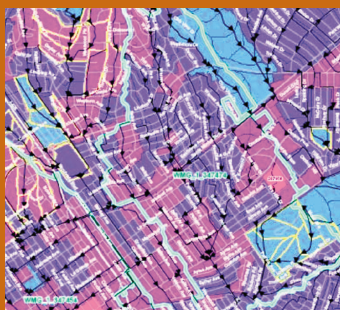
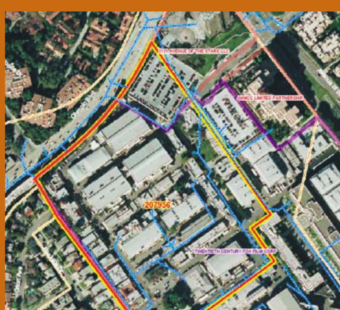
Los Angeles County-Wide

Structural BMP Prioritization Methodology

A Guidance Manual for Strategic Storm Water Quality Project Planning



Catchment Prioritization



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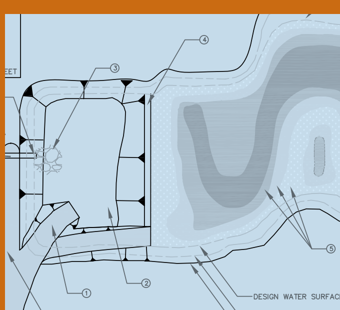

General BMP Evaluation

Site-Specific BMP Evaluation

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GUIDANCE MANUAL

Los Angeles County-wide
Structural BMP
Prioritization Methodology

2006

Submitted by:

County of Los Angeles – Department of Public Works
Heal the Bay
City of Los Angeles – Bureau of Sanitation
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1 INTRODUCTION

BACKGROUND

Runoff from Los Angeles County's urban landscape carries many pollutants into local creeks, rivers, Santa Monica Bay and the Pacific Ocean. Among the contaminants are gasoline, oil, metals, pesticides, fertilizers, detergents, bacteria, viruses and fecal matter. Curbing runoff pollution is a countywide priority driven not only by state and federal water quality regulations, but also by local and regional pollution prevention plans and environmental objectives.

The primary tools for reducing runoff pollution are usually referred to as best management practices (BMPs). BMPs are often categorized as either structural or nonstructural. Structural BMPs are those that improve water quality through some treatment mechanism. The mechanism can be regional, like a constructed wetland, or highly localized, like a parking lot bioretention swale. Examples of nonstructural BMPs are public education and ordinance-based controls.

To date, the implementation of structural BMPs in developed areas of the Los Angeles region has been largely opportunistic and site-specific. Projects are completed in response to a specific local funding opportunity or regulatory requirement, and often focus on only one or two pollutants (or sources). Project locations are often chosen based on land availability and public ownership, so sites such as school yards and parks are favored. Implementation planning has not emphasized the strategic location of BMPs that have been chosen to maximize pollution reduction within a watershed or other targeted geographic area.

OBJECTIVE

The objective of this project was to develop a new, systematic way of prioritizing structural BMP projects within Los Angeles County watersheds to optimize pollutant reductions in a cost-effective manner. The product of method application is the identification of high priority BMP projects including BMP type and project location. The GIS-based tool is designed to help watershed planners, managers, and stakeholders throughout LA County in preliminary, conceptual planning of structural BMP placement within a watershed.

The Los Angeles Countywide Structural BMP Prioritization Methodology (Methodology) meets a critical need in stormwater planning and management for Los Angeles County by providing a systematic, transparent, and reproducible methodology for ranking BMP implementation opportunities. The strength of the Methodology is its ability to consolidate and balance multiple issues and multiple data sources in a semi-automated, transparent, and reproducible manner. It is the strongest systematic approach to BMP planning yet developed for the Los Angeles region.

OVERVIEW OF THE METHODOLOGY

The Methodology is a tool designed to identify higher-priority, structural BMP projects within a watershed in a manner that maximizes improvements in stormwater quality. The tool is designed as a high-level, conceptual planning tool developed to help watershed groups, municipalities and regulators with structural BMP implementation. The Methodology identifies and prioritizes structural BMPs including small-scale distributed BMPs and large-scale regional BMPs. The tool employs GIS to aid the user in weighing the many factors that play a role in structural BMP placement within a watershed. Watershed factors include pollutants of concern, existing regulations, beneficial uses, land availability, existing stormwater infrastructure, and area of high pollutant loading. BMP factors include cost, effectiveness, and ability to implement. Additionally, the tool includes step-by-step procedures for desk-top and field validation of identified projects.

Specifically, the Methodology was designed to:

- Address wet-weather conditions only. However, some dry weather flow benefits would indirectly be gained through wet-weather structural BMP implementation
- Apply to all watershed within Los Angeles County
- Be semi-automated, GIS-based
- Use existing data to the maximum extent possible
- Be flexible and transparent so that stakeholders and stormwater managers throughout LA County can quickly adapt the method to their watershed needs and goals
- Be used in an iterative manner so that users can run multiple scenarios for their watershed
- Be adaptive so that future information can be incorporated into the Methodology as our knowledge and data sources improve
- Be easily accessible and useable by many stakeholders within Los Angeles County. A free comprehensive guidance document (complete with examples and references) available on-line is a key work product of this project.

In general, the developed Methodology is comprised of the following four steps:

1. Prioritize catchments based on need (i.e., pollutant-loading, receiving water issues, etc.)
2. Identify potential BMPs opportunities within high priority catchments (based on factors such as land ownership, etc.)
3. Identify appropriate BMPs (based on factors such as cost, maintenance, effectiveness, etc.)
4. Develop site-specific implementation strategies (based on site-specific evaluations).

Specifically, the Methodology ranks subcatchments of a watershed based on two factors: 1) need for a BMP project (pollution generation, impairment, regulatory requirements etc.) and 2) opportunity for BMP project (land availability, downstream of high-pollutant loading area, etc.). GIS is used to automate the processing of data critical to identifying high priority catchments for BMP installation within a watershed such as land use, pollution generation, hydrology, topography, parcel ownership, storm drain flow direction, etc. The Methodology also evaluates and scores various types of BMPs based on expected effectiveness, cost, maintenance requirements, and other criteria using information from such sources as the EPA/ASCE International BMP Database. The Methodology uses GIS to identify opportunities within the watershed for BMP placements based on factors such as land ownership, soil conditions, ecological resources, etc., and then combines the higher-priority catchment map with the opportunity map to generate higher-priority projects. Finally, the tool contains “desk-top” and field steps that include systematic processes for including data verification and screening-level fatal flaw analysis of identified projects.

Products generated by the Methodology include:

- Maps of higher-priority catchments – those catchments that generate high pollutant loads and rated a high score for BMP project placement opportunity.
- Recommended list of specific BMP projects for the higher-priority catchments. The identified projects have been preliminarily field-verified and screened for fatal flaws.
- Data and documentation to help support final design development.

A technical Project Team led by GeoSyntec Consultants developed the Methodology. The team also included representatives from Heal the Bay, the County of Los Angeles Department of Public Works, and the City of Los Angeles Bureau of Sanitation. The development process was unique in that it was informed by the expertise of a small, yet integral, subset of stakeholders with considerable interest in the project’s outcome. This made it possible for the project team to receive constructive technical input from the beginning of the project and at all levels of detail – from data collection feasibility to implementation and potential regulatory implications.

The Methodology is intended to be used as a high-level, conceptual planning tool for developing BMP implementation strategies on the watershed scale (Figure 1). Identified and ranked projects lists generated by the Methodology can serve many purposes such as ensuring limited funds for BMP implementation dollars are spent in a manner that maximizes water quality benefits; investigating the impact of different implementation strategies; and assisting watersheds groups in responding to and securing funding for water quality projects as funding opportunities arise. The products produced by the tool can assist in feasibility assessment of individual projects identified by the Methodology, but the Methodology is not intended to replace the feasibility analysis of specific projects. The tool is also not designed to compare the rank of projects across watersheds, instead identified projects are ranked relative to other projects within a given watershed.

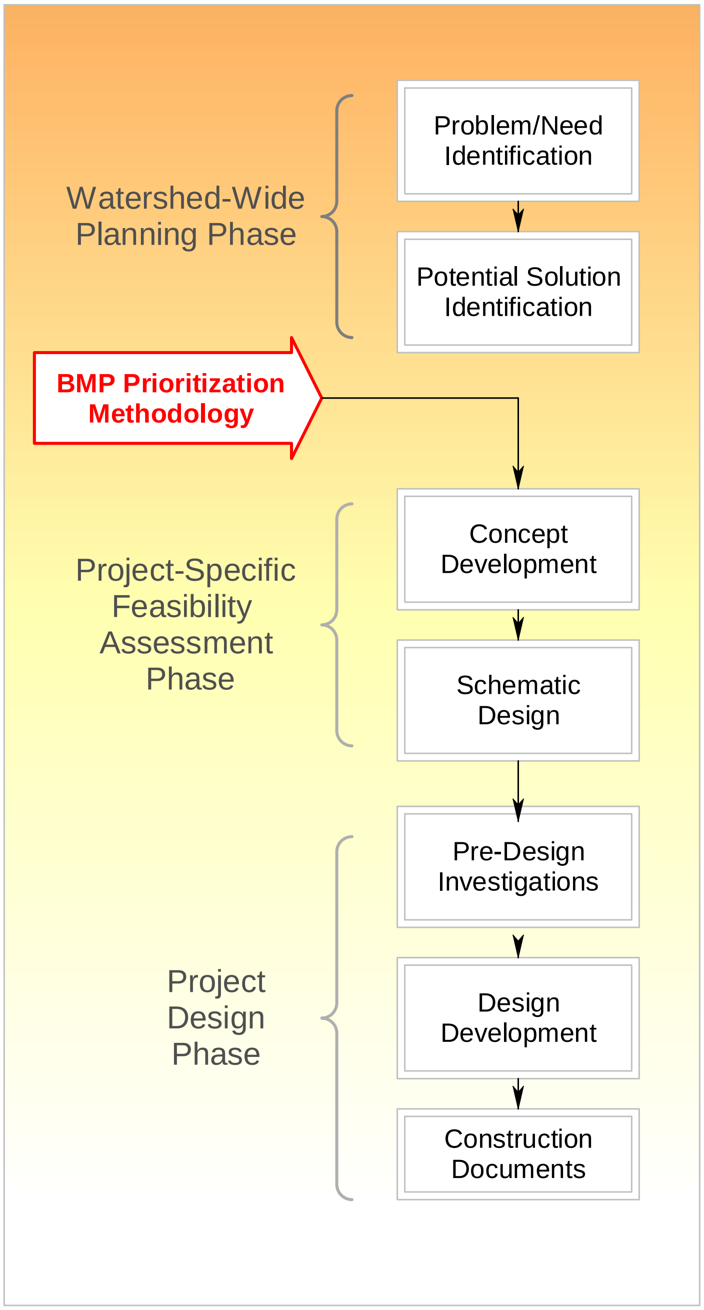

Figure 1. Use of the Prioritization Methodology within the General Project Planning and Design Process

METHODOLOGY DEVELOPMENT: OVERVIEW OF APPROACH AND PROCESS

The development of the Methodology was conducted in three phases (see Figure 2). This Guidance Document represents the completion of these three phases and the presentation of the final Methodology. The three phases were:

- Phase 1: Develop preliminary Methodology

- Phase 2: Implement and test Methodology in Ballona Creek Watershed
- Phase 3: Update and finalize Methodology

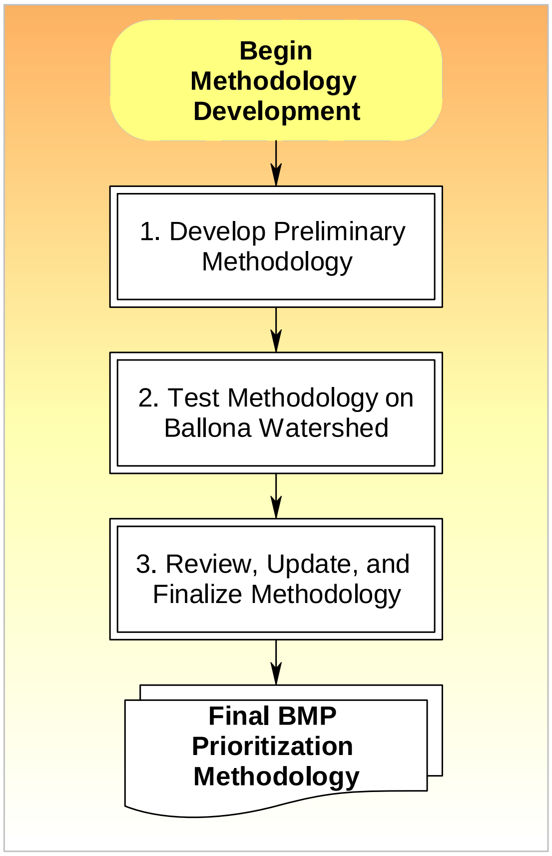

Figure 2. Overview of Methodology development

Phase I: Develop preliminary Methodology.

The project team considered a number of issues during Phase I, development of the preliminary Methodology. These included the intent to leverage efforts of other projects: One of the first steps was to establish the goals and objectives of this project and examine how it is similar and related to other projects. The team reviewed similar projects throughout California, including the Santa Barbara BMP Retrofit program, ongoing TMDL implementation planning efforts in Lake Tahoe and Santa Monica Bay, and various watershed management planning efforts throughout Southern California. The team leveraged the work of relevant projects, such as the City of Los Angeles Integrated Resources Plan, the Ballona Creek Watershed Stormwater BMP Planning and Implementation Strategy Concept Implementation Plan, and the Arroyo Seco Watershed Management and Restoration Plan.

Additionally, the team sought to Integrate City of LA Measure O requirements. Measure O is a voter-approved $500M bond authorization for the purchase and/or improvement of property for stormwater quality projects. The team decided against integrating Measure O's project selection criteria into the Methodology because of significant differences between the two efforts: 1) Measure O technically applies only to the City of Los Angeles, and this project is intended to represent the interests of all parties within the County of Los Angeles; and 2) the intent of the Methodology, per the SWRCB Agreement, is to focus on water quality benefits. However, where applicable, some elements of the Measure O criteria were incorporated into the Methodology.

Phase II: Implement and test Methodology in Ballona Creek Watershed.

Upon completion of the preliminary Methodology (Phase I), the Project Team tested it on a specific watershed: Ballona Creek Watershed, which drains to Santa Monica Bay. Ballona Creek Watershed was selected for this demonstration because of its unique history, its current water quality conditions (including many problems shared with other LA County receiving waters), its history of activity in terms of studies and BMP implementation, and the existence of relevant information from other planning efforts. Ballona Creek Watershed is highly urbanized, with most drainage courses either enclosed or lined with concrete. In its October 2004 Watershed Management Initiative, the Regional Water Quality Control Board identified several major issues in the watershed, including:

- trash loading from creek,
- wetlands restoration,
- contamination of sediments (Marina del Rey Harbor and offshore) by heavy metals from creek,
- toxicity of both dry-weather and storm runoff in creek, and
- high bacterial indicators at mouth of creek.

The Methodology was successfully applied to the watershed to create a list of prioritized structural BMP projects. This effort included the identification of potential sites, followed by field verifications of the feasibility of implementing BMPs. A separate report entitled *Los Angeles County-Wide BMP Prioritization Project Ballona Creek Demonstration Summary Report*, was prepared. This report summarized the results and made recommendations on adjustments to the Methodology.

Phase III: Update and finalize Methodology

Based on testing in the Ballona Creek Watershed, several modifications were made to the preliminary Methodology. These included changes to the area screening approach for Step 1 and the desktop- and field-level screening approaches for Step 4. The Methodology was then finalized upon incorporation of these changes along with minor additional points of clarification.

The Methodology presented in this Guidance Manual reflects the iterative process of development and testing and represents the recommended Methodology based on data and information currently available. This Methodology allows for continual improvement based on: (a) future field experience from projects recommended by the Methodology, and (b) better scientific understanding of all relevant parameters including the relationship between pollutant load and rainfall quantity.

2 METHODOLOGY

The basic approach of the BMP prioritization Methodology is to screen areas based first on *need* (i.e., pollutant load generation and downstream impairments) and then on *opportunity* (i.e., appropriateness for BMP implementation). During the area screening phase, areas are evaluated first at the "catchment" scale (i.e., approximately 40-acre drainage area units), where a Catchment Prioritization Index (CPI) is established, and then at the parcel scale. After areas are prioritized, BMP types are evaluated according to four criteria: cost, effectiveness, ease of implementation, and other environmental criteria. The BMP screening phase involves both a *general* comparison of BMP types and then a *site-specific* feasibility assessment. Figure 3 (below) shows these steps and the overall order and compartmentalization of the Methodology.

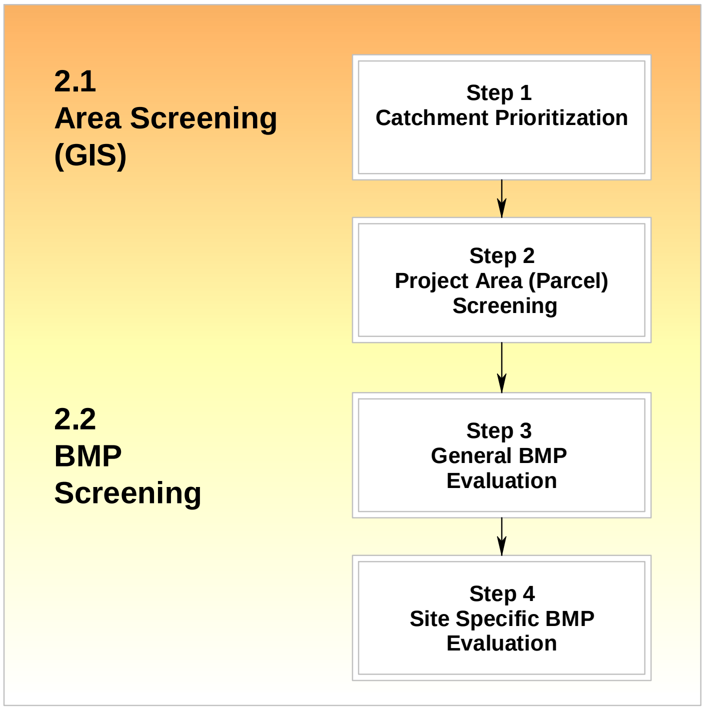

Figure 3. Overall Methodology flowchart

2.1 AREA SCREENING (GIS)

The objective of the area screening process is to prioritize catchments for BMP implementation. This is a GIS-based analysis designed to be quickly implemented and easily reproduced upon initial configuration.

Step 1 identifies higher-priority catchments (those having the greatest need for structural BMP implementation) based on:

- Pollutants of concern
- Pollutant loadings or concentrations
- Impairments (including downstream impairments)
- Regulatory requirements such as TMDLs

Step 2 identifies which of the higher-priority catchments provide the greatest opportunities for implementation based on:

- Available Space
- Ownership
- Slopes
- Liquefaction
- Environmentally Sensitive Areas
- Infrastructure

It should be noted, however, that this analysis is not meant to serve as a rigorous pollutant load modeling effort, but rather to roughly estimate catchment pollutant loads, and then translate these estimates into pollutant load "indices" for the purpose of ranking and binning catchments and highlighting higher-priority areas.
Figure 4 illustrates the area screening steps of the Methodology.

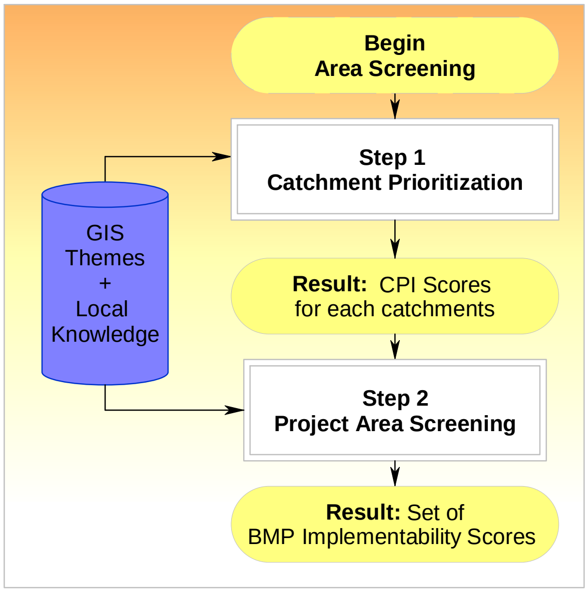

Figure 4. Area screening flowchart for first two steps of Methodology.

STEP 1: CATCHMENT PRIORITIZATION

The primary objective of this step is to develop a Catchment Prioritization Index (CPI) for each catchment area. The CPI represents the relative need for of each catchment for a BMP. Figure 5 illustrates the intermediate steps required for developing a CPI score for each catchment area of a watershed.

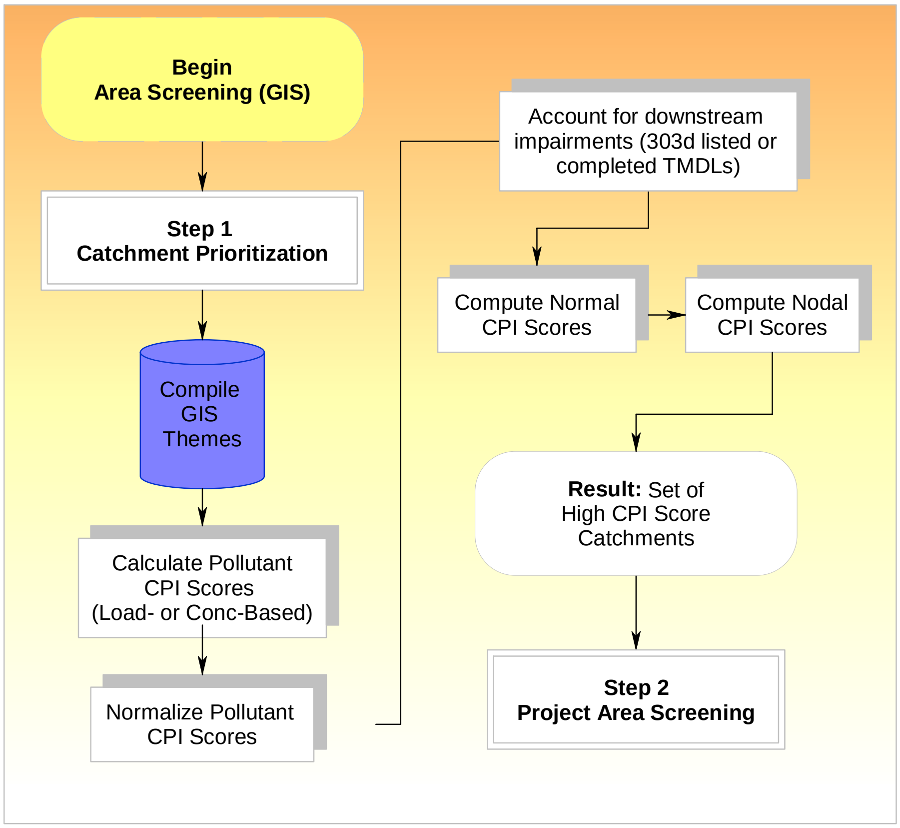

Figure 5. Step 1 - Catchment Prioritization flowchart.

a. **Compile relevant GIS themes.**

The following GIS layers are required for catchment prioritization: catchment drainage boundaries (approximately 40-acre scale), land uses (grouped by general land-use category; see Appendix Agrouping table), 85th-percentile 24-hour rainfall contours (i.e., SUSMP storm depth), reach 303(d) impairments and completed TMDLs (by pollutant group; see Appendix B grouping table), water bodies, and drainage network. Table 1 below summarizes the data types, scale/resolution, and purposes for each GIS theme proposed for use in this step.[1] If approximately 40-acre catchment boundaries are not available, perform necessary delineations. If delineations are not feasible, use available catchment sizes.[2]

[1] Availability of GIS data will vary with jurisdiction. The Methodology attempts to establish a hierarchy by which the best available data can be used for this effort. Should the best data not be available, alternate data sources can be used as described herein.

[2] Since the pollutant load estimates are normalized by area, this limitation should not significantly impact the pollutant load indices per acre estimates as long as catchment sizes are approximately the same. As land uses are summarized for larger catchment areas, there will be fewer catchments characterized by land-use extremes, and therefore the normalized CPI scores of larger catchments may tend more toward average priority conditions rather than high or low. In addition, it will not be feasible to examine the aerial photos of these larger prioritized catchments on 8½ x 11" printouts; poster-size graphic analyses may be required.

Table 1. GIS Data Used for Catchment Prioritization

Data	Type	Scale/ Resolution	Purpose
Catchment Prioritization			
Catchments	Polygon	40-acre drainage unit	Primary unit of analysis
Land use	Polygon or grid	Maximum mapping unit of 2½ acres	Calculate area-weighted runoff coefficient and pollutant-loading/EMC scores per catchment
85th-percentile 24-hour rainfall depth contours	Line		Calculate average storm event precipitation depth per catchment
Trash (from City/County catch basin monitoring studies)	Polygon		Compute catchment trash CPI scores (where actual monitoring data is available)
303(d)-listed impaired water bodies	Line/polygon		Designate catchments with downstream impairments
Completed TMDLs	Line/polygon		Designate catchments with downstream completed TMDLs
Hydrologic drainage network with connectivity (to/from nodes)	Line/Point		Designate catchments with downstream impairments/TMDLs
Topography	Grid (DEM)	10-m cellsize	If drainage network unavailable, used to designate catchments with downstream impairments/TMDLs

b. **Estimate relative pollutant loading indices.** Using the delineated catchment boundaries and available land-use and rainfall data, estimate relative pollutant loading for each catchment using the following steps.

b.1 **Compute area-weighted land-use percentages**. Intersect the land-use data layer with the catchment layer to create a set of "subpolygons" for each land use within each catchment. Sum the areas for these individual subpolygons by land use. Convert the sums to percentages by dividing by the total area of each catchment. This procedure can be automated in a GIS system to simultaneously compute these statistics for all catchments in a given study area.

b.2 **Calculate or obtain land-use runoff coefficients**. Bring land-use runoff coefficients into GIS database. *Calibrated* land-use runoff coefficients from Ackerman & Schiff 2003 mass emission modeling study of Southern California Bight (see Table 2) are recommended[3]. Subpolygon discretization may be required here as well.

[3] This reference was selected for the purpose of runoff coefficient estimation because its study area (Southern California Bight) is similar in scale and location to our own (Los Angeles County), and because these values have been calibrated to stream discharge volumes and rainfall, summarized by storm, for the 1993-1999 period. Therefore, these values represent reasonable parameter estimates for *average regional* runoff conditions. Users should note that by using such large-scale based runoff coefficients, volume estimates may be underestimated for small catchments. These coefficients were deemed acceptable for the purposes of computing *relative* load scores. Coefficient values should not be used for explicit catchment-scale pollutant load modeling.

Table 2. Recommended Land Use Runoff Coefficients - Optimized Model Runoff Coefficients by Land Use for Southern California Bight (Ackerman & Schiff, 2003)

Land Use	Runoff Coefficient
Agriculture	0.10
Commercial/Educational	0.61
Industrial/Transportation/Other Urban[4]	0.64
Open	0.06
Residential	0.39

Alternatively, runoff coefficients may be calculated based on imperviousness either by using land use-based imperviousness values or by using a watershed-wide imperviousness GIS layer to obtain site-specific runoff coefficients. Several guidance documents are available that provide imperviousness-dependent runoff coefficient equations including:

- WEF (1998). Urban Runoff Quality Management. WEF Manual of Practice #23. ASCE Manual and Report on Engineering Practice #87
- Schueler, T. (1987), Controlling Urban Runoff, A Practical Manual for Planning and Designing Urban BMPs, Metropolitan Washington Council of Governments.
- LACDPW (2006). Hydrology Manual. Los Angeles County Department of Public Works, Water Resources Division.

Figure 6 provides a graphical comparison of the three different types of imperviousness-dependent runoff coefficient equations. Note that the LACDPW equation requires soils information to estimate the undeveloped runoff coefficient (Cu) prior to estimating the developed runoff coefficient (Cd); Cu values of 0.1 and 0.5 are shown in Figure 6 to represent a potential range of soil types and precipitation intensities.

[4] "Other urban" category, which included includes "mixed industrial/commercial" and "under construction" SCAG land use categories, represents <1% of total County area.

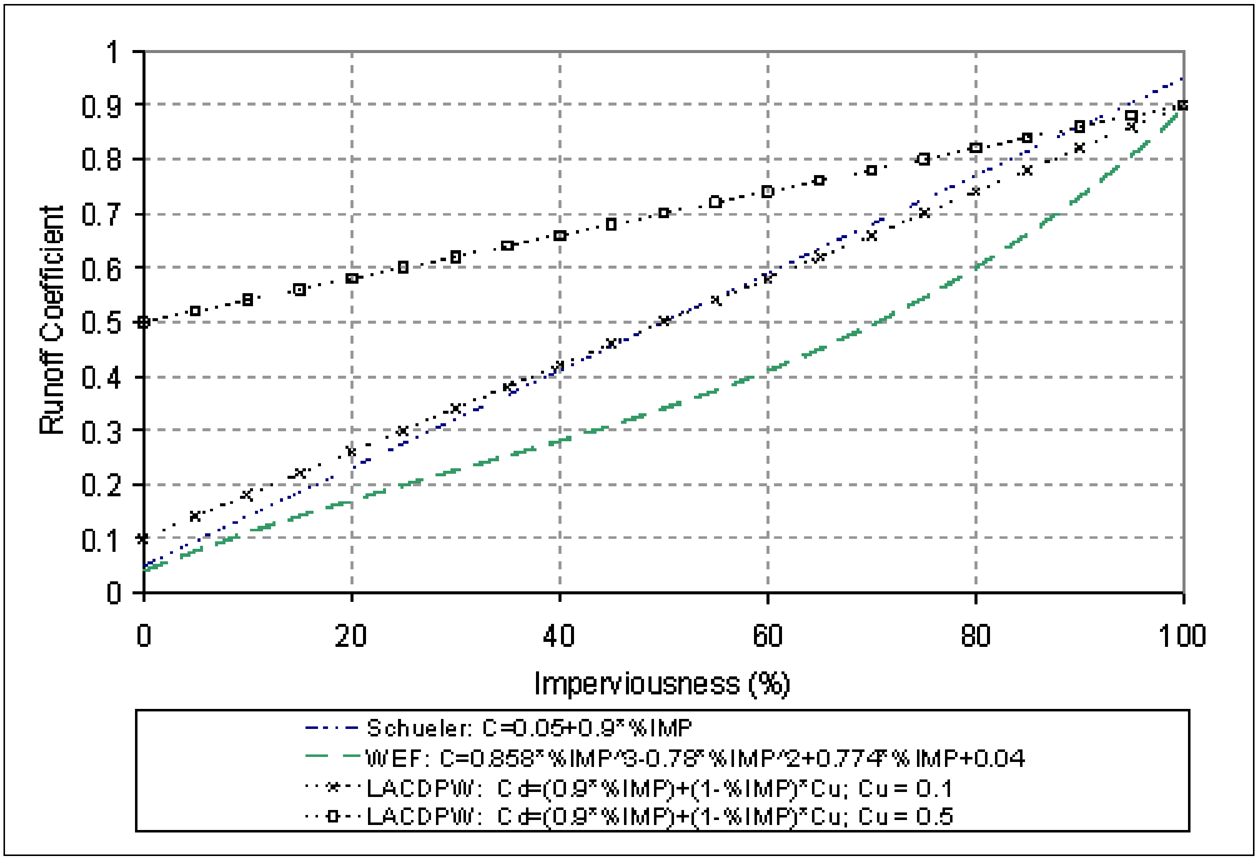

Figure 6. Comparison of imperviousness dependent runoff coefficient equations.

b.3 **Target storm size**. Define average target precipitation depth (see Figure 7) for each catchment. The LA County 85th-percentile 24-hour depth values are recommended and available as either rain gage (point) data or contour lines of equal rainfall (isohyets), which would be derived from the gage data. To create a grid version of rainfall, which can then be used to determine average rainfall per catchment, use the gage data[5]. Other rainfall indices may be used as well.

- Within the GIS, interpolate a grid from the gage point depths (1,000-foot grid using Inverse Distance Weighted interpolation scheme).
- Create zonal statistics for the catchments based on the newly created rainfall grid, and then use the mean rainfall value to represent the average rainfall for the catchment.

[5] Grid derivation based on method described in "Analysis of 85th-Percentile 24-hour Rainfall Depth Analysis within the County of Los Angeles," Los Angeles County Department of Public Works, Water Resources Division, February 2004. Use of rainfall data is not advised by LACDPW unless site specific Event Mean Concentrations are available.

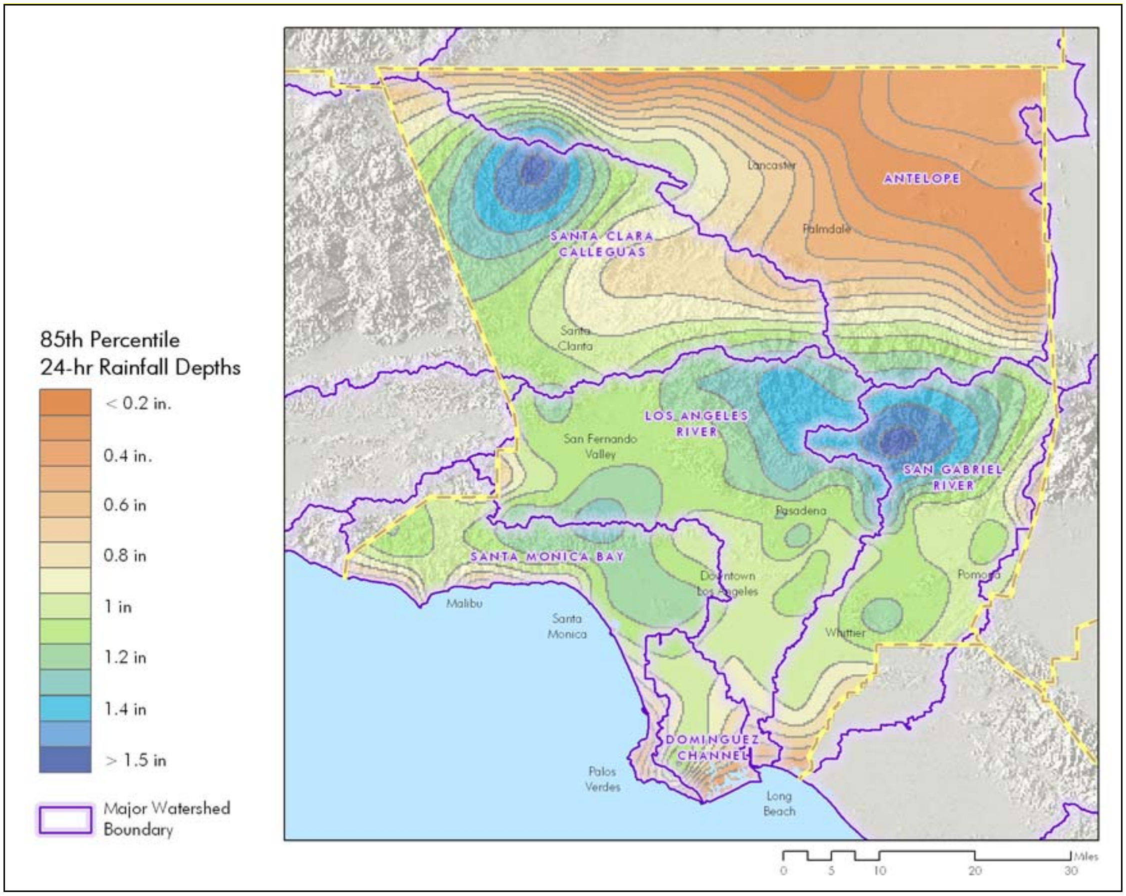

Figure 7. Recommended average target precipitation depths - Average annual precipitation isohyets for Los Angeles County

b.4 **Calculate or obtain land-use EMCs**. Bring land-use event mean concentrations (EMCs) using EMC values provided in Table 3 into GIS database. Recommended pollutant groups[6] (with indicator in parentheses) are: trash, nutrients (nitrate), metals (total copper, total lead, and total zinc), bacteria (fecal coliform), and sediment (TSS). The final determination of BMPs will require that the full distribution of EMC values be examined, along with numerous other factors.[7] A fundamental assumption inherent to this approach is that EMCs are solely a function of (or at least, best approximated by) land use.

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[6] These pollutant groups and indicators were to represent each of the major general TMDL pollutant categories, with specific focus on those known to be present in significant quantities in urban stormwater runoff. Total metals were preferred over dissolved metals – even though the dissolved fraction is the more bioavailable fraction – because dissolved fractions are influenced by hardness, and therefore total values represent the more conservative estimate of metals concentrations in the water column.

[7] It is recognized that actual stormwater pollutant concentrations can vary by over an order of magnitude above or below the "average" EMC values shown.

Table 3. Average[8] EMCs[9] by Land Use for Study Indicator Pollutants

<table>
<tr><th>Land Use</th><th>Trash[10], cf/ac</th><th>Nitrate, mg/L-N</th><th>Total Copper, ug/L</th><th>Total Lead, ug/L</th><th>Total Zinc, ug/L</th><th>Fecal Coliform[11], MPN/100ml</th><th>TSS, mg/L</th></tr>
<tr><td>Agriculture</td><td>0.0</td><td>11.3</td><td>84.1</td><td>20.4</td><td>246.6</td><td>6,842</td><td>699</td></tr>
<tr><td>Commercial/ Educational</td><td>1.0</td><td>0.46</td><td>18.8</td><td>2.1</td><td>127.5</td><td>72,035</td><td>58</td></tr>
<tr><td>Industrial/ Transportation/ Other Urban</td><td>1.0</td><td>0.49</td><td>31.6</td><td>4.3</td><td>289.5</td><td>32,679</td><td>81</td></tr>
<tr><td>Open</td><td>0.0</td><td>1.0</td><td>3.8</td><td>0.01</td><td>2.1</td><td>255</td><td>28</td></tr>
<tr><td>HDSF Residential</td><td>1.0</td><td>0.30</td><td>14.7</td><td>5.0</td><td>52.6</td><td rowspan="2">98,272[12]</td><td>65</td></tr>
<tr><td>MF Res/ Mixed Res.</td><td>1.0</td><td>0.57</td><td>12.3</td><td>2.5</td><td>116.3</td><td>32.6</td></tr>
</table>

8 Log-transformed arithmetic mean values shown, except for trash (see footnote below for trash EMC description).

9 EMCs for nitrate, metals, and TSS are based on Los Angeles County 1994-2000 flow-weighted composite-sampled land use runoff monitoring data, with the exception of agriculture, which was developed from Ventura County 1994-2004 land-use EMC data. Summary statistics shown are geometric mean values, determined using a robust Regression on Ordered Statistics (plus bootstrapping) method for estimating below-detection results (Hirsch & Stedinger 1987). Other land use runoff monitoring datasets (such as those of the Southern California Coastal Water Research Project (SCCWRP) and the National Urban Runoff Project (NURP)) were considered, however Los Angeles County's datasets were preferred as they are considered to be most statistically representative of the region.

10 Trash summary statistics shown are median values (which are nonparametric estimates of the geometric mean, and therefore comparable statistics to the "average" EMC values shown for the other pollutant groups) based on City of Los Angeles catch basin monitoring data, which could not be shown to correlate with land use or other census data studied. Rather, statistically significant differences could only be confirmed for the broad land use categories of "developed" and "undeveloped;" therefore only two different values are shown in the table above. For the Ballona Creek Watershed test application, directly measured trash loads (available as GIS shapefiles from the City of Los Angeles) may be used for the analysis. For non-City areas, if County trash sampling data is not available (i.e., actual monitoring data should be used preferentially), the median volumetric load per acre values shown in this table should be used. The precision of this trash dataset was to the nearest 1 cf/ac, with most of the results being either 0 or 1 cf/ac. The developed median value is 1 cf/ac and the undeveloped median is 0 cf/ac.

11 Fecal coliform geometric mean summary statistics are based on Los Angeles County grab and composite-sampled land use runoff monitoring data, with a Maximum Likelihood Estimation (plus jackknifing) method applied to account for censored data (below and above detection limit results), assuming lognormal concentration distributions (Shumway et. al. 2002).

Fecal coliform was selected because it is a common bacteria standard for freshwater and ocean criteria. (Fecal coliform and E. coli are the basis for freshwater standards; fecal coliform, total coliform, and enterococcus serve as the bases for ocean criteria.)

12 Lack of sufficient data did not allow for the discretization of high density single family (HDSF) residential land use data from that of the multi-family (MF) and mixed residential (combined) land use, so these fecal coliform EMC data were combined and utilized for all residential land uses.

b.5 **Calculate pollutant scores**. Compute pollutant CPI scores[13] for each land use for each pollutant, except trash[14], and then sum land use-specific pollutant loads for each catchment (see Figure 8 for conceptual diagram of computations) using either a load-based method (Method 1) or a concentration-based method (Method 2).

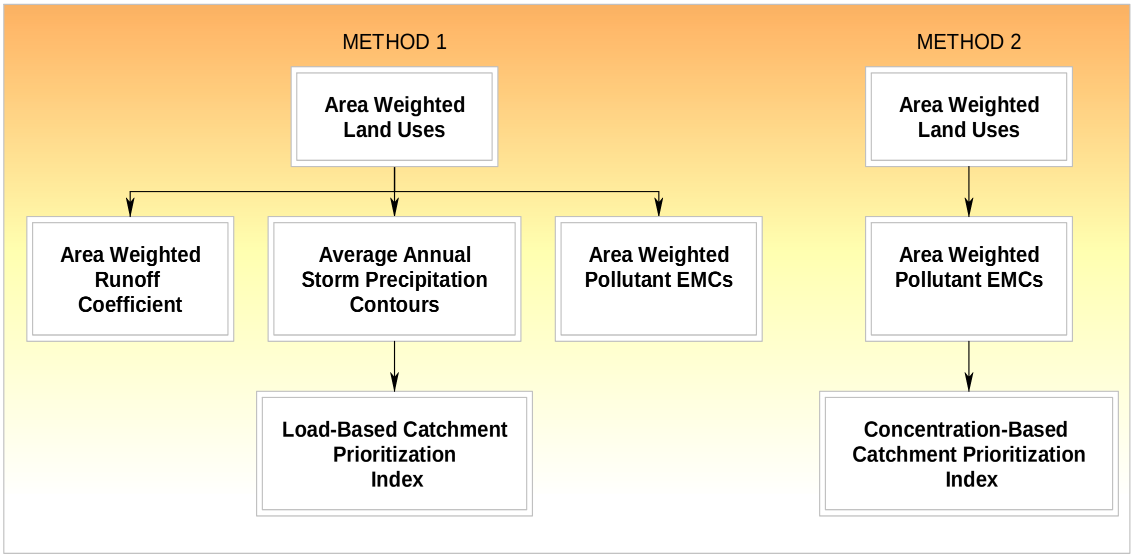

Figure 8. Load and concentration-based computation steps for CPI

Method 1

Method 1 uses EMCs, runoff coefficients, and rainfall intensity to determine the catchment priority index (CPI), a prioritization score on a scale from 1 to 5 with 5 being the highest priority. The County recommends using Method 1 when water quality data at the site indicates that the first flush phenomenon dominates pollutant loading in the area. Discussions of the data used to formulate Method 1, examples of Method 1 implementation in other contexts, and some limitations with use of the data are provided in Appendix F.

The load-based CPI calculation (Method 1) is consistent with UCLA, SCCWRP, and SMBRC stormwater quality studies (Stenstrom and Strecker, 1993; Ackerman and Schiff, 2003; GeoSyntec Consultants, 2005), as well as the City's GIS-based BMP planning tool (Sedrak and Murillo, 2005).

[13] It should be noted here that this step is not to be considered or used as pollutant load modeling or development of measures for TMDL compliance. While it is agreed that load modeling for TMDL compliance analysis is a needed effort, the purpose of this project is to prioritize stormwater retrofit opportunities to maximize water quality benefits. Accordingly, it focuses on the relative merits of opportunities, and not quantifiable improvements. However, this project is intended to be complementary to such future modeling and TMDL efforts.

[14] For trash, catchment pollutant scores should be based only on area-weighted EMCs since this load is not a function of rainfall or runoff coefficients.

Method 1 (load-based):

$$PCPI_x = \frac{\sum_y \left(EMC_{x,y} * RC_y * A_y * P \right)}{\sum_y A_y} \qquad \text{(Equation 1)}$$

Where:

$PCPI_x$ = load-based pollutant CPI for pollutant type "x" (e.g., nitrate, fecal coliform, total lead) for study catchment; note: Method 1 not applicable to trash as this EMC is in units of volume per area and therefore load is not a function of RC or P.

$EMC_{x,y}$ = Event Mean Concentration for pollutant x for land use type "y" (e.g., commercial, residential, industrial, open)

RC_y = Runoff coefficient for land use y

A_y = Total area for land use y in catchment (may involve summing areas of numerous disconnected polygon slivers)

P = Precipitation index value for study catchment

Method 2

Method 2 uses only the area-weighted EMC as the basis for prioritization, and may include the addition of a runoff coefficient component. The concentration-based CPI calculation (Method 2) was added at the County's request and compared to Method 1 in the Ballona Creek Watershed demonstration to evaluate the sensitivity of the Methodology to the CPI calculation approach. The County recommends Method 2 when water quality data shows a regenerative pollutant source affecting the study area. The assessment of this method in the Ballona Creek Watershed application revealed it to be an acceptable alternative. For further discussion on the basis for the Method 2 calculation approach, see the County's technical opinion memo included in Appendix F.

Method 2 (concentration-based):

$$PCPI_x = \frac{\sum_y \left(EMC_{x,y} * A_y \right)}{\sum_y A_y} \qquad \text{(Equation 2)}$$

Where:

$PCPI_x$ = concentration-based pollutant CPI for pollutant type "x" for study catchment

All other variables previously defined.

c. **Normalize and weight pollutant CPI scores**. In order for pollutant CPI scores (PCPI) to be comparable between catchments[15], they must be normalized by the maximum catchment pollutant score. The method allows the user to weight PCPI scores by pollutant type. Table 4

[15] The Methodology is not currently designed for multi-watershed prioritization planning or inter-watershed project comparison. However, if analysis is to be conducted for a multi-watershed study area, with CPI and BMP scores intended to be comparable between watersheds, then maximum pollutant scores *for entire study area* should be used to normalize pollutant load scores. Because implementation of this type of analysis has not been adequately tested, it cannot be recommended at this time. User may also wish to use maximum possible EMC, RC, and P values to compute a maximum theoretical load to normalize pollutant CPI scores so that they are comparable between watersheds.

reflects recommended pollutant weights. These pollutant weightings are based on stakeholder consensus on relative pollutant "importance". Alternative values may be selected by the user based on group priorities for the study watershed(s).

Table 4: Recommended Weights and Factors for CPI Calculation[16]

Candidate Catchment Factors	Max Points
1. Rank catchment by pollutant load per unit area (5 bins each)	**50**
Trash	10
Nutrients (Nitrate)	10
Bacteria (Fecal Coliform)	10
Total Metals (Total Cu, Total Pb, Total Zn)	15
Sediment (TSS)	5
2. Multiply pollutant score by 2 if a d/s impairment, by 3 if a d/s TMDL	**x2 or x3**
3. Add 5 points for each "other" impairment (bioaccumulation, toxicity, legacy pesticides, and ecological impacts)	**20**
Theoretical maximum catchment pollutant load score	**170**

c.1 Identify maximum PCPI (maxPCPI) in watershed and divide individual PCPIs by maxPCPI to create normalized PCPIs.

c.2 Weight normalized PCPIs. Round fractions up to the next highest integer value (See Table 4).

$$PCPI'_x = Roundup\left(\frac{PCPI_x}{\max PCPI_x} \cdot WF\right) \qquad \text{(Equation 3)}$$

Where:

- $PCPI'_x$ = normalized pollutant CPI (LCPI or CCPI) for pollutant type "x" for study catchment
- $PCPI_x$ = pollutant CPI for pollutant "x" for study catchment
- $\max PCPI_x$ = maximum $PCPI_x$ value for entire watershed for pollutant "x"
- WF = weight factor for pollutants (per Table 4, 10 for trash, nitrate, and fecal coliform; 5 for total copper, total lead, total zinc, and TSS)

See Example 1 for a demonstration of this pollutant load score calculation.

[16] Scoring and weights may be adjusted by the user.

EXAMPLE 1. CPI SCORE CALCULATION

Problem

For a 40-acre Ballona Creek tributary (mid-watershed) catchment comprised of 40% commercial and 60% HDSF residential land uses, compute the pollutant load score for total copper. Assume maximum catchment total copper load score for the watershed (needed for normalizing from pollutant load to pollutant load score) is equivalent to a 100% commercial catchment located in the 1.3" 85th-percentile rainfall zone.

Solution

1. Determine target precipitation index value (average 85th-percentile precipitation depth for catchment, see Figure 7). P = 1.2 in

2a. Compute CPIx using Method 1 (see Equation 1)

$$PCPI_x = \frac{\sum_y \left(EMC_{x,y} * RC_y * A_y * P\right)}{\sum_y A_y}$$

Where:

- EMCcopper,commercial = 18.8 ug/L, EMCcopper,residential = 14.7 ug/L,
- RCcommercial=0.61, RCresidential = 0.39,
- Acommercial = 16 ac, Aresidential = 24 ac

[(18.8 ug/L * 0.61 * 16 ac * 1.2 in) + (14.7 ug/L * 0.39 * 24 ac * 1.2 in)] / 40 ac = 9.63
(units to be normalized)

2b. If Method 2 is preferred, compute CPIx using Method 2 (see Equation 2)

$$PCPI_x = \frac{\sum_y \left(EMC_{x,y} * A_y\right)}{\sum_y A_y}$$

[(18.8 ug/L * 16 ac) + (14.7 ug/L * 24 ac)] / 40 ac = 16.3 ug/L

3. Repeat calculation for maximum condition (per example, this is 100% commercial land use, 1.3 in) to determine maximum catchment total copper load (needed for normalizing the score above).
maxPCPI = 100% * 0.61 * 1.3 in * 18.8 ug/L = 14.9
(If Method 2 is used, maxPCPI = 18.8 ug/L)

4. Normalize load (scale of 1-5) to compute catchment pollutant load score (PCPI).
(9.63/14.9) * 5 = 3.2
(If Method 2 is used (16.3/18.8)*5 = 4.3)

5. Report final total copper CPI score by rounding to next highest integer (i.e., report 1.2 result as 2).
3.2 → 4 (final total copper load-based pollutant CPI score, normal $PCPI_{copper}$)
4.3 → 5 (final total copper concentration-based pollutant CPI score, normal $PCPI_{copper}$))

d. **Account for “downstream” impairments and TMDLs**. Assign pollutant group impairments and TMDLs to each reach, based on the 303(d) and TMDL lists or other identified pollutants of concern as appropriate (see Appendix B) .[17] Using a hydrologic drainage network (a set of stream and/or drainage reaches that connect with directional to/from nodes; the network may be based on the actual drainage system or a simplified schematic representation), catchments upstream and downstream of each other can be easily identified in a GIS system. Reaches can then be linked to catchments by a spatial overlay, so that upstream catchments that eventually drain to an impaired reach can also be identified.[18] The following steps can be used to identify the “downstream” impairments and TMDLs.

d.1 To identify catchments that lie upstream of impaired and TMDL reaches, first identify impaired and TMDL reaches within the drainage network. This can be accomplished either visually or through a spatial join – any reaches within the drainage network that overlay a TMDL or impaired water body should be flagged as such. Each flagged TMDL or impaired reach should then be traced upstream within the network to identify all reaches that flow into the flagged reach. Identify upstream catchments based on a spatial join to the flagged upstream reaches, and then assign a value to the catchment based on the pollutant type of the impairment/TMDL (e.g., if a catchment is upstream of a reach with an existing TMDL for metals, it should receive a “true” value for a field created to identify TMDLs for metals, and no value if not).

d.2 Weights listed in Table 4 are recommended as follows. Multiply catchment’s PCPI score by 2 if it drains to an impaired reach or by 3 if it drains to a reach with a completed TMDL for the given parameter group. This provides additional emphasis for catchments which drain to impaired water bodies or even more emphasis to those receiving waters with TMDLs. (These weightings are again based on stakeholder consensus. Alternative values may be selected by the user based on group priorities for the study watershed(s).) Note: a reach cannot trigger both multipliers; it is an either-or condition.

$$PCPI''_x = \begin{cases} PCPI'_x \times 2 & \text{if catchment drains to 303(d) listed impaired water body} \\ PCPI'_x \times 3 & \text{if catchment drains to TMDL water body} \end{cases} \quad \text{(Equation 4)}$$

Where:

$PCPI'_x$ = normalized pollutant CPI for pollutant type “x” for study catchment

$PCPI''_x$ = adjusted pollutant CPI for pollutant type “x” for study catchment

e. **Compute catchment-specific CPI.** To compute catchment-specific CPI, PCPIs are summed, other impairment factors are added, and CPI scores are normalized.

e.1 Sum CPIs

- Other impairments may exist that are not directly associated to a single pollutant type (such as toxicity). Therefore, for each catchment, add all of the adjusted pollutant CPI scores plus additional impairment points (IP) for each additional “other” downstream impairment. IP is

[17] “Downstream” impairments include estuaries, but not beaches near watershed outlets.

[18] Note that this step requires Network Analyst extension to ArcGIS.

equal to 5 points as recommended in Table 4, but these values can be adjusted by the user. These "other" impairments include:

- Bioaccumulation
- Toxicity
- Legacy pesticides
- Ecological impacts

Calculate un-normalized CPI as follows (steps e.1 and e.2).

$$CPI = \sum_x PCPI''_x + (IP \cdot N) \qquad \text{(Equation 5)}$$

Where:

CPI = preliminary (un-normalized) CPI for study catchment
$PCPI''_x$ = adjusted pollutant CPI for pollutant type "x" for study catchment
IP = Impairment points = 5 (per Table 4)
N = number (1, 2, 3, or 4) of "other" downstream impairments for study catchment (bioaccumulation, toxicity, legacy pesticides, and/or ecologic impacts)

e.2 Normalize cumulative CPI values by again scaling to maximum CPI, then multiply by 5 to generate final normalized CPIs for all catchments, with results ranging from 1-5 (note that because CPI results are scaled relative to maximum value – rather than ranking and assigning to bins by percentile – there will be bins with more or fewer catchments than others).

$$CPI' = Roundup\left(\frac{CPI}{\max CPI} \cdot 5\right) \qquad \text{(Equation 6)}$$

Where:

CPI' = normalized CPI for study catchment
CPI = preliminary (un-normalized) CPI for study catchment
max CPI = maximum CPI score for watershed

Example 2 below demonstrates this scoring calculation for a hypothetical catchment. When completing these calculations for all catchments, this step results in a CPI map for the watershed. Figure 9 is an example normal load-based CPI map for the Ballona Creek Watershed.

EXAMPLE 2. CPI CALCULATION

Problem

Compute the Catchment Prioritization Index (CPI) for a 40-acre Ballona Creek (mid-watershed) catchment comprised of 40% commercial and 60% HDSF residential land uses, assuming the following normalized pollutant load scores. Assume downstream impairments and completed TMDLs for trash, bacteria, and metals. Also assume "other" downstream estuary impairments for bioaccumulation, toxicity, and legacy pesticides.

Assume following normalized CPI scores: trash (7), nitrate (3), total copper (3), total lead (4), total zinc (1), fecal coliform (7), TSS (2).

Solution

1. Determine total pollutant load score (per Table 4) by weighting by impairments (x2) and completed TMDLs (x3).

7*3 + 3*1 + 3*3 + 4*3 + 1*3 + 7*3 + 2*1 = 71

2. Determine "other" impairments score.

3*5 = 15

3. Compute total Catchment Prioritization Index for catchment.

71 + 15 = 86

4. Scale CPI (1-5) by normalizing to maximum possible CPI score (170), then rounding up to the next highest integer.

(86/170)*5 =2.5

CPI score = 3

f. Compute Nodal CPI Scores:

To account for regional BMPS opportunities that might existing downstream of high priority catchments, a Nodal CPI score is calculated. Downstream regional opportunities are defined here as high regional BMP score catchments (see Step 2 for BMP score calculation method) that are located "downstream" (based on the stormdrain network) of a group of higher-priority catchments. In order to then prioritize these downstream opportunities (again based on pollutant load, as with the CPI approach), the concept of a *nodal CPI* was developed, in which a catchment node is assigned a new nodal CPI score based on the area-weighted average CPI score of the upstream catchments. This calculation approach is described below.

f.1 Using the hydrologic drainage network described above, identify catchments tributary to each network node and calculate an area-weighted average CPI score for that node. Example 3 demonstrates how nodal CPI scores are computed.

$$Nodal\ CPI = \frac{CPI' \times A + \sum_u \left(CPI'_u \times A_u \right)}{A + \sum_u A_u} \quad \text{(Equation 7)}$$

Where:

Nodal CPI = nodal CPI for study catchment
CPI' = normalized CPI for study catchment
CPI'_u = normalized CPI for upstream catchment "u"
A, A_u = area of study catchment and of upstream catchment "u", respectively

f.2 Round average CPI values to the nearest integer and assign each catchment the rounded CPI value of its associated outlet node. This step results in a Nodal CPI map of the watershed. Figure 10 is an example load-based nodal catchment prioritization index (CPI) map for the Ballona Creek Watershed.

EXAMPLE 3. NODAL CPI CALCULATION

Problem

The 40-acre catchment of Example 2 drains to a point (node) of the drainage network that receives runoff from four other upstream catchments. These upstream catchments have areas of 25, 30, 50, and 65 acres and were assigned CPI scores of 5, 3, 4, and 5, respectively. Compute the nodal CPI score for the 40-acre catchment.

Solution

1. Calculate the area-weighted CPI score for the node receiving direct discharge from the 40-acre catchment, which was assigned a CPI score of 3, as shown in Example 2.

$$(40*3 + 25*5 + 30*3 + 50*4 + 65*5)/(40 + 25 + 30 + 50 + 65)= 4.1$$

2. Round to the nearest integer and assign this nodal CPI score to the catchment.

Nodal CPI score = 4

PRODUCT OF STEP 1:

Create CPI and Nodal CPI maps for the watershed utilizing the analysis results from the Step 1 analysis. The maps should be color coded by CPI score. These watershed maps should facilitate a big-picture review of the number and location of high priority catchments in the watershed. Figures 9 and 10 are example maps for the Ballona Creek Watershed.

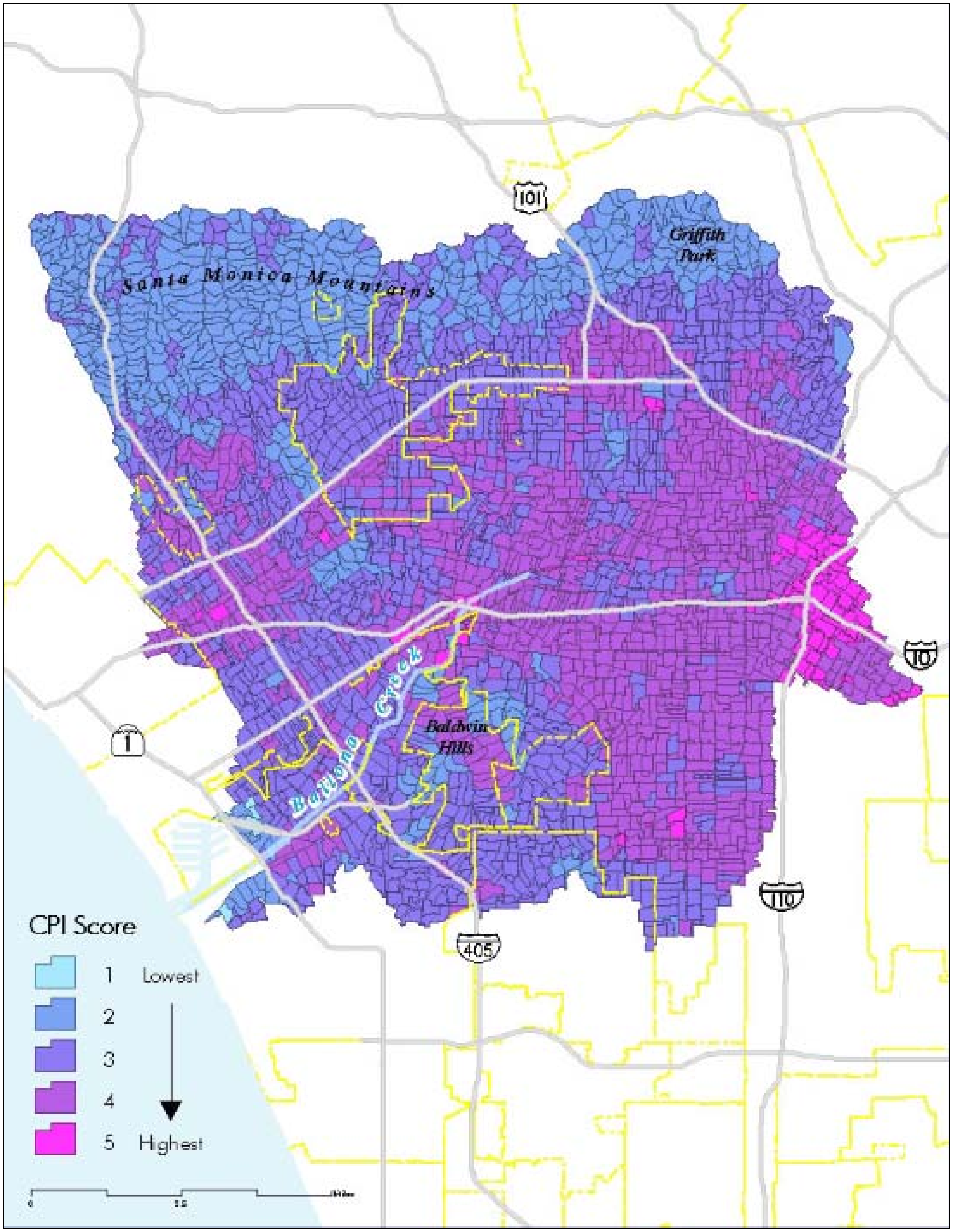

Figure 9. Example of a CPI map for the Ballona Creek Watershed

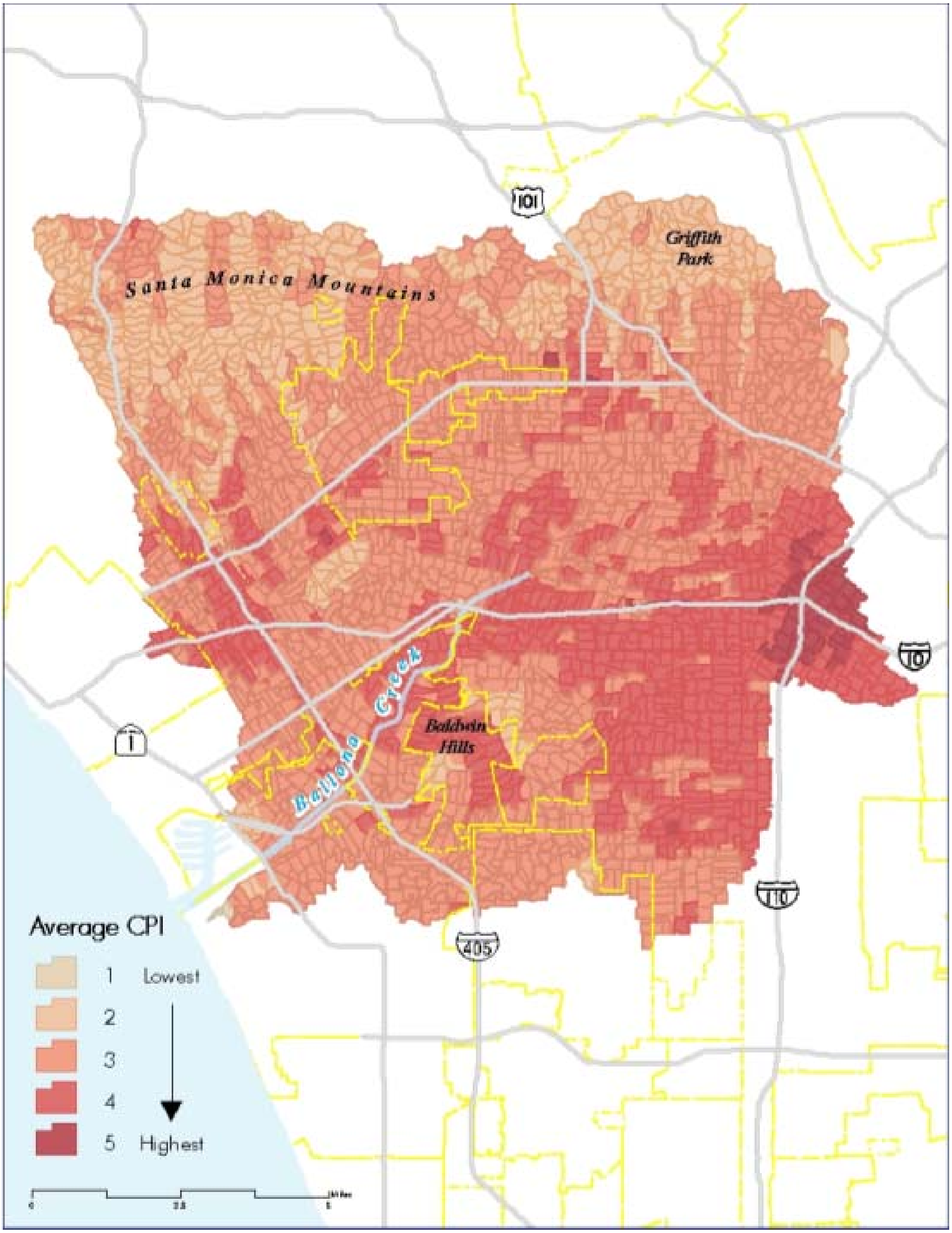

Figure 10. Example of a Nodal CPI map for the Ballona Creek Watershed

STEP 2: PROJECT AREA (PARCEL) SCREENING

The result of Step 1 is the development of CPI scores that can serve as a basis for establishing priority areas. Step 2 identifies parcels in or downstream of the higher-priority catchments that provide the greatest opportunities for structural BMP implementation. For the purposes of this Methodology, BMPs have been divided into three categories:

- Regional/subregional BMPs: centralized stormwater facilities, typically placed near the outlet of a catchment (a drainage area of approximately 40 acres) or subwatershed (a group of catchments with a common outlet) and designed to treat stormwater from a relatively large drainage area (order of magnitude, approximately 100 acres).
- Distributed BMPs: stormwater devices and landscaping practices dispersed throughout a catchment and typically serving relatively small drainage areas (order of magnitude, approximately 10 acres), such as a large single parcel, rooftop, or section of roadway.
- Structural institutional BMPs: stormwater devices or management practices that are implemented over large regions and typically involve the establishment of municipal stormwater management policies and incentive programs (e.g., residential downspout disconnect and retrofit-upon-sale/remodel programs), with impacted areas considerably smaller.

The focus of the Methodology's project area screening is on the first two BMP categories. Figure 11 illustrates the intermediate steps required for screening project areas and identifying higher-priority catchments with the greatest opportunity for structural BMP implementation.

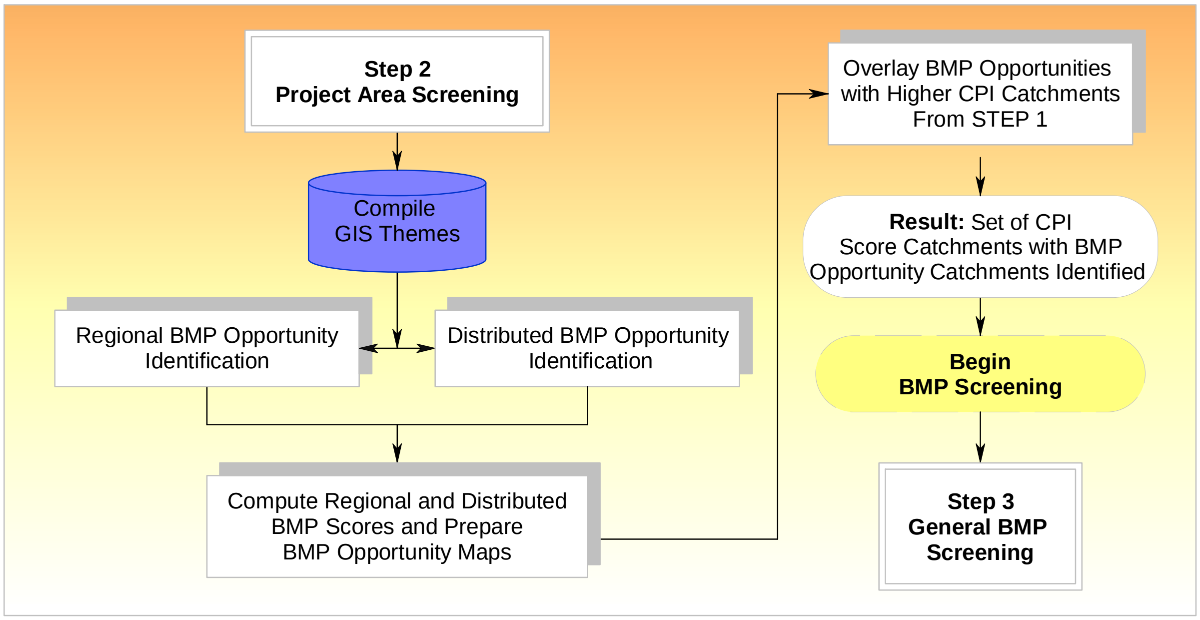

Figure 11. Step 2 - Project Area Screening flowchart.

a. **Compile relevant GIS themes:** Parcel boundaries and ownership information, land uses, roadways, and storm drains and channels (See Table 5).[19]

Table 5. Parcel Screening Data Summary

Data	Type	Scale/ Resolution	Purpose
Project Area Screening			
Parcel boundaries – public ownership	Polygon		Used to identify priority sites for BMP implementation
Parcel boundaries – private, commercially owned, non-residential	Polygon		Used to identify priority sites for BMP implementation
Roads	Line	1:24,000	Used to identify large roadway parcels
Storm drains and channels	Line		Used to identify large open space parcels near drainage network

a.1 **Parcel Classification**:

Parcel data is needed to identify and prioritize opportunities for implementation of both regional and distributed BMP types. Parcel data should, at a minimum, have a distinguishing field for public vs. private ownership and, if public, owner agency. Query parcel data to include all public parcels and to exclude any private parcels below a minimum size. By overlaying the parcel dataset with the land-use data, parcels can be classified as open space, residential, or other developed based on land use. Drop residential parcels from the analysis, as stormwater management for these is assumed to be best addressed through institutional BMPs. Further classify the remaining open space and developed parcels by ownership – City/County, other public agency, or private/commercial. All publicly owned roadway areas, if not available in the parcels data, may need to be approximated by isolating all non-parcel areas (i.e., subtracting parcels from the watershed area).

a.2 **Roadway Classification**:

It is generally assumed that roadway traffic can be an indicator of pollutant concentrations and loading, and that high-traffic roadways (with higher loadings) provide a significant opportunity for cost-effective BMP implementation. Furthermore, road right-of-ways in commercial and industrial areas may be the only feasible location for distributed BMPs. Therefore, if not already classified by type (e.g., major vs minor), roadway data should have number of lanes or, if available, average vehicle counts and speed limits (TIGER CFCC codes that can be used as a proxy if other data are unavailable). Based on these factors, classify roadway areas as major (i.e., highway/freeway, arterial, or local commercial/industrial) or minor (i.e., local residential/open).[20]

a.3 **BMP Opportunities Maps:**

[19] Availability of GIS data will vary with jurisdiction. The Methodology attempts to establish a hierarchy by which the best available data can be utilized for this effort. Should the best data not be available, alternate data sources can be used as described herein.

[20] Alternatively, this major/minor roadway discernment may be realized by intersecting the major transportation corridors (from the land-use GIS layer) with the non-parcel polygon (created out of the parcel GIS layer). This will result in two types of roadways -- major (non-parcel areas having transportation, commercial or industrial land use) and minor (non-parcel areas having residential or open land use).

Generate maps and catchment scores for two types of BMP opportunities: regional/subregional and distributed/onsite. Regional/sub-regional BMPs are defined here as structural treatment or volume mitigation BMPs implemented at the subwatershed or catchment scales. Distributed/onsite BMPs are defined here as structural treatment or volume mitigation BMPs implemented at the neighborhood, parcel or site scale. The following represent recommended criteria developed by the project team, but may be adjusted by the user.

a.4 Regional/Subregional BMP Opportunity Scoring:

1. Identify large (e.g., >1 acre) open space[21] parcels located near torm drains or channels, assigning 0 to all areas not selected;
2. For selected parcels, assign individual regional opportunity scores: 5 for all City- or County-owned public parcels, 4 for all other-owned public parcels (schools/universities, state and federal facilities, utilities, and highway corridors), and 2 for all private commercial or industrial parcels; assign 0 for all others (e.g., residential).

a.5 Distributed/Onsite BMP Opportunity Scoring:

1. Identify large (i.e., >1 acre area) developed[22] parcels, including all roadway areas;
2. For these parcels, assign individual distributed opportunity scores of 5 for all large City- or County-owned public parcels or "major" roadways, 4 for all other-owned public parcels (schools/universities, state and federal facilities, utilities, and "minor" roadways), and 2 for all private commercial or industrial parcels; assign 0 for all non-highlighted distributed opportunity parcels.

a.6 Generate BMP Opportunity Maps:

1. Calculate total regional BMP opportunity scores for each catchment by assigning the maximum parcel score within each catchment (for parcels with >1 acre within given catchment) to the catchment.
2. Calculate total distributed BMP opportunity scores for each catchment by summing area-weighted parcel scores and dividing by total catchment area.
3. Create regional and distributed BMP opportunity maps for the entire watershed.

b. **Relate Higher-priority Catchments to High-Scoring BMP Opportunity Catchments**

b.1 Overlay the distributed opportunity map with the CPI map created in Step 1. Identify catchments with high CPI scores (4 or 5) and potential distributed BMP opportunity (distributed BMP scores > 0). These are the priority distributed catchments.

b.2 Overlay the *nodal* CPI map created in Step 1 with the regional BMP opportunity map. Identify catchments with high nodal CPI scores (4 or 5) with potential regional BMP opportunity (regional BMP scores > 0). These are the priority regional catchments.

[21] Open space parcels are to be identified by intersecting the parcel theme with the land-use theme, and then sorting for vacant and open space/recreational land-use categories. Parcel ownership fields should also be queried to select utility easement areas or corridors to ensure that these regional BMP opportunity parcel types are not missed. As an alternative to an open space analysis, an identification of pervious areas could be done using remote sensing (commercial satellite imagery) data and spatial feature extraction software (Rogers *et. al.*, 2004).

[22] Developed parcels identified by unioning parcel GIS theme with land-use theme, using all non-residential and non-open/vacant land use categories.

PRODUCT OF STEP 2:

BMP opportunity maps overlain by high CPI scoring catchments. The following figures are example BMP opportunity maps. Based on the Methodology and assumptions described above, these maps identify those catchments in the Ballona Creek Watershed having the greatest potential for distributed (Figure 12) and regional (Figure 13) BMP opportunities, as well as those highest-priority catchments and drainage areas (in the case of the nodal CPI scores, shown in Figure 13). Therefore, from these two maps alone, the user is able to identify those catchments in the watershed that have both the greatest *need* (or priority) and the greatest *opportunity* (for BMP implementation). This is perhaps the most valuable single piece of information to come out of the Methodology for water quality planners and regional decision-makers alike.

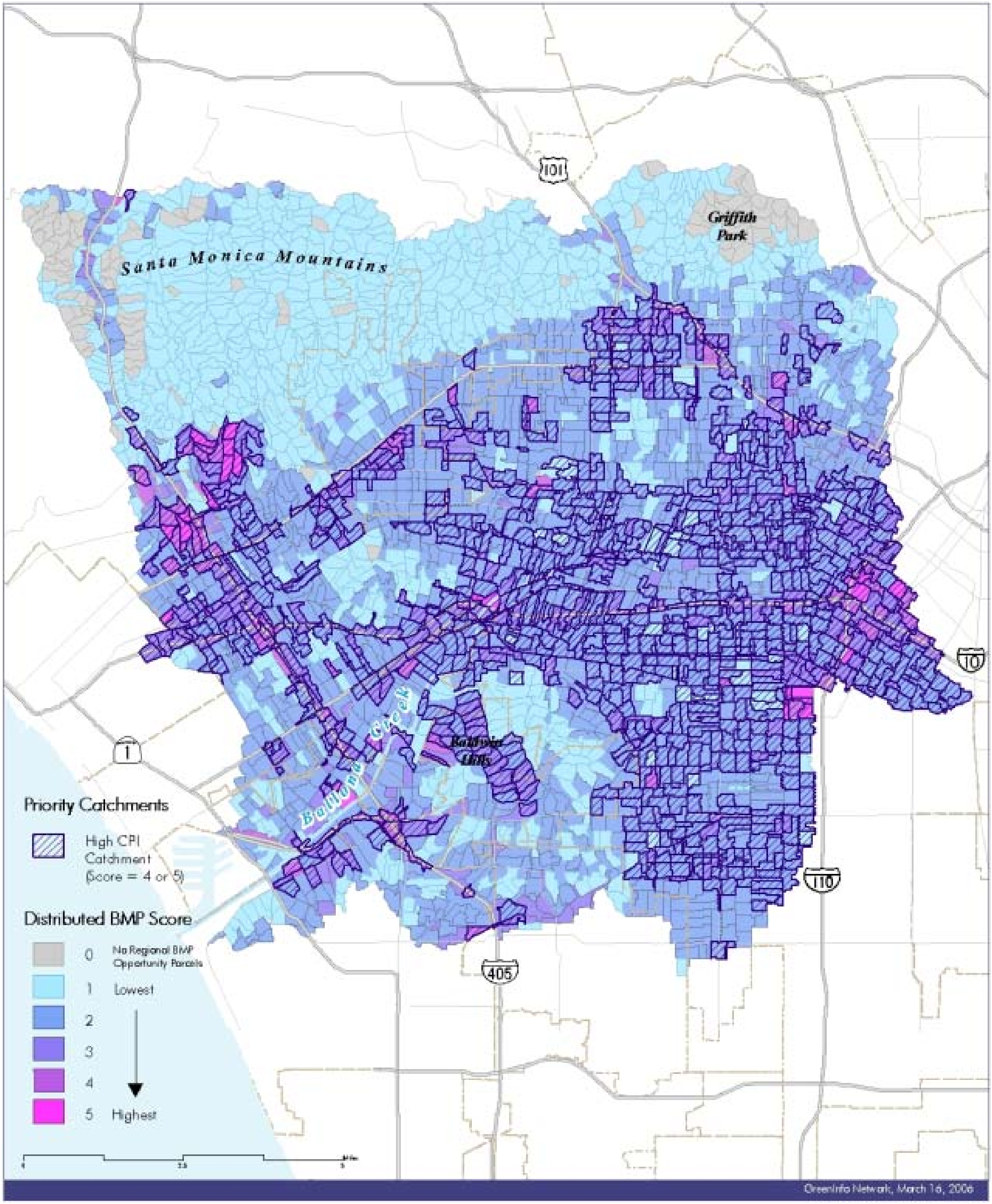

Figure 12. Example distributed BMP opportunities map overlain by high CPI scores for the Ballona Creek Watershed.

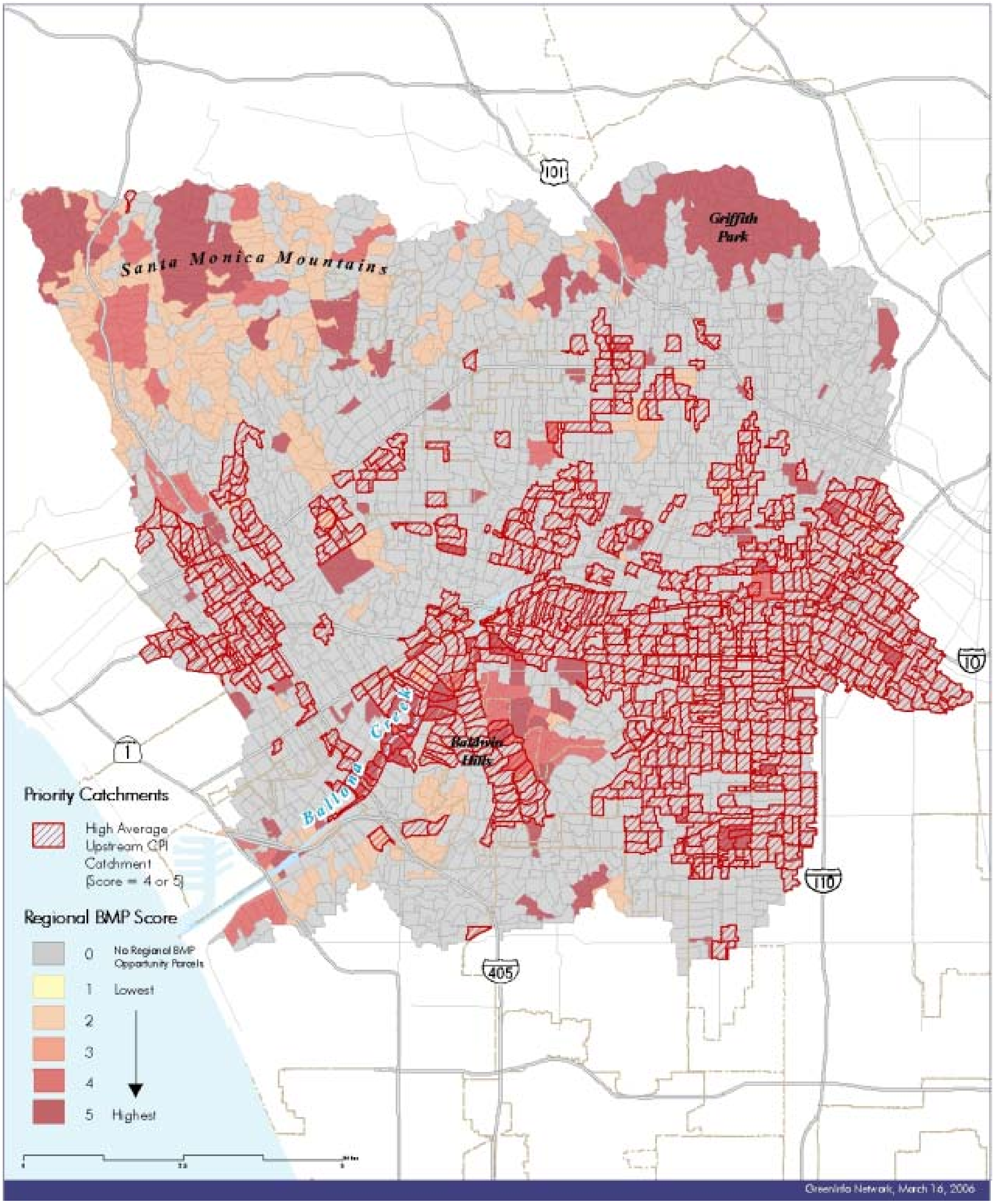

Figure 13. Example regional BMP opportunities map overlain by high nodal CPI scores for the Ballona Creek Watershed

2.2 BMP SCREENING

The objective of the BMP screening phase is to prioritize BMPs for catchment-level site-specific feasibility assessment and implementation planning[23]. Step 3 compares BMP types based on four criteria categories: cost, effectiveness, ease of implementation, and "other environmental factors." This is a general assessment, and the results are therefore fixed and available for application to all BMP opportunity identified in Step 2, Project Area (Parcel) Screening. However, for this task, Methodology implementers have the opportunity to review baseline weights and scores in the BMP comparison tables and evaluation criteria categories (for all BMP types) prior to each application of the Methodology. This could be useful if, for instance, modifications are necessary as new information becomes available regarding BMP costs or effectiveness, or as new BMP types are added.

Step 4 involves site-specific assessment of opportunities and constraints for various BMP types. This task requires an evaluation of the highest-scoring BMP types at each of the highest scoring BMP opportunity sites. Step 4 relies on best professional judgment and subjective assessment rather than an automated decision system.

Figure 14 illustrates the major steps of BMP screening.

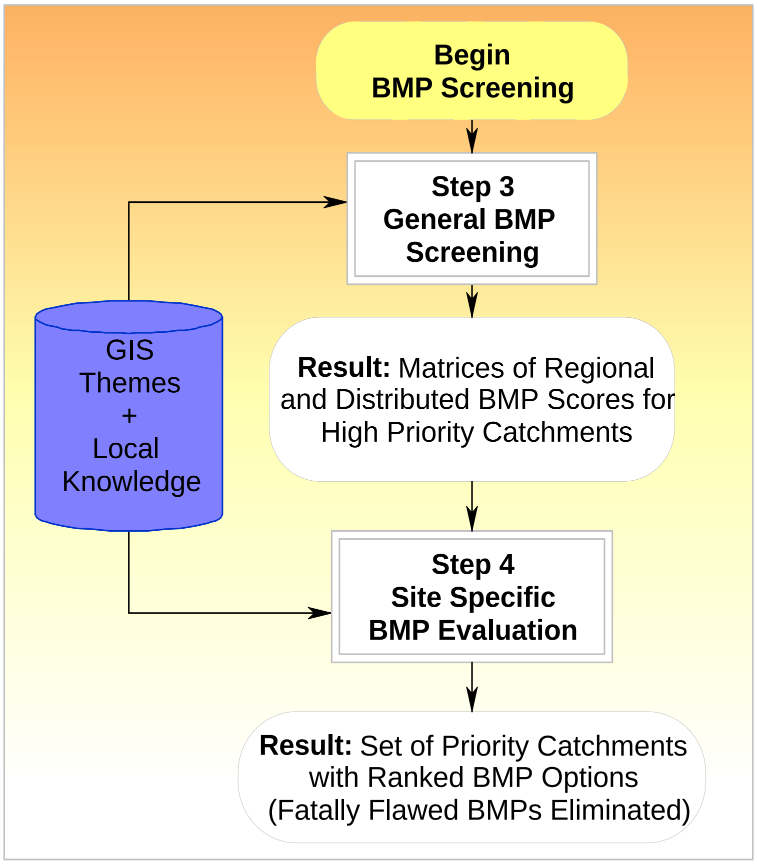

Figure 14. BMP Screening flowchart.

[23] It should be noted here that this methodology provides only a screening-level assessment of constraints, and is intended to increase the efficiency of the overall project identification and planning process. By using GIS to evaluate a very large study area (e.g., entire Ballona Creek Watershed) and identifying BMP opportunities with reasonable potential for implementation, it is assumed that the user can identify more successful projects more efficiently. However, further site-specific feasibility and fatal flaws assessments would of course need to be completed prior to initiating the project design stages.

STEP 3: GENERAL BMP EVALUATION

This analysis is to be conducted for the higher-priority distributed and regional BMP catchments (e.g, catchments having normal and nodal CPI scores greater than or equal to 4) identified in Step 2. The purpose of this step is to generally evaluate potential BMPs for the higher-priority catchments based on a semi-quantitative comparison procedure that considers cost, effectiveness, feasibility, and other benefits/impacts. Figure 15 illustrates the intermediate steps for generally evaluating BMP opportunities.

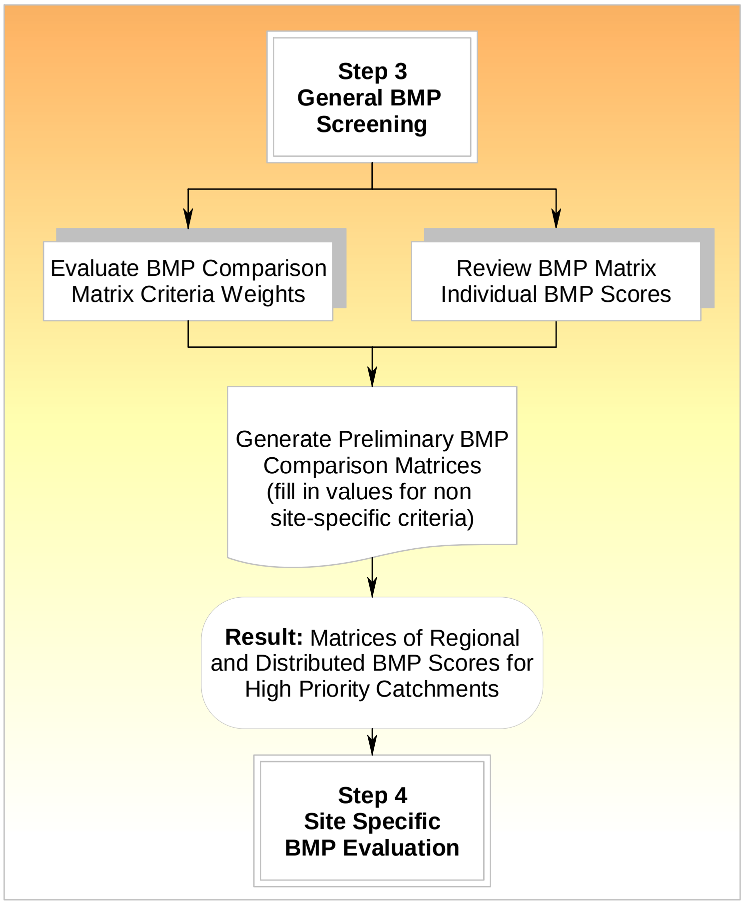

Figure 15.Step 3 - General BMP Screening flowchart.

For the purposes of this document the following BMP types have been included in the assessment (These BMP types were included in the analysis based on availability of cost, performance, and other data.):

- Regional/subregional BMP types: infiltration, detention, subsurface flow (SSF) wetlands (including detention), surface flow (SF) wetlands, treatment facilities, manufactured separation systems (hydrodynamic separators, trash nets/screens, etc.), and channel naturalization (storm drain daylighting, revegetation, wetland channel establishment, etc.).
- Distributed/onsite BMP types: cisterns, bioretention, vegetated swales, green roofs, porous/permeable pavements, gross solids removal devices (GSRDs), media filters, and catch basin inserts.

Substeps a. and b. described below involve the review of the general BMP evaluation matrices developed specifically for this Methodology (Tables 7 and 8). The matrices were developed based on best available current information and data for the regional and distributed BMPs described herein. The user should review the various categories and weights assigned to each category each time the Methodology is applied to ensure the matrices reflect the most current data and the users' specific objectives.

After the user has reviewed the general BMP screening categories and weights, BMP scores are calculated for each catchment (i.e., the matrices provided in Tables 7 and 8, should be created as database entries that are tailored for each catchment).

a. **Evaluate Criteria Weights**.

Review the weight assigned to each BMP evaluation criterion; total weight should sum to 100%. The default weights for each criteria group (shown in Tables 7 and 8) were developed by stakeholder consensus; they should be reviewed and can be changed to match the specific needs, goals, and perspectives of the user. The matrices provide a format in which changes to criterion weights can be seen and their sensitivity established.

b. **Review General BMP Scores for each BMP type.**

Review the default relative scores of each BMP for each criterion shown in Tables 7 and 8. The scores are based on available data, literature, and best professional judgment and should only be modified if additional information becomes available or if other BMPs are to be evaluated. Example data and literature here would include new or expanded BMP cost or effectiveness studies, such as more recent information extracted from the International Stormwater BMP Database (www.bmpdatabase.org) (ASCE/EPA, 2003).

b.1 **Relative Cost Scores**.

Review planning-level relative cost scores (1-5 points each) for each BMP type (default: 30% of total weight -- capital costs[24] 15% and operations and maintenance 15%). The relative capital and operations and maintenances (O&M) cost scores are based on an evaluation of reported literature values and best professional judgment. A detailed discussion of the derivation of these cost scores is provided in Appendix D. [25]

b.2 **Relative Effectiveness Scores**.

Review relative effectiveness scores for each BMP type (default: 30% of total weight). Effective scores are based on the factors described below. Default weights are provided, but could be changed by the user depending on the application.

- Effluent concentrations by pollutant group (15%). Effluent concentration scores are based on data presented in the United States Environmental Protection Agency (EPA) and American Society of Civil Engineers (ASCE) International BMP database (2003) and

[24] Land acquisition costs not considered in capital cost scoring.

[25] Alternatively, a lifecycle cost category may be added, with a weighting distribution of 10%/10%/10% for the 3 cost categories.

Water Environment Research Foundation (WERF) guidelines (2005), and California BMP Handbooks (CASQA 2003). The values (see Appendix C for details and references) are intended to be relative approximate indices of reported achievable *effluent concentrations* (as opposed to the less robust *percent removal* statistics) for each BMP type. Specific distribution of scoring weight among pollutants is a function of the catchment's pollutant CPI scores for distributed BMPs and nodal CPI scores for regional BMPs (after 303(d)/TMDL weighting; i.e., $PCPI''_x$ term from Equation 4 of Step 1) so that BMP effluent concentration scores are maximized when pollutants of greatest concern are matched with BMPs of greatest effectiveness. The percentage weighting of pollutant families for BMP prioritization should match the percent contribution of pollutant families in the catchment prioritization score, prior to adding points for "other impairments"; this calculation is discussed further in sub-step c below, and demonstrated in Example 4.[26]

- *Other pollutant* scores to address BMP effectiveness for bioaccumulation, toxicity, legacy pesticides, and ecological impacts (2.5%).
- *Volume mitigation* scores to address BMP effectiveness for reducing runoff volumes (2.5%)[27].
- *Reliability* scores to address BMP effectiveness and reliability for performance and sensitivity to operations and maintenance variability (note: fatal flaws may be identified for this category during the site-specific constraints screening in Step 4) (10%).

b.3 **Relative Implementability Scores.**

Review relative ease of implementation ("implementability") scores for each BMP type (default: 30% total weight). Implementability will require a general BMP assessment of environmental clearance and permitting factors and a site-specific BMP assessment of screening-level engineering feasibility, parcel ownership, and public safety. The former is addressed in this step (Step 3) and the latter in Step 4. Below is a list of the factors to consider in evaluating the relative implementability of BMPs.

- *Engineering/siting feasibility* scores; this is a site-specific evaluation and therefore will be conducted during Step 4, site-specific BMP evaluation (10%).
- *Ownership/Right-of-Way/Jurisdictions* scores; this is a site-specific evaluation and therefore will be conducted during Step 4, site-specific BMP evaluation (10%).
- *Environmental clearance* scores (5%).
- *Permitting/water rights* scores. Fatal flaws may be identified for this category during the site-specific constraints screening in Step 4 (2.5%).
- *Public safety* scores. Fatal flaws may be identified for this category during the site-specific constraints screening in Step 4 (2.5%).

b.4 **Other Benefits/Impacts Scores**.

Review relative *other benefits/impacts* scores for each BMP type (default: 10% total weight).

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[26] It should be noted that the basis for these evaluations was effluent concentrations and not pollutant removal percentages, as the former is considered a more reliable and robust proxy for water quality performance. See Appendix C for more discussion of the basis of the BMP effectiveness scores.

[27] Some commenters have expressed that this weight should be increased. The user has this option for specific development.

- *Other potential benefits* scoring includes the following subcategories. The score entered as cumulative other potential benefits score (6% total weight). An alternative scoring approach for this "other benefits" category could be for a BMP type to receive the entire 6% if it scores high in any one of the "other benefits" subcategories (flood control/detention storage, downstream impacts/hydromodification, integrated water resources/water conservation, and habitat development).
    - *Flood control/detention storage* (2%)
    - *Downstream impacts/hydromodification* (1%)
    - *Integrated water resources/water conservation* (2%)
    - *Habitat development* (1%)
- *Other potential impacts* scoring includes the following subcategories. Scores are entered as cumulative *other potential impacts* score. Fatal flaws may be identified for this category during the site-specific constraints screening in Step 4 (4% total weight):
    - *Vector issues* (1%)
    - *Bacteria source/regrowth issues* (e.g., potential to accumulate organic debris or sediment, attract avian populations, etc.) (1%)
    - *Competing site uses.* This may be a site-specific evaluation and therefore may be conducted during Step 4, site-specific BMP implementation (2%)

c. **Compute Preliminary BMP Scores for higher-priority catchments.**

Compute the effectiveness weights for all higher-priority catchments and compute total preliminary general (i.e., non-site-specific) score for each BMP type (see Tables 7 and 8). All remaining site-specific criteria scores should be established during next step (Step 4).

c.1 **Allocation of Pollutant-Specific Weights**. For the effluent concentration "effectiveness" criteria, allocate the 15% weight (or other if total weight is adjusted in *a* above) among the individual pollutant groups according to the contribution of each pollutant to each higher-priority catchment's pollutant CPI scores (before "other impairments" scores are included; i.e., $PCPI''_x$ term from Equation 4 of Step 1). Input these allocated pollutant weights into the distributed BMP comparison matrix (Table 4) for all higher-priority catchments. See Example 5 for demonstration of this weighting calculation.

c.2 **Nodal Analysis of Allocated Pollutant Weights**. Similar to the computation of nodal CPI scores, calculate an area-weighted average of the pollutant weights of the upstream catchments. Normalize the resulting pollutant weights, such that they total 15% (or other if adjusted in *a* above). Input these normalized pollutant weights into the regional BMP comparison matrix (Table 6) for all higher-priority catchments. Example 5 demonstrates the calculation of nodal pollutant weights.

c.3 **Calculate the Weighted BMP Scores**. For all higher-priority catchments, compute the weighted BMP scores for all non-site-specific criteria shown in Tables 6 and 7 by multiplying each BMP criterion score by the weight and summing.

EXAMPLE 4: POLLUTANT WEIGHTING OF EFFECTIVENESS CRITERIA

Problem

Compute the pollutant weights for the hypothetical catchment described in Example 2. Normalized catchment pollutant load scores: trash (7, x3 for TMDL listing), nitrate (3), total metals (8, x3 for TMDL listing), fecal coliform (7, x3 for TMDL listing), TSS (2). (from Example 2)

Solution

1. Determine the fraction of the pollutant load score attributed to each of the individual pollutant types. So for each pollutant, divide its normalized pollutant load score by the total of all pollutant scores, or 71 (=7x3+3+8x3+7x3+2).

Trash: 21/71 = 0.296
Nitrate: 3/71 = 0.042
Total Metals: 24/71 = 0.338
Fecal Coliform: 21/71 = 0.296
TSS: 2/71 = 0.028

2. Determine, out of 15% total, what the percent weighting is for each pollutant. Simply multiply the above fractions by 15%.

Trash: 0.296*15% = 4.4%
Nitrate: 0.042*15% = 0.6%
Total Metals: 0.338*15% = 5.1%
Fecal Coliform: 0.296*15% = 4.4%
TSS: 0.028*15% = 0.4\%

EXAMPLE 5. NODAL ANALYSIS OF POLLUTANT WEIGHTS

Problem

The 40-acre catchment of Examples 2, 3 and 4 drains to a point (or node) of the drainage network that also receives runoff from four other upstream catchments. The 40-acre catchment has a total metals weight of 5.1% (from Example 4 above). The other four catchments have areas of 25, 30, 50, and 65 acres and have total metals weights of 8%, 2.5%, 1%, and 6%, respectively. Compute the nodal pollutant weight for total metals for the 40-acre catchment.

Solution

1. Calculate the area-weighted average pollutant weight for total metals for the catchment node described above.
   (40*5.1% + 25*8% + 30*2.5% + 50*1% + 65*6%)/(40 + 25 + 30 + 50 + 65) = 4.4%
2. Repeat for all other pollutants and normalize pollutant weights by scaling to a total of 15%.

   (This is the final total metals effluent concentration weight value for entry in the regional BMP comparison matrix (Table 7) for the specific example catchment node described above.)

PRODUCT OF STEP 3:

Tables of preliminary individual regional and distributed BMP scores for all higher-priority catchments, which should be incorporated into a database so that it can be updated with subsequent evaluation.

Tables 6 and 7 are example preliminary BMP comparison matrices resulting from the general analysis for individual regional BMP scores and individual distributed BMP scores. Because site-specific information was not used to generate these tables, the engineering/siting feasibility and the ownership/right-of-way/jurisdictional scores are not yet included, and therefore do not influence the weighted BMP scores shown. Blank versions (for the site-specific ranking factors) of these tables can also be found in Appendix E.

Table 6.Example Regional BMP Comparison Matrix[28]

Ranking Factors	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF)						
			Infiltration Basins	Detention Basins	Detention w/SSF Wetlands	Constructed SF Wetlands	Treatment Facility	Hydrodynamic Devices	Channel Naturalization
Cost		**30%**							
– Capital	N	15%	4	4	2	4	1	3	4
– Operations and Maintenance	N	15%	1	3	2	2	2	4	3
Effectiveness		**30%**							
– Effluent Conc. (by pollutant group)	*Note that pollutant weights (in red below) are to be calculated for each catchment, creating a new table/database for each catchment*								
- Trash	N	**3.8%**	5	4	5	5	5	4	2
- Nutrients	N	**1.2%**	5	2	5	5	5	2	5
- Bacteria	N	**1.9%**	5	2	4	3	5	2	1
- Metals	N	**4.4%**	5	3	5	5	5	3	4
- Sediment	N	**0.7%**[29]	5	3	5	5	5	4	4
– Other Pollutants (toxicity, bioaccum.)	N	2.5%	5	3	4	4	4	3	3
– Volume Mitigation	N	2.5%	5	3	3	3	2	1	2
– Reliability	N	10.00%	2	3	3	3	5	3	3
Implementation		**30%**							
– Implementation Issues									
- Engineering/Siting Feasibility	Y	10.0%	**Based on Site-specific Evaluation**						
- Ownership/ROW/Jurisdictions	**Y**	10.0%							
- Environmental Clearance	N	5.0%	4	4	4	4	2	4	2
- Permitting, Water Rights	**Y**	2.5%	5	5	5	2	2	2	2
– Safety (Public)	**Y**	2.5%	3	3	3	3	4	4	3
Environment/Other Factors		**10.0%**							
– Other Potential Benefits (e.g., conservation)	N	6.0%	5	4	4	4	1	1	5
– Other Potential Impacts (e.g., vectors)	**Y**	4.0%	3	2	3	2	3	3	3
Weighted Score		**100%**	**2.45**	**2.07**	**2.25**	**2.48**	**2.35**	**2.04**	**2.34**

[28] BMP table criteria and weights were developed based on steering committee consensus and best professional judgment of the Project Team.
[29] Effluent concentration weight value for total metals is for catchment described in Example 5; other pollutant weights are arbitrary and shown for demonstration purposes only.

Table 7. Example Distributed BMP Comparison Matrix[30]

Ranking Factors	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF)							
			Cisterns	Bio-retention	Vegetated Swales	Green Roofs	Porous/ Permeable Pavements	GSRDs	Media Filters	Catch Basin Inserts
Cost		**30%**								
– Capital	N	15.0%	3	2	4	1	2	2	3	5
– Operations and Maintenance	N	15.0%	5	3	4	4	5	3	4	4
Effectiveness		**30.0%**								
– Effluent Conc. (by pollutant group)	*Note that pollutant weights (in red below) are to be calculated for each catchment, creating a new table/database for each catchment*									
- Trash	N	**4.4%**	5	5	4	4	5	4	5	4
- Nutrients	N	**0.6%**	5	5	4	4	5	1	3	1
- Bacteria	N	**4.4%**	5	5	1	4	5	1	3	1
- Metals	N	**5.1%**	5	5	4	4	5	2	4	1
- Sediment	N	**0.4%**[31]	5	5	3	4	5	3	5	2
– "Other" Poll. (e.g.,tox, bioaccum.)	N	2.5%	4	4	4	4	4	1	4	1
– Volume Mitigation	N	2.5%	3	4	4	4	4	1	1	1
– Reliability	**Y**	10.0%	3	4	4	3	2	3	3	3
Implementation		**30.0%**								
– Implementation Issues										
- Engineering/Siting Feasibility	**Y**	10.0%	**Based on Site-specific Evaluation**							
- Ownership/ROW/Jurisdictions	**Y**	10.0%								
- Environmental Clearance	N	5.0%	5	5	5	5	5	5	5	5
- Permitting, Water Rights	**Y**	2.5%	5	5	5	5	5	5	5	5
– Safety (Public)	**Y**	2.5%	4	3	3	4	3	4	4	4
Environment/Other Factors		**10.0%**								
– Other Potential Benefits(e.g., cons.)	N	6.0%	5	4	4	4	3	1	1	1
– Other Potential Impacts (e.g., vectors)	**Y**	4.0%	2	3	3	3	3	3	3	3
Weighted Score		**100%**	**2.44**	**2.11**	**2.29**	**1.86**	**2.21**	**1.47**	**2.09**	**2.02**

[30] BMP table criteria and weights were developed based on steering committee consensus and best professional judgment of the Project Team.
[31] Effluent concentration weight values shown are for example catchment described in Example 4.

STEP 4: SITE-SPECIFIC BMP EVALUATION

Steps 1 and 2 of the Methodology determined CPI scores and regional/distributed BMP opportunity scores and generated watershed-scale maps. Step 3 was a preliminary individual BMP evaluation of the higher-priority catchments identified in Step 2. It involved comparisons of regional/distributed BMP types according to cost, effectiveness, feasibility/implementability, and "other environmental" criteria in the framework of the BMP comparison matrices (Tables 7 and 8). In Step 4, the BMP comparison matrices are completed and specific project opportunities are identified for the higher-priority catchments via the following three-level site-specific constraints screening approach.

- **GIS-Level Screening**. This screening may be automated depending on the form of the available data and involves the screening of BMP opportunities according to available GIS "constraints" layers such as landslide zones, poor soil infiltration zones, and ESA zones.
- **Desktop-Level Screening**. This screening is a manual review of the higher-priority catchment maps for opportunities and constraints, such as available open space, rooftop, and parking lot area. As feasible, the identification of existing BMPs is incorporated in this step.
- **Field-Level Screening**. This screening is also manual and involves site visits to "ground truth" or verify previously-identified constraints and opportunities, as well as to identify additional fatal flaws or opportunities, such as downspout availability (for cisterns), catch basin availability (for catch basin inserts), flood control limitations (according to storm drain as-built drawings and other available information), slope and head limitations, jurisdictional limitations, storm drain proximity restrictions, and public safety issues. As feasible, the identification of existing BMPs is incorporated in this step.

Figure 16 outlines the recommended procedure for conducting the Step 4 site-specific BMP evaluation.

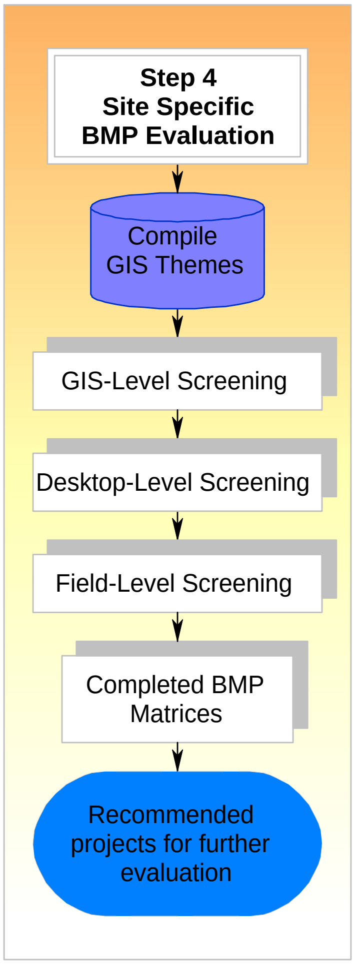


Figure 16.Step 4 - Site-specific BMP Evaluation flowchart.

All three screenings will produce fatal-flaws and site-specific opportunities and other information that will be incorporated in the final BMP comparison matrices. Fatal flaws are easily identified at each stage using guidance provided herein. The following discussion is provided to outline the procedure for implementing this three-level constraints and opportunities assessment, with demonstration examples included for clarification of each step at the end of the discussion. It should also be noted here that this site-specific project identification step represents only very preliminary concept feasibility screening, and that further feasibility screening studies are needed prior to the project design stage.

Compilation of GIS Information

At this stage, the evaluation involves gathering the relevant watershed data using local knowledge as well as relevant GIS themes to assist with site-specific evaluation. Collect and compile any of the following information, as available (See Table 8):

- Soils type data (or alternatively, zones of poor infiltration)
- Topographic contours and/or slope map data
- Digital elevation models or other topographic data
- Groundwater elevations/depths
- Floodplain (e.g., FEMA) map data
- Landslide and/or liquefaction risk zones data
- Biologically or Environmentally Sensitive Areas (BSA/ESA) and/or wetlands mapping data
- Aerial photographs at the highest resolution available
- Impervious surfaces
- Parcel ownership
- Storm drain as-built drawings (including flow direction, slopes, invert elevations, pipe sizes)

Table 8. Site-Specific BMP Evaluation Data Summary

Data	Type	Purpose
Site-Specific BMP Prioritization		
Significant ecological areas	Polygon	Used to identify significant habitat/wetland areas
Wetlands	Polygon	Used to identify significant habitat/wetland areas
Slope	Polygon, line, or grid	Used to identify areas of prohibitively steep slopes
Soils (if available for study area)	Polygon	Used to identify areas of low permeability
Landslide/liquefaction zones	Polygon	Used to identify landslide or liquefaction-prone slopes
Aerial imagery (if available for study area)	Image	Used to visually assess parcel/catchment characteristics
Impervious surfaces	Polygon or grid	Used to identify impervious and pervious areas for BMP implementation
Groundwater depth	Line	Used to identify areas of high groundwater elevation

a. GIS-Level Constraints and Opportunities Screening

This initial screening level consists of an identification of BMP constraints using GIS. This stage of the evaluation entails overlaying higher-priority catchments with the following GIS constraints layers if available:

- Landslide zones,
- Liquefaction zones,
- Steep (i.e., >20%) Slope zones,
- Environmentally sensitive areas (ESA),
- Wetlands areas,
- Low permeability soils (Hydrologic soils group: D)

If any of the above constraints are identified at the higher-priority catchment in question, use the BMP Fatal-flaw matrices (Tables 9 and 10) to identify BMPs to be flagged as potentially unsuitable for the site.

Opportunity identification will require, at a minimum, the following data:

- Aerial photographs
- Parcel data with potential for BMP application
- Land use coverage
- Storm drain data

Other data to be compiled include storm drain patterns and if available, existing BMPs in the subject area.

Product of GIS-Level Screening Effort

A number of maps are to be created as a product of the GIS-level screening. These include:

- Catchment constraint maps containing the constraints information listed above;
- Catchment opportunity maps containing the opportunities information listed above;
- Subwatershed catchment maps showing groups of catchments (focused on higher-priority catchments, with drainage patterns and parcels with regional BMP opportunities.)
- Regional catchment opportunity maps for downstream catchments identified in the subwatershed catchment mapping and nodal analysis phases.

See Example 6 below for a demonstration of a GIS constraints analysis, with a “constraints map” shown to support the analysis (created by overlaying the above GIS constraints layers on street and storm drain maps of the higher-priority catchments). As shown in the example, infiltration basins and porous/permeable pavement are flagged for fatal flaws, based on referencing the BMP fatal-flaws matrices. These fatal-flaw flags will be entered in the final regional and distributed BMP comparison tables for the catchment.

Table 9. Regional BMP Fatal-flaws Matrix

Screening Level	Constraint	Regional BMPs						
		Infiltration Basins	Detention Basins	Detention w/ SSF Wetlands	Constructed SF Wetlands	Treatment Facility	Hydrodynamic Separators	Channel Naturalization
GIS-Screening	Landslide Zone	FF						
	Liquefaction Zone	FF						
	Slope>20% Zone	FF	FF	FF	FF			
	Envtl. Sens. Area (ESA)	FF	FF	FF				
	Wetlands Zone	FF	FF	FF				
	Soil Infiltration-Limited Zone[2]	FF						
	Zero Reg. BMP Opp. Score (from Parcel Screening Step)	FF	FF	FF	FF			
	Zero Dist. BMP Opp. Score (from Parcel Screening Step)							
Desktop-Screening[1]	No Major Open Space (for Reg. BMP Opp.)	FF	FF	FF	FF			
	No Sign. Green Space (for Dist. BMP Opp.)							
	No Sign. Rooftop Area (non-residential)							
	No Sign. Surface Parking Lot Area							
Field-Screening[1]	Proximity to Stormdrain/Channel	FF	FF	FF	FF	FF	FF	FF
	Flood Control Limitations in Stormdrain/Channel	FF	FF	FF	FF	FF	FF	FF
	Slope/Head Limitations	FF	FF	FF	FF			
	Soil Infiltration Limitations[2]	FF						
	GW Depth Limitations (i.e., <5 ft to seasonal high gw level)	FF						
	Space Limitations (i.e., <2% of drainage area available)	FF	FF	FF	FF			
	Space Limitations for Smaller Treatment Devices					FF	FF	
	Access Limitations (for maintenance)					FF	FF	
	Jurisdictional Restrictions	FF	FF	FF	FF	FF	FF	FF
	Public Safety Issues	FF	FF	FF	FF	FF	FF	FF
	Effectiveness Reliability Issues	FF	FF	FF	FF	FF	FF	FF
	Permitting/Water Rights Issues	FF	FF	FF	FF	FF	FF	FF
	"Other" Limitations (e.g., vectors, bacteria regrowth/ sources, competing site uses)	FF	FF	FF	FF	FF	FF	FF
	Downspouts Unavailable/Inaccessible, or Too Far from Irrigation Area							
	Available BR Area Not Downhill from Drainage Area							
	Linear Area Unavailable for Conversion to Swale							
	Flat (<20%) Rooftops Unavailable							
	Catchbasins Unavailable/Inaccessible or Too Small/Few							

Notes:

1 Note that all identified desktop-screening constraints should be confirmed during field-screening step.

2 Soil infiltration-limited constraint is included in both the GIS-screening and field-screening steps because soil type GIS data may or may not be available for the analysis.

Table 10. Distributed BMPs Fatal-flaw Matrix

Screening Level	Constraint	Distributed BMPs							
		Cisterns	Bioretention	Vegetated Swale	Green Roofs	Porous/ Permeable Pavements	GSRDs	Media Filters	Catch Basin Inserts
GIS-Screening	Landslide Zone		FF			FF			
	Liquefaction Zone								
	Slope>20% Zone								
	Envtl. Sens. Area (ESA)		FF			FF			
	Wetlands Zone		FF			FF			
	Soil Infiltration-Limited Zone[2]								
	Zero Reg. BMP Opp. Score (from Parcel Screening Step)								
	Zero Dist. BMP Opp. Score (from Parcel Screening Step)	FF	FF	FF	FF	FF			
Desktop-Screening[1]	No Major Open Space (for Reg. BMP Opp.)								
	No Sign. Green Space (for Dist. BMP Opp.)	FF							
	No Sign. Rooftop Area (non-residential)	FF			FF				
	No Sign. Surface Parking Lot Area					FF			
Field-Screening[1]	Proximity to Stormdrain/Channel						FF	FF	
	Flood Control Limitations in Stormdrain/Channel						FF	FF	
	Slope/Head Limitations								
	Soil Infiltration Limitations[2]		FF			FF			
	GW Depth Limitations (i.e., <5 ft to seasonal high gw level)		FF			FF			
	Space Limitations (i.e., <2% of drainage area available)								
	Space Limitations for Smaller Treatment Devices						FF	FF	
	Access Limitations (for maintenance)								
	Jurisdictional Restrictions	FF	FF	FF	FF	FF	FF	FF	FF
	Public Safety Issues	FF	FF	FF	FF	FF	FF	FF	FF
	Effectiveness Reliability Issues	FF	FF	FF	FF	FF	FF	FF	FF
	Permitting/Water Rights Issues	FF	FF	FF	FF	FF	FF	FF	FF
	"Other" Limitations (e.g., vectors, bacteria regrowth/ sources, competing site uses)	FF	FF	FF	FF	FF	FF	FF	FF
	Downspouts Unavailable/Inaccessible, or Too Far from Irrigation Area	FF							
	Available BR Area Not Downhill from Drainage Area		FF						
	Linear Area Unavailable for Conversion to Swale			FF					
	Flat (<20%) Rooftops Unavailable				FF				
	Catchbasins Unavailable/Inaccessible or Too Small/Few								FF

Notes:

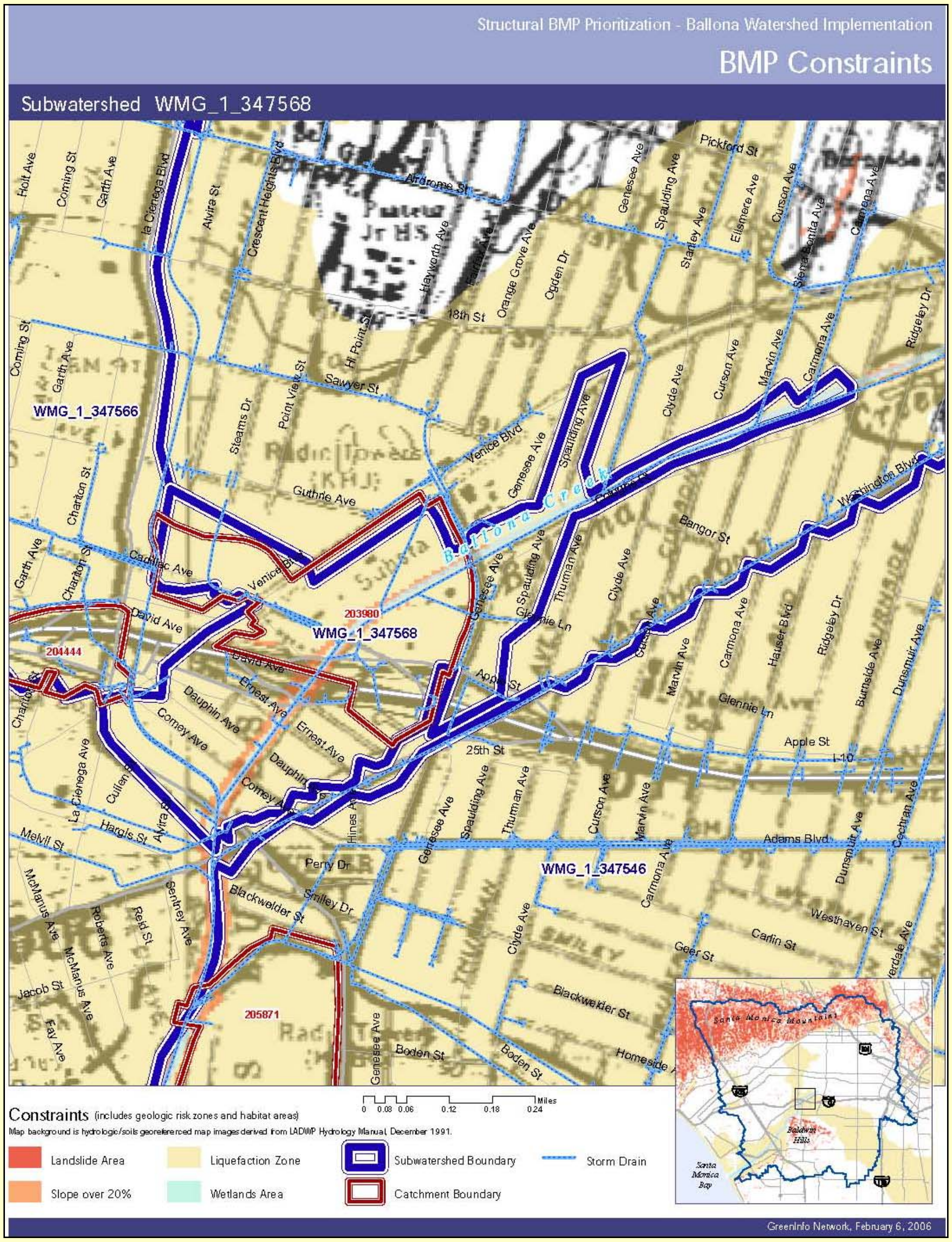
1 Note that all identified desktop-screening constraints should be confirmed during field-screening step.

2 Soil infiltration-limited constraint is included in both the GIS-screening and field-screening steps because soil type GIS data may or may not be available for the analysis.

EXAMPLE 6: GIS-LEVEL SCREENING EXAMPLE

Scenario

The site is priority catchment 203980 located in subwatershed WMG_1_347567 in the center of Ballona Creek Watershed. The BMP constraints map shows this high-priority catchment located within a liquefaction zone.



GIS Level Screening Example - Subwatershed 347567

Solution

1. List applicable GIS–Level Screening constraints (Liquefaction)
2. Reference fatal-flaws tables 9 and 10 and identify BMPs to be flagged for fatal flaws
3. Identified BMPs are infiltration type BMPs such as: Infiltration Basins
4. **Flag Infiltration Basins to complete this step**

b. **Desktop-Level Constraints and Opportunities Screening**

The "desktop-level screening" is intended to be conducted in the "office" prior to field investigations. This screening consists of a visual review of maps created in the GIS-Level Screening and the identification of BMP constraints and opportunities. These maps are:

- Catchment-specific constraints maps (with landslides, slopes, etc.)
- Catchment-specific opportunity maps (with aerial photos, storm drains, etc.)
- Subwatershed-level drainage/opportunity maps (with drainage patterns)
- Regional opportunity catchment maps.

In addition, CPI and nodal CPI maps should be consulted to assist in identifying highest priority catchments. This effort should initially be conducted only on higher-priority catchments identified at the end of Step 2. At this stage the following steps are needed:

b.1 **Verify constraints identified during initial GIS-level screening step**.

Verification of the GIS-Level Screening is necessary because false positive fatal flaws can be generated when even small portions of constraint areas are located in a higher-priority catchment. This verification can be done by visually reviewing the BMP constraints maps for each higher-priority catchment, to confirm all the fatal flaws identified during the GIS-level screening.

b.2 **Identify additional constraints and opportunities**

Identify the following constraint features by reviewing previously-developed catchment opportunity and constraints maps, which show aerial photos and boundaries of screening parcels for higher-priority catchments. This screening is not only intended to eliminate infeasible BMPs, but also to allow for reconsideration of BMPs that may have been previously eliminated (e.g., BMPs that, upon review of site-specific conditions, may actually be feasible). Considerations include the following:

- No major open space, with "major" being defined here as an "open" (or undeveloped) parcel with an area of 1 acre or more within the catchment. This 1-acre constraint is for regional opportunities such as infiltration basins, detention basins, and wetlands, but not including treatment facilities, manufactured separation systems, or channel naturalization.
- No significant green space near rooftops – such as median strips, parkway areas, landscaped areas, or planter boxes – which could provide adequate irrigation demand for runoff volume stored from contributing rooftop areas. This constraint is primarily for a cistern or other distributed BMP that depends on storage and irrigation reuse.
- No significant surface parking lot area, with "significant" being defined here as 1 acre or more of total parking lot area. This constraint is for pervious/permeable pavement and is based on the assertion that small parking lots are more cost-effectively retrofitted by other distributed BMP options.
- No significant non-residential rooftop area, with "significant" being defined here as 1 acre or more. This constraint is for green roofs with the assertion that residential or other small roof tops are more cost-effectively retrofitted by other distributed BMP options.

b.3 **Identify existing BMPs**.

Using available data sources (e.g., GIS layer, hard-copy maps, etc.), identify existing BMPs within the higher-priority catchments. For each identified BMP, evaluate the BMP type and tributary drainage area to determine whether the catchment is being sufficiently treated for the pollutants of concern. If so, remove catchment from higher-priority list.

b.4 **Look for additional potential downstream opportunities**.

This step utilizes the maps developed in the GIS-Level Screening step that are focused on regional solutions. While most of the potential downstream opportunities should have been identified during the nodal analysis of Step 1, some may have been missed during the automated catchment identification procedure. Additional opportunities should be evaluated by inspecting the maps produced at the end of Step 2 – which show subwatershed boundaries, higher-priority catchments, storm drains and flow directions, and high regional BMP opportunity score catchments.

- Using these maps, look for high regional BMP opportunity score catchments that are adjacent to a storm drain and located downstream of high CPI score catchment(s). Additional digital sources, such as aerials and detailed storm drain information, may also be useful during this stage.
- Confirm GIS-level constraints screening step for all downstream regional BMP opportunity catchments (which are not higher-priority catchments, and therefore have not been previously assessed for constraints). This step can also be done manually by inspecting the BMP constraints map. Check constraints map to confirm that regional BMP opportunity catchment is not located in a constraints zone (see GIS Screening step for list of GIS constraints layers). Next repeat desktop-level constraints screening step (i.e., review of catchment maps) for these downstream opportunity catchments.

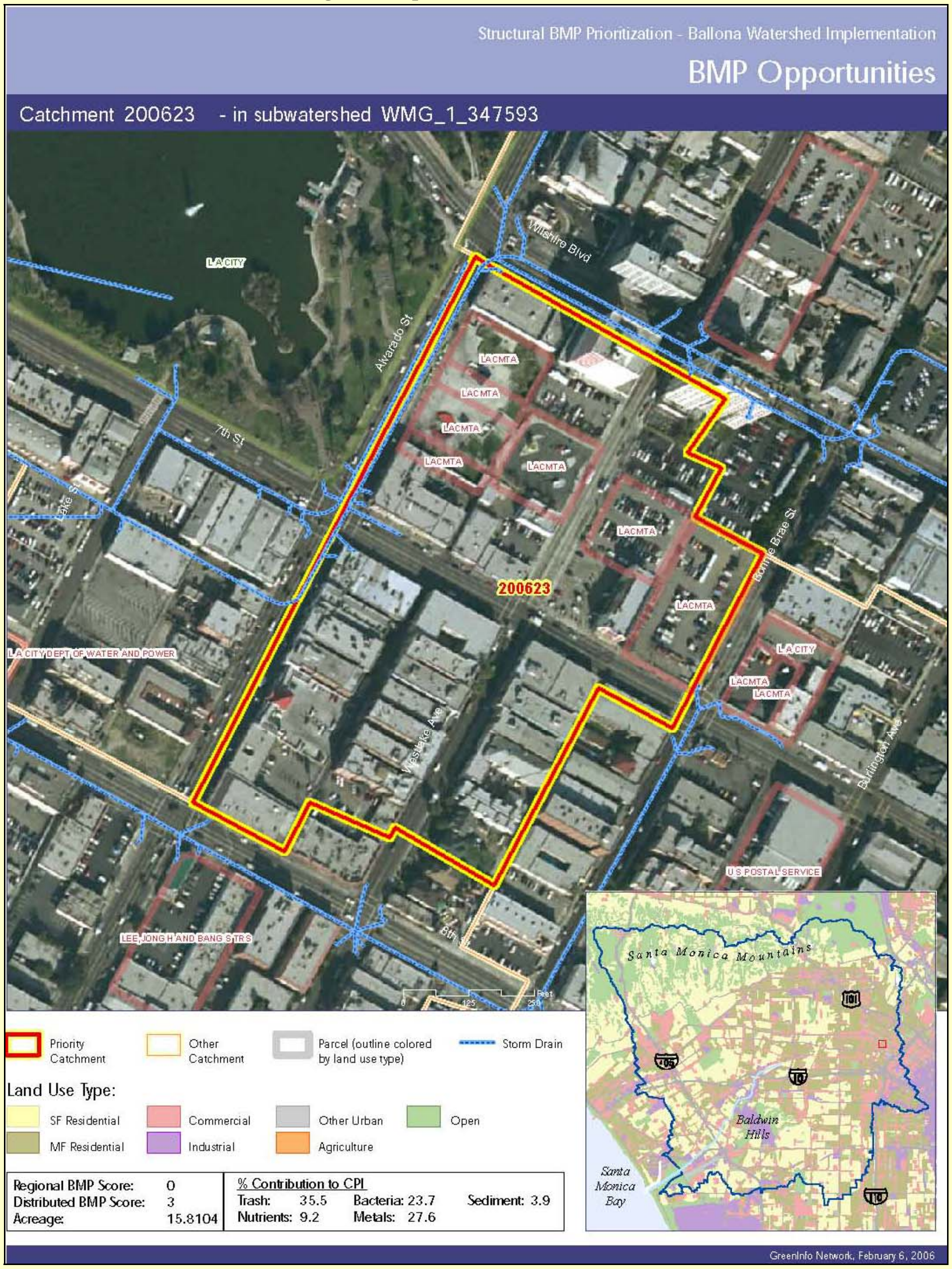
A demonstration of the desktop-level constraints screening procedure is shown below in Example 7, which includes a BMP opportunities map and a CPI scores map depicting a higher-priority catchment of the Ballona Creek Watershed.

EXAMPLE 7: DESKTOP-LEVEL SCREENING EXAMPLE

Scenario and Analysis

The high-priority catchment 200623 (see catchment map below) is located in subwatershed 347593 in the Ballona Creek Watershed. The following constraints-related observations can be made:

1. Regional BMP score is 0 (i.e., catchment not likely to have a regional BMP opportunity);
2. Distributed BMP score is 3 (i.e., catchment should have distributed BMP opportunities)
3. Lack of significant green space, but significant parking lot areas and some rooftops
4. LACMTA (public) properties covering large proportion of catchment on the north side.
5. Private commercial buildings to the south.
6. Trash and metals contribute highest to pollutant CPI

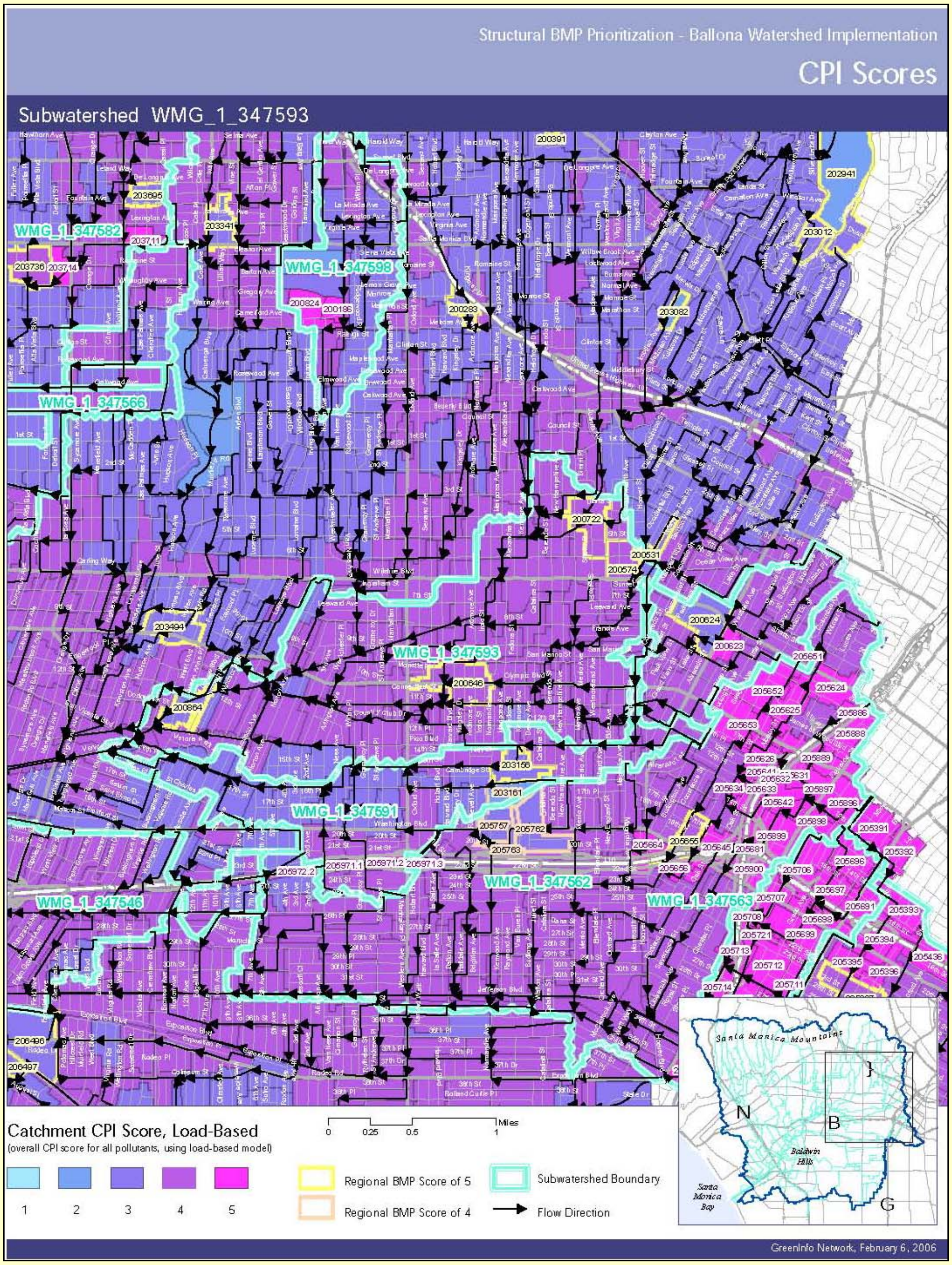


Desktop-Level Screening Example - Sample BMP Opportunities Map

EXAMPLE 7: DESKTOP-LEVEL SCREENING EXAMPLE (*CONTINUED)*

The following downstream opportunity-related observations can be made (see subwatershed map below):

7. The high-priority catchment 200623 may drain to southeast side of high-ranking regional BMP catchment 200624.
8. However, upon closer review of the aerial photo, catchment 200623 primarily drains by sheet flow toward the south, away from regional BMP opportunity catchment 200624.



EXAMPLE 7: DESKTOP-LEVEL SCREENING EXAMPLE *(CONTINUED)*

Solution

1. Verify constraints identified during initial GIS-Level screening
2. List applicable Desktop-Level Screening constraints and flag impacted BMPs using the BMP Fatal-flaw matrices (Table 11 and Table 12) as follows:
   a. No major open space – (flag regional BMPs such as infiltration basins, detention basins, detention with subsurface-flow wetlands, and constructed wetlands)
   b. No significant green space near rooftops – (flag cisterns based on lack of irrigation demand)
   c. No significant (<1 acre) non-residential rooftop areas – (flag green roof)
3. Identify downstream regional BMP opportunities:
   a. Not feasible to divert runoff toward potential downstream regional opportunity catchment to the west.
4. Identified potential BMPs are distributed BMPs such as:
   a. Bioretention
   b. Porous/Permeable Pavement
   c. Catch basin inserts
   d. Media filters
   e. Gross-Solids Removal Devices (GSRDs)

c. Field-Level Constraints and Opportunities Screening.

This step utilizes the maps and information used and/or generated during the GIS- and Desktop-Level Screening. Intended for a set of catchments that are found to require field investigation, this final screening level consists of an identification of BMP constraints by first collecting and reviewing local agencies' storm drain as-built drawings, soil maps, and/or groundwater elevation data (as available) for the areas of interest, and then field inspecting the identified higher-priority and downstream regional BMP opportunity catchments. Catchment maps (showing catchment boundaries, parcel boundaries, land uses, BMP scores, and CPI scores), aerial photos (particularly close-ups of any significant open space areas, such as parks, located in the study catchments), subwatershed and CPI maps (to see larger drainage area), storm drain as-built drawings (to see street flow directions and storm drain inlet locations), and other available supporting maps should be taken to the field during the inspection to help evaluate BMP opportunities and constraints within the inspected catchments. Thus, the results of both the GIS-Level and Desktop-Level Screening are leveraged in this portion of the analysis.

Figure 17 below is a blank field observation data sheet that should be used to guide the collection of observations in the field.

Catchment BMP Prioritization Field Observations Data Sheet

Catchment No.: ____________ **Date:** ________________

Field Personnel: ____

Regional BMP Score: ______________ CPI Score ______________

Distributed BMP Score: ______________ Total Acreage ______________

Major Land Uses ____

Major Cross-Streets ____

____

Drainage Description (general flow direction, major storm drains, location/no. of catch basins, downspouts, pervious areas)

____

Public Parcels Description (ownership/name, building characteristics, parking lots, landscaped areas, open space, x-streets)

____

Other (Private) Large Parcels Description/General Notes

____

Most Promising BMPs and Implementation Locations (see notes below)

____

Notes - Consider the following areas when evaluating potential BMPs:
- Rooftops (for cisterns, green roofs, bioretention)
- Roadways (for bioretention, swales, catch basin inserts, hydrodynamic separators, GSRDs, media filters)
- Sidewalks and walkways (for bioretention, swales, porous pavement)
- Parking lots (for porous pavement, swales, bioretention, catch basin inserts, media filters)
- Blacktop areas such as school playgrounds (for bioretention)
- Patios and common areas (for bioretention)
- Vacant lots (for any regional BMP, bioretention, swales, media filters)
- Parks and playfields (for any regional BMP, bioretention, swales, media filters)
- Utility corridors (for infiltration basins, swales, bioretention, media filters)
- Riparian corridors/open channels (for channel naturalization)

Photo Log (also note photo ID no. and direction on accompanying catchment/stormdrain maps):

____

Figure 17. Blank Field Observation Data Sheet

The following steps should be followed for the Field-Level Screening.

c.1 **Identify existing BMPs**.

Confirm the existence of any BMPs identified during the Desktop-Level Screening. Identify any additional BMPs located within the catchment. For each identified BMP, evaluate the BMP type and tributary drainage area to determine whether the catchment is being sufficiently treated for the pollutants of concern. If so, remove it from the higher-priority list. If not, consider modifying the existing BMPs or adding BMPs.

c.2 **Identify potential BMP locations within the opportunity parcels**.

The following locations should be considered while identifying constraints and opportunities within each inspected catchment.

- Rooftops (for cisterns, green roofs, bioretention[32])
- Roadways (for bioretention[33], swales, catch basin inserts, hydrodynamic separators, GSRDs, media filters)
- Sidewalks and walkways (for bioretention[34], swales, porous pavement)
- Parking lots (for porous pavement, swales, bioretention[35], catch basin inserts, media filters)
- Blacktop areas such as school playgrounds (for bioretention[36])
- Patios and common areas (for bioretention[37])
- Vacant lots (for any regional BMP, bioretention, swales, media filters)
- Parks and playfields (for any regional BMP, bioretention, swales, media filters)
- Open spaces (for regional BMPs)
- Utility corridors (for infiltration basins, swales, bioretention, media filters)
- Riparian corridors (for channel naturalization)

c.3 **Identify the following regional and distributed BMP constraint features via site visit(s), while also verifying all previously identified opportunities and constraints in the field (i.e., site verification, or "ground truthing")**:

- Proximity of site to storm drain/channel; this constraint applies to BMPs that require conveyance of flows to or from the implementation location (e.g., infiltration basins, detention basins, wetlands, swales, separation systems, etc.). If the proposed location is more than a predetermined distance (e.g., 300 feet) from the storm drain, note as a potential fatal flaw.
- Flood control limitations in storm drain/channel, which could prohibit installation of bypass/diversion structure; this would be based on review of as-built drawings and/or

[32] Bioretention here may include downspout disconnect to landscaped areas or planter boxes.
[33] Bioretention here may include traffic island or roadside landscaping improvements, or curb cuts to roadside pervious areas.
[34] Bioretention here may include reduction of sidewalk width to include landscaped strip, planter boxes and/or street trees.
[35] Bioretention here may include removal of pavement in one or more parking stalls, curb cuts to perimeter, or median landscaping.
[36] Bioretention here may include pervious area replacement, installation of planter boxes, or perimeter landscaping.
[37] Bioretention here may include planter boxes or perimeter landscaping.

confirmation from flood control engineering staff. All regional BMPs are subject to this constraint.

- Slope or elevation limitations, which could prohibit diversion and subsequent return of treated water by gravity; too mild a slope may cause ponding and backwater effects, too large a slope may cause scour at BMP inlets and outlets. Typically, given adequate vertical relief most designs may compensate for less-than-perfect site slopes with grading and excavation or by using modifications such as check dams and energy dissipaters. The following table (Table 11) should be used as a potential guideline for determining if a fatal flaw applies for a particular BMP for this slope/head constraint. If a BMP is not listed, it is not directly constrained by site slope or head limitations.

Table 11. Default Fatal-flaw Conditions for Slope or Head Constraints

BMP	Slope	Head (ft)
Detention Basin	None	<3
Wetlands	None	<3
Infiltration Basin	>15%	<3
Swales	<0.5% or >6%	<2

- Soil infiltration rate limitations (i.e., <0.5 in/hr not acceptable), which could prohibit implementation of infiltration basins[38].
- Depth to seasonal high groundwater table (i.e., <10 ft), which could prohibit implementation of infiltration basins[38].
- Space limitations, which could potentially prohibit implementation of both large-footprint (e.g., infiltration basins) and small-footprint (e.g., manufactured separation systems) regional BMPs.
- Access limitations, which could prohibit implementation of maintenance-intensive BMPs such as treatment facilities, manufactured separation systems, and catch basin inserts.
- Any identified ownership, right-of-way, or jurisdictional limitations.
- Any identified public safety limitations. The public safety hazards most commonly associated with BMPs include: vectors, drowning, and confined space access issues. If public access is restricted through the use of fencing and if adequate vector controls are implemented for any BMP with the potential for standing water, then the BMP should not be given a fatal flaw for safety.
- Any fatal flaws related to BMP reliability (can pertain to maintenance-related reliability).
- Any fatal flaws related to permitting (e.g., ACOE 404) or water rights.
- Any other fatal flaws (e.g., vector control/attraction issues, bacteria regrowth or source [such as birds] attraction issues, competing site uses, aesthetics, etc.).
- Downspouts unavailable/inaccessible or are not served by significant rooftop area, or greenspace area too small or far away to serve as feasible irrigation demand for cisterns.

[38] Bioretention and porous/permeable pavement BMPs may be constructed with underdrains, and therefore poor soil infiltration may not prohibit implementation of these BMP types.

- Proposed bioretention area (either existing open space or removed pavement) uphill from tributary drainage area and therefore requiring pumping.
- Linear area (>100 ft long, 8 ft wide, draining significant impervious area) unavailable for conversion to swale.
- Relatively flat (<20% slope) rooftops unavailable (for green roofs).
- Catch basins unavailable/inaccessible or too small/few (<5 in higher-priority catchment).

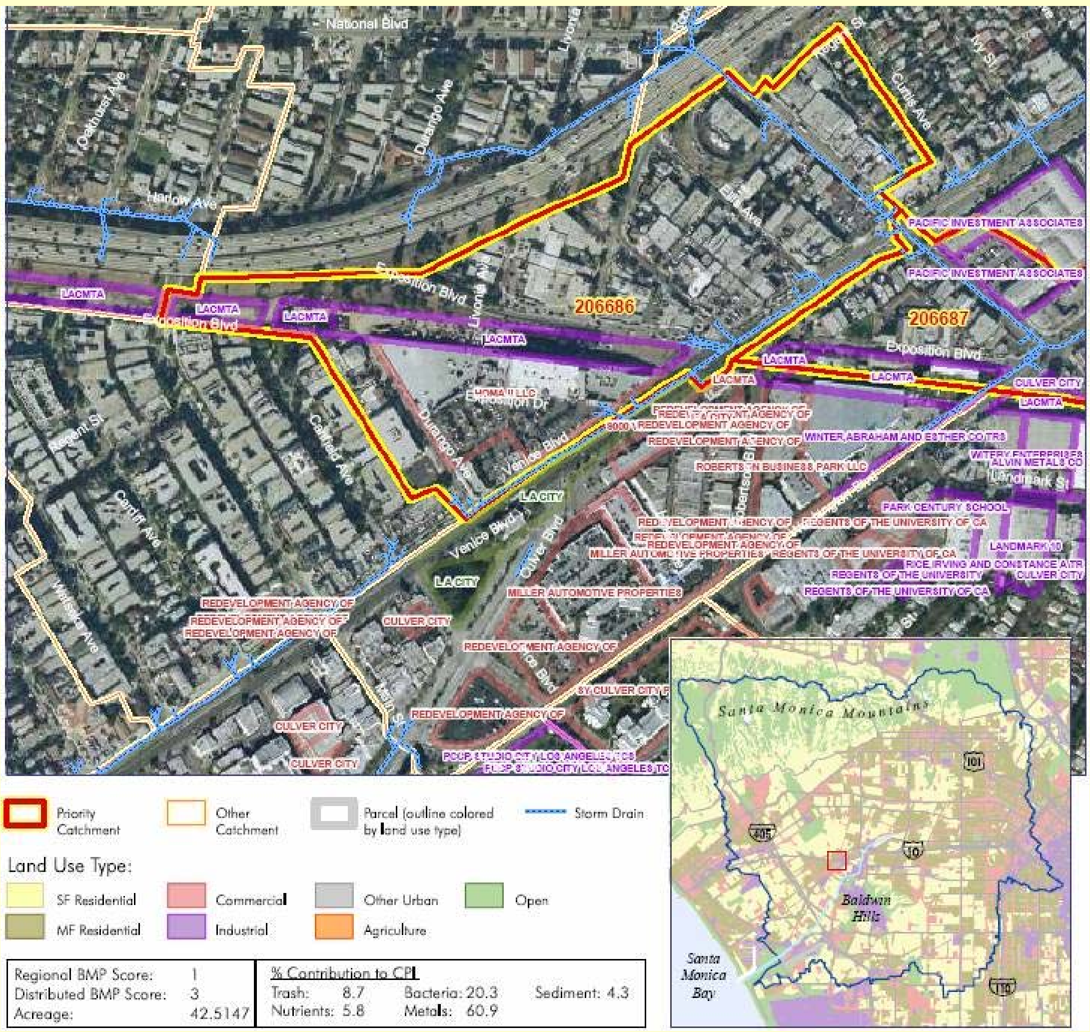
A demonstration of the Field-Level Screening procedure is shown in Example 8.

EXAMPLE 8: FIELD-LEVEL SCREENING EXAMPLE

Scenario

A site visit was conducted at high-priority catchment 206686 in the Ballona Creek Watershed near the intersection of Venice Blvd (see figure below) and Exposition Blvd. The following site conditions apply:

1. Land uses: Industrial and Commercial
2. Catchment Area (42.5 acres, obtained from GIS)
3. CPI score 5
4. Overall Distributed BMP score is 3 (from GIS-Level and Desktop-Level screening)
5. Overall Regional BMP score is 1 (from GIS-Level and Desktop-Level screening)



Field-Level Screening Example - Sample BMP Opportunities Map

EXAMPLE 8: FIELD-LEVEL SCREENING EXAMPLE *(CONTINUED)*

Solution

1. While onsite, verify constraints identified during initial GIS-Level screening.
2. While onsite, verify constraints identified during Desktop-Level Screening.
3. BMP opportunities identified (and noted on field observation data sheet):
   a. Downspout planter boxes adjacent to supermarket building and parking lot bioretention strip

   b. Swales near I-10 Freeway onramp and within LACMTA corridor.
   c. Catch basin inserts distributed throughout private commercial/industrial area on north side of catchment
   d. Media filter vaults within storm drains prior to discharging to Venice Blvd. main storm drain line.

d. **Tabulation of Fatal Flaws**. The following step summarizes the process of interpreting constraints that are identified and translating them into fatal-flaw flags for specific regional and distributed BMP types. The integration of this is highlighted in Figure 18, below.

d.1 List field-level screening constraints, and refer to BMP Fatal-flaws matrices (Tables 9 and 10) to identify regional and distributed BMP types that should be flagged for fatal flaws. These are the same matrices that were referred to during the previous screening steps.

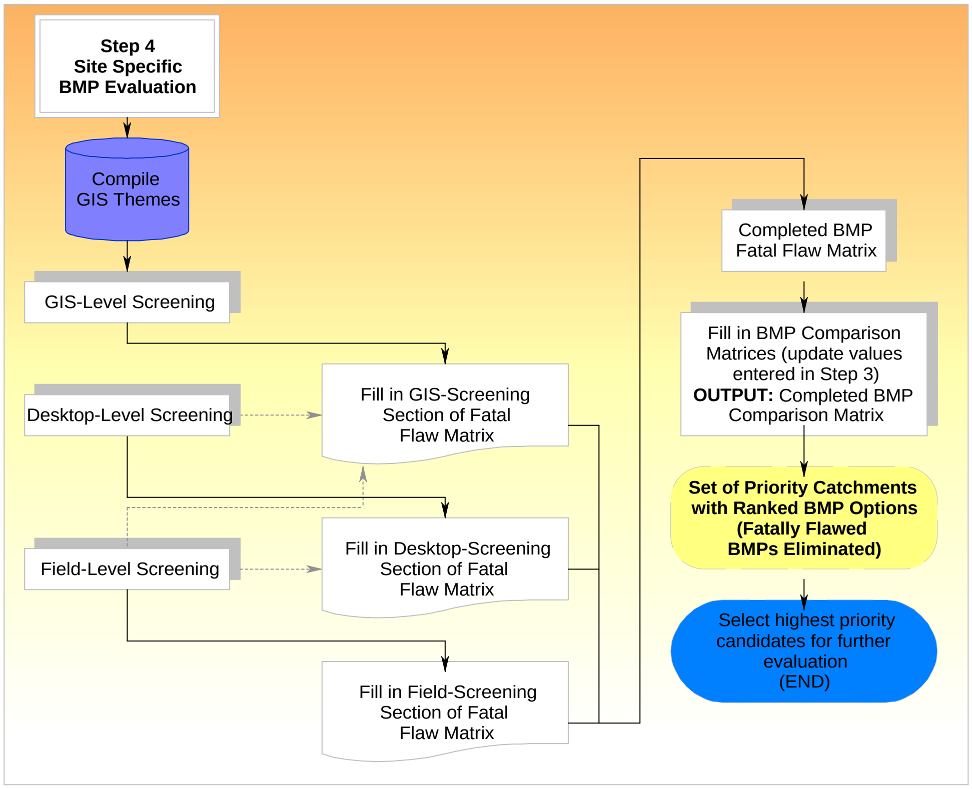


Figure 18. Integration of Fatal Flaw Screening into Step 4.

e. **Site-Specific Feasibility/Ownership Scoring Assessment.** Tables 6 and 7 illustrated a number of considerations for BMP selection but highlighted the need for site specific data to complete the BMP comparison matrices. The following site-specific scoring approach is recommended for the engineering/siting feasibility and ownership/ROW/jurisdictions criteria of the regional and distributed BMP comparison matrices. Table 12 provides a summary of recommended matrix scores for preliminary site-specific evaluations, but do not include site-specific considerations. For each BMP score, either a default value or recommended guidance is provided.

Table 12. Regional BMP Table Site-Specific Scoring Notes

Regional BMP Type	Engineering/ Siting Feasibility	Ownership/ROW/ Jursisdictions
Infiltration Basins	*Score if parcels have > 5 acres of total potential area = 5; otherwise score = 3.*	*Score = Input catchment's regional BMP opportunity score (i.e., max parcel score)*
Detention Basins		
Detention w/ SSF Wetlands		
Constructed SF Wetlands	*Default score = 3*	
Treatment Facility		
Hydrodynamic Devices		
Channel Naturalization	*If open channel, score = 4; otherwise score = 3*	*If open channel, score = 4; otherwise score = 0*

Table 13. Distributed BMP Table Site-Specific Scoring Notes

Distributed BMP Type	Engineering/ Siting Feasibility	Ownership/ROW/ Jursisdictions
Cisterns	*Default score = 3*	*Default score = 3*
Bioretention		
Vegetated Swales		
Green Roofs		
Porous Pavements		
GSRDs	*Default score = 3*	
Media Filters		
Catch Basin Inserts		

f. **Computation of Final Scores**

f.1 Compute final site-specific cumulative regional and distributed BMP scores for each "project" (i.e., BMP-parcel combination), and prioritize and rank projects.

f.2 Input scores into catchment BMP matrices (example provided in Tables 6 and 7) via database or excel spreadsheet.

f.3 Highest-ranked candidate projects can now be considered for further review by stakeholders, and eventually, implementation planning can begin with the conceptual/preliminary design phase. Preferentially select regional and distributed BMP opportunities that treat the greatest (approximate) total contributing impervious areas.

g. **Complete Project Recommendations Summary.** Compile and summarize information collected in field observation sheets by completing distributed and regional BMP project recommendations summary sheets. Example blank recommendations summary sheets are shown below in Figures 19 and 20.

Distributed BMP Opportunities Summary

Catchment ID:
Area (acres):
Normal CPI Score:
Dist. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]
Max. Total Approx. % of Catchment Area Treated:	90%

Catchment ID:
Area (acres):
Normal CPI Score:
Dist. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]
Max. Total Approx. % of Catchment Area Treated:	

Catchment ID:
Area (acres):
Normal CPI Score:
Dist. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]
Max. Total Approx. % of Catchment Area Treated:	

Catchment ID:
Area (acres):
Normal CPI Score:
Dist. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]
Max. Total Approx. % of Catchment Area Treated:	

[1] Focus recommendations on major parcels highlighted in catchment maps. Example notes: parcel's location in catchment, BMP's location in parcel, existing use of BMP location, etc.

[2] I.e., cistern, bioretention, veg. swale, green roof, perm. pavement, man. separator system, media filter, CBI

Figure 19 Distributed Project Recommendations Summary Sheet

Regional BMP Opportunities Summary

Suggested Maximum Drainage Area to BMP Area Ratios	
Infiltration Basin	25:1
Detention Basin	25:1
Det. w/ SSF Wetlands	25:1
SF Wetlands	25:1
Treatment Facility	N/A
Hydrodynamic Separator	Unknown
Channel Naturalization	N/A

Catchment ID:
Area (acres):
Nodal CPI Score:
Reg. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]	Max. Approx. BMP Footprint (acres)[3]	Max. Approx. Treatable Area (acres)[4]

Catchment ID:
Area (acres):
Nodal CPI Score:
Reg. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]	Max. Approx. BMP Footprint (acres)[3]	Max. Approx. Treatable Area (acres)[4]

Catchment ID:
Area (acres):
Nodal CPI Score:
Reg. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]	Max. Approx. BMP Footprint (acres)[3]	Max. Approx. Treatable Area (acres)[4]

Catchment ID:
Area (acres):
Nodal CPI Score:
Reg. BMP Score:

Potential BMP Location Description[1]	Recommended BMP Type[2]	Max. Approx. BMP Footprint (acres)[3]	Max. Approx. Treatable Area (acres)[4]

[1] E.g., parcel's location in catchment, BMP's location in parcel, existing use of BMP location, potential source of stormwater, etc.
[2] I.e., inf. basin, det. basin, det. w/ SSF wetlands, constructed SF wetlands, tmt. facility, hydro. separator, channel naturalization
[3] Estimated at desktop level by reviewing catchment map and/or aerial photos.
[4] Computed by multiplying estimated BMP footprint by drainage area ratio shown in table at top of page.

Figure 20. Regional Project Recommendations Summary Sheet

PRODUCT OF STEP 4:

Final BMP comparison matrices for each higher-priority catchment, with fatal flaws included. Field observation sheets for all visited higher-priority catchments. Distributed and regional BMP project recommendations summary sheets, which list all recommended projects for further evaluation and consideration.

Tables 15 and 16 show example BMP comparison matrices after fatal flaws have been identified via constraints screening (GIS-, desktop-, and field-level screenings). The site-specific factors shaded in gray have been assessed for fatal flaws during Step 4 of the Methodology. These data would be completed and updated for all catchments that are considered for implementation.

In addition, completed field observation sheets (see Ballona Demonstration Summary Report for examples) would be completed for all evaluated projects.

Table 14. Example Regional BMP Comparison Matrix for Ballona Watershed Catchment Number 207956

Regional BMP Comparison Matrix — Catchment: 207956

Ranking	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF)						
			Infiltration Basins	Detention Basins	Detention w/SSF wetlands	Constructed SF Wetlands	Treatment Facility	Manufactured Separation Systems	Channel Naturalization/ Wetland Channel
Cost									
Capital	N	15%	5	4	3	4	1	2	4
Operations and Maintenance	N	15%	3	4	3	4	1	3	5
Effectiveness									
Effluent Conc. (by pollutant group)									
Trash	N	1.3%	5	4	5	5	5	4	2
Nutrients	N	0.9%	5	2	5	5	5	2	5
Bacteria	N	3.0%	5	2	4	3	5	2	1
Metals	N	9.1%	5	3	5	5	5	3	4
Sediment	N	0.7%	5	3	5	5	5	4	4
Other Pollutants (e.g., toxicity, bioaccum.)	N	2.5%	5	3	4	4	4	3	3
Volume Mitigation	N	2.5%	5	3	3	3	2	1	2
Reliablility	N	10%	2	3	3	3	5	3	3
Implementation									
Implementation Issues									
Engineering/Siting Feasibility	Y	10%	FF	3	3	FF	3	3	3
Ownership/ROW/Jurisdictions	Y	10%	0	0	0	0	0	0	0
Environmental Clearance	N	5%	4	4	4	4	2	4	2
Permitting, Water Rights	Y	2.5%	5	5	5	2	2	2	2
Safety (Public)	Y	2.5%	3	3	3	3	4	4	3
Environmental/Other Factors									
Other Potential Benefits (e.g., conservation)	N	6%	5	4	4	4	1	1	5
Other Potential Impacts (e.g., vectors)	Y	4%	3	2	3	2	3	3	3
Weighted Score		100%		3.09	3.15		2.43	2.41	3.21

Table 15. Example Distributed BMP Comparison Matrix for Ballona Watershed Catchment Number 207956

Distrib uted BMP C omparison Matrix — Catchment: 207956

Ranking	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF)							
			Cisterns	Bio-retention	Vegetated Swales	Green Roofs	Porous/ Permeable Pavements	GSRDs/ Hydrod. Separators	Media Filters	Catch Basin Inserts
Cost										
Capital	N	15%	3	3	4	2	2	2	1	5
Operations and Maintenance	N	15%	2	3	3	2	2	1	1	2
Effectiveness										
Effluent Conc. (by pollutant group)										
Trash	N	1.3%	3	5	4	4	5	4	5	4
Nutrients	N	0.9%	5	5	4	4	5	1	3	1
Bacteria	N	3.0%	5	5	1	2	5	1	3	1
Metals	N	9.1%	5	5	4	4	5	2	4	1
Sediment	N	0.7%	5	5	3	4	5	3	5	2
Other Pollutants (e.g., toxicity, bioaccum.)	N	2.5%	4	4	4	4	4	1	4	1
Volume Mitigation	N	2.5%	4	4	4	4	4	1	1	1
Reliablility	Y	10%	4	4	4	3	2	3	3	3
Implementation										
Implementation Issues										
Engineering/Siting Feasibility	Y	10%	3	FF	2	3	2	2	2	2
Ownership/ROW/Jurisdictions	Y	10%	3	3	3	3	3	3	3	3
Environmental Clearance	N	5%	5	5	5	5	5	5	5	5
Permitting, Water Rights	Y	2.5%	5	5	5	5	5	5	5	5
Safety (Public)	Y	2.5%	4	3	3	4	3	4	4	4
Environmental/Other Factors										
Other Potential Benefits (e.g., conservation)	N	6%	5	4	4	4	3	1	1	1
Other Potential Impacts (e.g., vectors)	Y	4%	2	3	3	3	3	3	3	3
Weighted Score		100%	3.53		3.46	3.07	3.00	2.25	2.46	2.75

3 CONCLUSION

The Methodology for structural BMP prioritization presented here provides a systematic, semi-automated, and transparent tool for identifying and ranking BMP projects throughout the greater Los Angeles area. In general, the Methodology is an effective, conceptual-level planning tool that is ready for watershed groups, municipalities and other stakeholders to use in their stormwater quality planning efforts.

The Methodology can be used for a number of purposes:

- Watershed planning – Watershed groups, municipalities, and other stakeholders can use the Methodology to develop strategic lists of BMP projects that are designed to help achieve specific water quality and other water resources goals. Additionally, the list of BMP projects and the supporting documentation generated by the Methodology can be used as the basis for applying for local and state funding as funding opportunities become available.
- Integrated regional water management planning – The Methodology can be used to identify high priority projects that provide multiple water resources benefits.
- TMDL implementation planning – The Methodology can be used to identify and rank projects that will help achieve TMDL goals.

A specific strength of the Methodology is that it is flexible and transparent, so the users can easily adapt it to investigate various implementation scenarios or to obtain different goals. The current Methodology can be used to examine various BMP implementation strategies:

- The Methodology can be used to target specific pollutant types, regulatory requirements, impairment type, or multiple benefits goals by changing the weights associated with these factors.
- The Methodology can be used to investigate different BMP implementation strategies, again, by varying the weights of different factors such as ownership or parcel size. For example, regional BMP opportunities can be investigated by weighting land ownership differently (BMPs on public land versus land acquisition strategies). Recommended project lists can also be evaluated to guide the development of various general distributed BMP implementation strategies, such as retrofitting all parking lots or commercial/industrial rooftops over a certain size and located in high priority catchments.

Next Steps

The Methodology has been specifically designed to be transparent and flexible, so that, as additional data becomes available, and our understanding of stormwater pollution improves, users will be able to adapt the Methodology and make continual improvements.

Importantly, the Methodology provides a strong foundation for building next-generation tools for structural BMP planning that could greatly aid in conceptual watershed and regional stormwater management. Future improvements to the Methodology could include:

- Incorporating actual monitoring data as they becomes available

- Incorporating actual costs as a basis for rankings and to establish planning-level cost-benefit ratios.
- Ranking various BMP implementation schemes by estimating the amount of high-pollutant generating, impervious areas treated or infiltrated.
- Modifying the method to include numeric, conceptual-level estimation of water quality improvements (including load, concentration and flow reductions) that occur in the receiving waters as a result of various BMP implementation strategies.

4 DISCLOSURE & ACKNOWLEDGEMENTS

PROPOSITION 13 DISCLOSURE STATEMENT

Funding for this project was provided in full or in part through an agreement with the State Water Resources Control Board (SWRCB) pursuant to the Costa-Machado Water Act of 2000 (Proposition 13) and any amendments thereto for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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The project was conceived by Don Wolfe, Director of Public Works for the County of Los Angeles; Dr. Mark Gold, Executive Director of Heal the Bay; and Eric Strecker, Principal with GeoSyntec Consultants. They recognized the pressing need for a tool of this type and were instrumental in the initial concept development.

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- Dr. Shahram Kharaghani, Wing Tam, Elvin Yeck, and Betty Dong of the City of Los Angeles, Bureau of Sanitation, Watershed Protection Division, provided critical input, key data required for testing the Methodology, GIS support, and field-related support; and
- Ken Susilo (Technical Project Manager), Brandon Steets and Marc Leisenring, of GeoSyntec Consultants, were the principal investigators responsible for developing the Methodology.

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APPENDIX A
Land Use Groupings

LU01	LU_ALF	LU_Class	RC_Group	EMC_Group	Area_acres
2500	Poultry Operations	Poultry Operations	Agriculture	Agriculture	138
2400	Dairy, Intensive Livestock, and Associated Facilities	Dairy, Intensive Livestock, and Associated Facilities	Agriculture	Agriculture	148
2600	Other Agriculture	Other Agriculture	Agriculture	Agriculture	1,111
2200	Orchards and Vineyards	Orchards and Vineyards	Agriculture	Agriculture	3,381
2300	Nurseries	Nurseries	Agriculture	Agriculture	3,907
2700	Horse Ranches	Horse Ranches	Agriculture	Agriculture	4,281
2120	Non-Irrigated Cropland and Improved Pasture Land	Cropland and Improved Pasture Land	Agriculture	Agriculture	11,467
2110	Irrigated Cropland and Improved Pasture Land	Cropland and Improved Pasture Land	Agriculture	Agriculture	58,648
1213	Skyscrapers	General Office Use	Commercial	Commercial	78
1261	Pre-Schools/Day Care Centers	Educational Institutions	Commercial	Commercial	158
1247	Non-Attended Public Parking Facilities	Public Facililties	Commercial	Commercial	309
1242	Police and Sheriff Stations	Public Facililties	Commercial	Commercial	358
1266	Trade Schools and Professional Training Facilities	Educational Institutions	Commercial	Commercial	360
1420	Communication Facilities	Communication Facilities	Commercial	Commercial	470
1234	Attended Pay Public Parking Facilities	Other Commercial	Commercial	Commercial	481
1253	Other Special Use Facilities	Special Use Facilities	Commercial	Commercial	588
1243	Fire Stations	Public Facililties	Commercial	Commercial	651
1435	Natural Gas and Petroleum Facilities	Utility Facilities	Commercial	Commercial	958
1212	High-Rise Major Office Use	General Office Use	Commercial	Commercial	1,011
1500	Mixed Commercial and Industrial	Mixed Commercial and Industrial	Commercial	Commercial	1,035
1271	Base (Built-up Area)	Military Installation	Commercial	Commercial	1,085
1433	Liquid Waste Disposal Facilities	Utility Facilities	Commercial	Commercial	1,122
1246	Other Public Facilities	Public Facililties	Commercial	Commercial	1,238
1251	Correctional Facilities	Special Use Facilities	Commercial	Commercial	1,265
1231	Commercial Storage	Other Commercial	Commercial	Commercial	1,312
1252	Special Care Facilities	Special Use Facilities	Commercial	Commercial	1,441
1233	Hotels and Motels	Other Commercial	Commercial	Commercial	1,517
1434	Water Storage Facilities	Utility Facilities	Commercial	Commercial	1,925
1221	Regional Shopping Center	Retails Stores and Commercial Services	Commercial	Commercial	2,067
1244	Major Medical Health Care Facilities	Public Facililties	Commercial	Commercial	2,300
1241	Government Offices	Public Facililties	Commercial	Commercial	2,428
1436	Water Transfer Facilities	Utility Facilities	Commercial	Commercial	3,025
1232	Commercial Recreation	Other Commercial	Commercial	Commercial	3,074
1432	Solid Waste Disposal Facilities	Utility Facilities	Commercial	Commercial	3,770
1245	Religious Facilities	Public Facililties	Commercial	Commercial	3,947
1263	Junior or Intermediate High Schools	Educational Institutions	Commercial	Commercial	4,307
1265	Colleges and Universities	Educational Institutions	Commercial	Commercial	5,568
1264	Senior High Schools	Educational Institutions	Commercial	Commercial	7,632
1211	Low- and Medium-Rise Major Office Use	General Office Use	Commercial	Commercial	7,847
1340	Wholesaling and Warehousing	Wholesaling and Warehousing	Commercial	Commercial	9,171
1222	Retail Centers (Non-Strip With Contiguous Interconnected Off-Stree	Retails Stores and Commercial Services	Commercial	Commercial	9,633
1262	Elementary Schools	Educational Institutions	Commercial	Commercial	11,504
1224	Older Strip Development	Retails Stores and Commercial Services	Commercial	Commercial	13,923
1431	Electrical Power Facilities	Utility Facilities	Commercial	Commercial	19,119
1223	Modern Strip Development	Retails Stores and Commercial Services	Commercial	Commercial	22,466
1324	Major Metal Processing	Heavy Industrial	Industrial	Industrial	25
1313	Packing Houses and Grain Elevators	Light Industrial	Industrial	Industrial	65
1321	Manufacturing	Heavy Industrial	Industrial	Industrial	103
1325	Chemical Processing	Heavy Industrial	Industrial	Industrial	366
1312	Motion Picture and Television Studio Lots	Light Industrial	Industrial	Industrial	1,017
1314	Research and Development	Light Industrial	Industrial	Industrial	1,563
1322	Petroleum Refining and Processing	Heavy Industrial	Industrial	Industrial	4,185
1323	Open Storage	Heavy Industrial	Industrial	Industrial	4,522
1331	Mineral Extraction - Other Than Oil and Gas	Extraction	Industrial	Industrial	4,839

1332 Mineral Extraction - Oil and Gas	Extraction	Industrial	Industrial	6,970
1311 Manufacturing, Assembly, and Industrial Services	Light Industrial	Industrial	Industrial	43,535
3400 Beaches (Vacant)	Beaches (Vacant)	Open	Open	175
1822 Undeveloped Local Parks and Recreation	Open Space and Recreation	Open	Open	201
4400 Water Within a Military Installation	Water Within a Military Installation	Open	Open	468
1860 Specimen Gardens and Arboreta	Open Space and Recreation	Open	Open	502
3200 Abandoned Orchards and Vineyards	Abandoned Orchards and Vineyards	Open	Open	536
4300 Marina Water Facilities	Marina Water Facilities	Open	Open	589
1850 Wildlife Preserves and Sanctuaries	Open Space and Recreation	Open	Open	1,041
3300 Vacant With Limited Improvements	Vacant With Limited Improvements	Open	Open	1,457
1870 Beach Parks	Open Space and Recreation	Open	Open	1,762
1273 Air Field	Military Installation	Open	Open	2,776
1831 Developed Regional Parks and Recreation	Open Space and Recreation	Open	Open	3,386
1880 Other Open Space and Recreation	Open Space and Recreation	Open	Open	3,535
1840 Cemeteries	Open Space and Recreation	Open	Open	3,938
1437 Improved Flood Waterways and Structures	Utility Facilities	Open	Open	9,848
1832 Undeveloped Regional Parks and Recreation	Open Space and Recreation	Open	Open	10,077
1821 Developed Local Parks and Recreation	Open Space and Recreation	Open	Open	10,911
4100 Water, Undifferentiated	Water, Undifferentiated	Open	Open	11,060
1810 Golf Courses	Open Space and Recreation	Open	Open	11,835
4200 Harbor Water Facilities	Harbor Water Facilities	Open	Open	12,436
1272 Vacant Area	Military Installation	Open	Open	50,224
1418 Navigation Aids	Transportation	Other Urban	Other Urban	3
1460 Mixed Transportation and Utility	Mixed Transportation and Utility	Other Urban	Other Urban	298
1414 Park-and-Ride Lots	Transportation	Other Urban	Other Urban	355
1415 Bus Terminals and Yards	Transportation	Other Urban	Other Urban	582
1600 Mixed Urban	Mixed Urban	Other Urban	Other Urban	725
1416 Truck Terminals	Transportation	Other Urban	Other Urban	1,295
1440 Maintenance Yards	Maintenance Yards	Other Urban	Other Urban	1,612
1412 Railroads	Transportation	Other Urban	Other Urban	2,918
1450 Mixed Transportation	Mixed Transportation	Other Urban	Other Urban	2,945
1417 Harbor Facilities	Transportation	Other Urban	Other Urban	5,409
1411 Airports	Transportation	Other Urban	Other Urban	6,938
1700 Under Construction	Under Construction	Other Urban	Other Urban	9,722
1413 Freeways and Major Roads	Transportation	Other Urban	Other Urban	20,296
3100 Vacant Undifferentiated	Vacant Undifferentiated	Other Urban	Other Urban	1,571,379
1132 Mobile Home Courts and Subdivisions, Low-Density	Mobile Homes & Trailer Parks	Residential	SF Residential	137
1125 High-Rise Apartments and Condominiums	Multi-Family Residential	Residential	MF Residential	426
1151 Rural Residential, High-Density	Rural Residential	Residential	SF Residential	1,794
1122 Duplexes, Triplexes and 2-or 3-Unit Condominiums and Townhouses	Multi-Family Residential	Residential	MF Residential	2,395
1121 Mixed Multi-Family Residential	Multi-Family Residential	Residential	MF Residential	2,827
1124 Medium-Rise Apartments and Condominiums	Multi-Family Residential	Residential	MF Residential	3,183
1131 Trailer Parks and Mobile Home Courts, High-Density	Mobile Homes & Trailer Parks	Residential	SF Residential	4,900
1140 Mixed Residential	Mixed Residential	Residential	MF Residential	27,679
1152 Rural Residential, Low-Density	Rural Residential	Residential	SF Residential	28,350
1112 Low-Density Single Family Residential	Single Family Residential	Residential	SF Residential	36,254
1123 Low-Rise Apartments, Condominiums, and Townhouses	Multi-Family Residential	Residential	MF Residential	43,297
1111 High-Density Single Family Residential	Single Family Residential	Residential	SF Residential	332,316

APPENDIX B
303(d) and TMDL Pollutant Load Groupings

Pollutant_Stressor	303d_Group	303d_OtherSubcategory	Comments
Bacteria Indicators	Bacteria	N/A	
Beach Closures	Bacteria	N/A	most likely bacteria related
Beach Closures (Coliform)	Bacteria	N/A	
Enteric Viruses	Bacteria	N/A	although bacteria known to be poor indicator for pathogens
Fecal Coliform	Bacteria	N/A	
High Coliform Count	Bacteria	N/A	
Shellfish Harvesting Advisory	Bacteria	N/A	most likely bacteria related
Swimming Restrictions	Bacteria	N/A	most likely bacteria related
Hydromodification	Hydromod	N/A	for weighting BMP "volume mitigation" scores
Aluminum, Total	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Cadmium	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Cadmium (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Cadmium, Dissolved	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Chromium (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Copper	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Copper (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Copper (tissue & sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Copper, Dissolved	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Lead	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Lead (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Lead (tissue)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Lead, Dissolved	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Mercury	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Mercury (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Mercury (tissue)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Nickel (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Selenium	Metals	N/A	although Se is usually not an urban pollutant
Selenium, Total	Metals	N/A	although Se is usually not an urban pollutant
Silver (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Zinc	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Zinc (sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Zinc (tissue & sediment)	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Zinc, Dissolved	Metals	N/A	metals grouping given priority over toxicity/bioaccumulation grouping
Ammonia	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Chloride	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Debris	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Dichloroethylene/1,1-DCE	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Exotic Vegetation	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Fish barriers	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Habitat alterations	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Odors	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Oil	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Organic Enrichment/Low Dissolved Oxygen	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
pH	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Reduced Tidal Flushing	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Scum/Foam-unnatural	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Specific conductivity	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Tetrachloroethylene/PCE	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Trichloroethylene/TCE	N/A (No CPI pts awarded)	N/A	not an urban stormwater pollutant or relevant to BMP prioritization
Algae	Nutrients	N/A	most likely nutrient related, although could also be due to organic enrichment?
Eutrophic	Nutrients	N/A	most likely nutrient related, although could also be due to organic enrichment?
Nitrate	Nutrients	N/A	
Nitrate and Nitrite	Nutrients	N/A	
Nitrate as Nitrogen	Nutrients	N/A	
Nutrients (Algae)	Nutrients	N/A	

Fish Consumption Advisory	Other	Bioaccumulation	
PAHs	Other	Bioaccumulation	or alternatively, toxicity? doesn't matter for scoring
PAHs (sediment)	Other	Bioaccumulation	or alternatively, toxicity? doesn't matter for scoring
PAHs (tissue & sediment)	Other	Bioaccumulation	or alternatively, toxicity? doesn't matter for scoring
PCBs	Other	Bioaccumulation	or alternatively, toxicity? doesn't matter for scoring
PCBs (sediment)	Other	Bioaccumulation	or alternatively, toxicity? doesn't matter for scoring
PCBs (tissue & sediment)	Other	Bioaccumulation	or alternatively, toxicity? doesn't matter for scoring
PCBs (tissue)	Other	Bioaccumulation	or alternatively, toxicity? doesn't matter for scoring
Abnormal Fish Histology	Other	Ecological Impacts	wq-based eco impacts
Benthic Community Effects	Other	Ecological Impacts	wq-based eco impacts
Fish Kills	Other	Ecological Impacts	wq-based eco impacts
Aldrin (tissue)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
ChemA (tissue)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
Chlordane (sediment)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
Chlordane (tissue & sediment)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
Chlordane (tissue)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
DDT	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
DDT (sediment)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
DDT (tissue & sediment)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
DDT (tissue)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
Dieldrin (tissue)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
Toxaphene (tissue)	Other	Legacy Pesticides	pesticides grouping given priority over toxicity/bioaccumulation grouping; doesn't matter for scoring
Sediment Toxicity	Other	Toxicity	
Toxicity	Other	Toxicity	
Sedimentation/Siltation	Sediment	N/A	
Trash	Trash	N/A	

APPENDIX C
Basis for Relative BMP Effectiveness Scores

The purpose of this appendix is to describe the rationale behind the default BMP effectiveness scores used in the BMP comparison tables (Appendix E) as part of the BMP Prioritization Methodology. Two sources of information were used for comparing the relative performance of BMPs: the ASCE/EPA International Database and the California BMP Handbooks. The following paragraphs briefly describe the analysis of these sources and the thought process used for ranking BMP based on performance.

ASCE/EPA International BMP Database

The most recent BMP performance data contained in the ASCE/EPA International BMP Database (www.bmpdatabase.org) has been summarized in WERF (2005). Appendix A of this report includes pollutant fact sheets that describe sources, transport, and potential removal mechanism for several common urban stormwater pollutants. The fact sheets also summarize BMP performance monitoring data for the pollutants reported in the database. The BMP performance data is presented in two ways: the first summarizes the median of average effluent of individual BMP studies and the second summarizes the median of all effluent concentrations from all studies. The primary differences between the two is the first considers individual BMP studies as a single data point (average effluent EMC), while the second considers every event as a single data point (effluent EMC). Therefore, the second method gives a higher weight to studies with more data points, but may skew the geographical distribution of the individual studies contained in the database. Since a large amount of data in the database is from Caltrans' studies, the second method will tend to skew the summary statistics to California, which is hydrologically appropriate for this project and provides a larger number of data points for which to draw statistical conclusions.

Table C-1 provides a summary of the median effluent concentrations, confidence intervals, and no. of BMP studies as summarized in WERF (2005). Table C-2 summarizes the relative ranking scores assigned to each BMP based on these data. The color scheme below was used for defining the ranks.

Rank	5	4	3	2	1
Color Code	(yellow)	(cyan)	(orange)	(light green)	(white)

Table C-1. Median of Average Effluent Concentrations for BMPs Contained in the ASCE/EPA International BMP Database (Source: WERF, 2005).

Constituents		Detention Pond	Biofilter	Hydro-dynamic Devices	Media Filter	Wet Pond	Wetland Basin	Wetland Channel
Suspended Solids (mg/L)	Effluent Conc.s	22.0 (10.2-47.4)	16.5 (11.8-23.0)	77 (57.1-104)	8.0 (4.05-15.8)	10.6 (8.8-12.6)	6.4 (4.9-8.8)	17.0 (10.2-28.5)
	No. of BMPs	*9*	*14*	*13*	*18*	*21*	*6*	*3*
Total Copper (µg/L)	Effluent Conc.s	18.0 (15.5-20.9)	6.0 (5.0-7.3)	12.5 (10.2-15.4)	8.47 (7.2-10.2)	5.0 (4.47-5.59)	xx	xx
	No. of BMPs	*9*	*11*	*9*	*18*	*13*	*xx*	*xx*
Dissolved Copper (µg/L)	Effluent Conc.s	12.0 (10.2-14.1)	5.2 (4.1-6.6)	6.9 (4.6-10.4)	6.55 (5.5-7.8)	5.0 (4.7-5.3)	xx	xx
	No. of BMPs	*6*	*8*	*6*	*16*	*4*	*xx*	*xx*
Total Lead (µg/L)	Effluent Conc.s	14.0 (11.1-17.7)	6.95 (4.2-11.7)	13.0 (4.2-40.2)	5.5 (3.5-8.6)	5.0 (4.0-6.2)	1.0 (0.85-1.2)	5.0 (3.4-7.3)
	No. of BMPs	*9*	*13*	*8*	*18*	*16*	*3*	*3*
Dissolved Lead (µg/L)	Effluent Conc.s	1.5 (1.2-1.9)	1.0 (0.84-1.2)	1.1 (0.76-1.6)	1.0 (0.95-1.1)	3.0 (2.0-4.4)	xx	xx
	No. of BMPs	*6*	*8*	*6*	*16*	*5*	*xx*	*xx*
Total Zinc (µg/L)	Effluent Conc.s	77.5 (65.3-92.0)	30.0 (27.9-32.2)	73.6 (59.7-90.7)	37.0 (28.6-47.9)	20.0 (17.4-23.0)	18.0 (15.2-21.3)	xx
	No. of BMPs	*10*	*14*	*11*	*18*	*17*	*6*	*xx*
Dissolved Zinc (µg/L)	Effluent Conc.s	40.2 (32.3-50.1)	25.3 (22.0-29.0)	24.5 (17.2-34.9)	27.0 (21.1-34.5)	4.0 (2.9-5.5)	xx	xx
	No. of BMPs	*6*	*8*	*6*	*16*	*4*	*xx*	*xx*
Total Phosphorus (mg/L)	Effluent Conc.s	0.28 (0.25-0.32)	0.24 (0.20-0.28	0.16 (0.13-0.20)	0.13 (0.12-0.16)	0.12 (0.11-0.13)	0.06 (0.05-0.07)	0.17 (0.13-0.23)
	No. of BMPs	*8*	*15*	*9*	*17*	*20*	*7*	*3*
Dissolved Phosphorus (mg/L)	Effluent Conc.s	xx	xx	xx	xx	0.05 (0.05-0.06)	0.04 (0.03-0.05)	0.08 (0.06-0.10)
	No. of BMPs	*xx*	*xx*	*xx*	*xx*	*6*	*3*	*3*
Total Nitrogen (mg/L)	Effluent Conc.s	xx	0.06 (0.47-0.77)	xx	xx	0.94 (0.84-1.04)	1.22 (1.13-1.31)	1.35 (1.17-1.57)
	No. of BMPs	*xx*	*4*	*xx*	*xx*	*6*	*4*	*3*
Nitrate-Nitrogen (mg/L)	Effluent Conc.s	0.66 (0.56-0.78)	0.26 (0.21-0.31)	xx	0.60 (0.53-0.67)	0.25 (0.18-0.35)	0.17 (0.13-0.21)	0.20 (0.14-0.28)
	No. of BMPs	*7*	*12*	*xx*	*16*	*4*	*3*	*3*

Notes: xx - Lack of sufficient data to report median and confidence interval. Values in parenthesis are the 95% confidence intervals about the median. Original Source: International Stormwater BMP Database October 15, 2004 (www.bmpdatabase.org).

Table C-2. Ranking of BMPs According to the Median Effluent Concentrations in the ASCE/EPA International BMP Database.

Parameter		Detention Pond	Retention Pond (Wet Pond)	Wetland Basin	Wetland Channel	Biofilter (swales & filtrer strips)	Hydrodynamic separators	Media Filters
TSS (mg/L)	median effluent	22	10.5	6.4	17	16.5	77	8
	statistically different from influent	N	Y	Y	Y	N	Y	N
Total phosphorus (mg/L)	median effluent	0.28	0.12	0.06	0.17	0.24	0.16	0.13
	statistically different from influent	Y	Y	Y	Y	Y	Y	Y
Dissolved Phosphorus (mg-P/L)	median effluent		0.05	0.04	0.08			
	statistically different from influent		Y	Y	Y			
TKN (mg/L)	median effluent	1.55	1	1.1		1.46	1.23	1.5
	statistically different from influent	N	Y	Y		Y	N	N
Nitrate-N (mg/L)	median effluent	0.66	0.25	0.17	0.2	0.26		0.6
	statistically different from influent	N	Y	Y	N	N		Y
Dissolved Copper (ug/L)	median effluent	12	5			5.2	6.9	6.5
	statistically different from influent	N	Y			Y	N	N
Total Copper (ug/L)	median effluent	18	5			6	12.5	8.5
	statistically different from influent	Y	Y			Y	Y	Y
Dissolved Lead (ug/L)	median effluent	1.5	3			1	1.1	1
	statistically different from influent	N	N			N	N	Y
Total Lead (ug/L)	median effluent	14	5	1	5	2.6	6.7	3.3
	statistically different from influent	Y	Y	Y	Y	Y	Y	Y
Dissolved Zinc (ug/L)	median effluent	40	4			25	24	27
	statistically different from influent	N	Y			Y	N	Y
Total Zinc (ug/L)	median effluent	77	20	18		30	74	37
	statistically different from influent	Y	Y	Y		Y	Y	Y

California BMP Handbooks

Since the BMP database does not contain data for all BMP types for all pollutants, other sources of information were also evaluated. Table C-3 summarizes the relative BMP effectiveness rankings provided in the California BMP Handbooks.

Table C-3. Ranking of Treatment Control BMP Categories as Reported in the California BMP Handbooks.

Pollutant of Concern[3]	Treatment Control BMP Categories						
	Vegetated Swale (TC-30)	Extended Detention Basins (TC-22)	Infiltration Basins (TC 10, 11, & 12)	Wetponds or Constructed Wetlands (TC 20 & 21)	Buffer Strip (TC-31)	Media Filtration (TC-40)	Vortex Separator Devices (MP-51)
Sediment	M	M	H	H	H	H	M (L for turbidity)
Nutrients	L	L	H	M	L	L	L
Trash	L	H	H	H	M	H	H
Trace Metals	M	M	H	H	H	H	L
Bacteria[1]	L	M	H	H	L	M	L
Oil and Grease	M	M	H	H	H	H	M (with inserts)
Organics[2]	M	M	H	H	M	H	L

Source: California Stormwater Best Management Practices Handbook for New Development and Redevelopment (CASQA, 2003)
Note: H, M, L, indicates high, medium, and low removal efficiency.
1/ refers to indicator bacteria of human pathogens
2/ Organic compounds, including pesticides are a broads class of compounds that have a wide-range of chemical properties. Therefore treatment performance of these compounds will be compound specific.
3/ Chloride and MBAS are soluble and are not be expected to receive significant treatment.

Assigning Final Relative Scores

The assignment of relative effectiveness scores was based on an assessment of available performance data, reported effectiveness levels, and an analysis of the unit treatment processes within different BMP types. Since this is a general assessment, the influent loadings to any of these BMPs are not known so are not considered in the evaluation of relative BMP effectiveness. The paragraphs below briefly describe this assessment and Tables C-4 and C-5 summarize the final effectiveness scores assigned to each BMP for each pollutant group.

Regional BMPs

Infiltration Basins

Performance monitoring data for infiltration basins is generally lacking in the BMP database presumably due to the difficulty in sampling the infiltrated water and the common assumption that stormwater infiltrated equates to loads removed. Properly designed and maintained infiltration basins sized to infiltrate the water quality design storm (0.75 inches or 0.2 in/hr based on SUSMP requirements) will effectively remove all pollutant types (impacts to groundwater assumed to be negligible). These BMPs are assumed to be the most effective at removing all pollutant loads, which is in agreement with the California BMP Handbook. However, due to the propensity for clogging and the resulting bypass, the effectiveness reliability of infiltration basins may be less than other BMP types.

Detention Basins

Detention basins, or more accurately, extended detention basins provide treatment primarily through sedimentation with some volume loss due to infiltration and soil soaking. Limited biological and physiochemical treatment processes are typically provided due to lack of vegetation or constant presence of water necessary to support microbes. Monitoring results reported in the BMP database reflect the limited unit treatment processes in detention basins with median effluent EMCs ranging from mid-level treatment for sediment and particulate-bound constituents to low-level treatment for dissolved constituents.

Detention w/ SSF wetlands

Sub-surface flow wetlands have not been extensively studied for stormwater treatment effectiveness and the BMP database currently does not contain any data with regard to their performance. However, the treatment processes within sub-surface flow wetlands range from simple physical filtration mechanisms to complex chemical adsorption and microbial transformation. With the addition of a detention basin for settling of coarse materials, SSF wetlands can be considered an advanced treatment system nearly comparable (though less reliable) than a conventional wastewater treatment plant and would be expected to remove pollutants at least as effectively as constructed surface flow wetlands.

Constructed SF Wetlands

Constructed wetlands provide multiple biological and physiochemical treatment processes associated with aerobic and anaerobic soil zones, submerged and emergent vegetation, and associated microbial activities. Constructed surface flow wetlands for stormwater treatment are a relatively common structural BMP type with sufficient data in the BMP database to assess performance. The data indicate that constructed wetlands out-perform all BMP types for all monitored constituents reported in the database. The export of nitrogen from constructed wetlands during dormant periods and vegetation die-off has been observed in some studies and some have recommended plant harvesting to maximize nutrient retention (Moshiri, 1993). This observation for nitrogen export is reflected in the California BMP handbook relative ranking of medium for nutrients.

Treatment Facility

This BMP type is a general type that may include complete diversion of the water quality design storm to a wastewater treatment plant as well as a specialized facility designed specifically for stormwater. Conventional treatment practices, while not common for stormwater treatment, are considered to be the most effective at removing pollutants since they are highly engineered systems with designs driven by the constituents of concern.

Hydrodynamic Separators

Hydrodynamic devices, or vortex separators, provide treatment primarily through screening, baffle separation, and centrifugal settling. The short retention times typically provided in these devices do not allow for other treatment processes to occur. Based on the reported effluent concentrations in the BMP database and the relative performance rankings in the California BMP handbooks, these devices provide good treatment for bulk solids (e.g., trash) and moderate treatment for sediment. All other constituents are not effectively removed by hydrodynamic devices except potentially oil and grease if an absorbent is used.

Channel Naturalization/Wetland Channel

The effectiveness of daylighting of storm drains and pipes at reducing pollutant transport is not known. However, if it is assumed that as part of this naturalization process wetland vegetation is used such that wetland channels are established, this practice would be expected to achieve appreciable pollutant reductions. A few wetland channel studies have been reported in the BMP database and the media effluent concentrations for most constituents appear to lie between those reported for wetland basins and biofilters (swales and filter strips).

Distributed BMPs

Cisterns

While cisterns provide only limited unit treatment processes by themselves, if they are designed to capture the water quality design storm and then this water is slowly infiltrated or reused for irrigation the pollutant loads associated with the captured volume will essentially be removed. By diverting rooftop runoff that would otherwise be discharged to the street or directly to the storm drain, the transport of pollutants to receiving waters will effectively be reduced. As such, the pollutant removal effectiveness of cisterns is considered comparable to infiltration basins.

Bioretention

Bioretention is another BMP without much performance data to support a relative comparison between BMP types. However, the unit treatment processes associated with bioretention is a combination of infiltration, evapotranspiration, microbial transformation, and plant uptake. The USEPA (1999; 2000) has reported high effectiveness for bioretention, but the results are based on only a few studies. Based on the unit treatment processes, the actual effectiveness of bioretention is likely somewhere between infiltration basins and vegetated swales.

Vegetated Swales

Vegetated swales and filters strips are reported in the BMP database as biofilters. These BMP types provide filtration and some volume losses due to infiltration and evapotranspiration, but limited biological processes as compared to bioretention due to the shorter residence times. Based on the values reported in the database and the California BMP handbooks, swales provide moderate to good removal of sediment and trace metals and limited removal of nutrients and bacteria.

Green Roofs

Green roofs are another distributed BMP type with limited performance data. However, similar to the logic presented above for cisterns, green roofs would be expected to reduce volumes and therefore loads due to water retention in the planting media and evapotranspiration. These reductions may not be as high as for cisterns because once the soil is saturated the water can no longer be retained. Therefore, it has been assumed that green roofs provide moderate to a high level of treatment for all constituents.

Porous / Permeable Pavements

Similar to cisterns and infiltration basins, the volume reductions associated with infiltration in porous and permeable pavements is assumed to equate to load reductions. Therefore, assuming that these BMPs are appropriately sized and maintained, the relative effectiveness is assumed to be the maximum for all pollutants.

Gross Solids Removal Devices (GSRDs)

Gross-solids removal devices include a variety of technologies including screens, trash nets, baffle boxes (e.g. oil/grit separators), etc. The general physical treatment processes would be similar to hydrodynamic devices, except gravity settling would not be enhanced with centrifugal forces, so these devices are expected to be slightly less effective.

Media Filters

Media filters consist of sand filters, compost filters, cartridge filters, and any other BMP designed with filtration media that absorbs and adsorbs pollutants. There are currently 16 media filters in the BMP database and the performance ranges from high to moderate for all constituents except for nitrogen. This is consistent with the California BMP Handbooks.

Catch Basin Inserts

As with media filters, there are a variety of different types of catch basin inserts available on the market. These inserts typically screen bulk pollutants and provide some filtration of fine particulates and oil and grease. Despite their widespread use, there are limited data on their performance. However, due to the limited contact time of stormwater with the filtration media within these inserts, they are assumed to only provide limited treatment for all pollutant except for bulk solids, such as trash and debris.

Table C-4. Relative Effectiveness Scores Assigned to the Regional BMP Types for Each Pollutant Category.

Ranking Factors	Score (1=worst - 5=best, FF)						
	Infiltration Basins	Detention Basins	Detention w/SSF Wetlands	Constructed SF Wetlands	Treatment Facility	Hydrodynamic Devices	Channel Naturalization
– Effluent Conc. (by pollutant group)							
- Trash	5	4	5	5	5	4	2
- Nutrients	5	2	5	5	5	2	5
- Bacteria	5	2	4	3	5	2	1
- Metals	5	3	5	5	5	3	4
- Sediment	5	3	5	5	5	4	4
– Other Pollutants (e.g., toxicity, bioaccum.)	5	3	4	4	4	3	3
– Volume Mitigation	5	3	3	3	2	1	2
– Reliability	2	3	3	3	5	3	3

Table C-4. Relative Effectiveness Scores Assigned to the Distributed BMP Types for Each Pollutant Category.

Ranking Factors	Score (1=worst - 5=best, FF)							
	Cisterns	Bio-retention	Vegetated Swales	Green Roofs	Porous/ Permeable Pavements	GSRDs	Media Filters	Catch Basin Inserts
Effectiveness								
– Effluent Conc. (by pollutant group)								
- Trash	5	5	4	4	5	4	5	4
- Nutrients	5	5	4	4	5	1	3	1
- Bacteria	5	5	1	4	5	1	3	1
- Metals	5	5	4	4	5	2	4	1
- Sediment	5	5	3	4	5	3	5	2
– "Other" Poll (e.g.,tox, bioaccum.)	4	4	4	4	4	1	4	1
– Volume Mitigation	3	4	4	4	4	1	1	1
– Reliability	3	4	4	3	2	3	3	3

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APPENDIX D
Basis for Relative BMP Cost Scores

BMP CAPITAL AND MAINTENANCE COST RANKING

The BMP cost comparison scheme presented in this section is based on a comparison of capital costs (initial cost to implement BMPs) and annual operation and maintenance costs of the regional and distributed BMPs used in the methodology. The scores derived from this cost assessment are applied in step 4 of the methodology by plugging scores from Table 1 and Table 3 in this appendix into the BMP Comparison Matrix to determine the relative applicability of each class of BMP for a given catchment.

Preliminary sizing of the various BMPs is a necessary step in determining approximate costs. For the capital and maintenance cost estimates presented in this section, tributary areas of either 1 acre or 10 acres were used for distributed BMPs, and a tributary area of 100 acres was used for all regional BMPs. The economies of scale and variations in BMP sizing approaches necessitate the use of caution when applying units costs obtained from literature to real life projects. The exponential tributary area scale (1 acre, 10 acres, and 100 acres) was selected to optimize BMP sizing and capture the economy of scale while minimizing subjectivity and ambiguity. Sources of BMP capital and maintenance cost information are limited and often inconsistent and may not necessarily apply to site-specific conditions. Therefore cost estimates presented here should be used only as planning level cost estimates for quickly screening BMPs and not as actual costs. A discussion of the capital cost and annual maintenance cost comparisons follows.

BMP Capital Cost Assessment

The results of the capital cost assessment are presented in Table 1. The scores shown in the table are used as inputs to the BMP Comparison Matrix presented in Step 4 of the methodology.

Table 1: BMP Capital Costs and Associated Scores (1 – expensive, 5 – inexpensive)

BMP Scope	**Best Management Practice**	**Reference Catchment Size (acres)**	**Normalized Capital Cost / acre treated**	**Capital Cost Score**
Distributed	Cisterns	1	$ 7,800	3
	Bioretention	1	$ 23,100	2
	Vegetated Swales	10	$ 2,600	4
	Green Roofs	1	$ 223,300	1

	Porous Pavement	1	$ 31,000	2
	Manufactured Separation Systems	10	$ 44,700	2
	Catch Basin Inserts	10	$ 1,100	5
	Media Filters(StormFilter)	10	$ 9,600	3
Regional	Infiltration Basins	100	$ 3,700	4
	Dry Detention Basins	100	$ 2,100	4
	SSF Wetlands	100	$ 28,800	2
	Constructed SF Wetlands	100	$ 2,300	4
	Treatment Plants	100	$ 82,200	1
	Hydrodynamic Devices	100	$ 10,300	3
	Channel Naturalization	100	$ 2,300	4

The adjusted capital cost per acre treated values presented in Table 1 are based on "ball park" construction cost estimates, derived from regression equations found in literature and from construction estimates derived from RS Means. All costs are adjusted to reflect 2005 dollars and regional cost adjustment factors from USEPA (1999) have been applied to adjust costs to figures representative of Southern California. The baseline per acre costs were obtained by dividing capital costs with the respective assumed tributary areas shown in Table 1. A design intensity of 0.2 inches/hour and a design volume of 0.75 inches were used for all sizing computations. The break points for the scores are based on a visual assessment of the estimated relative costs. For all the equations presented below, C is the construction cost and V is the volume treated by the BMP. A summary of the assumptions applied to selected classes of BMPs follows:

- Cistern construction cost estimates are based on $1000 per 3000 gallon cistern. A tributary area of 1 acre was assumed for cisterns.

- Bioretention footprint is assumed to be equivalent to 12% of the tributary area. The construction cost of bioretention areas is based on the following regression equation: $C = 7.3V0.99$ (Muthukrishnan, 2004). A tributary area of 1 acre was assumed for Bioretention areas.

- For green roofs, the required footprint was determined by assuming an allowable ponding depth of 3” and the construction cost is based on an estimate of $15 to $20 per square foot (BES 2000). A tributary area of 1 acre was assumed for green roofs.

- For porous pavement the tributary area to footprint ratio was assumed to be 5:1 (Yoko, 2004) and construction costs are based on $2 to $3 per square foot (USEPA, 2004). A tributary area of 1 acre was assumed for porous pavement.

- The costs for hydrodynamic devices were determined as an average cost of four commonly used technologies. A tributary area of 100 acres was assumed for hydrodynamic devices.

- Catch basin inserts costs are based on an estimate of $100 to $2000 obtained from the California BMP Handbooks. A tributary area of 10 acres was assumed for catch basin inserts.

- Subsurface flow (SSF) wetlands are sized based on an estimate of 0.87 square foot / gallon treated per day (USEPA, 2000). Construction costs are based on $26,000 to $55,000 per acre of wetland constructed (Susilo et al, 2004). Detention basin costs were added to account for necessary detention and metering of flows to the wetland.

- Treatment plants are assumed to occupy a minimum of a quarter of an acre (0.25-acre) and capital costs are based on USEPA (b) estimates of $3 per gallon per day treated.

- Manufactured separation devices include a diverse array of technologies of which the Multi Chamber Treatment Train (MCTT) is considered a representative BMP. Therefore the cost estimate for manufactured devices is based on the cost of the MCTT estimated at $38,000 per acre treated (Bannerman et al, 2003). A tributary area of 10 acres was assumed for manufactured proprietary separation devices.

- All other costs are based on itemized estimates with unit costs primarily based on RS Means estimates.

BMP Maintenance Cost Assessment

The maintenance costs presented in this section are annual operating and maintenance costs derived from a variety of sources (see Table 2). Obtaining consistent maintenance cost information from literature still proves to be a challenge and is even more so for distributed BMPs. For this assessment, the basis for the majority of the unit annual maintenance cost is literature. However, upper or lower ranges of unit costs from cited sources are sometimes used when the average is deemed inappropriate in comparison to other BMPs. In a few cases, annual unit maintenance costs are based on the judgment of project professionalsdue to the absence of rational scalable estimates from the cited sources. Deviations from cited sources are noted and discussed further on in this section.

Table 2: Annual Maintenance Cost Assessment Unit Costs

BMP Scope	**Best Management Practice**	**Unit Annual Maintenance Costs**	**Reference**
Dis tri	Cisterns	$100	Geosyntec estimate
	Bioretention	$2/ft ($0.05/ft2)	Bannerman et al, 2003

		5% to 7% of C	SWRPC, 1991
	Vegetated Swales	$0.58 - $0.78 / ft	SWRPC, 1991
	Green Roofs	$2/ft (Approx. $0.05 / ft^2)	Assumed to be similar to bioretention estimates
	Porous Pavement	$290/acre of practice	Bannerman et al. 2003
	Manufactured Separation Systems	$2,200 / practice	Bannerman et al. 2003
	Catch Basin Inserts	50$ - $500 / practice	Geosyntec estimate
	Media Filters(StormFilter)	$1500 / acre treated	Geosyntec estimate
Regional	Infiltration Basins	1% to 3% of C	Livingston et al. 1997; SWRPC, 1991
	Dry Detention Basins	<1% of C	Wiegand et al., 1986; Schueler, 1987; SWRPC, 1991
	SSF Wetlands	$1064 / acre of practice	USEPA, 2000
		3% to 6% of C	Wiegand et al. 1986; Schueler, 1987; SWRPC, 1991
	Constructed SF Wetlands	2% of C	Livingston et al. 1997; Brown and Schueler, 1997
	Treatment Plants	$800 - $2000 / MGD	USEPA(b) 2000
	Hydrodynamic Devices	$500 / practice	Bannerman et al, 2003
	Channel Naturalization	<1% of C	Unit costs assumed to be cheaper than dry detention

The results of the maintenance cost assessment are present in Table 3. All costs are adjusted to 2005 Southern California dollars and ranks are assigned based on a uniformly distributed costs between the most expensive and the least expense BMP maintenance amounts. The annual maintenance costs are normalized by area and the values shown in the table are average prices derived from the available sources. The scores shown in the table are used as inputs to the BMP Comparison Matrix presented in Step 4 of the methodology.

Table 3: Annualized Maintenance Costs and Associated Scores (1 – expensive, 5 –inexpensive)

BMP Scope	Best Management Practice	Reference Catchment Size (acres)	Normalized Annual Average Maintenance Cost / acre treated	Annual Maintenance Score
Distributed	Cisterns	1	$ 100	5
	Bioretention	1	$ 2,500	3
	Vegetated Swales	10	$ 400	4
	Green Roofs	1	$ 600	4
	Porous Pavement	1	$ 100	5
	Manufactured Separation Systems	10	$ 2,600	3
	Catch Basin Inserts	10	$ 300	4
	Media Filters(StormFilter)	10	$ 1,500	4
Regional	Infiltration Basins	100	$ 11,800	1
	Dry Detention Basins	100	$ 3,300	3
	SSF Wetlands	100	$ 6,300	2
	Constructed SF Wetlands	100	$ 6,200	2
	*Treatment Plants	100	$ 5,300	2
	Hydrodynamic Devices	100	$ 588	4
	Channel Naturalization	100	$ 3,700	3

BMP specific assumptions used in the derivation of the costs in Table 2 are presented in below. For all equations presented below, M represents maintenance costs.

- Cistern maintenance costs estimates are based on the costs for two inspections per year. In situations where disinfection and vector control are required, cistern maintenance costs could be significantly higher.

- Bioretention annual maintenance costs are based on the following equation: M = $2/ft. (Bannerman et al, 2003). Using an assumed width of 40 feet resulted in a modified cost function as follows: M = $0.5/ft2.

- For green roofs the annual maintenance if assumed to be similar to that for Bioretention areas and is calculated based on Muthukrishnan (2004) as follows: M = $0.5/ft2.

- Catch basin inserts annual maintenance is assumed to average about 50% of the capital cost. The range of maintenance cost for the various catch basin insert designs vary widely due to the sheer number of options available on the market.

- Subsurface Flow Wetlands annual maintenance costs are based on average maintenance costs for five wetlands presented as cost per acre of wetland in USEPA 2000.

- Treatment plant maintenance costs are based on an estimate of $800 - $2000 per gallon treated USEPA (b) (2000). The upper value of the range presented was used in the analysis rather than the average.

- Hydrodynamic device annual maintenance costs are estimated at $1000 per year (USEPA 1999). This value is the cost per device and is not tied to the tributary area.

- All other costs are based on unit costs taken directly without modification out of Table 2.

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APPENDIX E
Blank BMP Matrices

Regional BMP Comparison Matrix[1]

Ranking Factors	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF)						
			Infiltration Basins	Detention Basins	Detention w/SSF Wetlands	Constructed SF Wetlands	Treatment Facility	Hydrodynamic Devices	Channel Naturalization
Cost		**30%**							
– Capital	N	15%	4	4	2	4	1	3	4
– Operations and Maintenance	N	15%	1	3	2	2	2	4	3
Effectiveness		**30%**							
– Effluent Conc. (by pollutant group)[2]									
- Trash	N	15% of Total[3]	5	4	5	5	5	4	2
- Nutrients	N		5	2	5	5	5	2	5
- Bacteria	N		5	2	4	3	5	2	1
- Metals	N		5	3	5	5	5	3	4
- Sediment	N		5	3	5	5	5	4	4
– Other Pollutants (e.g., toxicity, bioaccum.)	N	2.5%	5	3	4	4	4	3	3
– Volume Mitigation	N	2.5%	5	3	3	3	2	1	2
– Reliability	N	10.00%	2	3	3	3	5	3	3
Implementation		**30%**							
– Implementation Issues									
- Engineering/Siting Feasibility	Y	10.0%							
- Ownership/ROW/Jurisdictions	**Y**	10.0%							
- Environmental Clearance	N	5.0%	4	4	4	4	2	4	2
- Permitting, Water Rights	**Y**	2.5%	5	5	5	2	2	2	2
– Safety (Public)	**Y**	2.5%	3	3	3	3	4	4	3
Environment/Other Factors		**10.0%**							
– Other Potential Benefits (e.g., conservation)	N	6.0%	5	4	4	4	1	1	5
– Other Potential Impacts (e.g., vectors)	**Y**	4.0%	3	2	3	2	3	3	3
Weighted Score		**100%**							

Distributed BMP Comparison Matrix[4]

[1] BMP table criteria and weights were developed based on steering committee consensus and best professional judgment of the Project Team.
[2] Effluent concentration scores to be weighted by catchment CPI scores.
[3] To be evaluated during Step 3 - General BMP Evaluation.
[4] BMP table criteria and weights were developed based on steering committee consensus and best professional judgment of the Project Team.

Ranking Factors	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF) Cisterns	Bio-retention	Vegetated Swales	Green Roofs	Porous/ Permeable Pavements	GSRDs	Media Filters	Catch Basin Inserts
Cost		**30%**								
– Capital	N	15.0%	3	2	4	1	2	2	3	5
– Operations and Maintenance	N	15.0%	5	3	4	4	5	3	4	4
Effectiveness		**30.0%**								
– Effluent Conc. (by pollutant group)[5]										
- Trash	N	15% of Total[6]	5	5	4	4	5	4	5	4
- Nutrients	N		5	5	4	4	5	1	3	1
- Bacteria	N		5	5	1	4	5	1	3	1
- Metals	N		5	5	4	4	5	2	4	1
- Sediment	N		5	5	3	4	5	3	5	2
– Other Pollutants (e.g., toxicity, bioaccum.)	N	2.5%	4	4	4	4	4	1	4	1
– Volume Mitigation	N	2.5%	3	4	4	4	4	1	1	1
– Reliability	Y	10.0%	3	4	4	3	2	3	3	3
Implementation		**30.0%**								
– Implementation Issues										
- Engineering/Siting Feasibility	Y	10.0%								
- Ownership/ROW/Jurisdictions	Y	10.0%								
- Environmental Clearance	N	5.0%	5	5	5	5	5	5	5	5
- Permitting, Water Rights	Y	2.5%	5	5	5	5	5	5	5	5
– Safety (Public)	Y	2.5%	4	3	3	4	3	4	4	4
Environment/Other Factors		**10.0%**								
– Other Potential Benefits (e.g., conservation)	N	6.0%	5	4	4	4	3	1	1	1
– Other Potential Impacts (e.g., vectors)	Y	4.0%	2	3	3	3	3	3	3	3
Weighted Score		**100%**								

[5] Effluent concentration scores to be weighted by catchment CPI scores.
[6] To be evaluated during Step 3 - General BMP Evaluation.

APPENDIX F
Los Angeles County White Paper

The following white paper was developed by the County of Los Angeles in support of utilizing a concentration-based approach to developing the Catchment Prioritization Index described as Method 2 in the report. The County of Los Angeles Department of Public Works recommends using Method 2 when the County's land use based EMC values represent the water quality data. This recommendation is due to current limitations in the event mean concentration data used to generate loads in Method 1 as described in this paper.

Method 1 of this report reflects a load-based methodology. If site-specific water quality data are available for the areas of study, a load-based method is preferred. References supporting load-based analyses are provided below.

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Evaluation of BMP Siting Criteria Using EMC, Rainfall, and Runoff

Summary

The purpose of the Structural BMP Prioritization Methodology is to create a planning tool to determine the best locations for conducting site-specific BMP placement studies. The method currently relies on land use correlated EMCs, annual or 85th percentile rainfall, and a land use based runoff coefficient. These are multiplied to determine a Catchment Prioritization Index (CPI-M1) value for 40-acre subareas within major watersheds. This is described as Method 1 in the Structural BMP Prioritization Methodology.

The CPI-M1 value is then multiplied by other weighting factors to determine the most important water quality sites for further study. These factors include: 303d listing of the receiving waters, TMDL implementation in the watershed, regional opportunities, etc… The data is then normalized, ranked, and analyzed. The final result is a list of high priority sites that merit further investigation. The planning study also tries to determine the most effective types of BMPs for the area. These areas can then be reviewed by planners and prioritized for detailed site-specific studies.

Data inherently contains some uncertainty. Use of data requires understanding the uncertainties and determining if the uncertainties limit the uses of the data. Current EMC data is correlated only to land use, with no information on the relationship between total pollutant loading, rainfall, or runoff characteristics. How these relationships vary throughout the County is also unknown. The EMC values for individual storm events measured during the data collection varied significantly, up to orders of magnitude in difference. These values were then combined to create the land use correlated EMC values for this study.

Seasonal variations of pollutant generation may contribute to the order of magnitude differences measured in EMC values. However, this type of relationship has also not been defined. The relationships between rainfall, runoff, and pollutant generation, along with regional variation in these relationships, cannot currently be defined due to the EMC data collection procedures.

Although the EMC data set appears to be statistically robust, it has several limitations[1] that need to be recognized. These limitations also apply to BMP siting, even at a planning level. One major limitation is the fact that only one site was sampled for each land use to create the land use correlated EMC data set. This is not a statistically robust number of sites to determine general pollutant generation characteristics for an area of over 4,000 square miles. Current sampling by the Southern California Coastal Water Research Project (SCCWRP), if augmented by local agencies, could provide regional understanding of pollutant generation data and relationships to rainfall and runoff.

The CPI-M1 method combines the limitations of the EMC data set with the large uncertainties in relationships to rainfall, runoff, and seasonal variations in pollutant generation. The method exceeds the limits of understanding provided by the EMC data set. The EMC is multiplied by a rainfall value and a

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[1] Ackerman, D. and Schiff, K. Modeling Storm Water Mass Emissions to the Southern California Bight. Journal of Environmental Engineering. Vol. 129. Iss. 4. p. 316.

runoff coefficient. The EMC is multiplied by a rainfall value to generate a spatially distributed regional relationship.

The assumption that more rainfall produces more volume of pollutants will bias the prioritization based on relationships that are undefined. Use of this relationship indicates that Glendale and Azusa generate more pollutants than Long Beach just because it rains more. This bias may be masked based due to area-weighted runoff coefficients. The equation used to generate the CPI-M1 is CPI = C*I*A*EMC. If an area has equal area, and the same land use, the only thing that remains in the equation is the intensity. This indicates that subareas with equivalent land use values and differing rainfall values, more pollutants will be generated in the area with more rainfall. This relationship is not proven and biases the pollutant generation to areas with higher rainfall. More rainfall may actually decrease the concentration since there will more volume for diluting the pollutant mass.

The solution to the uncertainty problems is to use the land use correlated EMC values to provide an area-weighted EMC correlated to the land use for each subarea. The area-weighted EMC acts as an estimate of pollutant production capacity. The EMC should not be multiplied by rainfall or runoff coefficients. The planning tool will then be based only on the measured correlation to land use and does not add the unknown relationships with rainfall/runoff.

The rest of the procedure described in the BMP prioritization methodology report can then be utilized to determine subareas within watersheds that require site-specific studies. Although the method is not a standard for pollutant load calculations, it provides insight for planners to determine areas that require further study, while staying within the limitations of the data set. A more detailed discussion of the limitations is provided in the discussion section and recommendations are provided for solving the problems.

Discussion

The BMP site selection criteria that is currently being developed by Geosyntec has been reviewed by Water Resources Division and Watershed Management Division. The current siting procedure recommends using the event mean concentration (EMC), rainfall, a runoff coefficient, and other multipliers to determine high priority sites to conduct site-specific analysis for BMP siting. The site selection criteria are to be endorsed by Public Works, the City of Los Angeles, Heal the Bay, and the Regional Water Quality Control Board.

Currently, the method being developed uses the term Catchment Prioritization Index (CPI-M1). The CPI-M1 multiplies the EMC by a rainfall value and a runoff coefficient to get a type of load from this statistical model. The CPI-M1 will then be multiplied by other factors that reflect other important decision variables. These multipliers consider TMDLs implementation in the watershed, listing of the water bodies on the 303d list, areas of special ecological interest, etc… The result of the methodology is a numerical ranking based on the statistical model that will help planners determine where to conduct more detailed studies.

The SWMM software manual summarizes the issues with this type of statistical modeling approach:

> "…statistical methods recognize the frustrations of physically-based modeling and move directly to a stochastic result (e.g. a frequency distribution of EMCs), but they are even more dependent on available data than methods such as those found in SWMM. That is, statistical parameters such as mean, median and variance must be available from other studies in order to use the statistical methods. Furthermore, it is harder to study the effect of controls and catchment modifications using statistical methods."[2]

This section discusses concerns with the proposed statistical model due to the uncertainties in water quality data, uncertainties in the rainfall/runoff/pollutant load relationships, and in uncertainties in BMP efficiency databases. The section also discusses how these uncertainties relate to the Structural BMP Prioritization Methodology that uses the CPI-M1 method.

Uncertainties in Water Quality Data

The EMC data associated with land use comes from a study conducted by Public Works and other Southern California agencies from 1994 to 2000. Land use data within Los Angeles County was collected at locations in large watersheds with a majority of one of 8 land use types[3]. The eight locations selected were selected after visiting several sites for each land use and trying to determine a site that appeared to represent the average land use conditions[4]. Approximately 50 EMC data points were collected for each land use type. The Southern California Coastal Water Research Project (SCCWRP) describes the data sampling as follows:

> Two types of samples were collected by the monitoring agencies. The first type was a grab sample consisting of a bottle or bucket lowered into the channel or manhole. The second type was a composite sample, typically collected using a peristaltic pump with an intake strainer mounted in the bottom of channels or pipes. Composite samples, however, were weighted differently among agencies. Ventura Co., Los Angeles Co., and San Diego Co. used a single composite sample per event weighted by storm flow (e.g., sampling every set volume interval).
>
> Temporal variability within and among runoff events is compounded in the Southern California Bight by the different sampling strategies utilized by stormwater monitoring agencies. Our data set was comprised of individual grab, single and multiple weighted-composite samples. Grab and composite samples however, represent very different portions of a storm event. Grab samples represent a single snapshot of water quality during a storm event and, for the most part in 1994-95, were taken independently of flow regime or time since start of flow. Composite samples were actually multiple grab samples which, when combined together, were used to represent the mean water quality for an entire storm event. Composite samples, however, were weighted differently among the agencies. Some were weighted by storm flow (e.g., sampling every set volume interval); others were weighted by time (e.g. every hour, every 15 minutes, etc.). Flow-weighted composites sample more frequently during high flows than low flows, while

[2] Huber, W.C, et. al. Storm Water Management Model User's Manual. 9th Ed. May 2003.
[3] Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report. July 31, 2000.
[4] Personal communication with Bill DePoto of LACDPW Watershed Management Division. Phone. Oct. 25, 2005.

> time-weighted samples are distributed evenly throughout the storm event. Moreover, the number of samples per composite varied substantially among agencies (4 to 40+), or even within an agency (12 to 40+). The degree to which sampling strategies influence water quality results has not been quantified in terms of bias to the true EMC or the relative effect on seasonal loading estimates[5].

Geosyntec expressed the idea that the BMP implementation plan is trying to address long-term pollutant production using a constant average concentration.[6] Geosyntec felt that Public Works' concern may be related to pollutant production and provided several references related to mass-limited and volume-limited pollutant loads to help clarify the issue of pollutant production. Dr. Sansalone summed up the issue in his paper by stating, "[Pollutant] Particle transport was mass limited during long duration high intensity events, but flow limited during intermittent low intensity events…"[7]

Public Works expects that if the loading capabilities of the subarea are being evaluated over time, Southern California subareas will experience both types of pollutant loading limitation. Mass-limited events will occur during thunderstorms and low frequency events. Volume-limited events would be related to the longer less intense storms that occur during the regular storm season. The mass- and volume-limited transport phenomenon may partially explain the orders of magnitude difference in EMC measurements at the same location for different storm events. However, this relationship has not been established.

The types and mass of pollutants that will be washed into the system become the most important variables to determine which sites are high-priority for site-specific studies. That is, the pollutant generation capability of a subarea is what is being evaluated during the planning stage. When the concentration is held constant and the total load is based on runoff volume, rainfall and runoff assumptions become the driving factors in pollutant load calculations. This reduces the mass- and volume-limited discussion to statistical trends, the robustness of the data sample, and unknown relationships between rainfall, runoff, and pollutant generation.

The current method makes the assumption that all subareas with similar land use have the same pollutant generation mechanisms, and that on a per area basis, the available pollutant mass is equal. The proposed method relies on undefined rainfall/runoff relationships to determine which areas actually produce more pollutants. However, these relationships have not been established on a county-wide basis due to the very limited number of sampling locations used to determine the land use correlated EMCs. SCCWRP used the EMC data and data from mass emissions stations to determine pollutant loads delivered to the oceans in Southern California. Although discussing mass emissions for the Southern California Bight, the same problems are associated with EMC values correlated to land use.

> … the stormwater monitoring agencies are not mandated by the RWQCB to monitor every channel or every storm. As a result, the data set was incomplete and a number of assumptions were required that introduced considerable uncertainty in the quality of our

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[5] Review of Existing Stormwater Monitoring Programs for Estimating Bight-wide Mass Emissions from Urban Runoff. Los Angeles County Department of Public Works. 1996.

[6] Personal communication with Brandon Steets of Geosyntec. E-mail. Oct. 18, 2005.

[7] Sansalone, J.J., et. al. Physical Characteristics of Urban Roadway Solids Transported During Rain Events. Journal of Environmental Engineering. Vol. 124. Iss. 5. pp. 427-440.

> mass emissions estimates. First, it was necessary to assume that water quality measurements in monitored channels were equivalent to those from unmonitored channels. Based upon water quality results from monitored channels, 1994-95 median EMC's for channels within a county and between counties fluctuated widely, often ranging an order of magnitude or more for most constituents. Studies by SCCWRP (1992) also demonstrated tremendous variability among watersheds. For example, suspended solids flow-weighted mean concentrations ranged from 283 to 4,313 mg/L among the eight largest rivers and creeks in southern California during 1986-88. In 1994-95, only one of these eight channels was actually monitored by the stormwater management agencies. Since the corresponding data were not available from all channels, we are unable to assess the bias associated with our extrapolation to unmonitored watersheds[8].

In review, the statistical data is not robust enough to encompass regional variations in rainfall, runoff, and pollutant generating mechanisms for land use. In order to evaluate pollutant contributions from subareas for planning level studies, the EMC data is the only source of pollutant production information with a known relationship. The data is only correlated to land use. No other water quality relationships should be assumed since the data will not support the assumptions.

In order to create a dataset that is statistically robust for use in water quality studies, data is required that provides coverage of the county spatially. The data set must also contain temporal information that can be used to determine rainfall/runoff/pollutant load relationships during storms and over a storm season. SCCWRP is currently collecting data at 24 sites on an annually rotating basis[9]. The data collection includes sampling throughout the storm period. The samples are then tested individually for constituents and the resulting data is then averaged to get the EMC value. However, the pollutagraphs, the time series of pollutant concentrations, are available to compare to rainfall and runoff data. This type of data provides information on pollution generation mechanisms. In a study by Public Works developed for Kenter Canyon using the Storm Water Management Model with rainfall, runoff, and pollutagraphs, the conclusion states:

> "Water quality modeling involves the formulation of buildup, washoff, chemical, and biological processes of stormwater pollutants. More water quality data (pollutagraphs) is needed to improve the performance of the model."[10]

One suggestion to collecting the spatially and temporally inclusive water quality data is to have each city within the county establish one or two land use monitoring sites. This would establish approximately 80 to 160 sites. If the 8 types of land use measured for the previous study were used as categories, there would be approximately 10 to 20 regionally diversified sites to collect the data. Collecting the data for 5 years would provide approximately 50 EMC values for each site and an extensive database with more than 500 pollutagraphs for each land use type. Analysis of the pollutagraphs would provide necessary

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8 Review of Existing Stormwater Monitoring Programs for Estimating Bight-wide Mass Emissions from Urban Runoff. Southern California Coastal Water Research Project. 1996.

9 Personal communication with Eric Stein of SCCWRP. Phone. Oct. 17, 2005.

10 Urban Runoff Quality and Quantity Modeling in the Kenter Canyon Watershed Santa Monica Bay Drainage Basin, Phase III: Development of a Calibrated Stormwater Management Model. May 2000. pp. 24.

relationships between rainfall, runoff, and pollutant production. Seasonal relationships should also become more apparent.

The main problem associated with the suggested monitoring plan is the cooperation and coordination of the cities. Currently, Public Works has been responsible for most monitoring within the County, with the exception of the City of Los Angeles, and CalTrans. Existing funding and staffing constraints do not allow Public Works to implement this type of regional monitoring without cooperation of other municipal agencies. Coordination of data collection methods and data storage must also be considered. The monitoring and analyses needed prior to installation for proper assessment, design, and application of BMPs may be expensive and complex in the short term; however, reliable data collection may save even more expensive construction costs and may help designs improve water quality.[11]

Uncertainties in Rainfall/Runoff/Pollutant Load Relationships

Relationships between rainfall, runoff, and pollutant availability and loads are not understood. The current CPI-M1 method relies on statistical robustness of the data set to incorporate the range of EMC values and determine a mean concentration value. The EMC is then multiplied by a rainfall depth and a runoff coefficient to determine a pollutant load value that is then adjusted based on other factors.

With the EMC data collected, the CPI-M1 method must assume that pollutant loads are generated from the same mechanisms. No data is available to provide actual pollutant mass production on either a land use or spatially varied basis. This leaves the EMC data correlated to land use as the only pollutant production mechanism. The method must assume that deposition of oil, heavy metals, nitrates, bacteria, etc… occurs in the same amounts throughout the county, based on the land use type. The mass of pollutants on a per area basis must be the same, since no relationship has been established to show that pollutant generation varies geographically.

The relationships needed to determine the actual mass of pollutants generated from the sampling events have been removed. Due to the averaging of storm data to create storm EMCs and averaging storm EMCs to determine an average land use EMC, there is no way to determine the actual pollutant load delivered at the site.

Loss of the total mass produced poses the following problem: one storm may have had a high EMC value, with a short duration, resulting in a small pollutant mass delivery to the water body, while another storm may have had a low EMC over a long storm period, delivering large amounts of pollutants to the water body. There is no way to determine the effect of this averaging on the total loads of pollutants generated, even on the few areas studied, due to data collection procedures. However, the CPI-M1 method implies that all events are understood through a statistical distribution and that load is only a function of total runoff. However, no relationship has been researched or established.

Rainfall and runoff vary spatially over the county. They also vary temporally during the storm and through the storm season. The purpose for introducing the rainfall is to provide a relationship with

[11] Considerations in the Design of Treatment BMPs to Improve Water Quality. United States Environmental Protection Agency. September 2000. pp 4-4.

known geographic differences. The method hopes to determine the mass of pollutants generated to use for comparison.

If the pollutant generation mechanisms are the same for each land use, then the total load or total mass of constituents available will be equal on a per area basis. However, due to rainfall intensities and when a storm occurs in the season, the concentrations often vary considerably. It is not scientifically sound to categorize one area over another based on an assumed relationship between rainfall and pollutant concentration that has not been established. This type of relationship indicates that Glendale and Azusa generate more pollutants than Long Beach just because it rains more. This is not proven and appears to bias the pollutant generation to areas with higher rainfall.

Over the long-term, pollutants are not building up in the storm drain systems and impervious watershed surfaces. This indicates that over longer time periods, most pollutants are washed away. For planning purposes, the idea that all pollutants eventually wash off lends itself to using a pollutant production capacity based on the spatial land use distribution rather than trying to tie pollutant loads to rainfall and runoff relationships that have not been established.

Since some runoff event pollutant concentrations will be mass-limited and others will be volume-limited, use of a design storm type value may be inappropriate. Use of 85th percentile 24-hour rainfall indicates that a relationship between the rainfall volume and intensity to pollutant production are known. This is not the case. Use of an annual rainfall volume also indicates a relationship to rainfall, runoff, and pollutant production that has not been established. SCCWRP noted:

> Assumptions which are not well understood for southern California watersheds include relationships of water quality to antecedent dry periods (pollutant build-up) and rainfall intensity or duration (pollutant transport). Examples of the interactions between these two important parameters include concepts such as "first flush" (initial storm flows) or "seasonal flushing" (initial storms of the water year). Although several investigators have demonstrated portions of these concepts in other regions (Herricks 1995), they are not well-quantified in southern California. In some cases they appear significant (OCEMA 1996, RWQCB-LA 1988); in others, they do not (SCCWRP 1989).[12]

The relationship between rainfall characteristics and pollutant generation have not been determined. Use of the rainfall values to create a volume from which the pollutant load values are calculated adds a level of uncertainty that is unnecessary at the planning level and may bias results.

Converting the rainfall to a runoff volume then adds another level of uncertainty. The runoff coefficients in the CPI-M1 methodology are very general runoff values provided in a study by SCCWRP. The coefficients were determined based on runoff at mass emissions stations[13].

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[12] Review of Existing Stormwater Monitoring Programs for Estimating Bight-wide Mass Emissions from Urban Runoff. Southern California Coastal Water Research Project. 1996.

[13] Draft Structural BMP Prioritization Methodology. Geosyntec. August 15, 2005.

The CPI-M1 method requires collection of many GIS data layers that include: land use, grid rainfall data, digital elevation data, hydrologic drainage network connectivity, slopes, soil types, aerial imagery, ground water depth, etc. With this type of information, a full hydrologic model can be developed. From the hydrologic model, a runoff coefficient that is more representative of each subarea can be determined.

The use of macro scale runoff coefficients with micro scale rainfall and 40-acre subarea weighted EMCs is inconsistent. The runoff coefficients do not incorporate important information such as watershed slopes, soil types, watershed shape, etc… This data is available based on the information that is being requested for the planning study methodology.

The runoff relationship adds further uncertainty to the estimated pollutant load since no relationship has been established to link runoff volume to the pollutant mass that is produced in a watershed. If there is high runoff volume, more pollutant may be washed off the surface of the watershed. However, the large volume may reduce the measured concentration. No relationships are available to help understand the correlations between rainfall, runoff, and pollutant load concentrations, or even total pollutants generated.

Footnote 8 on page 13 of the Structural BMP Prioritization Methodology states:

> "While it is agreed that load modeling for TMDL compliance analysis is a needed effort, the purpose of this project is prioritizing of stormwater retrofit opportunities to maximize water quality benefits. As such, it focuses on the relative merits of opportunities, and not quantifiable improvements. "

The relative merits of BMP placement can be determined from the EMC data correlated to land use without adding the uncertainty of unknown relationships between rainfall, runoff, and pollutant loads.

In review, rainfall and runoff have not been adequately correlated to pollutant loads. There is no reason to include the rainfall and runoff coefficient values into the calculations used to determine which subareas have the highest pollution production capacity. Use of rainfall and runoff coefficients will bias the results in known and unknown ways as discussed above.

The pollution production capacity of each subarea can be determined through use of an area-weighted EMC for each subarea based on the land use types within the subarea. For planning purposes this is all that is necessary. Site-specific studies can then be used to determine the site-specific EMC, the range of pollutant concentrations at the site, and pollutant loading information. This information is necessary when determining which BMPs are to be implemented at the site since some BMPs are effective for low concentrations, while others are effective at high concentrations, just using the EMC may not cost effectively treat storm water. The result may be a BMP that does not significantly reduce the total pollutant load to the receiving waters. More about BMP effectiveness is provided in the following section.

Uncertainties in BMP Efficiency Databases

The Structural BMP Prioritization Methodology plans to pre-screen BMPs based on efficiency, cost effectiveness, reliability, and the ability to implement the BMP in the subarea. The idea is worthwhile, but there are many uncertainties associated with BMP effectiveness databases. The discussion of how the influent concentrations will be converted to effluent concentrations is not discussed in the BMP prioritization methodology. The methodology also does not discuss what the range in storm event EMCs means to BMP design. The only proposed influent concentration is based on the EMC and rainfall/runoff relationships. The EPA states:

> BMPs do not typically function with a uniform percent removal across a wide range of influent water quality concentrations. For example, a BMP that demonstrates a good percent removal under heavily polluted influent conditions may demonstrate poor percent removal when low influent concentrations exist. The decreased efficiency of BMPs receiving influent with low contaminant concentration has been demonstrated.[14]

The EMCs for different storms in the same land use category range over an order of magnitude. The effect of this range needs to be discussed. The effectiveness and type of BMP for each area may need to be moved to the site-specific evaluation. The following reminder provides insight on use of BMP databases for reliability and performance. It also discusses the need for site-specific evaluation before BMP implementation.

> It is important to understand which stormwater controls are suitable for specific site conditions and can achieve the required treatment goals. This knowledge will assist in the realistic evaluation of each practice for technical feasibility, implementation costs, and long-term maintenance requirements and costs. Unfortunately, the reliability and performance characteristics of many of these controls are not well established, with most still in the development stage. Emerging controls can be effective, but there is not a large amount of historical data on which to base designs and be confident that performance criteria will be met under local conditions. The most promising and best understood stormwater control practices are wet detention ponds. Less reliable in terms of predicting performance, but showing promise, are stormwater filters, wetlands, and percolation basins (Roesner et al., 1989). Grass swales have also shown great promise in the EPA's Nationwide Urban Runoff Program (NURP) (U.S. EPA, 1983) and other research projects.[15]

In review, BMP efficiencies are not well understood and documented for all ranges of conditions. Use of EMCs or estimated loads based on EMCs does not provide enough information for design of BMPs, but provides a general estimate. Screening the BMPs before the site-specific studies may prematurely limit BMP options in particular subareas.

Conclusions

The water quality industry is still developing. The cost of data collection has limited the availability of data. This leads to large uncertainties in water quality data and use of the data for planning studies for

[14] Considerations in the Design of Treatment BMPs to Improve Water Quality. United States Environmental Protection Agency. September 2000. pp 4-6.

[15] Durans, R. et. al. Stormwater Conveyance Modeling and Design. Haestad Press. September 2003. Chapter 15.

BMP placement throughout watersheds. The effort to develop standard planning level evaluations is worthwhile. At the same time, care needs to be taken to use data correctly, within the known limits. Unknown relationships should not be assumed and used. Assumed relationships may actually bias implementation away from areas that are higher priority.

The current storm water quality data available in the county consists of EMCs correlated only to land use. The EMC data set for each data collection site is statistically robust. However, the EMC data is statistically insignificant on a regional basis, which causes uncertainties in use of the data. Individual storm event EMCs varied over orders of magnitude. The causes for these variations are unknown. The data set is adequate to use for planning studies, but must be used correctly. Using the EMC for each land use estimating pollutant production capacity (Method 2) is adequate for a planning level study.

The CPI-M1 method in the Structural BMP Prioritization Methodology report extends the data and assumed relationships with rainfall and runoff beyond the capabilities of the data set. The method uses macro-scale runoff coefficients and water quality data with micro-scale subarea and rainfall data. This is inconsistent. For planning projects, macro-scale information should be adequate to determine areas with high priority for site-specific studies. These studies can investigate the micro-scale parameters to determine the best BMPs for the area.