting downspouts provide alternate runoff pathways from rooftops, sidewalks, driveways, and roads. Disconnecting downspouts from residential areas to pervious land can allow for depression storage and infiltration.	City-wide Residential and Commercial Areas	FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-11.4	Residential and Commercial BMP: Microirrigation	The existing PUD micro-irrigation rebate program will continue and increase for residential and commercial properties. Application of microirrigation aims to improve the efficiency of landscape irrigation through the precise application of water.	City-wide Residential Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
CSD-11.5	Provide Onsite Water Conservation Surveys.	Provide free onsite water conservation surveys to commercial and residential customers to reduce overirrigation and to encourage water conservation.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing	T&SW with DSD, PUD, PWD, & local water agencies
MS4 Infrastructure						
CSD-12	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, channels as allowed by resource agencies, detention basins, etc.) for water quality improvement and for flood control risk management.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW
CSD-12.1	Enhanced catch basin cleaning to increase pollutant removal (up to 4 times per year) in the rainy season.	To increase pollutant load removal, catch basins will be cleaned up to four times per year in the rainy season. The City of San Diego's pilot study found that major pollutants may vary from neighborhood to neighborhood (yard waste versus trash and sediment). Implementation may be adapted based on catch basin record keeping and cleaning optimization. Increase in frequency will be phased over 4 Fiscal Years.	Los Peñasquitos WMA: High priority areas identified in pilot study	FY16	Ongoing	T&SW
CSD-12.2	Increased frequency of catch basin inspection and as-needed cleaning.	For every segment of channel that is cleared, the City will conduct an inspection and as-needed cleaning of every catch basin within 100 feet of the cleared segment of channel. Additional inspection and as-needed cleaning will occur every three months for one year after the segment of channel is cleared.	Los Peñasquitos WMA (31 open channel segments)	FY13	5 years (ends FY18)	T&SW
CSD-12.3	Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.	In order to limit inflow of pollutants and reduce pollutant loads, proactive measures will be taken to improve, repair, and replace MS4 components. The City of San Diego will start a multi-year program of repairing and replacing storm drain pipes to reduce sediment loading to the MS4. Development of an assessment management program and bond issues will be addressed. Exploration of daylighting pipes will take place where feasible and appropriate.	City-wide	FY16	Ongoing	T&SW
CSD-13	Coordinate with other City departments (PUD) to implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with PUD
CSD-13.1	Identify sewer leaks and areas for sewer pipe replacement prioritization.	Risk assessment to include identifying targeted areas (age, location, proximity to MS4), coming up with methodology, pilot, desktop exercise/analysis.	City-wide	FY16	As needed	T&SW with PUD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Roads, Street, and Parking Lots						
CSD-14	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW
CSD-14.1	Outreach to street sweeping enhancement-targeted areas.	Division staff will conduct a thorough education and outreach effort beginning months in advance of the expansion of sweeping routes. Staff will work with the affected Council offices, community stakeholders, non-governmental organizations and community groups to build community awareness and acceptance of the enhanced sweeping program.	Los Peñasquitos WMA	FY16	Ongoing	T&SW
CSD-14.2	Enhance street sweeping through equipment replacement (replace mechanical sweepers with regenerative air sweepers) and route optimization (sweep all routes twice per month) in targeted areas.	Following outreach and posting, street sweeping efforts will be increased in target areas (those with sediment or metals as a highest priority water quality conditions). Replacement of street sweeping equipment with high-efficiency regenerative air and vacuum-assisted sweepers over time is expected to further increase load reductions (even if current routes and frequencies remain unchanged).	Los Peñasquitos WMA	FY17	Ongoing	T&SW
CSD-14.3	Initiate sweeping of medians on high-volume arterial roadways.	Medians of roadways are also a potential source of pollutants. Consider implementing or increasing sweeping of medians. Consider mechanical and hand sweeping techniques.	City-wide	FY17	Ongoing	T&SW
CSD-14.4	Implement additional street sweeping (Settlement Agreement).	City shall increase street sweeping frequency by prioritizing high traffic commercial routes adjacent to maintained channel with vacuum-assisted sweeper for every 400 linear feet of vegetation that is removed (except for removal of invasive species, e.g., Arundo) within a drainage area. Sweeping shall be conducted in median areas that are not subject to regular sweeping routes, and shall occur at a frequency of at least once per quarter for one calendar year after maintenance.	Los Peñasquitos WMA	FY13	5 years (ends FY18)	T&SW
Pesticide, Herbicides, and Fertilizer BMP Program						
CSD-15	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Refer to JRMP (currently under development).	City-wide	FY16	Ongoing	T&SW with Parks and Rec
Retrofit and Rehabilitation in Areas of Existing Development						
CSD-16	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Refer to JRMP (currently under development). The Offsite Alternative Compliance Program will include methods for identifying and assessing potential retrofit projects in existing development areas. Retrofit project selection will be based upon a variety of factors including proximity to high priority water quality conditions, potential pollutant load removal effectiveness, and feasibility of implementation. The program will include protocols related to funding mechanisms for project construction and long-term maintenance, payment and credit structures, and water quality equivalency standards.	City-wide	TBD	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-17	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Refer to JRMP (currently under development). The Offsite Alternative Compliance Program (Section 4.2.5.4 and Appendix N) will include methods for identifying and assessing potential stream, channel, or habitat rehabilitation projects in existing development areas. Rehabilitation project selection will be based upon a variety of factors including existing stream or habitat degradation, potential future cumulative stream or habitat impacts, and feasibility of implementation. The program will include protocols related to funding mechanisms for project construction and long-term maintenance, payment and credit structures, and water quality equivalency standards.	City-wide	TBD	Ongoing	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
Illicit Discharge, Detection, and Elimination (IDDE) Program						
CSD-18	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW
Public Education and Participation						
CSD-19	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW
CSD-19.1	Continue implementation of a Pet Waste Program.	Pet Waste Program includes outreach on "Scoop the poop", installation of posts for dispensers, distribution of lawn signs, and attendance at dog-related community activities.	City-wide	Prior to FY16	Ongoing	T&SW with Parks and Rec
CSD-19.2	Promote and encourage implementation of designated BMPs in commercial and industrial areas.	Provide education and outreach on BMPs for commercial businesses and industrial facilities.	City-wide Non-residential Areas	Prior to FY16	Ongoing	T&SW with PUD; Funding: Prop 84 and water districts (MWD)
CSD-19.3	Expand outreach to homeowners' association (HOA) common lands and HOA incentives.	Approaches to consider include: offering incentives to HOAs and maintenance districts to adopt water-conserving/efficiency and stormwater-reduction changes to their landscapes, irrigation, and maintenance; conducting workshops with property managers; providing supplemental standards, inspection, or enforcement for HOA-managed properties.	City-wide	FY16	Ongoing	T&SW
CSD-19.4	Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.	Approaches to engage HOAs and property managers include: conducting workshops with property managers, providing supplemental standards, inspections or enforcement around HOA properties, and offering incentives to HOAs and maintenance districts to adopt changes to landscapes, irrigation, or maintenance which promote water conservation or stormwater reduction. Property managers are also a target for enhanced outreach.	City-wide	FY16	Ongoing	T&SW

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-19.5	Enhance and expand trash cleanups through community-based organizations involving target audiences.	Increase effectiveness and reach of trash/beach cleanups and community based efforts by engaging community groups to self-define and carry-out trash clean-ups. Longstanding partnerships and sponsorships with I Love A Clean San Diego and others are recommended to be continued and enhanced. To effectively target stream clean-up efforts, focus on partnerships with community organizations which provide strong engagement with target audiences and communities.	City-wide	FY16	Ongoing	T&SW and Parks and Rec
CSD-19.6	Improve consistency and content of websites to highlight enforceable conditions and reporting methods.	Websites will be updated to provide a user-friendly format and clarity for stormwater violations, conditions which citizens can and should report, and how to make such reports. Examples of reports for common incidents will be developed and posted which may vary locally and regionally. Photographs of allowable practices as well as illegal practices should be shown for utmost clarity. Displaying hotline numbers prominently on the website and near the photographs of illegal practices will ensure that those seeking to report will be able to do so easily. Also ensure hotline number and website are searchable and can be retrieved by simple internet searches.	City-wide	Prior to FY16	Ongoing	T&SW
CSD-19.7	Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.	Educate residents on practices of small-scale or on-site composting to protect local water quality. May include targeted education of owners of chickens. Outreach can be coordinated through the San Diego County Agriculture, Weights, and Measures division.	Los Peñasquitos WMA	FY16	Ongoing	T&SW with County of San Diego Ag, Weights, and Measures
CSD-19.8	Enhance school and recreation-based education and outreach.	Develop curriculum and establish distribution in public schools. Includes education on water conservation.	City-wide	FY15	Ongoing	T&SW, PUD with community-based organization
CSD-19.9	Develop education and outreach to reduce irrigation runoff.	Example approaches to reduce or eliminate irrigation runoff may include: education and outreach, prohibition, enhanced enforcement of existing prohibitions, and pilot projects such as the City of Del Mar's pilot door hanger project.	City-wide	Prior to FY16	Ongoing	T&SW with PUD
CSD-19.10	Develop regional training for water-using mobile businesses.	Consider development of supplemental standards for mobile businesses including: covered trash enclosures, careful review of washing areas (grading, drainage, landscaping, sanitary sewer system connectivity), and appropriate signage (either through zoning for retrofits or "best fix" approaches, or through BMP Design Manual standards). Businesses may include carpet cleaners, tile installers, plumbers, etc.	City-wide	FY16	Ongoing	T&SW
CSD-19.11	Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.	Use effectiveness surveys to enhance existing education and outreach programs while proactively keeping up with and incorporating changing regulatory requirements.	City-wide	FY16	Ongoing	T&SW
CSD-19.12	Continue to promote and encourage implementation of Integrated Pest Management (IPM) for residents and businesses.	The City will continue to provide education on IPM techniques during presentations and on the City's Think Blue website.	City-wide	Prior to FY16	Ongoing	T&SW

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Enforcement Response Plan						
CSD-20	Continue to implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Storm Water Code Enforcement Unit's Standard Operating Procedures (SOPs) - Enforcement Response Plan.	Refer to JRMP (currently under development).	City-wide	Prior to FY16	Ongoing	T&SW with PUD, other City enforcement compliance programs
CSD-20.1	Increase enforcement of irrigation runoff.	Increased enforcement policies against irrigation runoff will be established in tandem with the education and outreach programs on how these actions lead to pollutant loading. By shifting to property-based inspections irrigation runoff can be handled as enforceable violations once the public is well-informed.	City-wide	FY16	Ongoing	T&SW
CSD-20.2	Increase enforcement of water-using mobile businesses.	In addition to education, pollution associated with mobile business sources can be handled through policy, code development, inspections of business practices, and enforcement.	City-wide	FY16	Ongoing	T&SW
CSD-21	Increase enforcement of all minimum BMPs for existing residential, commercial, and industrial development.	Increased enforcement of existing development minimum BMPs.	City-wide	FY16	As needed	T&SW
CSD-22	Increase enforcement associated with property-based inspections.	Shifting inspections from businesses-specific to property-based will increase effectiveness and sense of responsibility and ownership. Education and outreach must be followed up with inspection and enforcement of regulations to encourage proper landscape and water conservation strategies.	City-wide	FY16	Ongoing	T&SW
CSD-23	Increase enforcement of sweeping and maintenance of private roads and parking lots in targeted areas.	Refer to Minimum BMPs in JRMP.	City-wide	FY16	Ongoing	T&SW
CSD-24	Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.	Eroding and unstable slope areas on private property (excluding construction sites) will be identified as potential sediment loading sources and subject to enforcement. In the short term, this will target enhanced inspection and enforcement programs to ensure inspectors address erosion and slope instability for the purpose of education.	City-wide	FY16	Ongoing	T&SW
Additional Nonstructural Strategies						
CSD-25	Conduct a Comprehensive Benefits Analysis to identify benefits other than water quality that are applicable to each of the specific WQIP strategies.	The analysis identifies which other benefits apply to each strategy, and documents the assumptions making those linkages. The delineation of other benefits to strategies includes a general description of each benefit, and a listing of the assumptions that were made to link those benefits to strategies. In addition, the other benefits are characterized with respect to who is directly affected: the city, local residents, local businesses, or visitors. This analysis may be used as part of the adaptive management process to modify future strategies.	City-wide	FY15	One time	T&SW
CSD-26	Address and clean up trash from transient encampments with collaboration from the Homeless Outreach Team.	Coordinate with the Homeless Outreach Team to respond to transient encampment trash complaints.	City-wide	FY16	Ongoing	T&SW with Police, ESD, Urban Corps, Alpha Project

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CSD-27	Continue participating in source reduction initiatives.	Source reduction initiatives are ultimately the most effective measure to remove pollutants from surface waters, where feasible. Bans or progressive phase-outs that may be considered include: leaf blowers, plastic bags, architectural copper (generally a legacy issue), as well as prohibiting or more aggressively regulating vehicle washing. Additional source reduction initiatives to consider include pesticide sales at hardware stores and irrigation supply stores.	City-wide	Prior to FY16	Ongoing	T&SW
CSD-27.1	Coordinate with Fleet Services to replace City-owned vehicle brake pads with copper-free brake pads as they become commercially available.	Consider legislative mandate and cooperative implementation of copper-free brake pads on city-owned vehicle to reduce pollutant deposition.	City-wide	FY18	Ongoing	T&SW, ESD with PWD (Fleet Services)
CSD-28	Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property.	Actively identify and repair eroding slopes that may be contributing to sediment loading. Prepare an inventory and assessment of eroding areas and their risk to surface waters. Follow assessment with a schedule for ongoing inspection and stabilization (potentially based on a number or percentage of sites annually). Consider Caltrans program as a template.	City-wide	FY16	Ongoing	T&SW
CSD-29	Conduct special studies.	Special studies will be conducted to gather data to identify pollutant sources, appropriate targets, or other information. Includes collaboration with universities.	City-wide	FY16	Ongoing	T&SW
CSD-29.1	Los Peñasquitos Watershed Special Study	Los Peñasquitos WMA special study will assess sediment loads in the watersheds upstream of the Draft Sediment TMDL compliance monitoring locations. Includes the analysis of sediment water column loads, stream bedload, and air monitoring. Implemented in a phased approach. Monitoring will occur first in the Carroll Canyon subwatershed. The Los Peñasquitos Creek and Carmel Valley Creek subwatersheds will be monitored in subsequent phases. Refer to Section 5.1 for further details.	Los Peñasquitos WMA	FY16	One time	T&SW
CSD-29.2	Participate in Reference Watershed Study.	The San Diego Regional Reference Stream Study (currently being conducted by the Southern California Coastal Water Research Project). The study will develop numeric targets that account for “natural sources” to establish the concentrations or loads from streams in a minimally disturbed or “reference” condition. Refer to Section 5.1 for further details.	Region-wide	Prior to FY16	One time	T&SW, SCCWRP, Regional copermittees
CSD-29.3	Participate in Reference Beach Study.	The San Diego Regional Reference Beach Study will develop numeric targets that account for “natural sources” to establish the concentrations or loads from the beach in a minimally disturbed or “reference” condition. The purpose of this monitoring program is to advise the public of potential health risks that could occur with water contact recreation at local beaches. DEH will post a health advisory notice or close a beach when FIB results are above REC-1 water quality standards.	Region-wide (Los Peñasquitos WMA)	Prior to FY16	One time	T&SW, SCCWRP, Regional copermittees
CSD-29.4	Using adaptive management, delist the beach segment from the TMDL and Attachment E of the MS4 Permit.	Using the adaptive management process outlined in Section 6, remove 303(d) delisted beach segments from the Bacteria TMDL and Attachment E of the MS4 Permit.	Los Peñasquitos WMA	FY16	Ongoing	T&SW, Potential Stakeholders, Coastkeeper

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-29.5	Conduct a Cost of Service Study.	Conduct a Cost of Service Study that will examine the full cost of flood control and storm water strategies needed to comply with storm water regulations for the City of San Diego. The City of San Diego's Watershed Asset Management Plan will be used as the basis for the study.	City-wide	FY16	One time	TBD
CSD-29.6	Conduct a special study on outfall repair/relocation.	Implement fourth phase of a special study which will identify priority locations for outfall repair/relocation and sediment load reductions.	Los Peñasquitos WMA	FY16	One time	T&SW
CSD-30	Conduct Sustainable Return on Investment (SROI) analysis to estimate strategies' co-benefits and impacts to the public and the private sector on a common scale.	SROI is an economics-based framework for evaluating quantitative and qualitative performance metrics and monetizing them, if possible, along a triple bottom line (i.e. financial, societal, and environmental). This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, 4) partners have been identified and formal MOUs have been developed, and 5) consensus and community support has been achieved.	City-wide	Optional	TBD	T&SW and public participation
CSD-31	Collaborate with the County, if a County-led regional social services effort is established, to provide sanitation and trash management for individuals experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	Support a non-profit or consortium to provide sanitation services associated with hygiene as well as trash management for persons experiencing homelessness. Rented or purchased shower/sanitary trailers providing mobile showers may be organized at specifically scheduled locations and times. This provision has been proposed as a method for preventing surface water usage for sanitation and bathing, as well as opportunity for outreach and referral by social service agencies. The trash management services will include providing trash bags, trash collection areas, and shower/sanitary facilities at centers which provide daytime shelter to their clients, or on a mobile-basis for known transit camps. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, 4) partners have been identified and formal MOUs have been developed, and 5) consensus and community support has been achieved.	City-wide	Optional	TBD	T&SW
CSD-32	Participate in an assessment to determine if implementation of an urban tree canopy (UTC) program would benefit water quality and other City goals, where feasible.	Perform a feasibility study to determine if implementing an UTC program would be beneficial to the City's goals. UTC intercepts rainfall through increased coverage of leaves, branches, and stems and reduces runoff from the storm drainage system. Benefits associated with enhancing an UTC include reducing heat island effects and air pollution in addition to aesthetics and community benefits. Where feasible, native trees will be utilized to prevent invasive trees from migrating to open spaces and to conserve water. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	City-wide	Optional	TBD	Planning Dept. with T&SW, SANDAG, and Nature Conservancy

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CSD-33	Conduct a feasibility study to test Permeable Friction Course (PFC), a porous asphalt that overlays impermeable asphalt.	Perform an assessment to determine the feasibility of implementing PFC on City streets. PFC, an overlay of porous asphalt, is an innovative roadway material that improves driving conditions in wet weather and water quality. Placed in a layer 25-50mm thick on top of regular impermeable pavement, PFC allows rainfall to drain within the porous layer rather than on top of the pavement. PFC has also been shown to reduce concentrations of pollutants commonly observed in highway runoff. PFC incorporates stormwater treatment into the roadway surface and does not require additional right-of-way. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	City-wide	Optional	One time	T&SW with DSD, PWD, BIA, NGOs, Copermittees, and Engineering Community
CSD-34	As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and accepting privately-owned undeveloped open areas.	This strategy may be implemented if there is interest in participation by the public or private entity with current control of the land. Conditions to be met also include 1) identification of partners, if needed (public, private, non-profit), 2) identification of costs and potential sources of funding, 3) final agreement by public or private entity with current control of the land, 4) final agreement by all other participating partners including acceptance by intended land- or asset-owning City department, 5) funding in place, and 6) if it can be determined that the benefit of preventing increased pollutant loads and minimizing impacts of future growth through land conservation is a more cost effective strategy to meet interim and final numeric goals than other recommended strategies included in this plan (Chesapeake Bay Commission, 2013).	City-wide	Optional	TBD	TBD
CSD-35	Participate in a watershed council or group if one is established.	This strategy may be triggered as 1) partners have been identified and formal MOUs have been developed and 2) consensus and community support has been achieved.	City-wide	Optional	TBD	TBD
CSD-36	Prohibit introduction of invasive plants in new development and redevelopment projects.	Coordinate with the City's Development Services Department to continue to prohibit introduction of invasive species such as Arundo donax and Cortaderia selloana for new development or redevelopment projects as specified in the City's municipal code for landscape.	City-wide	Prior to FY16	Ongoing	T&SW with DSD
CSD-37	Collaborate with watershed stakeholders to plan and implement projects that will further Los Peñasquitos Lagoon restoration efforts and reduce flooding in the lower watershed.	Efforts may include 1) dredging of tidal channels and inlet area to restore and maintain tidal circulation and facilitate draw down times of floodwater in the lagoon and 2) modeling and/or studies to analyze sediment transport and flood control options. This strategy may be triggered as 1) funding is identified and secured, 2) staff resources are identified and secured, 3) partners have been identified and formal MOUs are developed and executed, 4) permits required by regulatory agencies are secured, and 5) consensus and community support is achieved.	Los Peñasquitos WMA	Optional	TBD	T&SW

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Green Infrastructure						
CSD-38	Del Mar Mesa Neighborhood Park (Project 985)	This site contains small catchment basins and some impervious areas treated by landscape buffers to treat a drainage area of 3.0 acres.	Los Peñasquitos Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-39	Miramar Water Treatment Plant (Project ID 1177)	Vegetated swales (19,213 SF) are in-place to treat an 18-acre drainage area.	Los Peñasquitos Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-40	Carroll Canyon Road Extension (Project ID 1007)	Vegetated swale will treat onsite runoff of a drainage area of 5.3 acres, in conjunction with other multiuse treatment areas.	Carroll Canyon Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-41	Mira Mesa Library Green Lot	Permeable pavement and bioretention is in-place in the parking lot and treats a drainage area of 1.22 acres.	Los Peñasquitos Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-42	Camino Ruiz Neighborhood Park (Project ID 140)	Vegetated swale is in-place to treat on-site runoff of a drainage area of 1.49 acres. Two bioretention areas are proposed to provide treatment of runoff generated by the 85th percentile storm from the parking lot area. These facilities are proposed to be installed within existing landscaping areas. Additional storage is required to capture the 85th percentile runoff volume from the north side of the parking area and is proposed to be provided in permeable pavement parking stalls adjacent to the proposed bioretention area. The retrofit exceeds applicable regulatory requirements by treating runoff from impervious surfaces through bioretention to capture the 85th percentile storm runoff.	Los Peñasquitos Creek Subwatershed	FY15	Ongoing	T&SW with PWD
CSD-43	Breen Park Site - Development (Project ID 857 & 858 & 859 & 860)	Vegetated swales are in-place to treat on-site runoff of a drainage area of 1.33 acres. Swales adjacent to the parking lot are proposed to be converted into bioretention areas to provide treatment for the runoff generated by the 85th percentile storm. The landscaped area on the north side of the park entrance is proposed to be converted to a bioretention area to provide additional treatment of existing impervious area that currently discharges from the site with no treatment. The retrofit exceeds applicable regulatory requirements by treating runoff from 50,377 more square feet of impervious surface than the initial site design and providing enhanced pollutant removal through bioretention and treatment of the 85th percentile storm.	Los Peñasquitos Creek Subwatershed	FY15	Ongoing	T&SW with PWD
CSD-44	Rancho Peñasquitos Skate park (Project ID 866)	Two small infiltration units (basins/trenches) are used to treat on-site runoff of a drainage area of 2.08 acres.	Los Peñasquitos Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-45	Fire Station #47 (Project ID 992)	Vegetated swale is in-place to treat on-site runoff of a drainage area of 1 acre.	Carmel Valley Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-46	Torrey Del Mar Neighborhood Park (Project ID 1022)	Two vegetated filter strips and two vegetated swales are in-place to treat on-site runoff of a drainage area of 3.68 acres.	Carmel Valley Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-47	Hilltop Community Park- Development of bioretention areas	Two bioretention facilities are proposed to provide for treatment of the majority of the study area, a drainage area of 0.273 acres. An existing landscaped area near Oviedo Way is proposed to be converted to a bioretention area along with the conversion of three landscaped areas within the existing parking lot area to bioretention areas. The parking lot bioretention areas are proposed to be linked by a narrow bioswale between parking stalls. Additional treatment is proposed to be provided through the conversion of 5 parking stalls to permeable pavement. The retrofit exceeds applicable regulatory requirements by treating runoff from impervious surfaces through bioretention to treat the 85th percentile storm runoff.	Carmel Valley Creek Subwatershed	FY15	Ongoing	T&SW with PWD
CSD-48	0.96 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 24-acre drainage area.	Staggered construction, operation, and maintenance of 0.96 acres of bioretention to treat a 24-acre drainage area.	Carmel Valley Creek Subwatershed	FY22	Ongoing	T&SW with PWD; Potential to collaborate with transit agencies, public school districts, and state and federal agencies
CSD-49	17.18 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 429.5-acre drainage area.	Staggered construction, operation, and maintenance of 17.18 acres of bioretention to treat a 429.5-acre drainage area.	Carroll Canyon Creek Subwatershed	FY26	Ongoing	T&SW with PWD; Potential to collaborate with transit agencies, public school districts, and state and federal agencies
CSD-50	2.40 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 60-acre drainage area.	Staggered construction, operation, and maintenance of 2.40 acres of bioretention to treat a 60-acre drainage area.	Los Peñasquitos Creek Subwatershed	FY26	Ongoing	T&SW with PWD; Potential to collaborate with transit agencies, public school districts, and state and federal agencies
CSD-51	1.33 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 32.5-acre drainage area.	Staggered construction, operation, and maintenance of 1.33 acres of bioretention to treat a 32.5-acre drainage area.	Los Peñasquitos Lagoon Subwatershed	FY28	Ongoing	T&SW with PWD; Potential to collaborate with transit agencies, public school districts, and state and federal agencies

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Green Streets						
CSD-52	53.2 acres of green streets (26.6 acres of bioretention and 26.6 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 1,746.8-acre drainage area.	Staggered construction, operation and maintenance of 53.2 acres of green streets (26.6 acres of bioretention and 26.6 acres of pervious pavement) to treat a 1746.8-acre drainage area.	Carmel Valley Creek Subwatershed	FY19	Ongoing	T&SW
CSD-53	55.92 acres of green streets (27.96 acres of bioretention and 27.96 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 2,345.5-acre drainage area.	Staggered construction, operation and maintenance of 55.92 acres of green streets (27.96 acres of bioretention and 27.96 acres of pervious pavement) to treat a 2345.5-acre drainage area.	Carroll Canyon Creek Subwatershed	FY23	Ongoing	T&SW
CSD-54	121.42 acres of green streets (60.71 acres of bioretention and 60.71 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 4,128.6-acre drainage area.	Staggered construction, operation and maintenance of 121.42 acres of green streets (60.71 acres of bioretention and 60.71 acres of pervious pavement) to treat a 4,128.6-acre drainage area.	Los Peñasquitos Creek Subwatershed	FY18	Ongoing	T&SW
CSD-55	9.06 acres of green streets (4.53 acres of bioretention and 4.53 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 261.92-acre drainage area.	Staggered construction, operation and maintenance of 9.06 acres of green streets (4.53 acres of bioretention and 4.53 acres of pervious pavement) to treat a 261.92-acre drainage area.	Los Peñasquitos Lagoon Subwatershed	FY28	Ongoing	T&SW
Multiuse Treatment Areas						
Infiltration and Detention Basins						
CSD-56	Ashley Falls	A 10.16 acre retention basin (large scale storm storage) designed to capture 29.7 acres.	Los Peñasquitos Creek Subwatershed	FY19	Ongoing	T&SW with PWD
CSD-57	Flintkote Sediment Detention Basin	A 0.2 acre sediment detention basin designed to treat 35 acres.	Los Peñasquitos Lagoon Subwatershed	FY28	Ongoing	T&SW with PWD
CSD-58	Upper Sorrento Valley Road Sediment Detention Basin	An 11.1 acre sediment detention basin designed to treat 9,306 acres.	Carroll Canyon Creek Subwatershed	FY22	Ongoing	T&SW with PWD
CSD-59	Los Peñasquitos Lagoon Sediment Basin	Construction of a custom-designed basin to maximize sediment interception from Los Peñasquitos Creek, while minimizing effects on surrounding habitat and protecting nearby developments from flooding and preserving view corridors of nearby residents (Los Peñasquitos Lagoon Sediment Basin Monitoring & Maintenance Plan). Total footprint for this basin is 10.16 acres designed to treat 36,375 acres.	Los Peñasquitos Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-60	A surface infiltration basin can be implemented in open space adjacent to Carmel Knolls Drive upon detailed site assessment.	Construction, operation and maintenance of a 2.3 acre (footprint) surface infiltration basin to treat a drainage area of approximately 301 acres (on 2.3 acres of available space, APN 3044604700).	Carmel Valley Creek Subwatershed	FY22	Ongoing	T&SW with PWD
CSD-61	A subsurface detention basin in Sandburg Park upon detailed site assessment.	Construction, operation and maintenance of a 3.2 acre (footprint) surface detention basin to treat a drainage area of approximately 268 acres (on 5 acres of available space, APN 3093215000). Subsurface detention basins would be designed and constructed per all applicable City safety codes and standards.	Los Peñasquitos Creek Subwatershed	FY26	Ongoing	T&SW with PWD
CSD-62	A surface infiltration basin can be implemented in Carmel Creek Neighborhood Park and Elementary School upon detailed site assessment.	Construction, operation and maintenance of a 1.5 acre (footprint) surface infiltration basin to treat a drainage area of approximately 66 acres (on 11.5 acres of available space, APN 3044501200).	Carmel Valley Creek Subwatershed	FY22	Ongoing	T&SW with PWD
CSD-63	A dry extended detention basin can be implemented in Maddox Park upon detailed site assessment.	Construction, operation and maintenance of a 5 acre (footprint) dry extended detention basin to treat a drainage area of approximately 570 acres (on 5 acres of available space, APN 3110304100).	Carroll Canyon Creek Subwatershed	FY22	Ongoing	T&SW with PWD
CSD-64	A subsurface detention basin can be implemented in Dingeman Elementary School and Spring Canyon Park upon detailed site assessment.	Construction, operation and maintenance of a 3.6 acre (footprint) subsurface detention basin to treat a drainage area of approximately 559 acres (on 11 acres of available space, APN 3194721200). Subsurface detention basins would be designed and constructed per all applicable City safety codes and standards.	Los Peñasquitos Creek Subwatershed	FY26	Ongoing	T&SW with PWD
CSD-65	A dry extended detention basin in open space next to Canyonside Park Driveway can be implemented upon detailed site assessment.	Construction, operation and maintenance of a 1.8 acre (footprint) dry extended detention basin to treat a drainage area of approximately 181 acres (on 4.6 acres of available space, APN 3094130100).	Los Peñasquitos Creek Subwatershed	FY26	Ongoing	T&SW with PWD
CSD-66	A subsurface detention gallery can be implemented in Del Mar Trails Park upon detailed site assessment.	Construction, operation and maintenance of a 0.1 acre (footprint) subsurface detention gallery to treat a drainage area of approximately 19 acres (on 3 acres of available space, APN 3073316700). Subsurface detention basins would be designed and constructed per all applicable City safety codes and standards.	Carmel Valley Creek Subwatershed	FY22	Ongoing	T&SW with PWD
CSD-67	A subsurface detention basin in Mira Mesa High school can be implemented upon detailed site assessment.	Construction, operation and maintenance of a 2.9 acre (footprint) subsurface detention basin to treat a drainage area of approximately 261 acres (on 9.6 acres of available space, APN 3110410200). Subsurface detention basins would be designed and constructed per all applicable City safety codes and standards.	Carroll Canyon Creek Subwatershed	FY22	Ongoing	T&SW with PWD
CSD-68	A subsurface detention gallery can be implemented in Sage Canyon Park upon detailed site assessment.	Construction, operation and maintenance of a 0.1 acre (footprint) subsurface detention gallery to treat a drainage area of approximately 14.4 acres (on 7.5 acres of available space; APN 4476123700, APN 4476123600). Subsurface detention basins would be designed and constructed per all applicable City safety codes and standards.	Los Peñasquitos Creek Subwatershed	FY26	Ongoing	T&SW with PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-69	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin(s) may be considered on publicly owned open spaces in canyon areas on a case-by-case basis when no other opportunities for load reductions exist.	Construction, operation, and maintenance of infiltration basin(s) in canyon areas. 8 potential canyon sites, owned by City of San Diego, have been identified in Los Peñasquitos WMA that provide up to 60 acres of available space (out of 174 acres of total parcel acreage). This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, and 3) staff resources are identified and secured.	Los Peñasquitos WMA	Optional	TBD	T&SW with PWD
Stream, Channel and Habitat Rehabilitation Projects						
CSD-70	El Cuervo del Norte Wetlands	The El Cuervo Norte wetlands were built upon 23.3 acres upstream of the long-term MLS monitoring station. Flows from Los Peñasquitos Creek are diverted into the wetlands, creating the potential for solids to settle out and thus reduce the TSS measured at the MLS.	Los Peñasquitos Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-71	El Cuervo del Sur Wetlands	On a total of 2.3 acres, the primary mitigation strategy in this plan involve the minor grading (one to three feet) of the Site to create three riparian plant zones. Maintenance activities planned during the maintenance and monitoring program revolve around the establishment of the plantings to a self-sufficient state.	Los Peñasquitos Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-72	If interim load reduction goals are not met and additional stream, channel, and habitat rehabilitation projects are required, implement as needed.	This strategy may be triggered as 1) funding to address MS4 discharges is identified and secured, 2) staff resources are identified and secured, 3) partners have been identified and formal MOUs have been developed, 4) permits required by regulatory agencies are secured, 5) recommendations from the community are identified and consensus and community support has been achieved, and 6) it can be determined that the benefit of preventing increased pollutant loads and minimizing impacts of future growth through land conservation is a more cost effective strategy to meet interim and final numeric goals than other recommended strategies included in this plan (Chesapeake Bay Commission, 2013).	Areas identified during feasibility studies	Optional	TBD	T&SW
Water Quality Improvement BMPs						
Proprietary BMPs						
CSD-73	Rehco Rd.	A HSU unit is used to treat onsite runoff on the north end of Rehco Road.	Carroll Canyon Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-74	North Torrey Pines Road Bridge (Project ID 1017)	Two drainage inserts are used to treat onsite runoff.	Carroll Canyon Creek & Los Peñasquitos Lagoon Subwatersheds	Prior to FY16	Ongoing	T&SW with PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
CSD-75	Scripps Ranch Boulevard Median Improvements (Project ID 901)	Two bioclean drainage inserts are used to treat onsite runoff.	Carroll Canyon Creek & Los Peñasquitos Lagoon Subwatersheds	Prior to FY16	Ongoing	T&SW with PWD
CSD-76	Northwest Area Police Substation (Project ID 1365)	A Hydrodynamic Separation System is used to treat onsite runoff.	Los Peñasquitos WMA	Prior to FY16	Ongoing	T&SW with PWD
CSD-77	Peñasquitos West Grading (Project ID 1051)	Two Hydrodynamic Separation Systems are used to treat onsite runoff.	Carmel Valley Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-78	Carmel Valley Road Enhancements (Project ID 860)	Hydrodynamic Separation Systems are used to treat onsite runoff.	Carmel Valley Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-79	Genesee Widening (Project ID 900)	Hydrodynamic Separation Systems are used to treat onsite runoff.	Carroll Canyon Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-80	Mira Sorrento Place and Vista Sorrento Parkway (Project ID 850)	Hydrodynamic Separation Systems are used to treat onsite runoff.	Carroll Canyon Creek Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-81	Ocean Air Park (Project ID 906)	Hydrodynamic Separation Systems are used to treat onsite runoff.	Los Peñasquitos Lagoon Subwatershed	Prior to FY16	Ongoing	T&SW with PWD
CSD-82	Otay Mesa/ Nestor Library- Development of treatment unit.	Because of the limited space available at the site and geotechnical issues associated with the proximity to steep slopes, it is recommended that a Filterra type or approved equivalent treatment unit be retrofitted to treat flows from the 85th percentile storm. The retrofit exceeds applicable regulatory requirements by treating runoff from 11,800 more square feet of impervious surface than the initial site design and by treating flows from the 85th percentile storm.	Los Peñasquitos WMA	FY15	Ongoing	T&SW with PWD
Dry Weather Flow Separation and Treatment Projects						
CSD-83	If interim load reduction goals are not met and additional dry weather flow separation and treatment projects are required, implement as needed.	Construction of dry weather flow separation and treatment projects, where identified. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, and 4) permits required by regulatory agencies are secured.	Downstream reaches where persistent dry weather flows have been observed	Optional	TBD	T&SW with PWD

ID	Strategy	Implementation Approach	Location	Implementation or Construction Year Start	Frequency of Implementation	Responsible City Department and Other Collaborating Departments or Agencies
Trash Segregation						
CSD-84	If interim load reduction goals are not met and additional trash segregation projects are required, implement as needed.	Construction of trash segregation (Trash Guards, etc.) projects, where identified. This strategy may be triggered as 1) interim goals are not met, 2) funding to address MS4 discharges is identified and secured, 3) staff resources are identified and secured, and 4) permits required by regulatory agencies are secured.	High-loading areas city-wide	Optional	TBD	T&SW with PWD
Additional Opportunities						
CSD-85	Participate in restorative efforts for the Los Peñasquitos Lagoon in collaboration with TMDL Responsible Parties and other stakeholders.	Collaborate with TMDL Responsible Parties and other stakeholders to promote and support the restoration of the Los Peñasquitos Lagoon. Efforts will be coordinated with the Lagoon Enhancement Program currently being updated by the Los Peñasquitos Lagoon Foundation. This effort will require that 1) funding to address MS4 discharges is identified and secured, 2) staff resources are identified and secured, 3) partners are identified and formal MOUs are developed and executed, 4) permits required by regulatory agencies are secured, and 5) consensus and community support are achieved.	Los Peñasquitos Lagoon Subwatershed	FY20	Ongoing	T&SW with TMDL Responsible Parties and Los Peñasquitos WMA stakeholders
CSD-86	Through adaptive management and additional analysis in the future, the City will identify and implement one or more of the following opportunities to meet numeric goals: 1) MS4 outfall repair and relocation, 2) slope stabilization, 3) stream restoration, 4) implementation of sediment detention basins upstream of Los Peñasquitos Lagoon or 5) new strategies not yet identified.	Through adaptive management and additional analysis in the future, the City will identify and implement one or more of the following opportunities to meet numeric goals: 1) MS4 outfall repair and relocation, 2) slope stabilization, 3) stream restoration, 4) implementation of sediment detention basins upstream of Los Peñasquitos Lagoon or 5) new strategies not yet identified.	Los Peñasquitos WMA	FY28	Ongoing	T&SW

Notes: DSD= Development Services Department; PUD = Public Utilities Department; PWD = Public Works Department; T&SW = Transportation and Storm Water Division; WAMP = Watershed Asset Management Plan; TBD = will be determined during the next fiscal year.

Reference: Chesapeake Bay Commission. 2013. *Crediting Conservation: Accounting for the Water Quality Value of Conserved Lands Under the Chesapeake Bay TMDL*. Available online at http://www.chesbay.us/Publications/CreditingConservationReport.pdf. June.

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Table I-5 City of San Diego Annual Schedule

Construction
Ongoing Implementation/ O&M
As needed/Design

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
Jurisdictional Strategies																								
Development Planning																								
All Development Projects																								
CSD-1	Establish guidelines and standards for all development projects; provide technical support related to implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area or implement easements to protect water quality, where applicable and feasible. Includes internal coordination and collaboration between City departments (DSD, PWD, and Engineering) to improve success and long-term benefits of BMPs.	City-wide	Prior to FY16	Ongoing																				
CSD-1.1	Investigation and research of emerging technology.	City-wide	Prior to FY16	As Needed																				
CSD-1.2	Approve and implement a green infrastructure policy.	City-wide on public parcels	FY16 (Begin)	As Needed																				
CSD-1.3	Develop Design Standards for Public LID BMPs.	City-wide	FY14-FY15	As Needed																				
CSD-1.4	Outreach to impacted industry regarding minimum BMP requirement updates.	City-wide	FY15	As Needed																				
CSD-2	Train staff on LID regulatory changes and LID practices.	City-wide	FY16		As Needed																			
CSD-3	Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities to support compliance with the MS4 Permit and TMDLs in a reasonable manner. Ensure consistency with the City of San Diego's BMP Design Manual. Update the Storm Water Standards Manual accordingly.	City-wide	FY15	As Needed																				
CSD-4	Create a manual that outlines right-of-way design standards.	City-wide	FY15	One time																				
CSD-5	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	City-wide	Prior to FY16	Ongoing																				
Priority Development Projects (PDPs)																								
CSD-6	For PDPs, provide technical support to other City departments to ensure implementation of on-site structural BMPs to control pollutants and manage hydromodification by developing City wide storm water development standards and design guidelines.	City-wide	FY16		Ongoing																			
CSD-6.1	Institute a program to verify and enforce maintenance and performance of treatment control BMPs.	City-wide	FY16		Ongoing																			
CSD-7	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	City-wide	FY15	Cycle																				
CSD-7.1	Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.	City-wide	FY15	One time																				

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-7.2	Amend BMP Design Manual for animal-related facilities, such as such as animal shelters, "doggie day care" facilities, veterinary clinics, breeding, boarding and training facilities, groomers, and pet care stores.	City-wide	FY15	One time																				
CSD-7.3	Amend BMP Design Manual for nurseries and garden centers.	City-wide	FY15	One time																				
CSD-7.4	Amend BMP Design Manual for auto-related uses.	City-wide	FY15	One time																				
CSD-8	Develop and administer an alternative compliance program for on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects). Refer to Section 4.2.5.	City-wide	FY15	Ongoing																				
CSD-8.1	Create a fund that allows habitat acquisition, protection enhancement, and restoration in conjunction with other cooperating entities including community groups, academic institutions, state county, and federal agencies, etc.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
Construction Management																								
CSD-9	Coordinate with other City departments to promote and confirm a thorough understanding of requirements for implementing temporary BMPs that control sediment and other pollutants during the construction phase of projects. Included in that understanding are requirements to inspect at appropriate frequencies and effectively enforce requirements through process controlled by other City departments.	City-wide	FY16		Ongoing																			
Existing Development																								
Commercial, Industrial, Municipal, and Residential Facilities and Areas																								
CSD-10	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.	City-wide	FY16		Ongoing																			
CSD-10.1	Update minimum BMPs for existing residential, commercial, and industrial development. Specific updates to BMPs include required street sweeping, catch basin cleaning, and maintenance of private roads and parking lots in targeted areas.	City-wide	FY15	Cycle																				
CSD-10.2	Outreach to property managers and trash haulers to elevate the emphasis of power washing as a pollutant source.	City-wide Residential, commercial and industrial areas	FY15	Ongoing																				
CSD-10.3	Implement property based inspections.	City-wide	Prior to FY16	Ongoing																				
CSD-10.4	Review policies and procedures to ensure discharges from swimming pools meet permit requirements.	City-wide	FY15	As Needed																				
CSD-11	Promote and encourage implementation of designated BMPs for residential and non-residential areas.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing																				
CSD-11.1	Residential and Commercial BMP: Rain Barrel	City-wide Residential Areas	Prior to FY16	Ongoing																				
CSD-11.2	Residential and Commercial BMP: Grass Replacement	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing																				

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-11.3	Residential and Commercial BMP: Downspout Disconnect	City-wide Residential and Commercial Areas	FY16		Ongoing																			
CSD-11.4	Residential and Commercial BMP: Microirrigation	City-wide Residential Areas	Prior to FY16	Ongoing																				
CSD-11.5	Provide Onsite Water Conservation Surveys.	City-wide Residential and Commercial Areas	Prior to FY16	Ongoing																				
MS4 Infrastructure																								
CSD-12	Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, channels as allowed by resource agencies, detention basins, etc.) for water quality improvement and for flood control risk management.	City-wide	FY16		Ongoing																			
CSD-12.1	Enhanced catch basin cleaning to increase pollutant removal (up to 4 times per year) in the rainy season.	Los Peñasquitos WMA: High priority areas identified in pilot study	FY16		Ongoing																			
CSD-12.2	Increased frequency of catch basin inspection and as-needed cleaning.	Los Peñasquitos WMA (31 open channel segments)	FY13																					
CSD-12.3	Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.	City-wide	FY16		Ongoing																			
CSD-13	Coordinate with other City departments (PUD) to implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.	City-wide	FY16		Ongoing																			
CSD-13.1	Identify sewer leaks and areas for sewer pipe replacement prioritization.	City-wide	FY16		As Needed																			
Roads, Street, and Parking Lots																								
CSD-14	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	City-wide	FY16		Ongoing																			
CSD-14.1	Outreach to street sweeping enhancement-targeted areas.	Los Peñasquitos WMA	FY16		Ongoing																			
CSD-14.2	Enhance street sweeping through equipment replacement (replace mechanical sweepers with regenerative air sweepers) and route optimization (sweep all routes twice per month) in targeted areas.	Los Peñasquitos WMA	FY17			Ongoing																		
CSD-14.3	Initiate sweeping of medians on high-volume arterial roadways.	City-wide	FY17			Ongoing																		
CSD-14.4	Implement additional street sweeping (Settlement Agreement).	Los Peñasquitos WMA	FY13																					
Pesticide, Herbicides, and Fertilizer BMP Program																								
CSD-15	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	City-wide	FY16		Ongoing																			

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
Retrofit and Rehabilitation in Areas of Existing Development																								
CSD-16	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	City-wide	TBD																					
CSD-17	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	City-wide	TBD																					
Illicit Discharge, Detection, and Elimination (IDDE) Program																								
CSD-18	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	City-wide	Prior to FY16	Ongoing																				
Public Education and Participation																								
CSD-19	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	City-wide	Prior to FY16	Ongoing																				
CSD-19.1	Continue implementation of a Pet Waste Program.	City-wide	Prior to FY16	Ongoing																				
CSD-19.2	Promote and encourage implementation of designated BMPs in commercial and industrial areas.	City-wide Non-residential Areas	Prior to FY16	Ongoing																				
CSD-19.3	Expand outreach to homeowners' association (HOA) common lands and HOA incentives.	City-wide	FY16		Ongoing																			
CSD-19.4	Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.	City-wide	FY16		Ongoing																			
CSD-19.5	Enhance and expand trash cleanups through community-based organizations involving target audiences.	City-wide	FY16		Ongoing																			
CSD-19.6	Improve consistency and content of websites to highlight enforceable conditions and reporting methods.	City-wide	Prior to FY16	Ongoing																				
CSD-19.7	Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.	Los Peñasquitos WMA	FY16		Ongoing																			
CSD-19.8	Enhance school and recreation-based education and outreach.	City-wide	FY15	Ongoing																				
CSD-19.9	Develop education and outreach to reduce irrigation runoff.	City-wide	Prior to FY16	Ongoing																				
CSD-19.10	Develop regional training for water-using mobile businesses.	City-wide	FY16		Ongoing																			
CSD-19.11	Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.	City-wide	FY16		Ongoing																			
CSD-19.12	Continue to promote and encourage implementation of Integrated Pest Management (IPM) for residents and businesses.	City-wide	Prior to FY16	Ongoing																				

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
Enforcement Response Plan																								
CSD-20	Continue to implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Storm Water Code Enforcement Unit's Standard Operating Procedures (SOPs) - Enforcement Response Plan.	City-wide	Prior to FY16	Ongoing																				
CSD-20.1	Increase enforcement of irrigation runoff.	City-wide	FY16		Ongoing																			
CSD-20.2	Increase enforcement of water-using mobile businesses.	City-wide	FY16		Ongoing																			
CSD-21	Increase enforcement of all minimum BMPs for existing residential, commercial, and industrial development.	City-wide	FY16		As needed																			
CSD-22	Increase enforcement associated with property-based inspections.	City-wide	FY16		Ongoing																			
CSD-23	Increase enforcement of sweeping and maintenance of private roads and parking lots in targeted areas.	City-wide	FY16		Ongoing																			
CSD-24	Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.	City-wide	FY16		Ongoing																			
Additional Nonstructural Strategies																								
CSD-25	Conduct a Comprehensive Benefits Analysis to identify benefits other than water quality that are applicable to each of the specific WQIP strategies.	City-wide	FY15	One time																				
CSD-26	Address and clean up trash from transient encampments with collaboration from the Homeless Outreach Team.	City-wide	FY16		Ongoing																			
CSD-27	Continue participating in source reduction initiatives.	City-wide	Prior to FY16	Ongoing																				
CSD-27.1	Coordinate with Fleet Services to replace City-owned vehicle brake pads with copper-free brake pads as they become commercially available.	City-wide	FY18				Ongoing																	
CSD-28	Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property.	City-wide	FY16		Ongoing																			
CSD-29	Conduct special studies.	City-wide	FY16		Ongoing																			
CSD-29.1	Los Peñasquitos Watershed Special Study	Los Peñasquitos WMA	FY16		One time																			
CSD-29.2	Participate in Reference Watershed Study.	Region-wide	Prior to FY16	One time																				
CSD-29.3	Participate in Reference Beach Study.	Region-wide (Los Peñasquitos WMA)	Prior to FY16	One time																				
CSD-29.4	Using adaptive management, delist the beach segment from the TMDL and Attachment E of the MS4 Permit.	Los Peñasquitos WMA	FY16		Ongoing																			
CSD-29.5	Conduct a Cost of Service Study.	City-wide	FY16		One time																			
CSD-29.6	Conduct a special study on outfall repair/relocation.	Los Peñasquitos WMA	FY16		One time																			
CSD-30	Conduct Sustainable Return on Investment (SROI) analysis to estimate strategies' co-benefits and impacts to the public and the private sector on a common scale.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-31	Collaborate with the County, if a County-led regional social services effort is established, to provide sanitation and trash management for individuals experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-32	Participate in an assessment to determine if implementation of an urban tree canopy (UTC) program would benefit water quality and other City goals, where feasible.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-33	Conduct a feasibility study to test Permeable Friction Course (PFC), a porous asphalt that overlays impermeable asphalt.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-34	As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and accepting privately-owned undeveloped open areas.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-35	Participate in a watershed council or group if one is established.	City-wide	Optional												If triggered, begin planning, acquiring funding and resources									
CSD-36	Prohibit introduction of invasive plants in new development and redevelopment projects.	City-wide	Prior to FY16	Ongoing																				
CSD-37	Collaborate with watershed stakeholders to plan and implement projects that will further Los Peñasquitos Lagoon restoration efforts and reduce flooding in the lower watershed.	Los Peñasquitos WMA	Optional												If triggered, begin planning, acquiring funding and resources									
Green Infrastructure																								
CSD-38	Del Mar Mesa Neighborhood Park (Project 985)	Los Peñasquitos Creek Subwatershed	Prior to FY16																					
CSD-39	Miramar Water Treatment Plant (Project ID 1177)	Los Peñasquitos Creek Subwatershed	Prior to FY16																					
CSD-40	Carroll Canyon Road Extension (Project ID 1007)	Carroll Canyon Creek Subwatershed	Prior to FY16																					
CSD-41	Mira Mesa Library Green Lot	Los Peñasquitos Creek Subwatershed	Prior to FY16																					
CSD-42	Camino Ruiz Neighborhood Park (Project ID 140)	Los Peñasquitos Creek Subwatershed	FY15																					
CSD-43	Breen Park Site - Development (Project ID 857 & 858 & 859 & 860)	Los Peñasquitos Creek Subwatershed	FY15																					
CSD-44	Rancho Peñasquitos Skate park (Project ID 866)	Los Peñasquitos Creek Subwatershed	Prior to FY16																					
CSD-45	Fire Station #47 (Project ID 992)	Carmel Valley Creek Subwatershed	Prior to FY16																					
CSD-46	Torrey Del Mar Neighborhood Park (Project ID 1022)	Carmel Valley Creek Subwatershed	Prior to FY16																					
CSD-47	Hilltop Community Park- Development of bioretention areas	Carmel Valley Creek Subwatershed	FY15																					

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32	FY 33	FY 34	FY 35
CSD-48	0.96 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 24-acre drainage area.	Carmel Valley Creek Subwatershed	FY22																					
CSD-49	17.18 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 429.5-acre drainage area.	Carroll Canyon Creek Subwatershed	FY26																					
CSD-50	2.40 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 60-acre drainage area.	Los Peñasquitos Creek Subwatershed	FY26																					
CSD-51	1.33 acres of bioretention have been identified as potential opportunities for green infrastructure implementation on public parcels to treat a 32.5-acre drainage area.	Los Peñasquitos Lagoon Subwatershed	FY28																					
Green Streets																								
CSD-52	53.2 acres of green streets (26.6 acres of bioretention and 26.6 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 1,746.8-acre drainage area.	Carmel Valley Creek Subwatershed	FY19																					
CSD-53	55.92 acres of green streets (27.96 acres of bioretention and 27.96 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 2,345.5-acre drainage area.	Carroll Canyon Creek Subwatershed	FY23																					
CSD-54	121.42 acres of green streets (60.71 acres of bioretention and 60.71 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 4,128.6-acre drainage area.	Los Peñasquitos Creek Subwatershed	FY18																					
CSD-55	9.06 acres of green streets (4.53 acres of bioretention and 4.53 acres of pervious pavement) have been identified as potential opportunities for green street projects to treat a 261.92-acre drainage area.	Los Peñasquitos Lagoon Subwatershed	FY28																					
Multiuse Treatment Areas																								
Infiltration and Detention Basins																								
CSD-56	Ashley Falls	Los Peñasquitos Creek Subwatershed	FY19																					
CSD-57	Flintkote Sediment Detention Basin	Los Peñasquitos Lagoon Subwatershed	FY28																					
CSD-58	Upper Sorrento Valley Road Sediment Detention Basin	Carroll Canyon Creek Subwatershed	FY22																					
CSD-59	Los Peñasquitos Lagoon Sediment Basin	Los Peñasquitos Creek Subwatershed	Prior to FY16																					
CSD-60	A surface infiltration basin can be implemented in open space adjacent to Carmel Knolls Drive upon detailed site assessment.	Carmel Valley Creek Subwatershed	FY22																					
CSD-61	A subsurface detention basin in Sandburg Park upon detailed site assessment.	Los Peñasquitos Creek Subwatershed	FY26																					
CSD-62	A surface infiltration basin can be implemented in Carmel Creek Neighborhood Park and Elementary School upon detailed site assessment.	Carmel Valley Creek Subwatershed	FY22																					

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-63	A dry extended detention basin can be implemented in Maddox Park upon detailed site assessment.	Carroll Canyon Creek Subwatershed	FY22																					
CSD-64	A subsurface detention basin can be implemented in Dingeman Elementary School and Spring Canyon Park upon detailed site assessment.	Los Peñasquitos Creek Subwatershed	FY26																					
CSD-65	A dry extended detention basin in open space next to Canyonside Park Driveway can be implemented upon detailed site assessment.	Los Peñasquitos Creek Subwatershed	FY26																					
CSD-66	A subsurface detention gallery can be implemented in Del Mar Trails Park upon detailed site assessment.	Carmel Valley Creek Subwatershed	FY22																					
CSD-67	A subsurface detention basin in Mira Mesa High school can be implemented upon detailed site assessment.	Carroll Canyon Creek Subwatershed	FY22																					
CSD-68	A subsurface detention gallery can be implemented in Sage Canyon Park upon detailed site assessment.	Los Peñasquitos Creek Subwatershed	FY26																					
CSD-69	If interim load reduction goals are not met and additional multiuse treatment areas are required, an infiltration basin(s) may be considered on publicly owned open spaces in canyon areas on a case-by-case basis when no other opportunities for load reductions exist.	Los Peñasquitos WMA	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to implement multiuse treatment area projects.									
Stream, Channel and Habitat Rehabilitation Projects																								
CSD-70	El Cuervo del Norte Wetlands	Los Peñasquitos Creek Subwatershed	Prior to FY16																					
CSD-71	El Cuervo del Sur Wetlands	Los Peñasquitos Creek Subwatershed	Prior to FY16																					
CSD-72	If interim load reduction goals are not met and additional stream, channel, and habitat rehabilitation projects are required, implement as needed.	Areas identified during feasibility studies	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to implement rehabilitation projects.									
Water Quality Improvement BMPs																								
Proprietary BMPs																								
CSD-73	Rehco Rd.	Carroll Canyon Creek Subwatershed	Prior to FY16																					
CSD-74	North Torrey Pines Road Bridge (Project ID 1017)	Carroll Canyon Creek & Los Peñasquitos Lagoon Subwatersheds	Prior to FY16																					
CSD-75	Scripps Ranch Boulevard Median Improvements (Project ID 901)	Carroll Canyon Creek & Los Peñasquitos Lagoon Subwatersheds	Prior to FY16																					
CSD-76	Northwest Area Police Substation (Project ID 1365)	Los Peñasquitos WMA	Prior to FY16																					
CSD-77	Peñasquitos West Grading (Project ID 1051)	Carmel Valley Creek Subwatershed	Prior to FY16																					

ID	Strategy	Location	Implementation or Construction Year Start	FY 15 and Earlier	FY 16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
CSD-78	Carmel Valley Road Enhancements (Project ID 860)	Carmel Valley Creek Subwatershed	Prior to FY16																					
CSD-79	Genesee Widening (Project ID 900)	Carroll Canyon Creek Subwatershed	Prior to FY16																					
CSD-80	Mira Sorrento Place and Vista Sorrento Parkway (Project ID 850)	Carroll Canyon Creek Subwatershed	Prior to FY16																					
CSD-81	Ocean Air Park (Project ID 906)	Los Peñasquitos Lagoon Subwatershed	Prior to FY16																					
CSD-82	Otay Mesa/ Nestor Library- Development of treatment unit.	Los Peñasquitos WMA	FY15																					
Dry Weather Flow Separation and Treatment Projects																								
CSD-83	If interim load reduction goals are not met and additional dry weather flow separation and treatment projects are required, implement as needed.	Downstream reaches where persistent dry weather flows have been observed	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to implement dry weather flow separation projects.									
Trash Segregation																								
CSD-84	If interim load reduction goals are not met and additional trash segregation projects are required, implement as needed.	High-loading areas city-wide	Optional												If triggered, begin planning (acquire funding and resources, conduct site feasibility analysis and site selection) to implement trash segregation projects.									
Additional Opportunities																								
CSD-85	Participate in restorative efforts for the Los Peñasquitos Lagoon in collaboration with TMDL Responsible Parties and other stakeholders.	Los Peñasquitos Lagoon Subwatershed	FY20																					
CSD-86	Through adaptive management and additional analysis in the future, the City will identify and implement one or more of the following opportunities to meet numeric goals: 1) MS4 outfall repair and relocation, 2) slope stabilization, 3) stream restoration, 4) implementation of sediment detention basins upstream of Los Peñasquitos Lagoon or 5) new strategies not yet identified.	Los Peñasquitos WMA	FY28																					

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I.5 County of San Diego Strategies

Open space, agriculture, and other low-density land uses cover much of the County of San Diego's jurisdiction within the Los Peñasquitos WMA. The jurisdictional strategies reflect this and were chosen because they are well suited for these types of land uses. The County of San Diego has identified the jurisdictional strategies in Table I-6 to assist in meeting the Water Quality Improvement Plan goals. A compliance analysis using a watershed model was conducted to identify the strategies required to be implemented to meet interim and final goals. The adaptive management process provides the framework to evaluate progress toward meeting the goals and allows for modification of strategies. As strategies are modified, the compliance analysis will be updated as needed to provide assurance that numeric goals will be met.

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Los Penesquitos Watershed
CoSD JRMP-WQIP Strategies

	Strategy	Program Type (see notes at bottom)	Permit Reference	Sources	Frequency	Schedule
Jurisdictional Runoff Management Programs (JRMP) Strategies						
Illicit Discharge, Detection, and Elimination (IDDE) Program						
1	Maintain MS4 map to facilitate IDDE program	Base	MS4 Permit, Section E.2.b(1)	N/A	Annually	FY15
2a	Use municipal personnel/contractors to identify and report ICIDs	Base	MS4 Permit, Section E.2.b(2)	IC/IDs	ongoing	ongoing
	updated focused training for County field staff	Enhanced		all pollutants	Annually	FY16
2b	Collect effluent on the ground (EOG), sanitary sewer overflow (SSO) data	Base	MS4 Permit, Section E.2.b( )	OWTS/SSO	ongoing	ongoing
	Address septic system failures where observed	Base		human sources	ongoing	ongoing
3	Maintain a hotline and email address for public reporting of potential ICIDs.	Base	MS4 Permit, Section E.2.b(3)	IC/IDs	ongoing	ongoing
	Refer homeless issue complaints to Sheriff or appropriate jurisdictions	Base		human sources	ongoing	ongoing
	Bilingual hotline answered by I Love a Clean San Diego (ILACSD; live operator) with multiple avenues for online reporting	Enhanced		IC/IDs	ongoing	FY16
	investigate the feasibility of developing a pilot program (including training) - volunteer surveillance program	Optional		IC/IDs	TBD/in dev.	FY16
4	Implement practices and procedures to address spills that may discharge into MS4	Base	MS4 Permit, Section E.2.b(4)	IC/IDs	ongoing	ongoing
	coordinate spill response with responsible sewer agencies	Base		SSOs	ongoing	FY16
	implement septic system rebate program with availability of grant funding	Optional		OWTS	ongoing	FY16
	develop a pilot online septic system maintenance outreach program	Optional committed		OWTS	ongoing	ongoing
5	Implement practices and procedures to prevent/limit infiltration of seepage from sanitary sewers	Base	MS4 Permit, Section E.2.b(5)	Sewer infrastructure	ongoing	ongoing
6	Coordinate with upstream Copermittees and/or entities to prevent ID from upstream sources into the MS4	Base	MS4 Permit, Section E.2.b(6)	IC/IDs	ongoing	ongoing
7	Monitor MS4 outfalls for discharges of potential ICIDs	Base	MS4 Permit, Section E.2.c	Persistent/ transient flows	Annually	ongoing
8	Develop and implement a strategy for investigating and addressing ICIDs.	Base	MS4 Permit, Section E.2.d	IC/IDs	One time	FY15
Development Planning						
9	All development projects: Implement or require implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	Base	MS4 Permit, Section E.3.a	new and redevelopment	ongoing	ongoing
10	Priority Development Projects: In addition to requirement for all development projects, implement or require implementation of onsite structural BMPs to control pollutants and manage hydromodification for PDPs.	Base	MS4 Permit, Sections E.3.b & E.3.c	new and redevelopment	ongoing	ongoing
11	Consider feasibility of developing an alternative compliance program to enable "offsite" compliance for new and redevelopment projects.	Optional	MS4 Permit, Section E.3.c(3)	new and redevelopment	in development	future
12	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.	Base	MS4 Permit, Section E.3.d	new and redevelopment	in development	FY16
	Conduct BMP Manual Training - Internal	Base		new and redevelopment	one time	FY16
	Conduct BMP Manual Training - External	Enhanced		new and redevelopment	one time	FY16
13	Implement a program that requires and confirms PDP structural BMPs are designed, constructed, and maintained to remove pollutants.	Base	MS4 Permit, Section E.3.e	new and redevelopment	ongoing	ongoing
14	Enforce legal authority established for all development projects to achieve compliance.	Base	MS4 Permit, Section E.3.f	new and redevelopment	ongoing	ongoing
	update county ordinance related to land development; reference to updated BMP manual	Base		new and redevelopment	one time	FY15
	Investigate feasibility of developing a Green Streets Program	Optional		All	TBD	TBD
Construction Management						
15	Maintain and update a watershed-based inventory of all construction projects issued a local permit that allows ground disturbance or soil disturbing activities.	Base	MS4 Permit, Section E.4.b(1)	Construction: waste management, portable toilets	quarterly	FY16

	Strategy	Program Type (see notes at bottom)	Permit Reference	Sources	Frequency	Schedule
16	Implement or require implementation of BMPs that are site specific, seasonally appropriate and construction phase appropriate. Includes inspections at an appropriate frequency and enforcement of requirements.	Base	MS4 Permit, Sections E.4.c & E.4.d(1)	Construction: waste management, portable toilets	TBD/in dev.	ongoing
17	Enforce legal authority established for all its inventoried construction sites to achieve compliance.	Base	MS4 Permit, Section E.4.e	Construction: waste management, portable toilets	as necessary	ongoing
	update county ordinance related to construction; reference to existing grading ordinance	Base		Construction: waste management, portable toilets	one time	FY15
18	Conduct internal training on Construction Management	Base	MS4 Permit, Section E.7.a(3)	Construction: waste management, portable toilets	Annually	ongoing
Existing Development						
19	Maintain and update a watershed-based inventory of all existing development that may discharge a pollutant load to and from the MS4.	Base	MS4 Permit, Section E.5.a	ICMR	Annually	on going
	make improvements to tracking watershed based inventories via consolidated database	Optional committed		ICMR	one time	FY16
20	Designate a minimum set of BMPs required for all existing development inventories, including special event venues. The designated minimum BMPs must be specific to facility or area types and pollutant generating activities, as appropriate.	Base	MS4 Permit, Section E.5.b	ICMR	one time	on going
	Create an Equestrian BMP Handbook	Optional Committed	County Program	equestrian land uses	one time	FY16
21	Require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types and pollutant generating activities, as appropriate.	Base	MS4 Permit, Section E.5.c	ICMR	ongoing	ongoing
	facilitate pet waste management in County Parks through outreach or bag dispensers	Enhanced		municipal parks	ongoing	ongoing
22	Operate and maintain (inspect and clean) MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Base	MS4 Permit, Section E.5.b.(1)(c)(ii)	MS4	Annually	ongoing
23	Operate and maintain (e.g., inspect, sweep) County maintained streets, unpaved roads, paved roads, and paved highways	Base	MS4 Permit, Section E.5.b.(1)(c)(iii)	transportation corridors	per JRMP	ongoing
24	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Base	MS4 Permit, Section E.5.b(1)(d)	ICMR	ongoing	ongoing
25	Promote and encourage implementation of designated BMPs at residential areas.	Base	MS4 Permit, Section E.5.b(2)	residential	ongoing	FY16
26	Conduct inspections of inventoried existing development to ensure compliance	Base	MS4 Permit, Section E.5.c	ICMR	20% per year, all within 5 years	FY16
	conduct focused residential inspections based on strategic assessments (modeling, MST, persistent flows, regulatory, monitoring data, SFR/MFR (112 RMAs based on HSA)	Enhanced		residential	20% per year, all within 5 years	FY16
	Investigate the feasibility of a residential inspections tracking program via mobile platform - miles, violations, etc.	Optional Committed		residential	ongoing with inspections	FY16
	Investigate the feasibility of improvements to inspections data tracking through mobile phone applications	Optional		ICRM		FY16
27	Enforce legal authority established for all inventoried existing development to achieve compliance	Base	MS4 Permit, Section E.5.d	ICMR	ongoing	ongoing
	update county ordinance related to existing development; reference to existing guidance documents	Enhanced		ICMR	one time	FY15
28	Develop a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Base	MS4 Permit, Section E.5.e(1)	municipal areas	internal and WMAA	FY15
	collaborate with partner agencies and groups to promote non-County sponsored incentive programs for BMP retrofits, including rain barrels, smart controllers, soil sensors, turf replacement, etc.	Enhanced		residential/ commercial	ongoing	ongoing
	Investigate the feasibility of developing and implementing an incentive program for BMP Retrofits (Public-Private Partnerships - a County sponsored program to offer incentives for rain barrel installation, downspout disconnects from the stormwater system, etc)	Optional committed				
29	Develop a strategy to identify candidate areas of existing development for stream, channel, and/or habitat rehabilitation projects and facilitate implementation of such projects.	Base	MS4 Permit, Section E.5.e(2)	municipal	internal and WMAA	FY15
	Outreach and Public Participation					

Los Penesquitos Watershed
CoSD JRMP-WQIP Strategies

	Strategy	Program Type (see notes at bottom)	Permit Reference	Sources	Frequency	Schedule
	Develop Sustainable Landscapes Program based on available grant funding	Optional		residential/ commercial	ongoing	FY16
	develop, improve, distribute outreach materials for existing development	Enhanced		ICMR	ongoing	ongoing
	conduct outreach to mobile landscaping service providers	Enhanced		ICMR	ongoing	ongoing
	Conduct large residential property pet waste management outreach	Optional committed		rural residential	ongoing	ongoing
	Consider expanding Homeowners Associations Outreach and Coordination (pilot project considered for San Luis Rey, San Dieguito and San Diego River) as needed and as funding is identified	Optional				TBD
	Sponsor Trash Collection Events	Enhanced	County Program	existing land use	TBD	ongoing
	Conduct Educational Workshops (e.g., IPM, manure management)	Enhanced	County Program	residential	ongoing	ongoing
	Conduct Education & Outreach Effectiveness Survey	Enhanced	County Program	ICMR	annual	ongoing
Enforcement Response Plan						
30	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Base	MS4 Permit, Section E.6	all MS4 related sources	ongoing	ongoing
31	Notify the SDWB by email (Nonfilers_R9waterboards.ca.gov) within five (5) calendar days of issuing escalated enforcement to a construction site that poses a significant threat to water quality as a result of violations or other noncompliance	Base	MS4 Permit E.6.e.(1)	construction	ongoing	FY16
32	Notify the SDWB by email (Nonfilers_R9waterboards.ca.gov) any persons required to obtain coverage under the statewide Industrial General Permit and Construction General Permit and failing to do so, within five (5) calendar days from the time the Copermittee become aware of the circumstances.	Base	MS4 Permit E.6.e.(2)	industrial	ongoing	FY16
Public Education and Participation						
33	Implement a public education and participation program to promote and encourage development of programs, management practices and behaviors that reduce the discharge of pollutants in storm water prioritized by high risk behaviors, pollutants of concern, and target audiences.	Base	MS4 Permit, Section E.7	MS4 sources	ongoing	ongoing
Physical Strategies						
	Investigate feasibility of Land Acquisitions for habitat restoration or preservation	Optional	WURMP WQ	ICMR	ongoing	
34	Investigate feasibility of planning for Structural BMPs	Optional	MS4 Permit, Section B.2.e	TBD	TBD	land development programs
39	Investigate feasibility of Retrofitting projects in areas of existing development	Optional	MS4 Permit, Section B.2.e	TBD	TBD	potential for implementation via alternative compliance program
40	Investigate feasibility of Stream, channel, and/or habitat rehabilitation projects	Optional	MS4 Permit, Section B.2.e	TBD	TBD	potential for implementation via alternative compliance program
Optional PlanningStrategies developed during WQIP process						
42	Consider development of incentive programs for water conservation (turf replacement, smart irrigation controllers, irrigation modifications, sustainable landscapes, rain barrels), in collaboration with water agencies and others, to reduce priority pollutants.	Optional				
43	Consider development of incentive programs, in collaboration with DEH, for pumping septic systems in high risk areas adjacent to waterways (within 600 ft) or stormwater system; subject to grant funding	Optional				
44	Consider partnerships with Master Gardeners to provide education opportunities on water use and practices for gardening	Optional				
45	Consider collaboration with community groups to provide “boots on the ground” local information to focus implementation efforts on reducing bacteria and other pollutants, close to the source	Optional				

Los Penesquitos Watershed
CoSD JRMP-WQIP Strategies

	Strategy	Program Type (see notes at bottom)	Permit Reference	Sources	Frequency	Schedule
46	Consider collaboration with COSD internal departments to leverage mutually beneficial projects to promote retrofits to include installation of controls to address priority pollutants, if feasible.	Optional				
47	Consider collaboration with watershed partners to encourage consistent messaging to specific targeted audiences (commercial, residents, and others) to conserve water and mitigate dry weather flows	Optional				
48	Consider collaboration with watershed partners on Round 4 of Proposition 84 IRWM grant opportunities to fund targeted educational programs, building of structural controls (brick and mortar projects), or incentive programs to reduce runoff	Optional				
49	Consider collaboration with watershed partners and Regional Water Quality Control Board on effective measures to reduce potential impact of pollutant loads to waterways from unauthorized encampments	Optional				
50	Consider collaboration with wastewater agencies to identify where sewer and stormwater infrastructure are in close proximity and confirm the absence of flow at nearby stormwater MS4 outfall during dry weather	Optional				
52	Consider collaboration with watershed partners to remove invasive non-native plants (Arundo) upstream areas rivers or tributaries to increase flood and fire protection and reduce the number of unauthorized encampments on the river bottom	Optional				
53	In collaboration with DEH, consider developing program for on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.	Optional				
54	Implement full scale residential pet waste projects (commitments, large property, urban)	Optional				
56	Consider investigating diverting persistent dry weather flows from storm drains to sanitary sewer, where feasible	Optional				
57	Consider the design of structural controls for persistent unpermitted dry weather flows where outreach has been unsuccessful and groundwater or other non-MS4 sources has been ruled out	Optional				
58	Consider developing a strategy to evaluate opportunities to naturalize concrete stormwater conveyances, and identify potential funding sources (such as grants) for design and implementation	Optional				
59	Consider evaluation and reprioritization of the AWM stormwater program to determine inspection priorities for agricultural and related facilities.	Optional				
60	*Consider collaboration with Caltrans on their implementation of TMDLs at stream reaches on the Caltrans TMDL Prioritization List that are within the County's jurisdiction.*	Optional				

Program Type Notes:
Base - Indicates requirements of the MS4 Permit that the County will implement.
Enhanced - Base program that has been enhanced beyond the MS4 Permit requirements. The enhanced portions of these strategies would be implemented if needed and if funding is available.
Optional - Strategies that are not required by the MS4 Permit. These strategies would be implemented if needed and if funding is available. Those that are "**committed**" are currently funded this fiscal year (FY14-15) and/or being undertaken or planned for undertaking.

Responsible party notes:
WPP = DPW Watershed Protection Program
ED = WPP, Existing Development
PS = WPP, Planning and Science
DC = WPP, Development and Construction
FC = DPW Flood Control
CIP = DPW Capital Improvement Projects
DEH = Department of Environmental Health
AWM = Department of Agriculture, Weights and Measures

APPENDIX J

Strategy Selection and Compliance Analysis

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Table of Contents

J.1 Prioritization of Sediment- and Bacteria-Loading Areas J-4
J.2 Nonstructural Strategies J-11
J.2.1 Non-Modeled, Nonstructural Strategy Assumptions J-11
J.2.2 Modeled Nonstructural Strategy Assumptions J-12
J.3 Structural Strategies J-30
J.3.1 Structural Strategy Modeling Assumptions J-30
J.4 Comprehensive Strategy Results J-50
J.4.1 Caltrans Results J-51
J.4.2 City of Del Mar Results J-51
J.4.3 City of Poway Results J-56
J.4.4 City of San Diego Results J-62
J.4.5 County of San Diego Results J-67

List of Tables

Table J-1 Summary of Current Street Sweeping Program for the City of San Diego in the Los Peñasquitos WMA J-17
Table J-2 Summary of Model Parameters for Street Sweeping Program Enhancements J-19
Table J-3 Enhancement Scenarios J-21
Table J-4 Pollutant Concentrations Used to Calculate Reductions J-22
Table J-5 Summary of Catch Basin Cleaning Program Enhancements in Los Peñasquitos WMA J-23
Table J-6 Model Parameters for Rain Barrel Program Enhancements J-24
Table J-7 Rain Barrel Program Enhancements* J-25
Table J-8 Model Parameters for Downspout Disconnection Program Enhancements J-27
Table J-9 Downspout Disconnection Program Enhancements J-27
Table J-10 Participation in Irrigation Reduction Program J-30
Table J-11 Prioritization Criteria for Multiuse Treatment Area BMP Implementation.. J-35
Table J-12 Tabulation of Identified Potential Multiuse Treatment Areas in the Los Peñasquitos WMA J-37
Table J-13 Prioritization Criteria for Potential Green Infrastructure BMP Locations ... J-41
Table J-14 Detailed Model Representation for Green Infrastructure BMPs J-42
Table J-15 Tabulation of Identified Los Peñasquitos Green Infrastructure Projects ... J-44
Table J-17 Predicted Wet Weather Load Reduction Summary for the City of Del Mar J-53
Table J-18 Predicted Dry Weather Load Reduction Summary for the City of Del Mar J-54

Table J-20 Predicted Wet Weather Load Reduction Summary for the City of Poway J-57
Table J-21 Predicted Dry Weather Load Reduction Summary for the City of Poway J-59
Table J-23 Predicted Wet Weather Load Reduction Summary for the City of San Diego J-63
Table J-24 Predicted Dry Weather Load Reduction Summary for the City of San Diego J-65
Table J-26 Predicted Wet Weather Load Reduction Summary for the County of San Diego J-69
Table J-27 Predicted Dry Weather Load Reduction Summary for the County of San Diego J-71

List of Figures

Figure J-1 Conceptual Diagram Illustrating Strategy Implementation (Not to Scale).... J-3
Figure J-2 Water Quality Dry-Weather Composite Score for Bacteria J-7
Figure J-3 Water Quality Wet-Weather Composite Score for Bacteria..... J-8
Figure J-4 Water Quality Wet-Weather Composite Score for Sediment..... J-9
Figure J-5 Total Water Quality Wet-Weather Composite Score for Bacteria and Sediment J-10
Figure J-6 Non-Modeled Nonstructural Strategies Load Reduction J-12
Figure J-7 Street and Median Sweeping Treatment Process J-13
Figure J-8 Catch Basin Cleaning Treatment Process..... J-20
Figure J-9 Catch Basin Cleaning Program Enhancement Scenarios (Wet Season) J-22
Figure J-10 Rain Barrel Treatment Process J-24
Figure J-11 Downspout Disconnection Treatment Process..... J-26
Figure J-12 Irrigation Reduction Treatment Process J-29
Figure J-13 Screening and Prioritization Methodology Concept..... J-31
Figure J-14 Parcel Screening Results J-32
Figure J-15 Multiuse Treatment Area BMP Representation J-36
Figure J-16 Locations of Multiuse Treatment Area BMPs in the Los Peñasquitos WMA J-39
Figure J-17 Conceptual Diagram of Selected Processes Associated with Structural BMPs..... J-43
Figure J-18 High-Ranked Locations of Optional Green Infrastructure Best Management Practices..... J-45
Figure J-19 Street Screening Results..... J-46

APPENDIX J. STRATEGY SELECTION AND COMPLIANCE ANALYSIS

This appendix details the basis for strategy selection and prioritization, implementation assumptions used to estimate strategy effectiveness within the simulation models, and the results of the modeling efforts including anticipated load reductions by strategy, subwatershed, jurisdiction, and pollutant. Figure J-1 provides a conceptual model of the quantification of benefits from the strategies represented in the model and discussed within this appendix. Section 4 of the Water Quality Improvement Plan provides a summary by jurisdiction of selected strategies, and Appendix I provides the schedule for implementation by jurisdiction.

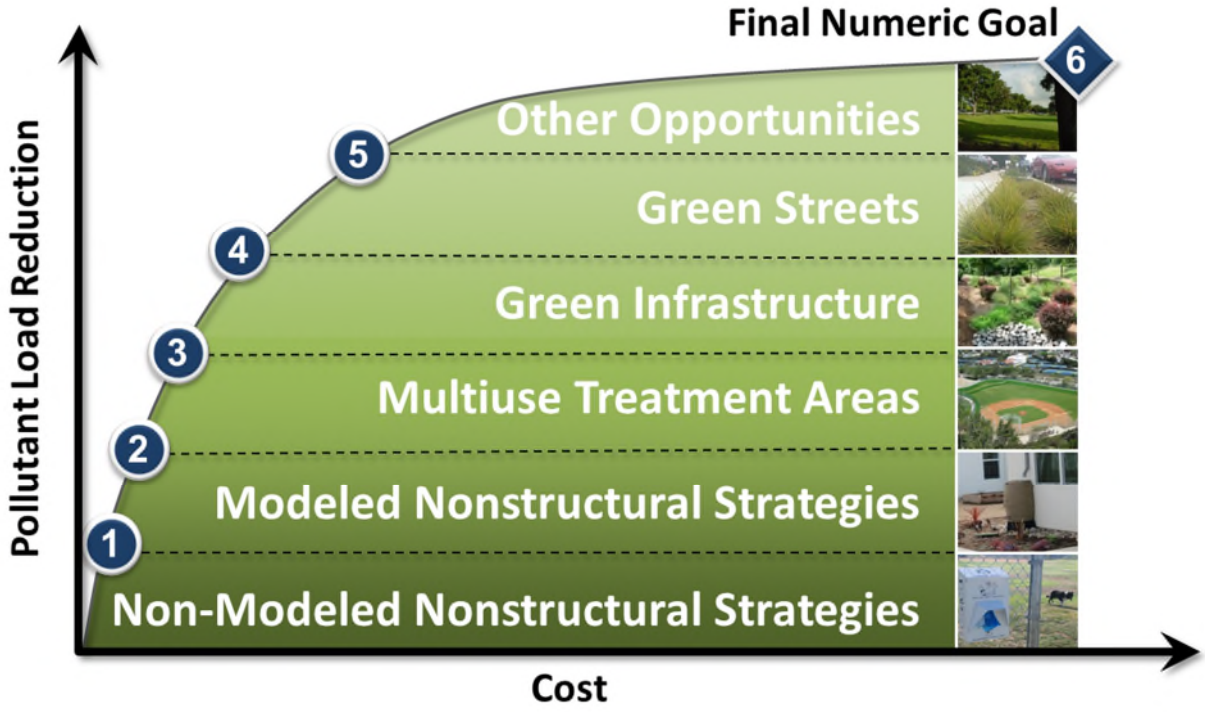

Figure J-1
Conceptual Diagram Illustrating Strategy Implementation
(Not to Scale)

Strategies were selected based on their ability to effectively and efficiently eliminate non-storm water discharges to the MS4, reduce pollutants in storm water discharges in the MS4 to the maximum extent practicable (MEP), and achieve the interim and final numeric goals. Efficiency in pollutant reduction is based on identifying the known and suspected areas or sources likely contributing to the highest priority water quality condition and targeting those sources. To assist in the geographical identification of sources, watershed modeling and GIS tools were used to estimate the relative sediment and bacteria loading within the Los Peñasquitos WMA, land ownership and availability of public land for implementation, and physical watershed characters such as slope and soil types for BMP selection.

Section J.1 presents the relative, estimated sediment and bacteria loading by drainage area in the Los Peñasquitos WMA. The relative loading results can assist Responsible Agencies in selecting locations to focus nonstructural and structural strategies within subwatersheds. Section J.2 provides additional detail on nonstructural strategy selection and implementation. Many of the nonstructural strategies overlap with administrative programs. Responsible Agencies may utilize the relative loading results to target application of administrative programs, such as street sweeping, rebate programs or education and outreach programs, in high priority areas. Specific load reductions for select nonstructural programs or activities that had a sufficient amount of data collected to estimate load reductions were modeled. Modeling assumptions for those activities are also presented in Section J.2. Section J.3 provides additional detail on structural strategy (BMP) selection and implementation. Additional factors to the relative loading analysis were considered in the selection of structural BMPs, such as parcel ownership, slope, and soil type. These additional factors generally have a greater influence on site selection for structural BMPs than just the relative loading by area. They also play an important role in determining the costs for implementation of structural BMPs and affect the cost-efficiency results. The structural BMP modeling assumptions are also provided in this section. Finally, Section J.4 provides a summary of the expected, cumulative load reductions estimated from the suite of strategies selected. A summary of the modeling assumptions used in the projection and the cost-effectiveness assessments are provided.

J.1 Prioritization of Sediment- and Bacteria-Loading Areas

The MS4 Permit requires the identification of known and suspected areas or sources causing or contributing to the highest priority water quality condition within the following Responsible Agency inventories: MS4 outfall, priority development project, construction site, and existing development. The sediment- and bacteria-generating activities within the WMA were identified in Section 3. To identify potential geographic areas where sediment- and bacteria-generating activities are contributing to watershed load, subwatersheds delineated in a recent modeling effort were prioritized based on modeled sediment and bacteria loading results (City of San Diego, 2012).

Modeling was conducted using the Loading Simulation Program in C++ (LSPC) watershed model (Shen et al. 2004; Tetra Tech and USEPA 2002), which estimated pollutant loading based on physical watershed characteristics (e.g., slope, soil types, precipitation zones) and land use-based runoff parameters. LSPC was calibrated to available flow and water quality data measurements in the receiving waters, which incorporate the effects of existing pollutant sources and current management actions upstream of the calibration points. The final calibrated model represents a simulation of baseline existing conditions for Water Year 2003 (which represents typical wet and dry weather conditions, based on an analysis of rainfall data over a 20-year time period) and recent land use data (using the San Diego Association of Governments 2009 data) in the Los Peñasquitos WMA; any pollutant load reductions resulting from jurisdictional strategies will be subsequently subtracted from the baseline conditions in the following sections to demonstrate progress towards meeting watershed load reduction goals. Watershed modeling is explained in detail in Appendix K.

The calibrated watershed models were used to prioritize subwatersheds within the Los Peñasquitos WMA using a relative estimate of sediment and bacteria loading. All modeled

bacteria results were averaged for dry weather and quintiles were established for each subwatershed and assigned to each pollutant. The individual quintile scores (1–5) for *Enterococcus*, fecal coliform, and total coliform were averaged to create a dry composite bacteria pollutant loading score (Figure J-2). The same procedure was performed for wet composite bacteria pollutant loading score, found in Figure J-3. A score of 5 indicates that the subwatershed pollutant loading was in the top 20th percentile (high pollutant loading), whereas a score of 1 represents a subwatershed loading in the bottom 20th percentile (low pollutant loading). The wet weather composite score was the average of the wet composite bacteria score and the wet sediment score, because both constituents are high priority water quality conditions (see Section 4.1 for more detail). The overall wet weather water quality composite score (2–10) is the summation of the wet composite bacteria score (Figure J-3) and wet composite sediment score (Figure J-4), which is shown in Figure J-5.

Areas that are expected to contribute the highest loading, and therefore suspected to have more sources, are darker, and areas that are less likely to contribute are lightly shaded. Subwatersheds with more development are expected to contribute more sediment and bacteria than less developed, open space. The model simulates pollutant loading based on land use. Sources identified in Section 3 of the Water Quality Improvement Plan are generally associated with land use types, but are not explicitly represented in this prioritization. For example, sources such as episodic sanitary sewer overflows are not explicitly included in the model; however, residential areas or areas with general development do have a higher bacteria load associated than undeveloped areas. This prioritization is meant as a guideline for identification of geographic areas within which to investigate sources. Each responsible Agency may have additional information to inform jurisdictional strategy implementation. Further analysis to determine the site suitability for structural strategies is discussed in Section J.3.

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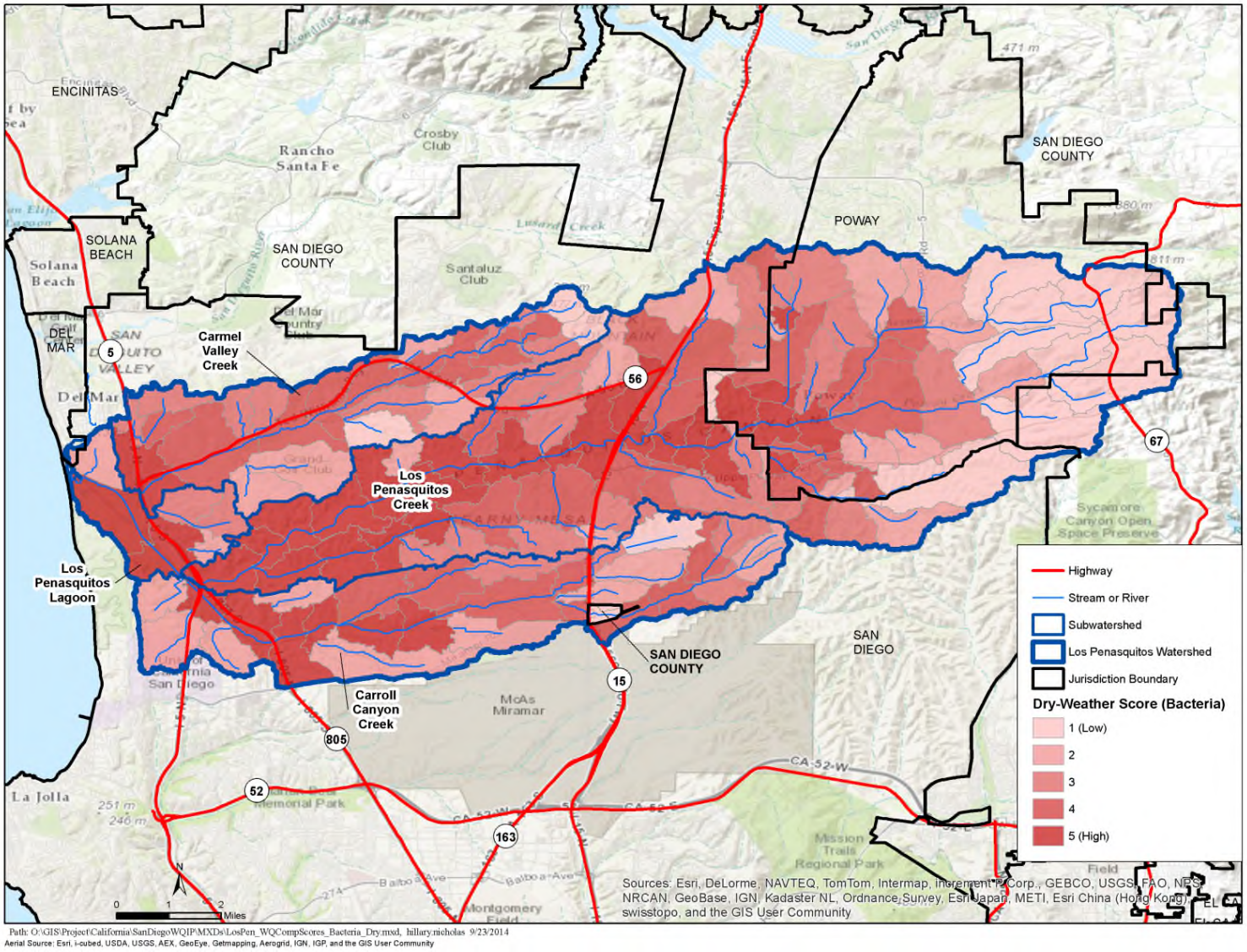


Figure J-2
Water Quality Dry-Weather Composite Score for Bacteria

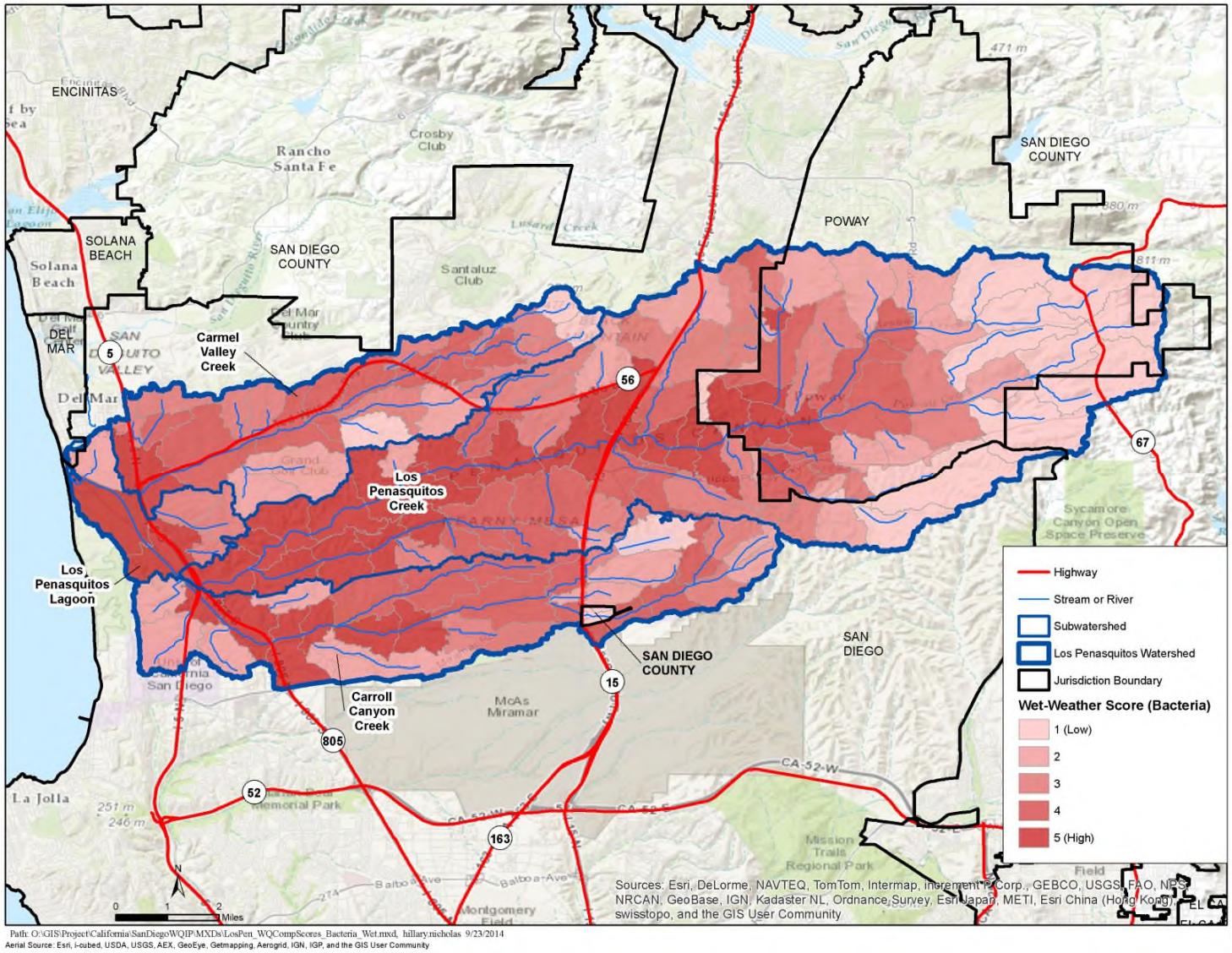
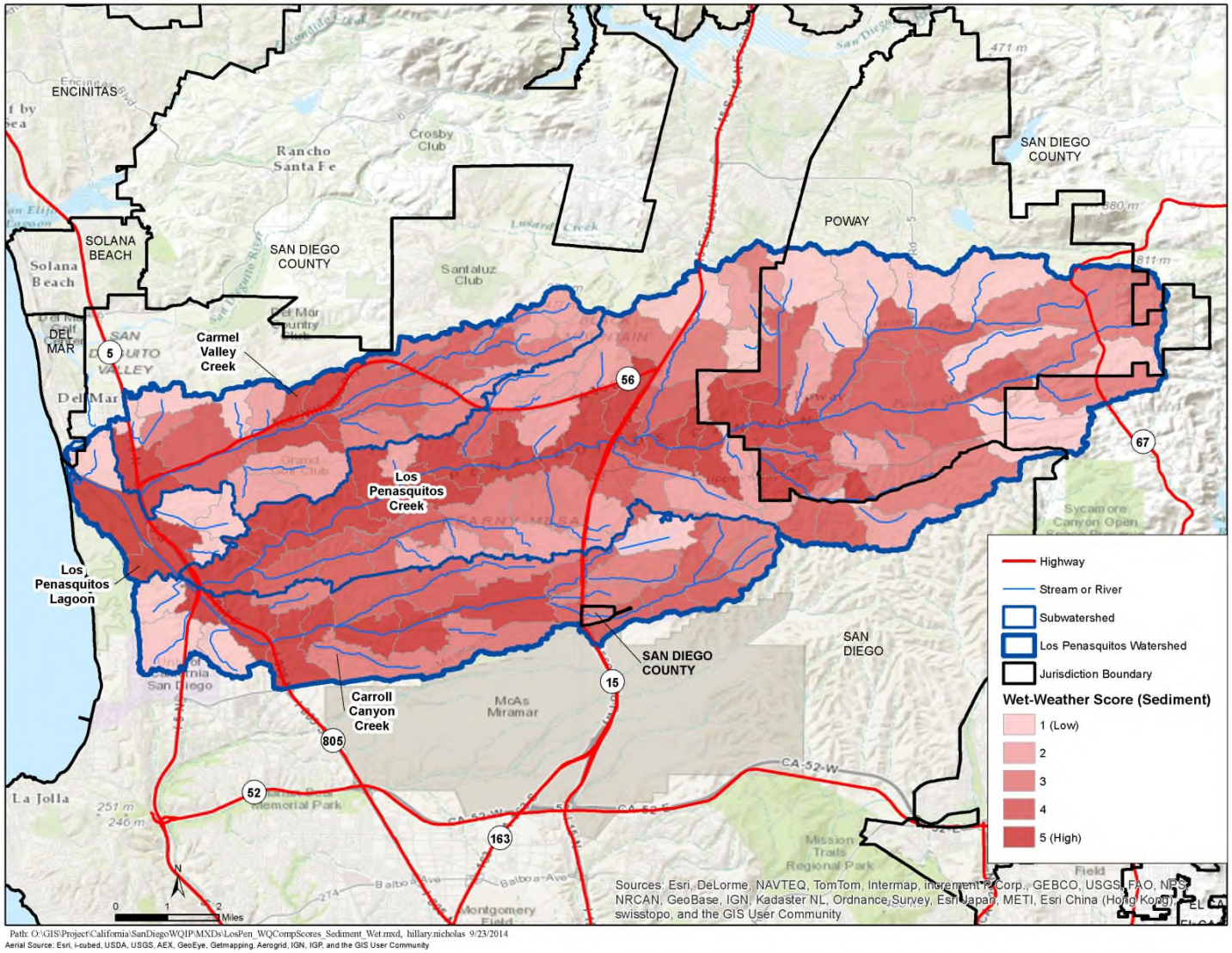


Figure J-3
Water Quality Wet-Weather Composite Score for Bacteria



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Aerial Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Figure J-4
Water Quality Wet-Weather Composite Score for Sediment

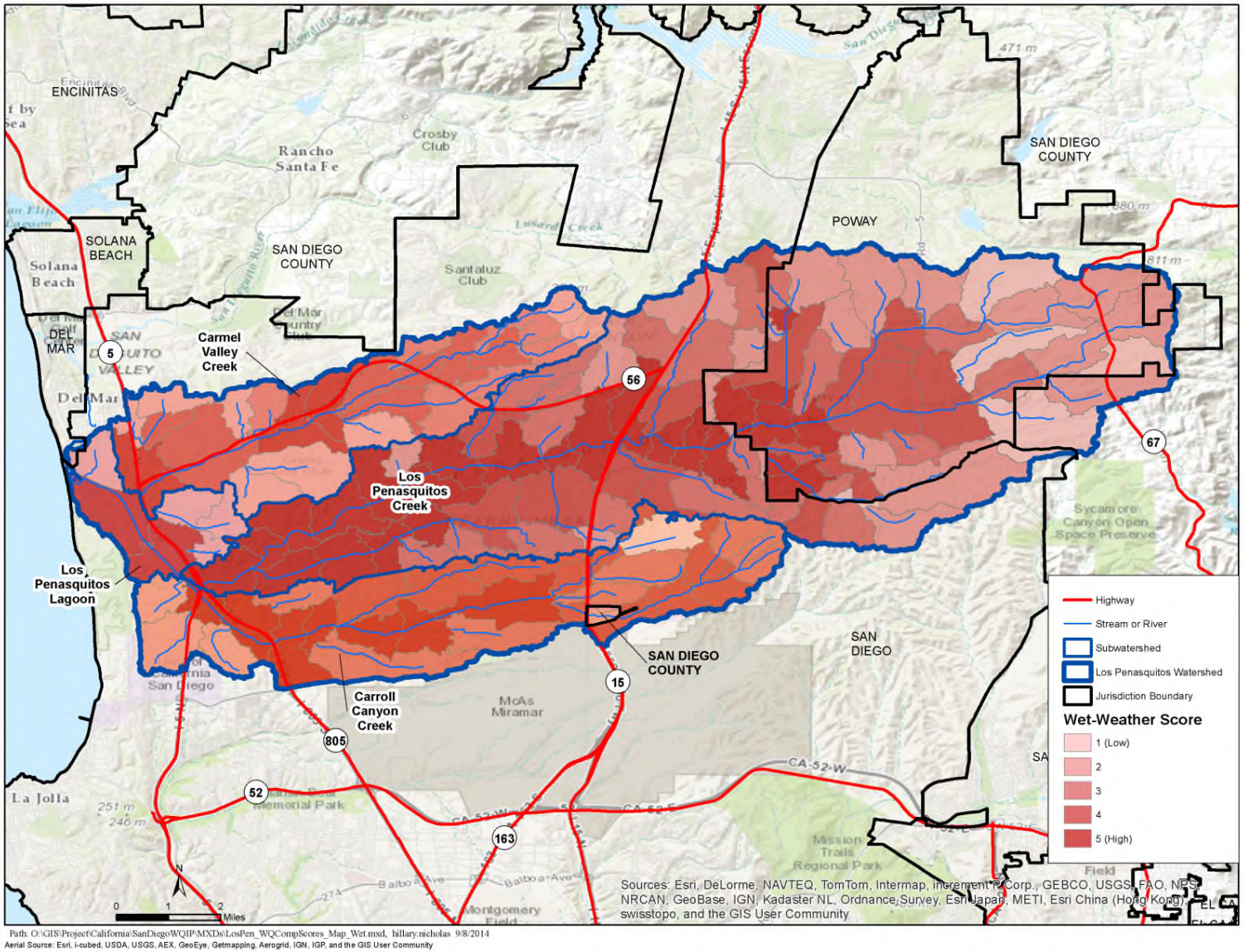

Figure J-5
Total Water Quality Wet-Weather Composite Score for Bacteria and Sediment

J.2 Nonstructural Strategies

To assist in the phased reduction of pollutant loads, various nonstructural strategies have been identified for implementation. Nonstructural reduction strategies are defined as those actions and activities that are intended to reduce storm water pollution and that do not involve construction or implementation of a physical structure to filter and treat storm water. These strategies are improvements of existing nonstructural programs, as well as implementation of new nonstructural best management practices (BMPs). Administrative policies, creation and enforcement of municipal ordinances, education and outreach programs, rebate and other incentive programs, and cooperation and collaboration with other WMA or regional partners are several examples of nonstructural strategies.

It is challenging to accurately quantify most nonstructural BMP benefits in terms of pollutant load reductions because it generally requires extensive survey and monitoring information. In addition, nonstructural BMPs may target pollutants, land uses, or populations, resulting in different load reductions depending on the implementation technique. The nonstructural strategies with sufficient data were modeled using LSPC to determine the pollutant load reductions from implementing these strategies. Pollutant load reductions from all strategies in this appendix are subtracted from loads simulated in the baseline model (discussed in the previous subsection) to quantify progress towards meeting the watershed numeric goals.

Estimated pollutant and flow reduction benefits from the non-modeled and modeled nonstructural BMPs provide the baseline from which additional reductions from structural BMPs will be achieved. Nonstructural BMPs are effective at reducing pollutant loads before they enter the storm drain and are generally cost-effective and require a shorter planning period; therefore, most nonstructural strategies are planned for implementation before or upon approval of the Water Quality Improvement Plan.

A summary of modeling assumptions used to quantify the load reduction potential from nonstructural strategies is provided in this section.

J.2.1 Non-Modeled, Nonstructural Strategy Assumptions

As previously stated, not all nonstructural strategies can be effectively modeled for load reductions due to their variable implementation, so these strategies are referred to as non-modeled nonstructural strategies. Since their benefits are not individually quantifiable, these strategies were assigned a conservative cumulative pollutant load reduction value of 10%, as shown in Figure J-6. Each of these non-modeled nonstructural strategies is described in further detail in the jurisdictional strategy tables in Appendix I.

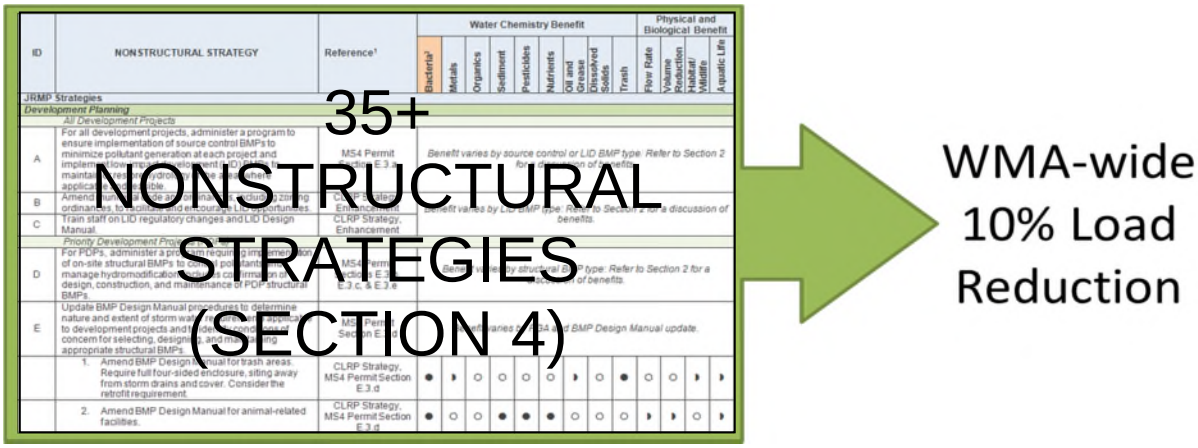

Figure J-6
Non-Modeled Nonstructural Strategies Load Reduction

As described in section 4.2.2.1 of the report, the 10 percent load reduction for non-modeled, nonstructural activities was estimated by averaging the range of measured and anticipated pollutant removal from the list of City of San Diego nonstructural strategies. Strategies were categorized as “high” percent removal, those with greater City control (operation and maintenance of MS4 infrastructure) or “low” percent removal, those requiring public behavior changes. The range of pollutant load reduction was as low as approximately 2 percent and as high as 72%. The overall average percent removal for all constituents and all activities is 10.1%. The average sediment and bacteria removal from the list of strategies was 17.9% and 11.7%, respectively (HDR, 2014).

J.2.2 Modeled Nonstructural Strategy Assumptions

Five of the nonstructural strategies selected for implementation in the Los Peñasquitos WMA were modeled: street sweeping, catch basin cleaning, Rain Barrels Incentive Program, Downspout Disconnection Incentive Program, and Irrigation Runoff Reduction Program. The following sections outline the nonstructural strategies that were modeled for the Responsible Agencies. Most of these strategies generally target residential or commercial land uses; therefore, not all are applicable to Caltrans’ jurisdiction.

J.2.2.1 Street Sweeping

Enhanced street and median sweeping technology can provide wet weather pollutant load reductions by removing pollutants from the land surface before washoff can occur during storm events. 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. Established street sweeping programs currently implemented by the Responsible Agencies are characterized in the baseline model. At this time, the City of San Diego, City of Poway, and San Diego County have committed to enhanced sweeping efforts above.

Treatment Process Model Overview

The LSPC model's street sweeping BMP process for pollutant removal is illustrated in Figure J-7. 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 –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.
- Sweeping Routes – Increased treatment area can also result in greater pollutant removal.

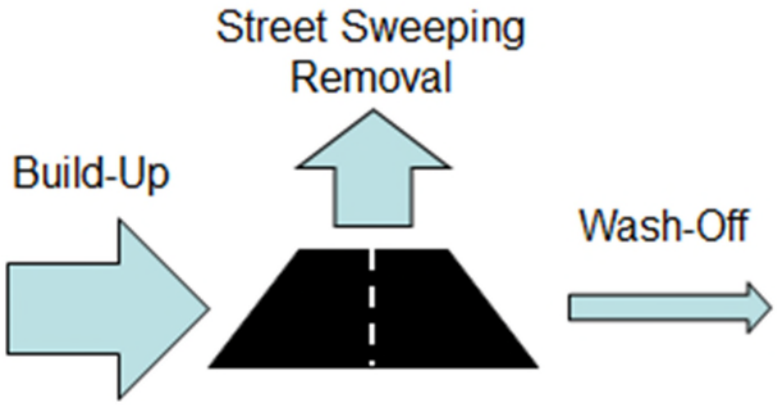

Figure J-7
Street and Median Sweeping Treatment Process

To develop a better understanding of the implications of assumptions associated with the proposed street sweeping program, an optimization analysis was performed. The optimization was set up to determine the optimal combination of enhancements to the street sweeping program to maximize sediment removal. Results from this optimization analysis were used to inform implementation decisions for individual watersheds.

The results of this analysis suggested 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.

The modeled results suggested 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.
- The “knee” of the cost-effectiveness curves, or where the slope of the curve begins to flatten and effectiveness begins to diminish, suggest that a frequency of bi-weekly, e.g. twice per month (third point from left), is the most cost effective frequency for street sweeping in Los Peñasquitos WMA.

Program Enhancements

Program enhancements are recommended based on a combination of optimization analysis results and findings gleaned from interviews with City of San Diego representatives (details regarding the interview process were presented in CLRP Phase II; City of San Diego 2013). The key findings of this analysis are:

- Enhancements of the street sweeping program should only be considered when sediment or metals load reduction is a concern (i.e. the effectiveness for reducing bacteria counts is minimal).
- Proposed and most cost-effective street sweeping frequency to implement in Los Peñasquitos WMA as part of the enhanced program is bi-weekly (or every other week) in all swept areas.

In summary, the enhanced street sweeping program in Los Peñasquitos WMA entails sweeping bi-weekly of all routes and the conversion of mechanical sweepers to regenerative-air sweepers. The current street sweeping program and proposed

enhancements are summarized in Table J-1. Summaries of street sweeping program enhancements and modeling parameters are included in Table J-2.

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Table J-1
Summary of Current Street Sweeping Program for the City of San Diego in the Los Peñasquitos WMA

Machine	Total Linear Miles Swept		Detailed Distribution of Swept Roads				Annual Miles Swept	
	Road Miles	Curb Miles	Residential, bi-monthly (road miles)	Commercial, 1x week (road miles)	Commercial, 2x week (road miles)	Recommended Frequency, bi-weekly (road miles)	Road Miles Swept per Year	Curb Miles Swept per Year
Current Program								
Mechanical	457	914	339	107	11		8,742	17,484
Regen-Air*	27	54	7	20	0		1,082	2,164
Enhanced Program								
Mechanical	-	-	-	-	-	-	-	-
Regen-Air*	484	968	-	-	-	484	12,584	25,168

Note:
*Regen-Air = Regenerative Air
Current program assumes that Route 5c roads are swept by Regen-Air sweepers and 2% of remaining swept roads are also currently swept by Regen-Air.

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Table J-2
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
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

Parameter	Value	Source
Concentration of bacteria in the removed sediment	0.00000521 x10^12 colonies per pound of street sediment	Pitt 1986

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

J.2.2.2 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.

Treatment Process Overview

A representation of the catch basin cleaning process and associated pollutant removal is provided in Figure J-8. 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.

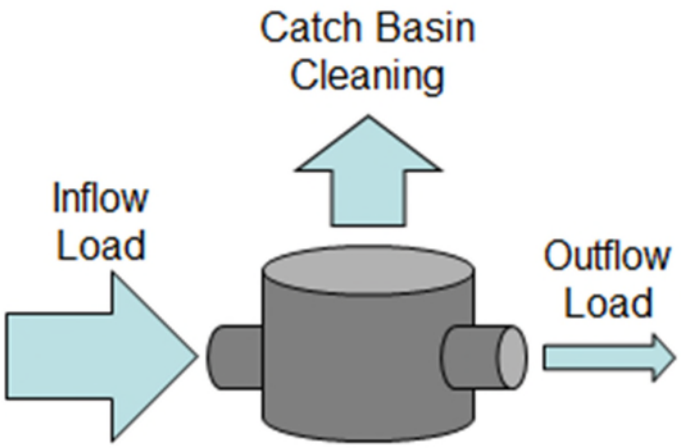


Figure J-8
Catch Basin Cleaning Treatment Process

To determine the maximum program enhancement scenario, manual clean-out data from 2009-2012 along with findings from the City of San Diego Catch Basin Cleaning Program Pilot Study (Tetra Tech, Inc. 2012, 2013a, and 2013b) were analyzed. As part of the pilot

study, a detailed assessment was performed to categorize catch basins according to their tendency to yield high, medium, or low debris weights per cleaning event. The pilot study 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 pilot study 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 J-3) and the associated pollutant load reductions were calculated based on concentrations of typical debris removal found in previous studies (Table J-4). The results of this analysis are presented in Figure J-9, which illustrates the cost-effectiveness of the increased cleaning activities relative to a 20-year implementation cost. It is important to note that catch basin cleaning activities achieve cost efficiency for certain pollutants (copper in particular) that is comparable to the implementation of green streets (City of San Diego 2013). However, cleaning activities can be implemented on a faster timescale and has less of an administrative burden than the construction of structural BMPs. It is also important to note that catch basin cleaning activities are not efficient for bacteria removal, as can be deduced from Figure J-9.

Table J-3
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
(8)	3	3	2
(9)	3	3	3

Table J-4
Pollutant Concentrations Used to Calculate Reductions

Pollutant	Concentration (per kg of dry debris)	Source
Copper	75 mg/kg	Tetra Tech 2012
Zinc	232 mg/kg	
Lead	36 mg/kg	
Total Nitrogen	2,629 mg/kg	
Total Phosphorous	551 mg/kg	
Fecal Coliform	6.13 MPN/kg	

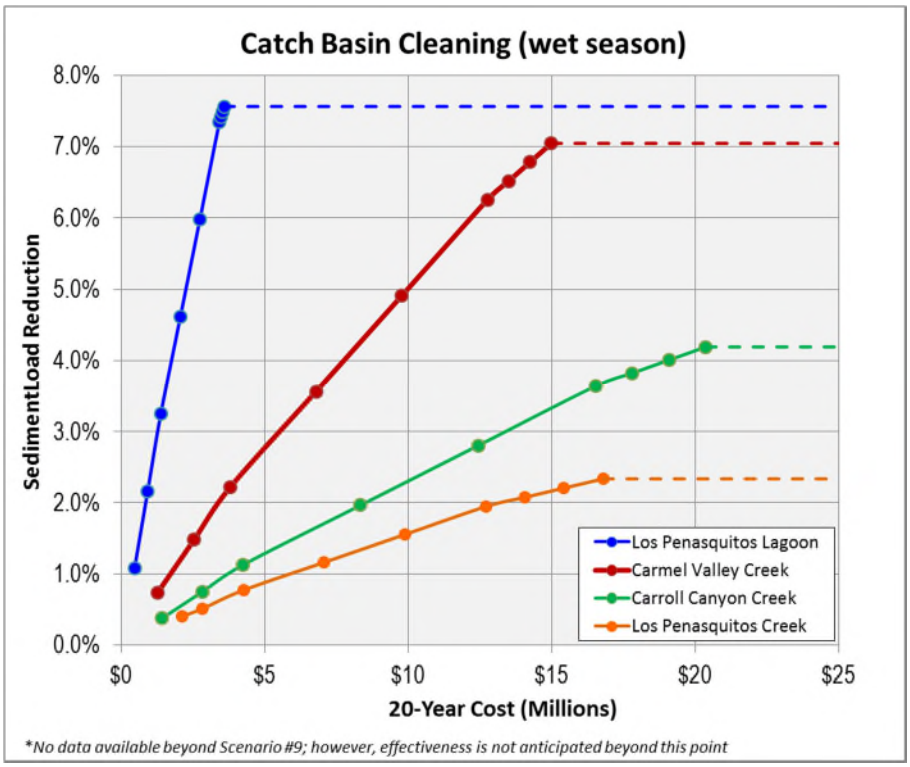


Figure J-9
Catch Basin Cleaning Program Enhancement Scenarios (Wet Season)

Program Enhancements

Program enhancements are recommended based on a combination of optimization analysis results and findings gleaned from interviews the City (details regarding the interview process were presented in CLRP Phase II; City of San Diego 2013). Because the critical pollutant for wet weather conditions is sediment in the Los Peñasquitos WMA, and because this BMP is sufficiently efficient, the City of San Diego's program was

recommended to be implemented to the optimal extent. Recommended program enhancements are summarized in Table J-5.

Table J-5
Summary of Catch Basin Cleaning Program Enhancements in Los Peñasquitos WMA

Cleaning Metric	City of San Diego
Estimated # of Catch Basins in WMA	6,033
Total number of cleaning per year recommended	4
Number of Additional Catch Basin Cleanings per Year	18.099

Note:
Number of catch basins presented is based on catch basins in the City Grids within Los Peñasquitos WMA for which historic cleaning data is available. Based on historic data, CSD currently performs catch basin cleanings once per year on average.

J.2.2.3 Rain Barrels Incentive Program

The City of San Diego Public Utilities Department currently operates a rebate program for customers who harvest rainwater, including with rain barrels and cistern-type devices. The goal of this program is to minimize pollutant loads to receiving waters by reducing the runoff volume and peak flow originating from rooftops. Rooftop runoff can be collected in rain barrels and retained for irrigation reuse or slowly released after a period of storage. Pollutant load is reduced by releasing captured runoff onto landscaped areas, where pollutants are removed by the natural processes of infiltration and evapotranspiration.

The City's rain barrel rebate program is part of a larger landscape-based rebate program to promote and encourage implementation of specific BMPs for residential and commercial areas. The rain barrel rebate aspect of the program currently focuses on single-family residential landscapes, but it is intended to expand the program to multifamily and commercial areas. The landscape-based rebate program has a budget of $250,000 of annual funding to support rebate costs for all aspects of the program including rain barrels, downspout disconnects, micro-irrigation, and grass replacement. Of this rebate budget, it is anticipated that 10% of funds will support rain barrel rebates. In addition to staffing, the City anticipates an annual 4% increase to the annual rebate budget for this program to accommodate program expansion.

Treatment Process Model Overview

Figure J-10 depicts rain barrel use to reduce runoff volume. As implementation of the rain barrel program grows, more rooftop runoff will be intercepted and temporarily stored in rain barrels. As a result, runoff volume and associated pollutant loads to receiving waters will also decrease. The effectiveness of a rain barrel program in reducing runoff volume

is a function of the number of rain barrels installed. As the program encourages more rain barrel installations, reducing runoff volume further can be expected.

Simulating long-term rainfall and runoff processes in the LSPC will help determine the average rain barrel capture performance (runoff reduction) per rooftop drainage acre. Rain barrel modeling parameters are summarized in Table J-6.

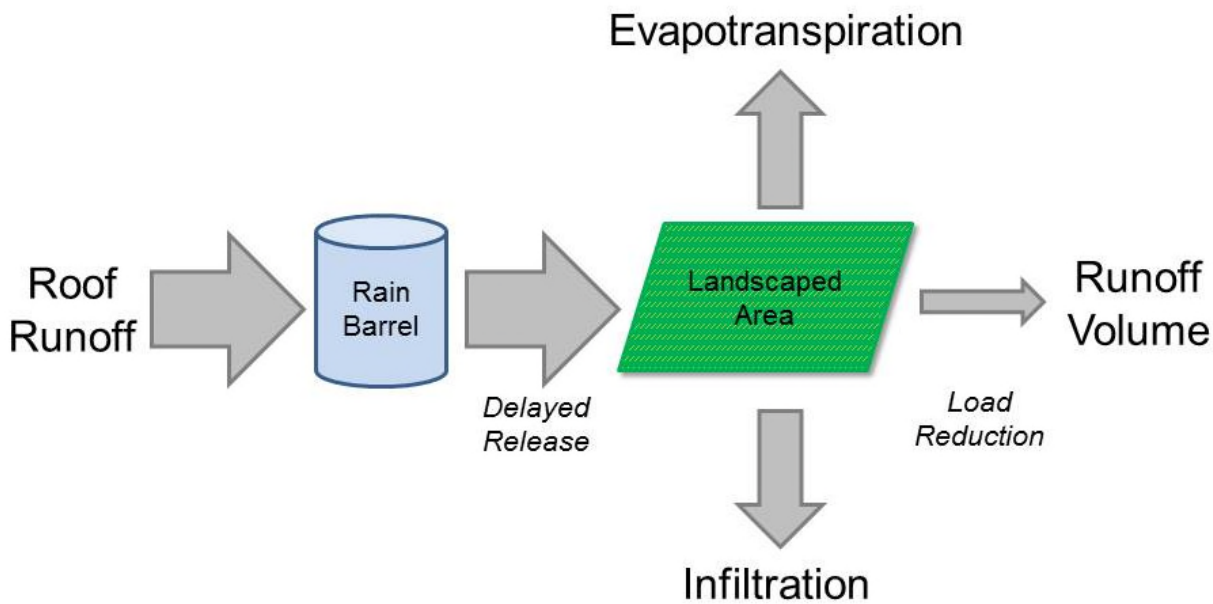


Figure J-10
Rain Barrel Treatment Process

Table J-6
Model Parameters for Rain Barrel Program Enhancements

Parameter	Value	Source
Contributing rooftop area to rain barrel in residential areas	500 square feet	City of San Diego
Rain barrel size (average)	65 gallons	City of San Diego
Primary outlet diameter (minimum)	0.5 inches	City of San Diego
Outlet pipe invert location	< 6 inches above bottom of barrel	City of San Diego
Overflow pipe diameter (minimum)	2 inches	City of San Diego
Maximum rain barrel outflow via 0.5-inch primary outlet	0.010 cubic feet per second	Orifice equation with depth = 2.5 feet
Rain barrel dewatering time	18 minutes	Typical value

Parameter	Value	Source
Assumed soil infiltration rate at rain barrel discharge	0.03 inches per hour	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 inches per hour	Typical regional value
Assumed allowable ponding depth in landscaping area	0.75 inches	Typical regional value
Required landscaped area downstream of rain barrel discharge location to prevent rain barrel runoff	144 square feet	Typical regional value
Landscaped area dewatering time	23 hours	Typical regional value

Program Enhancements

To maximize the benefit of implementation and to improve the effectiveness of the current program, program enhancements are recommended. As presented in the CLRP Phase I and II reports (City of San Diego 2012 and City of San Diego 2013), the recommended enhancements were determined based on rain barrel capture volumes and costs, potentially available single-family zoned parcels, available program budget, and discussions with City staff. Based on this information, it was estimated that 72 households per year will take advantage of rain barrel rebates in the Los Peñasquitos WMA. These figures are based on the single-family zoned parcels potentially available for implementation as well as input from City staff; see Table J-7.

Table J-7
Rain Barrel Program Enhancements*

Implementation Metric	City of San Diego
Single-family zoned parcels (SFZP) within watershed	71,000
SFZP percentage within Jurisdiction	23.4
Rain barrel installations per year (based on number of rebates per year)	90

Note:
Only the City of San Diego elected to participate in the rain barrel enhancements.

J.2.2.4 Downspout Disconnection Incentive Program

Downspout disconnections are a BMP alternative to reduce runoff volumes in highly impervious watersheds. The purpose of this cost-effective BMP is to disconnect downspouts from rooftop surfaces and reroute downspout runoff to pervious areas where

natural processes such as storage, infiltration, and evapotranspiration can remove pollutants.

The City of San Diego has recently initiated a pilot downspout disconnection program in the Newport Avenue area of the Ocean Beach community. The pilot program has demonstrated the effectiveness of downspout disconnections in reducing pollutant loads in highly impervious areas. As part of the City's larger landscape based rebate program, implementation of downspout disconnections are encouraged in residential and commercial areas. The landscape-based rebate program has an annual budget of $250,000 to support rebate costs for all aspects of the program. Of this rebate budget, it is anticipated that 10% of funds will support downspout disconnections in residential areas and 10% of funds will support downspout disconnections in commercial areas. In addition to staffing, the City anticipates an annual 4% increase to the annual rebate budget for this program to accommodate program expansion.

Treatment Process Model Overview

Downspout disconnection is modeled by routing roof runoff to pervious land surfaces where overland flow over a typical lawn can be simulated. As roof runoff flows over a pervious surface, such as a lawn, natural infiltrative and evapotranspiration processes occur, reducing runoff volume and removing pollutants.

An overview of downspout disconnection represented in LSPC is shown in Figure J-11.

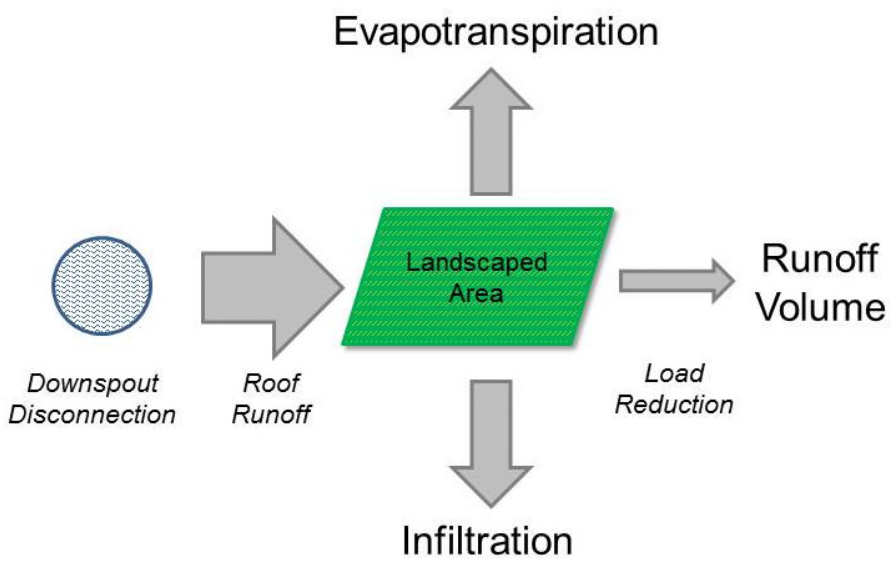


Figure J-11
Downspout Disconnection Treatment Process

Since the downspout disconnection program has recently been initiated, methods for improving runoff volume reduction through downspout disconnections are primarily additional facility installations. To estimate the number of anticipated downspout disconnection rebates in Los Peñasquitos WMA and throughout the City of San Diego,

single-family zoned parcels was used as a metric to determine the relative distribution of rebates. Assumptions regarding modeling parameters for downspout disconnections are summarized in Table J-8.

Table J-8
Model Parameters for Downspout Disconnection Program Enhancements

Parameter	Value	Source
Contributing rooftop area to rain barrel (residential areas/commercial areas)	500 square feet/ 3,600 square ft.	Typical area
85th percentile flow to disconnection	0.001 cubic feet per second	Rainfall intensity = 0.2 inches/hour
85th percentile runoff volume to disconnections	10 cubic feet	P = 0.6 inches
Assumed soil infiltration rate at rain barrel discharge	0.03 inches per hour	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 inches per hour	Typical regional value
Assumed allowable ponding depth in landscaping area	0.75 inches	Typical regional value
Landscaped area dewatering time	23 hours	Typical regional value

Program Enhancements

Based on the available City budget for the program, the cost of installation, and discussion with City staff, it is estimated that 147 downspout disconnections in residential areas and 147 downspout disconnections in commercial areas would be anticipated to occur in Los Peñasquitos WMA. A total of 294 downspout disconnection rebates is anticipated for this watershed, and the remaining downspout disconnection rebate budget is expected to support rebates in other WMAs. Estimated program enhancements and potential single-family parcels for implementation are summarized in Table J-9.

Table J-9
Downspout Disconnection Program Enhancements

Implementation Metric	City of San Diego
Single-family zoned parcels (SFZP) within watershed	71,754
SFZP percentage within watershed	23.4
Downspout disconnection installations per year in residential areas (based on number of rebates/year)	147

Implementation Metric	City of San Diego
Downspout disconnection installations per year in residential areas (based on number of rebates/year)	147

Note:
Only the City of San Diego elected to participate in the rain barrel enhancements.

J.2.2.5 Irrigation Runoff Reduction Program

Reductions of irrigation runoff help meet reduction goals for runoff volume and associated pollutant loads. This nonstructural strategy, 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.

The City of San Diego Public Utilities Department currently operates a rebate program for various landscape-based practices. As part of this program, implementation of irrigation reduction runoff measures, such as micro-irrigation and grass replacement, are encouraged in residential and commercial areas. The landscape-based rebate program has an annual budget of $250,000 to support rebate costs for all aspects of the program. Of this rebate budget, it is anticipated that 15% of funds will support micro-irrigation rebates in residential areas, 15% will support micro-irrigation rebates in commercial areas, 20% will support grass replacement rebates in residential, and 20% will support grass replacement rebates in commercial areas. In addition to staffing, the City anticipates an annual 4% increase to the annual rebate budget for this program to accommodate program expansion.

Treatment Process Model Overview

The irrigation runoff reduction program encourages three types of practices—grass replacement projects, micro-irrigation system conversions, and weather-based irrigation controllers—to reduce irrigation runoff. These practices reduce runoff by increasing the capacity of runoff infiltration, conserving water, and/or irrigating only as needed, based on weather and soil inputs. These practices, collectively, are modeled by adjusting (reducing) irrigation inputs to urban grass land uses and adjusting how irrigation overspray is allocated between impervious and pervious land uses. To reduce irrigated runoff, the model simulates a combination of 25% less irrigated area and elimination of overspray to impervious areas. As implementation of irrigation runoff reduction measures increase, runoff volume and associated pollutant loads to receiving waters decrease. Figure J-12 illustrates the irrigation reduction treatment process as represented in the LSPC model.

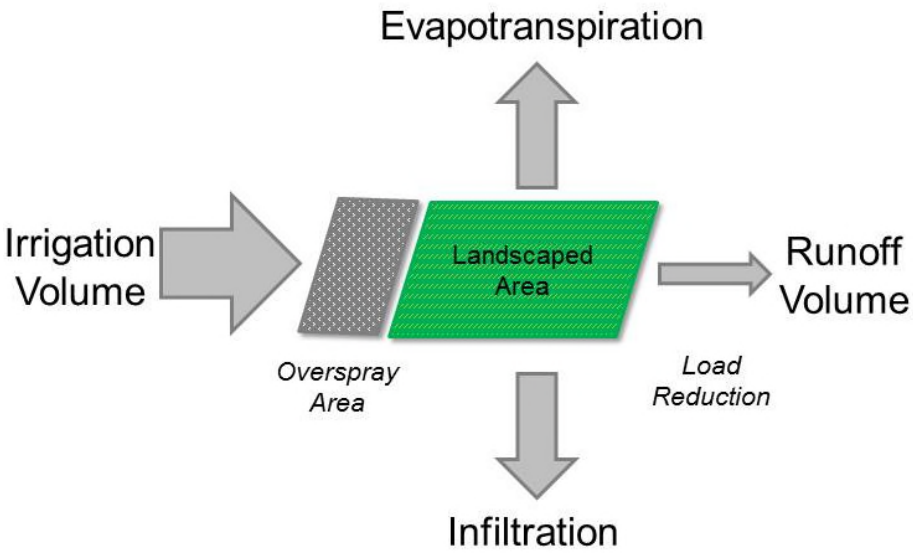


Figure J-12
Irrigation Reduction Treatment Process

Irrigation changes the normal water balance and influences all the components of hydrology. Most of the irrigated water is evaporated or transpired by the vegetation, but some of the irrigated water is added to baseflow. In semi-arid environments, the increase in baseflow can be substantial since natural baseflow is very low. There is also an increase in surface runoff. The soil is already saturated prior to rainfall events, so less rainfall soaks into the soil and more flows off the surface. Furthermore, urban landscapes often receive more irrigation than is needed to sustain the health of vegetation. Therefore, a reduction in irrigation leads to decreases in all components of hydrology. However, the response of the various components is not linear. For example, a small decrease in irrigation can prompt a large decrease in dry weather baseflow due to evapotranspiration. Since evapotranspiration demand is high in semi-arid environments, a greater proportion of the inputs (i.e. rainfall and irrigation) are lost through evapotranspiration.

Program Enhancements

Based on interviews with City of San Diego staff and the diverse options and means of implementation in the irrigation runoff reduction program, the recommendation to enhance this program is not a specific action or strategy, but a targeted outcome of 25% irrigation runoff reduction. Regardless of the reduction method, it is recommended that the Responsible Agencies reduce runoff from irrigation practices by 25%. The Responsible Agencies that elected to participate in an irrigation reduction program are listed in Table J-10.

Table J-10
Participation in Irrigation Reduction Program

	City of San Diego	County of San Diego	City of Poway	Caltrans	City of Del Mar
Participation for 25% reduction	Yes	Yes	Yes	No	Yes

J.3 Structural Strategies

Structural strategies (BMPs) provide the opportunity to intercept runoff and filter, infiltrate, and treat storm water. These structures tend to be more expensive than nonstructural strategies, but they also tend to have predictable and reliable effectiveness in removing pollutant loads. Additionally, structural BMPs provide other multiuse benefits to the community, such as habitat, aesthetics, and recreational opportunities.

Four major categories of potential structural BMPs were modeled in the Los Peñasquitos WMA using the LSPC and the System for Urban Stormwater Treatment and Analysis Integration model (SUSTAIN):

- Multiuse treatment areas,
- Green infrastructure,
- Water quality improvement BMPs, and
- Additional Watershed Opportunities

Section 4 describes these structural BMPs in detail, and this appendix summarizes representative BMP information for the four types of structural BMPs evaluated as part of this analysis.

J.3.1 Structural Strategy Modeling Assumptions

Structural BMPs will be an important element of the overall Water Quality Improvement Plan compliance strategy. The following subsections describe the assumptions that were applied to model the structural BMPs.

J.3.1.1 Multiuse Treatment Areas

Large treatment structural BMPs (referred to as multiuse treatment areas) are regional facilities that receive flows from neighborhoods or larger areas, which often serve dual purposes—flood control and groundwater recharge. These BMPs are often located in public spaces and can be collocated within parks or green spaces; these BMPs can provide excellent ecosystem services and aesthetic value to stakeholders. The first steps in evaluating potential multiuse treatment areas were primary site-selection screening and prioritization analysis, as shown in Figure J-13.

Figure J-13
Screening and Prioritization Methodology Concept

This analysis began by assessing parcels to screen out unsuitable site parameters for structural BMPs, such as steep slopes. These screened sites were then assessed for landscape characteristics, jurisdictional attributes, water quality needs, and general site sustainability to systematically evaluate and prioritize potential sites in each municipality throughout the WMA. Field investigations determined BMP feasibility and potential configuration; then the water quality and hydrology of the multiuse treatment areas were dynamically modeled. This subsection provides the process details and assumptions.

Screening and Prioritization Methodology

In 2009, the City of San Diego performed the *Parcel Evaluation for BMP Implementation Study* that provided a geographical information system (GIS) analysis and decision criteria for selecting parcels for BMP implementation in the City's jurisdiction. The study methodology was a starting point in developing the prioritization and screening process.

The process was further refined based on the experience of the Responsible Agencies and Tetra Tech, and based on CLRP Task 2 Pollutant Source Characterization data (City of San Diego 2012). The site-selection process identified parcels potentially suitable for BMP implementation using GIS-based analyses and the best available landscape and water quality data, as shown conceptually in Figure J-14.

Figure J-14
Parcel Screening Results

Site selection consisted of two major steps, including:

1. A primary screening to eliminate unsuitable parcels on the basis of physical and zoning characteristics; and

2. A separate site prioritization process for green infrastructure and multiuse treatment areas, to rank the suitability of the remaining parcels.

The primary screening for potential BMP opportunities was based on two parameters:

- **Parcel Zoning:** Parcels classified as single-family residential, based on the Nucleus Use Code attribute (a description of the use of the property provided by the county assessor), were not considered because of their average small size and the typically low cost-benefit ratio of implementing BMPs on single-family residential parcels. Research and experience nationally indicate that the runoff impacts of single-family parcels can be addressed more cost-effectively through outreach and education, or incentives for practices such as harvesting rainwater, improving irrigation, and converting turf and landscape.

- **Slope:** Parcels with a slope greater than 15 percent were not considered for BMP opportunities, other than parcels located in canyons. The screening was expanded to include areas in and around canyons for multiuse treatment areas. For this analysis, slope was determined on the basis of digital elevation maps or other available topographic data sets. In areas where the overall slope of the parcel was in question, slope was verified through review of aerial imagery.

The results of the primary screening provided a base list of parcels potentially suitable for BMP implementation. A GIS analysis was performed on the remaining parcels to identify the potential sites for optional multiuse treatment area placement and to rank their potential suitability.

Potential sites were then prioritized on the basis of the parcel characteristics, plus additional considerations and different numerical criteria for multiuse treatment areas that were developed and reviewed in discussions with the Responsible Agencies. The additional considerations for identifying potential sites for multiuse treatment areas mainly regarded the use of open space and contributing watershed characteristics; see the following list.

- **Hydrologic Soil Group:** The mapped hydrologic soils groups are used as an initial estimate for the infiltration rate and storage capacity of the soils. Sites where mapped hydrologic soils groups have infiltration rates suitable for infiltration BMPs receive higher priority.
- **Proximity to Wells and Contaminated Soils:** Areas near contaminated sites received lower priority because of their potential for increased costs and complications during implementation.
- **Proximity to Environmentally Sensitive Areas (ESAs):** Areas where runoff can be treated before draining to an ESA were given a higher priority.
- **Parcel Percent Impervious:** Parcels with a large extent of existing open space tend to be more cost effective for BMP retrofits. Additionally, multiuse treatment areas can commonly be incorporated into existing recreational facilities to provide enhanced community benefits. Sites with a lower impervious coverage therefore received higher priority.
- **Parcel Size:** The size of the parcel was used to prioritize sites for multiuse treatment areas, with larger parcels receiving higher priority.
- **Proximity to Existing BMPs:** To distribute treatment opportunities effectively throughout the watershed, areas close to existing or planned future BMPs were given a lower priority.
- **Proximity to Parks and Schools:** Parks typically have the largest available open area and the lowest percentage of impervious area, and are well suited for multiuse treatment area implementation. Schools also tend to have large open areas, providing opportunities for BMP implementation. Areas classified as parks were given the highest priority, followed by schools. Other areas were given higher priority because of their opportunity for public outreach and education.

- **Proximity to the Storm Drainage Network:** Because multiuse treatment areas are especially effective where runoff can be diverted from the existing drainage network for treatment and control, areas close to the storm drainage network received higher priority.
- **Contributing Area:** The size of the drainage area that could be diverted and treated at each potential site was evaluated, and areas that capture and effectively treat runoff from the largest drainage areas were given higher priority.
- **Impervious Coverage of Contributing Area:** During storms, contributing drainage areas with a higher percentage of imperviousness produce increased runoff relative to the watershed size. Drainage areas with higher imperviousness were targeted for greater potential volume reduction and water quality improvements
- **Proximity to Corrugated Metal Pipe Systems:** To incorporate future upgrades to the storm drainage network in the City of San Diego, the proximity to a corrugated metal pipe system is to be considered and ranked on the basis of the necessity for rehabilitation.

The advantage of this prioritization process is the ability to select BMP locations that are best suited for maximum cost-effectiveness, resulting in the greatest pollutant load reductions per dollar. Because structural BMPs at any scale involve identifying and setting aside land for stormwater treatment, assessing opportunities on existing publicly owned lands is especially important. Structural treatment often can be integrated into parks, playing fields, street rights-of-way, and medians without compromising function, so opportunities for incorporating BMPs in recreation areas, streets, and other public open spaces are typically prioritized and used as a first step in evaluating sites.

The agreed-upon weightings for each factor are listed in Table J-11.

As part of CLRP Phase I efforts, multiple desktop and field-screening exercises were completed to develop a full understanding of the opportunities that exist for multiuse treatment area implementation in this WMA (City of San Diego, 2012). The sites were pared down and prioritized, based on feasibility, potential for pollutant load reduction, and other physical characteristics. The top-ranked sites in each hydrologic area for each Responsible Agency jurisdiction were identified, then each was reviewed using aerial photography to assess the validity of the site. Sites that were potentially feasible per the aerial photography review were used to target parcels where field investigations would be conducted. On the basis of the field evaluations, the sites were ranked by implementation feasibility. Fact sheets were then composed to convey the design intent and potential configuration of each site.

Table J-11
Prioritization Criteria for Multiuse Treatment Area BMP Implementation

Factor	Score (1 = Worst; 5 = Best)				
	1	2	3	4	5
Parcel Type	All Others	All Private Commercial or Industrial Parcels	—	Other-Owned Public Parcels (Assigned a Priority Score of 8)	City or County Public Parcels (Assigned a Priority score of 10)
Hydrologic Soil Group	D	—	C	—	A, B
Proximity to Wells and Water Supplies, and Contaminated Soils (Feet)	< 100	—	> 100	—	—
Proximity to Environmental Sensitive Areas (ESAs)	—	—	—	Drains to	Adjacent
Parcel Percent Impervious	> 40	—	—	30–40	≤ 30
Parcel Size (Acres)	< 1	1–100	100–150	150–200	≥ 200
Proximity to Existing and Proposed BMP Site (Miles)	< 2	2–3	3–4	4–5	> 5
Proximity to Parks and Schools (Feet)	—	—	< 1,000	School	Park
Proximity to Storm Drainage Network (Feet)	> 300	< 300	< 100	—	—
Contributing Area (Acres)	< 50	> 50	> 100	> 150	> 250
Impervious Coverage of Contributing Area (%)	< 40	> 40	> 50	> 60	> 70
Proximity to Corrugated Metal Pipe (CMP) Systems	CMP requiring no action	—	CMP needing rehabilitation	—	CMP needing replacement

Note:
1. Schools and universities, state and federal facilities, and utilities

Model Representation

Each of the multiuse treatment area BMPs was represented directly in the LSPC using a storage-discharge relationship to simulate outflow and a background infiltration rate reflective of the underlying soils (as shown in Figure J-15). By incorporating these features directly into the LSPC, the dynamic effect on volume and water quality incorporates all of the spatial variability (land use distribution and precipitation time series) within the model.

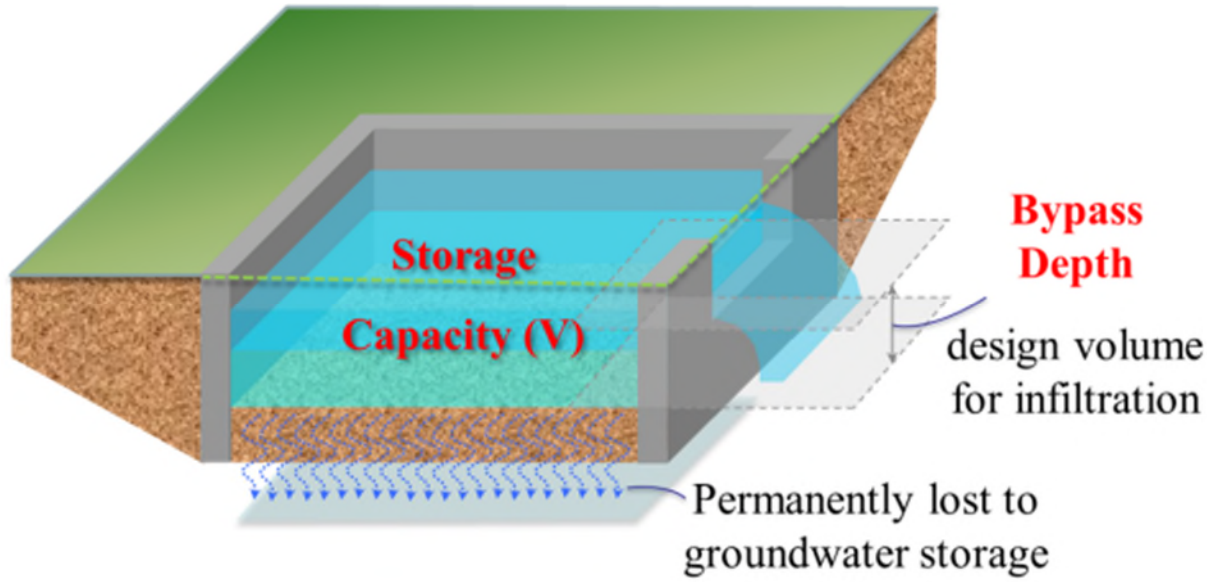


Figure J-15
Multiuse Treatment Area BMP Representation

The static storage volume of each optional multiuse treatment area was initially calculated as the required volume corresponding to the 85th percentile runoff depth, based on the average percent imperviousness in the upstream contributing drainage area (City of San Diego, 2008). The 85th percentile runoff depth was calculated uniquely for each multiuse treatment area, using the weather station assigned to the model subwatershed that includes each BMP. The storage volume and BMP dimensions were then verified and refined based on field reconnaissance to reflect realistic dimensions of the BMPs implemented at each unique location. Additionally, planned or already-implemented multiuse treatment areas with known dimensions and drainage areas were also represented modeled.

Modeling Results

From previous site selection optimization analyses, approximately 2,235 parcels were screened for BMP opportunities in the Los Peñasquitos WMA, resulting in 312 public parcels among the five Responsible Agencies. Eleven newly identified and nine known multiuse treatment area projects were identified during the screening and prioritization

process, as listed in Table J-12 and displayed in Figure J-16. As shown it the table, most BMPs were modeled in SUSTAIN, but several BMPs were included explicitly in the LSPC baseline model to improve calibration.

Table J-12
Tabulation of Identified Potential Multiuse Treatment Areas in the Los Peñasquitos WMA

Name of Multiuse Treatment Area	Responsible Agency	Subwatershed	Type of Best Management Practice (BMP)	Modeled Drainage Area (acres)
Modeled with SUSTAIN				
Los Peñasquitos Lagoon Sediment Basin	City of San Diego	Los Peñasquitos Creek	Sediment Detention Basin	36,375
Ashley Falls	City of San Diego	Carmel Valley Creek	Retention Basin	30
Carroll Canyon Road Extension - Flintkote Sediment Detention Basin (Project ID 1007)	City of San Diego	Los Peñasquitos Lagoon	Sediment Detention Basin	35
Carroll Canyon Road Extension - Upper Sorrento Valley Road Sediment Detention Basin (Project ID 1007)	City of San Diego	Carroll Canyon Creek	Sediment Detention Basin	9,306
Carmel Creek Neighborhood Park and Elementary School	City of San Diego	Carmel Valley Creek	Infiltration Basin	66
Del Mar Trails Park	City of San Diego	Carmel Valley Creek	Detention Basin	19
Open Space adjacent to Carmel Knolls Drive	City of San Diego	Carmel Valley Creek	Infiltration Basin	301
Sage Canyon Park	City of San Diego	Los Peñasquitos Creek	Detention Basin	14.4
Open Space next to Canyonside Park Driveway	City of San Diego	Los Peñasquitos Creek	Detention Basin	181
Dingeman Elementary School and Spring Canyon Park	City of San Diego	Los Peñasquitos Creek	Detention Basin	559
Sandburg Park	City of San Diego	Los Peñasquitos Creek	Detention Basin	268
Maddox Park	City of San Diego	Carroll Canyon Creek	Detention Basin	570
Mira Mesa High School	City of San Diego	Carroll Canyon Creek	Detention Basin	261
Open Space adjacent to Carriage Road	City of Poway	Los Peñasquitos Creek	Stormwater Wetland	9,567

Name of Multiuse Treatment Area	Responsible Agency	Subwatershed	Type of Best Management Practice (BMP)	Modeled Drainage Area (acres)
Hilleary Park - 01/23/14 - request has come in for a dog park	City of Poway	Los Peñasquitos Creek	Detention Basin	138
Included in Baseline Model				
Community Detention Basin	City of Poway	Los Peñasquitos Creek	Detention Basin	9.5
Gate Detention Basin	City of Poway	Los Peñasquitos Creek	Detention Basin	206
Kirkham Detention Basin	City of Poway	Los Peñasquitos Creek	Detention Basin	150
Stotler Detention Basin	City of Poway	Los Peñasquitos Creek	Detention Basin	32
Stowe Detention Basin	City of Poway	Los Peñasquitos Creek	Detention Basin	200

The multiuse treatment area BMPs on public parcels incorporated in the model were mostly detention facilities (see Table J-12) because sites were largely located on soils with low infiltration capacities. All sites should be analyzed in detail to optimize their design and to maximize the subwatershed-wide load reductions.

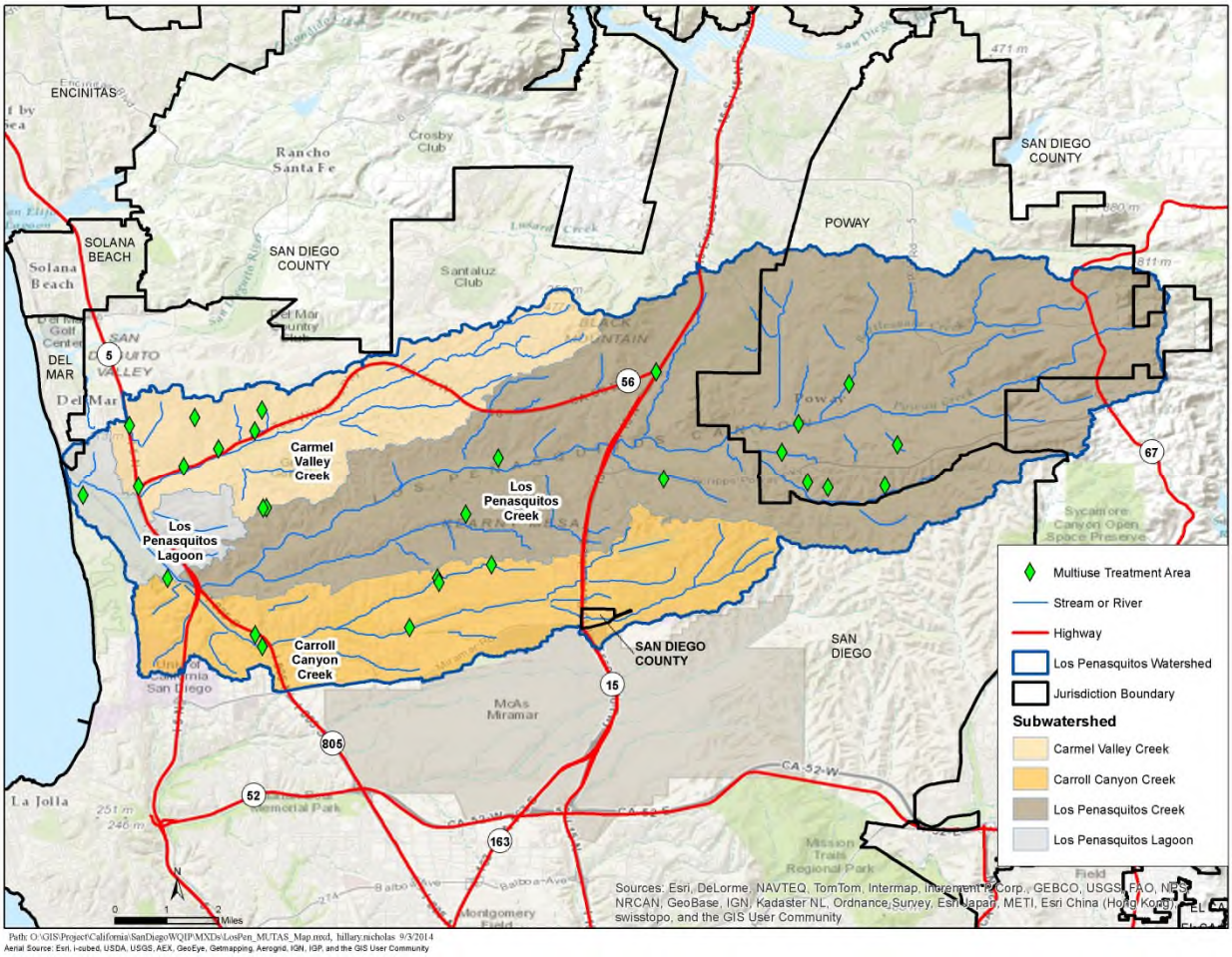


Figure J-16
Locations of Multiuse Treatment Area BMPs in the Los Peñasquitos WMA

J.3.1.2 Green Infrastructure

As with multiuse treatment areas, the first step in selecting the best potential new locations for green infrastructure BMPs was a site-selection and prioritization analysis. This analysis follows the concept presented in Section J.3.1.1, with some modifications specific to green infrastructure practices.

Screening and Prioritization Methodology

The same primary screening criteria presented in Section J.3.1.1 for multiuse treatment areas were used to initially screen out potentially unsuitable parcels for green infrastructure, based on slopes and land ownership. The results of the primary screening provided a base list of parcels potentially suitable for BMP implementation. Then a GIS analysis was performed on the remaining parcels to identify the potential sites for green infrastructure BMP placement and to rank their potential suitability. The following characteristics were used in this ranking:

- **Pollutant Loading:** Parcels where estimated pollutant loadings are greatest were given a higher priority. Land-based pollutant loadings were obtained from the CLRP Task 2 Pollutant Source Characterization modeling results. Pollutant loading percentiles were determined on a watershed basis, and represent the average pollutant loading scores. A composite wet- and dry-weather areal loading score was developed for each applicable TMDL pollutant in each watershed.
- **Parcel Zoning and Ownership:** Land costs generally are minimized by using existing public lands; therefore, a higher priority was placed on publicly-owned parcels.
- **Hydrologic Soil Groups:** The mapped hydrologic soils groups were used as an initial estimate of the infiltration rate and storage capacity of the soils. Sites where mapped hydrologic soils groups have infiltration rates suitable for infiltration BMPs received higher priority.
- **Wells, Water Supplies, and Contaminated Sites:** Areas near contaminated sites received lower priority because of their potential for increased costs and complications during implementation.
- **Environmentally Sensitive Areas:** Areas where runoff can be treated before draining to an ESA were given a higher priority.
- **Total Impervious Area:** Parcels with a larger total impervious area typically generate more runoff and greater pollutant loads, and so were given a higher priority. Where impervious data were not available, the impervious area was estimated using aerial imagery.
- **Percent Impervious:** Parcels with a higher percentage of impervious area also typically produce more runoff, and so were targeted on the basis of their greater potential to reduce volume and improve water quality.
- **Proximity to Existing BMPs:** To distribute treatment opportunities effectively throughout the watershed, areas close to existing or planned future BMPs were given a lower priority.
- **Proximity to Parks and Schools**: Areas closest to parks and schools were given a higher priority, in part to provide a greater opportunity for public outreach and education.
- **Proximity to the Storm Drainage Network:** Areas close to the storm drain network were given a higher priority. Green infrastructure BMPs on poorly draining soils require underdrain systems that tap into existing infrastructure, and siting these near the storm drain network can minimize cost.

Potential sites were prioritized using a scoring methodology developed in conjunction with the Responsible Agencies and presented in Table J-13. This scoring methodology puts an equally high emphasis on municipal or public ownership and areas most affected by land-based pollutant loadings (combined wet and dry weather loading). Ownership and pollutant loading can achieve a maximum score of 10; the remaining scoring criteria can achieve a maximum score of 5. Therefore, this methodology not only prioritizes locations

where green infrastructure BMPs are practicably feasible but allows for selecting BMPs in public parcels where the load reduction would be potentially most effective.

The top-ranked sites in each hydrologic or subwatershed area for each Responsible Agency were also identified.

Table J-13
Prioritization Criteria for Potential Green Infrastructure BMP Locations

Factor	Score (1 = Worst; 5 = Best)				
	1	2	3	4	5
Wet Weather Areal Pollutant Loading	<20th percentile	40-20th percentile	60-40th percentile	80-60th percentile	>80th percentile
Dry Weather Areal Pollutant Loading	<20th percentile	40-20th percentile	60-40th percentile	80-60th percentile	>80th percentile
Parcel Zoning and Ownership	All Other Parcels	All Private Commercial or Industrial Parcels	—	Other-Owned Public Parcels: Priority Score of 8	City- or County-Owned Public Parcels and Rights-of-Way: Priority Score of 10
Hydrologic Soil Group	D	—	C	—	A, B
Proximity to Wells, Water Supplies, and Contaminated Soils (Feet)	< 100	—	> 100	—	—
Proximity to ESA (Optional)	—	—	—	Drains to	Adjacent to
Impervious Area (Acres)	—	> 0.1	> 0.25	> 0.5	> 1
Percentage Impervious	< 50	—	—	80–90	60–80
Proximity to Existing or Proposed BMP Site (Miles)	< 2	2–3	3–4	4–5	> 5
Proximity to Parks and Schools (Feet)	> 1,000	—	< 1,000	—	—
Proximity to Storm Drainage Network (Feet)	> 300	< 300	< 100	—	—

Note:
1. Schools and universities, state and federal facilities, utilities, etc.

Model Representation

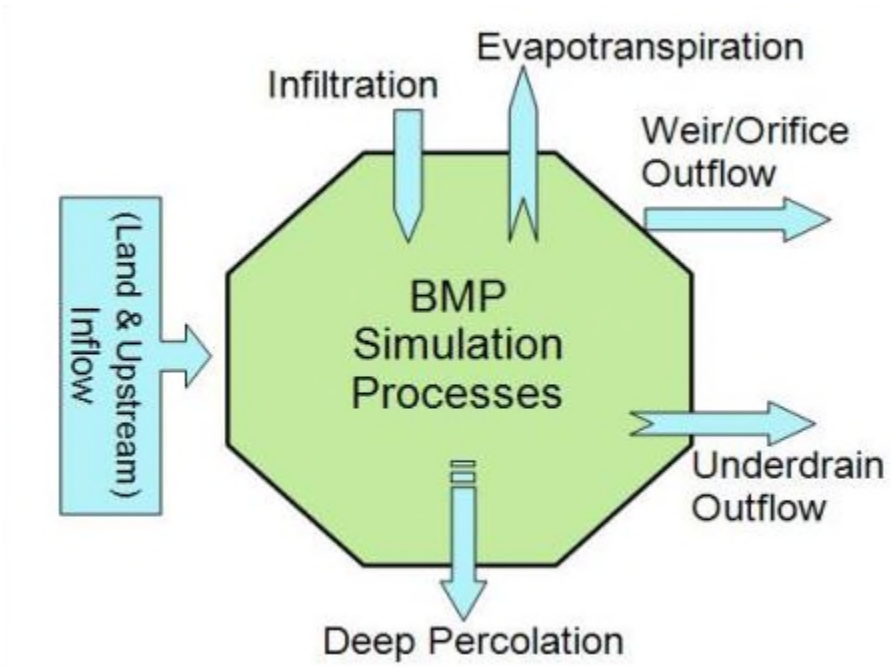
Green infrastructure BMPs were simulated in the LSPC, using bioretention or permeable pavement features. These BMPs' runoff and pollutant loading boundary conditions were generated for the modeling framework and were selected for evaluation in consideration of their suitability in various site configurations and their multiuse benefits. The model represented green infrastructure BMPs using a set of (a) physical characteristics that describe the feature geometry and (b) process-based parameters that describe the mechanisms related to flow and pollutant transport, such as evapotranspiration, infiltration, and pollutant loss. Physically, both bioretention and pervious pavement were conceptualized as having three compartments: (a) surface storage, which provides volume for ponding, (b) soil media or aggregate substrate, and (c) an optional underdrain reservoir when required by background soil conditions. Both bioretention and permeable pavement options were configured with and without underdrains, depending on the underlying soils. For instance, HSG B areas were modeled without underdrains and HSG C and D areas were modeled with underdrains. These modeling parameters are outlined in Table J-14.

Table J-14
Detailed Model Representation for Green Infrastructure BMPs

Parameter	Bioretention	Permeable Pavement
Surface Parameters		
Unit size (square feet) *(Varies with 85th percentile rainfall depth)*	808–1,520	1,388–2,610
Design drainage area (acres)*	1	1
Substrate depth (feet)	3	2
Underdrain depth (feet)	None for B Soil; 1.5 for C, D Soil	None for B Soil; 1.5 for C, D Soil
Ponding depth (feet)	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 soil 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 (inches per hour), f_c	2	2

The modeled BMPs incorporated a variety of pathways through which water and pollutants travel through the BMP (e.g., infiltration, evapotranspiration, weir overflow, and underdrain outflow). Figure J-17 is a schematic diagram of the soil media and underdrain components illustrating the related physical and process-based parameters. As discussed above, inflow from the land was represented using the time series from the LSPC.

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



Source: Lee et al., 2012

Figure J-17
Conceptual Diagram of Selected Processes Associated with Structural BMPs

Green infrastructure BMPs were modeled in CLRP Phase II by assuming that BMPs were sized to capture the 85th percentile runoff volume from each suitable public parcel in each subwatershed (City of San Diego 2013). Additionally, the City of San Diego is demonstrating progress towards reducing pollutant loads through a number of green infrastructure BMP projects that have already been implemented. Those green infrastructure projects (identified in Table J-15) were modeled with project-specific details to consider the water quality benefits provided by these practices.

Table J-15
Tabulation of Identified Los Peñasquitos Green Infrastructure Projects

Green Infrastructure	Responsible Agency	Subwatershed	Best Management Practice Type	Modeled Impervious Drainage Area (acres)
Miramar Water Treatment Plant	City of San Diego	Carroll Canyon Creek	Grass/Vegetated Swales	5.07
Del Mar Mesa Neighborhood Park	City of San Diego	Los Peñasquitos Creek	Inserts and buffers	0.83
Carroll Canyon Road Extension - added 4/11, under construction	City of San Diego	Carroll Canyon Creek	Grass/Vegetated Swale	5.30
Mira Mesa Library Green Lot	City of San Diego	Los Peñasquitos Creek	Bioretention, Permeable pavement	0.34
Camino Ruiz Neighborhood Park	City of San Diego	Los Peñasquitos Creek	Grass/Vegetated Swale	1.84
Breen Park Site - Development	City of San Diego	Los Peñasquitos Creek	Grass/Vegetated Swale	0.60
Rancho Peñasquitos Skate park	City of San Diego	Los Peñasquitos Creek	Infiltration Basin or Trench (2)	0.57
Fire Station #47	City of San Diego	Carmel Valley Creek	Grass/Vegetated Swale	0.28
Torrey Del Mar Neighborhood Park	City of San Diego	Carmel Valley Creek	Grass/Vegetated Filter Strips (2) AND Grass/Vegetated Swales (2)	1.02

Modeling Results

The screening and prioritization process identified the potentially suitable parcels for optional green infrastructure implementation in the Los Peñasquitos WMA, as shown in Figure J-18. These prioritized parcels provide a basis for selecting project sites throughout the WMA and should be cross-referenced with already-planned projects (e.g. parking lot improvements, utility work, landscaping enhancements, etc.) to ensure cost-effective scheduling and implementation. All projects should be sized to capture and treat the 85th percentile runoff volume from the contributing impervious parcel area.

The modeled quantities of green infrastructure that were predicted (in addition to other nonstructural strategies and structural BMPs) to meet the sediment wet weather load reductions are shown in Figure J-18 and listed in Table J-16. These BMPs should be applied throughout each modeled subwatershed, based on the list of prioritized parcels during CLRP I efforts (City of San Diego 2012) and shown in Figure J-18.

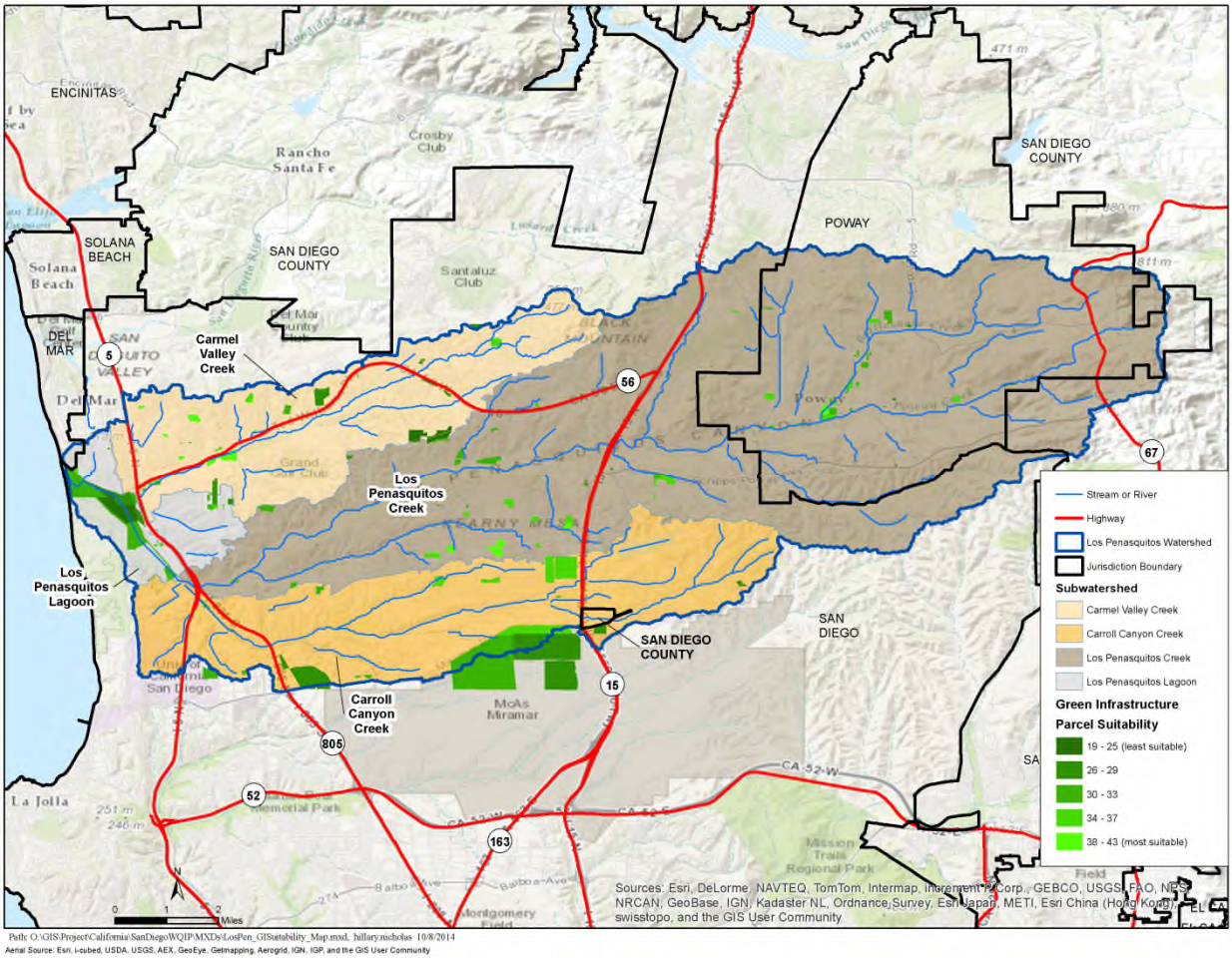


Figure J-18
High-Ranked Locations
of Optional Green Infrastructure Best Management Practices

J.3.1.3 Green Streets

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 reduction goals, an assessment was performed to identify green streets opportunities on a WMA-wide basis.

Screening and Prioritization Methodology for Potential Sites

Available green street implementation and contributing areas were determined using existing 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. These initial screening steps are illustrated in Figure J-19.

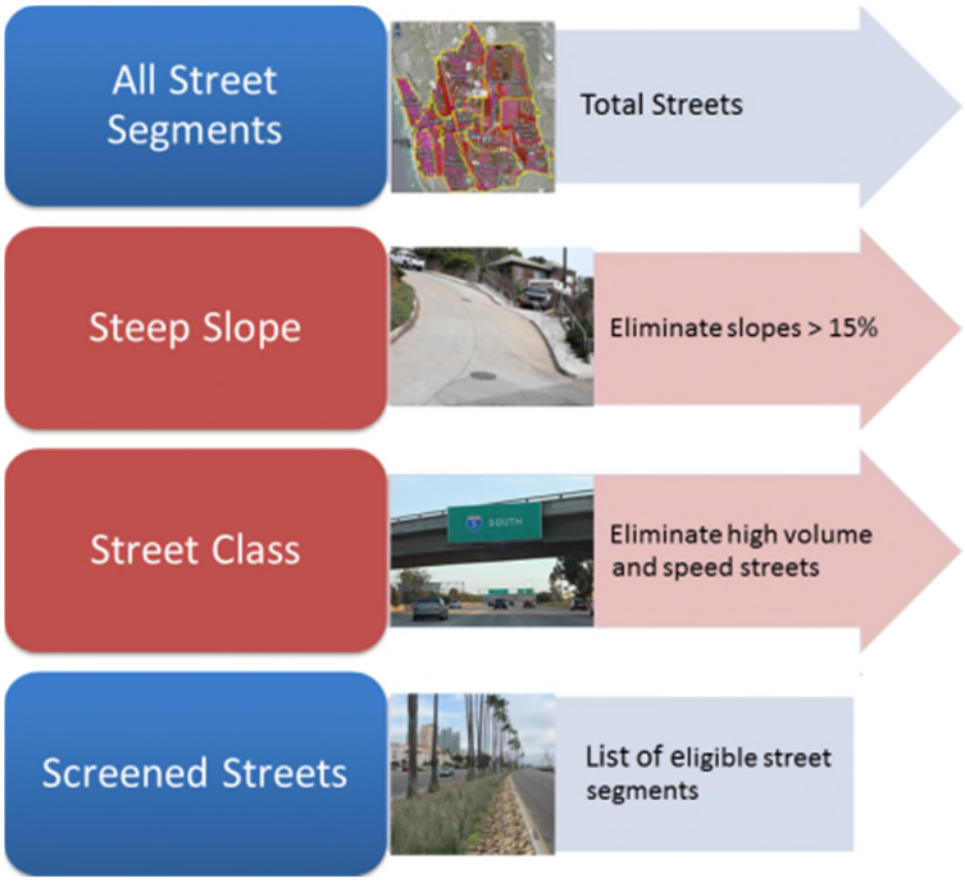


Figure J-19
Street Screening Results

Model Representation

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 J-3.1.2 of this appendix, except that the BMP-to-drainage area ratio was allowed to vary such that optimum solutions could be determined. Additionally, results were compared for both 18” and 24” depth bioretention areas in order to determine which was most cost-effective. It was found that 18” of substrate depth provided enough depth for effective pollutant load reduction for the Highest Priority Water Quality Condition in this case, sediment. Thus 18” was used for the bioretention areas substrate depths in the model.

Green street optimization was performed for each subwatershed in the WMA so that modeled implementation was dependent upon the loading and hydrologic conditions unique to each subwatershed.

Modeling Results

The screening process classified the percentage of suitable roads for green street implementation in each modeled drainage area, as shown in Figure J-20. The extents of suitable roads displayed in Figure J-20 and tabulated in Table J-16 represent the planning-level extent of green street retrofits in the Los Peñasquitos WMA. The table also tabulates the proportion of BMPs requiring underdrains to allow functionality in areas with poor draining soils. Implementation of all green street opportunities is needed to meet the Water Quality Improvement Plan sediment targets, and thus the locations for implementation were not optimized. Street-scale analysis is required to determine the most cost effective green street locations and drainage area ratios.

Table J-16
Modeled Green Street Sizes to Meet Subwatershed Goals

Subwatershed	Jurisdiction	Total Green Street BMP Footprint (ac)	Percentage of BMPs Requiring Underdrains
Carmel Valley Creek	City of San Diego	53.20	68%
Carroll Canyon Creek	County of San Diego	0.13	100%
	City of San Diego	55.92	65%
Los Peñasquitos Creek	City of Poway	64.64	73%
	County of San Diego	0.41	74%
	City of San Diego	121.42	97%
Los Peñasquitos Lagoon	City of Del Mar	0.06	33%
	City of San Diego	9.06	70%

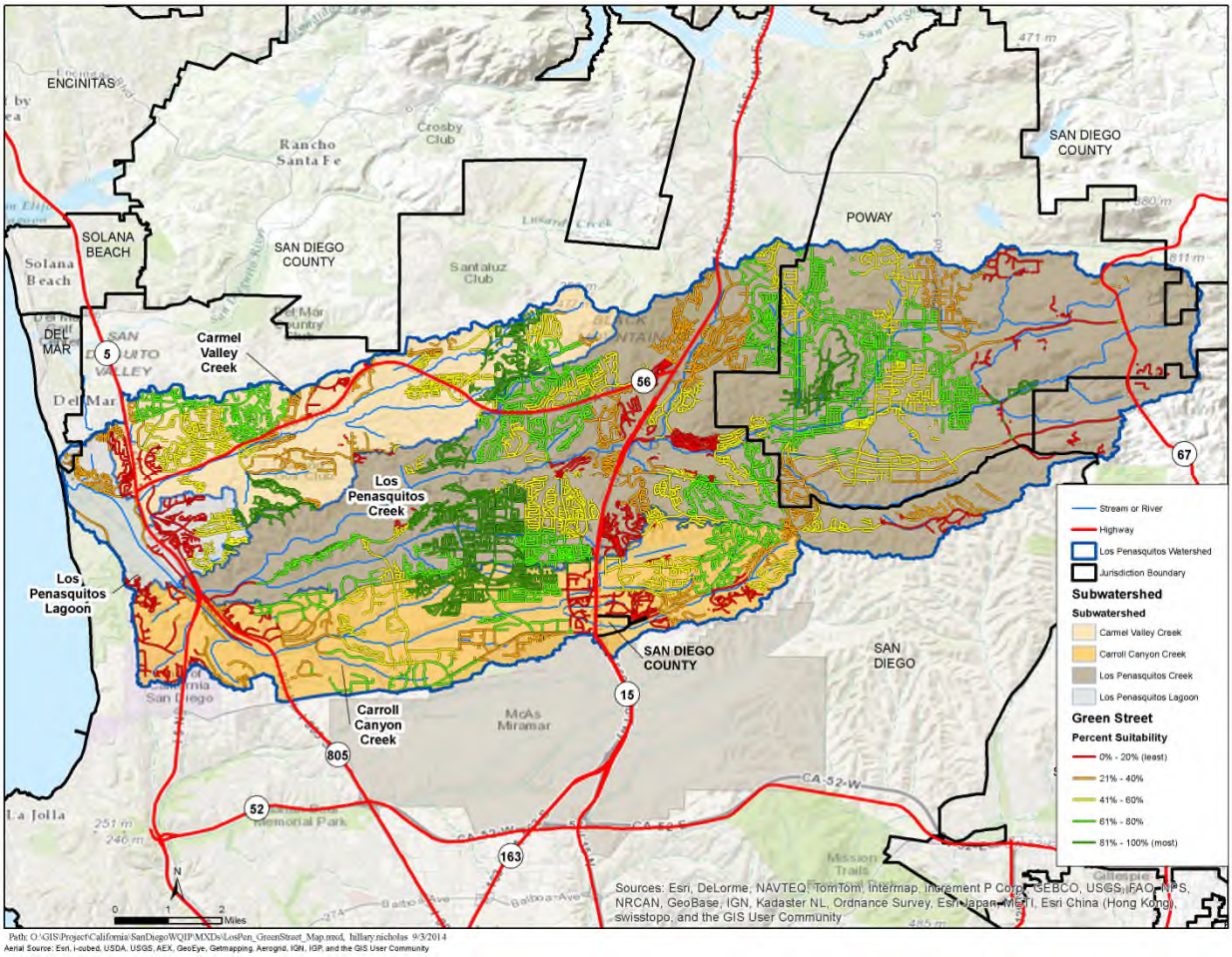


Figure J-20
Green Street Opportunity Screening Results (Potential Retrofit Suitability by Subwatershed) Water Quality Improvement BMPs

Water quality improvement BMPs include strategies such as low-flow diversions and proprietary BMPs. These BMPs can be useful where green infrastructure is not suitable because of design constraints. No water quality improvement BMPs were explicitly modeled within the Los Peñasquitos WMA.

J.3.1.4 Additional Opportunities

In the event that the combination of structural and nonstructural BMPs discussed above are not sufficient to meet reduction goals, additional strategies exist that can be identified and implemented through adaptive management to achieve interim and final numeric goals. In general, additional opportunities may include the creation of additional sediment detention basins, stream and canyon restoration, Lagoon restoration, new strategies not yet identified, phased implementation, operation, and maintenance of the additional required acreage of multiuse treatment area projects, or increased implementation of nonstructural and/or green infrastructure BMPs that would be equivalent to the storage volume required for treatment. Activities particularly relevant within the Los Peñasquitos WMA that target water quality improvement include upgrades to existing MS4 outfalls along canyon slopes to reduce scouring, low impact development measures in the developed mesas, restoration or enhanced sediment management of reaches affected by mining operations, and stabilization of various sections of Carroll Canyon Creek. In addition, development of a comprehensive Los Peñasquitos Lagoon Restoration strategy will provide an opportunity to reassess the watershed sediment load reduction needs and further refine the overall direction of the Water Quality Improvement Plan.

Because of limited restoration component details currently available, load reductions for additional opportunities were estimated as the implementation of two additional sediment detention bases, similar to the existing basin in Los Peñasquitos Creek subwatershed, restoration of five creek segments including repair or replacement of MS4 outfalls, and restoration of the Lagoon as discussed further in Section 4.2.5.1. Detailed modeling or technical analyses will need to be performed to quantitatively assess the water quality benefits as a result of the restoration and to identify other regional structural BMPs, if needed, to meet the Water Quality Improvement Plan numeric goals. As discussed in the following sections, if additional opportunities beyond the sediment basins, outfall repair and stream restoration, and Lagoon restoration are needed, the additional opportunities were modeled as additional multiuse treatment areas in non-publicly owned areas.

Screening and Prioritization Methodology for Potential Additional Multiuse Treatment Areas

Modeling of additional watershed opportunities was considered only at a conceptual level as it is not feasible to consider all factors needed to locate specific multiuse treatment areas due to unknown locations and land availability. As such, private parcels were considered as viable options for additional watershed opportunities; this assumption can be refined once detailed implementation strategies (including stream, channel, and habitat restoration projects and public private partnerships) are proposed and analyzed.

Model Representation of Additional Multiuse Treatment Areas

Individual SUSTAIN models were developed for each subwatershed to characterize the unit response of a hypothetical BMP. Unlike the green streets optimization, which was based upon a detailed desktop analysis of BMP opportunities, the optimization of additional watershed opportunities was founded on a higher level planning analysis due to the unknown locations and availability of private land acquisition. Specific spatial and climatic characteristics of each individual subwatershed were loaded into SUSTAIN and hypothetical BMPs were simulated with a fixed drainage area necessary to capture the design storm. Each BMP was represented by fixing the depth at 2 feet and allowing the footprint to vary based on the required volume. In few cases, some special BMP configurations were made. To meet targets, BMP depths were increased to 3 feet and orifices were raised 8 inches in City of San Diego jurisdiction in Carmel Valley Creek Watershed. To ensure equity of treatment BMPs in San Diego County in Carroll Canyon Creek, orifices were raised to 8 inches and depths remained at 2 feet. It is important to note that for these areas, special design considerations such as drawdown time, vector control, signage, and fencing may be necessary for these deeper sized BMPs. Modeling each individual subwatershed separately allowed quantification of a unique BMP response which is a function of both variation in precipitation and a unique land use distribution.

The optimization analysis included numerous combinations of BMP location and size scenarios. Construction costs were incorporated as a function of both BMP footprint and volume based on previous construction line item cost estimates completed for similar BMPs.

Model Results for Additional Multiuse Treatment Areas

The optimization system selected the most cost effective combinations of additional watershed opportunities in each subwatershed to attain the wet weather load reduction goal. Because specific project locations and configurations have not been identified for additional watershed opportunities, the modeling results represent a planning-level quantity of BMPs that must be implemented to achieve compliance. Adaptive management and more detailed analysis will be used to identify specific projects to achieve the load reduction goals.

J.4 Comprehensive Strategy Results

Nonstructural and structural strategies were modeled to demonstrate progress toward attaining the numeric goals outlined in the main body of this document. The focus of the optimization analysis is to consider the cost-effectiveness of subwatershed-wide implementation of BMPs. Optimization incrementally considers costs of BMP implementation and accounts for progress toward achieving the load reduction goals. The targets for optimization are the jurisdictional goals, the percent load reduction goal equitably distributed among jurisdictions, presented in Section 4.1. An equitable percent load reduction goal ensures an overall net load reduction for the entire subwatershed with the ability for each Responsible Agency to achieve the load reduction appropriately and effectively for each jurisdiction. A relative percent load reduction goal also ensures equitable distribution of the pollutant mass to be reduced—requiring the City of San Diego

(with higher existing loads) to implement more BMPs to reach the reduction goal, but still achieve the same percent reduction as other Responsible Agencies.

Strategies were prioritized by order of those that are most cost-effective. For instance, nonstructural strategies are effective in reducing pollutant loads before they enter the storm drain and are generally cost-effective and require a shorter planning period. Therefore, most nonstructural strategies are planned for implementation before or upon approval of the Water Quality Improvement Plan. Structural BMPs can be cost-effective when greater load reductions are needed and treatment must occur after the pollutants enter the storm drain system, particularly when benefits other than water quality improvements are considered. However, planning for structural BMPs requires more time to secure resources, design BMPs, and obtain permits. Most of the structural BMPs are planned for later in the compliance period to allow more time to ensure that the implementation is necessary to meet numeric goals and is designed to achieve the load reductions required, and that alternatives to these BMPs have been evaluated. The following sections summarize the combined load reductions predicted for all modeled strategies for each Responsible Agency.

J.4.1 Caltrans Results

Caltrans will voluntarily implement the strategies outlined in Section 4.2 of the Water Quality Improvement Plan, as resources are available, per the schedule provided in Appendix I. Attachment IV to the Caltrans MS4 permit, outlines a methodology for prioritizing stream segments included in TMDLs in which Caltrans is subject to. The permit establishes BMP implementation requirements evaluated in terms of compliance units, as opposed to load reduction targets. Caltrans is expected to achieve 1650 compliance units per year through the implementation of retrofit BMPs, cooperative implementation, and post construction treatment beyond permit requirements.

For Bacteria TMDLs, Caltrans is expected to eliminate dry weather flows by implementing control measures to ensure effective prohibition (Provision B.2 of the Permit). For wet weather flows, Caltrans is expected to implement control measures/BMPs to prevent discharge of bacteria from the ROW; this can be source control and preemptive activities such as street sweeping, clean-up of illegal dumping and public education on littering. Implementation of these controls is per the TMDL prioritization list currently under development. The Sediment TMDL has not been incorporated into the Caltrans MS4 Permit.

J.4.2 City of Del Mar Results

Table J-17 and Table J-18 summarize pollutant load reductions for wet and dry weather conditions for the City of Del Mar. These tables present the load reductions predicted for all modeled strategies within the WMA and demonstrate that the strategies presented in the Water Quality Improvement Plan will reach the dry and wet weather subwatershed percent load reduction goals. Mass of sediment removed in terms of tonnage is presented in Table J-19 for wet weather conditions.

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Table J-17
Predicted Wet Weather Load Reduction Summary for the City of Del Mar

Strategy and Level of Implementation[1]	City of Del Mar – Wet Weather Percentage Reductions									
	Total Sediment[2]	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Los Peñasquitos Lagoon Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	3.2%	0.1%	4.4%	0.6%	1.4%	0.2%	2.3%	4.0%	<0.1%	<0.1%
Green Infrastructure 0.001 acre of green infrastructure	0.1%	0.4%	0.2%	<0.1%	0.1%	0.1%	0.3%	0.2%	0.3%	0.1%
Green Streets[3] 0.06 acre BMP to treat a total drainage area of 2.59 acres	6.9%	9.1%	5.4%	11.6%	9.3%	11.7%	7.9%	5.9%	8.9%	8.7%
Additional Opportunities[3] 0.18 acres with a total storage volume of 0.35 ac-ft.	14.6%	21.2%	18.4%	17.6%	16.5%	17.6%	19.7%	17.4%	21.3%	21.1%
Total	**34.8%** **Goal = 34.8%**	**40.7%** **Goal = 2.0%**	**38.3%**	**39.8%**	**37.3%**	**39.7%**	**40.1%**	**37.4%**	**40.5%** **Goal = 1.9%**	**39.9%** **Goal = 1.6%**

Note:

1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Orange-shaded cells indicate highest priority water quality conditions for the Los Peñasquitos WMA.
3. Strategy has been identified as potential based on results of a model that may not be reflective of the small drainage area that leads from Del Mar to the lagoon. The strategy is presented until further analysis (including monitoring data) can confirm or revise the needs and strategies.

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

Table J-18
Predicted Dry Weather Load Reduction Summary for the City of Del Mar

Strategy and Level of Implementation[1]	City of Del Mar – Dry Weather Percentage Reductions									
	Total Sediment	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Los Peñasquitos Lagoon Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	32%	99%	32%	26%	37%	59%	65%	86%	99%	99%
Total	**42%**	**100%[3]** **Goal = 96.6%**	**42%**	**36%**	**47%**	**69%**	**75%**	**96%**	**100%[3]** **Goal = 99.4%**	**100%[3]** **Goal = 96.5%**

Note:
1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Orange-shaded cells indicate highest priority water quality conditions for the Los Peñasquitos WMA.
3. Mechanistic, process-based assumptions were not applied to non-modeled nonstructural BMPs, resulting in the cumulative dry weather load reductions exceeding 100% (this implies that the combination of strategies will be more than sufficient to achieve dry weather load reduction goals).

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

Table J-19
Predicted Wet Weather Load Sediment Mass Reduction Summary for the City of Del Mar (Tonnage)

Strategy	City of Del Mar – Wet Weather Sediment Tonnage Reduction[1,2,3]
	Los Peñasquitos Lagoon
Nonstructural, non-modeled	0.13
Nonstructural, modeled	0.04
Irrigation Reduction	
Structural, modeled	<0.01
Green Infrastructure	
Green Streets	0.09
Additional Opportunities	0.20

Note:
1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Sediment masses are land-based removals and do not account for in-stream processes.
3. The mass of sediment reduction is, in part, related to rainfall, which varies by year. Tonnage presented represents the estimated mass removed based on rainfall data during the wet period October 1, 2002– April 30, 2003.

J.4.3 City of Poway Results

Table J-20 and Table J-21 summarize pollutant load reductions for wet and dry weather conditions for the City of Poway. These tables present the load reductions predicted for all modeled strategies within the WMA and demonstrate that the strategies presented in the Water Quality Improvement Plan will reach the dry and wet weather subwatershed percent load reduction goals. Mass of sediment removed in terms of tonnage is presented in Table J-22 for wet weather conditions.

Table J-20
Predicted Wet Weather Load Reduction Summary for the City of Poway

Strategy and Level of Implementation[1]	City of Poway – Wet Weather Percentage Reductions									
	Total Sediment[2]	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Los Peñasquitos Creek Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	4.0%	0.1%	3.5%	0.9%	1.9%	0.3%	2.0%	2.5%	<0.1%	<0.1%
Street Sweeping[3] See Section 2.2.1	3.3%	<0.1%	<0.1%	9.5%	5.2%	8.3%	<0.1%	<0.1%	<0.1%	<0.1%
Multiuse Treatment Areas 3.3 acre BMP to treat a total drainage area of 9,705 acres with a total storage volume of 4.9 ac-ft.	0.6%	4.5%	6.4%	1.1%	1.1%	1.0%	4.6%	2.5%	5.9%	5.2%
Green Infrastructure 0.26 acre of green infrastructure	0.04%	0.22%	0.08%	0.02%	0.04%	0.04%	0.14%	0.09%	0.19%	0.05%
Green Streets 64.64 acre BMP to treat a total drainage area of 2,908.8 acres	26.5%	32.3%	10.4%	40.9%	29.7%	40.8%	22.9%	21.9%	33.6%	31.7%

Strategy and Level of Implementation[1]	City of Poway – Wet Weather Percentage Reductions									
	Total Sediment[2]	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Additional Opportunities	5.2%	5.3%	3.8%	3.8%	4.4%	4.4%	3.9%	3.7%	4.0%	4.3%
28.8 acre BMP with a total storage volume of 57.7 ac-ft.										
Total	**49.7%**	**50.6%**	34.4%	65.6%	51.7%	64.1%	42.8%	40.1%	**48.1%**	**46.1%**
	Goal = 47.2%	**Goal = 2.0%**							**Goal = 1.9%**	**Goal = 1.6%**

Note:

1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Orange-shaded cells indicate highest priority water quality conditions for the Los Peñasquitos WMA.
3. Nonstructural, modeling load reductions do not yet include street sweeping enhancements.

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

Table J-21
Predicted Dry Weather Load Reduction Summary for the City of Poway

Strategy and Level of Implementation[1]	City of Poway – Dry Weather Percentage Reductions									
	Total Sediment	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Los Peñasquitos Creek Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	37%	99%	33%	32%	43%	57%	64%	75%	99%	99%
Total	**47%**	**100%[3]** **Goal = 96.6%**	**43%**	**42%**	**53%**	**67%**	**74%**	**85%**	**100%[3]** **Goal = 99.4%**	**100%[3]** **Goal = 96.5%**

Note:
1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Orange-shaded cells indicate highest priority water quality conditions for the Los Peñasquitos WMA.
3. Mechanistic, process-based assumptions were not applied to non-modeled nonstructural BMPs, resulting in the cumulative dry weather load reductions exceeding 100% (this implies that the combination of strategies will be more than sufficient to achieve dry weather load reduction goals).

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

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Table J-22
Predicted Wet Weather Load Sediment Mass Reduction Summary for the City of Poway (Tonnage)

Strategy	City of Poway – Wet Weather Sediment Tonnage Reduction
	Los Peñasquitos Creek[1,2,3]
Nonstructural, non-modeled	61.5
Nonstructural, modeled	
Street Sweeping	20.4
Irrigation Reduction	24.8
Structural, modeled	
Multiuse Treatment Areas	3.4
Green Infrastructure	0.2
Green Streets	163
Additional Opportunities	32.3

Note:
1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Sediment masses are land-based removals and do not account for in-stream processes.
3. The mass of sediment reduction is, in part, related to rainfall, which varies by year. Tonnage presented represents the estimated mass removed based on rainfall data during the wet period October 1, 2002– April 30, 2003.

J.4.4 City of San Diego Results

Table J-23 and Table J-24 summarize pollutant load reductions for wet and dry weather conditions for the City of San Diego. These tables present the load reductions predicted for all modeled strategies within the WMA and demonstrate that the strategies presented in the Water Quality Improvement Plan will reach the dry and wet weather subwatershed percent load reduction goals. Mass of sediment removed in terms of tonnage is presented in Table J-25 for wet weather conditions. In compliance with the Settlement Agreement and Release (Settlement) made with San Diegans for Open Government (SDOG) and Coastal Environmental Rights Foundation (CERF), City of San Diego will conduct either increased street sweeping or additional catch basin inspection and cleaning efforts near channel facilities as they are cleared. According to the Settlement, the City of San Diego with either a) increase street sweeping of high traffic commercial routes adjacent to maintained channels to monthly, weekly, or twice weekly (beyond the recommended frequency of bi-weekly) or b) conduct an inspection and cleaning (as necessary) of every catch basin within 100 feet of the maintained segment every three months for one year after cleaning. There are 31 channel facilities located in the Los Peñasquitos WMA. The effects of these settlement agreement related activities are not quantified through modeling efforts as these efforts primarily address the impacts of channel clearing and not baseline pollutant loading.

Table J-23
Predicted Wet Weather Load Reduction Summary for the City of San Diego

Strategy and Level of Implementation[1]	City of San Diego – Wet Weather Percentage Reductions									
	Total Sediment[2]	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Street Sweeping See Section J.2.2.1	4.5%	<0.1%	<0.1%	13.2%	7.1%	11.6%	<0.1%	<0.1%	0.1%	<0.1%
Catch Basin Cleaning See Section J.2.2.2	3.5%	<0.1%	<0.1%	1.3%	0.8%	0.3%	0.7%	0.8%	<0.1%	<0.1%
Rain barrel installations See Section J.2.2.3	<0.01%	0.07%	0.04%	0.01%	0.02%	0.02%	0.04%	0.01%	0.10%	0.11%
Downspout Disconnect See Section J.2.2.4	0.03%	0.1%	0.04%	0.07%	0.06%	0.1%	0.05%	<0.01%	0.02%	0.02%
Irrigation reduction[3] Eliminate irrigation overspray and reduce irrigation by 25%	4.4%	0.1%	3.3%	0.9%	2.1%	0.4%	1.7%	2.5%	<0.1%	<0.1%
Multiuse Treatment Areas 20.5 acre BMP to treat a total drainage area of 2,239 acres with a total storage volume of 5.0 ac-ft.	2.9%	5.7%	1.1%	1.7%	1.7%	1.7%	2.8%	2.1%	0.6%	0.1%
Green Infrastructure 21.87 acres of green infrastructure	1.0%	4.7%	0.8%	0.6%	0.9%	1.1%	2.5%	2.1%	3.9%	1.0%
Green Streets 239.6 acres of green streets	20.9%	26.9%	7.7%	29.5%	22.2%	30.0%	18.9%	19.5%	28.9%	27.5%

Strategy and Level of Implementation[1]	City of San Diego – Wet Weather Percentage Reductions									
	Total Sediment[2]	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Additional Opportunities										
Lagoon restoration, outfall repair/replacement, stream restoration, and other opportunities	8.6%	Load Reductions from pollutants not assessed, but are anticipated.								
Total[4]	**55.8%**	**47.6%**	**22.9%**	**57.2%**	**44.8%**	**55.1%**	**36.6%**	**37.1%**	**43.6%**	**38.8%**
	Goal = 53.1%	**Goal = 2.0%**							**Goal = 1.9%**	**Goal = 1.6%**

Note:

1. Note that these numbers are planning-level calculated at a watershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Orange-shaded cells indicate highest priority water quality conditions for the Los Peñasquitos WMA.
3. Irrigation reduction strategies include the implementation of grass replacement projects, micro-irrigation system conversions, weather-based irrigation controllers, downspout disconnections, education and outreach and enforcement of regulations that prohibit runoff.
4. Load reduction totals that exceed the goals reflect coarseness in the model that can be improved with finer physical data at the parcel and/or street scale.

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

Table J-24
Predicted Dry Weather Load Reduction Summary for the City of San Diego

Strategy and Level of Implementation[1]	City of San Diego – Dry Weather Percentage Reductions									
	Total Sediment	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	47%	100%	39%	41%	54%	80%	68%	86%	99%	99%
Total	**57%**	**100%[3] Goal = 96.6%**	**49%**	**51%**	**64%**	**90%**	**78%**	**96%**	**100%[3] Goal = 99.4%**	**100%[3] Goal = 96.5%**

Note:
1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Orange-shaded cells indicate highest priority water quality conditions for the Los Peñasquitos WMA.
3. Mechanistic, process-based assumptions were not applied to non-modeled, nonstructural BMPs, resulting in the cumulative dry weather load reductions exceeding 100%.

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

Table J-25
Predicted Wet Weather Load Sediment Mass Reduction Summary for the City of San Diego (Tonnage)

Strategy	City of San Diego – Wet Weather Sediment Tonnage Reduction[1,2,3]
	Los Peñasquitos WMA
Nonstructural, non-modeled	315.1
Nonstructural, modeled	
Catch Basin Cleaning	110.8
Street Sweeping	143.2
Rain Barrels[4]	<0.1
Downspout Disconnect	1.0
Irrigation Reduction	138.8
Structural, modeled	
Multiuse Treatment Areas	90.8
Green Infrastructure	32.0
Green Streets	657.1
Additional Opportunities	269.6

Note:
1. Sediment masses are land-based removals and do not account for in-stream processes.
2. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
3. The mass of sediment reduction is, in part, related to rainfall, which varies by year. Tonnage presented represents the estimated mass removed based on rainfall data during the wet period October 1, 2002– April 30, 2003.
4. Load reduction through rain barrel implementation in Los Peñasquitos WMA, as modeled, results in negligible sediment removed.

J.4.5 County of San Diego Results

Table J-26 and Table J-27 summarize pollutant load reductions for wet and dry weather conditions for the County of San Diego. These tables present the load reductions predicted for all modeled strategies within the WMA and demonstrate that the strategies presented in the Water Quality Improvement Plan will reach the dry and wet weather subwatershed percent load reduction goals. Mass of sediment removed in terms of tonnage is presented in Table J-28 for wet weather conditions.

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Table J-26
Predicted Wet Weather Load Reduction Summary for the County of San Diego

Strategy and Level of Implementation[1]	County of San Diego – Wet Weather Percentage Reductions									
	Total Sediment[2]	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Carroll Canyon Creek Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Street Sweeping See Section 2.2.1	3.0%	<0.1%	<0.1%	18.4%	8.9%	22.5%	<0.1%	<0.1%	<0.1%	<0.1%
Irrigation Reduction Eliminate irrigation overspray and reduce irrigation by 25%	2.3%	0.3%	1.9%	1.0%	2.1%	0.6%	1.9%	0.9%	0.3%	0.9%
Green Streets 0.13 acre BMP to treat a total drainage area of 0.17 acres	1.1%	1.6%	0.7%	2.4%	1.7%	2.8%	0.9%	0.7%	2.7%	1.5%
Additional Watershed Opportunities 1 acre with a total storage volume of 1.9 ac-ft.	33%	45%	19%	31%	29%	32%	31%	26%	48%	46%
Total	**49.5%** **Goal = 48.2%**	**56.9%** **Goal = 2.0%**	**31.6%**	**62.9%**	**51.7%**	**67.8%**	**43.8%**	**37.7%**	**61.0%** **Goal = 1.9%**	**58.4%** **Goal = 1.6%**
Los Peñasquitos Creek Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Street Sweeping See Section 2.2.1	2.4%	<0.1%	<0.1%	19.8%	9.0%	25.1%	<0.1%	<0.1%	0.2%	<0.1%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	2.2%	0.3%	2.2%	1.3%	2.5%	0.7%	2.3%	1.0%	0.2%	0.2%

Strategy and Level of Implementation[1]	County of San Diego – Wet Weather Percentage Reductions									
	Total Sediment[2]	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Green Infrastructure 0.04 acre of green infrastructure	0.1%	5.4%	0.4%	0.3%	0.3%	0.6%	1.1%	0.3%	9.2%	2.7%
Green Streets 0.41 acre BMP to treat a total drainage area of 11.63 acres	3.2%	4.5%	1.1%	5.3%	4.8%	5.9%	2.1%	2.5%	4.7%	4.4%
Additional Opportunities 21.5 acre BMP with a total storage volume of 43.0 ac-ft.	30%	45%	32%	42%	35%	46%	30%	26%	46%	44%
Total	**48.2%** **Goal = 47.2%**	**65.6%** **Goal = 2.0%**	**45.6%**	**68.4%**	**51.5%**	**78.4%**	**36.1%**	**29.9%**	**70.2%** **Goal = 1.9%**	**61.6%** **Goal = 1.6%**

Note:

1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Highest priority water quality conditions

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

Table J-27
Predicted Dry Weather Load Reduction Summary for the County of San Diego

Strategy and Level of Implementation[1]	County of San Diego – Dry Weather Percentage Reductions									
	Total Sediment	Fecal Coliform[2]	Flow	Total Cu	Total Pb	Total Zn	Total N	Total P	Entero[2]	Total Coliform[2]
Carroll Canyon Creek Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	55%	100%	40%	52%	62%	88%	66%	90%	95%	96%
Total	**65%**	**100%[3]** **Goal = 96.6%**	**50%**	**62%**	**72%**	**98%**	**76%**	**100%**	**100%[3]** **Goal = 99.4%**	**100%[3]** **Goal = 96.5%**
Los Peñasquitos Creek Subwatershed										
Nonstructural, non-modeled See Section 4.2.4	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Irrigation reduction Eliminate irrigation overspray and reduce irrigation by 25%	42%	99%	33%	37%	49%	78%	66%	87%	98%	99%
Total	**52%**	**100%[3]** **Goal = 96.6%**	**43%**	**47%**	**59%**	**88%**	**76%**	**97%**	**100%[3]** **Goal = 99.4%**	**100%[3]** **Goal = 96.5%**

Note:
1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Highest priority water quality conditions
3. Mechanistic, process-based assumptions were not applied to non-modeled nonstructural BMPs, resulting in the cumulative dry weather load reductions exceeding 100% (this implies that the combination of strategies will be more than sufficient to achieve dry weather load reduction goals).

% = percent; Cu = copper; Pb = lead; Zn = zinc; N = nitrogen; P = phosphorus; FY = fiscal year

Table J-28
Predicted Wet Weather Load Sediment Mass Reduction Summary for the County of San Diego (Tonnage)

Strategy	County of San Diego – Wet Weather Sediment Tonnage Reduction[1,2,3]	
	Carroll Canyon Creek	Los Peñasquitos Creek
Nonstructural, non-modeled	0.2	2.3
Nonstructural, modeled		
Street Sweeping	0.1	0.5
Irrigation Reduction	0.1	0.5
Structural, modeled		
Green Streets	<0.1	0.7
Additional Watershed Opportunities	0.8	6.9

Note:
1. Note that these numbers are planning-level calculated at a subwatershed scale; structural BMPs should be designed to meet both jurisdictional standards and the numeric goals outlined above at each respective project site. Reported BMP sizes include projects that have already been implemented.
2. Sediment masses are land-based removals and do not account for in-stream processes.
3. The mass of sediment reduction is, in part, related to rainfall, which varies by year. Tonnage presented represents the estimated mass removed based on rainfall data during the wet period October 1, 2002– April 30, 2003.

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APPENDIX K

Model Calibration Report

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APPENDIX K. MODEL CALIBRATION REPORT

K.1 Introduction

The Los Peñasquitos WMA is in central San Diego County and drains into the Los Peñasquitos Lagoon (lagoon) before emptying into the Pacific Ocean (Figure K-1). Both the WMA and lagoon are included in the Los Peñasquitos Hydrologic Unit (906), which also includes Mission Bay and several coastal tributaries. The WMA is approximately 93 square miles (mi^2) and includes portions of the cities of San Diego, Poway, and Del Mar. In addition, a small portion of San Diego County is in the eastern headwaters area. There are also several major road corridors that Caltrans maintains within the WMA (City of San Diego 2010a).

Three major tributaries drain the WMA and flow into the tidal lagoon. Los Peñasquitos Creek is the largest subwatershed, draining 59 mi^2 through its central portion. Carroll Canyon Creek is the second largest subwatershed, draining 18 mi^2 through its southern portion. The Carmel Creek subwatershed is along the northern portion and drains the remaining 16 mi^2. While the Los Peñasquitos Lagoon is included in the Carmel Creek subwatershed, load reduction calculations were generated by separating out areas draining directly to the lagoon. There is one major dam in the Carroll Canyon Creek subwatershed, which drains 1 square mile. This dam forms Miramar Reservoir, which retains imported drinking water and does not discharge downstream. The WMA elevation rises from sea level at the outlet to 2,600 feet in the headwaters (City of San Diego 2010a).

The lagoon was included in the Clean Water Act (CWA) section 303(d) list for sediment/siltation. Increasing urban development has altered hydrology within the WMA and modified the geomorphic conditions of the three main tributaries that feed into the lagoon. These conditions have caused sedimentation and excess freshwater in the lagoon that have altered the natural habitat (City of San Diego 2009).

Watershed models have been used to support total maximum daily load (TMDL) development for bacteria and other water quality constituents in the San Diego region over the past decade. The Loading Simulation Program in C++ (LSPC) was the model of choice while developing the recently approved sediment TMDL for the Los Peñasquitos Lagoon. This model was updated to support pollutant source characterization and identification of High-priority management areas for the Comprehensive Load Reduction Plans (CLRPs) and implementation planning efforts associated with current development of the Water Quality Improvement Plan for the Los Peñasquitos WMA. The Water Quality Improvement Plan planning effort will include linkage to best management practice (BMP) simulation and optimization processes that require additional spatial resolution and representation of key land characteristics that influence BMP selection (e.g., imperviousness, soil infiltration, and slope). Therefore, significant updates of the previously developed LSPC models primarily focused on hydrology, which will have the largest impact on many of the structural BMP functions

planned in the Water Quality Improvement Plan. Additional refinements of water quality constituent calibrations were also performed.

This report describes the approach used to develop and refine the Los Peñasquitos WMA model for use in the Water Quality Improvement Plan. This report also presents and describes the model calibration/validation results.

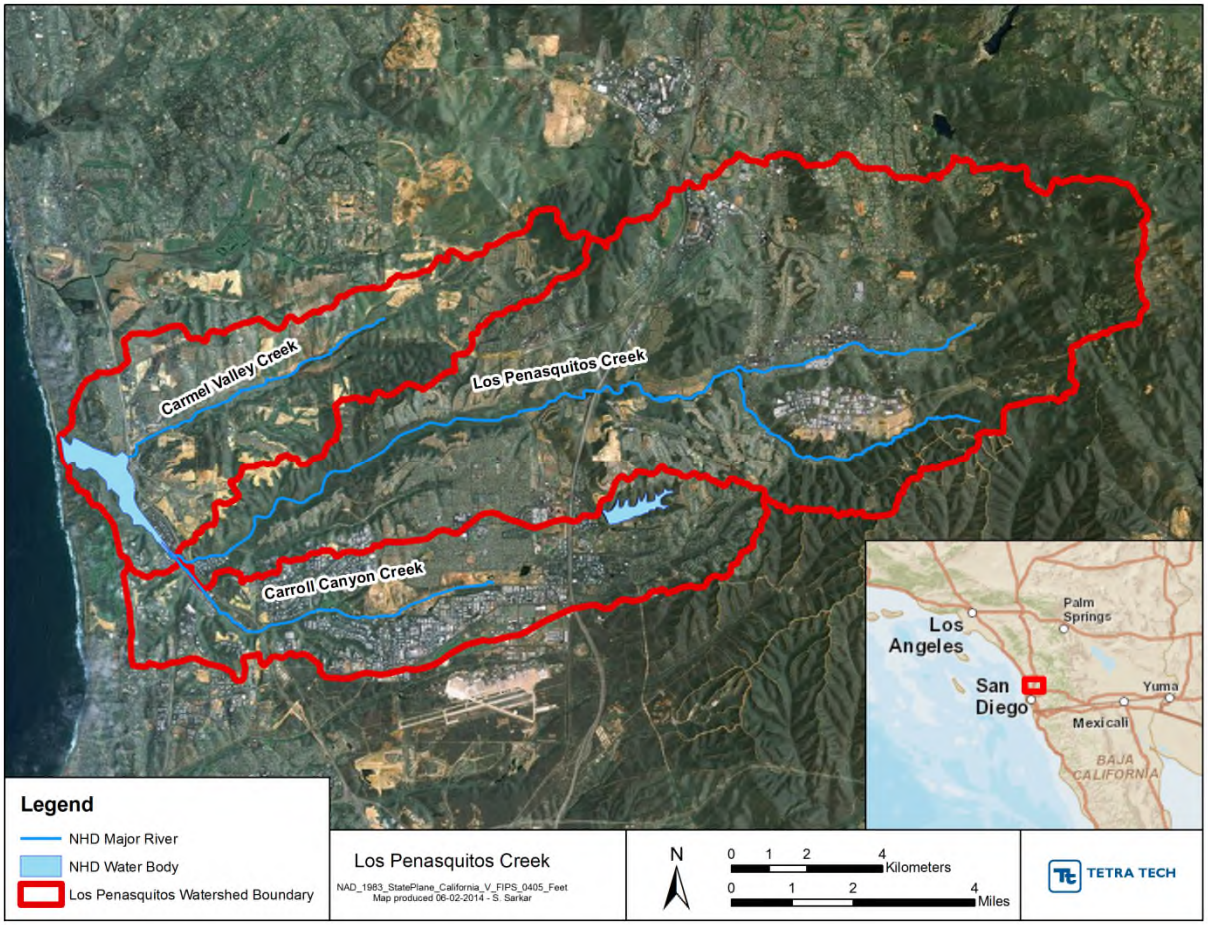

Figure K-1 Location of the Los Peñasquitos WMA

K.2 Model Selection

A watershed model is necessary to address the generation of pollutant loads over the land surface and through groundwater contributions and to predict the resulting water quality impact on receiving waters. A watershed model is comprised of a series of algorithms applied to watershed characteristics and meteorological data to simulate land- and stream-based processes over an extended period of time. Once a model has been adequately set up and calibrated, it can be used to quantify the existing loading of pollutants from subwatersheds or from land use categories, quantify pollutant loading from ungaged tributaries and diffuse overland flow sources, and assess the impacts of a variety of management scenarios.

The modeling analysis to support Water Quality Improvement Plan development builds on previous models developed in the region. TMDLs for indicator bacteria were developed to address 19 of the 38 bacteria-impaired water bodies in the San Diego region, as identified on the 2002 CWA section 303(d) List of Water Quality Limited Segments. This project is referred to as *Project I – Beaches and Creeks in the San Diego Region* or Bacti-I (SDRWQCB 2007b). An expansion of the regional modeling approach used in Bacti-I was conducted under *Bacteria-Impaired Waters TMDL Project II – Bays and Lagoons* (Bacti-II) and included representation of watersheds draining to impaired lagoons (SDRWQCB and USEPA 2005). Using Bacti-I and II as a foundation, additional modeling was conducted to support San Diego region lagoon TMDLs (SDRWQCB and USEPA 2008). This effort added a number of additional parameters to the modeling framework (SDRWQCB 2007a, 2010). In addition to this previous work, Los Peñasquitos was the subject of more recent LSPC modeling for hydrology and sediment to support the Los Peñasquitos Lagoon sediment TMDL (SDRWQCB 2012).

K.2.1 LSPC Watershed Model

LSPC is a watershed modeling system that excels at simulating hydrology, sediment and pollutant generation, transformation, and transport on land, as well as fate and transport within streams (Shen et al. 2004; Tetra Tech and USEPA 2002; USEPA 2003). The LSPC model has been successfully applied and calibrated for a large number of watersheds in Southern California including, but not limited to, the Los Angeles River, San Gabriel River, San Jacinto River, Lake Mathews, Chollas Creek, Los Peñasquitos, B Street/Downtown Anchorage, and multiple watersheds that drain to impaired beaches in the San Diego region (City of San Diego 2010c; USEPA 2011). The current effort builds on the results of previous modeling studies through the incorporation of recent monitoring data and key modeling enhancements.

The LSPC watershed modeling system includes Hydrologic Simulation Program FORTRAN (HSPF) algorithms for simulating watershed hydrology, erosion, and water quality processes, as well as in-stream transport processes. LSPC integrates a geographical information system (GIS), comprehensive data storage and management capabilities, the original HSPF algorithms, and a data analysis/post-processing system into a convenient, PC-based, Windows interface. LSPC's algorithms are identical to a subset of those in the HSPF model. LSPC is freely distributed by the U.S.

Environmental Protection Agency (EPA) Office of Research and Development in Athens, Georgia, and is a component of EPA's National TMDL Toolbox (www.epa.gov/athens/wwqtsc/index.html).

A key advantage of LSPC over HSPF and other watershed models is a data management feature that uses a Microsoft Access database to manage model data and weather files for driving the simulation. This provides great flexibility for data transfer and manipulation, which is critical for complex watershed studies. LSPC was designed specifically to handle very large-scale watershed and receiving water modeling applications at a high resolution. The model has been successfully used to model watershed systems composed of well over 1,000 subwatersheds and at least as many individual stream elements.

K.3 Watershed Model Development

K.3.1 Overview

This section provides a description of LSPC model configuration used for the Los Peñasquitos WMA. The watershed model represented the variability of sediment source contributions through dynamic representation of hydrology and land practices. A long-term simulation was developed spanning the period from 1/1/1988 to 9/30/2012. One year and ten months was used for model spin-up (allowing sufficient time for primarily stabilization of soil moisture). The hydrology model was calibrated to the 11-year period from 10/1/2001 to 9/30/2012 and validated to the 12-year period from 10/1/1989 to 9/30/2001. The water quality model was calibrated from 1/1/2001 to 9/30/2012 and was not validated because of limited available monitoring data. The following were key components of the watershed modeling:

- Watershed Segmentation (Section K.3.2)
- Meteorological Data (Section K.3.3)
- Land Use and Cover Representation (Section K.3.4)
- Hydrologic Representation (Section K.4.1)
- Observed Flow Data (Section K.4.2)
- Hydrology Model Calibration (Section K.4.3)
- Hydrology Model Validation (Section K.4.4)
- Hydrology Observations and Conclusions (Section K.4.5)
- Water Quality Model Overview (Section K.5.1)
- Modeled Constituents (Section K.5.2)
- Reach Group Representation (Section K.5.3)
- Sediment Representation (Section K.5.4)
- Nutrients, Metals, and Bacteria Representation (Section K.5.5)
- Water Quality Calibration (Section K.5.6)
- Observed Water Quality Data Calibration and Validation (Section K.5.7)
- Water Quality Observations and Conclusions (Section K.5.8)

K.3.2 Watershed Segmentation

Watershed segmentation refers to the subdivision of the entire model area into smaller, discrete subwatersheds and reaches for modeling and analysis. This subdivision was based primarily on existing hydrologic boundaries and engineered storm drain networks, and secondarily on topography and the locations of flow and water quality monitoring stations. A combination of 3-meter and 10-meter resolution digital elevation models (DEM) from the National Elevation Dataset (NED) were merged and then used to define the elevation throughout the WMA and assist with determining subwatershed boundaries. Figure K-2 shows the 10-meter resolution NED. Streams were defined primarily using National Hydrography Dataset (NHD) High-resolution GIS data. Where available, local storm drain networks augmented or replaced NHD data. Each subwatershed was configured with a single representative stream reach, with reach connectivity from headwaters to outlets.

Based on some of the previous work and the intended use of the CLRP models, the target for average subwatershed size was set at approximately 300 acres. This size tended to increase in the more rural, less developed areas. The subwatershed sizing was deemed appropriate for characterizing existing pollutant loading and facilitating the analysis of management strategies for future phases of the Water Quality Improvement Plan development. Figure K-3 presents the final subwatershed delineations and representative stream reaches.

Model reaches were derived via the watershed delineation process. Many of the reaches were defined using storm drain network GIS data from the City of San Diego (obtained from www.sangis.org) where available. Additional GIS coverage from other municipalities (San Diego County, City of Del Mar, and City of Poway) augmented those data. Within the LSPC models, reaches were aggregated in cases where a reach length was less than 1,000 meters to prevent the possibility of short travel times (relative to the 1-hour time step used in the modeling), leading to numeric instability.

Because of potential hydromodification impacts in the watersheds, the substrate of each reach was identified. The model reaches were defined as natural channel, concrete channel, or reinforced concrete pipe based on storm drain attributes from the GIS data, supplemented by visual investigation of model reaches as needed. Where storm drain networks were not available, natural reaches were assumed.

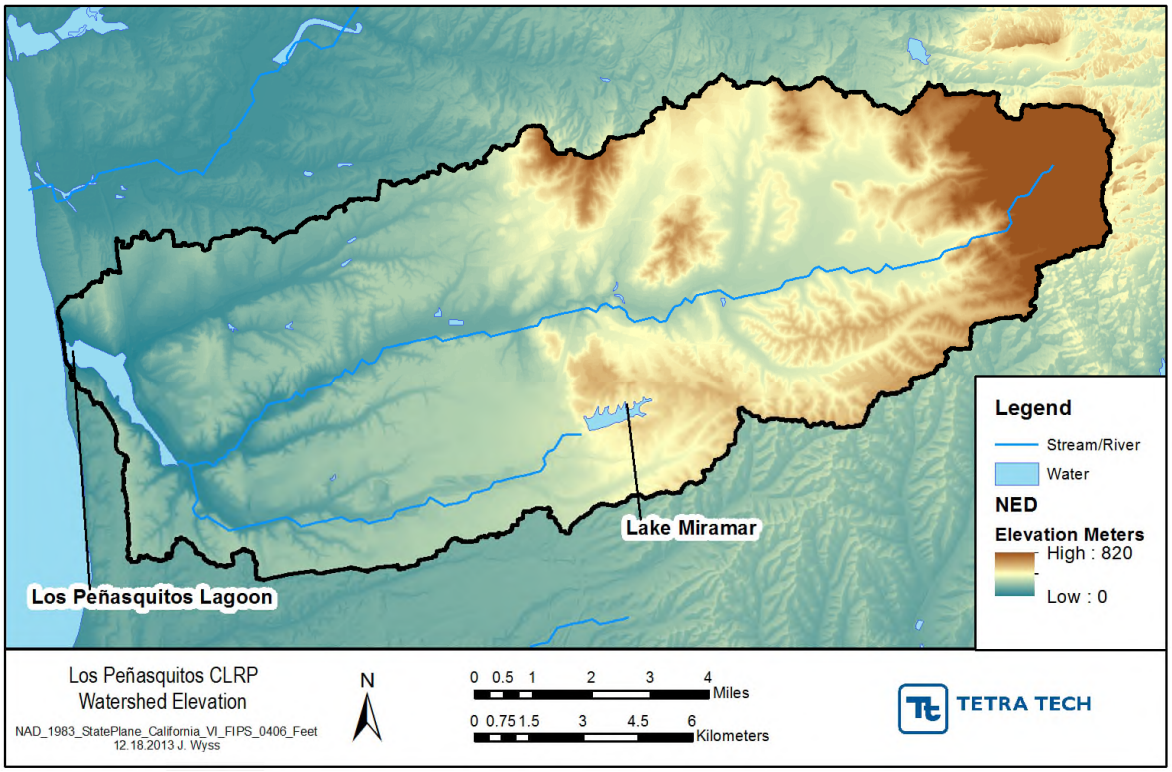

Figure K-2 Los Peñasquitos WMA NED 10-Meter DEM

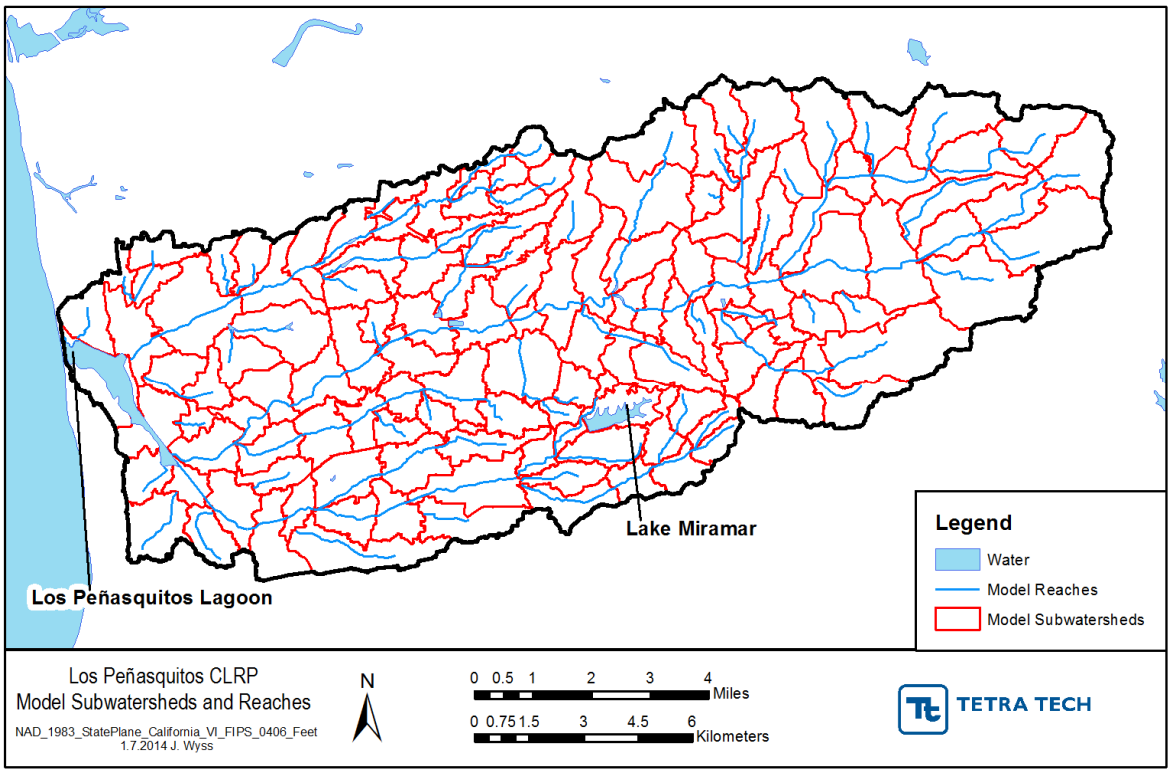

Figure K-3. Los Peñasquitos WMA Delineation and Representative Reaches

K.3.3 Meteorological Data

Meteorological data are a critical component of the watershed model. Models require appropriate representation of precipitation and potential evapotranspiration (PET). In general, hourly precipitation (or finer resolution) data are recommended for nonpoint source modeling and therefore are preferred, since daily flows tend to average out high peaks events. Precipitation data from the most representative station drove rainfall-runoff processes for each subwatershed. Those data provide necessary input to LSPC algorithms for hydrologic and water quality representation.

Successful hydrologic modeling depends on an accurate representation of the overall water balance. The two largest terms in the water balance are typically precipitation input and actual evapotranspiration (ET) output. Precipitation is specified from direct observations, while PET is either derived as a function of observed pan evaporation, or computed as a function of other weather data such as wind speed, air temperature, dew point temperature, and solar radiation. Together, these constitute the external meteorological time series needed to drive the model. This section focuses on the precipitation and evaporation/ET data, which were rigorously evaluated and processed for modeling purposes.

The accuracy of a hydrologic model is dependent on the accuracy of the meteorological time series. In most cases, precipitation and evaporation data are the most hydrologically sensitive and spatially variable data sets used in watershed modeling; therefore, having a complete quality-controlled continuous set of the data benefits the modeling effort. A major and crucial early effort for model development is thus assembly and processing of meteorology, which presents several challenges. First, precipitation data has historically been available as point-in-space measurements, rather than integrated totals over subwatershed areas. Second, precipitation, temperature, and other meteorological series typically show strong spatial gradients in response to elevation (orographic effects) and aspect.

K.3.3.1 Precipitation

Multiple sources of precipitation data were evaluated for model input, including National Climatic Data Center (NCDC) hourly precipitation and surface airways stations, NCDC Summary of Day (SOD) precipitation stations, San Diego County ALERT hourly rainfall gages, and California Irrigation Management Information System (CIMIS) stations. Data were screened for two purposes:

- Best representation of daily total precipitation
- Best representation of hourly precipitation, used as a pattern to disaggregate daily totals into hourly values

Experience has repeatedly demonstrated that precipitation collected on a daily basis from SOD stations provides a more accurate measure of total rainfall volume than accumulated volume from stations that monitor hourly. However, the spatial coverage was not adequate to capture rainfall variability, especially given the strong orographic

influence along the coast; therefore, ALERT stations were used to address the gaps. CIMIS stations were initially included as well, but were removed after a quality review revealed large annual discrepancies in rainfall total compared to nearby locations. A few ALERT stations were also excluded for similar reasons.

ALERT hourly values were aggregated to daily totals because of quality issues in hourly rainfall reporting. There were numerous instances where a large rainfall value (in excess of 1 inch) was reported for a single hour, and no rainfall was reported during the remaining hours of the day. To address gaps in the observed data, the accumulated, missing, and impaired data records were repaired based on rainfall patterns at other proximal stations with unimpaired data using the normal ratio method (Dunne and Leopold 1978), which estimates a missing rainfall record with a weighted average from surrounding index stations (assigned based both on proximity and similar elevation). Once gaps in daily totals were patched for all of the SOD and ALERT stations in the CLRP study area, annual and monthly rainfall totals were screened according to an increasing gradient of elevation. Daily SOD and ALERT totals were then disaggregated to hourly using surface airways and hourly precipitation data sites. For the Los Peñasquitos WMA model, five stations were selected as providing the best spatial coverage, unimpaired period of record, and consistency across yearly totals—two SOD stations and three ALERT stations (Table K-1). Model subwatersheds were assigned to precipitation stations based on a combination of proximity, elevation, and annual average precipitation reported by San Diego County (Figure K-4).

For each station a unique model input file was created which included the hourly rainfall time series from 1/1/1998 – 11/31/2012.

Table K-1
Summary of Precipitation Station for the Los Peñasquitos WMA Model

Station ID	Station Name	Elevation (ft.)	State	County	Latitude	Longitude
SOD 047111	Poway Valley	648	California	San Diego	33.018	117.029
SOD 047228	Ramona Fire Dept.	1,470	California	San Diego	33.011	-116.908
ALERT22	Encinitas	242	California	San Diego	33.044	-117.278
ALERT24	Poway	440	California	San Diego	32.949	-117.064
ALERT28	Kearny Mesa	455	California	San Diego	32.837	-117.130

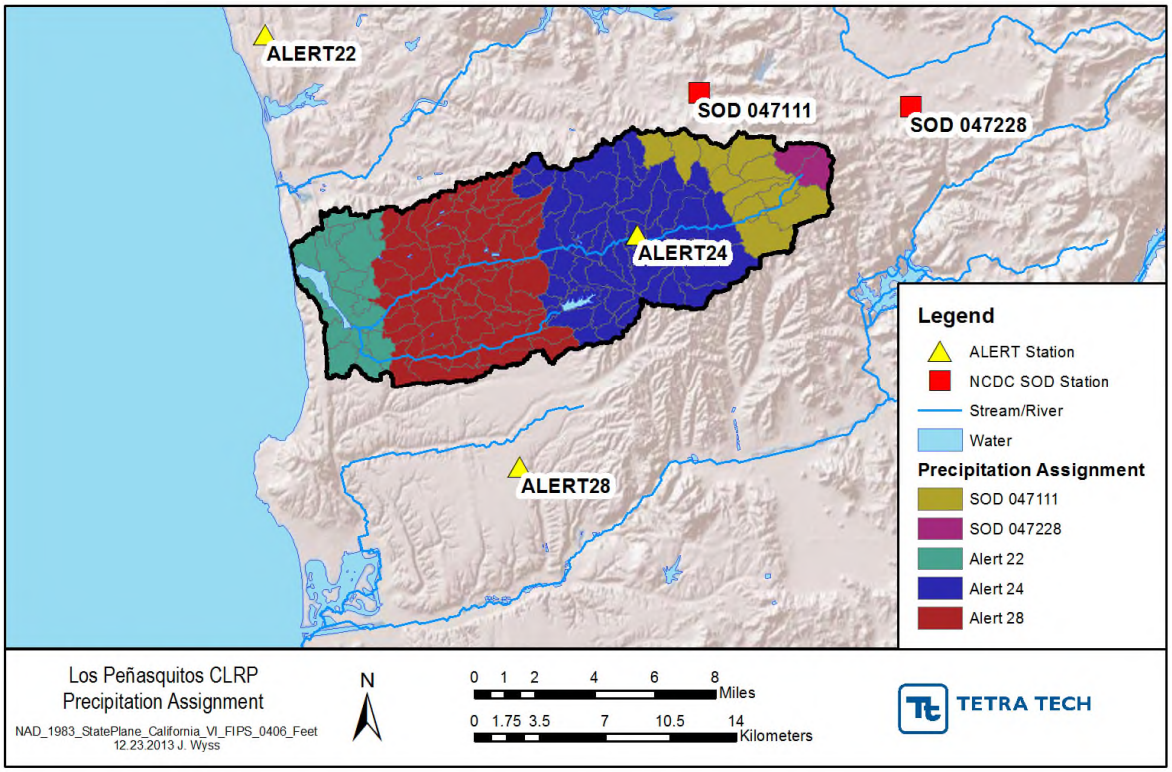

Figure K-4
Spatial Coverage and Assignment of Precipitation Stations used in the Los Peñasquitos WMA Model

The precipitation time series for both Encinitas (Alert 22) and Ramona Fire Department (SOD 047228) were summarized to provide insight into the orographic effects for the Los Peñasquitos WMA. Figure K-5 shows the yearly total precipitation for Encinitas and Figure K-6 shows the yearly total precipitation for Ramona Fire Department. Ramona experiences approximately 33 percent more rainfall than Encinitas but both locations experience extremely wet or extremely dry conditions during the same years. Figure K-7 shows the monthly average precipitation for Encinitas and Figure K-8 shows the monthly average precipitation for Ramona Fire Department. These figures also show that Ramona experiences approximately 33 percent more rainfall than Encinitas but both locations experience the same seasonal rainfall distribution. Figure K-9 shows the 24-hour total precipitation distribution for Encinitas and Figure K-10 shows the 24-hour total precipitation distribution for Ramona Fire Department. Approximately 84 percent of the rainfall in Encinitas falls in less than ½-inch 24-hour totals whereas approximately 74 percent of the rainfall in Ramona falls in less than ½-inch 24-hour totals. In addition, Ramona experiences much more intense rainfall, where approximately 5 percent of rainfall occurs in 1.5-inch or larger events, as compared to Encinitas, where approximately 2 percent of rainfall occurs in 1.5-inch or larger events.

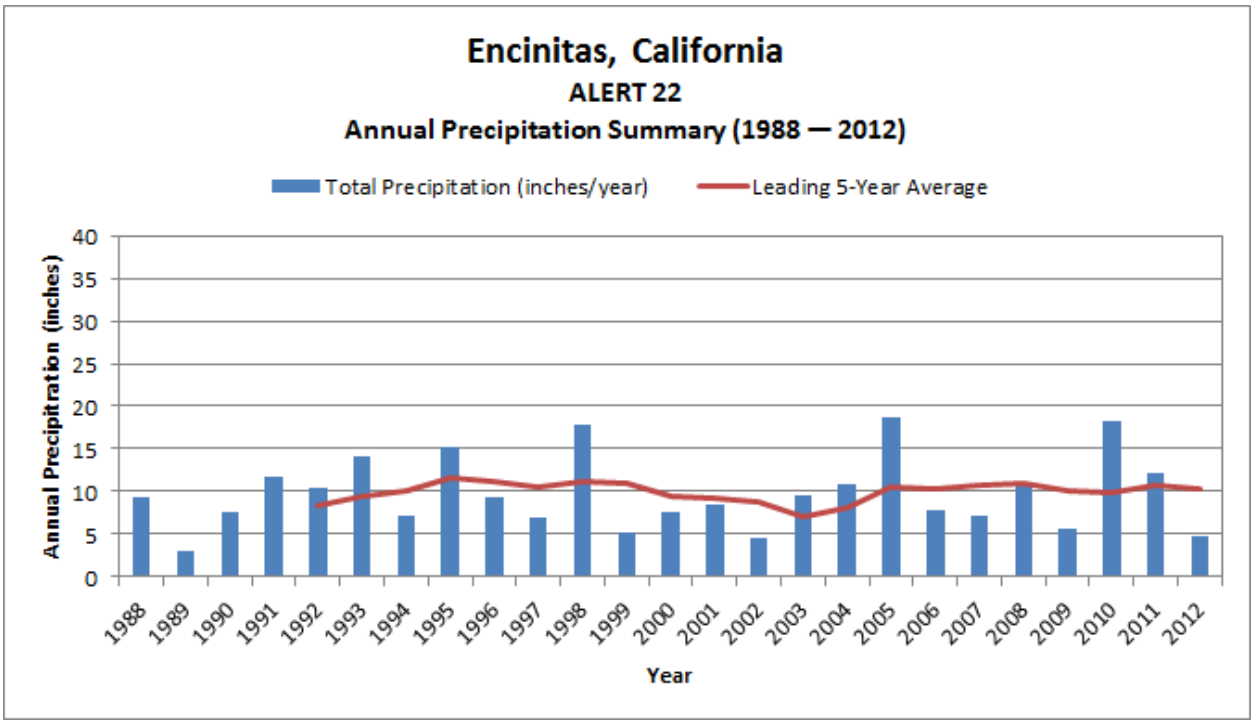

Figure K-5
Annual Precipitation Totals for Encinitas (ALERT 22)

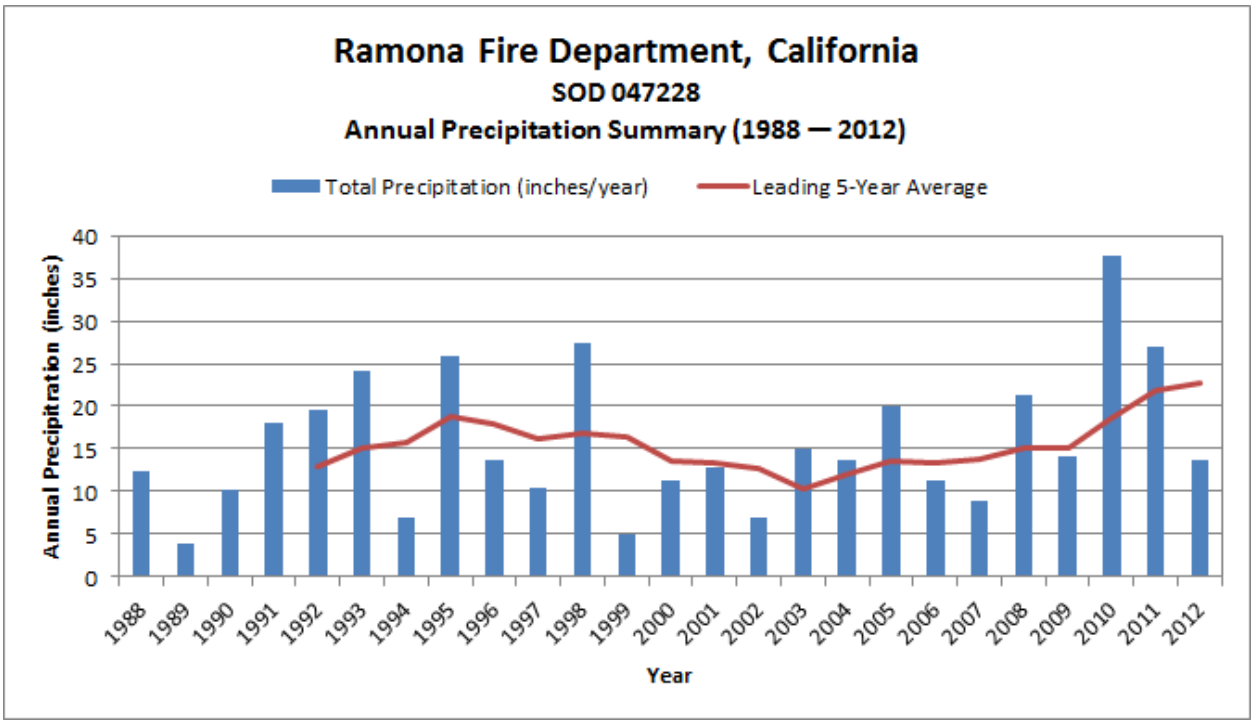

Figure K-6
Annual Precipitation Totals for Ramona Fire Department (SOD 047228)

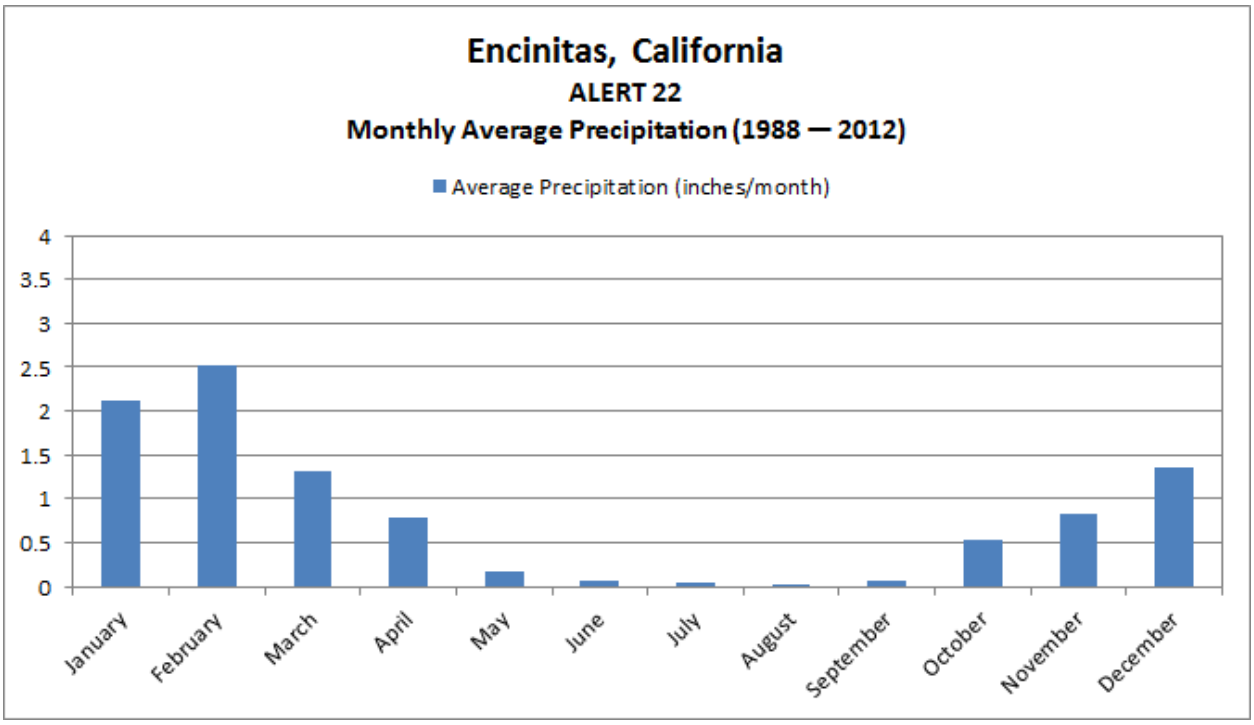

Figure K-7
Monthly Rainfall Summary for Encinitas (ALERT 22)

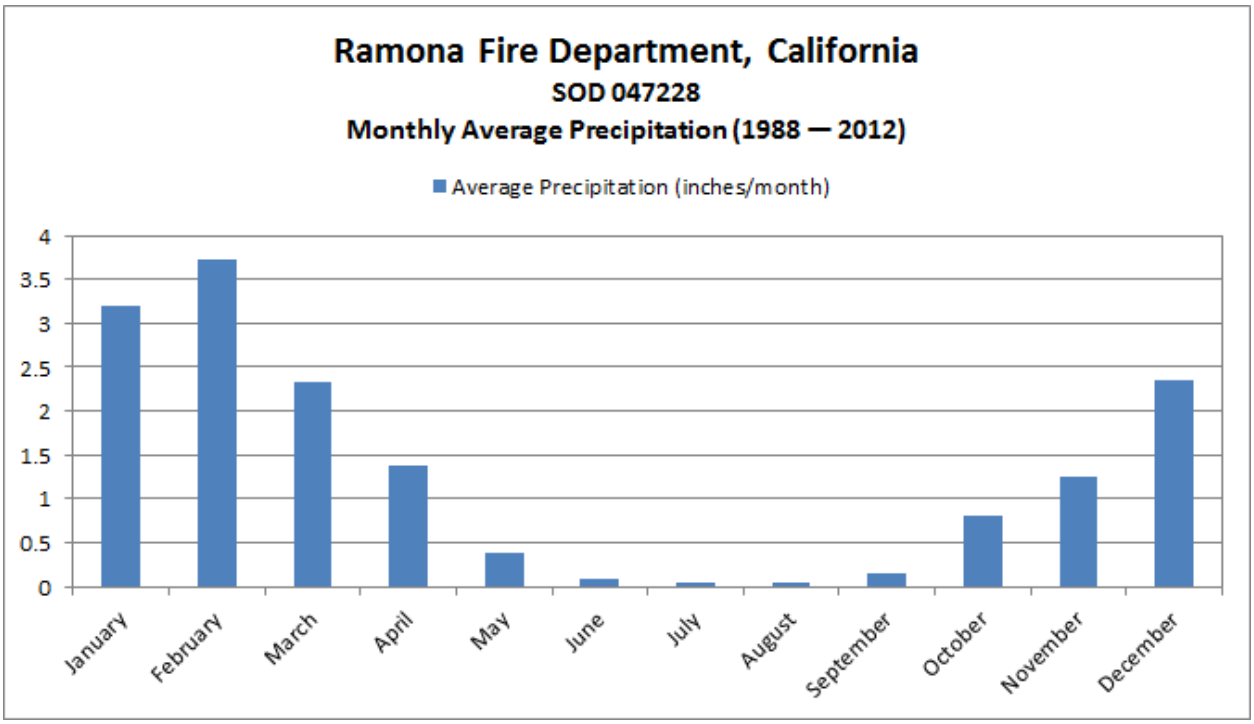

Figure K-8
Monthly Rainfall Summary for Ramona Fire Department (SOD 047228)

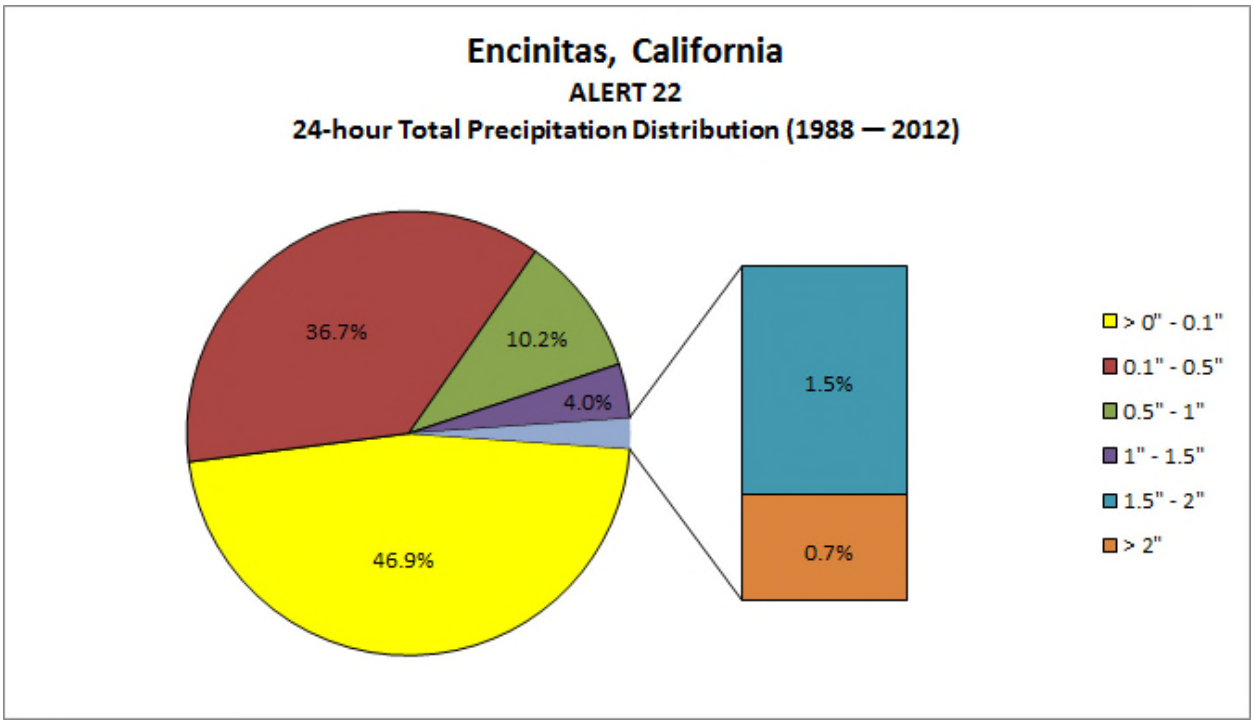

Figure K-9
Precipitation Distribution Summary for Encinitas (ALERT 22)

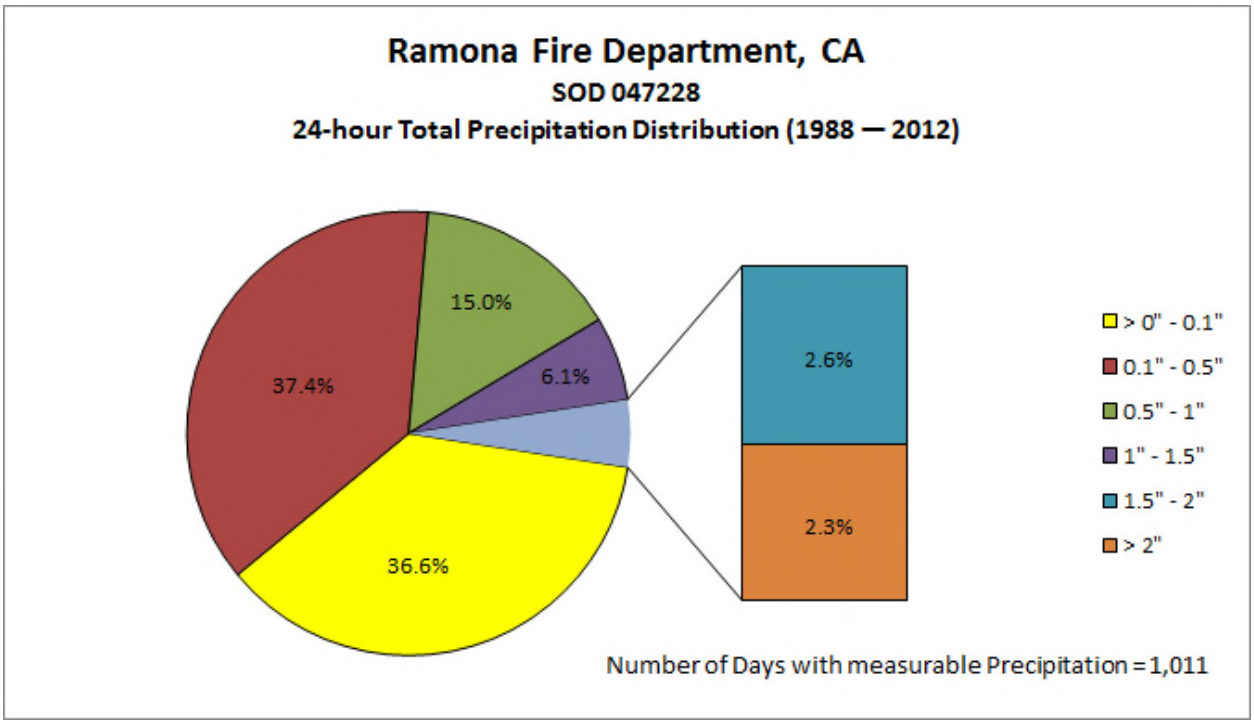

Figure K-10
Precipitation Distribution Summary for Ramona Fire Department (SOD 047228)

K.3.3.2 Potential Evapotranspiration

Evaporation in Southern California is typically limited by supply, rather than being capped by the potential. Observed pan evaporation data from San Diego (from reservoir sites) could not be utilized for a variety of reasons; notably, the data begin in 2004, and the data contain numerous gaps during the periods of record. On the other hand, CIMIS reference crop evaporation (ETo) data are available for a handful of locations in or near the WMA, with a nearly complete period of record for the 23 ¾-year simulation. CIMIS stations provide a United Nations Food and Agriculture Organization (FAO) standard estimate of ETo using the Penman-Monteith energy balance method, which is equivalent to actual ET from a standardized alfalfa crop without water limitation. As a result, CIMIS ETo was used to develop model PET.

The CIMIS data are not without gaps, both spatially and temporally. Based on the location of usable data, the following approach was adopted. Two CIMIS stations (184 and 153) had minor gaps in their period of record. PET was extracted from the EPA Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) meteorological data for two nearby NCDC surface airways stations. The BASINS daily PET (calculated using the Hamon method) was scaled to match the CIMIS ETo during periods of coincident data using fitted monthly adjustment factors. These monthly factors were then used to scale the calculated Hamon PET that was then subsequently used to fill the temporal gaps in the CIMIS data.

CIMIS 173 (at the coast) began reporting in 2000 and was deemed critical to retain in order to capture known differences in PET in the coastal fog zone. Using a similar procedure, as performed for patching CIMIS in the previous step, the coincident data from 173 was fitted to 184 using monthly factors. The monthly factors were then used to back-calculate the missing 12 years from 173 using 184 as the template.

The previous steps provided three patched PET data sets; however, the CLRP study area spans five CIMIS ETo zones, as seen in Figure K-11. The stations provide coverage for Zones 1, 4, and 9. Published CIMIS ETo zone monthly coefficients show measurable differences in seasonal ETo, especially for the high elevation (Zone 16). To address these gaps, the difference in monthly ETo coefficients between zones was used to calculate daily values for the lower elevation Zone 6 and the higher elevation Zone 16 using station 153 (Zone 9) as the template.

The four PET series associated with the Los Peñasquitos WMA (Zone 1, Zone 4, Zone 6, and Zone 9) were then associated with and assigned to each of the five rain stations, using the CIMIS ETo zones as guidance, but allowing variation based on elevation. The CIMIS ETo zones were developed and interpolated at a larger statewide scale and do not appear to account for local topography. A unique text file with an .air extension was created for each precipitation station, which included the hourly PET time series from 1/1/1998 to 11/31/2012. Table K-2 shows the precipitation station, PET zone assignment, and associated PET file used in the Los Peñasquitos WMA model. Attachment A provides tabular information pertaining to weather station assignments in the Los Peñasquitos WMA model.

Table K-2
Summary of Precipitation Station and PET Assignments for the Los Peñasquitos WMA Model

Model ID	Precipitation Station ID	PET Zone	PET File Name
1	SOD 047111	Zone 3	04711.air
2	SOD 047228	Zone 4	047228.air
3	ALERT0022	Zone 1	ALERT002.air
4	ALERT0024	Zone 3	ALERT0024.air
5	ALERT0028	Zone 2	ALERT0028.air

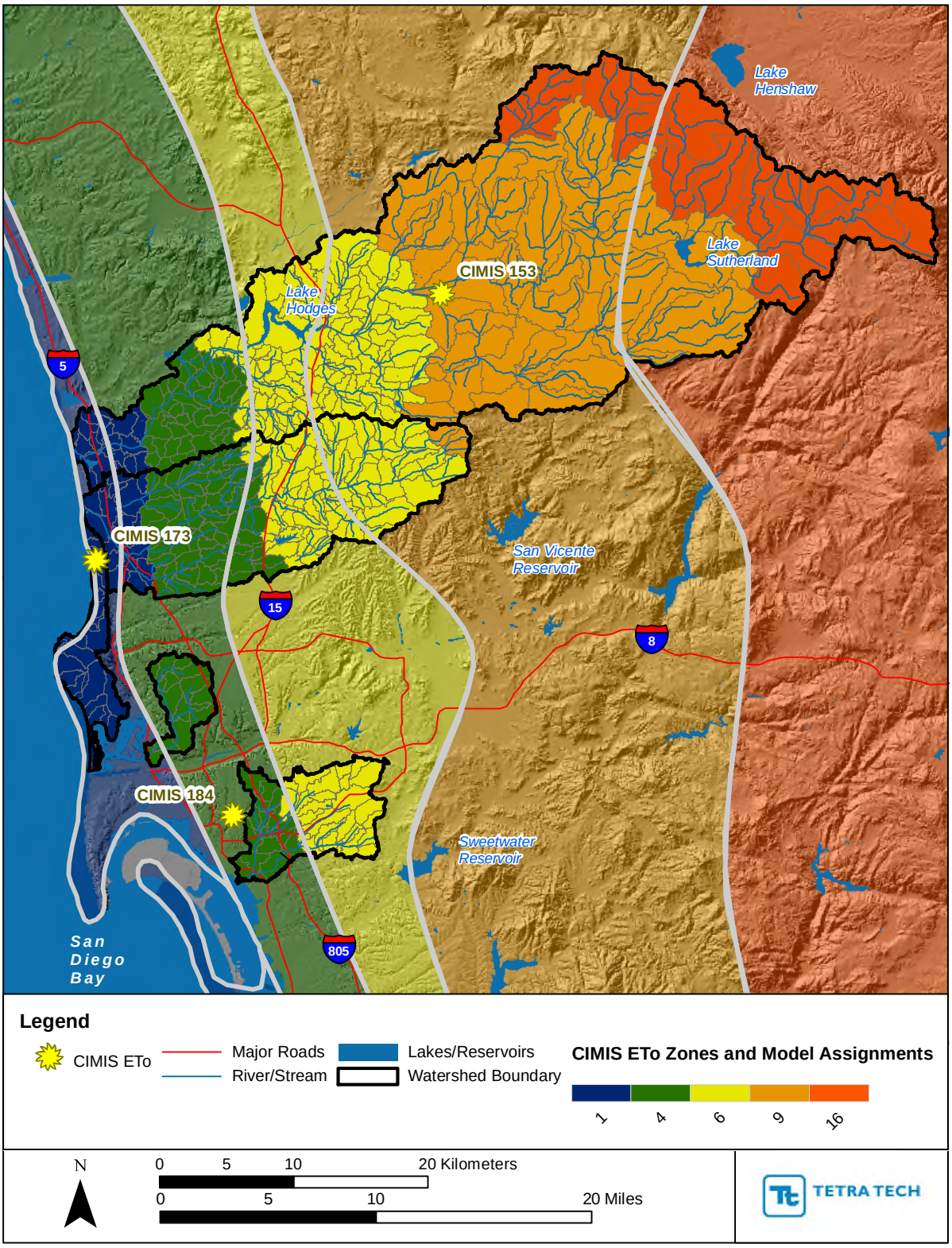

Figure K-11
CIMIS PET Stations and Zones in the CLRP Study Area

K.3.4 Land Use Representation

In a watershed model, land unit representation should be sensitive to the features of the landscape that most affect hydrology and pollutant transport, including land use (including impervious assumptions), soils, and slope. In urban areas, it is important to estimate the division of land use into pervious and impervious components. In rural areas, vegetative cover is more important. Depending on the goals of the model, if soil hydrologic groups are not homogenous in a watershed, it might be important to further divide pervious land cover by soil hydrologic group so that infiltration processes are better represented. Slope might also be an important factor, especially if steep slopes are prevalent; high slopes influence runoff and moisture storage processes. The combination of land use, soil hydrologic group, and slope were used to define the hydrologic response units (HRUs) for the Los Peñasquitos WMA model. The HRU approach provides certain advantages and efficiencies for model parameterization because it compartmentalizes the way process variables are assigned and insulates that exercise from spatially variable influences like meteorology, which will naturally manifest itself differently for the same HRU in different parts of the WMA. Although there are many similarities in the way HRUs in the current effort compare to previous work in the region, the current configuration utilizes the most recent and highest resolution data sources available.

The following are the main objectives for developing representative HRUs:

- To support representation of existing condition hydrology and pollutant loading processes generated from land areas for source characterization
- To support any potential future objectives of providing unit area hydrology and pollutographs in support of BMP optimization
- To capture sufficient variability in hydrology and pollutant loading as related to land uses and land covers
- To balance the need for capturing landscape variability with a goal of reducing model complexity

The following summarizes the HRU development approach:

1. Land use in urban areas was represented with a polygon layer developed by a regional planning authority, with polygon boundaries largely determined using parcel data.
2. The planning land use categories were simplified into broader model land use categories, as well as disaggregation of Single-Family Residential (SFR) planning categories into housing density groups.
3. Land cover in unmanaged land areas was represented with a grid data product based primarily on interpreted satellite imagery.

4. Unique percent impervious values were assigned to each urban area polygon, using best available data.

5. Each urban land use and unmanaged land cover (LULC) was classified by Hydrologic Soil Group (HSG).

6. Each LULC-HSG was further distinguished as a low or high slope class (SC).

7. The resulting over 100 potential HRU combinations of LULC-HSG-SC were simplified into a manageable number of model HRUs, using aggregation of classes with low contributing area or low importance to those with larger area or importance.

8. Irrigation assumptions were developed for urban land.

A detailed discussion of each step listed above is provided below.

K.3.4.1 Urban Land Use Coverage

The San Diego Association of Governments (SANDAG) 2009 land use polygon coverage was obtained and intersected with the study area boundary. Table K-3 presents unique SANDAG classes of modeled contributing land areas within the WMA boundary.

Table K-3
Water Quality Improvement Plan Model Land Uses

	Water Quality Improvement Plan Model Land Use	Notes
Residential	Unmanaged Land	Lot size > 10 acres
	Rural Residential	Lot size 2.0–10.0 acres
	LDR (Low-Density Residential)	Lot size 0.5–2.0 acres
	MDR (Medium-Density Residential)	Lot size 0.17–0.5 acres
	HDR (High-Density Residential)	Lot size 0.07–0.17 acres
	Multifamily Residential	Includes SFR lot size < 0.07 acres
	Office/Institutional	Lower vehicle/foot traffic
	Commercial	Higher vehicle/foot traffic
	Industrial	Manufacturing, warehouses, storage
	Transportation	streets, roads, and right-of-way
	Freeway	Limited-access highway corridors
	Barren	Construction sites and quarries/mines
	Park Land (irrigated)	Developed, higher intensity parks
	Open Water	Lakes, ponds
	Unmanaged Land	Undeveloped, low-intensity park/recreation, agriculture

K.3.4.2 Assignment of SANDAG Classes to Model Land Uses

For identification of modeled urban land uses (Table K-3), a critical goal was to capture types of use that are known to generate differential pollutant loads. For instance, commercial use is distinguished from office/institutional use by intensity of vehicle and foot traffic; a higher intensity of use tends to result in more residues on impervious surfaces. Table K-4 provides the crosswalk between SANDAG categories and land uses in Table K-3. The Unmanaged Land category includes all land uses that have very low levels of developed use (open space and low-intensity parkland, residential uses with parcel area in excess of 10 acres) or no developed use (undeveloped polygons and agricultural land). SANDAG classification of agricultural use was poor in comparison to High-resolution aerial photos, and appeared to overestimate agricultural land. SANDAG documentation notes that the agricultural classification is a source of error, and is based on data from 20 years ago. It is important to note that the land use aggregation was performed in a manner to optimize land use groupings with similar hydrology and pollutant loading characteristics.

SANDAG polygon boundaries typically follow parcel boundaries; however, areas with identical class assignment were aggregated into single polygons, most notably the residential uses with IDs 1000–1190. On the other hand, many larger parcels were split into multiple SANDAG use polygons. To allow for classification of Single Family Residential (SFR) categories into housing density classes, a union coverage of current parcel boundaries (November 2011) and 2009 SANDAG land use was created. Polygon area was calculated to perform the modeled residential land use assignment. Parcel boundary disagreements between the two data sets were present, though not common, and were rectified to the extent possible using automated geoprocessing techniques.

Table K-4
SANDAG Land Uses and Water Quality Improvement Plan Model Land Use Class Assignment

SANDAG Code	SANDAG Land Use	Area in CLRP Watersheds (acres)	Water Quality Improvement Plan Model Land Use Class
1000	Spaced Rural Residential	26,719	SFR [1,3]
1110	Single-Family Detached	35,926	SFR [1]
1120	Single-Family Multiple Units	3,204	SFR [1]
1190	Single-Family Residential Without Units	164	SFR [1]
1200	Multifamily Residential	3,958	Multifamily
1290	Multifamily Residential Without Units	14	Multifamily
1300	Mobile Home Park	404	Multifamily
1402	Dormitory	44	Multifamily
1403	Military Barracks	27	Multifamily
1409	Other Group Quarters Facility	157	Multifamily

SANDAG Code	SANDAG Land Use	Area in CLRP Watersheds (acres)	Water Quality Improvement Plan Model Land Use Class
1501	Hotel/Motel (Low Rise)	130	Commercial
1502	Hotel/Motel (High Rise)	9	Commercial
1503	Resort	159	Commercial
2001	Heavy Industry	19	Industrial
2101	Industrial Park	3,018	Industrial
2103	Light Industry – General	1,357	Industrial
2104	Warehousing	216	Industrial
2105	Public Storage	129	Industrial
2201	Extractive Industry	640	Barren
2301	Junkyard/Dump/Landfill	116	Industrial
4103	General Aviation Airport	254	Commercial
4111	Rail Station/Transit Center	13	Transportation
4112	Freeway	3,242	Freeway
4113	Communications and Utilities	855	Office/Institutional
4114	Parking Lot – Surface	166	Transportation
4115	Parking Lot – Structure	23	Transportation
4116	Park and Ride Lot	16	Transportation
4117	Railroad Right-of-Way	256	Transportation
4118	Road Right-of-Way	17,839	Transportation
4119	Other Transportation	65	Transportation
5001	Wholesale Trade	16	Commercial
5002	Regional Shopping Center	136	Commercial
5003	Community Shopping Center	765	Commercial
5004	Neighborhood Shopping Center	727	Commercial
5005	Specialty Commercial	4	Commercial
5006	Automobile Dealership	74	Commercial
5007	Arterial Commercial	617	Commercial
5008	Service Station	86	Commercial
5009	Other Retail Trade and Strip	228	Commercial
6001	Office (High Rise)	22	Office/Institutional
6002	Office (Low Rise)	1,162	Office/Institutional
6003	Government Office/Civic Center	34	Office/Institutional
6101	Cemetery	437	Park Land (irrigated)
6102	Religious Facility	743	Office/Institutional

SANDAG Code	SANDAG Land Use	Area in CLRP Watersheds (acres)	Water Quality Improvement Plan Model Land Use Class
6103	Library	24	Office/Institutional
6104	Post Office	75	Office/Institutional
6105	Fire/Police Station	92	Office/Institutional
6109	Other Public Services	94	Office/Institutional
6501	UCSD/VA Hospital/Balboa Hospital	5	Office/Institutional
6502	Hospital – General	110	Office/Institutional
6509	Other Health Care	104	Office/Institutional
6701	Military Use	67	Office/Institutional
6702	Military Training	5	Office/Institutional
6801	SDSU/CSU San Marcos/UCSD	419	Office/Institutional
6802	Other University or College	192	Office/Institutional
6803	Junior College	180	Office/Institutional
6804	Senior High School	862	Office/Institutional
6805	Junior High School or Middle School	486	Office/Institutional
6806	Elementary School	1,245	Office/Institutional
6807	School District Office	48	Office/Institutional
6809	Other School	142	Office/Institutional
7201	Tourist Attraction	646	Park Land (irrigated)
7203	Racetrack	88	Commercial
7204	Golf Course	3,758	Park Land (irrigated)
7205	Golf Course Clubhouse	143	Commercial
7207	Marina	6	Commercial
7210	Other Recreation – High	559	Park Land (irrigated)
7211	Other Recreation – Low	360	Unmanaged Land [3]
7601	Park – Active	1,679	Park Land (irrigated)
7603	Open Space Park or Preserve	68,833	Unmanaged Land [3]
7604	Beach – Active	155	Unmanaged Land [3]
7605	Beach – Passive	6	Unmanaged Land [3]
7606	Landscape Open Space	1,272	Residential Other [2]
7607	Residential Recreation	184	Park Land (irrigated)
8001	Orchard or Vineyard	5,686	Unmanaged Land [3]
8002	Intensive Agriculture	3,448	Unmanaged Land [3]
8003	Field Crops	21,922	Unmanaged Land [3]
9101	Vacant and Undeveloped Land	94,421	Unmanaged Land [3]

SANDAG Code	SANDAG Land Use	Area in CLRP Watersheds (acres)	Water Quality Improvement Plan Model Land Use Class
9200	Water	1	Park Land (irrigated)
9201	Bay or Lagoon	114	Open Water
9202	Lake/Reservoir/Large Pond	1,749	Open Water
9501	Residential Under Construction	393	Barren
9502	Commercial Under Construction	23	Barren
9503	Industrial Under Construction	41	Barren
9505	School Under Construction	71	Barren
9506	Road Under Construction	20	Barren

Note:
1. All SFR categories were disaggregated to five residential densities, based on parcel area.
2. In aerial photos, nearly all of these areas are fringes or easement areas in SFR developments. Many overlap impervious surfaces. These were disaggregated to residential pervious and impervious areas later in the HRU development process.
3. Unmanaged Land was removed, and reclassified into Agriculture, Forest/Shrub, and Grassland using LANDFIRE EVT. SFR in excess of 10 acres was also classified as Unmanaged Land and reclassified with LANDFIRE.

K.3.4.3 Land Cover for Unmanaged Land Areas

Available land cover data were reviewed for providing the best representation of undeveloped land cover and vegetation type in areas assigned to the Unmanaged Land category. U.S. Forest Service and Department of Interior LANDFIRE, also known as the Landscape Fire and Resource Management Planning Tools Project, provides a high level of detail about vegetation for wildfire management, and consists of a series of raster-based data products including vegetation type, vegetation cover (percent canopy), vegetation height, and others. The Existing Vegetation Type (EVT) data set provides details about plant communities, as well as some spatial information indicating areas of development and agricultural use. The data set was determined to be the best resource for characterizing land cover during a comparison to High-resolution aerial photography. This finding is consistent with previous Tetra Tech experience in Southern California. Agricultural land shown in LANDFIRE EVT was more consistent with aerial photography than SANDAG; error was fairly high at a close spatial scale (i.e., hundreds of feet), but the relative proportions at a subwatershed scale matched reasonably well.

Three categories were selected to represent undeveloped land cover, which were sufficient to capture variation in vegetation and land use germane to hydrology and pollutant loading processes—Forest, Grassland/Shrubland (or chaparral), and Agriculture. Given the relatively small area of agricultural land use within the watersheds as a whole, multiple agricultural categories (e.g., orchards, vegetable production) were not needed.

K.3.4.4 Impervious Area

The National Land Cover Dataset (NLCD) is developed under a national program overseen by the Multi-Resolution Land Characteristics Consortium, a group of federal agencies that cooperate to create a consistent land cover GIS grid-based product for the entire United States. The 2006 data is based on interpretation of multiseasonal Landsat satellite images into 30-meter grid cells, and includes a grid with assignment of percent impervious cover. Spatial analysis and post-processing calculations were performed to assign unique percent impervious values to each SANDAG polygon (excluding polygons assigned to Unmanaged Land Area and Open Water).

K.3.4.5 Hydrologic Soil Group

EPA recommends classifying HSPF pervious land uses by Hydrologic Soil Group or HSG (USEPA 2000). HSG defines a soil's ability to infiltrate rainfall in four categories, ranging from A soils that support high infiltration rates to D soils that support low infiltration rates. County-level soil GIS data files were obtained (SSURGO) to develop HSG GIS coverage. The HSG coverage was spatially intersected with the land use/land cover coverage to allow for specification of HSG.

K.3.4.6 Slope Class

Slope is also an important factor for HRU development, especially if steep slopes are prevalent; high slopes influence runoff and moisture storage processes. Percent slope was calculated from the 10-meter DEM from NED, and the slope values were classified as Low (< 10 percent), and High (> 10 percent). Slope classes (SCs) were dichotomized at 10 percent because past experience has shown that this threshold value strongly influences land use patterns (i.e., most urban development occurs on land with slopes less than 10 percent). The Low/High slope grid was converted to a polygon coverage, and spatially intersected with the land use/land cover coverage to allow for specification of SC.

K.3.4.7 Final HRU Selection

To reduce model complexity, the pool of potential discrete HRU types was simplified using the following observations of tabular HRU area, balanced by project goals:

- Developed polygon areas were split into impervious and developed pervious model HRUs, based on the assigned percent impervious value.
- In urbanized area, runoff response and pollutant loading is driven primarily by impervious surfaces; the urban land use designation was therefore retained and carried forward into the impervious HRU assignment.
- HSG and slope were considered more important for characterizing hydrology and pollutant loading for developed pervious land; therefore, HSG and SC were retained.

- HSG A soils comprise approximately 3.2% of the WMA area; to reduce model complexity, HSG A soils were lumped with HSG B soils.

- The majority of Forest and Grassland/Shrubland land covers were classified as having high slopes (87 percent and 76 percent, respectively); however, HSG classes were more evenly distributed. Low slope land was lumped with High slope land for both land covers.

- Agriculture and Barren land were evenly distributed by slope, but tended to be dominated by a single HSG; therefore, Low and High slopes only were used for both land covers.

- Both SC and HSG were retained for developed pervious land, resulting in six separate classes.

K.3.4.8 Irrigation Assumptions

LSPC provides a module for simulating the impacts of irrigation, beginning with a dynamic estimation of irrigation volume based on PET and recent rainfall depth, followed by application of irrigation back to the landscape. Individual model HRUs can be selected by the user for receiving irrigation, with appropriate application factors for the HRU. Irrigation input is lumped with precipitation, so the influence of irrigation on hydrology (i.e., wetter soils that promote more runoff during storm events, irrigation return flow via groundwater, etc.) and pollutant loading is carried through the entire model. However, not all developed land is irrigated, and the degree of irrigation can vary spatially depending on many factors. A review was performed to characterize expected urban irrigation rates by urban land use individually within each of the five CLRP watersheds. The review took into account open space requirements, zoning, lot size, landscaping requirements, review of aerial photos, and socioeconomic factors. Based on the results of the review, developed pervious land was split into irrigated and nonirrigated fractions according to the percentages shown in Table K-5. Previous modeling experience in the San Diego region indicated that overspray of irrigation water onto impervious area is a significant component of the hydrologic response in the extremely dry summer months. As a result, a small portion of impervious area, equal to 10% of the irrigated pervious area, was converted into impervious area that could be subjected to irrigation. These impervious areas were grouped into two separate HRUs, called Overspray-Other and Overspray-Road, to create distinct water quality responses between road and non-road surfaces.

Table K-5
Fraction of Developed Pervious HRU Areas Subject to Irrigation in the Los Peñasquitos WMA

Land Use	Los Peñasquitos WMA
Rural Residential	10%
LDR	14%
MDR	31%

HDR	35%
Multifamily	45%
Commercial	50%
Industrial	45%
Office/Institutional	50%
Park Land (irrigated)	50%
Transportation	30%

K.3.4.9 Model HRUs

The list of final model HRUs and associated land area in the Los Peñasquitos WMA are shown in Table-K-6.

Table-K-6
List of Final Model HRUs

Land Use/Land Cover	HSG	Slope Class	Area (Acres)	Area (%)
Open Water	N/A		165.2	0.27%
Agriculture		Low	110.0	0.18%
		High	51.3	0.08%
Barren		Low	350.4	0.58%
		High	393.9	0.65%
Forest	B		798.9	1.32%
	C		659.8	1.09%
	D		8,429.4	13.93%
Grassland/Shrubland	B		1,632.5	2.70%
	C		1,326.3	2.19%
	D		13,915.4	22.99%
Developed Pervious, No Irrigation	B	Low	1,008.5	1.67%
	C	Low	375.6	0.62%
	D	Low	5,422.2	8.96%
	B	High	705.4	1.17%
	C	High	648.9	1.07%
	D	High	3,787.2	6.26%
Developed Pervious, With Irrigation	B	Low	416.6	0.69%
	C	Low	171.1	0.28%
	D	Low	2,882.6	4.76%
	B	High	209.9	0.35%
	C	High	176.7	0.29%
	D	High	1,574.5	2.60%

Land Use/Land Cover	HSG	Slope Class	Area (Acres)	Area (%)
Low-Intensity Residential	Impervious		1,207.2	1.99%
High-Intensity Residential			5,494.8	9.08%
Office/Institutional			1,211.6	2.00%
Commercial			727.2	1.20%
Industrial			2,313.4	3.82%
Transportation			3,091.0	5.11%
Freeway			716.4	1.18%
Overspray Other			271.8	0.45%
Overspray Road			271.0	0.45%

K.3.4.10 Parameter Groups

LSPC allows for the model to be further segmented by parameter groups. A parameter group is an additional set of model HRUs that are assigned to subwatersheds that the user selects. This allows for different parameterization for HRUs in parameter group 1 as opposed to those used for HRUs in parameter group 2. Parameter groups were implemented into the Los Peñasquitos WMA model (Figure K-12) to account for the extremely high sediment loading associated with the Carroll Canyon Creek drainage area. All parameters associated with parameter groups 1 and 2 were set equal to each other besides those associated with the production and removal of sediment for the land. Carroll Canyon comprises only 19 percent of the total Los Peñasquitos WMA area, but preliminary studies show that the Carroll Canyon contributing subwatershed accounts for up to 92 percent of the total suspended sediment load to the Los Peñasquitos Lagoon ("Preliminary Assessment of Sediment Reduction Opportunities for Los Peñasquitos Lagoon – Carroll Canyon Watershed," ESA-PWA, June 23, 2011). Table K-18 contains tabular information pertaining to parameter group assignments in the Los Peñasquitos WMA model. Additional details are provided in Section 5.6.

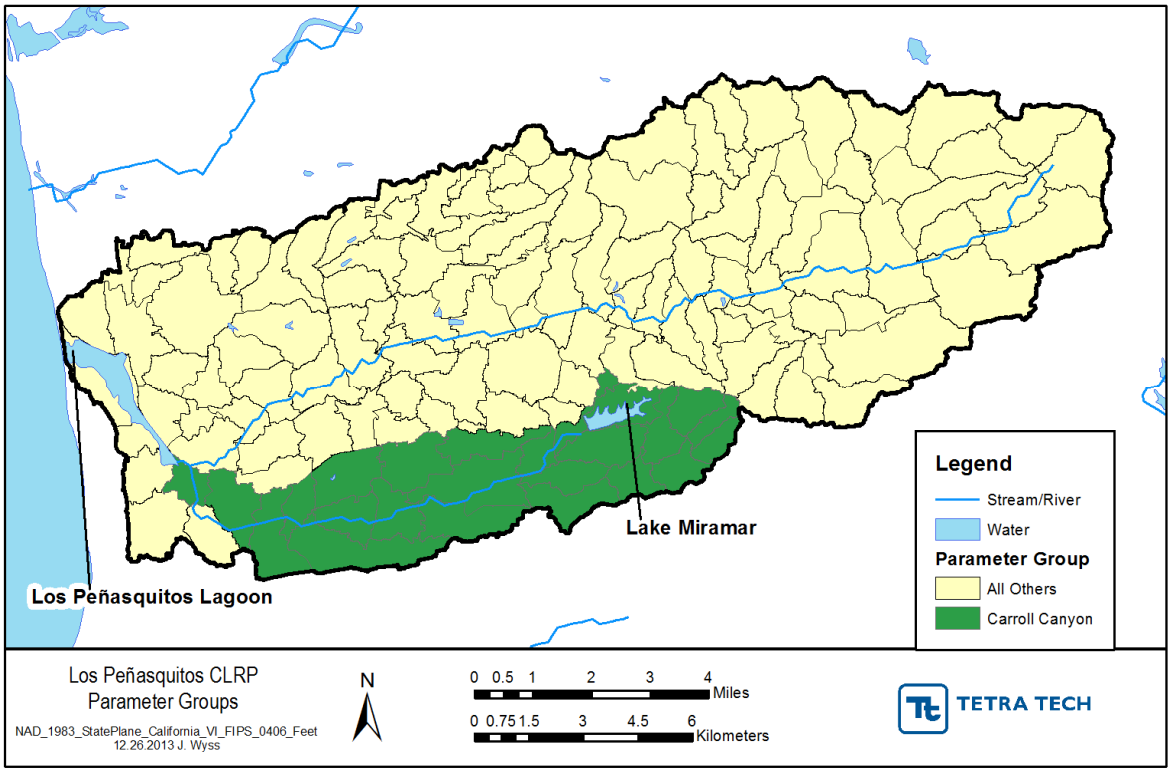

Figure K-12
Parameter Group Assignment used in the Los Peñasquitos WMA Model

K.4 Watershed Hydrology Model

K.4.1 Hydrologic Representation

Watershed hydrology plays an important role in the determination of flows and loadings to a water body. The watershed model must appropriately represent the spatial and temporal variability of hydrological characteristics within a watershed. Key hydrological characteristics include interception storage capacities, infiltration properties, evaporation and transpiration rates, and watershed slope and roughness. The LSPC/HSPF modules used to represent watershed hydrology include PWATER (water budget simulation for pervious land units) and IWATER (water budget simulation for impervious land units). The *HSPF Version 12 User's Manual* presents a detailed description of relevant hydrological algorithms (Bicknell et al. 2004).

Figure K-13 provides a schematic of the LSPC hydrology model. Rainfall first experiences interception storage (CEPSC). If there is space available in interception storage it is filled up and all remaining precipitation volume proceeds to the land surface. Once on the land, surface water is divided into subsurface flow and surface flow by infiltration (INFILT). Any water not being infiltrated is divided between upper zone storage (UZSN), interflow (INTFW) and overland flow. If space exists in upper zone storage it is filled first before becoming interflow or overland flow. Overland flow

travels directly to the stream and timing is based on the slope, length, and Manning's *n* value of the overland flow plane. Interflow travels to the stream under the surface of the land and the timing of interflow outflow is dependent on the interflow recession constant (IRC). Water in the upper zone storage is either evaporated or moves deeper into the soil profile through percolation. Infiltrated water first fills the capacity of lower zone storage (LZSN) and water is lost from lower zone storage through evapotranspiration (LZETP). Any remaining water then enters one of two groundwater storage components. Inactive groundwater (water not having the ability to become streamflow) is supplied by a value for DEEPFR. Active groundwater storage is released to the stream through a groundwater recession constant (AGWRC). Water can be lost from both active groundwater storage and groundwater outflow by values supplied for AGWETP and BASETP, respectively. The model simulates total actual ET by trying to fulfill PET by first removing water from baseflow outflow, then interception storage, then upper zone storage, then groundwater storage and finally lower zone storage. Some of the parameter values for the hydrology model are considered constant and others are allowed to vary by month but no parameters are allowed to vary by year.

Table K-7 provides the list of hydrology parameters and the temporal variability that was used for the Los Peñasquitos WMA model. All parameters were allowed to vary by HRU.

In Southern California another important component of watershed hydrology is irrigation. LSPC includes an irrigation routine which is based on a calculation for irrigation demand. Irrigation demand is simply the difference between ET and precipitation. ET is calculated as the product of PET and a crop coefficient (ETc). If the calculation produces a positive number, then irrigation is not in demand because the precipitation volume is greater than the volume of water lost through ET. If the calculation produces a negative number, then irrigation is in demand because precipitation volume is less than the amount of water lost through ET. Essentially, the irrigation demand calculation is a water-deficit calculation. If there is a deficit, then irrigation occurs until the deficit has been made up. LSPC allows the user to specify how many days, or length of time to utilize in the deficit calculation.

*Irrigation Demand = (PET*ETc) - Precip* (evaluated over time *ET Days*)

Where:

PET = Potential Evapotranspiration (inches)

ETc = Crop coefficient to evaluate actual evapotranspiration (unitless)

Precip = Precipitation (inches)

ET Days = number of days to utilize in the irrigation demand calculation (days)

The irrigation module of LSPC was designed with flexibility in mind. The modeler can choose to either supply a constant PET or utilize PET from the atmospheric forcing file. The modeler can also choose either a constant crop coefficient or one that varies monthly. The irrigation water can be applied to different soil moisture storage zones in the model, including the following: applied over the canopy (i.e., like precipitation); applied directly to the soil surface (i.e., flood irrigation); applied to either the upper soil zone or lower soil zone (i.e., via buried systems); and applied directly into the local groundwater (i.e., seepage irrigation). The modeler designates the modeled reach from which the irrigation water is withdrawn. If a reach does not exist or is not supplied, then irrigation demand is assumed to be satisfied from an external source.

Table K-8 provides the list of irrigation parameters (only applied to land uses where irrigation application is occurring) and the basic setup used for the Los Peñasquitos WMA model.

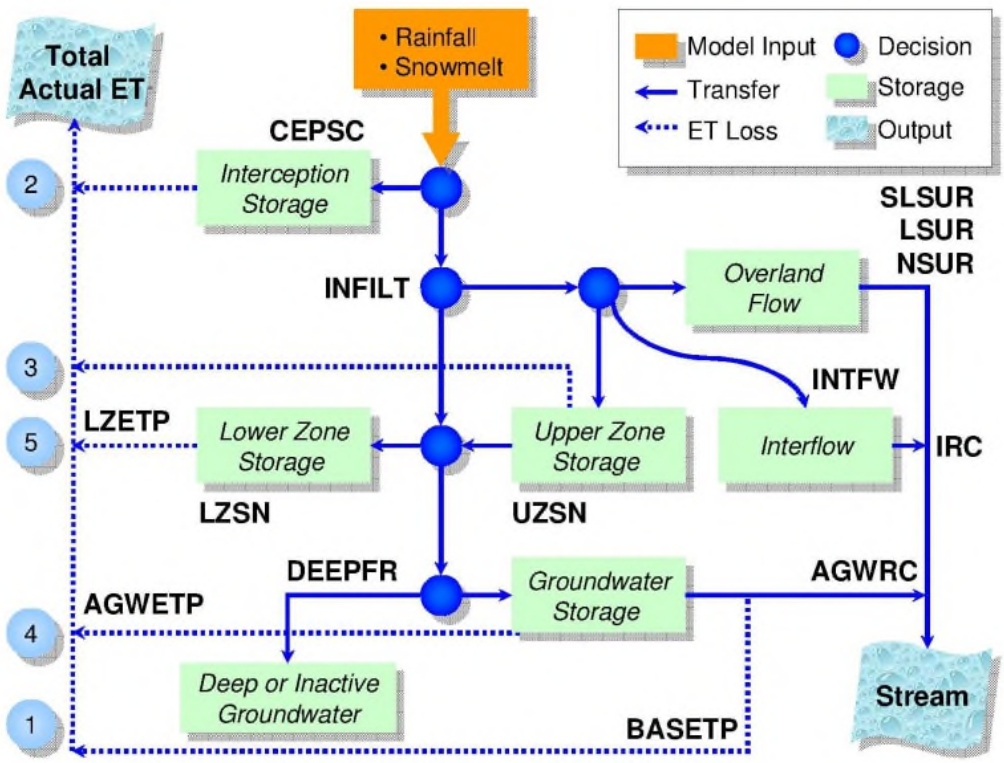

Figure K-13
Schematic of LSPC Hydrology Components and Pathways

Table K-7
Hydrology Parameters for the Los Peñasquitos WMA Model

Parameter	Definition	Units	Temporal Variability
LZSN	Lower zone nominal soil moisture storage	inches	Constant
INFILT	Index to the infiltration capacity of the soil	inches/hour	Constant
KVARY	Variable groundwater recession	1/inches	Constant
AGWRC	Base groundwater recession	none	Constant
PETMAX	Air temperature below which ET is reduced	deg F	Constant
PETMIN	Air temperature below which ET is set to zero	deg F	Constant
INFEXP	Exponent in the infiltration equation	none	Constant
INFILIF	Ratio between the maximum and mean infiltration capacities of the PLS	none	Constant
DEEPFR	Fraction of groundwater inflow that will enter deep groundwater	none	Constant
BASETP	Fraction of remaining potential ET that van be satisfied from baseflow	none	Constant
AGWETP	Fraction of remaining potential ET that van be satisfied from active groundwater	none	Constant
CEPSC	Interception storage capacity	inches	Monthly
UZSN	Upper zone nominal storage	inches	Constant
NSUR	Manning's *n* for the assumed overland flow plane	none	Constant
INTFW	Interflow inflow parameter	none	Constant
IRC	Interflow recession parameter	none	Constant
LZETP	Lower zone ET parameter	none	Monthly

Table K-8
Irrigation Parameters for the Los Peñasquitos WMA Model

Parameter	Definition	Units	Value
petfg	If = 1, use constant PET rather than time series from the air file	none	0
monVaryIrrig	If = 1, use monthly varying ET coefficient	none	1
startmonth	Startmonth of irrigation requirement	integer	1
endmonth	Endmonth of irrigation requirement	integer	12
fraction1	Fraction of irrigation requirement applied over the canopy	%	100%
fraction2	Fraction of irrigation water applied directly to the soil surface	%	0%
fraction3	Fraction of irrigation water applied to the upper soil zone via buried systems	%	0%
fraction4	Fraction of irrigation water likewise applied to the lower soil zone	%	0%
fraction5	Fraction of irrigation water entering directly into the local groundwater, such as seepage irrigation	%	0%
etcoeff	Coefficient to calculate actual ET, based on PET	%	Monthly Varying

Parameter	Definition	Units	Value
etdays	Number of threshold days to calculate irrigation demand	integer	2
rchid	Reach ID from where water is withdrawn (If reach does not exist then etdemand is assumed to be satisfied from an external source.)	none	0

K.4.2 Observed Flow Data

Available hydrologic data were reviewed and used for evaluating the predictive ability of the Los Peñasquitos WMA model. Hydrology monitoring stations were first georeferenced with both the subwatershed boundaries and reach layers to identify the associated model outflow points for comparison. Upstream drainage area characteristics, such as contributing land use distribution, were also summarized for each flow gage. Table K-9 provides a summary of the stations and Figure K-14 shows the in-stream hydrology stations in the Los Peñasquitos WMA available for use in hydrology calibration and validation.

The U.S. Geological Survey (USGS) maintains a long-term flow gage that had a complete period of record for the simulation period from 1/1/1988 to 9/30/2012. This gage, USGS11023340 – Los Peñasquitos Creek near Poway, California, was used as both a calibration and validation gage. Weston collected additional streamflow data at the Los Peñasquitos Creek Mass Loading Station (MLS) on lower Los Peñasquitos Creek as well as at two Temporary Watershed Assessment Stations (TWAS) on upper Los Peñasquitos Creek and on Carroll Canyon Creek. Data for the MLS and two TWAS gages were provided at a sub-daily interval, and therefore were converted to daily average flow values and utilized as additional model validation gages. Additional monitoring stations considered as part of the TMDL modeling effort included a Carmel Creek station and a USGS station near the mouth of Los Peñasquitos Creek.

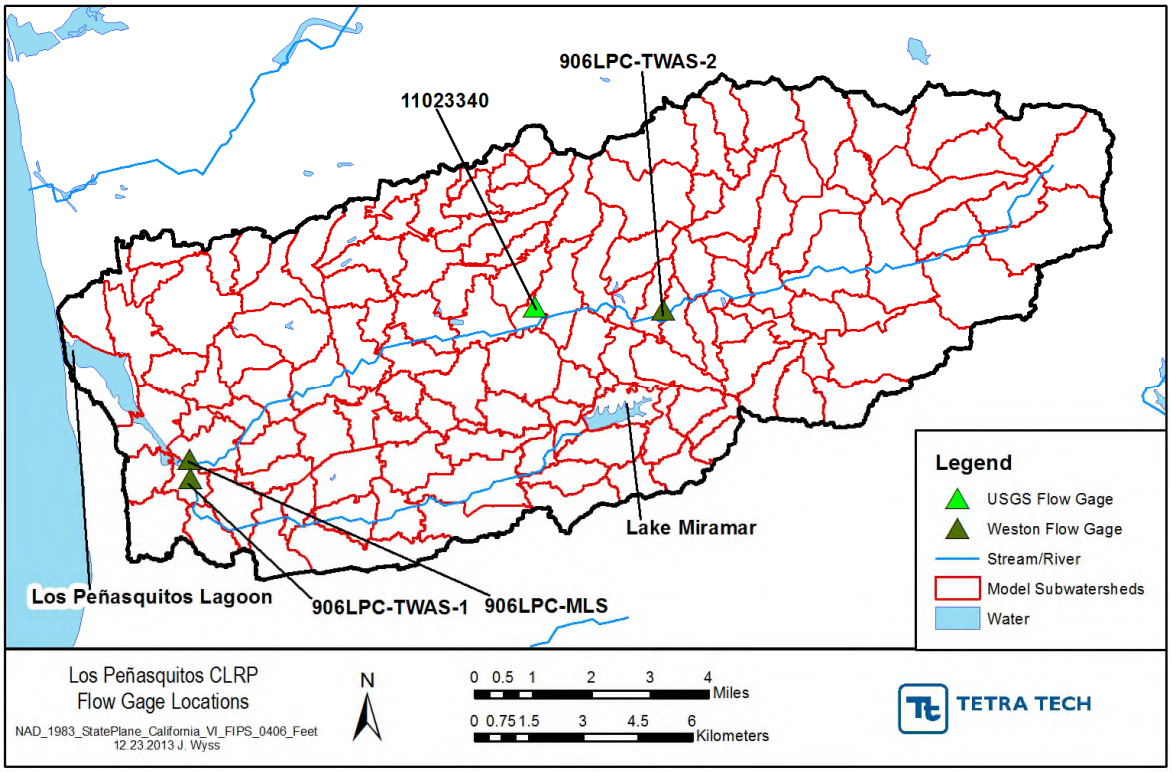

Figure K-14
Spatial Coverage of Calibration and Validation Stations used in the Hydrology Model

Table K-9
Flow Gages used for Calibration and Validation in the Los Peñasquitos WMA Model

Source	Gage ID	Site Name	USGS Drainage Area (acres)	LSPC Watershed	LSPC Drainage Area (acres)	Type	Period of Record Utilized
USGS	11023340	Los Peñasquitos Creek near Poway, CA	26,944	1146	26,988	Calibration/ Validation	10/1/1989–9/30/2012
Weston	906LPC-MLS	Lower Los Peñasquitos Creek	N/A	1132	36,866	Validation	9/13/2007–6/15/2009 & 8/17/2010–6/22/2011
Weston	906LPC-TWAS-1	Carroll Canyon Creek	N/A	1208	11,397	Validation	9/19/2007–8/11/2008 & 8/25/2010–6/22/2011
Weston	906LPC-TWAS-2	Upper Los Peñasquitos Creek	N/A	1154	21,074	Validation	9/27/2007–8/11/2008 & 8/22/2010–6/22/2011

K.4.3 Hydrology Model Calibration

Hydrologic calibration followed the standard operating procedures for the model described in Donigian et al. (1984) and Lumb et al. (1994). Daily, monthly, seasonal, and total modeled flows were compared to observed data, and error statistics were calculated for the percent difference. The percent errors were then compared to recommended tolerance targets from Donigian et al. (1984) and Lumb et al. (1994). Targets are shown in Table K-10 and represent long-term averages for relative error. In general, meeting these targets indicates that a model calibration can be rated as “very good.” In contrast, failure to achieve these targets does not indicate that the model is unusable, but rather indicates a need to consider the impacts of model uncertainty on decisions.

Model results were also visually compared to observed data using time series plots, and additional graphical and tabular monthly comparisons were performed. Less credence was placed in the seasonal summer and storm event summer statistics since runoff volumes are low (or nonexistent) during the dry seasons, and storms are rare.

Initial values for the hydrological parameters were taken from the shorter simulation period and regionally calibrated CLRP watershed model (Tetra Tech 2012). Values for hydrologic parameters were set in accordance with the ranges recommended in USEPA (2000) and adjusted during calibration. The key hydrologic parameters adjusted included infiltration, lower zone storage, lower zone evapotranspiration, and the irrigation component. The calibration of the hydrologic parameters was performed from 10/1/01 to 9/30/12.

Table K-10
Criteria for the Hydrology Calibration

Category	Recommended Criteria (%)
Error in total volume:	±10
Error in 50% lowest flows:	±10
Error in 10% highest flows:	±15
Seasonal volume error - Summer:	±30
Seasonal volume error - Fall:	±30
Seasonal volume error - Winter:	±30
Seasonal volume error - Spring:	±30
Error in storm volumes:	±20
Error in summer storm volumes:	±50

Source: Modified from Lumb et al. (1994) and Donigian et al. (1984).

K.4.4 Hydrology Model Validation

An important step of the modeling process is model validation. Model validation is the process of taking the hydrological parameters that have been calibrated, applying those parameters to other watersheds or a different period of time, and comparing the simulated flow to measured flow. Model validation is sometimes called model verification because essentially you are validating or verifying that hydrological parameters calibrated in one watershed will produce acceptable results in another watershed. It is important that when selecting watersheds to perform validations, those watersheds represent a wide variety of land uses and drainage areas. This will help to ensure that the hydrological parameters that were calibrated apply to a wide range of conditions. The validation of the hydrological parameters was performed from 10/1/1989 to 9/30/2001.

K.4.5 Hydrology Results, Observations and Conclusions

Statistics for the hydrologic calibration to the USGS gage on Los Peñasquitos Creek are shown in Table K-11 and compared to the targets discussed in the Calibration Approach section. All measures are within the pre-specified target tolerance ranges (with the exception of 50% lowest flow volumes, for which the percent error is slightly out of range and likely due to irrigation). Overall, the model performs very well, across a range of flow conditions and seasons.

A flow-duration plot (plot of flow versus percent of time exceeded, Figure K-15) shows excellent agreement for the highest flows, and overall good agreement for the rest of the flows. Mid-range flows are slightly over-predicted, and the lowest flows are slightly over. A plot of flow accumulation (Figure K-16) shows that the model tracks observed flow volume well over time, with little deviation.

Monthly observed and modeled flows at Los Peñasquitos Creek for the calibration period are plotted along with reported monthly rainfall (Figure K-17), and also show good agreement. When months are aggregated across the entire calibration period, both a scatterplot and time series show very little difference between simulated and observed average monthly values (Figure K-18).

Table K-11
Summary statistics: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek near Poway CA (Water Years 2002 through 2012 Daily Flow Calibration)

LSPC Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM SUBBASIN 1146 11-Year Analysis Period: 10/1/2001 - 9/30/2012 Flow volumes are (inches/year) for upstream drainage area		USGS 11023340 LOS PENASQUITOS CREEK NEAR POWAY CA Hydrologic Unit Code: 18070304 Latitude: 32.9431013 Longitude: -117.1216999 Drainage Area (sq-mi): 42.1	
Total Simulated In-stream Flow:	**4.41**	Total Observed In-stream Flow:	**4.40**
Total of simulated highest 10% flows:	**3.58**	Total of Observed highest 10% flows:	**3.39**
Total of Simulated lowest 50% flows:	**0.27**	Total of Observed Lowest 50% flows:	**0.33**
Simulated Summer Flow Volume (months 7-9):	**0.17**	Observed Summer Flow Volume (7-9):	**0.17**
Simulated Fall Flow Volume (months 10-12):	**1.53**	Observed Fall Flow Volume (10-12):	**1.59**
Simulated Winter Flow Volume (months 1-3):	**2.26**	Observed Winter Flow Volume (1-3):	**2.14**
Simulated Spring Flow Volume (months 4-6):	**0.46**	Observed Spring Flow Volume (4-6):	**0.50**
Total Simulated Storm Volume:	**3.17**	Total Observed Storm Volume:	**3.00**
Simulated Summer Storm Volume (7-9):	**0.02**	Observed Summer Storm Volume (7-9):	**0.03**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	0.22	10	
Error in 50% lowest flows:	**-15.76**	**10**	
Error in 10% highest flows:	5.59	15	
Seasonal volume error - Summer:	-2.10	30	
Seasonal volume error - Fall:	-4.07	30	
Seasonal volume error - Winter:	5.98	30	
Seasonal volume error - Spring:	-9.81	30	
Error in storm volumes:	5.88	20	
Error in summer storm volumes:	-32.19	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.879	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.721	as E or E' approaches 1.0	

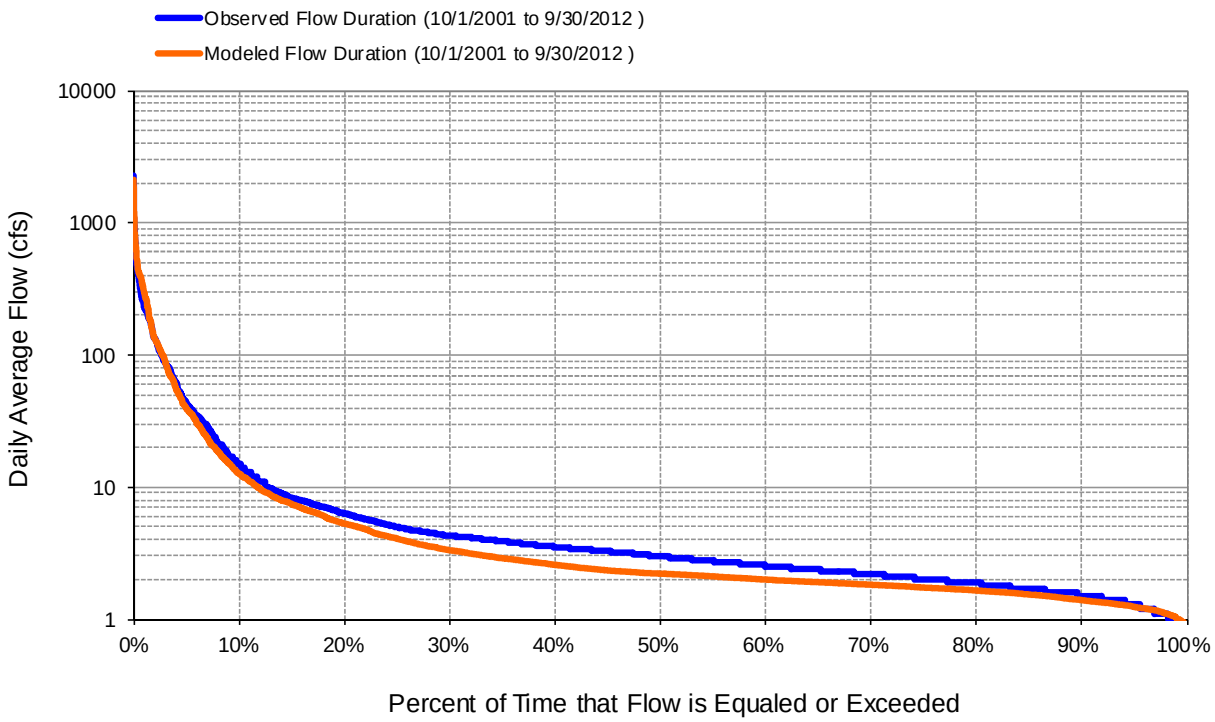

Figure K-15
Flow Exceedance: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek near Poway CA (Water Years 2002 through 2012 Calibration)

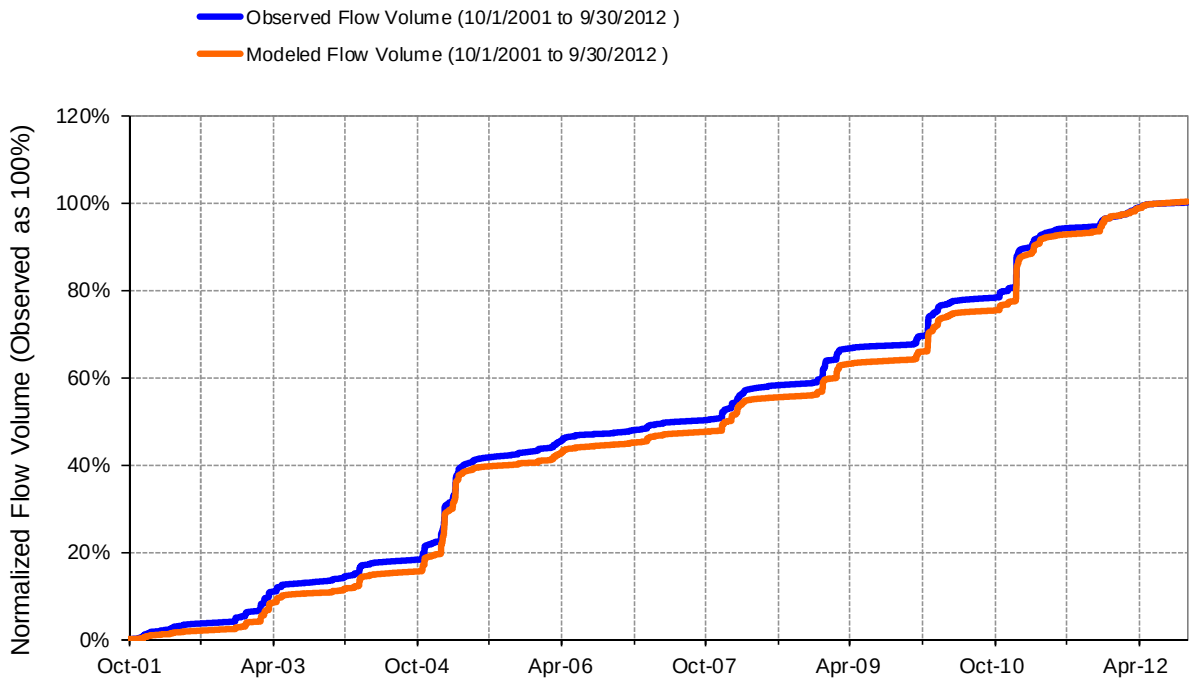

Figure K-16
Flow Accumulation: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek near Poway CA (Water Years 2002 through 2012 Calibration)

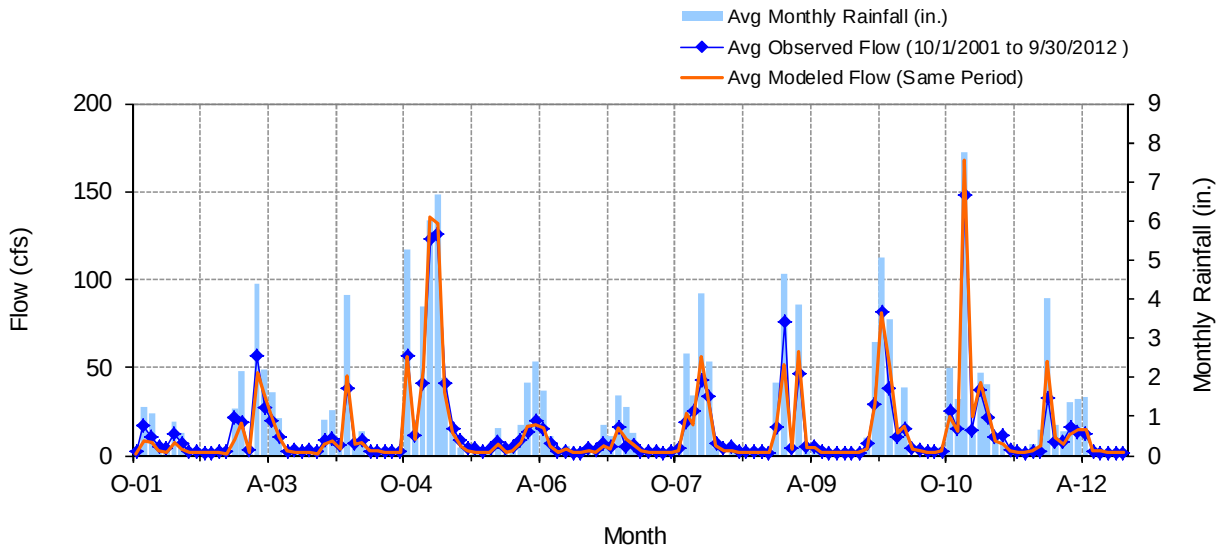

Figure K-17
Mean Monthly Flow: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek Near Poway CA (Water Years 2002 through 2012 Calibration)

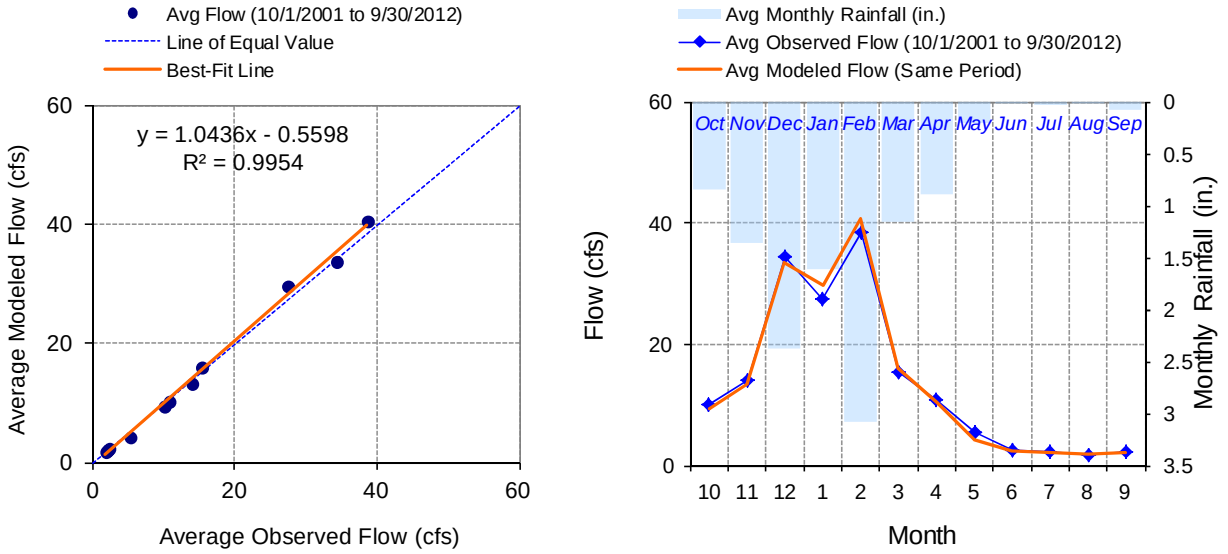

Figure K-18
Seasonal Regression and Temporal Aggregate: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek Near Poway CA (Water Years 2002 through 2012 Calibration)

Validation results are presented in Table K-12 and Figure K-19, Figure K-20, Figure K-21, and Figure K-22. The model shows excellent agreement to observed conditions, arguably the results of the validation are better than the calibration largely due to the better match of simulated and observed flow duration curves but the Nash Sutcliffe Coefficient of Efficiency is not of as high a quality as compared to the calibration. The validation results are very good.

Table K-12
Summary Statistics: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek near Poway CA (Water Years 1990 through 2001 Daily Flow Validation)

LSPC Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM SUBBASIN 1146 12-Year Analysis Period: 10/1/1989 - 9/30/2001 Flow volumes are (inches/year) for upstream drainage area		USGS 11023340 LOS PENASQUITOS CREEK NEAR POWAY CA Hydrologic Unit Code: 18070304 Latitude: 32.9431013 Longitude: -117.1216999 Drainage Area (sq-mi): 42.1	
Total Simulated In-stream Flow:	**5.12**	Total Observed In-stream Flow:	**5.16**
Total of simulated highest 10% flows:	**4.19**	Total of Observed highest 10% flows:	**4.15**
Total of Simulated lowest 50% flows:	**0.28**	Total of Observed Lowest 50% flows:	**0.29**
Simulated Summer Flow Volume (months 7-9):	**0.22**	Observed Summer Flow Volume (7-9):	**0.20**
Simulated Fall Flow Volume (months 10-12):	**0.47**	Observed Fall Flow Volume (10-12):	**0.50**
Simulated Winter Flow Volume (months 1-3):	**3.81**	Observed Winter Flow Volume (1-3):	**3.84**
Simulated Spring Flow Volume (months 4-6):	**0.62**	Observed Spring Flow Volume (4-6):	**0.62**
Total Simulated Storm Volume:	**3.67**	Total Observed Storm Volume:	**3.46**
Simulated Summer Storm Volume (7-9):	**0.05**	Observed Summer Storm Volume (7-9):	**0.05**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	-0.69	10	
Error in 50% lowest flows:	-2.51	10	
Error in 10% highest flows:	0.95	15	
Seasonal volume error - Summer:	10.40	30	
Seasonal volume error - Fall:	-6.85	30	
Seasonal volume error - Winter:	-0.82	30	
Seasonal volume error - Spring:	1.53	30	
Error in storm volumes:	5.92	20	
Error in summer storm volumes:	-13.31	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.397	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.619	as E or E' approaches 1.0	

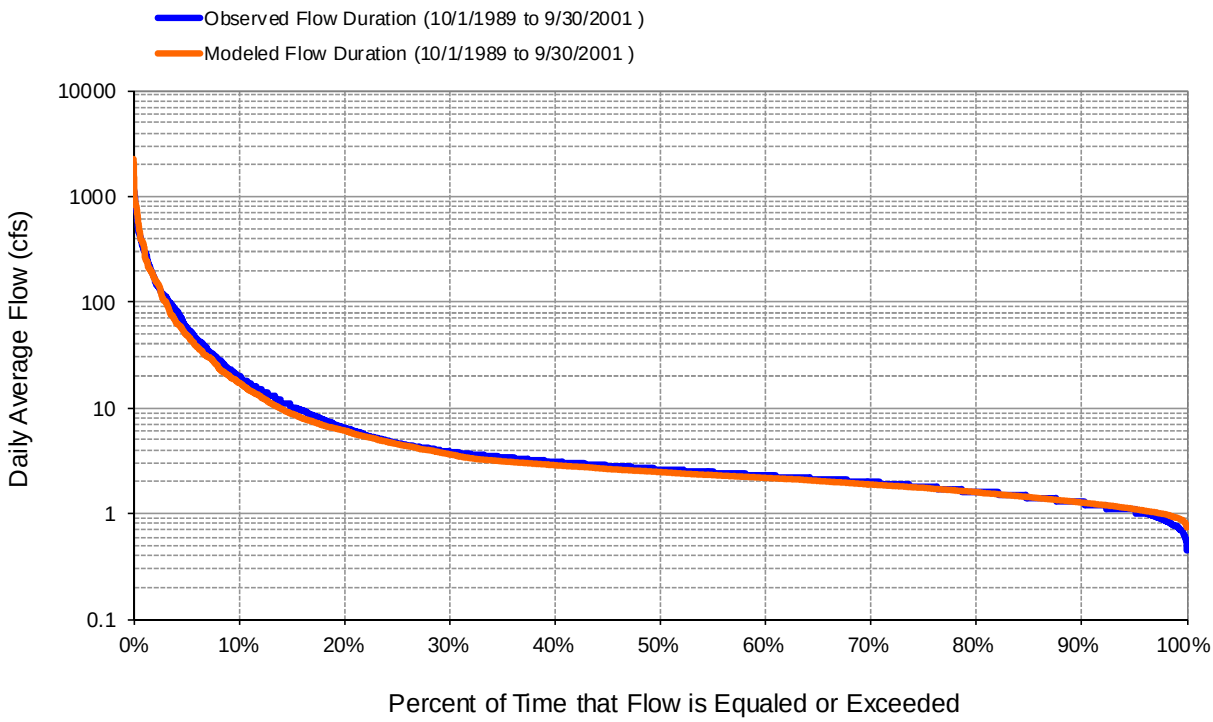

Figure K-19
Flow Exceedance: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek Near Poway CA (Water Years 1990 through 2001 Validation)

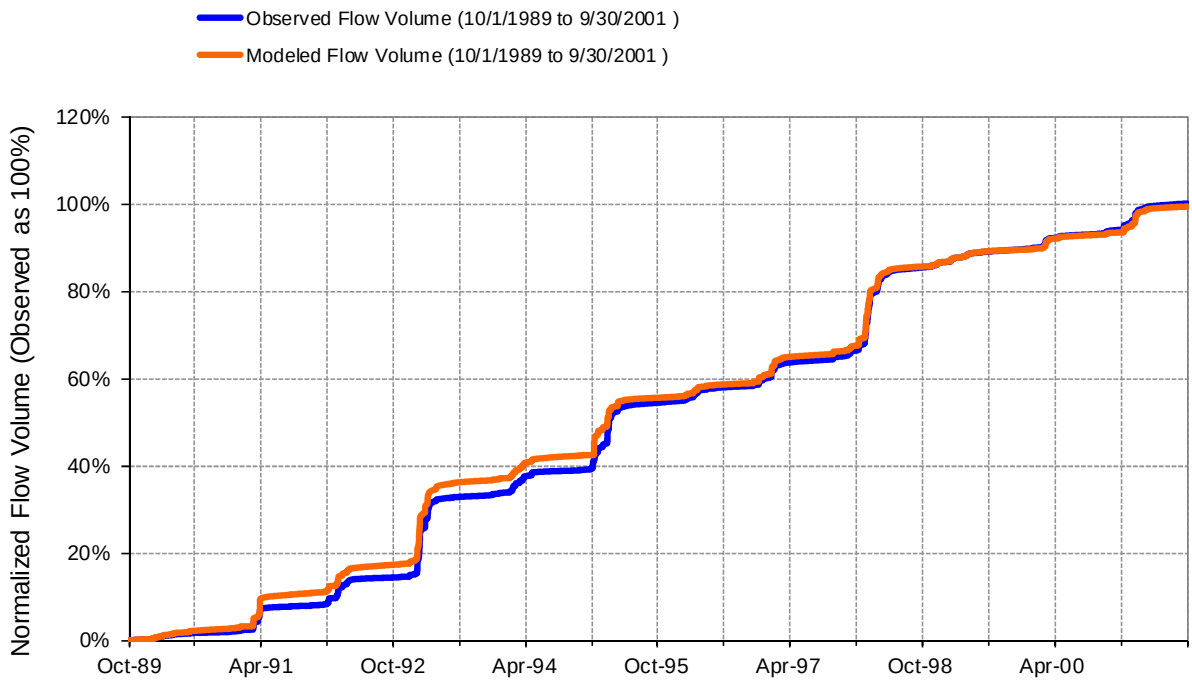

Figure K-20
Flow Accumulation: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek Near Poway CA (Water Years 1990 through 2001 Validation)

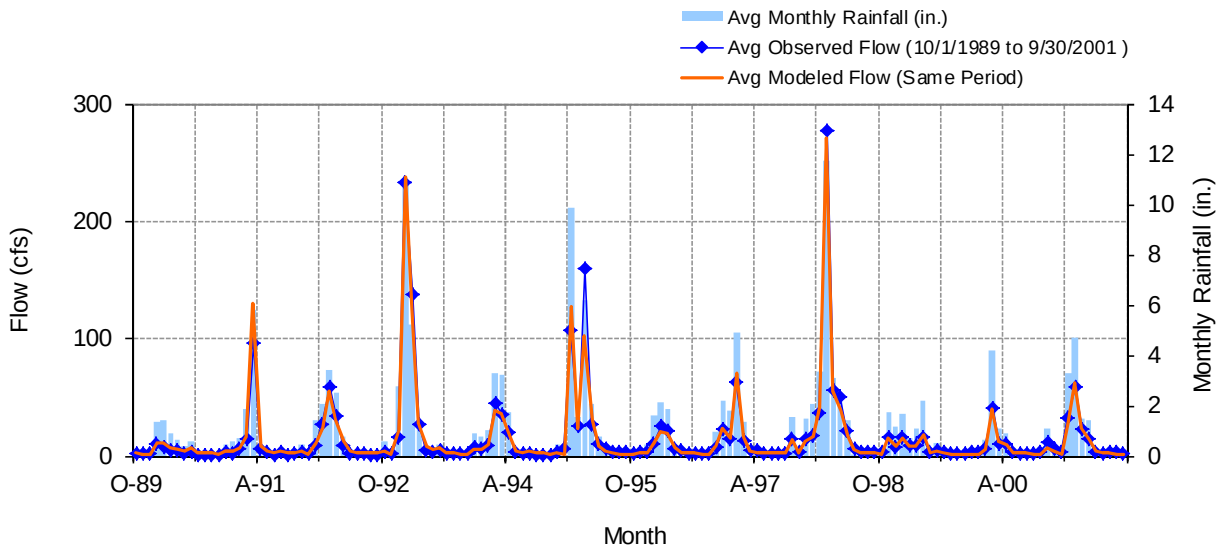

Figure K-21
Mean Monthly Flow: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek Near Poway CA (Water Years 1990 through 2001 Validation)

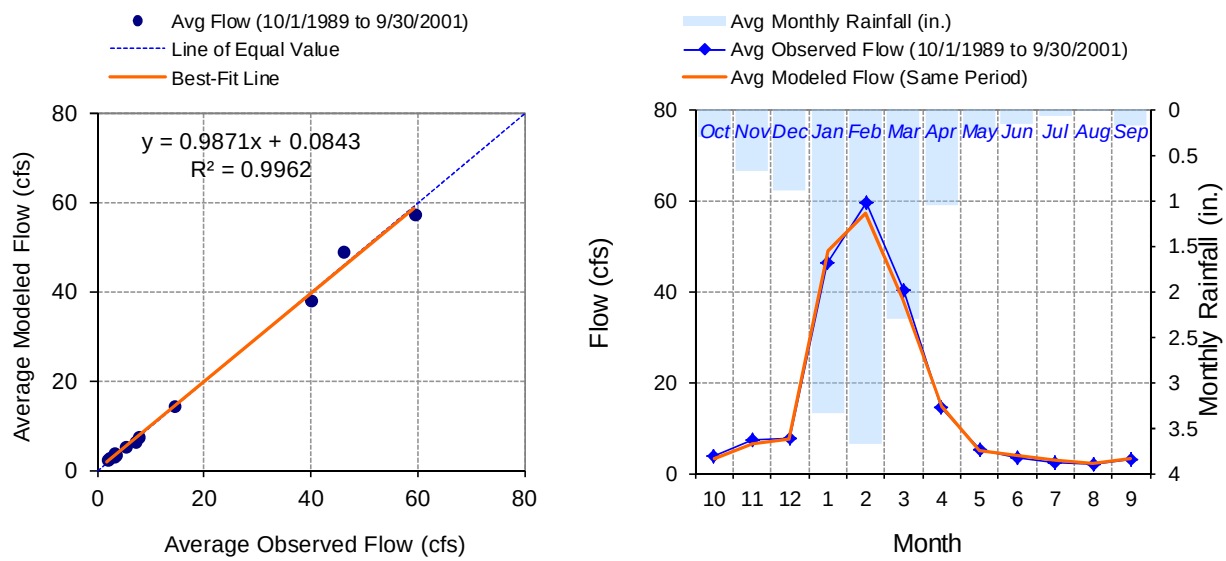

Figure K-22
Seasonal Regression and Temporal Aggregate: Model Outlet 1146 vs. USGS 11023340 Los Peñasquitos Creek Near Poway CA (Water Years 1990 through 2001 Validation)

During the calibration process it was observed that obtaining an acceptable hydrology calibration was largely dependent on the irrigation component of the model. The model was sensitive to all of the irrigation parameters (Table K-8) but extremely sensitive to the ETc (Crop coefficient to evaluate actual evapotranspiration parameter) and where the irrigation water was applied in the model.

For the irrigation component it was assumed that irrigation water could be applied in any month of the year and that the irrigation calculation would resolve the irrigation demand function over a period of 2 days (i.e. to calculate the irrigation demand function it would utilize rainfall and potential evapotranspiration from the previous 2 days). Additionally it was assumed that all irrigation water was supplied either over the canopy, which made irrigation water subject to interception losses, or to the soil surface (bypassing interception storage). Values for ETc ranged from 0.95 to 1.15, varying seasonally.

Research suggests a crop coefficient of 0.6 for lawns planted with warm season grasses and 0.65 for agricultural citrus production (University of California Cooperative Extensive 2000). To be able to use the suggested ranges all irrigation water would have needed to be supplied directly to the soil surface. This did not seem realistic with the types of irrigation systems being used in southern California. Therefore, the assumptions that all irrigation water was to be applied over the canopy and also using ETc as a calibration parameter were adopted. Further it was decided that the crop coefficients in the document were meant for use in irrigator's actual calculations to determine their irrigation need and is not necessarily reflective of the amount of irrigation water that is actually utilized and applied to the landscape. Lastly, through the

course of the calibration it was determined that supplying ETc as a monthly varying parameter resulted in a better comparison of simulated and observed flow values.

Due to the extreme sensitivity to ETc it was decided to perform and present the results of a sensitivity analysis. The model calibration was tuned to its final state and then monthly ETc was modified by adding 10% to the final calibrated values and subtracting 10% from the final calibrated values. Then Tetra Tech's hydrology calibration tool was used to analyze impacts between the final calibrated model (Baseline) and the simulation with the changed ETc values (Scenario) during the calibration period of the model.

Table K-13 presents the summary statistics comparing the two scenarios with the baseline calibrated model. The +10% scenario drastically increases the volumes in the summer and 50% lowest flows while the -10% scenario drastically decreases the volumes in the summer and 50% lowest flows. Figure K-23 shows the flow duration curve of the +10% scenario and graphically shows the increase in flow of the 50% lowest flows and Figure K-24 shows the flow duration curve of the -10% scenario and graphically shows the decrease in flow of the 50% lowest flows. The results of the sensitivity analysis indicate that the values used for ETc in the calibrated model are in an acceptable range when using the assumptions adopted during the course of model calibration.

Table K-13
Summary Statistics: Scenario +10% ETc (Modeled) vs. Baseline Calibration Outflow from Sub-Watershed 1146

Metric (Scenario-Baseline)	Scenario Comparison	
	ETc +10%	ETc -10%
Difference in total volume:	6.85	-6.23
Difference in 50% lowest flows:	42.22	-40.22
Difference in 10% highest flows:	2.73	-2.31
Seasonal volume difference - Summer:	37.33	-36.93
Seasonal volume difference - Fall:	5.91	-5.23
Seasonal volume difference - Winter:	3.51	-3.32
Seasonal volume difference - Spring:	15.52	-12.90
Difference in storm volumes:	2.98	-2.27
Difference in summer storm volumes:	13.48	-7.40

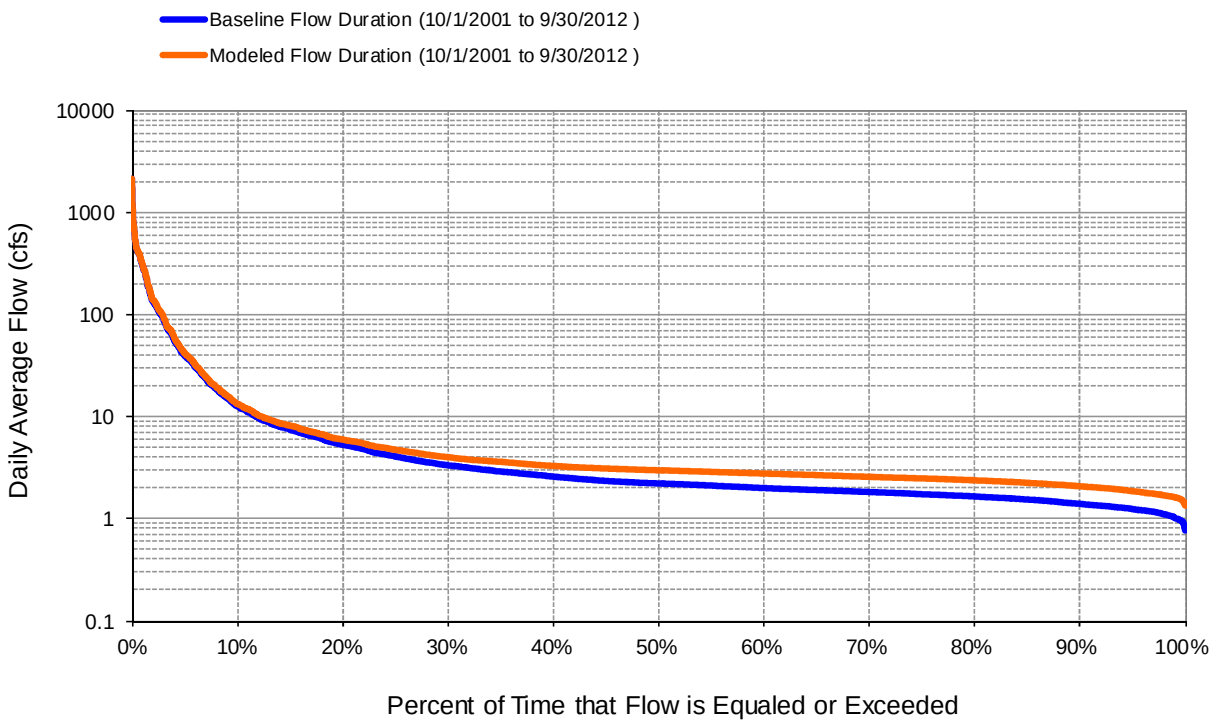

Figure K-23
Flow Exceedance: Scenario +10% ETc (Modeled) vs. Baseline Calibration Outflow from Sub-Watershed 1146

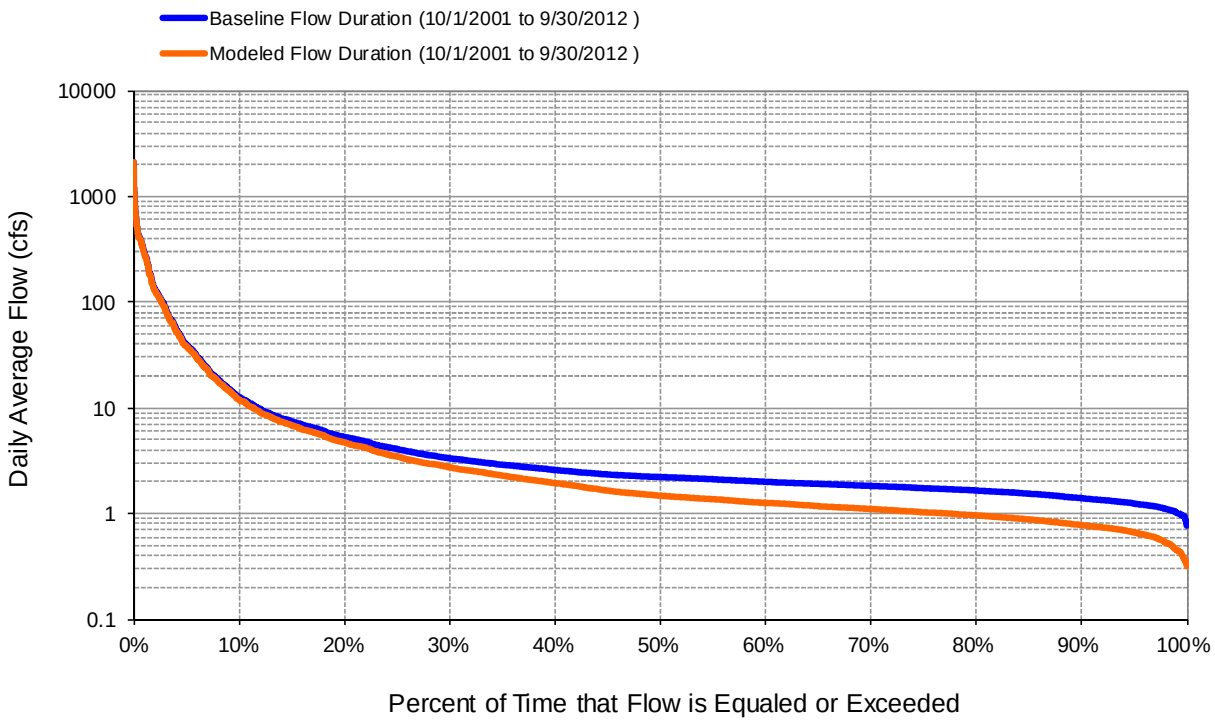

Figure K-24
Flow Exceedance: Scenario -10% ETc (Modeled) vs. Baseline Calibration Outflow from Sub-Watershed 1146

K.5 Watershed Water Quality Model

K.5.1 Water Quality Model Overview

Once the LSPC watershed hydrology model was calibrated, the model was used to create a water quality model of the Los Peñasquitos watershed. Many components of the water quality model were established during hydrology modeling. These components include watershed segmentation, meteorological data, and land use representation. The models simulate pollutant generation and accumulation on surfaces, and resulting pollutant runoff and delivery to receiving water bodies. Delivery of pollutants through subsurface pathways (i.e., interflow and groundwater) is also represented. Water quality parameters were determined to adequately represent the loading generation capabilities for the different modeled HRUs for a wide range of storm intensities and baseflows. Initial water quality parameterization was taken from the previous shorter simulation period and regionally calibrated CLRP watershed model (Tetra Tech 2012), and refined where appropriate to optimize the fit of simulated to observed concentration and load.

K.5.2 Modeled Constituents

The LSPC water quality model was set up to model Total Suspended Solids, Total Nitrogen (TN), Total Phosphorus (TP), Total Copper, Total Lead, Total Zinc, Fecal Coliform, Total Coliform, and *Enterococcus*.

K.5.3 Reach Group Representation

For in-stream water quality simulation, the user has the ability to model in-stream processes, for the modeled reaches, by assigning them to reach groups. Assigning reaches into groups allows for the assignment of unique values, for each reach group, for certain LSPC parameters. The parameters that can be assigned differently by reach group for the Los Peñasquitos WMA model include sediment bed storage parameters, cohesive and non-cohesive suspended sediment variables for in-stream transport, in-stream general quality constituent control, parameters for decay of contaminant adsorbed to sediment, and parameters for adsorption/desorption of contaminant adsorbed to sediment. In LSPC, reach group is analogous to the RCHRES block in HSPF. A detailed description of relevant in-stream and transport algorithms is presented in the *HSPF Version 12 User's Manual* (Bicknell et al. 2004).

For the Los Peñasquitos WMA model, each reach was assigned its own unique group. This was done primarily for the sediment transport component of the model. All of the values for stream group parameters that were not associated with sediment were set to the same value for each reach. The parameters that were associated with sediment transport were allowed to vary for each individual reach. Giving each reach its own reach group removed the phenomena where one reach in a particular group might always be accumulating silt and clay and scouring sand while another reach might always be scouring silt and clay and depositing sand. Additional details regarding parameters for specific reaches are provided in Section 5.6.

K.5.4 Sediment Representation

LSPC models sediment by using algorithms identical to those in the HSPF. The LSPC/HSPF modules used to represent sediment include SEDMNT (production and removal of sediment from a pervious land segment), SOLIDS (accumulation and removal of solids by runoff and other means from the impervious land segment), and SEDTRN (transport, deposition, and scour of inorganic sediment in free-flowing reaches and mixed reservoirs). A detailed description of relevant sediment algorithms is presented in the *HSPF Version 12 User's Manual* (Bicknell et al. 2004). In short, sediment is being removed from pervious lands via raindrop impact particle detachment and then subsequently the detached sediment is being carried to the stream via pervious land surface flow. For impervious land, buildup and removal rates are applied and solids are washed into the stream via impervious land surface flow during rain events. Once the sediment and solids are in the stream they either deposit or scour dependent on the conditions in the water column for each reach.

Sediment is one of the most difficult water quality parameters to accurately simulate with watershed models; therefore, the approach to modeling sediment in the Los Peñasquitos WMA model consisted of using the final calibrated parameter values from the previous shorter simulation period and regionally calibrated CLRP watershed model (Tetra Tech 2012) except the stream bank erosion component. The borrowed parameters were adjusted slightly in accordance with guidelines established in EPA *BASINS Technical Note 8: Sediment Parameter and Calibration Guidance for HSPF* (USEPA 2006) and *Sediment Calibration Procedures and Guidelines for Watershed Modeling* (Donigian and Love 2003). In addition, the in-stream transport component of sand, silt and clay were closely examined and calibrated for each reach to maintain a dynamic steady state during the long-term simulations.

Key processes for sediment include soil detachment, soil compaction, fraction of land use shielded from raindrop impact, sediment washoff rate, and in-stream transport which includes settling velocities and flow velocities that contribute to deposition and resuspension of sediment particles.

K.5.5 Nutrients, Metals, and Bacteria Representation

LSPC models nutrients, metals, and bacteria by using algorithms identical to those in the HSPF. The LSPC/HSPF modules used to represent nutrients, metals, and bacteria include PQUAL (water quality constituents or pollutants in the outflows from a pervious land segment using simple relationships with water and/or sediment yield); IQUAL (water quality constituents or pollutants in the outflows from an impervious land segment using simple relationships with water yield and/or solids); and GQUAL (simulate the in-stream behavior of a generalized constituent). A detailed description of relevant sediment algorithms is presented in The *HSPF Version 12 User's Manual* provides a detailed description of relevant sediment algorithms (Bicknell et al. 2004).

Accumulation and washoff rates play an important role in the determination of nonpoint source loadings to a water body. The watershed model must appropriately represent the spatial and temporal variability of hydrological characteristics within a watershed. It must

also appropriately represent the rate at which constituent's build up between rain events and wash off during rain events. Key general water quality characteristics include initial storage, washoff and scour potency, accumulation rates, and asymptotic maximum storage amounts. The water supplied to a stream from groundwater and through interflow also plays an important role in loading to a water body. LSPC allows the user to supply groundwater and interflow concentrations by parameter group and RMU. The accumulation, washoff, and interflow strongly influence peak flow water quality while groundwater reflects baseflow water quality.

Nutrients and bacteria on pervious and impervious HRUs were simulated using the buildup/washoff and assignment of concentrations to the interflow and groundwater flow paths. Metals on pervious and impervious HRUs were simulated as sediment-associated constituents by assigning a washoff potency factor (mass/ton of sediment) and concentrations to the interflow and groundwater flow paths. As a result of using potency factors, metals are strongly correlated with the sediment simulation. Once in the stream, all constituents were simulated as dissolved and it was assumed that there was no adsorption/desorption with sediment. Nutrients and bacteria were assigned general first-order in-stream loss rates to account for uptake and decay, but metals were assumed to not decay.

K.5.6 Water Quality Calibration

Sediment was the first constituent calibrated after hydrology. The land-based parameters were adjusted until the simulated land-based export closely matched the sediment target export coefficients (Table K-14). After the land-based sediment was reasonably calibrated the in-stream transport simulation of sediment was closely examined. The parameters for in-stream transport were modified as necessary to maintain a dynamic steady state for each sediment class for the long-term simulation.

Additional calibration was pursued for mining areas in Carroll Canyon Creek. Two new land use categories, 73 and 76, were adopted to explicitly represent activity on lands with <10% slope and >= 10%, respectively.

While there is a general consensus that mining areas are a major source of sediment, there are no quantitative estimates of loading. As a result, the model was parameterized for mining areas based upon published data. The Georgia Department of Natural Resources (2005) reports an estimated sediment load of 3.19 tons/ac/yr. from quarries, strip mines and gravel pits in Headstall Creek in Georgia. Diaz-Ramirez et al. (2008) have modeled sediment generation from barren land (which includes quarries/strip mines/gravel pits) in an HSPF model for the Luxapallila Creek watershed in Alabama and Mississippi. They report a simulated annual sediment rate of 6.3 mt/ha/yr. (~2.8 tons/ac/yr.) compared to an observed rate of 4.0 - 9.0 mt/ha/yr. (~1.8 - 4.0 tons/ac/yr.). The Tt model adopted similar parameter values for mining land uses (Table K-15).

Table K-14
Export Coefficients for Total Suspended Solids for Different Land Uses Literature Review

Eco-region type or Land Use	Export Coefficient (kg/ha/year)	Reference
Foothills Parklands	18.07 – 42.90	Sosiak 2000
Foothills Fescue	24.02 – 100.99	Sosiak 2000
Forest	250	USEPA 1976
Forest	253	Reckhow et al. 1980
Agricultural non intensive pasture/range	400	USEPA 1976
Agricultural non intensive pasture/hay	514.5	Reckhow et al. 1980
Agricultural intensive mixed	4900	Van Vliet & Hall 1991
Agricultural intensive wheat	1440	Larney et al. 1995b
Nonnative land use		
Urban	2000	USEPA 1976
Urban, residential	208.6	Reckhow et al. 1980
Industrial	868.7	Reckhow et al. 1980

Extracted from (Tetra Tech 2011)

Table K-15
Sediment Parameter Values for Mining Land Uses

Parameter	Value
kser	10.0
jser	2.0
kger	10.0
jger	2.2

The model was also configured to generally represent the trends in sediment production and delivery observed in the ESA-PWA geomorphology/sedimentation reports. These included,

- Specifying the initial sediment fraction (by weight) of bed materials to 90% sand, 5% silt and 5% clay based upon particle size distribution of bed materials in the Carroll Canyon Creek subwatershed.
- The model generally has *ksand* and *expsand* set to 1.5 and 1, respectively, for all reaches in Carroll Canyon Creek subwatershed. These values were revised for some reaches (Table K-16), depending upon the erosive or depositional nature of the reach.

Table K-16
Values of ksand and expsand in Carroll Canyon Creek

Reach	*ksand*	*expsand*
1211	1.5	1.2
1213	1.5	2.3
1214	1.5	2
1215	1.5	2
1216	1.5	1.2
1218	1.5	2
1225	1.5	2
1226	1.5	2
1227	1.5	2
1228	1.5	2

The parameterization for the three classes of bacteria (enterococcus, fecal coliform, total coliform) were obtained from the previous shorter simulation period and regionally calibrated CLRP watershed model (Tetra Tech 2012), and unmodified for the model extension effort.

K.5.7 Observed Water Quality Data for Calibration and Validation

Available in-stream water quality data were reviewed and used for evaluating the predictive ability of the Los Peñasquitos WMA model. Water quality monitoring stations were first georeferenced with both the subwatershed boundaries and reach layers to identify the associated model outflow points for comparison. Upstream drainage area characteristics, such as contributing land use distribution, were also summarized for each water quality station. Table K-17 provides a summary of the stations and Figure K-25 shows the in-stream water quality stations in the Los Peñasquitos WMA available for use in water quality calibration. Because of the limited number of samples available for water quality calibration, the water quality model was not validated.

Water quality data for many constituents were collected at the Los Peñasquitos Creek MLS on lower Los Peñasquitos Creek as well as at two TWAS on upper Los Peñasquitos Creek and on Carroll Canyon Creek. These three locations are at the same location as the Weston flow measurement stations used for Hydrology validation.

Table K-17
Water Quality Stations used for Calibration in the Los Peñasquitos WMA Model

Station	Site Name	Drainage Area (mi^2)	Drainage Area (acres)	LSPC Watershed	Parameters	Period of Record Utilized	# of Samples
906LPC-MLS	Lower Los Peñasquitos Creek	57.60	36,866	1132	Total Suspended Sediment *Enterococcus* Fecal Coliform Total Coliform	11/29/2001 –5/12/2011	27
906LPC-TWAS-1	Carroll Canyon Creek	17.81	11,397	1208	Total Suspended Sediment *Enterococcus* Fecal Coliform Total Coliform	9/26/2007–5/12/2011	8
906LPC-TWAS-2	Upper Los Peñasquitos Creek	32.93	21,074	1154	Total Suspended Sediment *Enterococcus* Fecal Coliform Total Coliform	9/26/2007–5/12/2011	8

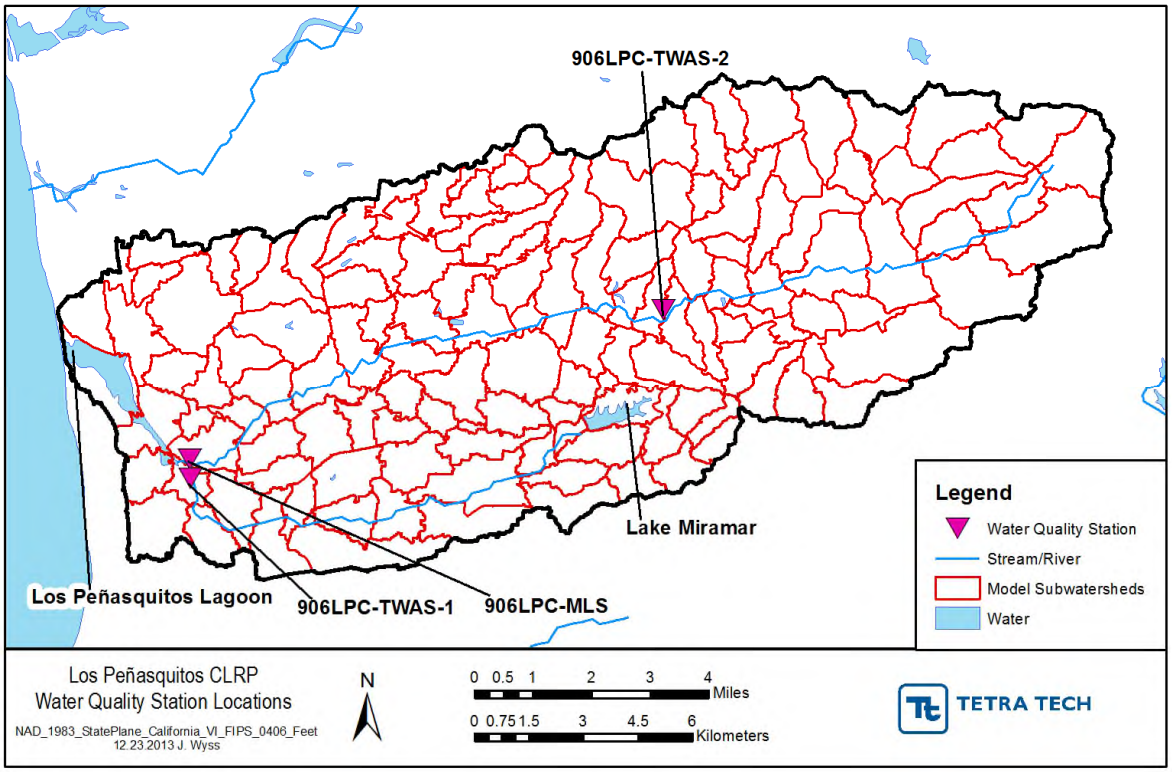

Figure K-25
Spatial Coverage of Calibration and Validation Stations used in the Water Quality Model

K.5.8 Water Quality Results, Observations and Conclusions

Presented below are the results of the water quality calibration at 906LPC-MLS on lower Peñasquitos Creek. Shown are time-series plots comparing continuous simulation concentration output to point in time grab sample measurements. Also shown are simulated and observed load/load regressions and simulated and observed load duration curves. In order to calculate observed load, long-term daily observed flow is needed. There is not long-term daily observed flow at the water quality gages so simulated flow has been used in its place. Therefore any difference in load between simulated and observed is entirely dependent on concentration since both simulated and observed loads are being calculated with the same flow time-series. Additionally, for the load calculations all concentrations were assumed to be in mg/L and calculated loads were assumed to be in pounds/day. Metals and bacteria are simulated in different units (µg/L and #/100ml respectively) so the loads are not actual masses and should only be used for comparative purposes.

K.5.8.1 Sediment

Table K-18 shows the simulated average sediment unit area loading by HRU for each parameter group. Time-series comparisons in standard and log format are shown in Figure K-26 and Figure K-27, respectively. Observed and simulated concentrations generally have similar distributions and magnitudes. The regression plot (Figure K-28) of simulated versus observed load shows little or no bias across the range of loads sans the line of five samples that have low observed load and high simulated load. These samples were measured as less than detection and the TSS value used for that sample was input at ½ the detection limit. In the load duration curve (Figure K-29), observed loads generally follow the distribution of simulated loads across the entire flow regime sans the five less than detection samples in the lower left hand corner of the plot. Overall the results of the sediment calibration are acceptable and the model should be useful for the CLRP and future implementation planning efforts.

Table K-18
Sediment Unit Area Land Use Export for Both Simulated Parameter Groups

Parameter Group		Carroll Canyon	All Others
DELUID	Land Use Name	Average Ton/Acre/Year	Average Ton/Acre/Year
3	Water	0.000	0.000
11	Agriculture Low Slope	0.000	0.029
15	Agriculture High Slope	0.250	0.210
23	Barren Low Slope	0.011	0.016
26	Barren High Slope	0.339	0.240
34	Forest/Shrub HSG B	0.001	0.001
35	Forest/Shrub HSG C	0.010	0.020
36	Forest/Shrub HSG D	0.114	0.111
44	Grassland HSG B	0.003	0.002
45	Grassland HSG C	0.017	0.056
46	Grassland HSG D	0.214	0.192
51	DevPerv HSG B Low Slope No Irrigation	0.012	0.014
52	DevPerv HSG C Low Slope No Irrigation	0.036	0.086
53	DevPerv HSG D Low Slope No Irrigation	0.183	0.157
54	DevPerv HSG B High Slope No Irrigation	0.012	0.014
55	DevPerv HSG C High Slope No Irrigation	0.040	0.083
56	DevPerv HSG D High Slope No Irrigation	0.189	0.164
61	DevPerv HSG B Low Slope Irrigation	0.062	0.104
62	DevPerv HSG C Low Slope Irrigation	0.185	0.305
63	DevPerv HSG D Low Slope Irrigation	0.502	0.434
64	DevPerv HSG B High Slope Irrigation	0.071	0.091
65	DevPerv HSG C High Slope Irrigation	0.181	0.278
66	DevPerv HSG D High Slope Irrigation	0.488	0.420
73	Mining, Low Slope (<10%)	0.078	0.000

Parameter Group		Carroll Canyon	All Others
DELUID	Land Use Name	Average Ton/Acre/Year	Average Ton/Acre/Year
76	Mining, High Slope (>10%)	2.185	0.000
91	Residential Low Slope Impervious	0.143	0.103
92	Residential High Slope Impervious	0.140	0.112
93	Institutional/Office Impervious	0.089	0.077
94	Commercial Impervious	0.521	0.413
95	Industrial Impervious	0.633	0.402
96	Road Impervious	0.278	0.231
97	Freeway Impervious	0.238	0.219
98	Overspray Residential Impervious	0.146	0.115
99	Overspray Road Impervious	0.280	0.238

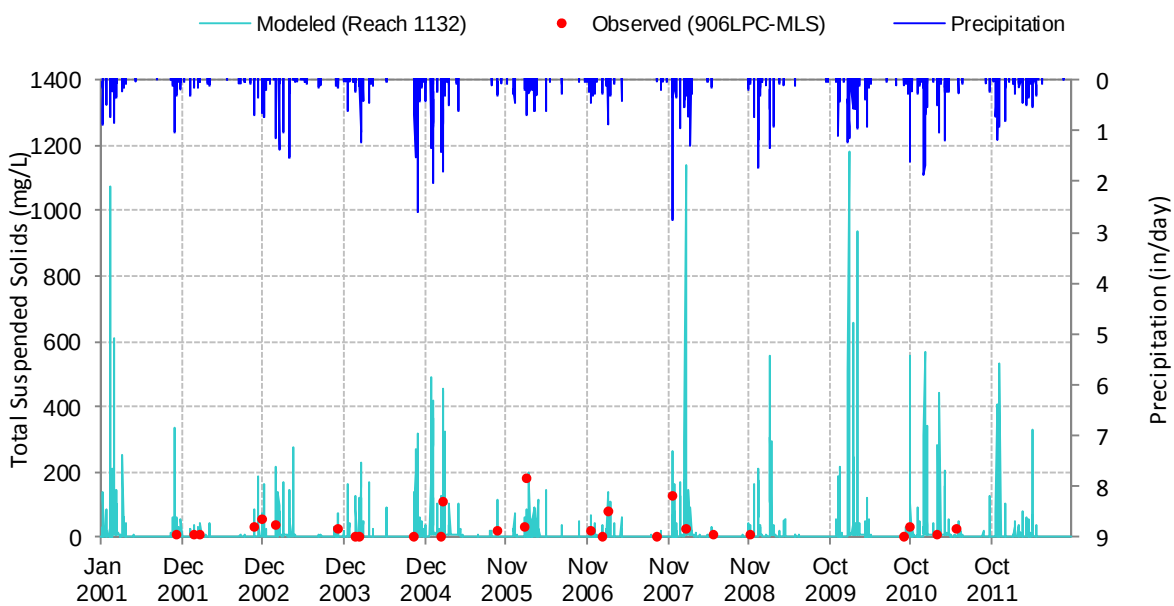

Figure K-26
Modeled vs. Observed Total Suspended Solids (mg/L)
at 906LPC-MLS

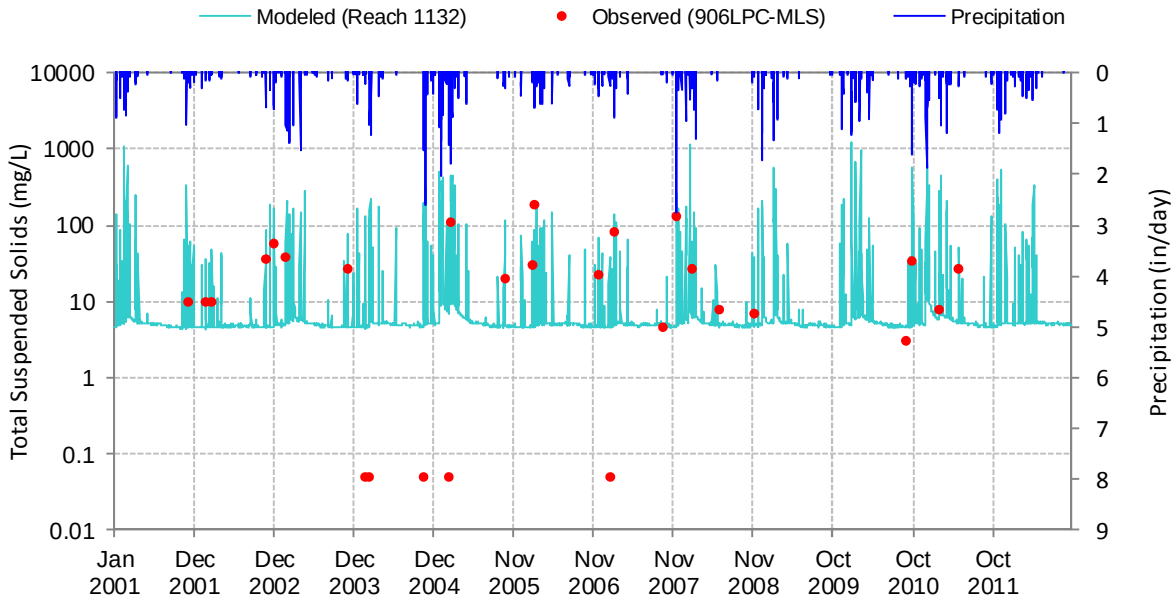

Figure K-27
Modeled vs. Observed Total Suspended Solids (mg/L)
at 906LPC-MLS (log scale)

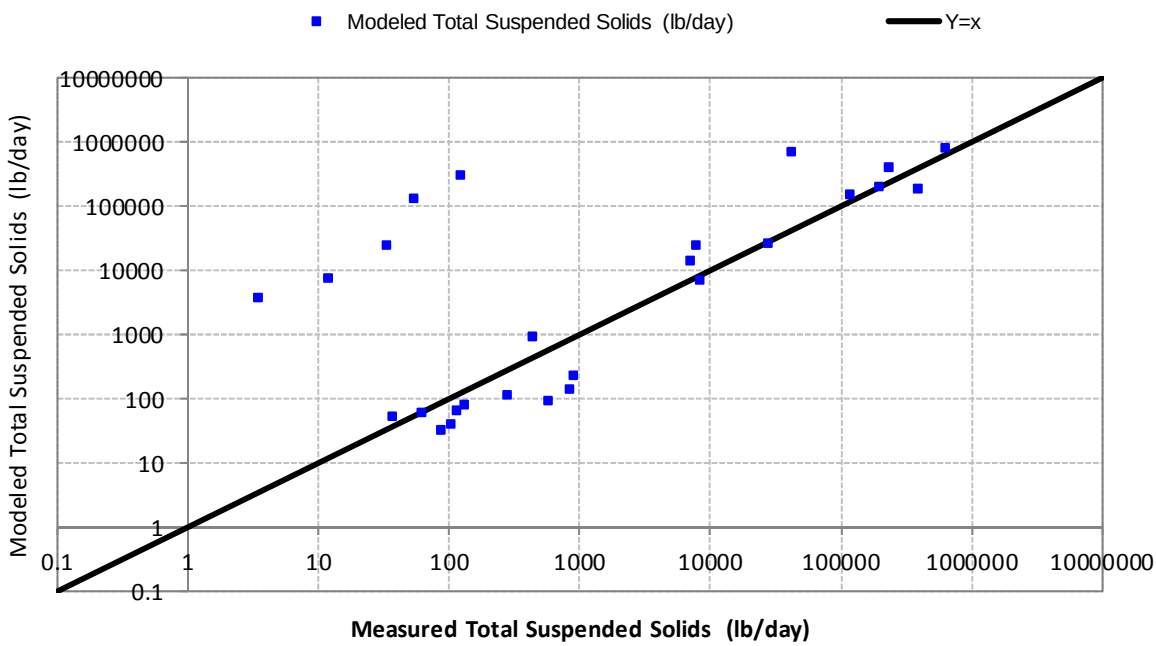

Figure K-28
Modeled vs. Observed Load Total Suspended Solids (pounds/day)
at 906LPC-MLS

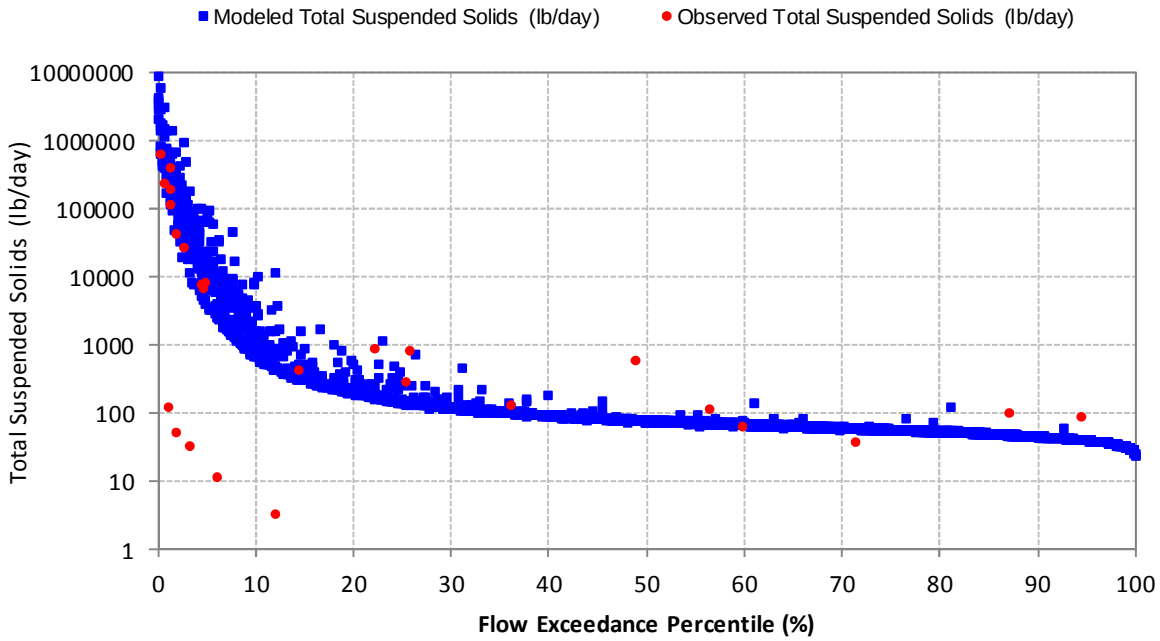

Figure K-29
Modeled vs. Observed Load Total Suspended Solids (pounds/day) at 906LPC-MLS

Results of the Tt LSPC model, with the mining land uses parameterized similar to the Diaz-Ramirez HSPF model (Diaz-Ramirez et al. 2008) are shown in Figure K-30.

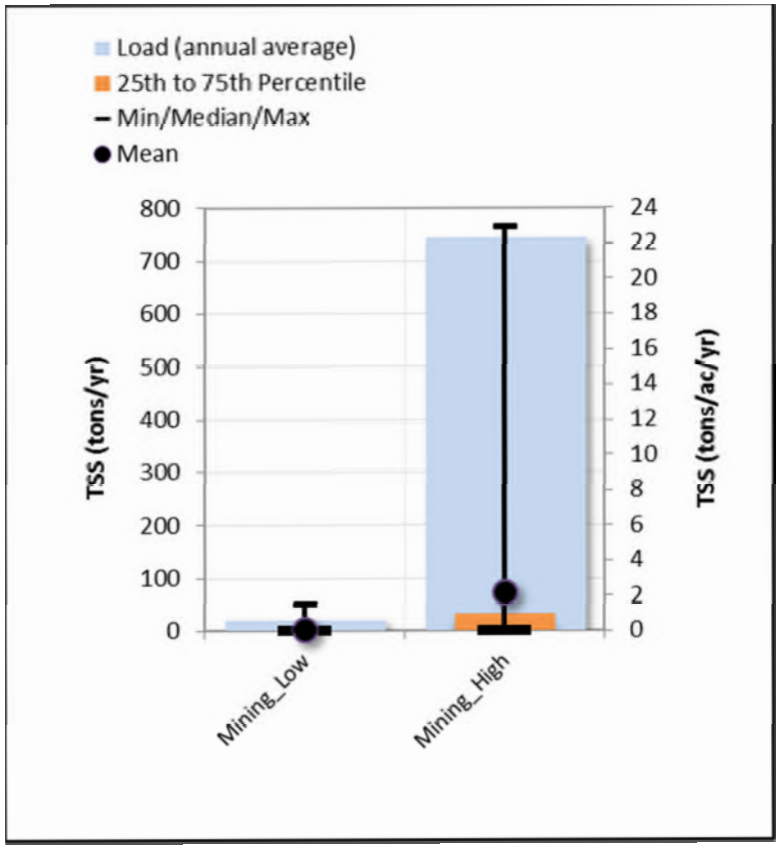

Figure K-30
Average Annual Sediment Load from Mining Land Uses
(for Water Years 1991 to 2012)

Figure K-31 shows the sediment loading from mining land uses in the Carroll Canyon Creek subwatershed in comparison to other land uses. It is evident that the unit area loading rate from mining land uses is noticeably higher than the other land use categories.

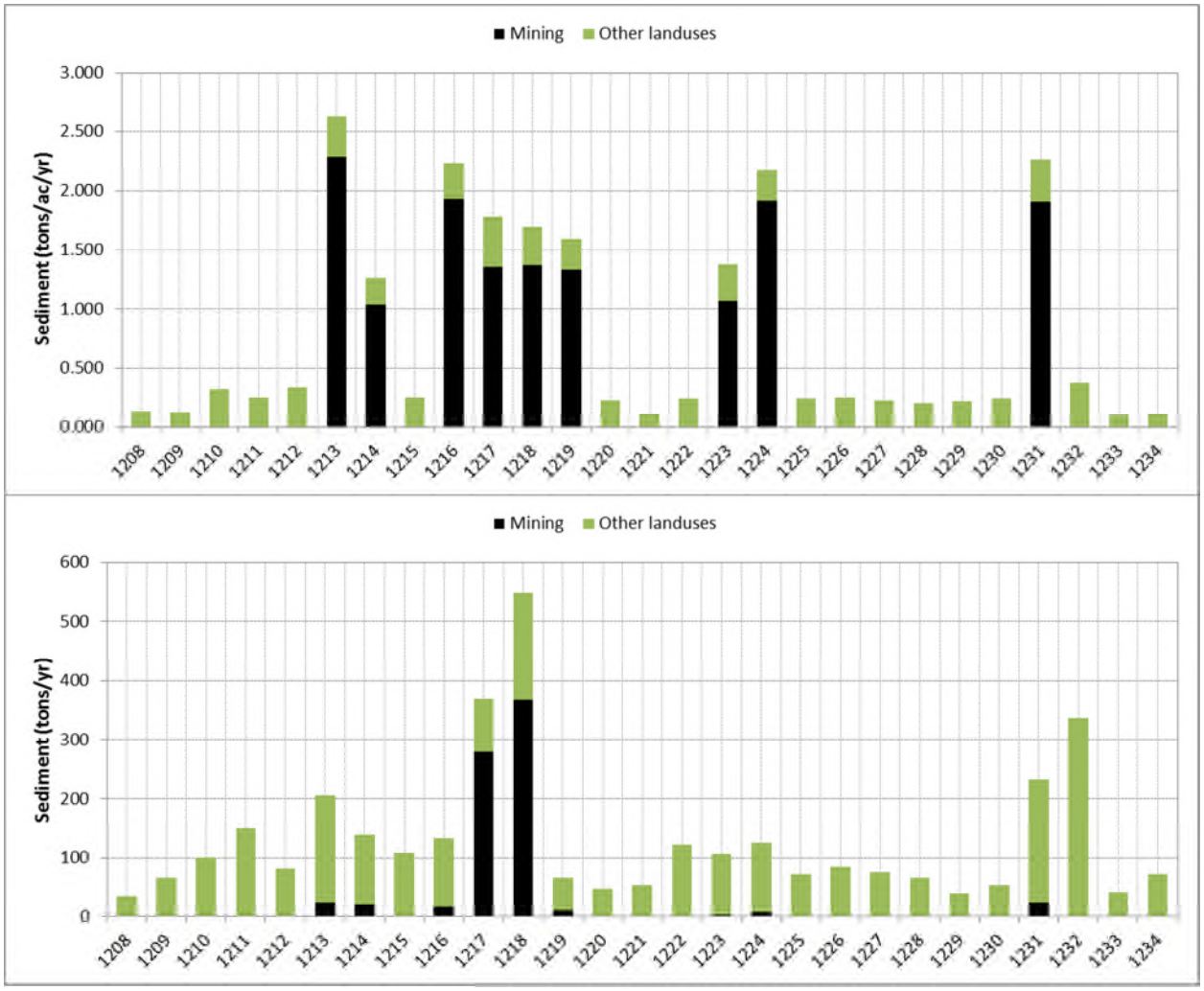

Figure K-31
Average Annual Sediment Load from Mining Land Uses Compared To Other Land Uses (for Water Years 1991 to 2012)

Figure K-32 shows the net scour and deposition for all the modeled reaches in Carroll Canyon Creek. While most of the reaches are depositional, some exhibit a net scour. Figure K-33 shows the total amount of sediment output by each modeled reach in Carroll Canyon Creek. These results are generally in agreement with the findings of the ESA-PWA report.

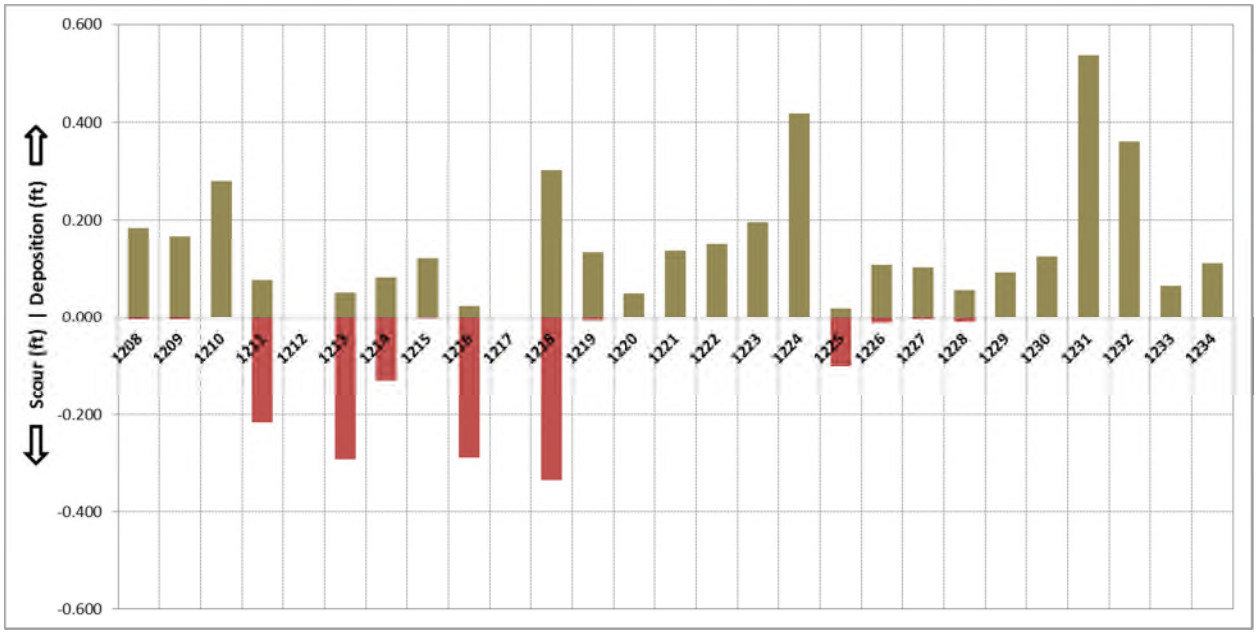

Figure K-32
Scour and Deposition for Each Modeled Reach (10/1/1990 to 9/30/2012)

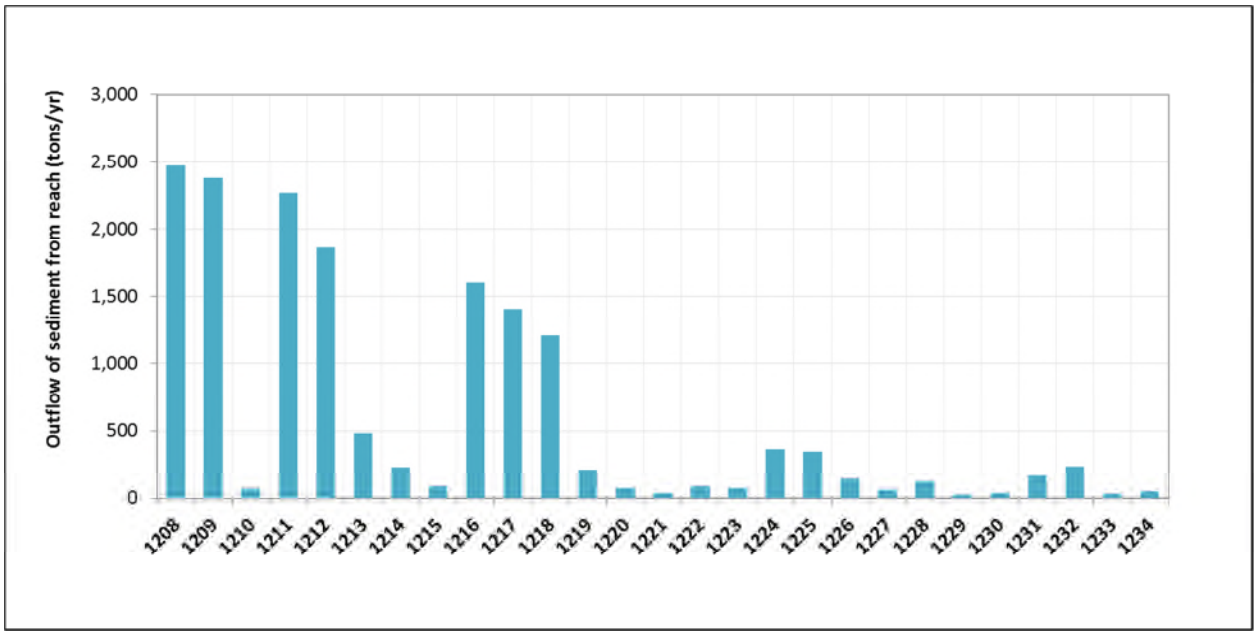

Figure K-33
Average Annual Outflow of Sediment from Modeled Reaches (10/1/1990 to 9/30/2012)

Figure K-34 and Figure K-35 show the amount of sediment generated and delivered by Carroll Canyon Creek in comparison with the other watersheds. It is important to note that the sediment rate generated by Carroll Canyon Creek is much higher than the other watersheds (Table K-19).

Table K-19
Sediment Load by Subwatershed

Subwatershed	Upland Load (tons/yr.)	Rate (tons/ac/yr.)	Delivered Load (tons/yr.)
Carmel Valley Creek	1,247	0.14	896
Carroll Canyon Creek	3,536	0.31	2,476
Los Peñasquitos Creek	5,438	0.15	3,938
Los Peñasquitos Lagoon	235	0.08	196

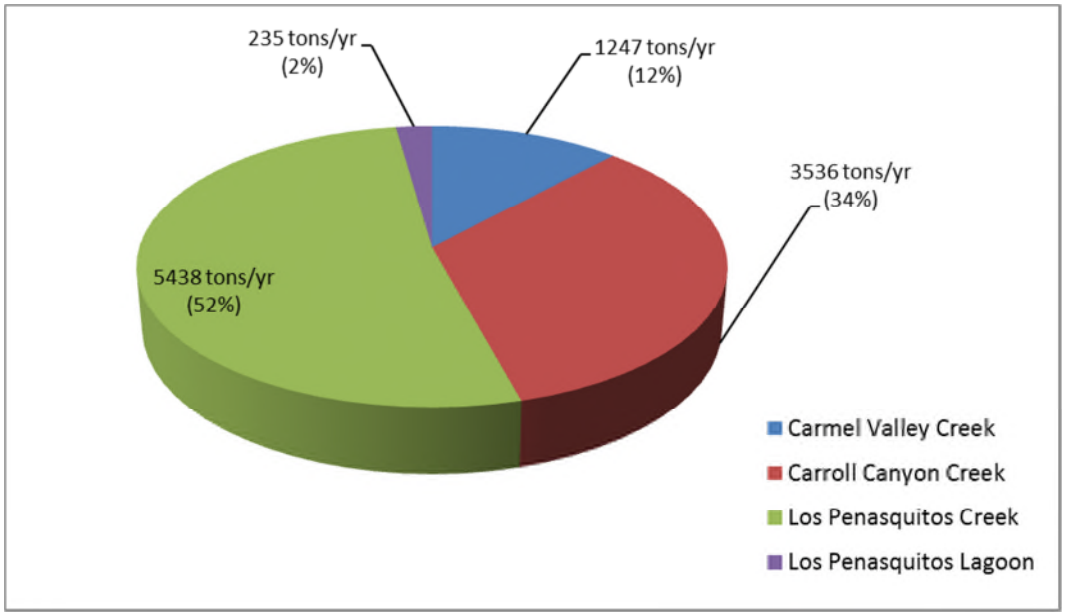

Figure K-34
Average Subwatershed Annual Upland Sediment Loads (10/1/1990 to 9/30/2012)

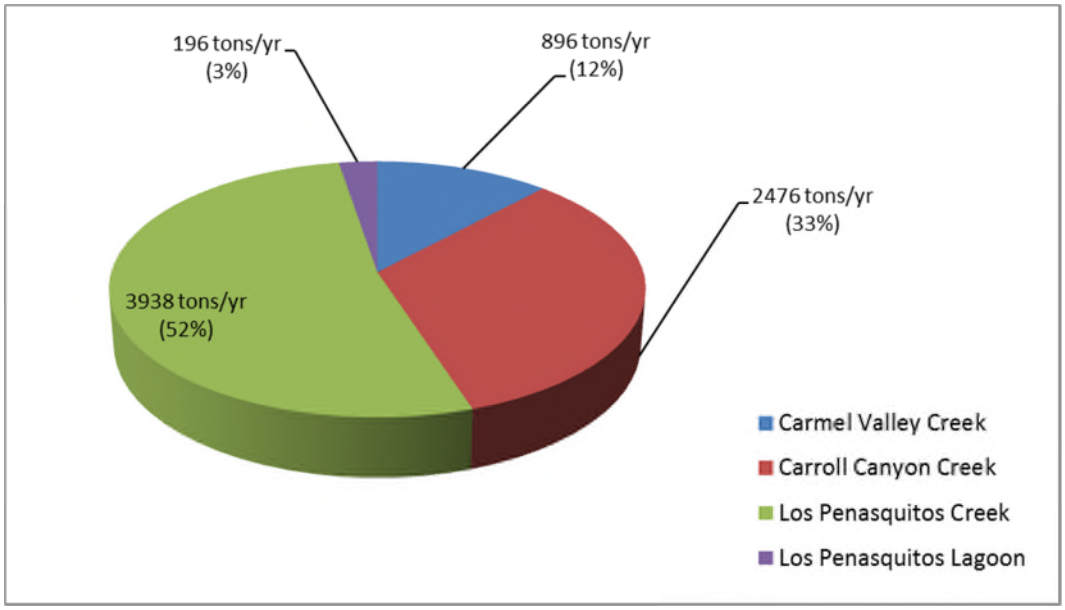

Figure K-35
Average Subwatershed Annual Sediment Output From Modeled Reaches (10/1/1990 to 9/30/2012)

K.5.8.2 Bacteria

The bacteria parameters were obtained from the previous shorter simulation period and regionally calibrated CLRP watershed model (Tetra Tech, 2012) and unmodified for the model extension effort. The results are included here for completeness.

Groundwater and interflow bacteria concentrations were updated as shown in Table K-20 to reflect the median value of observed monitoring data collected in the Poche Beach Bacterial Source Identification Study (Weston Solutions 2013).

Table K-20
Subsurface Bacteria Concentration

Land use group	Model land use name	Subsurface bacteria conc. (#/100 mL)		
	(group_soil_slope_irrigation)	fecal	total	entero
Water		0	0	0
Agriculture	Agri_Low	110	1,330	270
	Agri_High	110	1,330	270
Barren/Mining	Barren_Low	100	1,650	100
	Barren_High	100	1,650	100
Open Space	ForestShrub_B	10	167	150
	ForestShrub_C	10	167	150
	ForestShrub_D	10	167	150
	Grassland_B	10	167	150
	Grassland_C	10	167	150
	Grassland_D	10	167	150
Developed Pervious	Devperv_B_Low_NoIrg	100	1,650	700
	Devperv_C_Low_NoIrg	100	1,650	700
	Devperv_D_Low_NoIrg	100	1,650	700
	Devperv_B_High_NoIrg	100	1,650	700
	Devperv_C_High_NoIrg	100	1,650	700
	Devperv_D_High_NoIrg	100	1,650	700
	Devperv_B_Low_Irrg	100	1,650	700
	Devperv_C_Low_Irrg	100	1,650	700
	Devperv_D_Low_Irrg	100	1,650	700
	Devperv_B_High_Irrg	100	1,650	700
	Devperv_C_High_Irrg	100	1,650	700
	Devperv_D_High_Irrg	100	1,650	700

Enterococcus time-series comparisons in standard and log format are shown in Figure K-36 and Figure K-37, respectively. The regression plot (Figure K-38) of simulated versus observed load shows a slight high bias across the range of loads. The load duration curve (Figure K-39) shows a high bias across the entire flow regime.

Fecal Coliform time-series comparisons in standard and log format are shown in Figure K-40 and Figure K-41 respectively. The regression plot (Figure K-42) of simulated

versus observed load shows a slight high bias across the range of loads. The load duration curve (Figure K-43) shows a high bias across the entire flow regime.

Total Coliform time-series comparisons in standard and log format are shown in Figure K-44 and Figure K-45 respectively. The regression plot (Figure K-46) of simulated versus observed load shows a slight high bias across the range of loads. The load duration curve (Figure K-47) shows a high bias across the entire flow regime.

Overall the results of the bacteria calibration are acceptable and the model should be useful for future planning and implementation efforts.

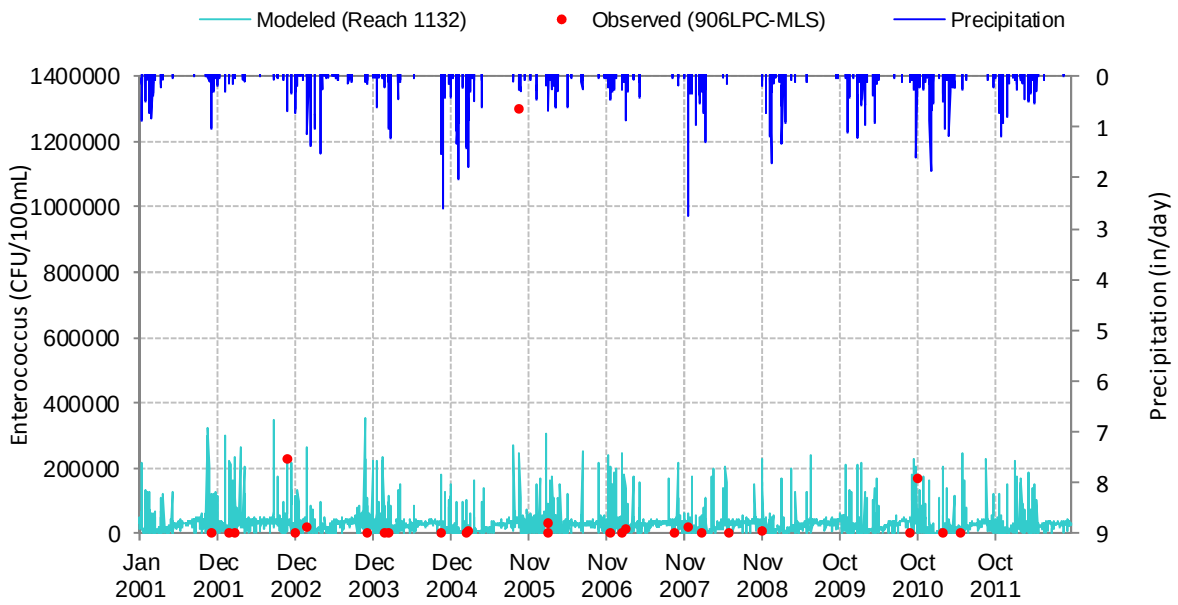

Figure K-36
Modeled vs. Observed Enterococcus (CFU/100mL) at 906LPC-MLS

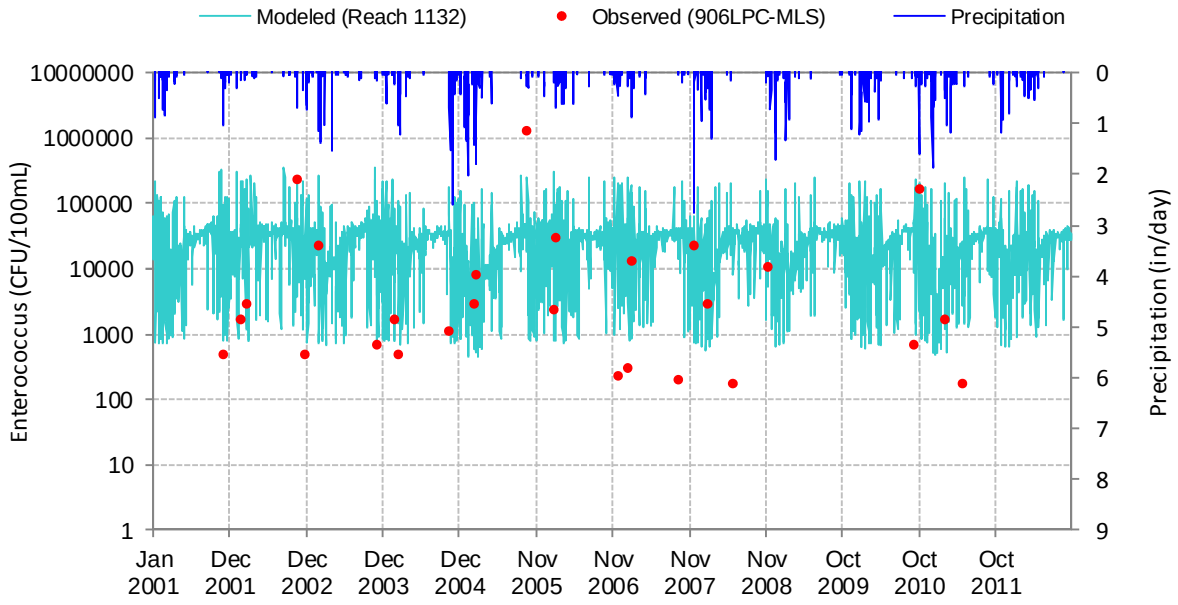

Figure K-37
Modeled vs. Observed Enterococcus (CFU/100mL)
at 906LPC-MLS (log scale)

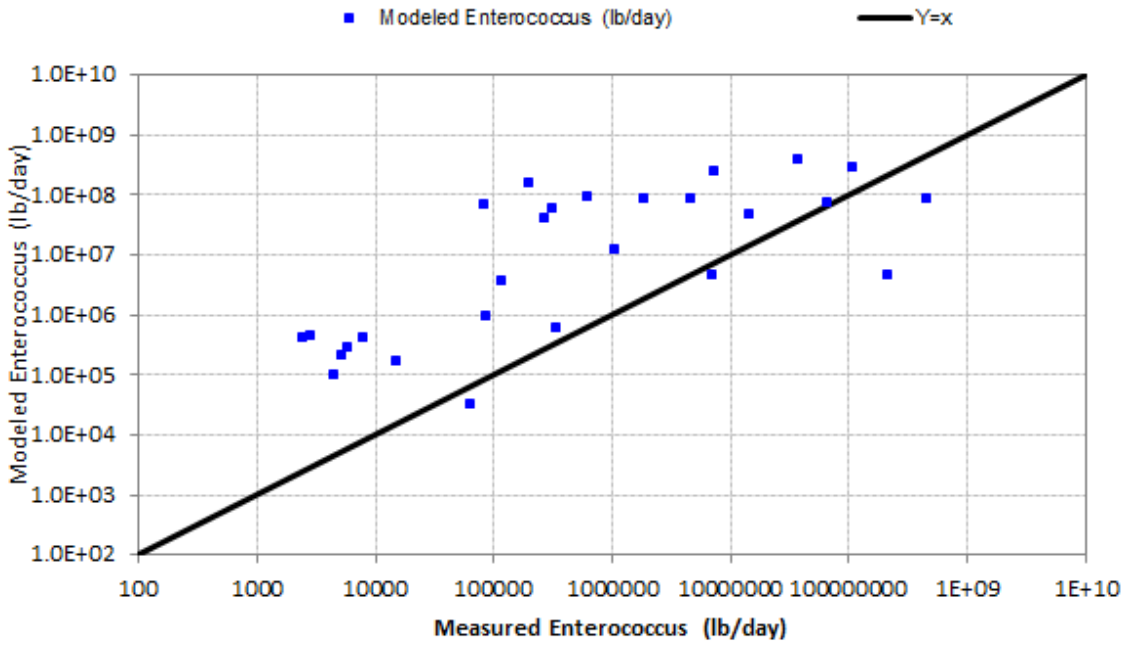

Figure K-38
Modeled vs. Observed Load Enterococcus (CFU/100mL)
at 906LPC-MLS

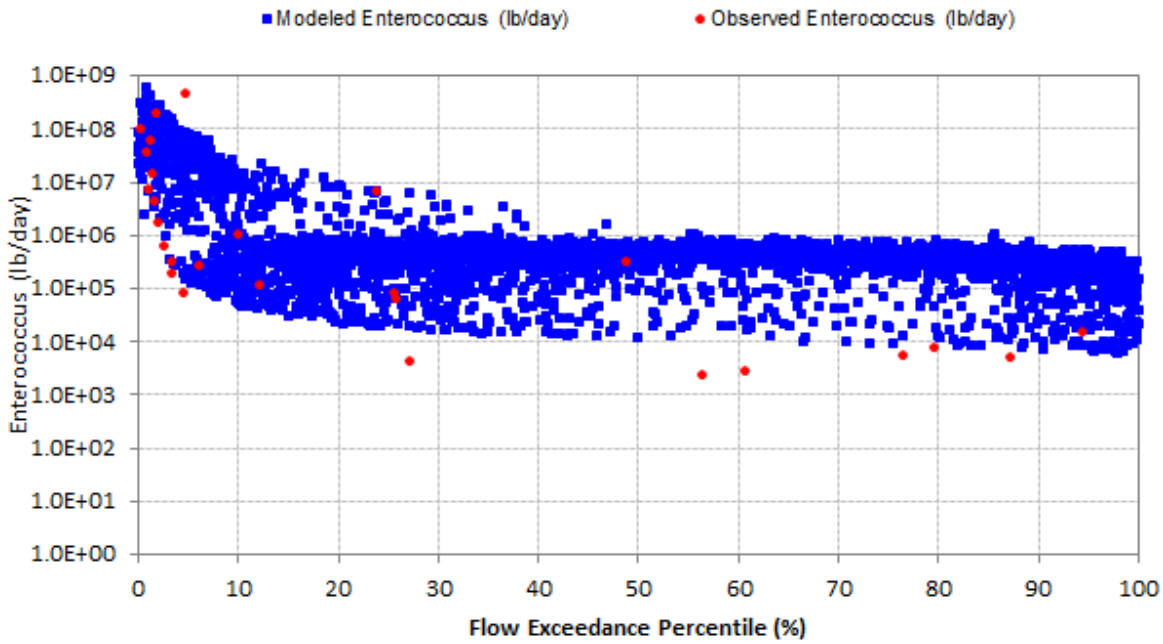

Figure K-39
Modeled vs. Observed Load Enterococcus (CFU/100mL) at 906LPC-MLS

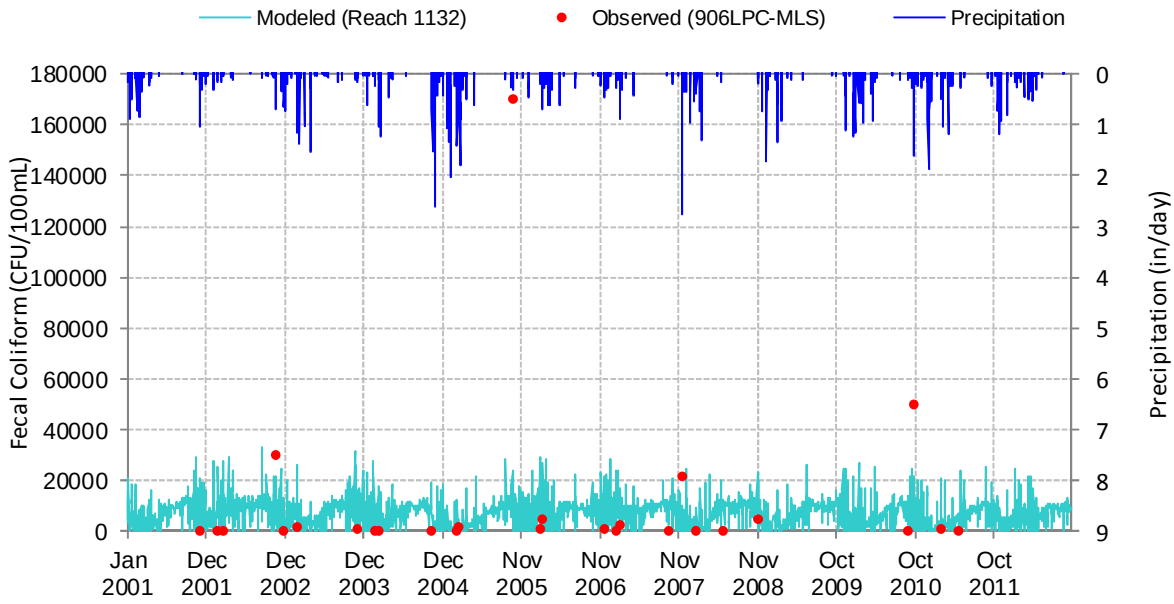

Figure K-40
Modeled vs. Observed Fecal Coliform (CFU/100mL) at 906LPC-MLS

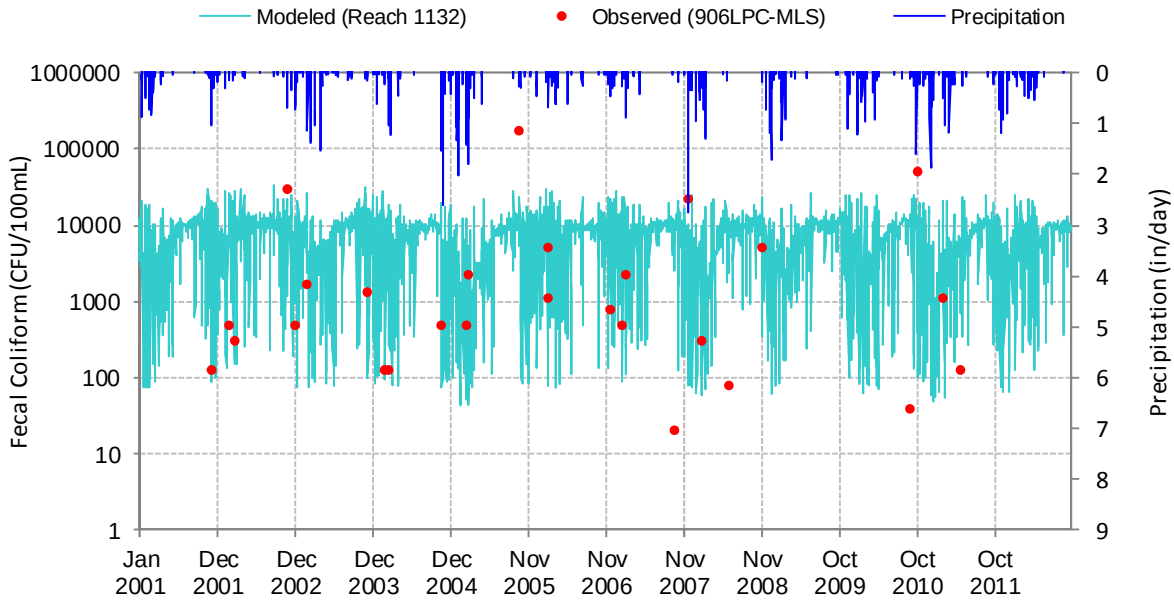

Figure K-41
Modeled vs. Observed Fecal Coliform (CFU/100mL)
at 906LPC-MLS (log scale)

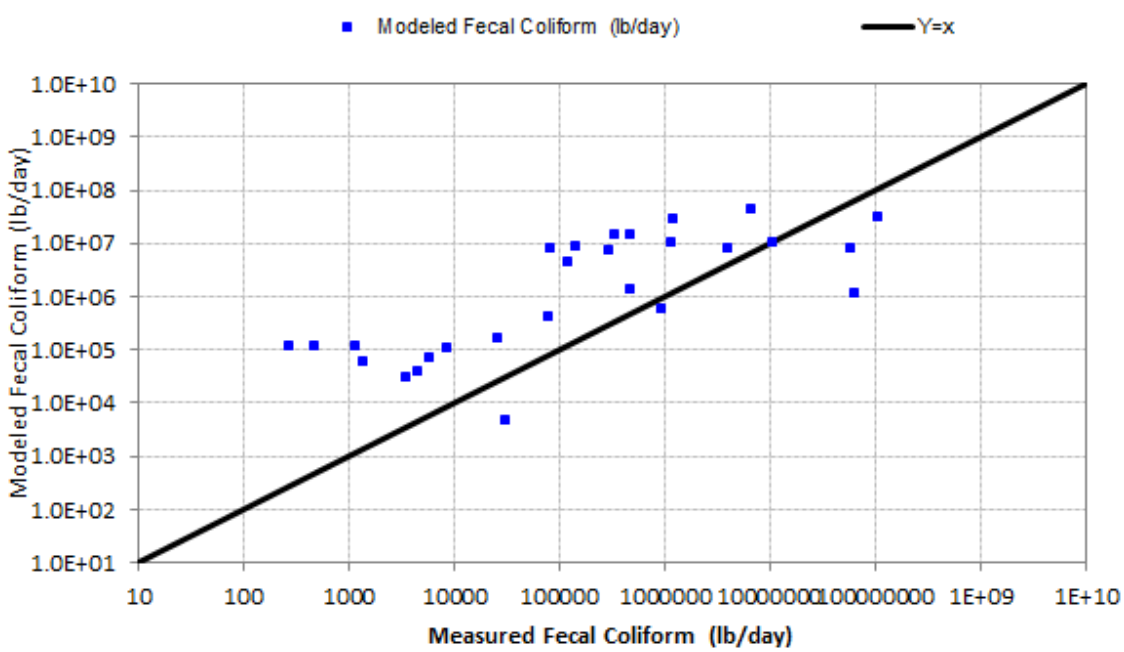

Figure K-42
Modeled vs. Observed Load Fecal Coliform (CFU/100mL)
at 906LPC-MLS

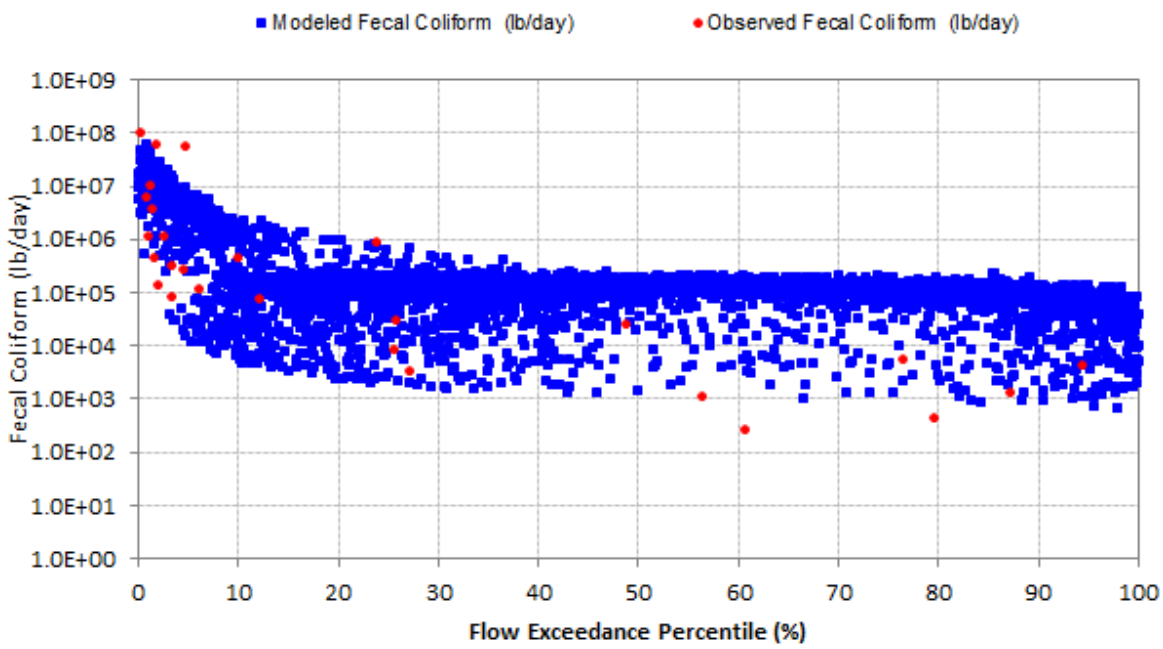

Figure K-43
Modeled vs. Observed Load Fecal Coliform (CFU/100mL) at 906LPC-MLS

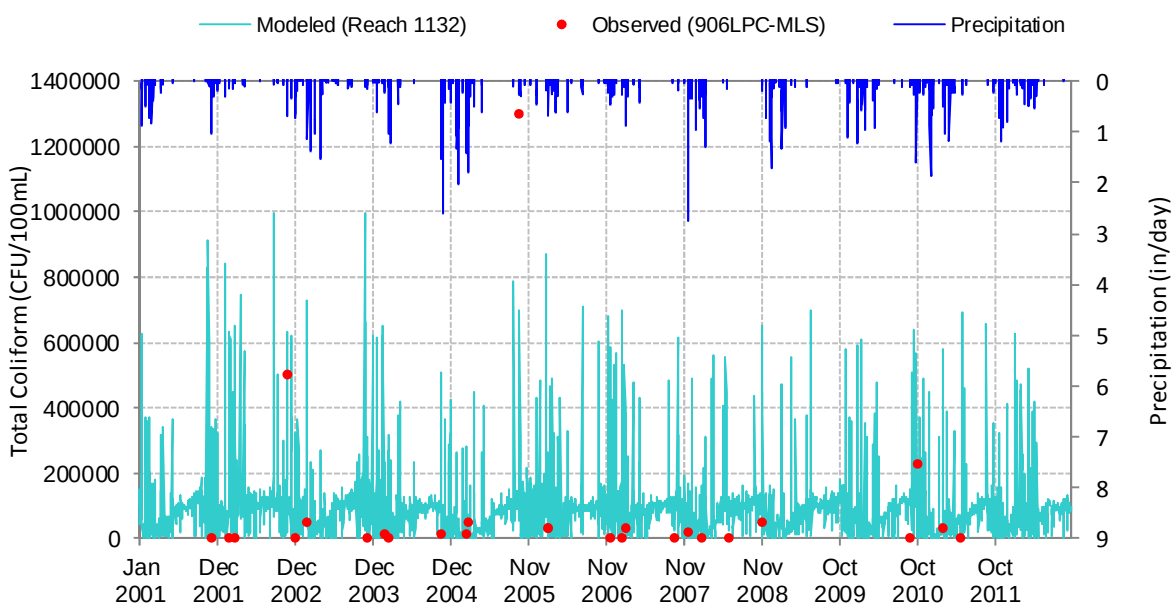

Figure K-44
Modeled vs. Observed Total Coliform (CFU/100mL) at 906LPC-MLS

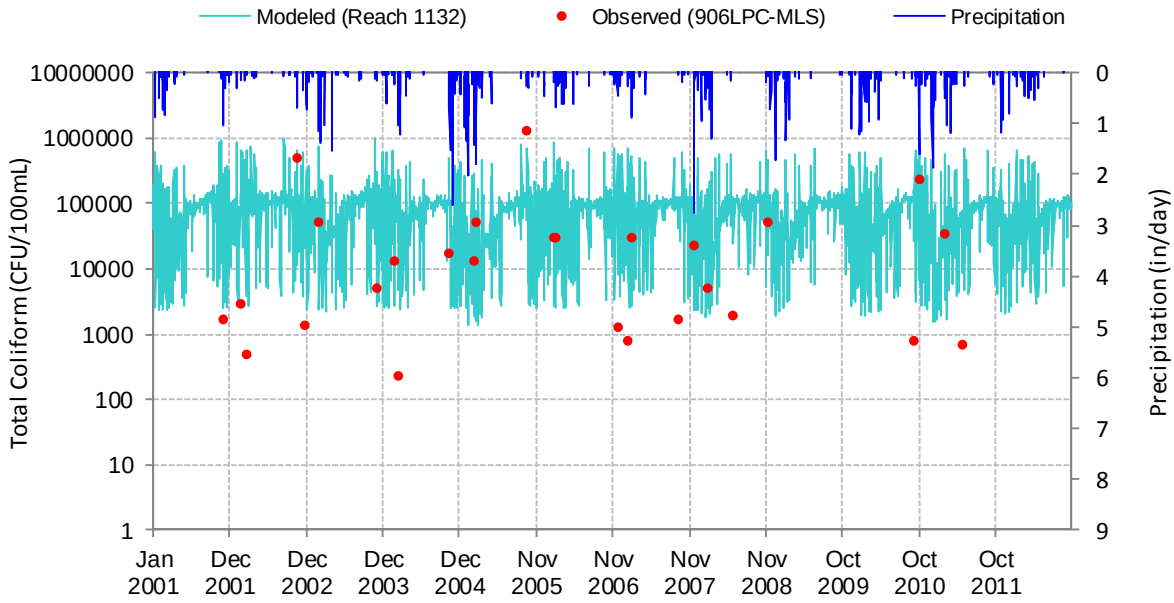

Figure K-45
Modeled vs. Observed Total Coliform (CFU/100mL)
at 906LPC-MLS (log scale)

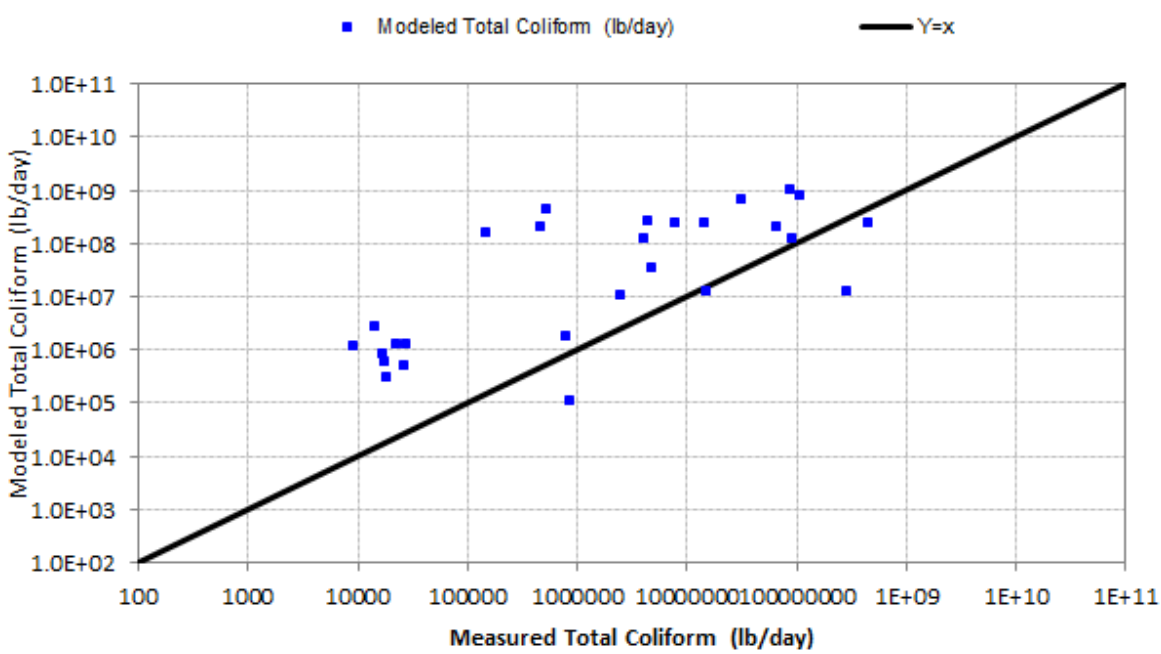

Figure K-46
Modeled vs. Observed Load Total Coliform (CFU/100mL)
at 906LPC-MLS

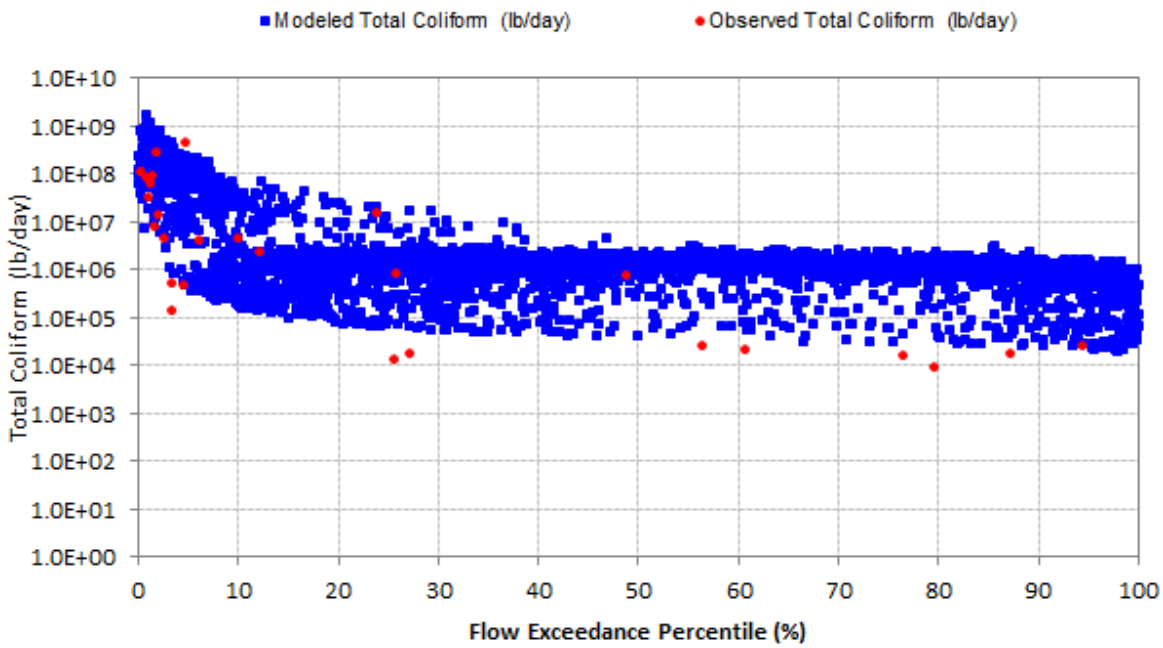

Figure K-47
Modeled vs. Observed Load Total Coliform (CFU/100mL)
at 906LPC-MLS

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APPENDIX L

Strategy Benefits and References

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APPENDIX L. STRATEGY BENEFITS AND REFERENCES

The following references provide supporting documentation for the water chemistry, physical, and biological benefits associated with strategy categories presented in the strategy benefit tables in Section 4.2.

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APPENDIX M

Comprehensive Benefits Analysis of Water Quality Improvement Plan Strategies

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Appendix M
Comprehensive Benefits Analysis of Water Quality Improvement Plan Strategies

Final Technical Memorandum

November 2014

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Summary

The City of San Diego Storm Water Division ("Division") is developing Water Quality Improvement Plans (WQIPs) that consist of a range of structural and nonstructural strategies for meeting TMDL regulatory requirements in each watershed. However, the Division recognizes that these strategies differ with respect to their contribution to "additional" or "other" benefits to the local community, environment, and economy that are beyond specific water quality improvements in streams. This assessment has been implemented to provide the Division with supplemental information on these potential benefits. The Division aims to consider these other benefits in selecting strategies only in cases when strategies yield the same level of water quality improvements but which may produce markedly different levels of other benefits.

This document outlines a framework for assessing other benefits from these strategies. The framework assesses how each type of strategy could impact one or more types of other benefits. These additional benefits consist of various types of changes beyond water quality improvements in terms of environmental resources, quality of life, property values, business development, and others.

In the WQIPs, individual strategies are grouped into a series of categories that are defined as either 'Nonstructural' or 'Structural.' Over 20 categories of strategies have been defined based on their similarity in how they can improve water quality and include *Development Planning*, *Construction Management*, *Existing Development*, *Illicit Discharge*, *Detection, and Elimination (IDDE) Program*, *Public Education and Participation*, and *Enforcement Response Plan*.

The framework for assessing the potential for additional benefits from strategies has several dimensions including::

- *Strategy Categories* are defined by how they influence water quality improvements (see Section 2). There are three Structural and four Nonstructural types of strategy categories including.
  - *Structural Strategies*, as defined in the WQIP include: (a) Green infrastructure, (b) multi-use treatment areas, or (c) water quality improvement BMPs
  - *Nonstructural Strategies,* as defined in this assessment based on how these strategies aim to: (a) Improve Structural Systems Performance, (b) Increase the Number of Structural Systems, (c) Change Behavior; or (d) Reduce Pollutants Directly.
- *Benefit Categories* include a range of economic, social and environmental outcomes. This assessment determines the relevance and impact of each strategy category on a benefit category (see Section 3).

- *Impact Levels* of a strategy category in a benefit category is classified as either (a) monetizable, (b) measurable, (c) potential, or (d) not applicable. (See Section 3). These impact levels are indented to provide *order of magnitude* information about the potential impact of a strategy on each type of benefit.

- A scoring system is established for the magnitude of benefits evaluation to compare different strategies (see Section 3). In addition, the total number of applicable benefits is provided for additional information about the relative advantage of different strategies.

A discussion and rationale for assessing the level of impact for a given strategy on a benefit category is provided in Section 4. This assessment is intended to be an initial, order of magnitude of benefits of different strategies. It can only be an illustrative assessment since details on the design and location of any individual strategy is not available at this stage. The framework however is intended to indicate how and to what degree benefits could be estimated once a strategy is in place. As an order of magnitude assessment, strategies with measurable and monetizable would be expected to exhibit successively higher levels of estimable benefits compared to strategies that are classified as only having a potential connection to benefits.

The results, as presented in Section 5, indicate that structural strategies (especially, Green Infrastructure and Multiuse Treatment Areas) have the highest potential to generate sizable benefits. However, a number of nonstructural strategies (e.g. Initiatives to Change Behavior for Existing Development, Priority Development Projects, Construction Management, Public Education and Enforcement, among others) could also provide additional benefits. Many other non-structural strategies have the potential to generate a wide range of different benefits for the community.

A cross-cutting theme in this assessment is the impact of strategies on property values and business development. Some strategies, such as ones that foster on-site water retention and reduction of street debris, have the potential to provide tangible and intangible benefit to communities and local businesses by reducing water and clean-up costs and providing an overall improved aesthetic environment. Depending on where and how a strategy is implemented, benefits can be higher or lower. The literature review in Appendix 1 discusses cases where these benefits have measured.

A next step for this assessment would entail site-specific evaluations of strategies and potential additional benefits of WQIP at a planning level. As strategies become more defined and specific data becomes available on project conditions, this framework could be adapted further to create more detailed results for prioritizing strategies. This step would include applying current research to site specific projects to more direct monetize and quantify the outcomes of strategies in terms of cost savings and property value enhancements. Better still would be a pre- and post-monitoring program to assess the singular and combined effects of strategies to different stakeholders.

Table of Contents

Page

Summary ..... M-i
1 Introduction M-1
2 Strategy Classifications M-2
3 Benefit Categories and Levels of Impact M-5
3.1 Description of Benefit Categories M-5
3.2 Characterization of the Benefit Level from a Strategy M-8
3.3 Scoring System M-9
4 Framework for Assessment of Strategies M-10
4.1 Jurisdictional Strategies M-11
4.1.1 All Development Projects (Ref 1) M-11
4.1.2 Priority Development Projects (PDPs) (Ref 2) M-12
4.1.3 Construction Management (Ref 3) M-13
4.1.4 Commercial, Industrial, Municipal, and Residential Facilities and Areas – Improve Structural Systems Performance (Ref 4) M-13
4.1.5 Commercial, Industrial, Municipal, and Residential Facilities and Areas – Initiatives to Change Behavior (Ref 5) M-14
4.1.6 MS4 Infrastructure (Ref 6) M-14
4.1.7 Roads, Street, and Parking Lots (Ref 7) M-15
4.1.8 Pesticide, Herbicides, and Fertilizer BMP Program (Ref 8) M-15
4.1.9 Retrofit and Rehabilitation in Areas of Existing Development – Improve Structural Systems Performance (Ref 9) M-16
4.1.10 Retrofit and Rehabilitation in Areas of Existing Development – Increase the Number of Structural Systems (Ref 10) M-16
4.1.11 Illicit Discharge, Detection, and Elimination (IDDE) Program (Ref 11) M-16
4.1.12 Public Education and Participation: Initiatives to Change Behavior (Ref 12) M-17
4.1.13 Public Education and Participation: Initiatives to Reduce Pollutants Directly (Ref 13) M-17
4.1.14 Enforcement Response Plan: Initiatives to Change Behavior (Ref 14) M-18
4.1.15 Enforcement Response Plan: Initiatives to Reduce Pollutants Directly (Ref 15) M-18
4.1.16 Enforcement Response Plan - Improve Structural Systems Performance (Ref 16) M-19
4.1.17 Additional Nonstructural Strategies- Reduce Pollutants Directly (Ref 17) M-19

Table of Contents (continued)

Page

4.1.18 Additional Nonstructural Strategies - Improve Structural Systems Performance (Ref 18) M-19
4.1.19 Green Infrastructure (Ref 19) M-20
4.1.20 Green Infrastructure: Green Streets (Ref 20) M-21
4.1.21 Multiuse Treatment Areas: Infiltration and Detention Basins (Ref 21) M-21
4.1.22 Multiuse Treatment Areas: Stream, Channel and Habitat Rehabilitation Projects (Ref 22) M-22
4.1.23 Water Quality Improvement BMPs: Proprietary BMPs (Ref 23) M-22
4.2 Optional Jurisdictional Strategies M-22
4.2.1 Additional Nonstructural Strategies (Ref 24) M-23
4.2.2 Green Infrastructure – Optional Jurisdictional Strategies (Ref 25) M-24
4.2.3 Green Infrastructure: Green Streets – Optional Jurisdictional Strategies (Ref 26) M-24
4.2.4 Multiuse Treatment Areas: Infiltration and Detention Basins – Optional Jurisdictional Strategies (Ref 27) M-24
4.2.5 Multiuse Treatment Areas: Stream, Channel, and Habitat Rehabilitation Projects – Optional Jurisdictional Strategies (Ref 28) M-24
4.2.6 Multiuse Treatment Areas: Other Opportunities – Optional Jurisdictional Strategies (Ref 29) M-25
4.2.7 Water Quality Improvement BMPs: Trash Segregation – Optional Jurisdictional Strategies (Ref 30) M-25
5 Results of Assessment M-26
Appendix 1: Sustainable Return on Investment Assessment of Water Quality Improvement Strategies. Draft Report. June 2014 ..... M-43

Table of Contents (continued)

Page

List of Tables

Table 1. Overview of Benefit Scoring M-9
Table 2: Overview of Jurisdictional Strategies in Descending Order M-27
Table 3: Overview of Optional Jurisdictional Strategies by Descending Order M-30
Table 4: Key to Symbols M-31
Table 5: Key to Strategy Outcome M-31
Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies M-32
Table 7: Overview of Potential Other Benefits of Water Quality Improvement Plan – Optional Jurisdictional Strategies M-40

Acronyms and Abbreviations

Acronym or Abbreviation	Definition
ac	Acres
BCA	Benefit Cost Analysis
BES	Bureau Of Environmental Services
BMP	Best Management Practice
Btu	British Thermal Unit
CAMX	California-Mexico Power Area
CEA	Cost-Effectiveness Analysis
CLRP	Comprehensive Load Reduction Plan
CNT	Center For Neighborhood Technology
CO2	Carbon Dioxide
CSO	Combined Sewer Overflow
DOT	Department Of Transportation
EIA	Economic Impact Analysis
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GI	Green Infrastructure
HOA	Home Owner's Association
IDDE	Illicit Discharge, Detection, And Elimination
kWh	Kilowatt Hour
LACDPW	Los Angeles County Department Of Public Works
LID	Low Impact Development
M Wh	Mega Watt Hour
MMSD	Milwaukee Metropolitan Sewage District
MODA	Multi-Objective Decision Analysis
MS4	Municipal Separate Storm Sewer System
NOx	Nitric Oxide And Nitrogen Dioxide
NPV	Net Present Value
NRDC	Natural Resources Defense Council
O&M	Operations And Maintenance
O3	Oxide
PDP	Priority Development Projects
PFC	Permeable Friction Course
PGA	Pollutant Generating Activities

Acronyms and Abbreviations (continued)

Acronym or Abbreviation	Definition
PM	Particulate Matter
PWD	Philadelphia Water District
QMRA	Quantitative Microbial Risk Assessment
SO2	Sulfur Dioxide
SPU	Seattle Public Utilities
SROI	Sustainable Return On Investment
TBL	Triple Bottom Line
TIGER	Transportation Investment Generating Economic Recovery
TMDL	Total Maximum Daily Load
UTC	Urban Tree Canopy
WAMP	Watershed Asset Management Plan
WERF	Water Environment Research Foundation
WQIP	Water Quality Improvement Plan

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1 Introduction

The City of San Diego Storm Water Division (Division) has prepared many potential strategies as part of its Water Quality Improvement Plan (WQIP). These strategies have identified a range of structural best management practices (BMPs) (e.g., a constructed runoff reduction system, such as a bio-swale), and nonstructural BMP activities (e.g., programs that promote installation of constructed systems, or reduce pollutants directly through education and outreach). This memo seeks to assess the potential for strategies to generate "additional" or "other" benefits beyond water quality improvements. The Division seeks such information to contribute to prioritization of strategies that meets regulatory requirements and generates the best value for the community and local businesses.

The concept for evaluating the other benefits of proposed strategies has been under discussion since April 2014. A technical memo was developed as an initial task to classify additional benefits from the Division's stormwater management strategies. That memo is contained in Appendix 1 and includes a literature review of potential benefit categories and case studies of green infrastructure program benefits. The economic framework was presented to stakeholders at a meeting on May 20, 2014. Feedback was elicited during and after that meeting, and has been incorporated into this document and to the Division's current approach to evaluating strategies (see presentation, handout, and comments from workshop in Appendix 2).

The next several sections in this document present the approach and draft evaluation of additional benefits. The evaluation has been applied to a comprehensive list of strategies from the City's three draft WQIPs (Mission Bay, Los Peñasquitos, and San Dieguito). The framework entails the characterization of strategy categories by type of impact (Section 2), definition of potential types of benefit categories (Section 3) and a classification of benefits for each strategy category (Section 4). Results of this evaluation are contained in Section 5.

This assessment of additional benefits of WQIP strategies is conducted for initial planning purposes only. As strategies become more defined and specific data becomes available on project conditions, this framework could be adapted further to create more detailed results for prioritizing strategies. This step would include applying current research to site specific projects to more directly monetize and quantify the outcomes of strategies areas such as recreational, property value and business development benefits.

2 Strategy Classifications

The WQIP identifies a number of strategy categories as either "Nonstructural" or "Structural", and in terms of whether they are Jurisdictional Strategies or Optional Jurisdictional Strategies. Optional strategies are those strategies that may be triggered in the future to achieve the interim and final numeric goals." In the analysis of benefits, the main distinction is between Nonstructural or Structural types which are defined in the following ways.

Nonstructural Strategies include "those actions and activities intended to reduce storm water pollution, which do not involve construction of a physical component or structure to filter and treat storm water." Individual strategies are grouped into over 25 different categories including: *Development Planning*, *Construction Management*, *Existing Development*, *Illicit Discharge, Detection, and Elimination (IDDE) Program*, *Public Education and Participation*, *Enforcement Response Plan*, and *Non-JRMP Strategies*. For each watershed, a list of potential nonstructural strategies has been developed that reflect the needs, opportunities and constraints in different locations. In general, many of these initiatives have been implemented by the Division for many years and are integral to regulatory compliance on a watershed-specific basis.

Nonstructural strategy categories are further defined in this assessment by *how* they improve water quality, which in turn indicates how they may generate other benefits. For example, four types of mechanisms include the ways in which strategies:

- ***Improve Structural Systems Performance:*** These include strategies that relate to new design standards and performance monitoring would be measured by the improvement in the performance of installed structural systems. The benefits of these nonstructural strategies would ultimately draw from the benefits of structural systems that are implemented.
- ***Increase the Number of Structural Systems*:** These strategies aim to increase the rate of BMP adoption is due to training in the community or general promotion of BMPs, lead to benefits whenever they are installed. The outcome of these strategies then depends on the number of *additional* systems that are installed.
- ***Change Behavior*:** These strategies target efforts to encourage improved environmental stewardship and storm water protection by residents and businesses throughout the community. Various types of actions that people may take who become more aware of environmental impacts through these strategies include adoption of rain barrels, reducing litter, and reducing unnecessary levels of pesticides, herbicides and fertilizers.

- ***Reduce Pollutants Directly:*** These strategies include those that aim to directly control pollution through actions that the Division and other public agencies can take independently, such as internal training, enforcement and administrative changes. These strategies can lead to behavior change by individuals but initially through a focus on public entities.

Structural Strategies, in contrast to Nonstructural strategies, are physical infrastructure that are designed for site-specific conditions and placed strategically across a watershed to improve water quality. The effectiveness and feasibility of implementing any of these BMPs varies depending on their design and site conditions. For example, the effectiveness of a BMP for enhanced infiltration capacity of a watershed depends on amenable soil types. Other site-specific considerations include the physical land area available for effective implementation and maintenance. Also, the capital and maintenance costs of a BMP influence its feasibility for the Division, especially in comparison to other BMPs which can be implemented more cost-effectively. The structural strategies that have been identified as potentially suitable for San Diego watersheds and have been classified as one of three types: (1) green infrastructure, (2) multiuse treatment areas, and (3) water quality improvement BMPs.

- ***Green Infrastructure*** covers a range of BMPs that are designed to be integrated in a broader site plan to maintain healthy waters, provide multiple environmental benefits, and support sustainable communities. Green infrastructure is distinguished from other methods by making deliberate and effective use of vegetation and soil to manage storm water.

- ***Multiuse Treatment Areas*** in the Water Quality Improvement Plan are identified as large-scale treatment areas such as multiuse basins and stream, channel, and habitat rehabilitation projects. These systems are designed as regional facilities that can receive flows from neighborhoods or larger areas and become cost-effective solutions that provide multiple benefits. For example, such systems can be integrated in public spaces, such as soccer fields and parks, which provide recreational areas and flood control, ground water recharge, restoration, habitat enhancement, and recreation. In addition stream bank projects that reduce erosion can improve water quality and simultaneously improve habitat.

- ***Water Quality Improvement BMPS*** include systems that supplement the design performance of existing infrastructure. For example, systems that segregate trash includes inlet devices, such as trash guards or racks that capture debris before they enter surface waters. Another example are proprietary commercial products that often aim to use settling, filtration, absorptive/adsorptive materials, vortex separation, and sometimes vegetative components to remove pollutants from runoff. Finally, dry weather flow separation and treatment projects target non-storm water dry season flows and divert these flows for treatment either on-site or to sanitary sewer systems and ultimately wastewater treatment plants.

Overall, 30 different groups of strategies have been classified as either “Jurisdictional” (strategy types numbered 1-23, in Table 2 and Table 6 or “Optional Jurisdictional” (strategies types numbered 24-30, in Table 3 and Table 7). Optional strategies are those strategies that may be triggered in the future to achieve the interim and final numeric goals." The number ordering for these strategies follows from documents provided by the Division and reflects the most comprehensive list of current strategies under consideration. Specific strategies have also been identified by the Division within each strategy group.

3 Benefit Categories and Levels of Impact

Stormwater management strategies can generate various types of benefits and have different levels of impact. Economic research has shown that stormwater management strategies can generate a range of benefit categories with economic, environmental and social impacts for the local residents, businesses, and public agencies. The level of impact of a strategy can differ across benefit categories and depends on the design of the strategy, site conditions where the strategy is implemented, and characteristics in the community. Estimation of economic benefits from a strategy depends on the degree to which linkages can be quantified between strategy and a benefit category and then available economic literature to value this change. In some cases, only a part of the link between a strategy and a benefit category can be quantified (e.g. the volume of water retained by a green infrastructure system can be measured, but not its impact on stream bank stabilization).

3.1 Description of Benefit Categories

This section below discusses a number of benefit categories that are found in economic literature. They are grouped by financial, environmental and social dimensions. A broader discussion from the literature is contained in the Appendix 1.

Financial Benefits

- ***Water Cost Savings:*** This type of benefit could occur when potable water needed for landscaping, washing or other property maintenance is reduced. Green infrastructure strategies could enable such savings if water retention reduces water demand, or some part of the system improves irrigation efficiency. The reduction in demand lowers water costs. These savings could be quantified and monetized if the volumes of water retained at a site can be measured.

- ***Energy Cost Savings:*** Green infrastructure can generate energy cost savings in several ways. For example, buildings which are adjacent to trees or which install green roofs can benefit from lower the heating and cooling energy costs because of shading and insulation, respectively. Some research suggests that if such green infrastructure system were installed throughout a city, the overall ambient temperature would decline and which would in turn reduce cooling loads for other buildings. Finally, in cases when green infrastructure provides water storage that lowers pumping costs, there would be a corresponding reduction in energy costs.

Environmental Benefits

- ***Flood Risk Reduction:*** Reduced runoff in an urban watershed can reduce the frequency and severity of flooding in downstream neighborhoods in some cases. The magnitude of these benefits though depends on if such a neighborhood is downstream and on the design and scale of a strategy that reduces flooding. Other factors include rainfall conditions, soil characteristics, slope, elevation and watershed characteristics. A first step in quantifying the potential for flood risk reduction benefits requires an understanding how much water is retained.

- ***Air Particulate Entrapment:*** Some green infrastructure systems can trap airborne pollutants, such as particulate matter (e.g. PM10), directly from the environment on their leaves and in turn reduce adverse human health impacts.[1] The total amount of particulate trapping depends on the type of vegetation, and local climate conditions. For trees, the US Forest Service published a report that provides benchmark values for use in calculations.[2] This type of benefit can be quantified and potentially monetized based on the amount and type of plants.
- ***Climate Impacts:*** Carbon sequestration is a natural process in which plants store carbon in biomass and soils as they grow. When atmospheric carbon dioxide is taken up by trees, grasses, and other plants, it can reduce greenhouse gas effects on the planet. The amount of carbon that can be sequestered by a green infrastructure system depends on the above ground quantity of biomass of the tree, green roof or bio-swale. Economic valuation of climate change effects can be used to monetize carbon sequestration.
- ***Habitat Related Benefits:*** Green infrastructure that can provide habitat benefits include strategies that create new habitat areas, or improve existing ones. For example, vegetated infiltration systems can improve the habitat for flora and fauna, birds, and insect species. These different types of habitats are usually small in size and have limited impacts. Greater benefits may arise from large-scale strategies that enhance habitat connectivity in existing corridors. This type of benefit is readily quantified based on the acreage and plantings at a green infrastructure site, or stream bank stabilization effects, but more difficult to monetize because of limitations in economic research.
- ***Air Quality Emission Reduction:*** The total amount of reduction in criteria air contaminant emissions, such as particulate matter, from a power plant is directly tied to the reduction in energy use as discussed above. Energy savings are readily converted to its emission rate reductions by utilizing data from EPA and other public sources. Reduction in air pollution would generate health-related benefits for people. This benefit can be quantified and monetized if information is available on the amount of water and energy reduced at a treatment facility.
- ***GHG Emission Reduction:*** Similar to air quality emission reductions, energy demand reduction also reduces greenhouse gas emissions. The tons of greenhouse gas emissions are computed from the same data sources as criteria air contaminants. The economic damage caused by greenhouse gas emissions are broadly related to changes in productivity and damage costs.

[1] Center for Neighborhood Technology, The Value of Green Infrastructure. 2010

[2] http://www.fs.fed.us/psw/programs/uesd/uep/products.shtml

Social / Community Benefits

- ***Property Value Enhancement:*** Green infrastructure and other strategies can lead to enhanced property values under a variety of circumstances. For example, strategies that improve the overall visual appearance of a community simply by having planted material, street trees and bioswales among impervious surfaces have been shown to enhance value of nearby properties. In addition, some BMPs strategies aim to directly reduce litter or debris from public spaces to make it more visually appealing. These effects improve the overall quality of life in those neighborhoods. Benefits can be quantified by measuring the number of properties that are adjacent to the green infrastructure. Monetization of the effect would depend on the applicability of economic research on a site specific basis.

- ***Recreational Benefits:*** Certain green infrastructure strategies provide recreational benefits if they facilitate pedestrian, bicycle use, or connect to an existing recreational corridor or trails. Benefits would be monetized by the number of participants in a recreational activity at a site and their value per use. Other quantitative measures include the number and type of design features that offer recreational options.

- ***Business Development & Jobs:*** Green infrastructure, such as comprehensive green street designs, and initiatives to reduce street debris can lead to an enhanced sense of place, and increase in foot traffic that can support retail activity. Additionally, spending on capital investments and operations and maintenance (O&M) leads to job creation. This benefit can be measured by assessing the number of jobs created in an area where a green infrastructure strategy is implemented. In addition, these jobs can be associated with wider economic development benefits.

- ***Crime Reduction:*** Research suggests that fewer crimes occur near buildings with trees and non-invasive vegetation. Maintained areas of vegetation encourage informal social gatherings outdoors. Incidence of crime declines when with the presence of people and possibly by psychological precursors to crime.

- ***Public Education/ Environmental Stewardship:*** Promoting strategies that seek to change people's behaviors and make them more aware of their environmental impacts helps to cultivate a *stewardship perspective* in the community about its local natural resources. Quantification of this type of benefit may be measured in terms of how many people are reached with messages of programs aimed to enhance knowledge and ultimately actions towards to improve stormwater management.

- ***Heat Island Effect:*** Trees and other vegetation can reduce ambient temperatures in cities that have higher air temperatures. Lower temperatures can reduce health effects especially in populations that are at risk of heat stroke. Additionally, the overall lowering of temperatures can reduce cooling needs at properties located within the area. This type of benefit is only quantifiable in cases where the strategy is applied over a large scale.

- ***Noise Reduction:*** Some green infrastructure systems, such as wetlands or trees, are effective in reducing ambient noise because they can absorb it. This is also true for porous concrete and green roofs, but there is limited research in quantifying these benefits.

3.2 Characterization of the Benefit Level from a Strategy

The potential magnitude of benefits differs across strategy types. To account for these differences, four 'levels' are defined that represent a decreasing association between the impact of a strategy and a benefit category. These levels include:

Monetizable – The level of benefits indicates impacts that can be quantified and where economic research has been produced to determine a monetary value.

Measurable – There exists a connection for some measure of non-monetary impact can be identified and measured, even if economic research is not available to monetize the impacts.

Potential - A conceivable connection exists between a strategy and benefit category but it is not likely to be measurable.

Not Applicable - There is no discernible connection between a strategy and benefit category.

At this stage in program implementation and project design, the impact of each strategy on a benefit category can only be considered to be an order of magnitude assessment. An estimation of the actual impact would be highly uncertain since most strategies currently lack site-specific data about the design and implementation. Instead, these levels of impact are intended to provide separable categories that indicate the order of magnitude of benefits that a strategy may be able to generate. That is, it is only possible to assess the likelihood that a project can generate monetizable benefits, not the actual size of monetizable benefits.

At the same time, these four categories are intended to provide a broad degree of separation between strategies in terms of their measurable connection with each benefit category. For instance, if a strategy can be classified as having monetizable benefits, then its overall level of measurable benefits can be reasonably assumed to be higher than another strategy that is classified as being quantifiable, even if only in part. By the same rationale, these classifications would likely have more direct impact for a benefit category than a strategy whose impact can only be presumed

This assessment aims to achieve consistency in evaluations within a specific strategy outcome group, as well as across strategy outcome groups. While some strategies have design or location specifications (e.g., total acres of bioretention), or target certain groups (developers vs. residential), others entail broad descriptions. Due to this uncertainty, the evaluation has taken a conservative approach to drawing conclusions about the magnitude of benefits that could arise from a strategy.

3.3 Scoring System

A scoring system is established to support comparisons of strategies with respect to the potential benefits they can generate (see Table 1). Each benefit level is assigned a point value that has been established through discussions with the Division. The values are intended to provide an indication of the strategy's impact across all benefit categories. In this case, potentially monetizable benefits are assigned a higher score than one that is only quantifiable (and not monetizable). This approach is intended to separate the types of benefits that are likely to be larger in magnitude from others that cannot be monetized nor quantified.

Table 1. Overview of Benefit Scoring

Level	Description	Point Value
Monetizable	Strategy can realize quantifiable impacts, and sufficient economic evidence supports placing a dollar value on these impacts.	1
Measurable	Strategy can realize quantifiable impacts, but lacks sufficient economic evidence to support placing a dollar value on these impacts.	0.667
Potential	Strategy most likely provides a positive impact, but the magnitude of the impact is uncertain.	0.333
Not Applicable	Strategy will not impact the benefit category in any meaningful way.	0

This scoring system places higher weight on strategies which may generate benefits that can be monetized (3 times the weight of a potential benefit level). Accordingly, in some cases a strategy that influences many additional benefit categories at a "*Potential"* level could score lower than one with fewer categories but with "*Monetizable"* impacts. This scoring system is designed for that type of result to give greater emphasis on strategy impacts that can be measured and are thus more tangible. Potential impacts are circumstantial and small, as compared to more significant impacts that can be measured and monetized. Furthermore, the implications of this scoring system have been taken into account in a consistent approach in determining which impacts of strategy are classified as monetizable, measureable or potential.

This scoring system is applied to the strategies in Table 2 through Table 7. This scoring system is only relevant for comparing strategies with respect to additional benefits, not in ways that influence a ranking towards meeting permit requirements and/or encourages other program objectives such as habitat restoration.

In addition, the total number of applicable benefit categories is also shown in Table 2 through Table 7 for additional reference on the impact of these strategies.

4 Framework for Assessment of Strategies

Determination of the applicability of benefits for each strategy depends primarily on the assignment of a strategy to one of the structural or nonstructural categories (defined in Section 2). Consistency in the applicability of a benefit category (defined in Section 3) for a strategy is maintained by jointly evaluating all strategies of a specific type. This section discusses the framework for assessing potential additional benefits that can arise from the implementation of each strategy. The aim of this exercise is to apply a consistent and transparent rationale for each strategy. Since available evidence is limited with respect to each strategy, the application of a consistent set of assumptions to each strategy underlies the basis for determining (a) which benefit categories are applicable, and (b) the potential magnitude of benefits, if a category is applicable.

The approach to assigning a magnitude level began with an assessment of the strategy for which the most information is available about its potential impact: Green Infrastructure (Ref 19). This type of strategy is used as a benchmark for assigning benefit categories and potential magnitudes of benefits due to the availability of evidence from projects implemented elsewhere in the U.S. To illustrate this approach for Green Infrastructure (Ref 19), consider the rationale below:

- In some cases, sufficient information available about the specific strategies specifies the area of bioretention and permeable pavement to be installed and the location of the project. Due to the size of these initiatives, and knowing that the vegetation can improve air quality through the uptake of criteria pollutants and improve the climate through carbon sequestration, it is assumed that the total pollutant and CO2 removal from the atmosphere can be quantified. These quantified amounts of pollutant and CO2 can then be monetized using standard practices that are currently being used to value these impacts.
- Additionally, it is assumed that these projects will provide aesthetic improvements to the existing site, which can be quantified with information regarding the number of properties within a certain radius and the property value changes.
- These sites will also need to be maintained, which will require spending on jobs, and depending on the specific site location, the improved aesthetics can also improve businesses located near the site.
- The total land area of the bioretention and permeable pavement will allow for quantifying the amount of rain water which gets absorbed onsite, and does not cause localized flooding, where applicable.
- The remaining other benefit categories are assumed to see positive impacts. For example, GHG emission reductions may occur from the lifecycle CO2 emissions for permeable pavement being lower than the lifecycle CO2 emissions of asphalt or pavement. However, there is not enough information at this time to accurately quantify that impact.

- Similarly, permeable pavement absorbs less heat than conventional pavement, which is a benefit for Urban Heat Island reduction. The amount of heat, and how that will affect public health cannot be quantified.

The potential impacts of all other strategies have been evaluated relative to the benchmark as established by the above assumptions for green infrastructure. As an example, the first group of strategies evaluated below, All Development Projects (Ref 1). focuses on improving existing systems performance. It is assumed that specific actions, such as administrative training or increased monitoring, will have positive impacts for the same benefit categories as a green infrastructure project. But since there is no way to quantify any of those impacts, the magnitude of benefits is assumed to be lower.

The remainder of this section discusses the assessment of Jurisdictional and Optional Jurisdictional Strategies. Note that these strategies represent the latest consideration in an evolving process of identification, specification and assessment. Not all strategies have been implemented or have plans for immediate implementation. At the same time, the specification of the design standards also varies from strategy to strategy. This assessment takes into account the *potential* benefits that may occur, given the information available, and assumptions that are listed in each strategy.

4.1 Jurisdictional Strategies

This section discusses the rationale and methodology for assigning scoring categories to the Jurisdictional Strategies, based on the most recent description of the strategy. This list of individual strategies has been grouped according to the same categories that are proposed for the draft WQIPs and are presented in the same chronological order. The information found in the parenthesis next to the strategy group name (*Ref X*), refers to the number in the far left columns of Table 2 and Table 6. Note that in some cases (e.g., Commercial, Industrial, Municipal, and Residential Facilities and Areas) the strategies are separated into two types (i.e., Improve Structural Systems Performance and Initiatives to Change Behavior) based on the specific ways in which a strategy creates benefits.

4.1.1 All Development Projects (Ref 1)

Strategies in this group consist of administrative and other tasks that center on improving the structural system's performance. Many of these types of strategies focus on broad initiatives such as training or source control. The list of strategies includes the following:

- Administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.
- Investigation and research of emerging technology.
- Train staff on LID regulatory changes and LID practices.

- Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities. Ensure consistency with the City of San Diego's BMP Design Manual.
- Develop and implement Green Infrastructure Program and Guidelines.
- Develop Design Standards for Public LID BMPs.
- Create Right-of-Way Design Manual.

In scoring these strategies, it is assumed that the programs that target the administration or enforcement of BMPs would mostly affect the same benefit categories as a Green Infrastructure (GI) project which increases the acres of bioretention, but on a smaller scale. It is assumed that these projects would generate a positive impact but due to the uncertainty of the implementation and magnitude of the effect of these strategies, it cannot be measured.

Some of the broad initiatives are deemed to have too much uncertainty to reasonably assign a specific benefit level. It is however reasonable to assume that overall public awareness and knowledge of the issue will increase.

4.1.2 Priority Development Projects (PDPs) (Ref 2)

Similar to the strategies in the All Development Projects section, PDP initiatives are assumed to increase the number of structural systems and improve existing structural systems. These strategies include the following:

- For PDPs, administer a program requiring implementation of on-site structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs.
- Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs.
    - Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.
    - Amend BMP Design Manual for animal-related facilities, such as such as animal shelters, "doggie day care" facilities, veterinary clinics, breeding, boarding and training facilities, groomers, and pet care stores.
    - Amend BMP Design Manual for nurseries and garden centers.
    - Amend BMP Design Manual for auto-related uses.
- Administer a program to inspect and enforce updated BMPs in BMP Design Manual

- Develop and administer an alternative compliance program to on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects).

Scoring the impact of programs that target the administration or enforcement of BMPs would mostly affect the same benefit categories as a green infrastructure project which increases the acres of bioretention, but on a smaller scale. Initiatives that focus on updating various components of the design manual are assumed to increase the efficiency of the already existing systems. However, the total magnitude of this improvement cannot be estimated without additional information, and thus other benefits for this group cannot be measured.

4.1.3 Construction Management (Ref 3)

There is one specific strategy under this group, and it is assumed it will improve structural system performance. Construction Management strategy is:

- Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.

The scoring for this strategy is assumed to be the same as previously discussed strategies that improve the performance of existing systems.

4.1.4 Commercial, Industrial, Municipal, and Residential Facilities and Areas – Improve Structural Systems Performance (Ref 4)

The specific initiatives under this strategy group focus on improving structural systems performance. These strategies differ from the strategies in the next group, which also are included under Commercial, Industrial, Municipal, and Residential Facilities and Areas in the Water Quality Improvement Plan, but target a different outcome. Administering programs which require minimum BMPs are assumed to affect the same benefit categories as a GI project which increases the acres of bioretention, but a smaller scale. These strategies include:

- Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspection of existing development at appropriate frequencies and using appropriate methods.
    - Update minimum BMPs for existing residential, commercial, and industrial development. Specific updates to BMPs include require sweeping, catch basin cleaning and maintenance of private roads and parking lots in targeted areas.
    - Power-washing minimum BMPs: Outreach to property managers and trash haulers to elevate the emphasis of washing as a pollutant source. Emphasize non-compliant washing as an enforceable violation.

- Implement property based inspections.
- Review policies and procedures to ensure discharges from swimming pools meet permit requirements.

Strategies that target pollutants directly, such as the power-washing minimum BMPs, can be assumed to reduce the amount of pollutants entering the environment. However, while these strategies protect habitats and improving aesthetics, the total amount of pollutants reduced cannot be measured until more information is known regarding the current level of pollutant discharges, and how many people are targeted as part of this initiative. These initiatives are assumed to require some level of public outreach or promotion, and public awareness of these issues will be raised.

4.1.5 Commercial, Industrial, Municipal, and Residential Facilities and Areas – Initiatives to Change Behavior (Ref 5)

While also focusing on Commercial, Industrial, Municipal, and Residential Areas, these strategies seek to initiate changes in behavior. This list includes:

- Implement pet waste program
- Consider installing trash bins, pet waste bag dispensers and pickup services on Rose Creek Bicycle Path and Rose Canyon Bicycle Path.
- Promote and encourage implementation of designated BMPs for residential and non-residential areas.
- Residential BMP: Rain Barrel.
- Residential and Commercial BMP: Grass Replacement.
- Residential and Commercial BMP: Downspout Disconnect.
- Residential and Commercial BMP: Microirrigation.
- Onsite Water Conservation Survey.

These types of initiatives can also lead to measurable impacts. Specifically, initiatives which encourage water conservation allow for quantification if a simple number of variables are known, such as the number of Rain Barrels, and average annual rainfall.

4.1.6 MS4 Infrastructure (Ref 6)

The specific strategy initiatives for MS4 Infrastructure focus on improving the structural systems performance. The list of MS4 Infrastructure Strategies includes:

- Implementation of operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.) for water quality improvement and for flood control risk management.
    - Optimize catch basin cleaning to maximize pollutant removal (4 times per year for metals and sediment TMDLs, elsewhere 1 per year).

  - Increased frequency of catch basin inspection and as-needed cleaning (Settlement Agreement).
  - Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.
- Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.
- Identify sewer leaks and areas for sewer pipe replacement prioritization.

Since these projects specifically focus on sub-surface activities, it is assumed that other benefits associated with changes above ground are not affected. Due to the specificity of these initiatives, it is reasonable to assume they will have a positive impact on local flood risk reduction, which in turn could potentially affect habitat related benefits, and possibly aesthetics.

4.1.7 Roads, Street, and Parking Lots (Ref 7)

These strategies specifically target street litter or debris will create aesthetic improvements. These strategies include:

- Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.
- Outreach to street sweeping enhancement-targeted areas.
- Enhance street sweeping through equipment replacement (replace every 4 years) and route optimization (sweep all areas twice a month).
- Initiate sweeping of medians on high-volume arterial roadways.
- Implement additional street sweeping near commercial routes adjacent to maintained MS4 channels..

The impact of these strategies can be quantified by estimating the volume of litter and street pollutants removed. Also, depending on the local land-use for the streets targeted, it is conceivable that a cleaner environment can lead to business development and investment. Jobs then would be supported by the money spent on operation and maintenance activities.

4.1.8 Pesticide, Herbicides, and Fertilizer BMP Program (Ref 8)

This category includes a broad initiative to reduce pollutant loads. The strategy entails:

- Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.

While there is too much uncertainty at this time to be able to assign specific measurable benefits, this reduction in pollutants entering the environment will benefit habitats, and aesthetics. It is assumed that overall public awareness and knowledge of the issue will increase.

4.1.9 Retrofit and Rehabilitation in Areas of Existing Development – Improve Structural Systems Performance (Ref 9)

The goal of this strategy is to improve existing systems, specifically:

- Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.

As this strategy focuses on retrofitting, is assumed to follow the same methodology for scoring other projects which increase the number of structural systems.

4.1.10 Retrofit and Rehabilitation in Areas of Existing Development – Increase the Number of Structural Systems (Ref 10)

This strategy was separated from the previous as it focuses on rehabbing existing ecological areas.

- Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.

Specific improvements in streams and other systems will improve habitats and aesthetics and can be measured using the area of each project.

4.1.11 Illicit Discharge, Detection, and Elimination (IDDE) Program (Ref 11)

This program is assumed to change behavior, specifically, reduce pollutants entering the environment through illegal discharges and disposal. The strategy is defined as:

- Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMP. Requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.

While broad strategies cannot be measured, it is assumed that the targeting of pollutants will improve the environment and benefit habitats and aesthetics. It is also assumed that overall public awareness and knowledge of the issue will increase.

4.1.12 Public Education and Participation: Initiatives to Change Behavior (Ref 12)

Strategies under Public Education and Participation are grouped under two categories, those which seek to change behavior, and are targeted at the community at large, and those which seek to reduce pollutants directly, by targeting business and industries. The strategies in this grouping target changing behavior, and are listed below:

- Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.
- Expand outreach to homeowners' association (HOA) common lands and HOA incentives.
- Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.
- Enhance and expand trash cleanups through community-based organizations involving target audiences.
- Improve consistency and content of websites to highlight enforceable conditions and reporting methods.
- Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.
- Enhance school and recreation-based education and outreach.
- Develop education and outreach to reduce over-irrigation.
- Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.

4.1.13 Public Education and Participation: Initiatives to Reduce Pollutants Directly (Ref 13)

These strategies differ from the previous group, it that they aim to reduce pollutants directly by targeting business and industries. This list includes:

- Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.
- Develop regional training for water-using mobile businesses.
- Promote and encourage implementation of designated BMPs in commercial and industrial areas.
- Outreach to impacted industry regarding minimum BMP requirement updates. Affects commercial, industrial, residential development.

While the total effect of the strategies cannot be determined at this time, it is assumed that the targeting of pollutants will improve the environment and benefit habitats and aesthetics.

The strategies which target commercial areas are assumed to effect more benefit categories, consistent benefit category scoring for other strategies which require minimum BMPs.

4.1.14 Enforcement Response Plan: Initiatives to Change Behavior (Ref 14)

The Enforcement Response Plan strategies can be categorized by 3 separate desired outcomes, and have been grouped separately. These strategies are focused at changing behavior.

It can be assumed that irrigation cost savings will occur as one strategy specifically targets over-irrigation. Where irrigation cost savings occur, there can potentially be emission savings. This is due to the reduced energy needed to provide the water, which in turn reduces the emissions generated from energy production. More information would be needed about these projects to determine the extent to which irrigation cost savings are realized.

List of Enforcement Response Plan Strategies to Change Behavior:

- Continue to implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.
- Increase enforcement of over-irrigation.

4.1.15 Enforcement Response Plan: Initiatives to Reduce Pollutants Directly (Ref 15)

This strategy differs from the previous, in that its outcome creates initiatives to reduce pollutants directly.

List of Enforcement Response Plan Strategies to Reduce Pollutants Directly:

- Increase enforcement associated with property-based inspections.
- Increase enforcement of sweeping and maintenance of private roads and parking lots in targeted areas.
- Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.
- Increase enforcement of water-using mobile businesses.

4.1.16 Enforcement Response Plan - Improve Structural Systems Performance (Ref 16)

This strategy in the Enforcement Response Plan is assumed to improve structural systems performance through minimum BMP enforcement, which is different from the targeted outcome of the other strategies:

- Increase enforcement of minimum BMPs for existing residential, commercial, and industrial development, including power washing.

As this strategy targets commercial and industrial areas, consistent benefit category scoring for other strategies which require minimum BMPs is used.

4.1.17 Additional Nonstructural Strategies- Reduce Pollutants Directly (Ref 17)

The remaining Nonstructural strategies related to pollutant reduction are grouped together, and separated from the additional strategies which improve structural systems performance. They are assumed to see habitat related benefits, but due to the broad nature and lack of specific details, that is the only benefit category affected. Additional outreach is assumed to provide Public Education benefits.

List of Additional Nonstructural Strategies which Reduce Pollutants Directly:

- Address and clean up pollutants from homeless encampments through Homeless Outreach Team
- Continue participating in source reduction initiatives
- Coordinate with other City of San Diego Departments to replace City-owned vehicle brake pads with copper-free brake pads as they become commercially available
- Pesticide Use Reduction
- Zinc Reduction Program
- San Dieguito Source Identification and Prioritization Process

4.1.18 Additional Nonstructural Strategies - Improve Structural Systems Performance (Ref 18)

These strategies differ from those which seek to reduce pollutants directly, as these target outcomes to improve structural systems and have specific tasks such as ‘actively monitor erosion’ are expected to positively impact habitat and flooding benefits. All the strategies which are research studies are assumed to provide public education benefits.

List of Additional Nonstructural Strategies which Improve Structural Systems Performance:

- Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property
- Using adaptive management, delist the beach segment from the TMDL and Attachment E of the MS4 Permit
- Los Peñasquitos Watershed Special Study
- Reference watershed study
- Reference beach study
- Tecolote Creek Quantitative Microbial Risk Assessment (QMRA)
- Implement ASBS Compliance Plan
- Collaborate with City of San Diego PUD and other watershed stakeholders in the Lake Hodges Water Quality Concentration Study. Study will characterize conditions and identify sources.
- Develop and implement targeted roof replacement incentive program for Chollas

4.1.19 Green Infrastructure (Ref 19)

These strategies produce a large amount of quantifiable benefits due to the research that exists demonstrating the effectiveness of green infrastructure. This means that in most cases, at a minimum, the benefits can be measured. In certain cases, they can be monetized when enough information is available. As the specific strategies vary by watershed, a high level summary is provided.

Several BMPs involve increasing the total area (acres) of bioretention and permeable pavement on public parcels. Other strategies focus on specific target sites such as parks on green lots.

Strategies with specific design features (such as size of bioretention, etc.) allow for the ability to calculate the amount of storm water runoff retained, which can be used in to quantify Flood Risk Reduction, where applicable.

Less information is known about how these systems will fully operate, so it is possible that there could be irrigation cost savings, but such benefits cannot be accurately quantified without additional information. Where instances of irrigation cost savings could occur, some level of emission savings could also occur because of reduced energy use for delivering water.

Changes in biomass at a site (due to green streets plantings, or bioretention) can have quantifiable impacts on air quality and climate. The quantified amount depends on the specific properties of the new vegetation. Assuming that changes in biomass can be quantified, it is possible to suggest that noise reduction is a potential benefit, and local

aesthetics would be improved. Local aesthetics would be quantified by the area of improved land.

An increase in biomass could reduce ambient temperatures, but the scale would be localized and small overall. Thus, we scored this other benefit category as 'potential.''

In instances where aesthetics are realized, business development can be quantified if enough information is available about the local characteristics of a green Infrastructure site (i.e., the proximity of the site to existing retail businesses).

Projects which provide pedestrian or bike access such as a green street or open space are assumed to provide quantifiable recreational benefits, such as additional miles of walkable or livable streets. The amount of these benefits will depend on data on size of the local population, the area of the site, and site usage.

4.1.20 Green Infrastructure: Green Streets (Ref 20)

Due to the information available regarding bioretention and the size of implementation, it can be assumed green streets will have the same scoring as the green infrastructure projects. As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve increasing the total area (acres) of green streets on specific avenues or subwatersheds.

4.1.21 Multiuse Treatment Areas: Infiltration and Detention Basins (Ref 21)

This section describes the process for scoring the structural strategies consisting of infiltration and detention basins.

It is assumed that the strategies for both golf courses involve similar wetland system projects, which are assumed to increase total biomass and provide entrainment and sequestration. If the total biomass change can be quantified, air and climate benefits can be measured and monetized.

While underground systems will be able to provide flood risk reduction, which in turn protects local habitats and ecological systems, any benefit categories that depend on changes in the above ground environment (such as habitat benefits) will not be affected, and are indicated as 'Not Applicable.' Projects that occur on public land, such as schools, provide the opportunity for educating the public or students about the strategy, and can be quantified by the number of people who learn about the strategy. These benefits depend on the number of students enrolled at the school, or the population of a neighboring community where public outreach about the project occurs.

Where instances of irrigation cost savings are thought to occur, emission savings could occur, but more information would be needed about these projects to determine the extent to which irrigation cost savings are realized.

As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve the installation of a subsurface detention galley on public parcels. Other options include dry detention systems, sediment basins, infiltration basins, and hyrdomodification BMPs.

4.1.22 Multiuse Treatment Areas: Stream, Channel and Habitat Rehabilitation Projects (Ref 22)

As these strategies target streams and other ecological areas, it is assumed habitats and aesthetics will improve, and can be measured using the area of the project. This strategy is assumed to be similar to the MS4 and Retrofit and Rehabilitation in Areas of Existing Development strategies.

As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve either wetlands or the Chollas Creek.

4.1.23 Water Quality Improvement BMPs: Proprietary BMPs (Ref 23)

Due to the nature of these projects, a basic assumption is the projects will improve water flow, and flood control and habitat benefits can occur. However, no other benefit categories can reasonably be expected to be impacted until more specific details about the sites and projects are known.

As the specific strategies vary by watershed, a high level summary is provided. Several BMPs involve drainage inserts on public parcels. Others involve hydrodynamic separation systems, dry-weather, or low flow diversions. Some are broader in nature, and provide direction on implementing a certain amount of acres of multiuse treatment area projects on private parcels and/or through public-private partnerships with various total storage sizes.

4.2 Optional Jurisdictional Strategies

This section provides a discussion of the methodology for assigning scoring categories to the Optional Jurisdictional Strategies, as well as sub-categories. Optional strategies are those strategies that may be triggered in the future to achieve the interim and final numeric goals." Many of these strategies are assumed to have a similar outcome and thus a similar other benefit category scoring as their Jurisdictional counterpart. The scores take into account the *potential* benefits that may occur, given the information available, and assumptions that are listed in each strategy. The scoring for these strategies is presented in Section 5, in Table 3 and Table 7. These strategies represent the latest consideration in an evolving process of identification, specification and assessment. Not all strategies have been implemented or have plans for immediate implementation. At the same time, the specification of the design standards also varies from strategy to strategy.

This list of individual strategies has been grouped according to the same categories that are contained in the Water Quality Improvement Plan and are presented in the same chronological order. The information found in the parenthesis next to the strategy group name (*Ref X*), refers to the number in the far left columns of Table 3 and Table 7.

4.2.1 Additional Nonstructural Strategies (Ref 24)

Many of these strategies are studies, which until they are completed, and the recommendations are implemented, cannot produce any benefits other than public education at the moment. Additionally, initiatives that involve participating or collaborating with other agencies or organizations are not applicable to other benefit categories at this time. The removal of invasive plants should protect existing habitats.

Additonal Nonstructural Strategies include:

Project	Location
Conduct Sustainable Return on Investment (SROI) analysis to estimate strategies' co-benefits and impacts to the public and the private sector on a common scale.	City-wide
Collaborate with the County, if a County-led regional social services effort is established, to provide sanitation and trash management for person experiencing homelessness and determine if the program is suitable and appropriate for jurisdictional needs to meet goals.	City-wide
Identify strategy resources and funding to support mapping and assessment of agricultural operations.	SDG above Lake Hodges
Coordinate with County of San Diego and identify resources and funding to implement a program to target on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.	SDG
Participate in an assessment to determine if implementation of an urban tree canopy (UTC) program would benefit water quality and other City goals.	City-wide
Conduct a feasibility study to test Permeable Friction Course (PFC), porous asphalt that overlays impermeable asphalt.	City-wide
As opportunities arise and funding sources are identified, protect areas that are functioning naturally by avoiding impervious development and degradation on unpaved open space areas, creating permanent open space protections on undeveloped city-owned land, and accepting privately-owned undeveloped open areas.	City-wide MB-Rose Canyon
Add permanent open spaces protections to underdeveloped city-owned land in and on the rim of Rose canyon and San Clemente Canyon.	MB, Rose Canyon
Forming a linear "park" from the southern end of Marian Bear Natural Park to the mouth of Rose Creek.	MB, Rose Canyon
Lake Hodges Natural Treatment System Project	SDG: Lake Hodges

Project	Location
If a regional collaboration is established for the Los Peñasquitos Lagoon, participate in restorative efforts in collaboration with TMDL Responsible Parties and TMDL responsible parties and other stakeholders.	Los Peñasquitos Lagoon Subwatershed
Participate in a watershed council or group and support the establishment of a watershed coordinator if one is established.	City-wide
Participate in a watershed council or group and support the establishment of a watershed coordinator if one is established. Includes participation in Rose Creek Watershed Team.	MB, Rose Canyon
Removal of invasive plants.	MB, Rose Canyon

4.2.2 Green Infrastructure – Optional Jurisdictional Strategies (Ref 25)

These strategies follow the same scoring as Jurisdictional Green Infrastructure projects. Under certain circumstances, these Green Infrastructure Strategies could be implemented.

4.2.3 Green Infrastructure: Green Streets – Optional Jurisdictional Strategies (Ref 26)

This strategy follows the same scoring as Jurisdictional Green Streets projects. Green Streets Strategies could be implemented if:

- If interim load reduction goals are not met and additional green infrastructure is required, the additional acreage of bioretention and permeable pavement can be implemented through green streets if potential opportunities for green infrastructure implementation on public parcels are not available.

4.2.4 Multiuse Treatment Areas: Infiltration and Detention Basins – Optional Jurisdictional Strategies (Ref 27)

These strategies follow the same scoring as Jurisdictional Multiuse Treatment Areas: Infiltration and Detention Basins projects.

4.2.5 Multiuse Treatment Areas: Stream, Channel, and Habitat Rehabilitation Projects – Optional Jurisdictional Strategies (Ref 28)

These strategies follow the same scoring as Jurisdictional Multiuse Treatment Areas: Stream, Channel, and Habitat Rehabilitation projects. List of Stream, Channel, and Habitat Rehabilitation Project includes:

- If interim load reduction goals are not met and additional stream, channel, and habitat rehabilitation projects are required, implement as needed.

- Day lighting Cudahy Creek implementation.
- An example of this would be to lengthen the Genesee Avenue Bridge in Rose Canyon in order to eliminate the berm that bisects the riparian corridor. This would restore the natural riparian corridor and promote wildlife and recreational passage under Genesee.

4.2.6 Multiuse Treatment Areas: Other Opportunities – Optional Jurisdictional Strategies (Ref 29)

This strategy follows the same scoring as Jurisdictional Multiuse Treatment Areas: Other Opportunities projects. Other Opportunity Strategy is defined as:

- If interim load reduction goals are not met and additional multiuse treatment area projects are required, implement, as needed, on private parcels and/or through public-private partnerships.

4.2.7 Water Quality Improvement BMPs: Trash Segregation – Optional Jurisdictional Strategies (Ref 30)

These projects specifically target street litter or debris, and are assumed to create an aesthetic improvement, and can be quantified with estimates on the volume of litter removed. Depending on the local land-use for the streets targeted, business development could potentially increase. Jobs can also be supported by the money spent on operation and maintenance activities. Trash Segregation Strategies would be implemented under conditions defined as:

- If interim load reduction goals are not met and additional trash segregation projects are required, implement as needed.
- If interim load reduction goals are not met and additional proprietary projects are required, implement as needed.
- If interim load reduction goals are not met and additional dry weather flow separation and treatment projects are required, implement as needed.

5 Results of Assessment

An overview of all the strategies, with the number of benefits, by benefit level, shown in descending order is presented in Table 2 and Table 3. Additionally, the total point value across the other benefit categories is presented in the far right column, with the header 'Total Point Value.' For example, green infrastructure has the greatest benefit score for both the jurisdictional and optional jurisdictional strategies. It is located at the top of Table 2, with a 'Total Point Value' of 7.3. This is calculated by:

- Multiplying the number of monetizable benefits (2), by their benefit scoring value (1);
- Multiplying the number of measurable benefits (3), by their benefit scoring value (0.667),
- Multiplying the number of potential benefits (10), by their benefit scoring value (0.333),
- Multiplying the number of not applicable benefits (0), by their benefit scoring value (0),
- Adding the subtotals together results in a total score of (2 + 2 + 3.3 + 0 = 7.3).

A detailed summary of the potential level of impact for each strategy and benefit category is presented in Table 6 and Table 7. For convenience, the number in the far left column, with the header 'Ref,' corresponds to the number next to the strategy group descriptions in the previous sections, and is consistent across all tables. Using Green Infrastructure as an example, the number in the first column of Table 2, (19) can be found in Table 6, and corresponds to the discussion of green infrastructure in the previous section, *Green Infrastructure (Ref 19)*

Table 2: Overview of Jurisdictional Strategies in Descending Order

Ref.[1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable Benefits
19	Green Infrastructure	Structural	Green Infrastructure	2	3	10	0	7.33	15
20	Green Streets	Structural	Green Infrastructure	2	3	10	0	7.33	15
5	Commercial, Industrial, Municipal, and Residential Facilities and Areas[2]	Non-Structural	Initiatives to Change Behavior	0	5	6	4	5.33	11
21	Multiuse Treatment Areas - Infiltration and Detention Basins	Structural	Multiuse Treatment Areas	2	1	6	6	4.67	9
1	All Development Projects	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	14	1	4.67	14
2	Priority Development Projects (PDPs)	Non-Structural	Increase # Of Structural Systems	0	0	14	1	4.67	14
3	Construction Management	Non-Structural	Improve Structural Systems Performance	0	0	14	1	4.67	14
4	Commercial, Industrial, Municipal, and Residential Facilities and Areas[1]	Non-Structural	Improve Structural Systems Performance	0	0	14	1	4.67	14
9	Retrofit and Rehabilitation in Areas of Existing Development - Structures	Non-Structural	Increase # Of Structural Systems	0	0	14	1	4.67	14

Table 2: Overview of Jurisdictional Strategies in Descending Order (continued)

Ref.[1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable Benefits
13	Public Education and Participation: Reduce Pollutants Directly	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	14	1	4.67	14
15	Enforcement Response Plan: Improve Structural Systems Performance	Non-Structural	Improve Structural Systems Performance	0	0	14	1	4.67	14
22	Multiuse Treatment Areas - Stream, Channel and Habitat Rehabilitation Projects	Structural	Multiuse Treatment Areas	0	2	8	5	4.00	10
14	Enforcement Response Plan: Initiatives to Change Behavior	Non-Structural	Initiatives to Change Behavior	0	1	6	8	2.67	7
10	Retrofit and Rehabilitation in Areas of Existing Development	Non-Structural	Improve Structural Systems Performance	0	2	3	10	2.33	5
16	Enforcement Response Plan: Initiatives to Reduce Pollutants Directly	Non-Structural	Initiatives to Reduce Pollutants Directly	0	2	3	10	2.33	4
12	Public Education and Participation: Initiatives to Change Behavior	Non-Structural	Initiatives to Change Behavior	0	1	4	10	2.00	4
11	Illicit Discharge, Detection, and Elimination (IDDE) Program	Non-Structural	Initiatives to Change Behavior	0	1	3	11	1.67	4
7	Roads, Street, and Parking Lots - Cleaning Maintaining, etc	Non-Structural	Improve Structural Systems Performance	0	1	2	12	1.33	3

Table 2: Overview of Jurisdictional Strategies in Descending Order (continued)

Ref.[1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable Benefits
8	Pesticide, Herbicides, and Fertilizer BMP Program	Non-Structural	Initiatives to Reduce Pollutants Directly	0	1	2	12	1.33	3
6	MS4 Infrastructure	Non-Structural	Improve Structural Systems Performance	0	0	3	12	1.00	3
18	Additional Nonstructural Strategies: Improve Structural Systems Performance	Non-Structural	Improve Structural Systems Performance	0	0	3	12	1.00	3
17	Additional Nonstructural Strategies: Initiatives to Reduce Pollutants Directly	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	2	13	0.67	2
23	Water Quality Improvement BMPs - Proprietary BMPs	Structural	Water Quality Improvement	0	0	2	13	0.67	2

1. The reference number refers to strategy groups presented in pages 9-28.

Table 3: Overview of Optional Jurisdictional Strategies by Descending Order

Ref.[1]	Description of Strategy Group	Category	Strategy Outcome	Monetizable	Measurable	Potential	Not Applicable	Total Point Value	Number of Applicable Benefits
25	Green Infrastructure – Optional Strategies	Structural	Green Infrastructure	2	3	10	0	7.33	15
26	Green Streets – Optional Strategies	Structural	Green Infrastructure	2	3	10	0	7.33	15
27	Multiuse Treatment Areas-Infiltration and Detention Basins – Optional Strategies	Structural	Multiuse Treatment Areas	2	1	6	6	4.67	9
28	Multiuse Treatment Areas-Stream, Channel and Habitat Rehabilitation Projects – Optional Jurisdictional Strategies	Structural	Multiuse Treatment Areas	0	2	8	5	4.00	9
29	Multiuse Treatment Areas- Other Opportunities – Optional Strategies	Structural	Multiuse Treatment Areas	0	1	8	6	3.33	9
30	Water Quality Improvement BMPs-Trash Segregation – Optional Strategies	Structural	Water Quality Improvement	0	0	3	12	1.00	2
24	Additional Nonstructural Strategies – Optional Jurisdictional Strategies	Non-Structural	Initiatives to Reduce Pollutants Directly	0	0	2	13	0.67	2

1. The reference number refers to strategy groups presented in pages 9-29.

In Table 6 and Table 7, a detailed summary of the potential level of impact for each strategy and benefit category is presented. For these tables, a key to symbols and point value is presented for each level of impact in Table 4. In some cases, the strategy group includes individual strategies that are classified by different types of strategy outcomes. Table 5 shows the numerical key used in Table 6 and Table 7. To make the evaluation process more transparent, a discussion about the assumptions and rationale for the assignment of a benefit category level to a specific strategy is briefly discussed for each type of Water Quality Improvement Plan strategy following the summary tables. The reference for the discussion below for each strategy is listed in column 1 of Table 6 and Table 7. In addition to presenting point values, the total number of potentially applicable benefits is also shown.

Table 4: Key to Symbols

Symbol	Level of Impact	Point Value
●	Monetizable	1
◉	Measurable	0.67
○	Potential	0.33
⊗	Not Applicable	0

Table 5 provides a key to the number in the column with the header 'Strategy Outcome.' For example, the first strategy group listed, All Development Projects, has the number 6 in the 'Strategy Outcome' column. The number 6 in Table 5 indicates that All Development Projects are Nonstructural Strategies comprised of Initiatives to Reduce Pollutants Directly.

Table 5: Key to Strategy Outcome

ID	Category of Strategy	Type of Strategy Outcome
1	Structural	Green Infrastructure
2	Structural	Multi Use Treatment
3	Structural	Water Quality Improvement
4	Nonstructural	Improve Structural Systems Performance
5	Nonstructural	Increase the Number of Structural Systems
6	Nonstructural	Initiatives to Reduce Pollutants Directly
7	Nonstructural	Initiatives to Change Behavior

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
1	All Development Projects	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	4.7	14
2	Priority Development Projects (PDPs)	5	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	4.7	14
3	Construction Management	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	4.7	14
4	Commercial, Industrial, Municipal, and Residential Facilities and Areas	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	4.7	14

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
5	Commercial, Industrial, Municipal, and Residential Facilities and Areas	7	◉ [0.67]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	◉ [0.67]	◉ [0.67]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	○ [0.33]	5.3	11
6	MS4 Infrastructure	4	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	1.0	3
7	Roads, Street, and Parking Lots	4	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	1.3	3
8	Pesticide, Herbicides, and Fertilizer BMP Program	6	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	1.3	3

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
9	Retrofit and Rehabilitation in Areas of Existing Development - Improve Structural Systems Performance	5	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	4.7	14
10	Retrofit and Rehabilitation in Areas of Existing Development - Increase the Number of Structural Systems	4	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	◉ [0.67]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	2.3	5

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
11	Illicit Discharge, Detection, and Elimination (IDDE) Program	7	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	1.7	4
12	Public Education and Participation: Initiatives to Change Behavior	7	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	2.0	4

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
13	Public Education and Participation: Initiatives to Reduce Pollutants Directly	6	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	4.7	14
14	Enforcement Response Plan: Initiatives to Change Behavior	7	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	2.7	9
15	Enforcement Response Plan: Improve Structural Systems Performance	4	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	4.7	14

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
16	Enforcement Response Plan: Initiatives to Reduce Pollutants Directly	6	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊙ [0.67]	⊗ [0]	○ [0.33]	⊗ [0]	⊙ [0.67]	⊗ [0]	⊗ [0]	2.3	4
17	Additional Nonstructural Strategies: Initiatives to Reduce Pollutants Directly	6	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	0.7	2

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
18	Additional Nonstructural Strategies: Improve Structural Systems Performance	4	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	1.0	3
19	Green Infrastructure	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	7.3	15
20	Green Streets	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	7.3	15
21	Multiuse Treatment Areas - Infiltration and Detention Basins	2	○ [0.33]	○ [0.33]	○ [0.33]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	4.7	9

Table 6: Overview of Potential Other Benefits of Water Quality Improvement Plan Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
22	Multiuse Treatment Areas - Stream, Channel and Habitat Rehabilitation Projects	2	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	4.0	10
23	Water Quality Improvement BMPs	3	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	0.7	2

1. The reference number refers to strategy groups presented in pages 9-29.
2. Strategy Outcome as described in Table 5.

Table 7: Overview of Potential Other Benefits of Water Quality Improvement Plan – Optional Jurisdictional Strategies

			Financial		Environmental						Social								
Ref[1]	Strategy Group	Strategy Outcome[2]	Water Cost Savings	Energy Cost Savings	Flood Risk Reduction	Air Particulate Entrainment	Climate Impacts	Habitat Related Benefits	Air Quality Emission Reduction	GHG Emission Reduction	Property Value Enhancement	Recreational Benefits	Business Development & Jobs	Crime Reduction	Public Education/ Environmental Stewardship	Noise Reduction	Heat Island Effect	Total Point Value	Number of Applicable Benefits
24	Additional Nonstructural Strategies	6	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	0.7	2
25	Green Infrastructure	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	7.3	15
26	Green Streets	1	○ [0.33]	○ [0.33]	◉ [0.67]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	7.3	15
27	Multiuse Treatment Areas - Infiltration and Detention Basins	2	○ [0.33]	○ [0.33]	○ [0.33]	● [1]	● [1]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	◉ [0.67]	⊗ [0]	⊗ [0]	4.7	9

Table 7: Overview of Potential Other Benefits of Water Quality Improvement Plan – Optional Jurisdictional Strategies (continued)

			Financial		Environmental						Social								
Ref[1]	**Strategy Group**	**Strategy Outcome[2]**	**Water Cost Savings**	**Energy Cost Savings**	**Flood Risk Reduction**	**Air Particulate Entrainment**	**Climate Impacts**	**Habitat Related Benefits**	**Air Quality Emission Reduction**	**GHG Emission Reduction**	**Property Value Enhancement**	**Recreational Benefits**	**Business Development & Jobs**	**Crime Reduction**	**Public Education/ Environmental Stewardship**	**Noise Reduction**	**Heat Island Effect**	**Total Point Value**	**Number of Applicable Benefits**
28	**Multiuse Treatment Areas - Stream, Channel and Habitat Rehabilitation Projects**	2	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	◉ [0.67]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**4.0**	**9**
29	**Multiuse Treatment Areas - Other Opportunities**	2	○ [0.33]	○ [0.33]	◉ [0.67]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	**3.3**	**9**
30	**Water Quality Improvement BMPs - Trash Segregation**	3	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	○ [0.33]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	⊗ [0]	**1.0**	**2**

1. The reference number refers to strategy groups presented in pages 9-29.
2. Strategy Outcome as described in Table 5.

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Appendix 1: Sustainable Return on Investment Assessment of Water Quality Improvement Strategies. Draft Report. June 2014

Note to reader: This appendix is a re-print of the Phase 1 Draft Report from this project. Some aspects of the strategies and framework differ from what is included in the main report. The literature review in the following Phase 1 report provides a foundation for all subsequent analysis.

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SUSTAINABLE RETURN ON INVESTMENT ASSESSMENT OF WATER QUALITY IMPROVEMENT STRATEGIES

Draft Report

June 2014

Prepared for:

City of San Diego, Storm Water Division

Prepared by:

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Executive Summary

The aim of this project is to help the City of San Diego Storm Water Division account for the costs and benefits of storm water management strategies. Benefits (sometimes called “co-benefits”) include a variety of outcomes beyond improved water quality that some storm water strategies may achieve. The Division has identified a range of structural best management practices (BMPs (e.g., a constructed runoff reduction system such as a bio-swale), and nonstructural BMP activities (i.e. programs that promote installations of constructed systems, or reduce pollutants directly through education and outreach, for example). The Division now seeks to incorporate information on benefits of strategies into a prioritization approach so that as the Division selects strategies to meet its regulatory requirements, it is generating the best value for the community and local businesses.

This report summarizes the findings of a literature review on storm water management benefits and costs and a programmatic assessment of the Division’s strategies and associated benefits. The purpose of the assessment is to determine which types of benefits, beyond water quality improvements, might arise from the Division’s different storm water management strategies and to determine if and how these benefits can be quantified, and included in a decision making framework.

Our findings in this report indicate that many types of benefits can accrue to local residents, businesses, and the general public. Common types of benefits that have been evaluated in a number of cities around the U.S. include flood risk reduction, reduced energy consumption (and associated air quality emissions), and improved aesthetics. Computing benefits of BMPs has been standardized to some extent in the Center for Neighborhood Technology (CNT) report which outlines the data and calculations for a number of benefits (CNT, 2010). For the Division, a similar calculation process could be implemented and it would be consistent with efforts implemented in other cities. However, a significant level of uncertainty would arise in preparing such estimates without specific data on BMP designs and activities for each strategy as well as site specific information about where they would be implemented.

The City developed several dozen storm water management strategies ranging from types of structural BMPs to projects designed to affect public or municipal employee polluting behavior. Some of the strategies listed are assessment projects that provide information necessary to make decisions or to implement a subsequent non-structural strategy. To initiate this study, we grouped the strategies into specific categories:

- Structural
  - Green Infrastructure
  - Multiuse Treatment Areas
  - Water Quality Improvements

- Non Structural
    - Results in increases in the number of structural systems
    - Results in improved performance of existing structural systems
    - Results in changes in behavior that reduced pollutant loads
    - Results in direct removal of pollutants from watersheds

The next best evaluation strategy for the Division at present would entail a simplified assessment of the likely *existence* of quantifiable net benefits for each strategy. In this report, we have evaluated the degree to which benefits can be quantified (and potentially monetized) for each type of strategy. A net result of benefits exceeding negative attributes has been qualitatively assessed based on findings in the literature. This is not to say that the benefit would be greater than implementation costs, but that co-benefits would likely exceed negative impacts to the community of implementing the strategy.

The results of this assessment are shown in Table 1. A “Yes” in one of the table cells indicates that there would be sufficient evidence to quantifiably determine the value of a strategy, provided that information about the strategy and implementation location is better understood. In this high-level summary, it may be assumed that if a quantifiable benefit exists, they would be large enough to generate observable public value and influence decisions accordingly.

These initial findings however must be developed in more detail to provide practical use in prioritizing strategies for the Division. In particular, the feasibility of estimating benefits must assessed for each individually identified strategy (see Appendix 2), not its strategy group as shown in Table 1. With this information, the Division can establish an initial indication of specific strategies that provide the best value. This effort is planned for phase two of this project.

Table 1: Summary of Evidence for Estimating Benefits for Structural and Nonstructural Strategies

Strategy	Structural			Nonstructural			
	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives To Change Behavior	Initiatives To Reduce Pollutants Directly
Flood Control	YES	YES	YES	YES	YES	YES	
Irrigation Cost Savings	YES			YES	YES	YES	
Energy Cost Savings	YES			YES		YES	YES
Air Particulate Entrainment	YES			YES		YES	YES
Climate Impacts	YES			YES		YES	YES
Habitat Related Benefits							
Air Quality Emission Reduction	YES			YES		YES	YES
GHG Emission Reduction	YES			YES		YES	YES
Heat Island Effect	YES	YES		YES	YES	YES	
Aesthetics	YES	YES		YES	YES	YES	YES
Recreational Benefits	YES	YES		YES	YES	YES	YES
Noise Reduction							
Business Development & Jobs	YES			YES	YES	YES	YES
Crime Reduction							
Public Education/ Environmental Stewardship							

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Table of Contents

Executive Summary i
1 Introduction 1
2 Literature Review on Storm water Management Benefits 2
2.1 What are Economic Benefits and Impacts? 2
2.2 What are the Key Economic Benefits of Storm water Management? 3
2.2.1 Runoff Retention/Detention Benefits 4
2.2.2 Energy Cost Savings Benefits 5
2.2.3 Emissions Reduction Benefits 5
2.2.4 Ecosystem Service Benefits 6
2.2.5 Community Livability Benefits 8
2.3 What Evidence Of Benefits Have Been Found Elsewhere? 11
3 Summary of Water Quality Improvement Strategies 18
3.1 Program Background 18
3.2 Structural WQIP Strategies 18
3.2.1 Types of Strategies 18
3.2.2 Measuring Impacts of Structural Strategies 21
3.3 Nonstructural Strategies 22
3.3.1 Types of Strategies 22
3.3.2 Measuring Impacts of Nonstructural Strategies 23
4 Accounting for Benefits of BMP Strategies in San Diego 26
4.1 Evaluation of Benefits for BMP Strategies 26
4.1.1 Structural Strategies – Economic and Environmental Benefits 26
4.1.2 Structural Strategies – Community Livability Benefits 27
4.1.3 Nonstructural Strategies – Economic and Environmental Benefits 28
4.1.4 Nonstructural Strategies – Community Livability Benefits 29
4.2 Review of BMP Prioritization Frameworks 30
5 Summary of Key Findings 34
6 Bibliography 36
Appendix 1: Benefit Calculations 39
Flood Risk Reduction Benefits 39
Irrigation Cost Savings 40
Energy Cost Savings 41
Air Pollution Emission Reduction 42
Greenhouse Gas Emission Reduction 43
Air Particle Entrainment 44
Carbon Sequestration 46

Table of Contents (continued)

Aesthetic Improvements 47
Recreation Benefits 48
Crime Reduction Benefits 49
Business Development Benefits 50
Job Creation Benefits 51
Appendix 2: Comprehensive List of Nonstructural Strategies 52
Appendix 3: Workshop Summary 60
Workshop Presentation 60
Workshop Handout: 64
Workshop Comments Received 72

List of Figures

Figure 1: Illustration of Sample Structural BMP: Green Streets 22
Figure 2: Illustration of Nonstructural BMP: Water Harvesting 25
Figure 3: Flood Control Benefits 39
Figure 4: Irrigation Cost Savings 40
Figure 5: Energy Cost Savings 41
Figure 6: Air Pollution Emission Reduction 42
Figure 7: Greenhouse Gas Emission Reduction 43
Figure 8: Air Particle Entrainment 44
Figure 9: Carbon Sequestration 46
Figure 10: Aesthetic Improvements 47
Figure 11: Recreation Benefits 48

Table of Contents (continued)

List of Tables

Table 1: Summary of Evidence for Estimating Benefits for Structural and Nonstructural Strategies iii
Table 2: Examples of Potential Benefits from Green Infrastructure 3
Table 3: Excerpt of EPA Case Studies on Economic Evaluation of Storm water Management BMPs 12
Table 4: Benefits Evaluated in Great Lakes Study 14
Table 5: City-wide present value benefits of key CSO options: Cumulative through 2049 (2009 Dollars) 15
Table 6: Value of Benefits from 40,000 SQFT Ecoroof (2008 Dollars) 16
Table 7: Description of Alternatives for Sun Valley Watershed 17
Table 8: Values by benefit over 50 years (2002 Dollars) 17
Table 9: List of Structural BMPs – Green Infrastructure 19
Table 10: Green Infrastructure BMPs and Pollutant Reduction BMP 20
Table 11: List of Structural BMPs – Multiuse Treatment Areas 21
Table 12: Nonstructural Strategies 23
Table 13: Nonstructural Categories by Type of Impact and Identified Strategies 24
Table 14: Structural Strategies – Economic and Environmental Benefits 27
Table 15: Structural Strategies – Community Livability Benefits 28
Table 16: Nonstructural Strategies – Economic and Environmental Benefits 29
Table 17: Non Structural Strategies – Community Livability Benefits 30
Table 18: Summary of Evidence for Estimating Benefits for Structural and Nonstructural Strategies 35
Table 19: Green Infrastructure Retention Parameters 40
Table 20: Sample Criteria Pollutant Emission Factors 42
Table 21: Costs of Pollutants 42
Table 22: Pollutant Removal Factors for Green Roofs 44
Table 23: Annual Criteria Pollutant Reductions, 40 year Average 45
Table 24: Green Roof Carbon Sequestration Rates 46
Table 25: Sample Carbon Sequestration Rates for Different Trees 46
Table 26: Premiums on Property Value due to Aesthetics 47
Table 27: Increase in Retail Sales after Street Development 50

Acronyms

BCA – Benefit Cost Analysis
BES – Bureau of Environmental Services
BMP – Best Management Practice
Btu – British Thermal Unit

CAMX - California-Mexico Power Area
CEA – Cost-Effectiveness Analysis
CLRP – Comprehensive Load Reduction Plans
CNT – Center for Neighborhood Technology
CO2 – Carbon Dioxide
CSO – Combined Sewer Overflow

DOT – Department of Transportation

EIA – Economic Impact Analysis
EPA –Environmental Protection Agency

IDDE – Illicit Discharge, Detection, and Elimination

kWh – Kilowatt Hour

LACDPW – Los Angeles County Department of Public Works
LID – Low Impact Development

MMSD – Milwaukee Metropolitan Sewage District
MODA – Multi-Objective Decision Analysis
M Wh – Mega Watt Hour

NRDC – Natural Resources Defense Council
NOx - Nitric oxide and nitrogen dioxide
NPV – Net Present Value

O3 – Oxide

PFC – Permeable Friction Course
PM – Particulate Matter
PWD – Philadelphia Water District

SO2 – Sulfur Dioxide
SPU – Seattle Public Utilities
SROI – Sustainable Return on Investment

TBL – Triple Bottom Line
TIGER – Transportation Investment Generating Economic Recovery
TMDL – Total Maximum Daily Load

UTC – Urban Tree Canopy

WAMP – Watershed Asset Management Plan
WERF – Water Environment Research Foundation
WQIP – Water Quality Improvement Plan

1 Introduction

The City of San Diego Storm Water Division (Division) seeks a framework for prioritizing storm water management strategies that have been identified as part of the Water Quality Improvement Plans for each watershed. These strategies include a range of best management practices (BMPs) in structural systems (i.e., a constructed runoff reduction system, such as a bio-swale), and nonstructural activities (i.e. programs that promote installations of constructed systems, or reduce pollutants directly through education and outreach, for example). Each of the identified strategies is intended to contribute to meeting Total Maximum Daily Load (TMDL) regulatory requirements.

At the same time, each strategy can also provide *additional* benefits (sometimes called "Co-benefits") to the community. Depending on the type of strategy, such benefits can include flood risk reduction, reduced energy consumption and associated air quality emissions, improved aesthetics and habitat creation. Of course, not all BMPs generate positive benefits – property damage can occur if infiltration systems are poorly performing or additional street sweeping miles would increase air pollution costs. [3] Whatever the case, accounting for such benefits is challenging because each one is measured in different units and data is rarely available to quantify existing conditions and predicting changed conditions. Even so, estimating benefits can contribute to decision making. WERF (2014) notes that while a number of studies have shown storm water BMPs to be cost-effective and efficient at achieving water quality goals, traditional engineering costing methods fail to adequately value the multiple benefits and improved life-cycle costs that storm water BMPs provide.

The Division has contracted HDR to apply its *Sustainable Return on Investment (SROI)* process to develop a sound prioritization framework that accounts for storm water management benefits. SROI is an economics-based approach to evaluating and communicating the economic benefits and expenditure-based impacts across a *triple bottom line* – the financial, environmental and societal outcomes of a project. The process includes: (a) transparent review of evidence; (b) economic framework for evaluation; (c) workshop-based discussion of evidence; and (d) accounting for risk and uncertainty in key drivers of outcomes. SROI is a proven process, having been implemented in billions of dollars in capital projects over the last 8 years. In this project, we apply SROI to evaluate key economic benefits and use this to develop a sound framework for prioritizing strategies.

This document discusses our initial tasks in this effort. We report on findings from a literature review for substantiating the existence of such benefits, and an evaluation of strategies, to assess how different benefit categories may apply. We also discuss an initial assessment of the applicability of different types of benefits for individual BMP strategies. In addition, we report on an introductory workshop with stakeholders on the concept of storm water management benefits and frameworks to include estimated benefits in decision making. In addition, this phase will also determine the methods to account for co-benefits in qualitative, quantitative or monetized metrics.

[3] To make the discussion more concise, "Benefits" refer to both positive and negative outcomes.

2 Literature Review on Storm water Management Benefits

Conceptual frameworks and empirical evidence on economic benefits of storm water management have been developed in a number of studies. This chapter characterizes this evidence to establish a foundation for understanding the types of benefits from storm water management that are included in project evaluations in a SROI process. The findings of this literature also indicate that the estimation of benefits beyond water quality improvements is an emerging field. The potential for life cycle cost savings of green infrastructure in suitable locations has been fairly well established. Yet, it has been more difficult to establish standards for estimating the benefits from other aspects of BMPs that affect environmental and societal outcomes. Significant uncertainties remain over the degree to which a BMP can generate tangible benefits. In most cases, benefits depend largely on the design and site conditions.

2.1 What are Economic Benefits and Impacts?

Economic benefits are the fundamental measure of a project's overall worth to society.[4] Storm water management benefits,[5] whether they relate to avoided flood damage, improved air quality, or energy cost savings are evaluated in the same theoretical framework. Economic researchers assess the value for products and services from data on people's expenditures and their preferences for goods that are not sold (e.g. air quality).[6] Research can provide a basis for understanding how people value storm water benefits in terms of financial, environmental and societal benefits. Moreover, this evidence can support agency staff in developing strategies to manage environmental investments to maximize environmental benefits per dollar spent (WERF, 2014, Ecosystem Valuation, 2007).

A complementary measure of the worthiness of a project reflects the expenditures to build and maintain it. These expenditures and their connection to the broader economy are defined as *economic impacts*. The expenditures on materials, labor, land, and monitoring over the project lifecycle are implementation costs that are measureable and tangible. Economic impacts of storm water management spending are straightforward to

[4] Benefits are a somewhat esoteric theoretical economic construct of how people value a product or service. The benefit of a product or service is derived from the premise that some people gain greater *value* from the use of a product or service, especially its initial use, than the price they paid for it. For example, the first glass of water to a thirsty person would be much more highly valued and than the last one consumed, even if the price is the same for each glass. It is further assumed that they would be *willing to pay* some amount to gain that value from it, even if it is above the market price. The idea that a person's willingness to pay can be greater than a market price is a fundamental principal of the value gained by consumers.

[5] In standard economic terminology, benefits can be *positive* or *negative* depending on whether they are desirable or undesirable. A negative storm water management benefit can arise if flood control measures that entail infiltration cause damage to neighboring properties.

[6] Goods that are not sold in markets, such as the recreational value from natural areas, can be derived from the expenditures of persons who visit these areas, or the responses of people to responses to structured surveys which to determine a willingness to pay for the hypothetical avoidance of some undesirable impact to such areas.

estimate since expenditures are readily estimable and the wider economic impacts can be assessed using economic impact multipliers. Results from economic impact analysis, such as the numbers of jobs created from storm water management strategies reflect the impact on the overall economy and can be estimated at the local, regional and even national levels.

2.2 What are the Key Economic Benefits of Storm water Management?

A growing number of researchers have evaluated the economic benefits and impacts of storm water BMPs in addition to cost savings (See: EPA, 2013; WERF, 2014; and CNT, 2010). Some of the most commonly cited benefits stem from the functional ability of BMPs to reduce the risk of flood damage, costs of public infrastructure, and pollution and water treatment costs. EPA (2013) research on case studies of economic benefits of low impact development and green infrastructure revealed that a number of benefits can be characterized along the triple bottom line (Table 2).

Table 2: Examples of Potential Benefits from Green Infrastructure

Environmental benefits	Financial benefits	Societal benefits
Improved water quality	Reduced construction costs relative to grey infrastructure	Improved aesthetics
Improved air quality from trees	Reduced scale of grey infrastructure design	More urban greenways
Improved ground water recharge	–	Increase in public awareness of storm water management
Energy savings from reduced air conditioning	–	Reduced flash flooding
Reduced greenhouse gas emissions	–	Green jobs
Reduced urban heat stress	–	Increase in economic development from improved aesthetics
Reduced sewer overflow		

Source: EPA (2013)

Estimating benefits however can be challenging because of a lack of data on the physical changes and value of such changes. Data gaps can arise for either or both existing site conditions (prior to project implementation) or predicted changes in conditions (after implementation). In all cases, data must be collected at a specific site and project to develop credible benefit estimates. Where data gaps exist, analytical decisions can be made with respect to evaluating some types of benefits in qualitative terms (such as multi-objective decision analyses) or by quantifying uncertainty (using Monte Carlo simulation).

Several categories of benefits have been identified and described in published literature on storm water management benefits. This section reports on results from a literature review that focused on defining benefit categories and describing the conditions when it

can arise. More detail on values and calculation methods are discussed in the Appendix 1. To facilitate the understanding of benefits, several groups of benefit categories are defined including: runoff retention/ detention, energy cost savings, air quality improvements, ecosystem services, and community livability. The categories of benefits in each of these groups are described below.

2.2.1 Runoff Retention/Detention Benefits

Several types of green infrastructure (e.g. green roofs, bio-retention, permeable pavement, rain barrels, etc.) are designed to detain, retain and/or infiltrate rain where it falls. Corresponding reductions in storm water runoff lower the total and peak volumes in the storm water system. Benefits of runoff retention / detention include a reduction in downstream flood risk to properties, and reduced irrigation costs for property owners, that is, if the retention systems can supplement irrigation needs. Another potential benefit includes any reduction in erosion in streams and corresponding habitat impacts, but this are rarely evaluated due to data limitations. The effectiveness of green infrastructure in reducing runoff and generating benefits is determined by several factors including local precipitation characteristics, design capacity and maintenance practices over its functional lifespan.

Flood Risk Reduction: Reduced runoff can reduce the frequency and severity of flooding in neighborhoods that are particularly susceptible to it. The effectiveness of green infrastructure on flooding depends on the design capacity and rainfall conditions, scale of implementation across a watershed, soil characteristics (for systems that facilitate infiltration), and watershed characteristics.[7] In addition, if the storm sewers are connected to combined sewer systems, the reduced volume can generate operational cost savings at the wastewater treatment plant.[8] The value of flood control is estimated as a reduction in property damage if flooding occurs.

Irrigation Cost Savings: On-site water retention in rain barrels or other similar systems can supplement irrigation needs in yards and gardens. Available captured water can generate an added benefit of reducing potable demand for irrigation and associated costs for owners. Key drivers of the life cycle cost savings for these systems include local rainfall characteristics (e.g. frequency and depth), storage capacity and water rates. The extent to which these systems can generate irrigation cost savings above installation costs (maintenance costs are often low), depends on the demand for irrigation and ability to meet this demand with stored water. For property owners, supplemental irrigation directly reduces the volumes demanded from public sources and its costs. From a utility and public perspective, reductions in water volumes demanded translate into lower levels of energy consumed for water treatment, which in turn reduces air contamination and greenhouse gas emissions (these benefits are discussed in Section 2.2.3).

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[7] Kane County, IL and Lenexa, KS evaluated flood control benefits of future land development scenarios (EPA, 2013). However, because these benefits are site-specific, the results cannot be generalized to other sites.

[8] Wastewater treatment operational cost savings, in the context of combined sewer systems, include reductions in: (a) treatment costs; (b) air pollution emissions; and (c) greenhouse gas emissions (CNT, 2010).

2.2.2 Energy Cost Savings Benefits

Several aspects of green infrastructure can lower energy use and generate cost savings. For instance, green roofs and trees can change the gain or loss of energy in buildings, and in turn decrease costs for heating or cooling (NRDC, 2013).[9] These benefits are influenced by several site and design factors and accrue directly to property owners.

Energy Cost Savings: Site-specific research has shown that the shade that trees provide adjacent buildings and the additional insulation of green roofs on buildings can lower the heating and cooling energy costs in buildings. Of course, the effectiveness of these BMPs in lowering energy use depends on many factors including the BMP design, type of plant material, building characteristics, and climate conditions (CNT, 2010). In addition, for trees, the benefits would not be realized for several years until they have reached a height and width that provides noticeable shading. In another example, green roofs and other storage systems have been installed at water utilities and have provided a supplemental water source that has reduced energy and operational costs for pumping (EPA, 2013).[10] These costs savings would constitute a benefit directly for the utility, and by extension to its rate-payers.

2.2.3 Emissions Reduction Benefits

Generation of electricity is reduced when green infrastructure (e.g. green roofs or trees) reduces energy demand in buildings, or when water harvesting reduces energy demand at treatment plants. Reductions in electricity demand means that some amount of burning fossil fuels is avoided. As a result, there would be a reduction in the harmful emissions of criteria air contaminants (e.g. NOx, SOx, PM, etc.) and greenhouse gas emissions. The U.S. electrical grid enables energy to flow from a large interconnected network and makes it nearly impossible to link a specific source of generation with a particular use. Still, it is possible to generalize over the types of energy consumed in a State and to use this information to characterize how a reduction in energy consumption leads to a reduction in pollution. The benefit of emissions reduction is then estimated using established economic valuation standards.

[9] These cost savings are additive to air pollution emissions savings from avoided energy generation (EPA, 2013).

[10] The L.A. County Department of Public Works in its Sun Valley Watershed Management Plan accounted for decreased energy demand for pumping water because the harvested and infiltrated water provide supplemental supplies. (EPA, 2013)

Air Pollution Emission Reduction: The total amount of reduction in criteria air contaminant emissions from a power plant is directly tied to the reduction in energy use in a specific location. Energy savings are readily converted to its emission rate reductions by utilizing data from EPA and other public sources. The economic value of lower air pollutants is inferred from its impact on human health and lower medical costs. The reduction of each type of criteria air contaminant has a different economic benefit value per ton. Evidence of the conversion of a reduction in emissions to economic benefits relies on published economic research and from Federal regulatory rule-making, in which values are ultimately approved by the US Office of Management and Budget.[11]

Greenhouse Gas Emission Reduction: Similar to criteria air contaminants, greenhouse gas emissions from energy generation also cause economic damages. The tons of greenhouse gas emissions are computed from the same data sources as criteria air contaminants. The value of lower greenhouse gas emissions is linked to a reduction in in long-term damage to the global economy. While the Federal government provides guidelines on the value per ton of greenhouse gas emission reduction, other agencies have used different values. For example, the Portland Bureau of monetized this reduction in carbon emissions due to cooling and heat savings in buildings with Ecoroofs (EPA, 2013).

2.2.4 Ecosystem Service Benefits

Green infrastructure such as green roofs, bio-swales and trees can also provide a number of additional environmental and ecosystem services. These include entrainment of air particulates, carbon sequestration and habitat creation. Each of these benefit categories is directly related to the plant material that is installed as part of the green infrastructure system. Accrual of benefits depends on a variety of design and site conditions though research is available to quantify some of the physical performance measures of green infrastructure. Estimation of economic benefits at a new site would in most cases require new research at that site since limited information has been broadly developed.

Air Particle Entrainment: Some green infrastructure systems have the ability to uptake pollutants directly from the environment, which reduces adverse human health impacts. The criteria air contaminant pollutants that can be entrained include nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2) and particulate matter classifies as PM10.[12] Key drivers of these benefits include the amount (in square

[11] Many economic values originally come from regulatory rule-making in which an economic analysis is reviewed and ultimately accepted by the Office of Management and Budget before the rule becomes a law.

[12] The Charlotte-Mecklenburg Storm Water Services, serving an area of 526 square miles, included these entrainment benefits when analyzing their reforestation in their LID/GI approach, as it is relatively inexpensive but offers large benefits in terms of air quality and storm water management, the county has simply committed to making reforestation a priority (EPA, 2103)

footage, or number of trees) of green infrastructure, as well as the current levels of criteria pollutants, and size of the local population, especially those whose health is more vulnerable to environmental conditions. The quantified amount of pollutants entrained can be monetized using the same economic values per ton that are applied in the air pollution emission reduction calculations.

Carbon Sequestration: Carbon sequestration is the process of storing carbon in biomass and soils as atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis. The amount that can be sequestered is dependent on the above ground biomass of the tree, green roof or bio-swale. Sequestration benefits only last as long as the plants or trees are alive and that they vary with the age of the vegetation. Carbon sequestration rates depend on the type of species and location where it is grown (Pepper, 2012). Carbon sequestration in green roofs can have high variability due to roof age and substrate depth.[13] Other factors that affect carbon sequestration in green roofs are geographic region, plant species and roof management or maintenance (Getter, K. L. et al., 2009; Wise, S. et al., 2010; City of Portland BES, 2010; CNT, 2010). In addition, healthy and large trees can store about 1000 times more carbon than smaller trees and if those trees have a long lifespan they also tend to be the biggest contributor to carbon removal (Nowak, D. J. & Crane, D. E., 2001; Escobedo, et. al. 2012; McPherson, E. G. et al., 2007; CNT, 2010). The value of carbon sequestration is estimated with the same benefit parameters as with greenhouse gas emissions.

Habitat Related Benefits: Green roofs, rain gardens and other vegetated infiltration systems can improve the habitat for flora and fauna, such as bird and insect species. These different types of habitats are usually small in size and have limited impacts. But, it is conceivable that greater benefits may arise from large-scale strategies that are connected to habitat corridors. Limited research is available to directly assess the economic value of habitat creation. As a first step, a biological survey would be required to assess current conditions and to evaluate potential changes in flora and fauna habitat and other ecosystem services. Valuation of these changes though would remain difficult because of a lack of economic research on the benefits of small scale habitats. Potential proxy values may be drawn from wetland valuation research for some types of green infrastructure, but developing accurate estimates would be highly uncertain. Still, in some studies such as the benefit cost analysis in Ann Arbor, the value of habitat creation is estimated (ECONorthwest, 2011).

[13] One study indicated that three roofs with similar substrate depth had increased carbon with age of the roof and vegetation. Data from another study showed green roofs stored, on average, between 60 to 240 grams of carbon per square meter in the aboveground plant and between 30 and 185 g C·m-2 in belowground biomass.

2.2.5 Community Livability Benefits

A series of quantifiable and qualitative benefits also enhance the quality of life across a community. Emerging research on these benefits stems in part from the ways in which *social capital* forms and grows in a community. For example, the Portland Bureau of Environmental Services writes "social capital is the benefits that individuals and communities derive from having social contacts and networks throughout their communities and is based on the notion that individuals who interact with each other will support each other to the benefit of the entire community" (Portland BES, 2010). Green infrastructure, and especially ones that encourage use of the outdoors, can help induce interactions and connections across the community. This includes the personal value of health and recreation, as well as an improvement in the level of investment in business district.

Reduced Health Effects - Heat Island Related Impacts: The term "heat island" describes a landscape characteristic in which cities tend to be hotter than nearby rural areas.[14] These hotter temperatures come from the radiant heat off of impervious surfaces and buildings, and a lack of plant material to produce evapotranspiration that cools the air (EPA, 2008; Grimmond, C. et al., 2010; Wise, S. et al., 2010; Burden, D., 2006; City of Portland Bureau of Environmental Services, 2010; Grimmond, C. et al., 2010; and Stratus Consulting Inc., 2009). Across a city, higher temperatures can lead to adverse health effects on people (e.g. respiratory difficulties, exhaustion, heat stroke and heat-related mortality), particularly older and more vulnerable populations.[15] Green infrastructure can reduce temperatures and lead to lower health effects if implemented widely across a city. Urban trees, for example, emit low volatile organic compounds (VOC), and reduce air temperatures through transpiration. Research has shown that trees can reduce local temperatures up to 8.7°F compared to impervious surfaces. In Chicago, a study showed substantial differences in roof surface temperatures between green and conventional coverings. The effect of green infrastructure on mitigating heat island effects depends on wide scale implementation (Stratus, 2009). Data on the demographics of an area also influence related benefits because certain age cohorts are more susceptible to heat related illnesses than others.

Aesthetic Improvements: Some strategies improve the overall visual appearance of a community simply by having planted material among impervious surfaces. In addition, some BMPs strategies aim to directly reduce litter or debris from public spaces to make it more visually appealing. These aesthetic improvements are difficult to estimate directly but can be observed in differences in the prices on properties which are in the vicinity of aesthetically attractive areas. To estimate benefits of these improvements, property value studies are conducted to isolate

[14] http://www.epa.gov/heatisland/index.htm

[15] The heat island mitigation to lowering emission levels of air pollutants and greenhouse gases through the reduced energy demand (via greater air conditioning needs) and lower demand for outdoor irrigation needs. These effects, if they can be quantified, are discussed above.

only a small portion of price differences that relate to being near the green infrastructure installation. A number of researchers have evaluated such property value differences and used them in BCAs. For example, the Alachua County Environmental Protection Department and Public Works Department (in Florida) examined the changed in property values due to the county's green infrastructure programs and found that the increase in land values for properties adjacent to some measures (EPA, 2103). The application of findings from one site to another is not always straightforward and depends on site specific conditions.

Recreational Benefits: In addition to providing a pleasant visual experience, certain green infrastructure can provide recreational benefits as well. Philadelphia estimated the number of persons who would use (i.e. walk or bike on) a vegetated acre, as part of their triple bottom line analysis of the Combined Sewer Overflow Long Term Control Plan Update (PWD, 2009). The residents of Alachua County in Florida noted that recreational benefits that stem from green infrastructure were a top priority for the impacts of development. Their concerns for these issues have driven the county's pursuit of GI programs (EPA, 2013). For the Blackberry Creek Watershed Alternative Study, open spaces and natural greenways to preserve and connect significant natural features for valued for aesthetic, recreational, and/or alternative transportation uses (EPA, 2013). Valuation of recreational features stems from economic research on the time and money spent to reach a recreational area.

Noise Reduction: Some green infrastructure systems, such as wetlands or trees, are effective in reducing ambient noise because they can absorb it. CNT (2010) discusses the noise-reducing properties of GI for porous concrete and green roofs, but does not provide a methodology for quantifying these benefits. A case study in Lancaster County, PA notes that positive effects of green infrastructure can arise from noise pollution reduction (EPA, 2014).

Crime Reduction: Researchers from the University of Illinois asked the question "Does Vegetation Reduce Crime?" and came to the conclusion that the greener a buildings surroundings were, the fewer crimes reported (Kuo and Sullivan, 2001). This study examined crime activity levels around apartment buildings in Chicago, and measured differences in the amount of trees and grass cover between sites. Vegetation may deter crime both by increasing informal surveillance and by mitigating some of the psychological precursors to violence. While these are just theories and have not been comprehensively examined, what this research shows is that vegetation does not necessarily facilitate crime by providing cover – a long-held belief among some planners. Instead, a green environment encourages outdoor use, and as such, provides a deterrent because more people are in places where crimes can be committed. The benefits of crime reduction would be derived through data per crime on the avoided costs for the judicial system.

Public Education/Environmental Stewardship. Promoting strategies that seek to change people's behaviors and make them more aware of their environmental impacts helps to cultivate a stewardship perspective in the community about its local natural resources. CNT (2010) notes that community tree planting provides a valuable educational opportunity for residents since in this process they become more aware of the benefits of green infrastructure. Research on urban tree planting has shown that such environmental initiatives make environmentally sound behaviors more likely to occur in the future. Other strategies involving public education and advertising has appeared to be less effective in changing attitudes (Kuo and Sullivan, 2001; and Summitt and Sommer, 1997). The economic valuation of such changes though has not been sufficiently studied for it to be included in a BCA. In this case, only a qualitative assessment of changes in stewardship could be included in a decision framework.

Business Development: Green infrastructure, especially on the scale of a comprehensive green street design can lead to an enhanced sense of place, and increase in foot and bicycle traffic can support retail development. The NRDC found that consumers are willing to spend more on products, visit more frequently, or travel farther to shop in areas with attractive landscaping, good tree cover, or green streets (NRDC, 2013). Case studies by the New York City DOT examined before and after changes in Retail Sales Tax Filings, Commercial Leases & Rents, and City−Assessed Market Value. While the study's methodology does not ultimately prove causality between the street improvement projects and any resulting economic changes, some locations of green street development saw a significant increase in retail sales compared to the changes in retail sales for the borough as a whole.

Job Creation and Economic Impacts: Spending on capital investments and operations and maintenance (O&M) leads to job creation. Moreover, since installation and maintenance of most of these systems requires unskilled labor, the economic benefits of job creation often goes directly to those who may be in most need of work. The total economic impact of capital and O&M expenditures is measured in terms of the number of jobs created, change in income, gross regional product, and sales and property tax revenue. In addition, wider impacts across the region can also be estimated by applying appropriate economic *multipliers*. As an example, PWD (2009) focused on the fact that many of these jobs are for unskilled labor, which provides a valuable social benefit in an urban setting.

2.3 What Evidence Of Benefits Have Been Found Elsewhere?

Economic benefits of storm water management depend on site conditions and characteristics of the green infrastructure systems and program. While CNT (2010) establishes a number of methods for computing benefits, for each set of calculations it is necessary to collect (or establish assumptions) site specific data about BMPs performance and establish analytical standards for the suitability of economic valuation parameters. Despite these constraints and uncertainties, some agencies have pushed forward in collecting data and using these methods. The most recent review of economic evaluations of green infrastructure is found in EPA (2013). This document has developed a fairly comprehensive assessment of the efforts by some utilities to evaluate economic benefits of storm water management. Table 3 presents an excerpt from the EPA (2013) report and indicates that some of case studies performed BCAs, as opposed to other analytical approaches such as cost-effectiveness.

Table 3: Excerpt of EPA Case Studies on Economic Evaluation of Storm water Management BMPs

Entity	LID/GI program description	Type of analysis	Outcome of analysis
Lenexa Public Works Department, KS	Adoption of LID/GI-oriented development standards, BMPs, and systems development fees as part of the Rain to Recreation program.	Capital cost assessment	Savings of tens to hundreds of thousands of dollars in site work and infrastructure costs with GI BMPs.
Charlotte-Mecklenburg Storm Water Services, NC	Restoration of streams damaged by runoff from development, and BMPs to reduce impacts of rapid development, were assessed to determine impacts on drinking water quality.	Cost-effectiveness	Analysis showed that stream restoration is the most cost-effective way to immediately control sediment in this area.
Capitol Region Watershed District (CRWD), MN	Eighteen BMPs in a 298-acre watershed designed to reduce localized flooding and storm water runoff, improve water quality, enhance recreation in local park.	•Capital cost assessment •Cost-effectiveness	Initial capital cost assessment found substantial cost savings with GI compared with grey infrastructure.
New York City Mayor's Office of Long-term Planning and Sustainability, NY	Distributed GI controls to reduce storm water runoff and CSOs, improve water quality, and increase public access to tributaries, compared to conventional CSO controls such as tunnels and basin storage.	Cost-effectiveness	Cost savings with GI compared to grey infrastructure
Seattle Public Utilities (SPU), WA	Natural drainage system (NDS) projects on residential streets; LID/GI-based storm water regulations and Residential Rainwise Program to encourage customers to reduce the volume of storm water sent to the public system.	Cost-effectiveness	By integrating LID/GI into asset management process, SPU can minimize life-cycle costs to meet established levels of service and balance the risks to minimize life-cycle costs.
West Union, IA	Pilot community for Iowa Sustainable Green Streets Initiative to replace aging infrastructure and reduce localized flooding in downtown area.	•Life-cycle cost analysis •Benefit valuation (avoided costs)	Lower maintenance and repair costs for deicing permeable pavement result in projected savings over the life-span of the pavement.
Kirkland Public Works Department, WA	Integration of LID/GI into conceptual design phase of all capital improvement projects within public rights-of-way.	Quantitative ranking of costs, benefits	LID/GI options for CIP projects are investigated as early in the planning phase as possible.
Kane County, IL	Adoption of county storm water ordinance and corresponding LID/GI-based BMPs, including development approaches that preserve natural areas and use naturalized drainage/retention/detention (i.e., conservation-based development).	Fiscal impact analysis	Study found that conservation development alternative incurs a lower public cost than the conventional alternative.

Table 3: Excerpt of EPA Case Studies on Economic Evaluation of Storm water Management BMPs (Continued)

Entity	LID/GI program description	Type of analysis	Outcome of analysis
Milwaukee Metropolitan Sewerage District (MMSD), WI	Integration of distributed LID/GI strategies into overall planning efforts including facilities plans and CSO control plan; projects on both public and private lands.	•Cost effectiveness •Benefit valuation	Results will be used to help select which projects to implement in the future, and to show where the use of GI is a valid and effective approach
Alachua County Environmental Protection and Public Works Departments, FL	County acquires and preserves open-space lands through ACF program to reduce development impacts and improve water quality.	Benefit-cost analysis (BCA)	Proximity to open space adds to parcel value, for an increase in property tax revenue of several million dollars per year.
Portland Bureau of Environmental Services (BES), OR	Ecoroof Program includes incentives for green roofs on privately owned buildings and green roof requirements for new city-owned buildings.	BCA analysis	Ecoroofs generate significant public and environmental benefits, as well as benefits to developers and building owners (due to extended life of ecoroofs compared to traditional roofs).
Sun Valley Watershed, LACDPW, CA	Goal of watershed-based project was to alleviate localized flooding while providing multiple benefits. Fifteen project elements with LID/GI components.	BCA analysis	Demonstrated potential for multi-objective storm water strategies to provide greater community value than a single-objective flood control strategy would provide.
PWD, PA	Green City Clean Waters Program aims to reduce CSOs and improve water quality in part through distributed GI controls and comprehensive stream restoration program.	BCA analysis	LID/GI-based approaches provide important environmental and social benefits that are generally not provided by grey infrastructure.

A summary of several case studies is presented below. These studies integrated local data with some aspects of the CNT (2010) framework to estimate quantifiable benefits.

Economic Benefits of Green Infrastructure in Milwaukee, WI and Ann Arbor, MI: ECONorthwest (2011), evaluated benefit analyses of storm water management efforts in Milwaukee, WI and Ann Arbor, MI. In *Milwaukee,* the Department of Public Works - Infrastructure Division, manages infrastructure consisting of about 300 miles of sewer pipes, 3,000 miles of municipal pipes, and 3,000 miles of private laterals. A primary focus is to reduce the quantity of total suspended solids entering its waterways by 40 percent by 2013, as required by the Wisconsin Department of Natural Resources (City of Milwaukee, 2011). The Systems Planning Unit in Ann Arbor has a much smaller management responsibility and consists of just 359 miles of underground pipes and over 11,000 inlets and catch basins to manage storm water (City of Ann Arbor, 2011). In both communities, monetizable, quantifiable and qualitative benefits are evaluated (see Table 4) using the methodology established by CNT (2010). Where appropriate and possible, local data was integrated into calculations to estimate benefits. A number of additional assumptions are made to illustrate the scale of benefits that could arise from a much larger future program.

Table 4: Benefits Evaluated in Great Lakes Study

Quantified and Monetized	Quantified, but not Monetized	Qualitative
Avoided costs of reduced storm water runoff and water quality	Flood Reduction	Public Education
Avoided costs related to water quality benefits	Heat Island Effect	
Avoided costs of additional future gray infrastructure capacity	Aesthetics	
Avoided costs of treatment operations and maintenance for combined sewer flows	Improved health and well-being from recreation	
Energy Cost Savings Benefits	Improving well-being by reducing noise pollution	
Decreased air pollution emissions from reduced energy use		
Improved air quality from vegetation on green roofs and trees		
Reduced CO2 equivalent emissions from reduced energy use		
Increased carbon sequestration from trees and green roofs		
Wetland habitat protection		

Economic Benefits of Green Infrastructure in Lancaster, PA: With a population of 60,000, the city has a combined sewer system (CSS) and needed to address burden on the treatment facility when intense precipitation events occurred. The EPA notes that combined sewer overflows (CSOs) discharge approximately 750 million gallons of untreated wastewater and storm water into the Conestoga River (EPA, 2014). To address this issue, Lancaster County published a Green Infrastructure plan which estimated water quality benefits, but not the additional environmental, social, and economic benefits. The EPA published this case study to highlight and bring awareness to quantify and highlight these benefits. The specific benefits they monetized were energy, air quality, and climate-related benefits. They also estimated the avoided capital costs of gray infrastructure, and the avoided wastewater pumping and treatment costs. The methodology used in quantifying and monetizing the benefits followed CNT (2010). They also made several high-level assumptions with regard to long-term reduction, the future distribution of green infrastructure projects, and when the monetary benefits would begin accruing.

Philadelphia Combined Sewer Overflow Long Term Control Plan Update: The purpose of the City's report was to demonstrate the full range of societal benefits of the Green City Clean Waters Program. The program aims to reduce CSOs and improve water quality in part through distributed GI controls and comprehensive stream restoration program. The analysis helped PWD to determine that a GI-based approach, coupled with targeted grey infrastructure, is their preferred approach for city to follow. A table of the monetized benefits over 40 years is presented below. It is assumed that these benefits arise from a 50% level of LID coverage throughout the city.

Table 5: City-wide present value benefits of key CSO options: Cumulative through 2049 (2009 Dollars)

Benefit categories	Value
Increased recreational opportunities	$524.50
Improved aesthetics/property value (50%)	$574.70
Reduction in heat stress mortality	$1,057.60
Water quality/aquatic habitat enhancement	$336.40
Wetland services	$1.60
Social costs avoided by green collar jobs	$124.90
Air quality improvements from trees	$131.00
Energy savings/usage	$33.70
Reduced (increased) damage from SO2 and NOx emissions	$46.30
Reduced (increased) damage from CO2 emissions	$21.20
Disruption costs from construction and maintenance	($5.60)
Total	$2,846.40

Alachua County Environmental Protection and Public Works Departments, FL: The county developed a comprehensive low impact development (LID) / green infrastructure (GI) program based on three different components: (1) LID/GI-based land development policies and regulations developed through the county's Comprehensive Plan; (2) Alachua County Forever (ACF), a conservation and land acquisition program; and (3) a unique governance structure designed to increase interdepartmental collaboration to promote the adoption of LID/GI program elements. To demonstrate the benefits of ACF and alleviate public concerns that the program reduces property tax revenue, the county calculated the benefits for the increase in property values from increased open space. This measure was used to compare with any lost tax revenue to acquire, protect, and manage environmentally significant lands in order to protect water resources, wildlife habitat, and natural areas suitable for resource-based recreation. Twelve thousand seven hundred parcels in the county are close enough to open space to show an increase in value due to their proximity to water. The total impact on their value is just under $150 million, which would result in additional property tax revenues of approximately $3.5 million per year.

Portland Bureau of Environmental Services, OR. The Portland BES performed an analysis of ecoroofs versus conventional roofs to gain support and increase implementation of ecoroofs in the city. Portland receives an average of 37 inches of precipitation per year, which creates an annual volume of storm water runoff of about 10 billion gallons. As part of its storm water management programs, BES has implemented the Sustainable Storm water Management Program, which focuses on green infrastructure initiatives, including the Ecoroof Program.

Table 6: Value of Benefits from 40,000 SQFT Ecoroof (2008 Dollars)

Benefit categories	Total Over 40 Years
Cooling demand reduction	$19,983
Heating demand reduction	$23,509
Carbon reduction	$845
Improved air quality	$104,576
Habitat creation	$25,300
Total	$174,213

Sun Valley Watershed, Los Angeles, California: The Sun Valley watershed is in the San Fernando Valley, about 14 miles northwest of downtown Los Angeles. It encompasses the communities of Sun Valley and North Hollywood. The watershed is approximately 4.4 square miles and six miles in length from north to south.

The economic analysis was undertaken because the county and other stakeholders needed to show that although the costs of the LID/GI-oriented solutions would be much greater than the cost of traditional infrastructure, and they would yield significantly higher benefits. The results of the analysis were used to help to gain public support, bring in outside partners, and raise funds. The tables below show the descriptions of each alternative the value of alternatives compared to a grey infrastructure scenario.

Table 7: Description of Alternatives for Sun Valley Watershed

	1 - Infiltration	2 - Water Conservation	3 - Storm water Reuse	4 - Urban Storm Protection
Description	Widely Distributed Small Projects	Maximizes Wildlife Habitat	Maximizes Storm water Reuse for Industry	Full Conveyance with Regional BMPs
Retention Basin Size	50-Year	50-Year: Subareas 1-6 10-Year: Subareas 7-8	50-Year	10-Year

Table 8: Values by benefit over 50 years (2002 Dollars)

Benefit	Grey Infrastructure	1	2	3	4
County Flood Control					
Regional damage avoidance	$64.46	$64.46	$64.46	$64.46	$64.46
Change in downstream flooding	-$1.03	$5.37	$3.65	$5.37	$3.22
City Flood Control	$10.01	$10.01	$10.01	$10.01	$10.01
Avoided cost of imported water	$0.00	$22.35	$17.89	$24.07	$22.65
Energy Reduction	$0.00	$4.30	$1.70	$4.30	$1.70
Air Quality	$0.00	$20.50	$8.10	$20.50	$8.10
Greenwaste	$0.00	$20.00	$10.00	$20.00	$10.00
Ecosystem Restoration	$0.00	$1.86	$4.04	$4.58	$4.48
Recreation	$0.00	$23.34	$23.34	$23.34	$23.34
Property Values	$0.00	$10.20	$3.90	$10.20	$3.90
Total Benefits	**$73.44**	**$270.47**	**$295.39**	**$274.93**	**$239.95**

3 Summary of Water Quality Improvement Strategies

3.1 Program Background

The Division has been working for several years with other jurisdictions and community groups to establish Water Quality Improvement Plans (WQIPs) for each of its watersheds. WQIPs draw from the processes in developing Watershed Asset Management Plans (WAMPs) and Comprehensive Load Reduction Plans (CLRPs) which aim to protect, preserve, enhance, and restore water quality in receiving waters. WAMPs provide an understanding of critical assets owned by the Division and the management and investment strategies necessary to deliver required services. CLRPs are efforts to identify BMPs and funding levels needed to comply with TMDL and other storm water regulations established by the Regional Water Quality Control Board. These efforts, as described below, have identified a series of projects and initiatives that have been defined as either structural or nonstructural initiatives.

3.2 Structural WQIP Strategies

3.2.1 Types of Strategies

Structural BMPs are physical infrastructures that are designed for site-specific conditions and placed strategically across a watershed to improve water quality. The effectiveness and feasibility of implementing any of these BMPs varies depending on the design and site conditions. For example, the effectiveness of a BMP in enhanced infiltration capacity of a watershed depends on amenable soil types. Other site-specific considerations include the physical land area available for effective implementation and maintenance. Also, the capital and maintenance costs of a BMP influence its feasibility for the Division, especially in comparison to other BMPs which can be implemented more cost-effectively.

Various types of structural strategies have been identified as potentially suitable for San Diego watersheds and have been classified as one of three types: (1) green infrastructure, (2) multiuse treatment areas, and (3) water quality improvement BMPs.[16] Each of these types of structural BMPs is discussed below.

Green Infrastructure

Green infrastructure covers a range of BMPs that are designed to be integrated in a broader site plan to maintain healthy waters, provide multiple environmental benefits, and support sustainable communities. Green infrastructure is distinguished from other methods by making deliberate and effective use of vegetation and soil to manage storm water (USEPA, 2014). Table 9 presents a series of green infrastructure BMPs that can be integrated into site designs and implemented at the site scale (on-site treatment) or street right-of-way scale (green streets).

[16] San Dieguito Potential Strategies Final Draft 4/11/14

Table 9: List of Structural BMPs – Green Infrastructure

BMP*	BMP Description
Bioretention	Shallow vegetated features constructed in green spaces alongside roads, sidewalks, and other paved surfaces. Bioretention includes an engineered soil media designed to encourage pollutant treatment and water storage.
Infiltration Trenches	Narrow, linear BMPs that have similar functions as bioretention areas with variable surface materials, including rock or decorative stone, designed to allow storm water to infiltrate into subsurface soils.
Bioswales	Shallow, open channels designed to reduce runoff volume through infiltration and pollutant removal by filtering water through vegetation within the channel and infiltration into bioretention soil media. Bioswales can serve as storm water conveyance, but the primary objective is water quality enhancement (often referred to as linear bioretention).
Planter Box	Fully contained system containing soil media and vegetation that functions similarly to a small biofiltration BMP, but includes an impermeable liner and underdrain.
Constructed Wetland	Engineered, shallow marsh systems designed to control and treat storm water runoff. Particle-bound pollutants are removed through settling and other pollutants are removed through biogeochemical activity.
Permeable Pavement	Allows streets, parking lots, sidewalks, and other impervious covers to retain their natural infiltration capacity while maintaining the structural and functional features of the materials they replace. Roads such as highways can include PFC overlays which provide water quality benefits when traditional permeable pavement is not suitable.
Sand Filters	Treatment systems that removes particulates and solids from storm water runoff by facilitating physical filtration.
Vegetated Swales	Shallow, open channels that are designed primarily for storm water conveyance. Pollutants such as trash and debris are removed by physically straining/filtering water through vegetation in the channel.
Vegetated Filter Strips	Bands of dense, permanent vegetation with a uniform slope, designed to provide pretreatment of runoff generated from impervious areas before flowing into another BMP as part of a treatment train.
Green Roofs	Roofing systems that layer a soil/vegetative cover over a waterproofing membrane and can reduce runoff through interception and evapotranspiration.

*Source: San Dieguito River WMA Water Quality Improvement Plan (2014)

Table 10 outlines the expected levels of effectiveness in green infrastructure in handling different types of impacts of storm water, including water chemistry and physical and biological impacts. This chart is adapted from the San Dieguito River WMA Water Quality Improvement Plan (2014) provides an initial indication of the kinds of benefits (beyond water quality improvements) that can be achieved by green infrastructure BMPs. In particular, while trash removal is a water chemistry benefit, its removal from streets can lead to more aesthetically pleasing neighborhoods, which in turn can foster economic value. In addition, depending on the extent to which these BMPs improve

physical and biological factors, there can be follow-on improvements in recreational value and ecosystem value of streams and riparian areas. It is noted here that only constructed wetlands have the potential to generate tangible improvements in habitat or wildlife.

Table 10: Green Infrastructure BMPs and Pollutant Reduction BMP

	Water Chemistry Benefit									Physical and Biological Benefits			
	Bacteria[1]	Metals	Organics	Sediment	Pesticides	Nutrients	Oil and grease	Dissolved minerals	Trash	Flow rate	Volume reduction	Habitat or Wildlife	Aquatic Life
Bioretention	●	●	●	●	●	◗	●	◗	●	●	●	○	◗
Infiltration Trenches	●	●	●	●	●	●	●	●	●	●	●	○	●
Bioswales	●	●	●	●	●	◗	●	◗	●	●	●	○	◗
Planter Boxes	●	●	●	●	●	◗	●	◗	●	◗	◗	○	◗
Permeable Pavement	◗	●	◗	●	●	◗	◗	◗	◗	●	●	○	◗
Constructed Wetlands	●	●	◗	●	●	●	◗	◗	●	●	◗	●	◗
Sand Filters	●	●	●	●	●	◗	●	○	●	◗	◗	○	◗
Vegetated Swales	◗	◗	◗	●	◗	◗	◗	○	●	◗	◗	○	◗
Vegetated Filter Strips	◗	◗	◗	●	◗	◗	◗	○	●	◗	◗	○	◗
Green Roofs	◗	◗	○	●	○	○	○	○	○	●	◗	○	◗

Key: ● - Primary pollutant reduction; ◗ - Secondary pollutant reduction; ○ - Minimal or no pollutant reduction.

Multiuse Treatment Areas

San Dieguito River WMA WQIP (2014) identifies large-scale treatment areas such as multiuse basins and stream, channel, and habitat rehabilitation projects. These systems are designed as regional facilities that can receive flows from neighborhoods or larger areas and become cost-effective solutions that provide multiple benefits. For example, such systems can be integrated in public spaces such as active (soccer fields) and passive (parks) recreation areas and provide benefits in flood control, ground water recharge, restoration, habitat enhancement, and recreation. In addition streambank projects that reduce erosion can improve water quality and simultaneously improve habitat. Table 11 defines the list of measures considered in San Dieguito River WMA WQIP (2014).

Table 11: List of Structural BMPs – Multiuse Treatment Areas

BMP*	BMP Description
Infiltration and Detention Basins	Large multiuse surface BMPs (on public parcels) that provide treatment through the runoff detention and infiltration (e.g. infiltration basins and dry extended detention basins). These BMPs are designed to hold runoff for an extended period of time to allow water to evaporate into the atmosphere, infiltrate into native soils, or be transpired by vegetation, while accommodating for overflow and bypass during large storm events.
Stream, Channel, and Habitat Rehabilitation Projects	Stream, channel, and habitat restoration or enhancement projects can help sustain habitat for wildlife and provide water quality benefits downstream of these activities.
Other Opportunities	Construction of multiuse treatment areas BMPs on private land to achieve the load reductions. These BMPs are the cost effective and considered a low priority.

Water Quality Improvement BMPs

Additional structural BMPs include systems that supplement the design performance of existing infrastructure. For example, systems that segregate trash includes inlet devices, such as trash guards or racks that capture debris before they enter surface waters. Another example are proprietary commercial products that often aim to use settling, filtration, absorptive/adsorptive materials, vortex separation, and sometimes vegetative components to remove pollutants from runoff. Finally, dry weather flow separation and treatment projects target non-storm water dry season flows and divert these flows for treatment either on-site or to sanitary sewer systems and ultimately waste water treatment plants.

3.2.2 Measuring Impacts of Structural Strategies

The benefits of structural systems - both the type of benefit and the magnitude – depend on the system's design and surrounding site characteristics. Some strategies such as constructed wetlands can generate a range of benefits (which are partially indicated by Table 10) and may also include recreational and aesthetic values. Most of these benefits accrue to the general public who may have access or benefit from proximity to the wetland. Green roofs, on the other hand, create both public benefits in water retention as well as potential private benefits for property owners in terms of energy savings, from additional roof insulation.

The effectiveness of each structural system in generating benefits is determined directly from key physical features associated with its design. That is, each system benefit, whether it includes flood risk reduction, air quality improvement, or aesthetics, depends on a characteristic of the system that is measured in physical units. For example, flood risk reduction benefits depend fundamentally on the quantity of water retained by the BMP – that benefit's *unit of measure*.

The unit of measure of green streets (Figure 1) would certainly include the designs of various BMPs on the street such as bio-swales, permeable pavement and tree

plantings. In aggregate however, a standard green street design would be measured by its length in miles. In addition, the features and length of the green street may also influence the value of properties on either side of it. Site specific characteristics associated with the type of neighborhood (e.g. mixed use, residential, commercial, etc.), population / employment density, socio-economic characteristics (e.g. income, household size), safety conditions and other factors could influence different types of benefits.

Figure 1: Illustration of Sample Structural BMP: Green Streets

Bioswales: can reduce runoff and downstream flood potential and create aesthetically appealing environment

Permeable Pavement: can reduce runoff and downstream flood potential

Tree Plantings: can reduce runoff and downstream flood potential, entrain harmful particulates, create aesthetically appealing environments, lower ambient temperatures

3.3 Nonstructural Strategies

3.3.1 Types of Strategies

The Division and its stakeholders have also identified nonstructural strategies that may achieve water quality improvements. Nonstructural strategies include “those actions and activities intended to reduce storm water pollution, which do not involve construction of a physical component or structure to filter and treat storm water.” These strategies include administrative policies, creation and enforcement of municipal ordinances, education and outreach programs, rebate and other incentive programs, and cooperation and collaboration with other watershed or regional partners. In general, many of these initiatives have been implemented by the Division for many years and are considered to be integral to regulatory compliance on a watershed-specific basis.

WQIP documents have organized Nonstructural Strategies into a number of categories (see Table 12). These categories include: Development Planning, Construction Management, Existing Development, Illicit Discharge, Detection, and Elimination (IDDE) Program, Public Education and Participation, Enforcement Response Plan, and Non-JRMP Strategies. Across the watersheds and jurisdictions, a long list of potential nonstructural strategies in each category has been developed – reflecting the differing site characteristics in different locations. A comprehensive list of specific strategies across all of the watersheds is included in Appendix 2.

Table 12: Nonstructural Strategies

Strategy Category	Strategy Description
Development Planning	Program uses Responsible Agencies' land use and planning authority to require implementation of best management practices (BMPs) to address effects from new development and redevelopment.
Construction Management	Program addresses pollutant generation from construction activities associated with new development or redevelopment.
Existing Development	Program addresses pollutant generation from existing development including commercial, industrial, municipal, and residential land uses. It includes stream, channel, and habitat restoration and retrofitting in areas of existing development.
Illicit Discharge, Detection, and Elimination (IDDE) Program	Program actively detects and eliminates illicit discharges and improper disposal of wastes into the MS4.
Public Education and Participation	Promotes and encourages the development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water to the maximum extent practicable (MEP), prevent controllable non-storm water discharges from entering the MS4, and protect water quality standards in receiving waters.
Enforcement Response Plan	Enforcement of each JRMP is required.
Non-JRMP Strategies	Strategies that are outside of the JRMPs, but are designed to effectively prohibit non-storm water discharges to the MS4, protect the beneficial uses of receiving waters from MS4 discharges, or achieve the interim and final numeric goals identified in the Water Quality Improvement Plan.

3.3.2 Measuring Impacts of Nonstructural Strategies

The economics perspective on nonstructural strategies is manifested in the change that they create, which in turn causes a change in value for the community. In particular, the impact of some nonstructural strategies that are directly related to structural systems, such as new design standards for BMPs, generates value when the design standard is used to improve BMP performance. The value of this nonstructural strategy is captured through the value of the structural systems that are implemented. Other nonstructural strategies directly generate value that is separate from a structural BMP. For example, an educational campaign that aims to reduce litter would directly target people's behavior and its effectiveness would be determined by how many people's behavior is changed. The value of this change would be captured by benefit categories associated with improved community livability and business development.

To reflect these differences in nonstructural strategies, we have developed several categories to differentiate them in terms of how they generate value. These categories include strategies that: (a) Increase # of structural systems; (b) Improve structural systems performance; (c) Initiatives to change behavior; and (d) Initiatives to reduce pollutants directly. The revised grouping of specific nonstructural strategies is briefly described in Table 13.

Table 13: Nonstructural Categories by Type of Impact and Identified Strategies

Changing Behavior to reduce pollutants at the source
Implement pet waste program
Identify and reduce incidents of power washing discharges from nonresidential sites.
Require BMPs to address pesticides, herbicides, and fertilizers issues
Implement Illicit Discharge, Detection, and Elimination (IDDE) Program
Implement a public education and participation program
Enhance education and outreach
Technical education and outreach on the MS4 Permit and WQIP
Implement escalating enforcement responses to compel compliance
Continue participating in source reduction initiatives.
Improve / Maintain BMPs or LIDs
Update BMP Design Manual procedures
Administer an alternative compliance program
Oversee implementation of BMPs during the construction
Require implementation of minimum BMPs for existing development
Gather monitoring information about priority conditions or beneficial uses
Collaborate with entities potentially including, but not limited to:
Increasing # of BMPs or LIDs
For all development projects, ensure source control BMPs
Amend municipal code to encourage LID
Train staff on LID regulatory changes and LID Design Manual.
For PDPs, require implementation of on-site structural BMPs or LIDs
Promote and encourage implementing designated BMPs at residential areas.
Develop pilot project to identify and carry out site disconnections in targeted areas.
Promote and encourage implementation of designated BMPs in nonresidential areas.
Monitor for erosion, and slope stabilization on municipal property.
Identify sites for pilot study to test Permeable Friction Course (PFC)
Identify candidate areas for retrofitting projects
Identify areas for stream, channel, or habitat rehabilitation projects
Enforcement of actionable erosion and slope stabilization issues
Conduct a feasibility study on urban tree canopy (UTC) program
Removing pollutants or sources directly
Implement operation and maintenance activities
Implement controls to prevent infiltration of sewage into the MS4
Implement operation and maintenance activities for public streets
Require sweeping and maintenance of private roads and parking lots in targeted areas.
Develop a program to address and capture trash and debris.
Sanitation and trash management for persons experiencing homelessness.
Protect areas that are functioning naturally.

As mentioned above, the first two of these nonstructural categories relates directly to structural systems themselves. In this case, whether the change in BMP adoption is due to training in the community or general promotion of BMP adoption, the success of these strategies would be determined directly by how many additional BMPs are installed and then by the various benefits generated by their installation. Similarly, new design standards and performance monitoring would be measured by the improvement in the performance of installed structural systems.

On the other hand, nonstructural strategies can generate water quality and other benefits on their own. For example, some of these strategies entail education, enforcement and outreach activities which attempt to alter behavior that leads to water quality pollution. These strategies may at the same time lead to an overall aesthetically better environment with less litter on the street. In addition, programs to promote rain barrels and other water harvesting systems on private property can generate benefits to the property owner and the general public. Measured in terms of their water holding capacity, these systems have the potential to offset water demand for irrigation purposes which has the dual effect of reducing water costs for the owner and water treatment demand from the utility. Lower water demand would reduce energy demanded and associated pollutants.

Figure 2: Illustration of Nonstructural BMP: Water Harvesting

Irrigation costs savings: Quantity of water retained for irrigation purposes (retained water also reduces energy emissions from lower energy use at the water treatment plant)

Each of these types of strategies will be discussed in greater detail relative to the benefits that they can generate in the next chapter.

4 Accounting for Benefits of BMP Strategies in San Diego

Discussions above on the economic benefits of storm water management and the varied types of structural and nonstructural BMPs strategies under consideration by that the Division sets up the potential to evaluate strategies with an economic framework. The challenge in performing an economic analysis is that some benefits may not be quantifiable, let alone monetizable. In that case, the Division faces some options in how to account for benefits that are perceived to be relevant in decision making. This section begins with an outline of the types of benefits which could be applicable to different categories of strategies and then closes with a discussion on the options for analytically accounting for benefits with different levels of information.

4.1 Evaluation of Benefits for BMP Strategies

This assessment of the applicability of benefits to different BMP strategies represents an initial effort to characterize and differentiate BMPs by the value that they may create for the economy, environment and community. In a series of tables (Table 14) through Table 17), each category of benefit is evaluated relative to applicability for each type of structural and nonstructural strategy. This initial assessment determines for each strategy type whether a benefit can be: (a) monetized; (b) monetized but depending on site specific conditions; (c) quantified but not monetized; or (d) qualitatively evaluated.

To facilitate the review of these tables, a standard symbol key is created to establish how benefits may be evaluated for each strategy.

Key to Symbols for Table 14 through Table 17	
●	Monetizable
⊙	Monetizable, but site-specific
⊗	Quantifiable
O	Qualitative

The following delineation of how benefits can be evaluated for a general strategy can only be viewed as our initial assessment. Recall that Table 13 briefly identifies individual strategies under each of these major groups. At this stage, only a general indication of applicability of benefits is discussed. Further evaluation of benefits per strategy would be developed in a subsequent report.

4.1.1 Structural Strategies – Economic and Environmental Benefits

Table 14 represents the additional economic and environmental benefits that could arise from various structural strategies. As shown, many benefits are readily monetizable for *Green Infrastructure* strategies. This finding reflects the fact that much of the existing research that can be applied in San Diego has focused on the various BMPs identified as green infrastructure. Such research and the various storm water management BCA case studies that have been produced provide standardized methods, data, and evidence that can be applied to new sites and projects. As noted in the table, with some additional data on site conditions (e.g. evidence of flood risk, and

irrigation demand, for example), many of the green infrastructure systems have the potential to be monetized. Only benefits related to habitat creation would be unlikely to be monetized. The reason is that not only to these types of benefit calculations require detailed biological surveys, but predictions on the improvement in habitat services with green infrastructure are not well understood at present. Any assessment of monetary benefits would be highly uncertainty and thus, this type of benefit is better characterized in quantitative terms, such as in units of habitat area created.

Multiuse Treatment Area strategies differ from green infrastructure because of the scale and placement of these systems. Benefits can arise from these strategies, especially in flood control because of the volumes that can be potentially detained but the quantification of benefits depends on whether there is a downstream flooding risk. The planted material in these systems can provide benefits in air particulate entrainment, carbon sequestration, and habitat creation but the evidence is not established well enough to characterize these impacts in monetary terms. Other benefits would entail a qualitative assessment.

Water Quality Improvement strategies do not have as clear an impact on economic and environmental benefits as green infrastructure and multi-use treatment areas. For example, trash guards or racks that capture debris before they enter surface waters can improve fish habitat but do not have enough supporting documentation to clearly assess benefits from some of the improved livability characteristics. If less trash in surface waters can be attributed to less trash on neighborhood streets, associated benefits in business development and social capital could arise, but such a connection is not likely to be quantifiable.

Table 14: Structural Strategies – Economic and Environmental Benefits

Strategy	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement
Flood Risk Reduction	⊙	⊙	⊙
Irrigation Cost Savings	⊙	○	○
Energy Cost Savings	⊙	○	○
Air Particulate Entrainment	●	⊗	○
Climate Impacts	●	⊗	○
Habitat Related Benefits	⊗	⊗	⊗
Air Quality Emission Reduction	●	○	○
GHG Emission Reduction	●	○	○

4.1.2 Structural Strategies – Community Livability Benefits

Community livability benefits from structural systems (Table 15) represent benefits which directly or indirectly enhance local development and quality of life. These benefits are largely derived from the physical features of structural strategies in creating benefits

to local residents and property owners. For example, green roofs are noted in their ability to provide noise insulation in a building and tree plantings along green streets can lead to local retail business development because the environment is a more pleasant place to shop.

Similar to economic and environmental benefits in the table above, the applicability of community livability benefits to *Green Infrastructure* also depends on site specific characteristics. For example, the influence of aesthetic improvements on property values usually depends on the type of neighborhood (e.g. residential, commercial, or mixed-use areas). In commercial districts, monetized benefits would be observed in property values, increased sales or employment levels.

The other types of strategies, *Multiuse Treatment Areas* and *Water Quality Improvements*, have fewer types of benefits which can be quantified, let alone monetized. *Multiuse Treatment Areas* certainly have the potential to be located in areas that by design can create recreational opportunities. However, the type of features at the site depends on how it can be used for recreational purposes. The choice of plant materials (e.g. tree species) at the site would affect aesthetics and heat island / health effects but it depends on the location and installation scale of these systems. For *Water Quality Improvements*, it is not clear if there are quantifiable benefits that extend beyond water quality improvements themselves and thus, these benefit categories may be evaluated only in qualitative terms.

Table 15: Structural Strategies – Community Livability Benefits

Strategy	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement
Heat Island Effect	⊙	⊙	○
Aesthetics	⊙	⊙	○
Recreational Benefits	⊙	⊙	○
Noise Reduction	⊗	○	○
Business Development & Jobs	⊙	○	○
Crime Reduction	⊗	○	○
Public Education/ Environmental Stewardship	⊗	⊗	⊗

4.1.3 Nonstructural Strategies – Economic and Environmental Benefits

The potential applicability of economic and environmental benefits for *Nonstructural Strategies* is presented in (Table 16). As discussed above, some types of nonstructural strategies relate directly to structural systems by *Increasing the Number of Structural Systems* and *Improving the Structural Systems Performance*. Accordingly, estimating monetary benefits in of these is directly linked to whether the influence of a nonstructural strategy on implementing a structural system can be quantified. If so, then

benefits are assessed relative to the structural system itself. The assessment of benefit estimation in the first two columns is therefore similar to that of structural systems, assuming though that the effectiveness of these nonstructural strategies can be estimated.

The two other nonstructural approaches, *Initiatives to Change Behavior* and *Initiatives to Reduce Pollutants Directly,* generate benefits from their own effectiveness in changing behavior or pollution control initiatives. Initiatives to Change Behavior primarily target efforts to encourage improved environmental stewardship and storm water protection throughout the community. Various types of actions then that people may take who are more area of environmental impacts include adoption of rain barrels, reducing litter, and reducing unnecessary levels of pesticides, herbicides and fertilizers. These types of activities could generate a range of economic and environmental benefits, some of which can be monetized if there is sufficient site specific information. In addition, *Initiatives to Reduce Pollutants Directly*, including a number of public agency initiatives in street sweeping, storm water system maintenance and trash removal, can also generate quantifiable and monetizable benefits. On the other hand, street sweeping initiatives entail some amount of environmental costs (or "negative benefits") associated with emissions from vehicle use. These costs could be compared with any benefits created from cleaner streets.

Table 16: Nonstructural Strategies – Economic and Environmental Benefits

Strategy	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives to Change Behavior	Initiatives to Reduce Pollutants Directly
Flood Risk Reduction	⊙	⊙	⊙	○
Irrigation Cost Savings	⊙	⊙	⊙	○
Energy Cost Savings	●	⊗	⊙	●
Air Particulate Entrainment	●	⊗	⊙	⊙
Climate Impacts	●	⊗	⊙	⊙
Habitat Related Benefits	⊗	⊗	⊗	⊗
Air Quality Emission Reduction	●	⊗	⊙	●
GHG Emission Reduction	●	⊗	⊙	●

4.1.4 Nonstructural Strategies – Community Livability Benefits

The effectiveness of nonstructural strategies in enhancing various aspects of community livability are similar to those for economic and environmental outcomes. That is, some of these strategies influence the adoption and performance of structural systems and some aim to change behavior and municipal operations. Also, similar to

the structural strategies for the same types of benefits, fewer of these benefits can be evaluated without some site specific information. For the most part though, the evaluation of potential benefits for green infrastructure has been applied to nonstructural systems that aim to increase the numbers and performance of these systems.

Strategies which seek to change behavior such as proper storage of pesticides or the use of rain barrels/water harvesting can have a positive impact, but the scale of that impact will be dependent upon factors such as the number of persons or households who change their behavior. This same uncertainty applies to strategies to reduce pollutants directly. While there is likely to be a net positive impact on society, these impacts on the broader quality of life are less clear. With respect to improved education and awareness, it is possible to quantify the numbers of people who attended a class or have been exposed to an advertising campaign, it is less clear how this information changes behavior or leads to increased number or maintenance of BMPs.

Table 17: Non Structural Strategies – Community Livability Benefits

Strategy	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives to Change Behavior	Initiatives to Reduce Pollutants Directly
Heat Island Effect	⊙	⊙	⊙	○
Aesthetics	⊙	⊙	⊙	⊙
Recreational Benefits	⊙	⊙	⊙	⊙
Noise Reduction	⊗	⊗	⊗	⊗
Business Development & Jobs	⊙	⊙	⊙	⊙
Crime Reduction	⊗	⊗	⊗	○
Public Education/ Environmental Stewardship	⊗	⊗	⊗	⊗

4.2 Review of BMP Prioritization Frameworks

In consideration of the types of benefits that can and cannot be estimated with data for various types of BMP strategies, a number of options are available for summarizing the likely outcomes for decision making. As noted in the tables, some benefit categories are readily monetized under certain conditions and others require site specific information to perform computation. Many other benefits may arise from a specific BMP strategy but cannot be explicitly quantified. Evaluations of any of these benefits for consideration in decision making also entails some significant uncertainties.

Accordingly, several approaches for summarizing benefits and impacts for decision making are available including: cost-effectiveness, benefit-cost analysis, multi-criteria analysis, and SROI. Each of these approaches has strengths and weaknesses for meeting the Division's objectives in developing a prioritization strategy. Overall though,

each method can be implemented in a process that applies principles of economics, even in multi-objective decision analyses which do not require monetization, so that the categories of benefits are not overlapping or over-estimating value.

Cost-Effectiveness Analysis (CEA): This type of analysis focuses on identifying the best value for money in achieving a specific goal, such as storm water reduction. The process is not necessarily identifying the least costly strategy but the one that generates the greatest quantity of a goal per unit of cost (e.g. dollars per gallon of water detained). Costs in these analyses include the capital, maintenance and operations for implementing. This type of analysis is suitable for evaluating projects in which outcomes (benefits) can not be measured in dollar units but can be quantified. Cost-effectiveness analyses often apply a 'knee-of-the-curve' criterion to identify selecting the most cost-effective strategy because beyond this level of investment cost the effectiveness may increase but at a declining rate. These analyses have been used by communities across the country to identify opportunities for saving money while achieving storm water management goals.

Benefit-Cost Analysis (BCA): Since storm water BMPs can offer more benefits than conventional storm water management systems, cost-effectiveness analysis fails to offer decision makers adequate information for evaluating the alternatives (MacMullen, 2007). Benefit-cost analyses attempt to monetize as many benefits as possible to compare results with costs. This approach is a more direct way of accounting for multiple environmental, societal and economic benefits on a common basis and is not limited to a single goal as is often performed in a conventional cost-effectiveness framework. In some cases, direct environmental value cannot be computed directly, but observed from avoided damage costs or inferred from changes in property values. BCAs account for separate evaluation of benefit categories provided that they are not overlapping. In addition, BCA can be used to evaluate the benefits and costs to individual stakeholders, and comparison with strictly financial benefits with combined environmental and societal benefits – all in the same units of measure. The comparison of costs and benefits allows an explicit consideration of the trade-offs in project options. A BCA can determine whether the benefits of preservation (or restoration) are "worth" the costs and when the project is best implemented. In this sense, it ensures that the limited resources used to provide goods and services to society are used in the most efficient way—that is, to achieve the greatest net benefit (NRC, undated). The overall economic worth of an option can be summarized with a Net Present Value (NPV) or Benefit/Cost Ratio (BCR).[17] BCA results do not incorporate perspectives on who gains or loses but whether the overall net

[17] The NPV is the difference between the present value of benefits and the present value of costs. The present value of benefits is the discounted sum of all future benefits. The present value of costs is the discounted sum of all future costs. The BCR is a ratio of the present value of benefits to the present value of costs. It measures how much benefit would be obtained for each unit of cost invested in a project or policy.

benefits justify the investment. [18] Also, where impacts are perceived to be important but a lack of data is available to assign monetary values to it, additional consideration must be given beyond BCA metrics. For example, a trade-off analysis can be used to compare monetary net benefits with non-monetary impacts to determine a best overall value.

Economic Impact Analysis (EIA): The creation of jobs and business development is a direct and tangible measure of value to the community from expenditures to install storm water BMPs. As mentioned above, since these systems can be installed by low-skilled labor, implementation of these types of systems can provide opportunities for some of those who are most in need. Economic impact analyses trace the levels of expenditures on BMPs through the economy to reveal a total impact for the region. Also, green infrastructure tends to use more local labor and materials compared to grey infrastructure and as such would generate a larger local economic impact. The results can be determined in units of numbers of jobs created, increased income, value added, output, and tax revenue. To many stakeholders, these outcomes are more tangible because the results are shown in units that can be related to the unemployment rate and in gross regional product. For decision making purposes, economic impacts are directly proportional to the level of expenditure. As a result, larger projects would appear to provide greater value even if they are not the most cost-effective. These analyses also do not account for benefits that affect the local community and environment.

Multi-Objective Decision Analysis (MODA): For some project impacts, quantitative and monetary metrics are difficult to determine and the appropriateness of any related assumptions would be highly uncertain. MODA formalizes the process of including non-monetary characteristics of a project into decision making. Just like monetary measures, non-monetary measures try to account in a transparent way stakeholders' preferences for certain characteristics. These preferences are the basis for weights on criteria, which are used to compute an index for ranking projects. Non-monetized performance measures may be weighted with monetary values to produce a single performance metric, or reported alongside monetized values for assessing tradeoffs in decisions. These approaches can be as simple as establishing an equal weight and equal score to all benefit categories – whether they can be monetized or not – to sophisticated frameworks in which non-monetary and monetary benefits are scored and weighted in ways that can be consistent with economic principles. The drawback is that weights are subjective and not based on economic theory or evidence.

[18] In theory, an initiative or project would be rated positively if the benefits to some are large enough to compensate the losses of others, assuming some mechanism existed.

Sustainable Return on Investment (SROI): SROI is a proven, economics-based method for appropriately estimating the monetary value of infrastructure. In such cases, the SROI process first identifies measurable performance indicators that can determine the impact of the infrastructure in specific categories of monetizable benefits. In the context of storm water, benefit categories can include those readily monetized as well as those with some quantitative indicators. In this way, SROI uses stakeholder input to estimate values for inclusion in monetary valuation. The SROI process has several notable features that separate it from more conventional evaluation methods. For instance, true to its economics roots, SROI ensures that key performance indicators do not measure overlapping outcomes which would 'double-count' benefits. In addition, the SROI process is marked by its transparency in accounting for uncertainty through Monte Carlo simulation. Uncertainty in the performance, cost and unit values of green infrastructure benefits would be modeled with probability distributions that account for the entire range of reasonable outcomes. Through Monte Carlo simulation, the full range of value for each strategy would be revealed and decisions can be made relative to the upside and downside risk. To be transparent, the probability distributions are established through facilitated discussions in a workshop setting.[19] The discussions are guided towards reaching consensus on how to best use available evidence, including the formation of quantitative descriptions of the uncertainty in the data.

Each of these approaches has strengths and weaknesses for the Division's purposes. For example, BCA is an established approach for evaluating the worthiness of an investment, such as green infrastructure. Benefits which cannot be monetized because they lack sufficient evidence would be treated in a qualitative assessment, but not included in a benefit-cost comparison. In such contexts a MODA approach can be taken to establish weights and scores for non-monetary outcomes and produce an index of value that can be compared with BCA results. Alternatively, an SROI approach can be undertaken that establishes monetary values for all key benefit categories through a collaborative review of evidence and then risk analysis methods are applied to quantify the uncertainty in quantitative and monetary parameters. MODA methods in establishing weights and scores can be used to support SROI results but ultimately with a SROI process, all key categories of benefits would be evaluated in monetary terms.

The next step for the Division is to develop a sound basis for using this information to prioritize BMPs across each watershed. Many challenges arise in prioritizing BMP strategies with the types of varying benefits presented in Chapter 4. Ideally, a prioritizing approach would be objective, based on site-specific and peer-reviewed evidence, account for life cycle outcomes and reflect various sources of uncertainty. Several prioritization options exist that address some of these goals for the framework.

[19] An initial workshop was held in May in San Diego to discuss benefit categories, strategies and decision making frameworks. Comments received from this workshop are included in Appendix 3.

5 Summary of Key Findings

Our findings in this report indicate that many types of benefits can accrue to local residents, businesses, and the general public. Computing benefits of BMPs has been standardized to some extent in the Center for Neighborhood Technology (CNT) report which outlines the data and calculations for a number of benefits (CNT, 2010). For the Division, a similar calculation process could be implemented and it would be consistent with efforts implemented in other cities. However, a significant level of uncertainty would arise in preparing such estimates without specific data on BMP designs and activities for each strategy as well as site specific information about where they would be implemented.

The next best evaluation strategy for the Division at present would entail a simplified assessment of the likely *existence* of quantifiable benefits for each strategy. In this report, we have evaluated the degree to which benefits can be quantified and potentially monetized for each type of strategy. Drawing from the previous tables in Chapter 4, the results of this assessment are shown in Table 18. A “Yes” in one of the table cells indicates that there would be sufficient evidence to quantifiably determine the value of a strategy, provided that information about the strategy and implementation location is better understood. In this high-level summary, it may be assumed that if a quantifiable benefit exists, they would be large enough to generate observable public value and influence decisions accordingly.

These initial findings however must be developed in more detail to provide practical use in prioritizing strategies for the Division. In particular, the feasibility of estimating benefits must assessed for each individually identified strategy (see Appendix 2), not its strategy group as shown in Table 18. With this information, the Division can establish an initial indication of specific strategies that provide the best value. This effort is planned for phase two of this project.

Table 18: Summary of Evidence for Estimating Benefits for Structural and Nonstructural Strategies

	Structural			Nonstructural			
Strategy	Green Infrastructure	Multiuse Treatment Areas	Water Quality Improvement	Increase # Of Structural Systems	Improve Structural Systems Performance	Initiatives To Change Behavior	Initiatives To Reduce Pollutants Directly
Flood Risk Reduction	YES	YES	YES	YES	YES	YES	
Irrigation Cost Savings	YES			YES	YES	YES	
Energy Cost Savings	YES			YES		YES	YES
Air Particulate Entrainment	YES			YES		YES	YES
Climate Impacts	YES			YES		YES	YES
Habitat Related Benefits							
Air Quality Emission Reduction	YES			YES		YES	YES
GHG Emission Reduction	YES			YES		YES	YES
Heat Island Effect	YES	YES		YES	YES	YES	
Aesthetics	YES	YES		YES	YES	YES	YES
Recreational Benefits	YES	YES		YES	YES	YES	YES
Noise Reduction							
Business Development & Jobs	YES			YES	YES	YES	YES
Crime Reduction							
Public Education/ Environmental Stewardship							

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Appendix 1: Benefit Calculations

This appendix discusses the quantitative calculations and data involved in estimating benefits for those categories which can be converted to monetary values, given site specific data. Benefit categories that can be readily quantified and monetized are discussed here. Benefit categories that are not included here are: Habitat Creation Benefits, Heat Island Effects, and Environmental Awareness / Stewardship.

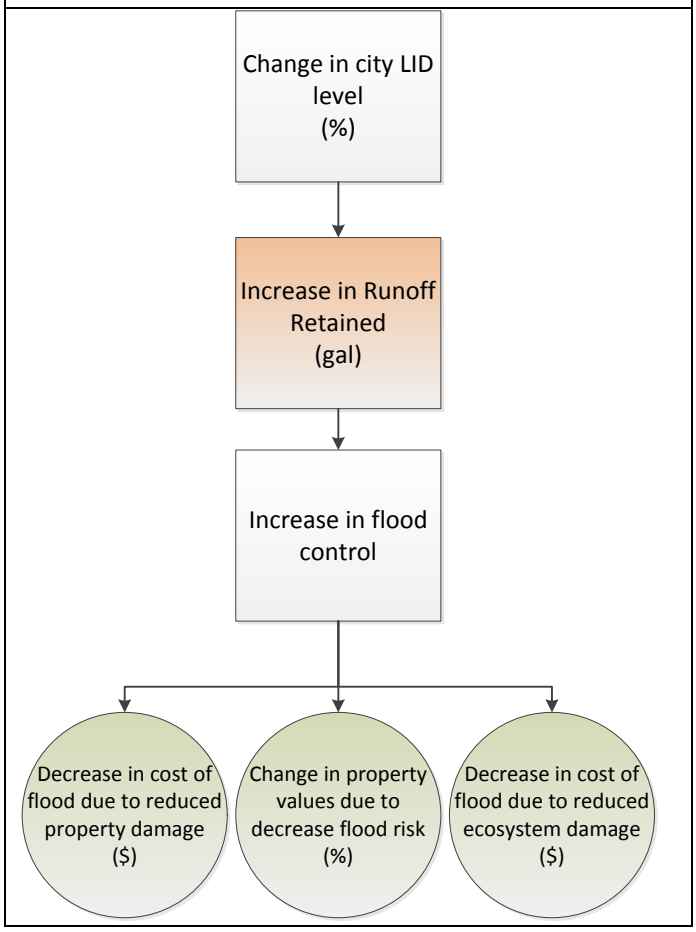
Flood Risk Reduction Benefits

By reducing the volume of storm water runoff, the proposed strategies can reduce the frequency and severity of flooding. The impact of green infrastructure on flooding is highly site and watershed specific, and thus this guide does not provide general instructions for quantifying the reduction in flood risk resulting from a green infrastructure program. There are several methods[20] for valuing the impact of flood control:

- Hedonic pricing to examine how flood risk is priced into real estate markets;
- Insurance premiums paid for flood damage insurance as a proxy for the value of reducing the risk of flood damage;
- Avoided damage cost approach; and
- Contingent valuation methods

The diagram presents a high level overview of how the benefits could be monetized. The 'Increase in Flood Control' could be monetized using any of the methods suggested above. Some methods have more robust information than others. CNT recommends using a range of 2–5 percent property value increase for removal from the floodplain (CNT, 2010).

Figure 3: Flood Control Benefits



[20] Downstream Economic Benefits From Storm-Water Management. Journal of Water Resources Planning and Management. Braden, J.B. and D.M. Johnston. November/December, 2004

Irrigation Cost Savings

The method for determining the irrigation cost savings begins with quantifying the reduction in water demand from utilities based on the amount that is harvested on site.

This amount can be calculated by using the various water retention factors for the various green infrastructure and multiplying by the annual precipitation.

A diagram is provided here that determines benefits of retention based on cost avoidance. This information would be used in calculating the Decrease in Potable Water. The cost of the water would be derived from local utilities.

Figure 4: Irrigation Cost Savings

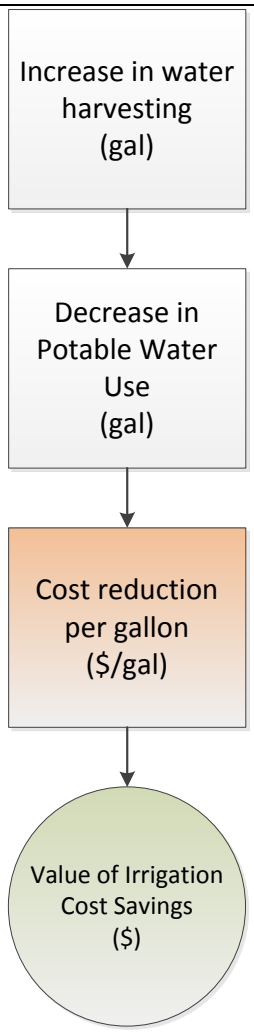


Table 19: Green Infrastructure Retention Parameters

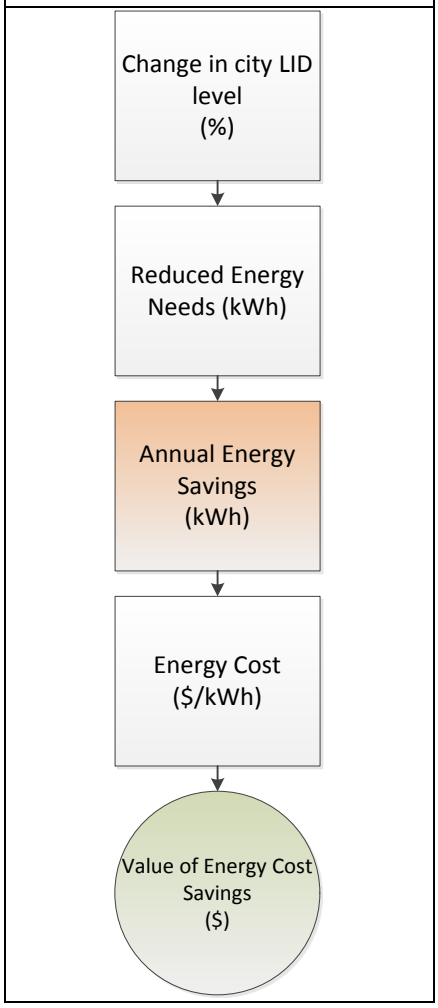
	Amount Retained	Unit	Scale
Water Harvesting	0.62	Gallons of runoff	Per inch of Rain

Source: CNT, 2010, McPherson, E. et al. 2006

Energy Cost Savings

The most important step in this calculation will be the reduced energy needs which will depend on the number of buildings which will benefit from the temperature control provided by green infrastructure and LID and the scale of LID/GI implementation. The data on the physical characteristics of GI to insulate or reduce energy use are provided as well.

Figure 5: Energy Cost Savings



The first step to valuing the benefits of reduced energy use is determining the amount of energy saved by BMP. The benefit of energy savings can be terms of kilowatt hours (kWh) of electricity and British thermal units (Btu) of natural gas reduced.

As noted, the total reduction is very specific to the type of improvement/change. The actual benefits realized in terms of energy savings due to the implementation of a green roof will be significantly impacted by the following variables:

- Growing media composition, depth and moisture content
- Plant coverage and type
- Building characteristics, energy loads and use schedules
- Local climate variables and rainfall distribution patterns

These characteristics will influence the R values for conventional and green roofs in region (which will be used to calculate the annual energy savings from reduced energy needs). Other data needs are:

- Annual number of cooling degree days (°F days) in your region
- Annual number of heating degree days (°F days) in your region

Having calculated the direct kWh and BTU saved in reduced building energy use, it is possible to assign a dollar value to these savings.

One may calculate the direct cost savings by multiplying the kilowatt hours or BTUs of electricity and natural gas, respectively, by local utility rates

Air Pollution Emission Reduction

Practices that indirectly lower emissions of air pollution include any practices that reduce energy consumption through decreased energy use in neighboring buildings or through reduced water treatment needs.

The kilowatt hours (or million BTUs) of reduced energy from the energy cost savings will be used in calculating the air pollution emission reduction benefit. The total amount of energy saved will be converted to the pounds of criteria pollutants reduced. The values, in dollars per pound, of the pollutants will come from existing guidance from the EPA and other sources that value these pollutants.

The EPA provides estimates for annual output emissions rates of national electricity production and natural gas:

Figure 6: Air Pollution Emission Reduction

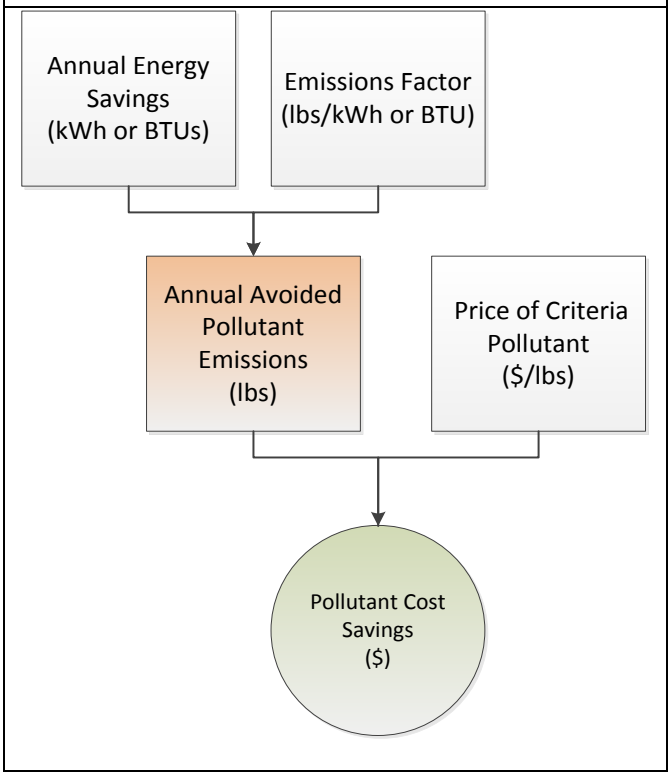


Table 20: Sample Criteria Pollutant Emission Factors

Pollutant	lbs/kWh	lbs/Million Btu
NO2	0.001937	0.721
SO2	0.005259	0.266

Table 21: Costs of Pollutants

Pollutant	Value per lb
NO2	$3.34
O3	$3.34
SO2	$2.06
PM-10	$2.84

Source: CNT (2010), McPherson et al. (2006), Wang and Santini (1995)

Greenhouse Gas Emission Reduction

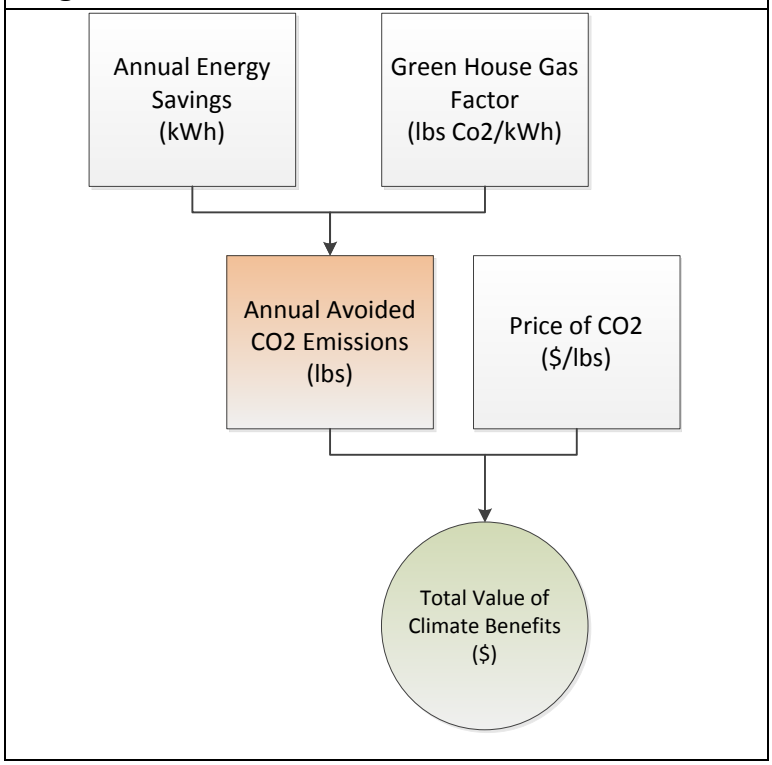
This benefit calculation follows the same methodology as the air pollution emission reduction benefit, only different conversion factors for CO2 will be used, and different monetary values.

The amount of CO2 emissions from power plants varies depending on the electricity source (e.g. coal, nuclear, wind, etc), so the EPA eGRID program should be consulted.

The CAMX subregion for 2010 has 932.82 lb per M Wh[21].

The current recommended price of CO2 is $40 per metric ton[22].

Figure 7: Greenhouse Gas Emission Reduction



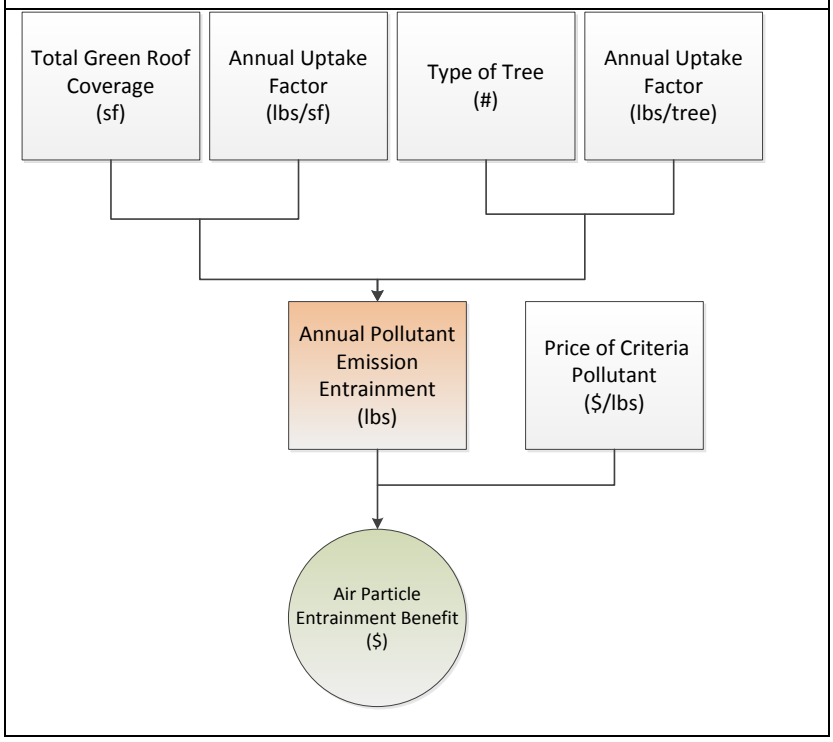
[21] http://www.epa.gov/cleanenergy/energy-resources/egrid/

[22] Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (May 2013; revised November 2013), page 18

Air Particle Entrainment

This section quantifies the direct uptake and deposition of air pollutants by green infrastructure and provides a framework for establishing value these impacts in monetary terms. The criteria pollutants addressed here are nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2) and particulate matter of aerodynamic diameter of ten micrometers or fewer (PM-10).

Figure 8: Air Particle Entrainment



Practices that provide a direct benefit of uptake and deposition include green roofs, trees and bio-infiltration. Similar to the methodology for emission cost savings from reduced energy use, the air particle entrainment benefits will quantify the amount (in pounds) of criteria pollutants removed from the environment. The total amount will depend on the scale of LID/GI and the type of GI. Table 22 provides values compiled by CNT (2010) per square foot of green roof installed. It should be noted that local values should be used if available (CNT, 2010). Factors such as local climates will influence plants ability to grow, and climates with longer growing seasons will see greater air quality improvements than those with shorter ones. Additionally, trees provide benefits in a similar manner. The Forest Service *Tree Guides* provides information for trees for particular climate regions (Table 23).

Table 22: Pollutant Removal Factors for Green Roofs

	Low (lbs/SF)	High (lbs/SF)
NO2	3.00×10^{-4}	4.77×10^{-4}
O3	5.88×10^{-4}	9.20×10^{-4}
SO2	2.29×10^{-4}	4.06×10^{-4}
PM-10	1.14x10-4	1.33x10-4

Table 23: Annual Criteria Pollutant Reductions, 40 year Average

	Small tree: Crabapple (22 ft tall, 21 ft spread)	Medium tree: Red Oak (40 ft tall, 27 ft spread)	Large tree: Hackberry (47 ft tall, 37 ft spread)
NO2	0.39 lbs	0.63 lbs	1.11 lbs
SO2	0.23 lbs	0.42 lbs	0.69 lbs
O3	0.15 lbs	0.2 lbs	0.28 lbs
PM-10	0.17 lbs	0.26 lbs	0.35 lbs

Carbon Sequestration

Similar to the air particle entrainment methodology, LID/GI can provide carbon sequestration benefits. The pounds of carbon sequestered per unit area depend on several local factors, including the specific practice, the types of species planted and the local climate.

For green roofs, the recommended range of grams of carbon sequestered per square meter from aboveground biomass, as determined by research synthesized in a Michigan State University report offers average carbon sequestration values provided by extensive green roofs' aboveground biomass (Getter et al. 2009).

Figure 9: Carbon Sequestration

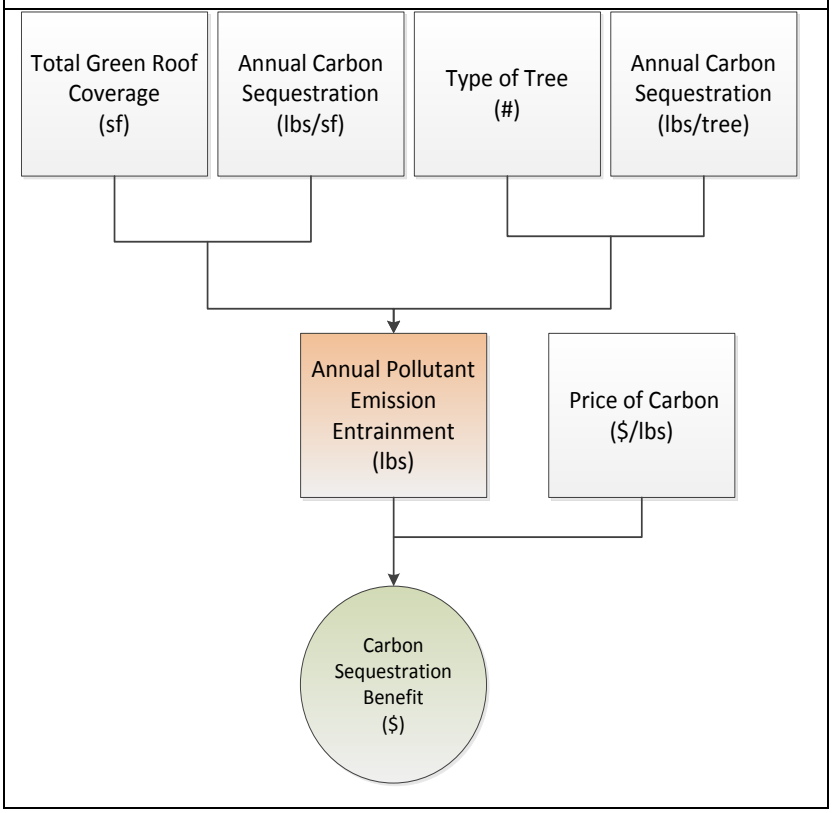


Table 24: Green Roof Carbon Sequestration Rates

	Low (lbs/SF)	High (lbs/SF)
CO2	0.0332	0.0344

Table 25: Sample Carbon Sequestration Rates for Different Trees

Net CO2 (lbs)	Residential Yard Opposite West-Facing Wall	Residential Yard Opposite South-Facing Wall	Residential Yard Opposite East-Facing Wall	Public Tree on a Street or in a Park
Small tree: Crabapple (22 ft tall, 21 ft spread)	390	226	335	336
Medium tree: Red Oak (40 ft tall, 27 ft spread)	594	212	487	444
Large tree: Hackberry (47 ft tall, 37 ft spread)	911	665	806	735

Aesthetic Improvements

The current method to calculate the benefit of aesthetics is to look at the changes in property values due to LID/GI. While the research on this subject supports the belief that there is a positive (increase) in property value due to LID/GI, there is much uncertainty regarding the size and scale of that. The methodology for calculating this benefit is to apply a premium on property that will capitalize on the aesthetic benefits of LID/GI.

Street trees and urban vegetation have been estimated by realtors to add $15,000 to $25,000 in value to a property compared to similar areas with o trees. The NRDC notes that buildings with green roofs can rent at a 16% premium.[23] Additionally, the NRDC reports that Tyrväinen and Miettinen (2000) found that units in multifamily buildings with views of trees or forest cover can increase rents by as much as 4.9 percent (Wolf 2007)[24].

Figure 10: Aesthetic Improvements

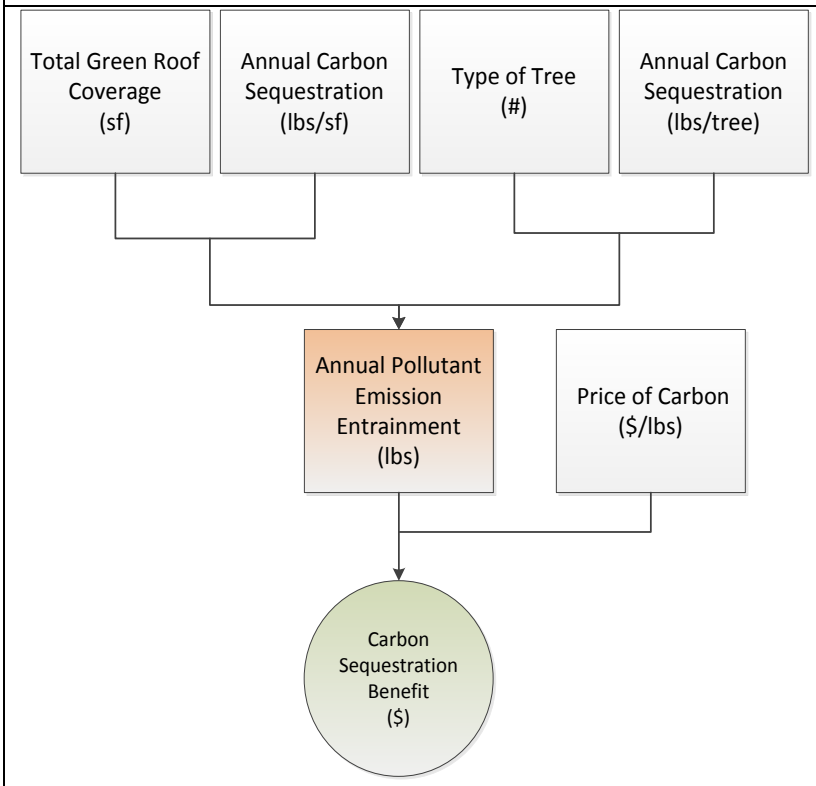


Table 26: Premiums on Property Value due to Aesthetics

Action	Monetized Benefit	Location	Source
LID and proximity to trees and other vegetation	0 to 7% Increase in Property Value	Philadelphia, PA	Stratus 2009
LID of adjacent properties	3.5 to 5% Increase in Property Value	King County, WA	Ward et al. 2008

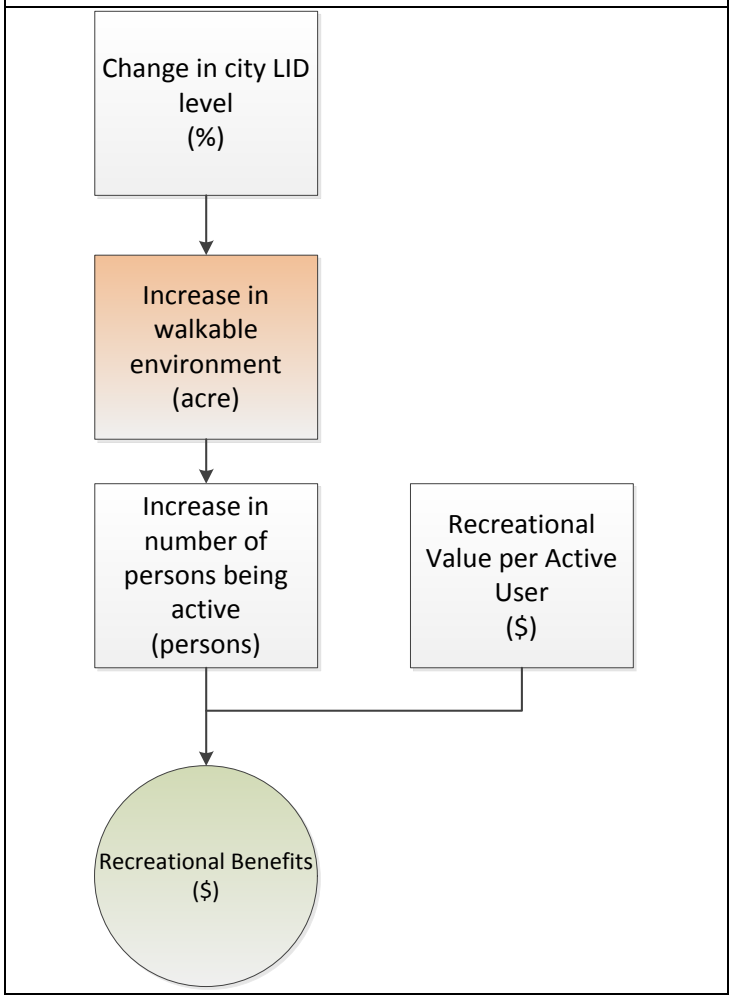
[23] Natural Resources Defense Council 2013

[24] Ibid

Recreation Benefits

The methodology for calculating this benefit will involve determining the total number of recreational users of the new LID/GI facilities and applying a monetary value per user to get total benefits.

Figure 11: Recreation Benefits



The total number of users will be based on local information. The monetized value of recreational benefits comes from different research fields. Some research from the transportation literature suggests benefits can be determined on an individual user basis. A wide variety of studies of outdoor recreational activities (non-bicycling) generated typical values of about $40 per day (in 2004 dollars).[25]

The value of time is estimated based on US DOT guidance for TIGER VI. The value of time for personal travel is $12.98 per hour. The benefit per trip for the appropriate facility is multiplied by the number of daily existing and induced commuters, and then doubled to include trips both to and from work. This results in a daily mobility benefit.

A premium on the value of a trip is developed from the January 2010 UK's Department of Transport *Guidance on the Appraisal of Walking and Cycling Schemes*. This Guidance reports a premium value of an off-road bicycle track versus an on-road facility. Hopkinson & Wardman (1996) developed estimates of on-road segregated cycle lane assuming benefits of £0.02 per minute. This benefit is assigned to existing recreational cyclists that would enjoy the new bike facility's quality, comfort and convenience.

[25] San Francisco County Transportation Authority Department of Parking and Traffic. *Maintain Bicycle Facilities (spreadsheet)*. 2004 2/28/2004, as cited in *Guidelines for Analyzing the Benefits and Costs of Bicycle Facilities*, Krizek et al., 2005.

Crime Reduction Benefits

Residents living in "greener" surroundings report lower levels of fear, fewer incivilities, and less aggressive and violent behavior. While there is not literature with respect to monetizing this benefit, there is research that looks at quantifying the benefit of crime reduction do to a greener environment. This study was performed in a public housing complex in an urban environment, so the actual percentage reduction may not be the same in other areas.

However, that does not mean there is no impact on crime. A possible methodology is to look at current crime levels in areas where proposed LID/GI will occur, and apply a reduction, but smaller in size than those listed below.

	Areas with Medium Level of Vegetation	Areas with High Levels of Vegetation
Total Crimes	42%	52%
Property Crimes	40%	48%
Violent Crimes	44%	56%

Source: Environment and Crime in the Inner City: Does Vegetation Reduce Crime? Kuo & Sullivan. Environment and Behavior, Volume 33 No.3, May, 2001

Business Development Benefits

In areas where green streets lead to an enhanced the sense of place, and increase in foot and bicycle traffic can support retail development. Case studies by the New York City DOT examined before and after changes in Retail Sales Tax Filings, Commercial Leases & Rents, and City−Assessed Market Value. The study's methodology does not ultimately prove causality between the street improvement projects and any resulting economic changes; however, some locations of green street development saw a significant increase in retail sales compared to the changes in retail sales for the borough as a whole.

Researchers do believe that any benefits from the green streets will be fully realized 2 years after development, and so applying this growth to retail sales further in the future is not applicable.

We can apply these percentages to current retail sales of businesses located along areas that will be developed into green streets to see the potential impact on businesses.

Table 27: Increase in Retail Sales after Street Development

Area	Change in Sales Year 1	Change in Sales Year 2
Vanderbilt Ave	39%	59%
Borough	27%	19%
Area	**Change in Sales Year 1**	**Change in Sales Year 2**
St. Nicholas Avenue/Amsterdam	18%	48%
Borough	17%	39%

Job Creation Benefits

Determining the number of jobs created, and the economic impact of those jobs, is simply a function of the total amount spent on the program. In general, the larger the area (or economic base) the larger the impact. Direct, indirect and induced economic impacts from spending on the strategies can be calculated using Economic Impact Analysis models.

The creation of jobs, and such, salaries for the workers to spend, would also have tax impacts at the State, Local, and Federal government level.

Current guidance on a methodology from the Council of Economic Advisors' [26] methodology as assumes that for every **$76,923** of additional government spending, one job-year is created. A job-year means one job for one year. To estimate the employment impacts in terms of job-years one simply adds up the number of jobs created every year over the analysis period.

The number of jobs created is a division of the total spending by the CEA recommended value.

[26] Executive Office of the President, Council of Economic Advisers, "Estimates of Job Creation from the American Recovery and Reinvestment Act of 2009," Washington, D.C., May 11, 2009; and September 2011 Update.

Appendix 2: Comprehensive List of Nonstructural Strategies

This list of strategies has been compiled from a review of each WAMP, CLRP and WQIP document

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
Jurisdictional Runoff Management Program (JRMP) Strategies			
Development Planning			
All Development Projects			
1	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement low-impact development (LID) BMPs to maintain or restore hydrology of the area, where applicable and feasible.	For all development projects, ensure source control BMPs	Increasing # of BMPs or LIDs
2	Amend municipal code and ordinances, including zoning ordinances, to facilitate and encourage LID opportunities.	Amend municipal code to encourage LID	Increasing # of BMPs or LIDs
3	Train staff on LID regulatory changes and LID Design Manual.	Train staff on LID regulatory changes and LID Design Manual.	Increasing # of BMPs or LIDs
Priority Development Projects (PDPs)			
4	For PDPs, administer a program requiring implementation of on-site structural BMPs or LIDs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of PDP structural BMPs or LIDs.	For PDPs, require implementation of on-site structural BMPs or LIDs	Increasing # of BMPs or LIDs
5	Update BMP Design Manual procedures to determine nature and extent of storm water requirements applicable to development projects and to identify conditions of concern for selecting, designing, and maintaining appropriate structural BMPs or LIDs.	Update BMP Design Manual procedures	Improve / Maintain BMPs or LIDs
	1. Amend BMP Design Manual for trash areas. Require full four-sided enclosure, siting away from storm drains and cover. Consider the retrofit requirement.		Improve / Maintain BMPs or LIDs
	2. Amend BMP Design Manual for animal-related facilities.		Improve / Maintain BMPs or LIDs
	3. Amend BMP Design Manual for nurseries and garden centers.		Improve / Maintain BMPs or LIDs
	4. Amend BMP Design Manual for auto-related uses.		Improve / Maintain BMPs or LIDs

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
6	Administer an alternative compliance program to on-site structural BMP implementation (includes identifying Watershed Management Area Analysis [WMAA] candidate projects).	Administer an alternative compliance program	Improve / Maintain BMPs or LIDs
	1. Develop a mitigation policy for public and private development projects that links development with mitigation within the same watershed.		Improve / Maintain BMPs or LIDs
	1a. Create an In-Lieu Fee		Improve / Maintain BMPs or LIDs
Construction Management			
7	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	Oversee implementation of BMPs during the construction	Improve / Maintain BMPs or LIDs
Existing Development			
Commercial, Industrial, Municipal, and Residential Facilities and Areas			
8	Administer a program to require implementation of minimum BMPs for existing development (commercial, industrial, municipal, and residential) that are specific to the facility, area types, and PGAs, as appropriate. Includes inspecting existing development at appropriate frequencies and using appropriate methods. (Inspections for PGAs of concern: Vehicle Washing area inspections and inspections for food-related businesses, animal-related businesses, nurseries and garden centers, and auto-related businesses.)	Require implementation of minimum BMPs for existing development	Improve / Maintain BMPs or LIDs
	1. Update minimum BMPs for existing residential, commercial, and industrial development and enforce them.		Improve / Maintain BMPs or LIDs
	2. Design, implement, and enforce property- and PGA-based inspections.		Improve / Maintain BMPs or LIDs
	1. Review policies and procedures to ensure discharges from swimming pools meet permit requirements.		Improve / Maintain BMPs or LIDs
	3. Develop a self-reporting inspection option for select industrial and commercial facilities.		Improve / Maintain BMPs or LIDs
9	Implement pet waste program. May include installation and maintenance of pet waste bag dispensers and trash bins, signage and education, physical removal of pet waste, or enforcement.	Implement pet waste program	Changing Behavior to reduce pollutants at the source
10	Promote and encourage implementing designated BMPs at residential areas.	Promote and encourage implementing designated BMPs at residential areas.	Increasing # of BMPs or LIDs
	1. Expand residential BMP (irrigation, rainwater harvesting, and turf conversion) rebate programs to multi-family housing in target areas.		Increasing # of BMPs or LIDs

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	2. Residential BMP: Rain Barrel		Increasing # of BMPs or LIDs
	3. Residential BMP: Irrigation Control (Turf Conversion)		Increasing # of BMPs or LIDs
	4. Residential BMP: Downspout Disconnect		Increasing # of BMPs or LIDs
	5. Provide financial incentives to property owners to convert landscaping to site-specific native plants.		Increasing # of BMPs or LIDs
11	Develop pilot project to identify and carry out site disconnections in targeted areas.	Develop pilot project to identify and carry out site disconnections in targeted areas.	Increasing # of BMPs or LIDs
12	Identify and reduce incidents of power washing discharges from nonresidential sites.	Identify and reduce incidents of power washing discharges from nonresidential sites.	Changing Behavior to reduce pollutants at the source
13	Promote and encourage implementation of designated BMPs in nonresidential areas.	Promote and encourage implementation of designated BMPs in nonresidential areas.	Increasing # of BMPs or LIDs
14	Proactively monitor for erosion, and complete minor repair and slope stabilization on municipal property.	Monitor for erosion, and slope stabilization on municipal property.	Increasing # of BMPs or LIDs
	MS4 Infrastructure		
15	Implement operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, detention basins, etc.).	Implement operation and maintenance activities	Removing pollutants or sources directly
	1. Optimize catch basin cleaning to maximize pollutant removal.		Removing pollutants or sources directly
	2. Proactively repair and replace MS4 components to provide source control from MS4 infrastructure.		Removing pollutants or sources directly
	3. Increase frequency of open-channel cleaning and scour pond repair to reduce pollutant loads.		Removing pollutants or sources directly
16	Implement controls to prevent infiltration of sewage into the MS4 from leaking sanitary sewers.	Implement controls to prevent infiltration of sewage into the MS4	Removing pollutants or sources directly

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	1. Identify sewer leaks and areas for sewer pipe replacement prioritization.		Removing pollutants or sources directly
Roads, Streets, and Parking Lots			
17	Implement operation and maintenance activities for public streets, unpaved roads, paved roads, and paved highways.	Implement operation and maintenance activities for public streets	Removing pollutants or sources directly
	1. Enhance street sweeping through equipment replacement and route optimization.		Removing pollutants or sources directly
	2. Initiate sweeping of medians on high-volume arterial roadways.		Removing pollutants or sources directly
	3. Increase maintenance on access roads and trails.		Removing pollutants or sources directly
18	Require sweeping and maintenance of private roads and parking lots in targeted areas.	Require sweeping and maintenance of private roads and parking lots in targeted areas.	Removing pollutants or sources directly
19	Identify sites for pilot study to test Permeable Friction Course (PFC), which is a porous asphalt that overlays impermeable asphalt.	Identify sites for pilot study to test Permeable Friction Course (PFC)	Increasing # of BMPs or LIDs
Pesticide, Herbicides, and Fertilizer Program			
20	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, and municipal properties. Includes education, permits, and certifications.	Require BMPs to address pesticides, herbicides, and fertilizers issues	Changing Behavior to reduce pollutants at the source
Retrofit and Rehabilitation in Areas of Existing Development			
21	Develop and implement a strategy to identify candidate areas of existing development appropriate for retrofitting projects and facilitate the implementation of such projects.	Identify candidate areas for retrofitting projects	Increasing # of BMPs or LIDs
22	Develop and implement a strategy to identify candidate areas of existing development for stream, channel, or habitat rehabilitation projects and facilitate implementation of such projects.	Identify areas for stream, channel, or habitat rehabilitation projects	Increasing # of BMPs or LIDs

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	IDDE Program		
23	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program per the JRMPs. Requirements include maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for publicly reporting illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Implement Illicit Discharge, Detection, and Elimination (IDDE) Program	Changing Behavior to reduce pollutants at the source
	Public Education and Participation		
24	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce pollutant discharge in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Implement a public education and participation program	Changing Behavior to reduce pollutants at the source
	1. Expand outreach to homeowners' association (HOA) common lands and HOA rebates.		Changing Behavior to reduce pollutants at the source
	2. Develop an outreach and training program for property managers responsible for HOAs and maintenance districts.		Changing Behavior to reduce pollutants at the source
	3. Conduct trash cleanups through community-based organizations involving target audiences.		Changing Behavior to reduce pollutants at the source
	4. Target human behavior in parks and other public areas including trash reduction or other high-impact behavior to habitat, wildlife, and water quality.		Changing Behavior to reduce pollutants at the source
	5. Improve consistency and content of websites to highlight enforceable conditions and reporting methods.		Changing Behavior to reduce pollutants at the source
	6. Contribute to San Diego County-led effort through regional education group for outreach, education, and policy measures for the equestrian community and property owners.		Changing Behavior to reduce pollutants at the source
	1. Develop a targeted education and outreach program for homeowners adjacent to or with tributaries or streams within their property.		Changing Behavior to reduce pollutants at the source
	1. Develop a targeted education and outreach program for homeowners with orchards or other agricultural land uses on their property.		Changing Behavior to reduce pollutants at the source

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
	2. Enhance school and recreation-based education and outreach		Changing Behavior to reduce pollutants at the source
	3. Develop education and outreach to reduce over-irrigation		Changing Behavior to reduce pollutants at the source
	7. Develop regional training for water-using mobile businesses.		Changing Behavior to reduce pollutants at the source
25	Enhance education and outreach based on results of effectiveness survey and changing regulatory requirements.	Enhance education and outreach	Changing Behavior to reduce pollutants at the source
26	Provide technical education and outreach to the development community on the design and implementation requirements of the MS4 Permit and Water Quality Improvement Plan requirements.	Technical education and outreach on the MS4 Permit and WQIP	Changing Behavior to reduce pollutants at the source
Enforcement Response Plan			
27	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Implement escalating enforcement responses to compel compliance	Changing Behavior to reduce pollutants at the source
	1. Increase enforcement of over-irrigation.		Changing Behavior to reduce pollutants at the source
	2. Focus locally on enforcement of water-using mobile businesses.		Changing Behavior to reduce pollutants at the source
28	Increase identification and enforcement of actionable erosion and slope stabilization issues on private property and require stabilization and repair.	Enforcement of actionable erosion and slope stabilization issues	Increasing # of BMPs or LIDs
Optional Strategies			
29	Continue participating in source reduction initiatives. (Varies. For example, the Brake Pad Partnership is existing. Considered may be a plastic bag ban, banning leaf blowers, banning pesticides or herbicide.)	Continue participating in source reduction initiatives.	Changing Behavior to reduce pollutants at the source
30	Develop a program to address and capture trash and debris.	Develop a program to address and capture trash and debris.	Removing pollutants or sources directly

ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
31	Support partnership efforts by social service providers to provide sanitation and trash management for persons experiencing homelessness.	Sanitation and trash management for persons experiencing homelessness.	Removing pollutants or sources directly
32	Protect areas that are functioning naturally.	Protect areas that are functioning naturally.	Removing pollutants or sources directly
	1. Develop a policy to avoid additional hardscape development and degradation in unpaved open space areas.		Removing pollutants or sources directly
	2. Add permanent open space protections to undeveloped city-owned land.		Removing pollutants or sources directly
	3. Acquire privately owned undeveloped parcels of land.		Removing pollutants or sources directly
	Mapping and risk assessment of agricultural operations.		Removing pollutants or sources directly
	Implement a program to target on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.		Removing pollutants or sources directly
	Removal of invasive plants and animals.		Removing pollutants or sources directly
33	Conduct a feasibility study to determine if implementing an urban tree canopy (UTC) program would benefit water quality and other goals.	Conduct a feasibility study on urban tree canopy (UTC) program	Increasing # of BMPs or LIDs
	Investigate alternative pollutant removal or treatment strategies such as fungus used to remove soil contaminants.		Removing pollutants or sources directly
34	Conduct special studies to gather additional monitoring information about priority conditions or beneficial uses. (Monitoring may include investigative measures such as genetic tracking for bacteria sources or geomorphic studies for sediment sources or processes. - LOS PEN)	Gather monitoring information about priority conditions or beneficial uses	Improve / Maintain BMPs or LIDs

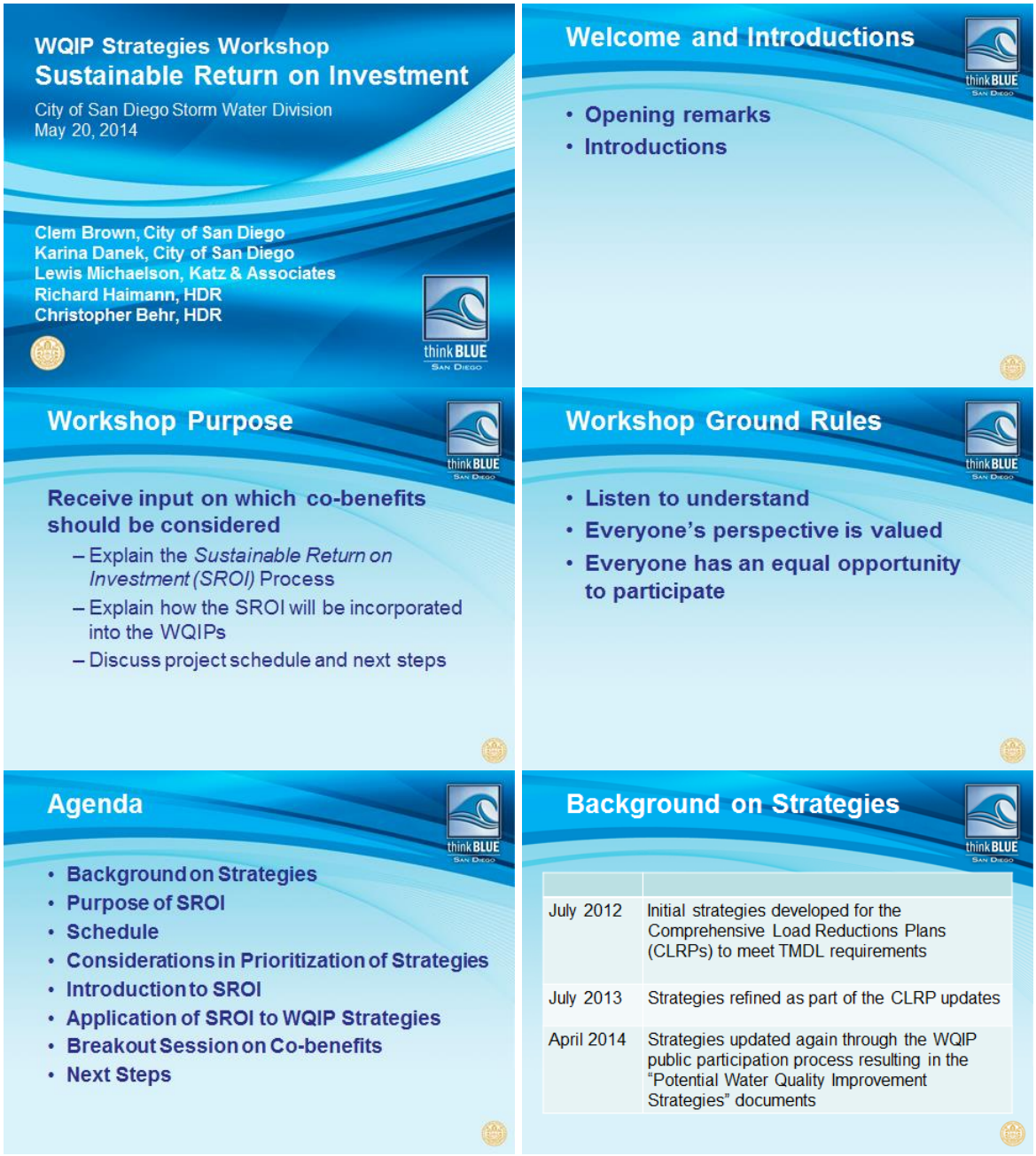
ID	NONSTRUCTURAL STRATEGY (Official Description)	Short Description	Category
35	Collaborate with entities potentially including, but not limited to:	Collaborate with entities potentially including, but not limited to:	Improve / Maintain BMPs or LIDs
	• Departments within the same Responsible Agency.		Improve / Maintain BMPs or LIDs
	• Other governmental agencies such as water, transportation, or public health agencies.		Improve / Maintain BMPs or LIDs
	• Nongovernmental agencies such as environmental and community groups and private corporations.		Improve / Maintain BMPs or LIDs
	• Dischargers regulated under other permits including the Phase II National Pollutant Discharge Elimination System (NPDES) Permit, Industrial General Permit, and Construction General Permit.		Improve / Maintain BMPs or LIDs
	Collaboration may take the form of joint participation in stakeholder meetings, studies or development studies or BMPs, hiring of a Watershed Coordinator to facilitate communication between community groups and the City, formation of a City Watershed team to protect and restore the watershed, or participating in existing groups, such as Integrated Regional Water Management (IRWM) groups.		Improve / Maintain BMPs or LIDs
	1. Funding for collaborative strategies may include providing in-kind services, shared costs through agreements, and preparation and competition for grant funding.		Improve / Maintain BMPs or LIDs
Added			
	Vehicle Washing areas supplemental standards		Improve / Maintain BMPs or LIDs
	Keeping of large animals		Improve / Maintain BMPs or LIDs
	Xeriscaping, turf conversion and other irrigation, pesticide and fertilizer reduction (Caltrans specific. CLRP P. E-19)		Changing Behavior to reduce pollutants at the source
	Garden and landscape practices (primarily for Contractors. Otherwise covered in W.)		Changing Behavior to reduce pollutants at the source
	Increase street sweeping frequency (otherwise covered in P.)		Improve / Maintain BMPs or LIDs
	Rebates/Incentives to residential and non-residential. (Otherwise covered in J.)		Improve / Maintain BMPs or LIDs

Notes: Purple highlighting where there was a modification between the "Potential Strategies" documents.

Appendix 3: Workshop Summary

This section includes the presentation provided to the stakeholders, which guided discussion on benefits. Stakeholder comments were written down post workshop and sent back to the Division for consideration. These comments are included below.

Workshop Presentation

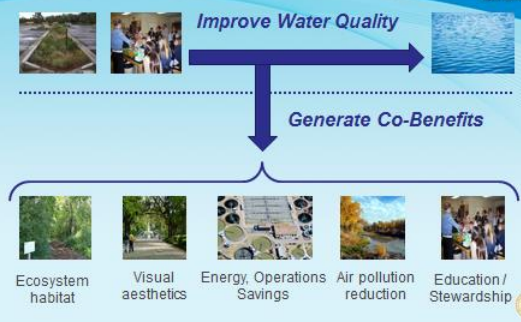


Schedule

May 20, 2014	Co-benefit Workshop
May 27, 2014	Comments on Co-benefits Due
June - August 2014	Preliminary SROI Analysis
Late August, 2014 (tentative)	SROI Workshop Review
September, 2014	Finalize Analysis
Late September 2014	Potential Changes to WQIP Strategies (non-structural)

Choices

Co-benefits



How to choose

- Desirable Elements of Decisions
  - Quantitative measures
  - Transparent assessment
  - Objective evidence
  - Account for uncertainty
  - Provide best value

Ultimately… need to know:
What is the best value?
How do you know?

Introduction to Sustainable Return on Investment (SROI) Process

- Best practices:
  - Objective, theory-based
  - Peer-reviewed evidence
  - Life cycle monetary outcomes
  - Accounts for uncertainty
  - Avoids double-counting
- Key Features:
  - Comprehensive
  - Transparent analysis
  - Impact distribution
  - Adaptable to local conditions
  - Decision metrics that matter

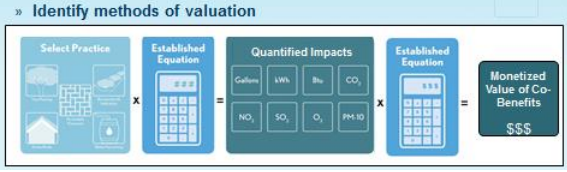
SROI: A Four Step Process

- Step 1: Determine Co-Benefits
  - Determine key performance metrics
- Step 2: Preliminary Analysis
  - Research and analyze potential project performance
- Step 3: Stakeholder Workshop
  - Review methods, metrics and risks
- Step 4: Quantitative Analysis
  - Generate results for decision making

Application of SROI to Prioritizing Potential Strategies

- Identify types of co-benefits (examples)

- Identify methods of valuation



Alignment of Strategies to Co-Benefits

Structural Strategy (Examples)	Economic		Environmental				Societal (Quality of Life)				
	On-site Energy Savings	Operational Cost Savings	Carbon Sequestration	Carbon Emissions Reduction	Visual Aesthetics	Ecosystem / Habitat	Air Quality	Urban Heat (esp. with trees)	Property Value	Recreation (access dependent)	Jobs
Green roof	O	⊗	⊗	⊗		×	⊗		×		⊗
ROW bio-swales (with trees)		⊗	⊗	⊗		×	⊗	O	⊗		⊗
Large Bio-retention Facilities		⊗	⊗	⊗	O	×	⊗		O	⊗	⊗
Porous pavement		⊗		⊗			⊗		O		⊗

⊗ Measurable and Monetizable Benefit
× Measurable Benefit
O Perceived Benefit

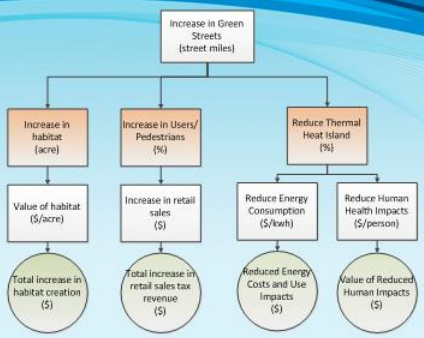
Potential Structural Strategies

- **Green Infrastructure**
  - Green streets, permeable pavement etc.
- **Multiuse Treatment Areas**
  - Infiltration and detention basins, stream rehabilitation, etc.
- **Water Quality Improvement**
  - Trash segregation, Proprietary BMPs, etc.

Co-Benefits of Green Streets

- » **Unit of Measure**
  - » Street miles of improvements
- » **Drivers of Impact**
  - » Water retained
  - » Type of improvement (trees, etc.)
- » **Key Co-Benefits**
  - » Habitat creation
  - » Business investment
  - » Human health improvement
  - » Energy Reduction

Green Streets Co-Benefit Calculations



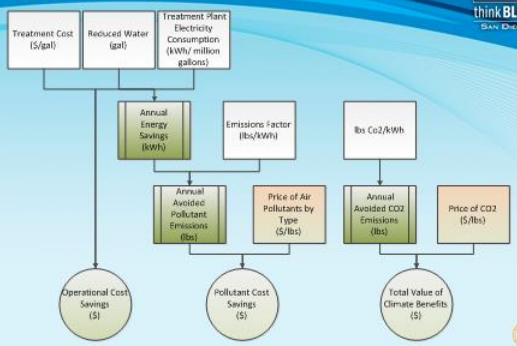
Potential Non-Structural Strategies

- » **Increase # of structural systems**
  - Training, promotion, etc.
- » **Improve structural systems performance**
  - Design codes, monitor, etc.
- » **Initiatives to change behavior**
  - Education, enforcement, outreach, reduced pesticides, etc.
- » **Initiatives to reduce pollutants directly**
  - Street sweeping, protect natural areas, etc.

Co-Benefits of Water Harvesting Strategy

- » **Unit of Measure**
  - » Reduction in stormwater runoff
- » **Drivers of Impact**
  - » Less water processed
- » **Key Co-Benefits**
  - » Reduced water consumption, less municipal water diversion
  - » Reduced energy use and air pollution, GHG impacts

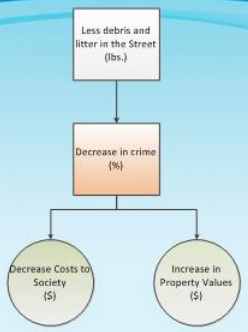
Water Harvesting Co-Benefit Calculations



Co-Benefits of Education / Promotion of Think Blue Campaign

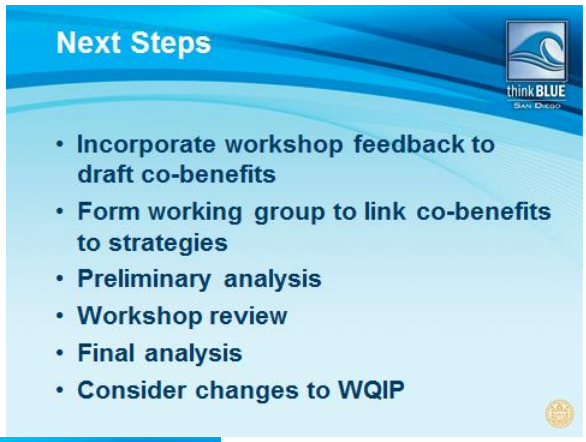
- » **Unit of Measure**
  - » # of people reached
- » **Drivers of Impact**
  - » # of people who reduce litter
- » **Key Co-Benefits**
  - » Improved residential neighborhoods aesthetics
  - » Increase in business investment reduction in crime

Think Blue Program Co-Benefit Calculations (Partial)



- **Evidence**
  - Cleaner environments leads to decrease in crime
  - Urban housing with higher levels of vegetation and clean street showed decline in crime in nearby buildings

Breakout Session
Property Owners
Aesthetics
Flood Control
Business Investment
Environmental
Green House Gas Reductions
Habitat Creation
Soil Stabilization
General Public
Recreational
Human Health
Stewardship
Heat Island
Air Quality
Crime Reduction
Operational Cost Savings
Jobs
Other
?


Next Steps
• Incorporate workshop feedback to draft co-benefits
• Form working group to link co-benefits to strategies
• Preliminary analysis
• Workshop review
• Final analysis
• Consider changes to WQIP

Closing Remarks
Questions?
Thanks for your participation!

Workshop Handout:

Water Quality Improvement Plans Co-Benefits Description Workbook

Co-Benefit: Aesthetics

Description: Visually appealing environments in communities, especially neighboring properties

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, # of Affected Properties, Proximity to BMP, % increase in Property Value

Unit of Value: $ increase per property

Comments:

Co-Benefit: Air Quality

Description: Reduction of pollutants which cause health impacts

Unit of Measure: Tons of Pollutant

Drivers of Value: Reduction in Energy Use, Increase in Absorbtion of Air Pollutants

Unit of Value: $ per ton of pollutant reduced

Comments:

Co-Benefit: Business Development

Description: Increase in investment and revenue in clean, walkable environments

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, # of Affected Properties,

Proximity to BMP, % pedestrian activity

Unit of Value: $ increase in retail sales

Comments:

Co-Benefit: Crime Reduction

Description: Clean/green neighborhods reduce incidents

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, # of Affected Properties,

Proximity to BMP, % decrease in crime incidents

Unit of Value: $ per incident reduced

Comments:

Co-Benefit: Environmental Stewardship

Description: Increased awareness and environmental responsibility

Unit of Measure: # of persons educated

Drivers of Value: Population

Unit of Value: # of persons educated

Comments:

Co-Benefit: Flood control

Description: Reduced flood risk

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: $ Cost per flood

Unit of Value: $ per flood damage reduced

Comments:

Co-Benefit: Green House Gas Reduction

Description: Reduction of CO2

Unit of Measure: Tons of CO2

Drivers of Value: Reduction in Energy Use, Increase in Carbon Sequestration

Unit of Value: $ per ton of CO2 reduced

Comments:

Co-Benefit: Habitat Creation

Description: Protection or Creation of habitats

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: Acres of urban habitat protected/create

Unit of Value: $ per reduced heat related illness

Comments:

Co-Benefit: Heat Island Reduction

Description: Reduced ambient temperatures

Unit of Measure: Area of BMPs

Drivers of Value: # of Reduced Heating Degrees Days

Unit of Value: $ benefits from reduction in health

Comments:

Co-Benefit: Jobs

Description: Increase in # of local jobs in installation and maintenance

Unit of Measure: Capital & Maintenance Expenditures

Drivers of Value: $ spent

Unit of Value: Number of jobs created

Comments:

Co-Benefit: Operational Savings

Description: Reduction in energy use to process water

Unit of Measure: Gallons of water reduced

Drivers of Value: Cost per gallon processed

Unit of Value: $ per gallon of Water Reduced

Comments:

Co-Benefit: Public Health

Description: Reduced exposure to pesticides and other chemicals

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: # and Type of BMP, Ton of chemicals reduced

Unit of Value: $ per ton of chemicals reduced

Comments:

Co-Benefit: Recreation

Description: Increase in walkable environment

Unit of Measure: Size of recreational facility

Drivers of Value: Number of Recreational Users

Unit of Value: $ per recreational user

Comments:

Co-Benefit: Soil Stabilization

Description: Reduction in soil erosion

Unit of Measure: Area of BMPs or Reduction in Street Debris

Drivers of Value: Acres of Stabilized Soil, Cost of Land Damage

Unit of Value: $ per acre of soil protect

Comments:

Workshop Comments Received

	Structural		
	Green Infrastructure (co-benefits)	Multi-Treatment Areas	Water Quality Improvements
1	Given that on the mesas, we have mostly clay soils that do not absorb storm water runoff, some of these potentials are limited. However, implementation of cisterns, vegetated filter strips, etc. have the potential to * Decrease flood risks as water is released into existing creeks over a longer period of time * Improve habitat as habitat is changing due to excessive water from urban run off (especially dry weather run off) * Dry water flow diversions will also reduce the excessive flows in many of our streams (compared to historical conditions)		
2	Topographic Blending of BMP/IMP approaches: upper watershed, mid, lower, coast Need to think beyond MS4 Parkways/sidewalks as filters, volume reduction, peakflow	Athletic Fields Parks - temp flooding,sedmiment capture	Micro - capture/treat; avoid regional systems Let habitat/green space do treatment
3	Comprehensive approach to improve water quality, reduce storm runoff and dry weather flows while providing education/outreach, as well as improving quality of life (improved feeling of "wellness", reduction in health costs associated with polluted and/or stressful environments). Weight native landscapes (endemic to location) to give higher value than standard palette approach that uses species that excel in erosion control and/or coverage to meet landscaping sign off criteria as quickly as possible	Construct facilities (e.g. detention basins) that are specifically designed for the location versus "cookie-cutter" approach to design and implementation. Favor designs that can be passively converted back to native landscapes (e.g. basin becomes a wetland). Weight native landscapes (endemic to location) to give higher value than standard palette approach that uses species that excel in erosion control and/or coverage to meet landscaping sign off criteria as quickly as possible. Factor in maintenance needs (costs, access, mitigation, permits) and responsibilities into design and implementation. Consult with other divisions and departments within the City, as well as consultation with key stakeholder groups (neighboring communities, jurisdictions, NGOs that include	KEY CO-BENEFITS - Eliminating dry weather flows and reducing peak flows of storm runoff will provide a suite of co-benefits. Freshwater itself causes problems when inputs become perennial (e.g. habitat conversion, non-native species introduction and establishment, vector breeding habitat). More effective management and (hopeful) elimination of dry weather inputs could provide co-benefits by reducing the aforementioned impacts and assist in efforts to mitigate and, eventually, remediate them. Eliminating dry weather inputs will be needed for compliance for the Los Penasquitos Lagoon's Sediment TMDL, since restoring salt marsh habitat within the lagoon in areas recently converted to brackish/freshwater habitat is one of the key compliance targets. Eliminating dry weather flows will also assist in compliance with the County-wide bacteria TMDL, since many "hot spots" are created or exacerbated by dry weather flows. Peak flows of storm runoff augmented by MS4 design or placement can create

	Structural		
	Green Infrastructure (co-benefits)	Multi-Treatment Areas	Water Quality Improvements
		non-profit management entities) to avoid conflicts in BMP implementation that include violation of NPDES permits, TMDLs, downstream impacts to receiving water bodies and valued habitats, creation of breeding habitat for harmful vectors, etc.	another suite of nasty things with regard to water quality that include loaded and delivery of contaminants to receiving water bodies, as well as contribute greatly to erosion and downstream sedimentation that create additional maintenance costs (e.g. digging out a box culvert or clearing sediment from a street) and can impact sensitive habitats that include receiving water bodies. Managing peak flows will also be needed to comply with the Lagoon's sediment TMDL, the county-wide bacteria TMDL, and load reductions for constitutes of concern and other harmful pollutants (e.g. pyrethroids) that cause impacts but have yet to be labeled "constituent of concern." Co-benefits of water quality improvements will need to consider improving the conditions of receiving water bodies (reduced bacteria loads, loss of functional habitats native to the region) rather than box checking to meet compliance targets (reduction of % of load by certain date, sending X amount of educational fliers out to communities). This will most likely involve consideration of qualitative data at some point, which should be captured some how (e.g. using it to weight criteria or alternatives under consideration. 10 Need to internalize costs associated with unintended and/or offsite consequences. For example - habitat conversion or creation of vector breeding habitat as a result of lowflow diversion that simply moves dry weather runoff somewhere else instead of addressing source(s) of the dry weather flows.
		Follow a comprehensive approach that considers benefits and impacts of both individual BMPs and a network of BMPs implemented throughout the watershed, including 9 receiving water body and valued habitats. Avoid knee-jerk reaction of putting out fires at specific locations. Rather, develop a comprehensive and adaptive approach that can be phased in over time to address water-quality priorities throughout their stages (shortterm, mid-term, long-term), take advantage of windows of opportunities (e.g. grant funding ops) and efficiently use available funding while setting up justification for future (and, when needed continuous) funding needs.	
4	Possible portable water purification systems that operates on solar/wind energy	Treat the water before it enters the main body of water (canal, creek, river, lagoon, bay, ocean) by means of detention ponds, catch basins, vaults, diversion systems, sump wells, or any underground storage unit.	Removing bacteria and metals that are associated with trash and run-off.
5			

	Non-Structural			
	Increase Number of Structural Systems (co-benefits)	Improve Structural System Performance	Initiatives to Change Behavior (co-benefits)	Reduce Pollutants directly
1	Stream and/or habitat rehabiliation projects will increase biological diversity and provide more nature in our neighborhoods. Multi-treatment areas when focused on habitat restoration will enhance recreational opportunities, improve air quality, enhance aesthetics, contribute to heat island reduction, create jobs for upkeep and maintenance and providing living laboratories for our children to take their classroom learning into the field.		Initiatives to educate public and professional users of pesticides, herbicides and fertilizers will increase human health. Requiring interagency teams to deal with issues of homelessness will increase public safety while at the same time reducing feces and other toxic substances in our water. Initiatives to encourage proper disposal of pet waste will increase human health Initiatives to more quickly remove trash from recreational areas to keep them out of surface water will also improve recreational experiences and increase human health by limiting the amount of food available to rodents and hence reduce the rat population. Insuring that trash containers are available in all areas will keep trash out of surface water and will also improve recreational experiences and increase human health by limiting the amount of food available to rodents and hence reduce the rat population.	

	Non-Structural			
	Increase Number of Structural Systems (co-benefits)	Improve Structural System Performance	Initiatives to Change Behavior (co-benefits)	Reduce Pollutants directly
2	School Cirriculum, Incentives			
3	Improve or replace existing MS4 structures before building new ones when feasible (the City cannot maintain what it has now, let alone new structures) Hire additional staff to manage permits and contracts to third-parties hired to assist Storm Water Division. improve enforcement actions (e.g. controlling dry weather runoff that meets water quality criteria or circumvents MS4 (e.g. freshwater mounding) but still creates impacts to receiving waters, such as habitat conversion, invasive plant establishment, breeding habitat for disease transmitting vectors).	Design and implement monitoring programs that make sense (e.g. answers questions or generates useful data) rather than just following programmatic lines. Review and enforce third-party agreements (e.g. HOAs maintaining private BMPs). Provide incentives to landowners and businesses to comply with hydromod requirements in areas already developed (and exempt from hydromod regs)	Coordinate with other stakeholder groups (e.g. NGOs) to help promote efforts that provide co-benefits to local communities and clarify/modify resource regulation that does not apply or should not in certain cases where lines of evidence support the effort over the regulation. Promote and incentivize native landscapes and water re-use	Improve controls over dry weather flows to address freshwater mounding and seepage into the MS4 or open space areas. Remove City infrastructure (e.g. MS4, sewer lines, water lines) from sensitive lands (e.g. Los Peñasquitos Lagoon).
	Include lessons learned from case studies regarding design, implementation and maintenance. Use site specific design and implementation rather than cookie-cutter approach to BMP and private properties (e.g. Hansen Agregate). Re-locate businesses built and operating in the flood zone (e.g. Sorrento Valley) as a longterm solution that is more cost-effective than annual maintenance and lawsuits.			

	Non-Structural			
	Increase Number of Structural Systems (co-benefits)	Improve Structural System Performance	Initiatives to Change Behavior (co-benefits)	Reduce Pollutants directly
4	Private properties, as mentioned by the participants of the meeting on May 20th. (My company has had the privilege or working with Barona Casino I Barona Creek Golf where we found that they recycle all or their water run-off including rain, pavement, parking structure, landscaping and irrigation, which they all filter into one pond system for treatment. In addition, they are in the process of building reservoirs.}	Retrofit new proprietary technologies into existing structures by enhancing performance, focusing on set goals of contaminants of concern as overseen by SDRWQCB, EPA, etc. (Quantum Ozone has retrofitted into an existing vault/Catch Detention System prior to entering into a State Park, into a County Flood Tunnel, and also into existing ponds/lakes/reservoirs. We are open to any county/city or private property that would be willing to co-venture on a pilot project.)	Research outside the box of standard set BMP guidelines, to more natural /innovative technologies that are not part of existing BMPs. For example, ozone is 3,125 times more powerful than chlorine, and the misconception of it being "harmful" is due to lack of education. When properly applied, ozone will not cause negative bi-products, as Quantum Ozone has proved by not producing one negative bi-product in 7 years. We are an ozone planet, constantly having 0.02 parts per million of ozone constantly around us naturally.	Ground level education and awareness to future generations (3rd grade on up) to have Environmental Stewardship as part of the school curriculum along with' history and math, so that the governments that they create in the future will have these ideas naturally implemented into city maintenance and daily living.
5				Strategy: Elimination, to the maximum extent possible, of toxic chemicals in the environment, including herbicides, pesticides, detergents, poisons, paints, and petrochemicals. Co-benefit: an urban ecosystem that supports, to the maximum extent possible, a functioning food web from micro organisms to invertebrates and vertebrates. Co-benefit: recreation and educational opportunities in the form of diverse and inter-dependent organisms to observe and study. Co--benefit: swimmable and fishable waters.