Appendix

B

Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

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Appendix B Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

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B.1 DCV

DCV is defined as the volume of storm water runoff resulting from the 85th percentile, 24-hr storm event. The following hydrologic method must be used to calculate the DCV:

$$DCV = C \times d \times A \times 43{,}560\ sf/ac \times 1/12\ in/ft$$
$$DCV = 3{,}630 \times C \times d \times A$$

Where:

DCV = Design Capture Volume in cubic feet

C = Runoff factor (unitless); standard runoff factors are discussed in section B.1.1, adjustment factors are discussed in Section B.2.

d = 85th percentile, 24-hr storm event rainfall depth (inches), refer to section B.1.3

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingles with project runoff and drains to the BMP. Refer to Chapter 3, Section 3.3.3 for additional guidance. Street redevelopment projects consult section 1.4.3.

*Note that additional volume reductions may be applied through appropriate incorporation of tree wells and rain barrels as identified in section B.2.

Worksheet B.1-1 on the following page allows applicants to determine the initial design capture volume and apply any applicable reductions associated with site design techniques including dispersion to pervious surfaces, incorporation of tree wells, and incorporation of rain barrels.

Worksheet B.1-1. DCV

Category	#	Description	Value	Units
Standard Drainage Basin Inputs	0	Drainage Basin ID or Name		unitless
	1	Basin Drains to the Following BMP Type		unitless
	2	85th Percentile 24-hr Storm Depth		inches
	3	Impervious Surfaces Not Directed to Dispersion Area (C=0.90)		sq-ft
	4	Semi-Pervious Surfaces Not Serving as Dispersion Area (C=0.30)		sq-ft
	5	Engineered Pervious Surfaces Not Serving as Dispersion Area (C=0.10)		sq-ft
	6	Natural Type A Soil Not Serving as Dispersion Area (C=0.10)		sq-ft
	7	Natural Type B Soil Not Serving as Dispersion Area (C=0.14)		sq-ft
	8	Natural Type C Soil Not Serving as Dispersion Area (C=0.23)		sq-ft
	9	Natural Type D Soil Not Serving as Dispersion Area (C=0.30)		sq-ft
Dispersion, Tree Well, & Rain Barrel Inputs (Optional)	10	Does Tributary Incorporate Dispersion, Tree Wells, and/or Rain Barrels?		yes/no
	11	Impervious Surfaces Directed to Dispersion Area per SD-B (Ci=0.90)		sq-ft
	12	Semi-Pervious Surfaces Serving as Dispersion Area per SD-B (Ci=0.30)		sq-ft
	13	Engineered Pervious Surfaces Serving as Dispersion Area per SD-B (Ci=0.10)		sq-ft
	14	Natural Type A Soil Serving as Dispersion Area per SD-B (Ci=0.10)		sq-ft
	15	Natural Type B Soil Serving as Dispersion Area per SD-B (Ci=0.14)		sq-ft
	16	Natural Type C Soil Serving as Dispersion Area per SD-B (Ci=0.23)		sq-ft
	17	Natural Type D Soil Serving as Dispersion Area per SD-B (Ci=0.30)		sq-ft
	18	Number of Tree Wells Proposed per SD-A		#
	19	Average Mature Tree Canopy Diameter		ft
	20	Number of Rain Barrels Proposed per SD-E		#
	21	Average Rain Barrel Size		gal
Final Adjusted Runoff Factor Calculations	22	Total Area Tributary to BMP		sq-ft
	23	Composite Runoff Factor for Standard Drainage Areas		unitless
	24	Initial Composite Runoff Factor for Dispersed & Dispersion Areas		unitless
	25	Total Impervious Area Dispersed to Pervious Surface		sq-ft
	26	Total Pervious Dispersion Area		sq-ft
	27	Dispersed Impervious Area / Pervious Dispersion Area		ratio
	28	Adjustment Factor for Dispersed & Dispersion Areas		ratio
	29	Final Adjusted Tributary Runoff Factor		unitless
Volume Reduction Calculations	30	Final Effective Tributary Area		sq-ft
	31	Initial Design Capture Volume		cubic-feet
	32	Volume Reduction per Tree Well		cubic-feet
	33	Total Tree Well Volume Reduction		cubic-feet
	34	Total Rain Barrel Volume Reduction		cubic-feet
Result	35	Design Capture Volume Tributary to BMP		cubic-feet

Worksheet B.1-1 General Notes:

A. Applicants may use this worksheet to calculate design capture volumes. Applicants must provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Notes corresponding with each line item are provided on the following page. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

B. Impervious surfaces include roofs, concrete, asphalt, or pervious pavements with an impervious liner.

C. Semi-pervious surfaces include decomposed granite, cobbles, crushed aggregate, or compacted soils such as unpaved parking.

D. Engineered pervious surfaces include pervious pavements providing full retention of the 85th percentile rainfall depth, or areas with soils that have been amended and mulched per Section 86.709 of the Landscape Ordinance.

E. Dispersion areas are pervious or semi-pervious surfaces that receive runoff from impervious surfaces (C=0.90) and reduce stormwater runoff as outlined in Fact Sheet SD-B.

Worksheet B.1-1 Line Item Notes

0. User Input from stormwater plans.
1. User Input from stormwater plans.
2. User Input from Figure B.1-1.
3. User Input from stormwater plans.
4. User Input from stormwater plans.
5. User Input from stormwater plans.
6. User Input from stormwater plans.
7. User Input from stormwater plans.
8. User Input from stormwater plans.
9. User Input from stormwater plans.
10. User Input (Default="No").
11. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-B.
12. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-B.
13. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-B.
14. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-B.
15. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-B.
16. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-B.
17. User Input from stormwater plans. Must satisfy criteria from Fact Sheet SD-B.
18. User Input. Must satisfy criteria from Fact Sheet SD-A.
19. User Input. Must satisfy criteria from Fact Sheet SD-A. Acceptable range from 0-30 feet.
20. User Input. Must satisfy criteria from Fact Sheet SD-E. Cannot provide more than 0.25DCV volume reduction.
21. User Input. Must satisfy criteria from Fact Sheet SD-E. Acceptable range 0-100 gallons for generic volume reductions.
22. Sum of Lines 3 through 17.
23. [0.9(Line 3) + 0.3(Line 4 + Line 9) + 0.1(Line 5 + Line 6) + 0.14(Line 7) + 0.23(Line 8)] /(Line 3 + Line 4 + Line 5 + Line 6 + Line 7 + Line 8 + Line 9)
24. [0.9(Line 11) + 0.3(Line 12 + Line 17) + 0.1(Line 13 + Line 14) + 0.14(Line 15) + 0.23(Line 16)] /(Line 11 + Line 12 + Line 13 + Line 14 + Line 15 + Line 16 + Line 17)
25. Line 11
26. Summation of Lines 12-17.
27. [Line 25 / Line 26]. If greater than 4.0 dispersion benefits are not quantified.
28. Lookup values from Table B.2-1 weighted with respect to distribution of dispersion areas specified in Lines 12-17.
29. [Line 23 x (Line 3 + Line 4 + Line 5 + Line 6 + Line 7 + Line 8 + Line 9) + Line 24 x Line 28 x (Line 11 + Line 12 + Line 13 + Line 14 + Line 15 + Line 16 + Line 17)] / Line 22
30. Line 22 x Line 29
31. [(Line 2/12) x Line 30]
32. Lookup value from Section B.2.2.1 of BMP Design Manual.
33. [Line 18 x Line 32]
34. [Line 20 x Line 21/7.48]. If Line 21>100 or Line 10 is "n/a" or "no", then this value must be zero.
35. [Line 31 - Line 33 - Line 34]. Minimum of 0.

B.1.1 Runoff Factor

Estimate the area weighted runoff factor for the tributary area to the BMP using runoff factor (from Table B.1-1) and area of each surface type in the tributary area and the following equation:

$$C = \frac{\sum C_x A_x}{\sum A_x}$$

Where:

C_x = Runoff factor for area X

A_x = Tributary area X (acres)

These runoff factors apply to areas receiving direct rainfall only. For conditions in which runoff is routed onto a surface from an adjacent surface, see Section B.2 for determining composite runoff factors for these areas.

Table B.1-1: Runoff factors for surfaces draining to BMPs – Pollutant Control BMPs

Surface	Runoff Factor
Roofs[9]	0.90
Concrete or Asphalt[1]	0.90
Unit Pavers (grouted)[1]	0.90
Decomposed Granite	0.30
Cobbles or Crushed Aggregate	0.30
Mulched and Amended Soils per the Water Conservation in Landscaping Ordinance, Section 86.709 & Fact Sheet SD-F in Appendix E	0.10
Compacted Soil (e.g., unpaved parking)	0.30
Natural (A Soil)	0.10
Natural (B Soil)	0.14
Natural (C Soil)	0.23
Natural (D Soil)	0.30
Swimming pools, fountains, ponds, and other impoundments with appropriate freeboard.	0.00

[9] Surface is considered impervious and could benefit from use of Site Design BMPs and adjustment of the runoff factor per Section B.2.1.

B.1.2 Offline BMPs

Diversion flow rates for offline BMPs must be sized to convey the maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of every storm event. The following hydrologic method must be used to calculate the diversion flow rate for off-line BMPs:

$$Q = C \times i \times A$$

Where:

Q = Diversion flow rate in cubic feet per second

C = Runoff factor, area weighted estimate using Table B.1

i = Rainfall intensity of 0.2 in/hr

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drain to the BMP. Refer to Chapter 3, Section 3.3.3 for additional guidance. Street redevelopment projects also consult Section 1.4.3.

B.1.3 85th Percentile, 24-Hour Storm Event

The 85th percentile, 24-hour isopluvial map is provided as Figure B.1-1. The rainfall depth to estimate the DCV must be determined using Figure B.1-1. The methodology used to develop this map is presented below:

B.1.3.1 Gage data and calculation of 85th percentile

The method of calculating the 85th percentile is to produce a list of values, order them from smallest to largest, and then pick the value that is 85 percent of the way through the list. Only values that are capable of producing run off are of interest for this purpose. Lacking a legislative definition of rainfall values capable of producing runoff, Flood Control staff in San Diego County have observed that the point at which significant runoff begins is rather subjective, and is affected by land use type and soil moisture. In highly-urbanized areas, the soil has a high impermeability and runoff can begin with as little as 0.02" of rainfall. In rural areas, soil impermeability is significantly lower and even 0.30" of rain on dry soil will frequently not produce significant runoff. For this reason, San Diego County has chosen to use the more objective method of including all non-zero 24-hour rainfall totals when calculating the 85th percentile. To produce a statistically significant number, only stations with 30 years or greater of daily rainfall records are used.

B.1.3.2 Mapping the gage data

A collection of 56 precipitation gage points was developed with 85th percentile precipitation values based on multiple years of gage data. A raster surface (grid of cells with values) was interpolated from that set of points. The surface initially did not cover the County's entire jurisdiction. A total of 13 dummy points were added. Most of those were just outside the County boundary to enable the software to generate a surface that covered the entire County. A handful of points were added to enforce a plausible surface. In particular, one point was added in the desert east of Julian, to enforce a gradient from high precipitation in the mountains to low precipitation in the desert. Three points were added near the northern boundary of the County to adjust the surface to reflect the

effect of elevation in areas lacking sufficient operating gages.

Several methods of interpolation were considered. The method chosen is named by Environmental Systems Research Institute as the Natural Neighbor technique. This method produces a surface that is highly empirical, with the value of the surface being a product of the values of the data points nearest each cell. It does not produce peaks or valleys of surface based on larger area trends, and is free of artifacts that appeared with other methods.

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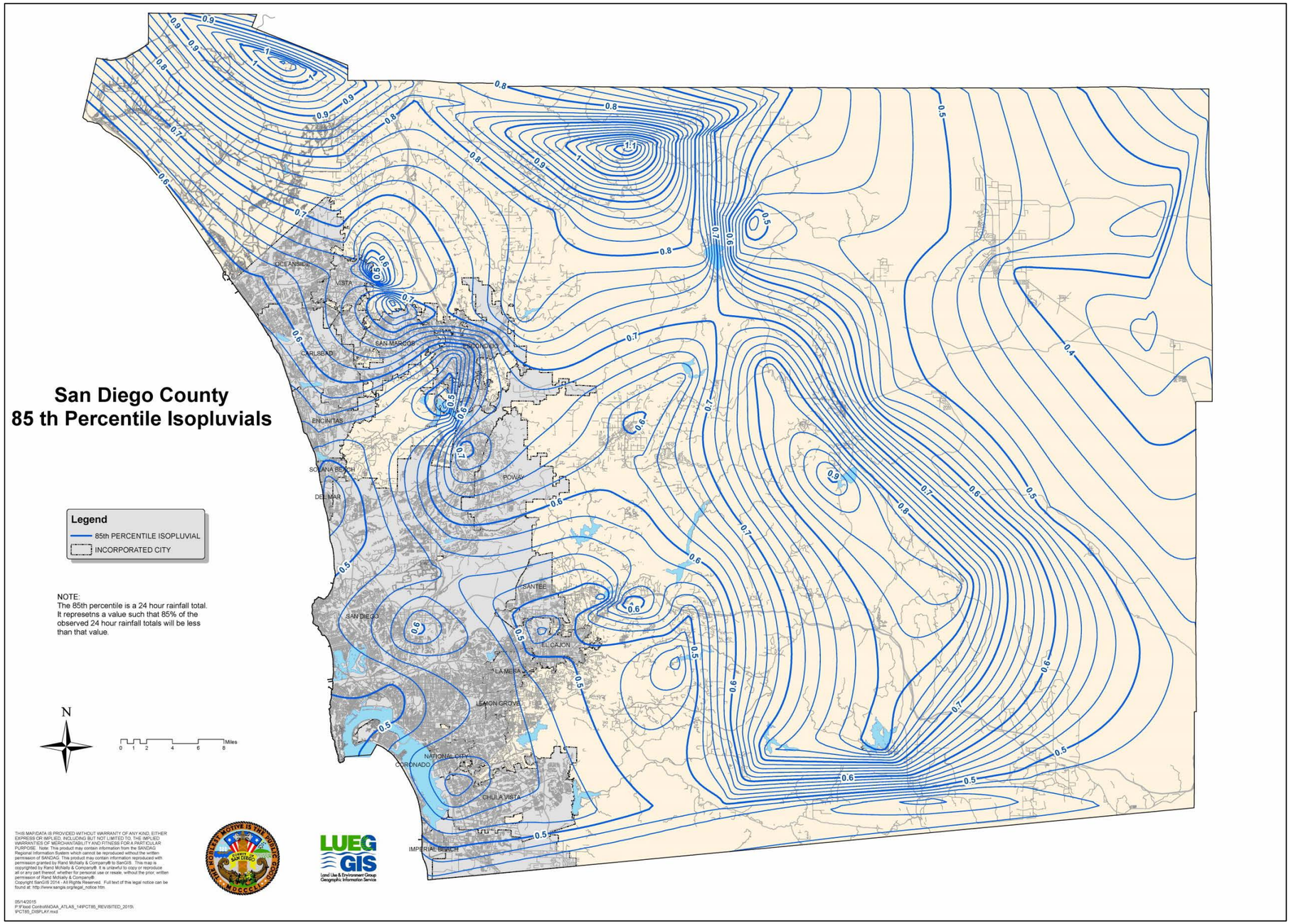

Figure B.1-1: 85th Percentile 24-hour Isopluvial Map

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B.2 Adjustments to Account for Site Design BMPs

This section provides methods to adjust the DCV (for sizing pollutant control BMPs) as a result of implementing site design BMPs. The adjustments are provided by one of the following two methods:

- Adjustment to impervious runoff factor
- Adjustment to DCV

B.2.1 Adjustment to Impervious Runoff Factor

When one of the following site design BMPs is implemented the runoff factor of 0.9 for impervious surfaces identified in Table B.1-1 should be adjusted using the factors listed below and an adjusted area weighted runoff factor must be estimated following guidance from Section B.1.1 and used to calculate the DCV.

- SD-B Impervious area dispersion
- SD-C Green roofs
- SD-D Permeable pavement

B.2.1.1 Impervious area dispersion (SD-B)

Adjustment to conventional runoff factors may be permitted when storm water runoff from impervious surfaces is dispersed through pervious dispersion areas in accordance with the SD-B fact sheet located in Appendix E. Among other criteria, this fact sheets requires dispersion areas to be pervious, have a minimum width of 10 feet, and a maximum slope of 5%.

Runoff factor adjustments may be applied to drainage areas with a 4:1 maximum ratio of impervious to pervious area. In order to be eligible for runoff factor adjustments, impervious areas must have a runoff factor of 0.9 and must be directed towards a pervious dispersion area. In order to provide runoff factor adjustments, pervious dispersion areas must have a runoff factor of less than 0.30 and must receive runoff from an adjacent impervious surface.

As depicted in Table B.2-1 runoff factor adjustments are a function of the ratio of impervious to pervious area and the hydrologic soil group of the pervious dispersion area. If an applicant proposes amended soils per the Water Conservation in Landscaping Ordinance Section 86.709 and the SD-F fact sheet, the underlying hydrologic soil group need not be considered. Applicants applying runoff reduction factors must identify appropriate factors presented in the table below and multiply that factor by the original composite runoff factor of the impervious area and the dispersion area.

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Table B.2-1: Impervious area adjustment factors that accounts for dispersion

Pervious area hydrologic soil group	Ratio = Impervious area/Pervious area			
	<=1	2	3	4
A/Amended Soil	0.00	0.00	0.21	0.32
B	0.00	0.24	0.38	0.48
C	0.31	0.50	0.60	0.67
D	0.77	0.84	0.87	0.90

Continuous simulation modeling in accordance with Appendix G is required to develop adjustment factors for surfaces that have an unadjusted runoff factor less than 0.9. Approval of adjustment factors for surfaces that have an unadjusted runoff factor less than 0.9 is at the discretion of County staff.

The adjustment factors in Table B.2-1 were developed by performing continuous simulations in SWMM with default parameters from Appendix G and impervious to pervious area ratios of 1, 2, 3, and 4. When using adjustment factors from Table B.2-1:

- **Linear interpolation** must be performed if the impervious to pervious area ratio of the site is in between one of ratios for which an adjustment factor was developed;
- Use adjustment factor for a ratio of 1 when the impervious to pervious area ratio is less than 1; and
- Adjustment factor is not allowed when the impervious to pervious area ratio is greater than 4, when the pervious area is designed as a site design BMP.

Example B.2-1: DMA is comprised of one acre of impervious area that drains to a 0.4 acre hydrologic soil group B pervious area and then the pervious area drains to a BMP. Impervious area dispersion is implemented in the DMA in accordance with SD-B factsheet. Estimate the adjusted runoff factor for the DMA.

- Initial Runoff Factor: Per problem statement and Table B.1-1, [(1*0.9+0.4*0.14)/1.4] = 0.68
- Impervious to Pervious Ratio: Per problem statement, 1 acre/0.4 acres = 2.5
- Adjustment Factor: From Table B.2-1 the adjustment factor for hydrologic soil group B and a ratio of 2.5 can be linearly interpolated as 0.31
- **Final Adjusted Runoff Factor:** Initial Runoff Factor * Adjustment Factor = 0.68 * 0.31 **= 0.21**

B.2.1.2 Green Roofs

When green roofs are implemented in accordance with the SD-C factsheet the green roof footprint must be assigned a runoff factor of 0.10 for adjusted runoff factor calculations.

B.2.1.3 Permeable Pavement

When a permeable pavement is implemented in accordance with the SD-D factsheet and it **does not have an impermeable liner** and has an equivalent storage depth greater than the 85th percentile 24 hour precipitation depth below the underdrain, if an underdrain is present, then the footprint of the permeable pavement must be assigned a runoff factor of 0.10 for adjusted runoff factor calculations.

Permeable Pavement can also be designed as a structural BMP to treat run on from adjacent areas. Refer to INF-3 factsheet and Appendix B.4 for additional guidance.

B.2.2 Adjustment to DCV

When the following site design BMPs are implemented the anticipated volume reduction from these BMPs must be deducted from the DCV to estimate the volume for which the downstream structural BMP should be sized for:

- SD-A: Tree Wells
- SD-E Rain barrels

B.2.2.1 Tree Wells

Tree Well credit volume (tree BMPs) is a sum of three runoff reduction volumes provided by trees that decrease the required DCV for a tributary area. The following reduction in DCV is allowed per tree based on the mature diameter of the tree canopy, when trees are implemented in accordance with SD-A factsheet:

Mature Tree Canopy Diameter (ft)	Tree Well Credit Volume (ft^3/tree)
5	10
10	40
15	100
20	180
25	290
30	420

Basis for the reduction in DCV:

Tree Well credit volume is estimated based on typical characteristics of Tree Wells as follows:

It is assumed that each tree is considered a single BMP, with calculations based on the soil media reservoir volume and/or the individual tree within the tree BMP as appropriate. Tree Well credit volume is calculated as:

$$\boldsymbol{TWCV = TIV + TCIV + TETV}$$

Where:

- *TWCV* = Tree Well credit volume (ft^3)
- *TIV* = Total infiltration volume of all storage layers within tree BMPs (ft^3)
- *TCIV* = Total canopy interception volume of tree BMPs (ft^3)
- *TETV* = Total evapotranspiration volume, sums the media evapotranspiration storage within each tree BMP (ft^3)

Total infiltration volume is calculated as the total volume stored within the tree BMP soil media reservoir. Infiltration volume was assumed to be 20% of the total BMP soil media reservoir volume, the available pore space in the soil media reservoir (porosity – field capacity).

Total canopy interception volume was calculated as the average interception capacity for the entire mature tree canopy projection area. Interception capacity was determined to be 0.04 inches per square foot for all tree sizes, an average from the findings published by Breuer et al (2003) for coniferous and deciduous trees.

Total evapotranspiration volume is the available evapotranspiration storage volume (field capacity – wilting point) within the BMP storage layer media. TEVT is assumed to be 10% of the minimum soil volume. The minimum soil volume as required by SD-A fact sheet of 2 cubic feet per unit canopy projection area was assumed for estimating reduction in DCV.

There may be rain events that generate more runoff than the tree well can handle. Installing an overflow above the design storm water retention level of the reservoir can prevent system failure during extreme weather events. Placement of the overflow should be determined based on the infiltration rate of the subsoil.. If infiltration is not adequate to remove water from the rooting zone (the top 18 to 24 inches of soil media reservoir) within 48 hours, the depth of the soil media reservoir may be increased, and the overflow should be placed such that if water rises to the level of the rooting zone it will drain in less than 48 hours.

B.2.2.2 Rain Barrels

Rain barrels are containers that can capture rooftop runoff and store it for future use. Credit can be taken for the full rain barrel volume when each barrel volume is smaller than 100 gallons, implemented per SD-E fact sheet and meet the following criteria:

- Total rain barrel volume is less than 0.25 DCV and
- Landscape areas are greater than 30 percent of the project footprint.

Credit for harvest and use systems that do not meet the above criteria must be based on the criteria in Appendix B.3 and HU-1 fact sheet.

B.3 BMP Feasibility

The purpose of this section is to determine the BMP types that are acceptable for implementation at the project site. Through completion of Worksheet B.3-1, applicants will evaluate the feasibility of harvest & use, full retention, and partial retention BMPs at their project site.

Worksheet B.3-1. Project-Scale BMP Feasibility Analysis

Category	#	Description	Value	Units
Capture & Use Inputs	0	Design Capture Volume for Entire Project Site		cubic-feet
	1	Proposed Development Type		unitless
	2	Number of Residents or Employees at Proposed Development		#
	3	Total Planted Area within Development		sq-ft
	4	Water Use Category for Proposed Planted Areas		unitless
Infiltration Inputs	5	Is Average Site Infiltration Rate Less than 0.5 Inches per Hour?		yes/no
	6	Is Retention of the Full DCV Anticipated to Produce Negative Impacts?		yes/no
	7	Is Retention of Any Volume Anticipated to Produce Negative Impacts?		yes/no
Calculations	8	36-Hour Toilet Use Per Resident or Employee		cubic-feet
	9	Subtotal: Anticipated 36 Hour Toilet Use		cubic-feet
	10	Anticipated 1 Acre Landscape Use Over 36 Hours		cubic-feet
	11	Subtotal: Anticipated Landscape Use Over 36 Hours		cubic-feet
	12	Total Anticipated Use Over 36 Hours		cubic-feet
	13	Total Anticipated Use / Design Capture Volume		cubic-feet
	14	Are Full Capture and Use Techniques Feasible for this Project?		unitless
	15	Is Full Retention Feasible for this Project?		yes/no
	16	Is Partial Retention Feasible for this Project?		yes/no
Result	17	Feasibility Category		1, 2, 3, 4, 5

Worksheet B.3-1 General Notes:

A. Applicants may use this optional worksheet to determine the feasibility of implementing capture and use techniques on their project site. Applicants should provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Projects demonstrating feasibility or potential feasibility via this worksheet are encouraged to incorporate capture and use features in their project. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

B. Negative impacts associated with retention may include geotechnical, groundwater, water balance, or other issues identified by a geotechnical engineer and substantiated through completion of Form I-8.

C. Feasibility Category 1: Applicant must implement capture & use, retention, and/or infiltration elements for the entire DCV.

D. Feasibility Category 2: Applicant must implement capture & use elements for the entire DCV.

E. Feasibility Category 3: Applicant must implement retention and/or infiltration elements for the entire DCV.

F. Feasibility Category 4: Applicant must implement partial retention BMPs.

G. Feasibility Category 5: Applicant must implement biofiltration BMPs.

H. PDPs participating in an offsite alternative compliance program are not held to the feasibility categories presented herein.

Worksheet B.3-1 Line Item Notes:

0. User input determined by summing all Design Capture Volumes within the Project footprint.
1. User input based on predominate land use type within the project footprint.
2. User input.
3. User input from stormwater plans.
4. User Input from stormwater plans.
5. User Input from site soils investigation.
6. User Input from site soils investigation as supported by Form I-8.
7. User Input from site soils investigation as supported by Form I-8.
8. Lookup Value from Table B.3-1 divided by 7.48 and multiplied by 1.50 to get cubic-feet per 36 hours.
9. Line 2 x Line 8
10. Lookup value from Table B.3-3 divided by 7.48 to get cubic-feet per 36 hours.
11. (Line 3/43,560) x Line 10
12. Line 9 + Line 11
13. Line 12 / Line 0
14. If Line 13 ≥ 1.0 then "Yes", otherwise "No".
15. If Line 5 = "No" AND Line 6="No", then result is "Yes". All other combinations result in "No".
16. If Line 5 = "Yes" AND Line 7="No", then result is "Yes"
17. Based on Results of Line 14:Line 15:Line 16. (1=Yes:Yes:Yes), (2=Yes:No:No or Yes:No:Yes), (3=No:Yes:Yes), (4=No:No:Yes), (5=No:No:No)

B.3.1 Planning Level Harvest and Use Feasibility

Harvest and use feasibility should be evaluated at the scale of the entire project, and not limited to a single DMA. For the purpose of initial feasibility screening, it is assumed that harvested water collected from one DMA could be used within another. Types of non-potable water demand that may apply within a project include:

- Toilet and urinal flushing*
- Irrigation
- Vehicle washing
- Evaporative cooling
- Dilution water for recycled water systems
- Industrial processes
- Other non-potable uses

Worksheet B.3-1 provides a screening process for determining the preliminary feasibility for harvest and use BMPs. This worksheet should be completed for the overall project.

Note: At the time of publication of this document, there is not a program in place to permit the use of storm water for indoor use. Check with PDS prior to calculating indoor water use.

B.3.2 Harvested Water Demand Calculation

The following sections provide technical references and guidance for estimating the harvested water demand of a project. These references are intended to be used for the planning phase of a project for feasibility screening purposes.

B.3.2.1 Toilet and Urinal Flushing Demand Calculations*

The following guidelines should be followed for computing harvested water demand from toilet and urinal flushing:

- If reclaimed water is planned for use for toilet and urinal flushing, then the demand for harvested storm water is equivalent to the total demand minus the reclaimed water supplied, and should be reduced by the amount of reclaimed water that is available during the wet season.
- Demand calculations for toilet and urinal flushing should be based on the average rate of use during the wet season for a typical year.
- Demand calculations should include changes in occupancy over weekends and around holidays and changes in attendance/enrollment over school vacation periods.
- For facilities with generally high demand, but periodic shut downs (e.g., for vacations, maintenance, or other reasons), a project specific analysis should be conducted to determine whether the long term storm water capture performance of the system can be maintained despite shut downs.
- Such an analysis should consider the statistical distributions of precipitation and demand, most importantly the relationship of demand to the wet seasons of the year.

Table B.3-1 provides planning level demand estimates for toilet and urinal flushing per resident, or employee, for a variety of project types. The per capita use per day is based on daily employee or resident usage. For non-residential types of development, the "visitor factor" and "student factor" (for schools) should be multiplied by the employee use to account for toilet and urinal usage for non-employees using facilities.

Note: At the time of publication of this document, there is not a program in place to permit the use of storm water for indoor use. Check with PDS prior to calculating indoor water use.

Table B.3-1. Toilet and Urinal Water Usage per Resident or Employee

Land Use Type	Toilet User Unit of Normalization	Per Capita Use per Day		Visitor Factor[4]	Water Efficiency Factor	Total Use per Resident or Employee
		Toilet Flushing[1,2]	Urinals[3]			
Residential	Resident	18.5	NA	NA	0.5	9.3
Office	Employee (non-visitor)	9.0	2.27	1.1	0.5	7 (avg)
Retail	Employee (non-visitor)	9.0	2.11	1.4	0.5	
Schools	Employee (non-student)	6.7	3.5	6.4	0.5	33
Various Industrial Uses (excludes process water)	Employee (non-visitor)	9.0	2	1	0.5	5.5

1 - Based on American Waterworks Association Research Foundation,1999. Residential End Uses of Water. Denver, CO: AWWARF

2 - Based on use of 3.45 gallons per flush and average number of per employee flushes per subsector, Table D-1 for MWD (Pacific Institute, 2003)

3 - Based on use of 1.6 gallons per flush, Table D-4 and average number of per employee flushes per subsector, Appendix D (Pacific Institute, 2003)

4 - Multiplied by the demand for toilet and urinal flushing for the project to account for visitors. Based on proportion of annual use allocated to visitors and others (includes students for schools; about 5 students per employee) for each subsector in Table D-1 and D-4 (Pacific Institute, 2003)

5 - Accounts for requirements to use ultra low flush toilets in new development projects; assumed that requirements will reduce toilet and urinal flushing demand by half on average compared to literature estimates. Ultra low flush toilets are required in all new construction in California as of January 1, 1992. Ultra low flush toilets must use no more than 1.6 gallons per flush and Ultra low flush urinals must use no more than 1 gallon per flush. Note: If zero flush urinals are being used, adjust accordingly.

B.3.2.2 General Requirements for Irrigation Demand Calculations

The following guidelines should be followed for computing harvested water demand from landscape irrigation:

- If reclaimed water is planned for use for landscape irrigation, then the demand for harvested storm water should be reduced by the amount of reclaimed water that is available during the wet season.
- Irrigation rates should be based on the irrigation demand exerted by the types of landscaping that are proposed for the project, with consideration for water conservation requirements.
- Irrigation rates should be estimated to reflect the average wet season rates (defined as October through April) accounting for the effect of storm events in offsetting harvested water demand. In the absence of a detailed demand study, it should be assumed that irrigation demand is not present during days with greater than 0.1 inches of rain and the subsequent 3-day period. This irrigation shutdown period is consistent with standard practice in land application of wastewater and is applicable to storm water to prevent irrigation from resulting in dry weather runoff. Based on a statistical analysis of San Diego

County rainfall patterns, approximately 30 percent of wet season days would not have a demand for irrigation.

- If land application of storm water is proposed (irrigation in excess of agronomic demand), then this BMP must be considered to be an infiltration BMP and feasibility screening for infiltration must be conducted. In addition, it must be demonstrated that land application would not result in greater quantities of runoff as a result of saturated soils at the beginning of storm events. Agronomic demand refers to the rate at which plants use water.

The following sections describe methods that should be used to calculate harvested water irrigation demand. While these methods are simplified, they provide a reasonable estimate of potential harvested water demand that is appropriate for feasibility analysis and project planning. These methods may be replaced by a more rigorous project-specific analysis that meets the intent of the criteria above.

B.3.2.2.1 Demand Calculation Method

This method is based on the San Diego Municipal Code Land Development Code Landscape Standards Appendix E which includes a formula for estimating a project's annual estimated total water use based on reference evaporation, plant factor, and irrigation efficiency.

For the purpose of calculating harvested water irrigation demand applicable to the sizing of harvest and use systems, the estimated total water use has been modified to reflect typical wet-season irrigation demand. This method assumes that the wet season is defined as October through April. This method further assumes that no irrigation water will be applied during days with precipitation totals greater than 0.1 inches or within the 3 days following such an event. Based on these assumptions and an analysis of Lake Wohlford, Lindbergh and Oceanside precipitation patterns, irrigation would not be applied during approximately 30 percent of days from October through April.

The following equation is used to calculate the Modified Estimated Total Water Usage:

$$\text{Modified ETWU} = ETo_{Wet} \times [[\Sigma(PF \times HA)/IE] + SLA] \times 0.015$$

Where:

Modified ETWU = Estimated daily average water usage during wet season
ETo_{Wet} = Average reference evapotranspiration from October through April (use 2.7 inches per month, using CIMS Zone 4 from Table G.1-1)
PF = Plant Factor

Table B.3-2. Planning Level Plant Factor Recommendations

Plant Water Use	Plant Factor	Also Includes
Low	< 0.1 – 0.2	Artificial Turf
Moderate	0.3 – 0.7	
High	0.8 and greater	Water features
Special Landscape Area	1.0	

HA = Hydrozone Area (sq-ft); A section or zone of the landscaped area having plants with similar water needs.
Σ(PF x HA) = The sum of PF x HA for each individual Hydrozone (accounts for different landscaping zones).
IE = Irrigation Efficiency (assume 90 percent for demand calculations)
SLA = Special Landscape Area (sq-ft); Areas used for active and passive recreation areas, areas solely dedicated to the production of fruits and vegetables, and areas irrigated with reclaimed water.

In this equation, the coefficient (0.015) accounts for unit conversions and shut down of irrigation during and for the three days following a significant precipitation event:

0.015 = (1 mo/30 days)×(1 ft/12 in)×(7.48 gal/cu-ft)×(approximately 7 out of 10 days with irrigation demand from October through April)

B.3.2.2.2 Planning Level Irrigation Demands

To simplify the planning process, the method described above has been used to develop daily average wet season demands for a one-acre irrigated area based on the plant/landscape type. These demand estimates can be used to calculate the drawdown of harvest and use systems for the purpose of LID BMP sizing calculations.

Table B.3-3. Planning Level Irrigation Demand by Plant Factor and Landscape Type

General Landscape Type	36-Hour Planning Level Irrigation Demand (gallons per irrigated acre per 36 hour period)
Hydrozone – Low Plant Water Use	390
Hydrozone – Moderate Plant Water Use	1,470
Hydrozone – High Plant Water Use	2,640
Special Landscape Area	2,640

B.3.2.3 Calculating Other Harvested Water Demands

Calculations of other harvested water demands should be based on the knowledge of land uses, industrial processes, and other factors that are project-specific. Demand should be calculated based on the following guidelines:

- Demand calculations should represent actual demand that is anticipated during the wet season (October through April).
- Sources of demand should only be included if they are reliably and consistently present during the wet season.
- Where demands are substantial but irregular, a more detailed analysis should be conducted based on a statistical analysis of anticipated demand and precipitation patterns.

B.3.3 Sizing Harvest and Use BMPs

Sizing calculations must demonstrate that one of two equivalent performance standards is met:

1. Harvest and use BMPs are sized to drain the tank in 36 hours following the end of rainfall. The size of the BMP is dependent on the demand (Section B.3.2) at the site.
2. Harvest and use BMP is designed to capture at least 80 percent of average annual (long term) runoff volume.

B.3.4 Consideration of Retention and Partial Retention

If an applicant is not fully implementing capture & use techniques, the feasibility of storm water infiltration must be investigation through geotechnical analysis as outlined in Appendix C.

B.4 Bioretention and Infiltration BMPs

Sizing calculations for BMPs solely providing bioretention or infiltration treatment measures must demonstrate the following performance standard is met:

1. The BMP or series of BMPs infiltrates at least 80 percent of average annual (long term) runoff volume. This can be demonstrated using the percent capture method (Section B.4.1), through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in Appendix G, as acceptable to County staff. This method is **not** applicable for sizing biofiltration BMPs.

Worksheets B.4-1 and B.4-2 on the pages that follow allow applicants to determine how effectively a proposed bioretention or infiltration BMP addresses the performance standard above. These worksheets require basic inputs for tributary and BMP characteristics and provided standardized calculations to determine associated drawdown times, infiltration volumes, and BMP effectiveness. The result of these worksheets is a "deficit of effectively treated storm water". BMPs that are in compliance with performance standards have a deficit of zero. BMPs with a negative deficit value are not in compliance with performance standards and must be redesigned or augmented with flow-thru treatment and mitigated for through an offsite alternative compliance project.

Worksheet B.4-1: Sizing Infiltration BMPs

Category	#	Description	Value	Units
BMP Inputs	0	Drainage Basin ID or Name		unitless
	1	Design Capture Volume Tributary to BMP		cubic-feet
	2	Provided Infiltration Surface Area		sq-ft
	3	Provided Surface Ponding Depth		inches
	4	Provided Soil Media Thickness		inches
	5	Provided Gravel Storage Thickness		inches
	6	Native Soil Infiltration Rate		in/hr
Infiltration Calculations	7	Volume Infiltrated Over 6 Hour Storm		cubic-feet
	8	Soil Media Pore Space	0.40	unitless
	9	Gravel Pore Space	0.40	unitless
	10	Effective Depth of Infiltration Storage		inches
	11	Drawdown Time for Surface Ponding (Post-Storm)		hours
	12	Drawdown Time for Entire Infiltration Basin (Including 6 Hour Storm)		hours
	13	Volume Infiltrated by BMP		cubic-feet
	14	Fraction of DCV Infiltrated		ratio
	15	Percentage of Performance Requirement Satisfied		ratio
Result	16	**Deficit of Effectively Treated Stormwater**		cubic-feet

Worksheet B.4-1 General Notes:

A. Applicants may use this worksheet to size Infiltration-Only BMPs (INF-1). Applicants must provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Notes corresponding with each line item are provided below. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

Worksheet B.4-1 Line Item Notes

0. Populated per result of Worksheet B.1-1
1. Populated per result of Worksheet B.1-1
2. User Input
3. User Input
4. User Input
5. User Input, use a value of zero if gravel does not cover entire bottom
6. User Input from Worksheet D.5-1 of BMP Design Manual.
7. Minimum between Line 1 or [Line 2 x (Line 6/12) x 6]
8. Default = 0.40 for Infiltration-Only BMPs
9. Default = 0.40
10. [Line 3 + (Line 4 x Line 8) + (Line 5 x Line 9)]
11. [Line 3 / Line 6]. Must be less than 96 hours for vector control.
12. [Line 10 / Line 6] + 6.0. Must be between 6 and 120 hours.
13. [Line 2 x (Line 10/12) + Line 7]
14. [Line 13/Line 1]. Maximum of 3.00
15. Look up value from Retention Percent Capture Curves and divide by 0.80. Maximum result of 1.00.
16. [Line 1 x Line 15] - Line 1

Worksheet B.4-2: Sizing Bioretention BMPs

Category	#	Description	Value	Units
BMP Inputs	0	Drainage Basin ID or Name		unitless
	1	Design Capture Volume Tributary to BMP		cubic-feet
	2	Provided Bioretention Surface Area		sq-ft
	3	Provided Surface Ponding Depth		inches
	4	Provided Soil Media Thickness		inches
	5	Provided Gravel Storage Thickness		inches
	6	Native Soil Infiltration Rate		in/hr
Retention Calculations	7	Volume Infiltrated Over 6 Hour Storm		cubic-feet
	8	Soil Media Pore Space	0.30	unitless
	9	Gravel Pore Space	0.40	unitless
	10	Effective Depth of Retention Storage		inches
	11	Drawdown Time for Surface Ponding (Post-Storm)		hours
	12	Drawdown Time for Entire Bioretention Basin (Including 6 Hour Storm)		hours
	13	Volume Retained by BMP		cubic-feet
	14	Fraction of DCV Retained		ratio
	15	Percentage of Performance Requirement Satisfied		ratio
Result	16	**Deficit of Effectively Treated Stormwater**		cubic-feet

Worksheet B.4-2 General Notes:

A. Applicants may use this worksheet to size Bioretention BMPs (INF-2) Applicants must provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Notes corresponding with each line item are provided below. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

Worksheet B.4-2 Line Item Notes

0. User Input from stormwater plans.
1. Populated per result of Worksheet B.1-1
2. User Input
3. User Input
4. User Input, 18 inches minimum
5. User Input, use a value of zero if gravel does not cover entire bottom
6. User Input from Worksheet D.5-1 of BMP Design Manual.
7. Minimum of Line 1 or [Line 2 x (Line 6/12) x 6]
8. Default = 0.30 for Retention-Only BMPs
9. Default = 0.40
10. [Line 3 + (Line 4 x Line 8) + (Line 5 x Line 9)]
11. [Line 3 / Line 6]. Must be less than 24 hours for plant health.
12. [Line 10 / Line 6] + 6.0. Must be between 6 and 120 hours.
13. [Line 2 x (Line 10/12) + Line 7]
14. [Line 13/Line 1]. Maximum of 3.00
15. Look up value from Retention Percent Capture Curves and divide by 0.80. Maximum result of 1.00.
16. [Line 1 x Line 15] - Line 1

B.4.1 Percent Capture Method

This section describes the recommended method of sizing volume-based BMPs to achieve the 80 percent capture performance criterion. This method has a number of potential applications for sizing BMPs, including:

- Use this method when a BMP can draw down in less than 36 hours and it is desired to demonstrate that 80 percent capture can be achieved using a BMP volume smaller than the DCV.
- Use this method to determine how much volume (greater than the DCV) must be provided to achieve 80 percent capture when the drawdown time of the BMP exceeds 36 hours.
- Use this method to determine how much volume should be provided to achieve 80 percent capture when upstream BMP(s) have achieved some capture, but have not achieved 80 percent capture.

By nature, the percent capture method is an iterative process that requires some initial assumptions about BMP design parameters and subsequent confirmation that these assumptions are valid. For example, sizing calculations depend on the assumed drawdown time, which depends on BMP depth, which may in turn need to be adjusted to provide the required volume within the allowable footprint. In general, the selection of reasonable BMP design parameters in the first iteration will result in minimal required additional iterations. Figure B.4-1 presents the nomograph for use in sizing retention BMPs in San Diego County.

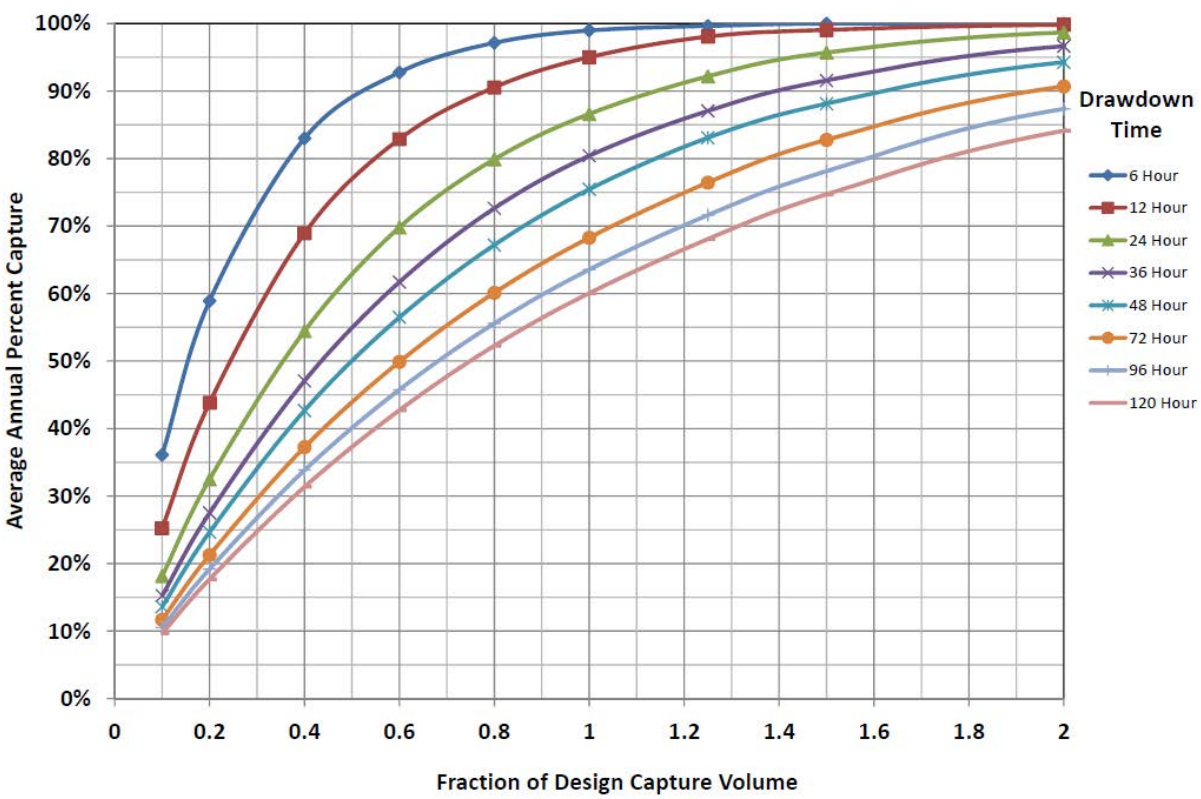


Figure B.4-1: Percent Capture Nomograph

B.4.1.1 Stepwise Instructions for sizing a single BMP:

1. Estimate the drawdown time of the proposed BMP by estimating the design infiltration rate (Worksheet D.5-1) and accounting for BMP dimensions/geometry. See the applicable BMP Fact Sheet for specific guidance on how to convert BMP geometry to estimated drawdown time.
2. Using the estimated drawdown time and the nomograph from Figure B.4-1 locate where the line corresponding to the estimated drawdown time intersects with 80 percent capture. Pivot to the X axis and read the fraction of the DCV that needs to be provided in the BMP to achieve this level of capture.
3. Calculate the DCV using Worksheet B.2-1.
4. Multiply the result of Step 2 by the DCV (Step 3). This is the required BMP design volume.
5. Design the BMP to retain the required volume, and confirm that the drawdown time is no more than 25 percent greater than estimated in Step 1. If the computed drawdown time is greater than 125 percent of the estimated drawdown, then return to Step 1 and revise the initial drawdown time assumption.

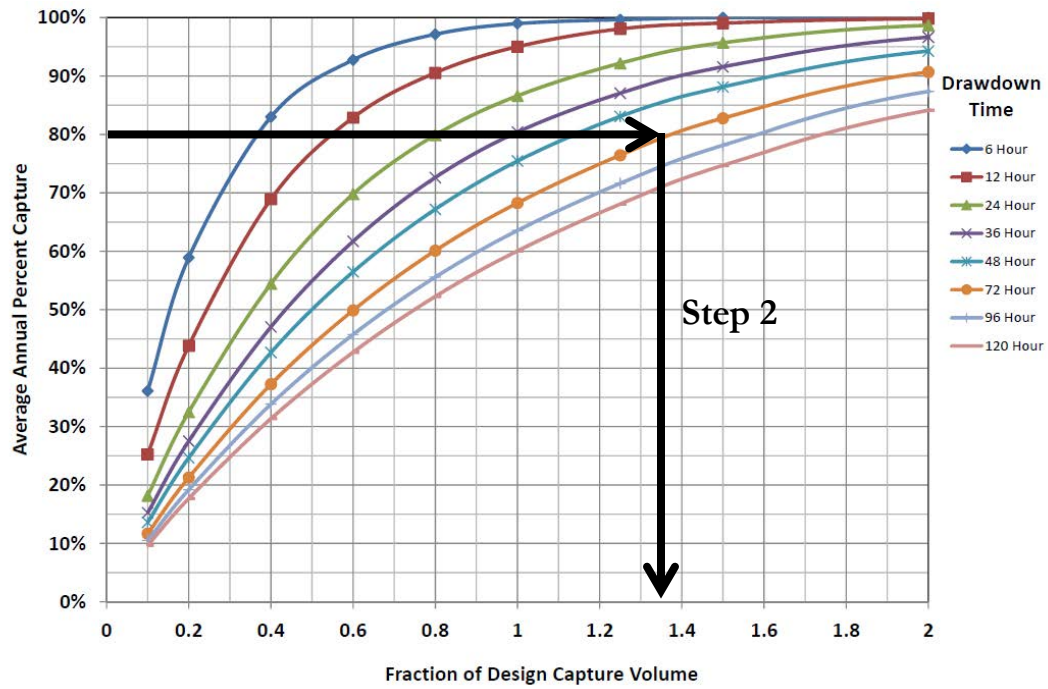
See the respective BMP facts sheets for BMP-specific instructions for the calculation of volume and drawdown time. The above method can also be used to size and/or evaluate the performance of other retention BMPs (evapotranspiration, harvest and use) that have a drawdown rate that can be approximated as constant throughout the year or over the wet season. In order to use this method for other retention BMPs, drawdown time in Step 1 will need to be evaluated using an applicable method for the type of BMP selected. After completing Step 1 continue to Step 2 listed above.

Example B.4.1.1 Percent Capture Method for Sizing a Single BMP:

Given:
• Estimated drawdown time: 72 Hours • DCV: 3000 ft^3
Required:
• Determine the volume required to achieve 80 percent capture.
Solution:
1. Estimated drawdown time = 72 Hours 2. Fraction of DCV required = 1.35 3. DCV = 3000 ft^3 (Given for this example; To be estimated using Worksheet B.2-1) 4. Required BMP volume = 1.35 x 3000 = 4050 ft^3 5. Design BMP and confirm drawdown Time is $\leq$ 90 Hours (72 Hours +25%)

Example B.4.1.1 Continued:

Graphical Operations Supporting Solution:



Percent Capture Nomograph

B.4.1.2 Stepwise Instructions for sizing BMPs in series:

For projects where BMPs in series have to be implemented to meet the performance standard the following stepwise procedure must be used to size the downstream BMP to achieve the 80 percent capture performance criterion:

1. Using the upstream BMP parameters (volume and drawdown time) estimate the average annual capture efficiency achieved by the upstream BMP using the nomograph.
2. Estimate the drawdown time of the proposed downstream BMP by estimating the design infiltration rate (Worksheet D.5-1) and accounting for BMP dimensions/geometry. See the applicable BMP Fact Sheet for specific guidance on how to convert BMP geometry to estimated drawdown time. Use the nomograph and locate where the line corresponding to the estimated drawdown time intersects with 80 percent capture. Pivot to the horizontal axis and read the fraction of the DCV that needs to be provided in the BMP. This is referred to as X_1.
3. Trace a horizontal line on the nomograph using the capture efficiency of the upstream BMP estimated in Step 1. Find where the line traced intersects with the drawdown time of the downstream BMP (Step 2). Pivot and read down to the horizontal axis to yield the fraction of the DCV already provided by the upstream BMP. This is referred to as X_2.

4. Subtract X_2 (Step 3) from X_1 (Step 2) to determine the fraction of the design volume that must be provided in the downstream BMP to achieve 80 percent capture to meet the performance standard.
5. Multiply the result of Step 4 by the DCV. This is the required downstream BMP design volume.
6. Design the BMP to retain the required volume, and confirm that the drawdown time is no more than 25 percent greater than estimated in Step 2. If the computed drawdown time is greater than 125 percent of the estimated drawdown, then return to Step 2 and revise the initial drawdown time assumption.

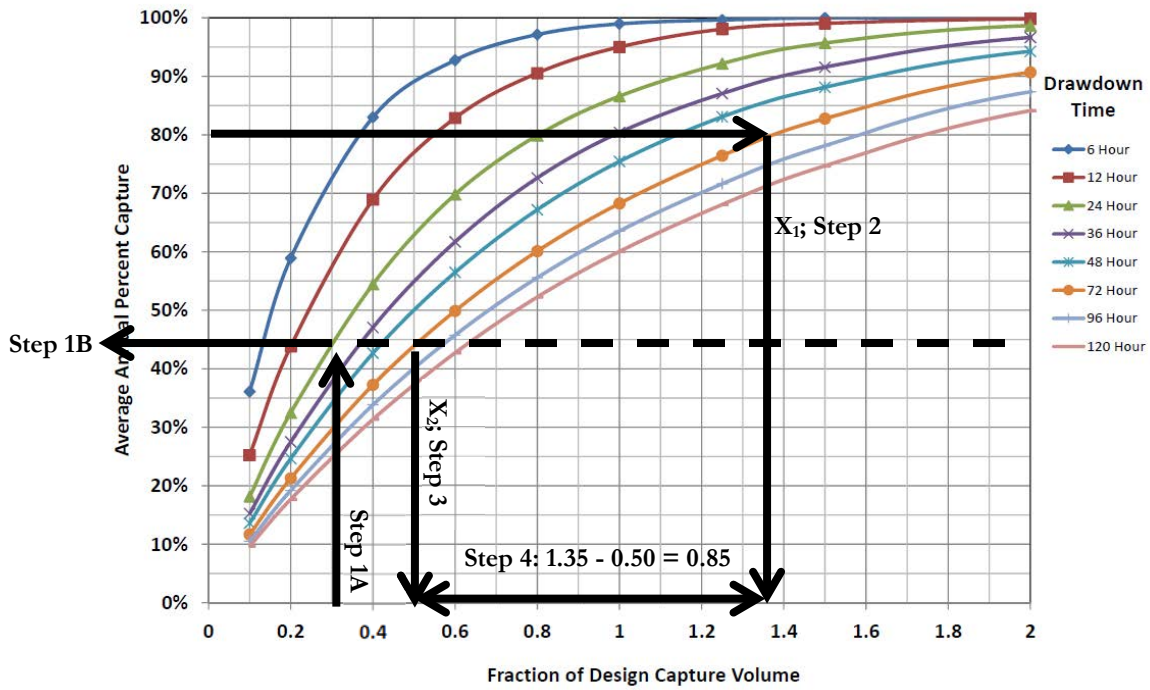
See the respective BMP facts sheets for BMP-specific instructions for the calculation of volume and drawdown time.

Example B.4.1.2 Percent Capture Method for Sizing BMPs in Series:

Given:
• Estimated drawdown time for downstream BMP: 72 Hours • DCV for the area draining to the BMP: 3000 ft^3 • Upstream BMP volume: 900 ft^3 • Upstream BMP drawdown time: 24 Hours
Required:
• Determine the volume required in the downstream BMP to achieve 80 percent capture.
Solution:
1. Step 1A: Upstream BMP Capture Ratio = 900/3000 = 0.3; Step 1B: Average annual capture efficiency achieved by upstream BMP = 44% 2. Downstream BMP drawdown = 72 hours; Fraction of DCV required to achieve 80% capture = 1.35 3. Locate intersection of design capture efficiency and drawdown time for upstream BMP (See Graph); Fraction of DCV already provided (X_2) = 0.50 (See Graph) 4. Fraction of DCV Required by downstream BMP = 1.35-0.50 = 0.85 5. DCV (given) = 3000 ft^3 ; Required downstream BMP volume = 3000 ft^3 x 0.85 = 2,550 ft^3 6. Design BMP and confirm drawdown Time is $\leq$ 90 Hours (72 Hours +25%)

Example B.4.1.2 Continued:

Graphical Operations Supporting Solution:



Percent Capture Nomograph

B.4.2 Technical Basis for Equivalent Sizing Methods

Storm water BMPs can be conceptualized as having a storage volume and a treatment rate, in various proportions. Both are important in the long-term performance of the BMP under a range of actual storm patterns, depths, and inter-event times. Long-term performance is measured by the operation of a BMP over the course of multiple years, and provides a more complete metric than the performance of a BMP during a single event, which does not take into account antecedent conditions, including multiple storms arriving in short timeframes. A BMP that draws down more quickly would be expected to capture a greater fraction of overall runoff (i.e., long-term runoff) than an identically sized BMP that draws down more slowly. This is because storage is made available more quickly, so subsequent storms are more likely to be captured by the BMP. In contrast a BMP with a long drawdown time would stay mostly full, after initial filling, during periods of sequential storms. The volume in the BMP that draws down more quickly is more "valuable" in terms of long term performance than the volume in the one that draws down more slowly. The MS4 permit definition of the DCV does not specify a drawdown time, therefore the definition is not a complete indicator of a BMP's level of performance. An accompanying performance-based expression of the

BMP sizing standard is essential to ensure uniformity of performance across a broad range of BMPs and helps prevents BMP designs from being used that would not be effective.

An evaluation of the relationships between BMP design parameters and expected long term capture efficiency has been conducted to address the needs identified above. Relationships have been developed through a simplified continuous simulation analysis of precipitation, runoff, and routing, that relate BMP design volume and storage recovery rate (i.e., drawdown time) to an estimated long term level of performance using United States Environmental Protection Agency (USEPA) SWMM and parameters listed in Appendix G for Lake Wohlford, Lindbergh, and Oceanside rain gages. Comparison of the relationships developed using the three gages indicated that the differences in relative capture estimates are within the uncertainties in factors used to develop the relationships. For example, the estimated average annual capture for the BMP sized for the DCV and 36 hour drawdown using Lake Wohlford, Lindbergh, and Oceanside are 80%, 76% and 83% respectively. In an effort to reduce the number of curves that are made available, relationships developed using Lake Wohlford are included in this manual for use in the whole San Diego County region.

Figure B.4-1 demonstrated that a BMP sized for the runoff volume from the 85th percentile, 24-hour storm event (i.e., the DCV), which draws down in 36 hours is capable of managing approximately 80 percent of the average annual. There is long precedent for 80 percent capture of average annual runoff as approximately the point at which larger BMPs provide decreasing capture efficiency benefit (also known as the "knee of the curve") for BMP sizing. The characteristic shape of the plot of capture efficiency versus storage volume in Figure B.4-1 illustrates this concept.

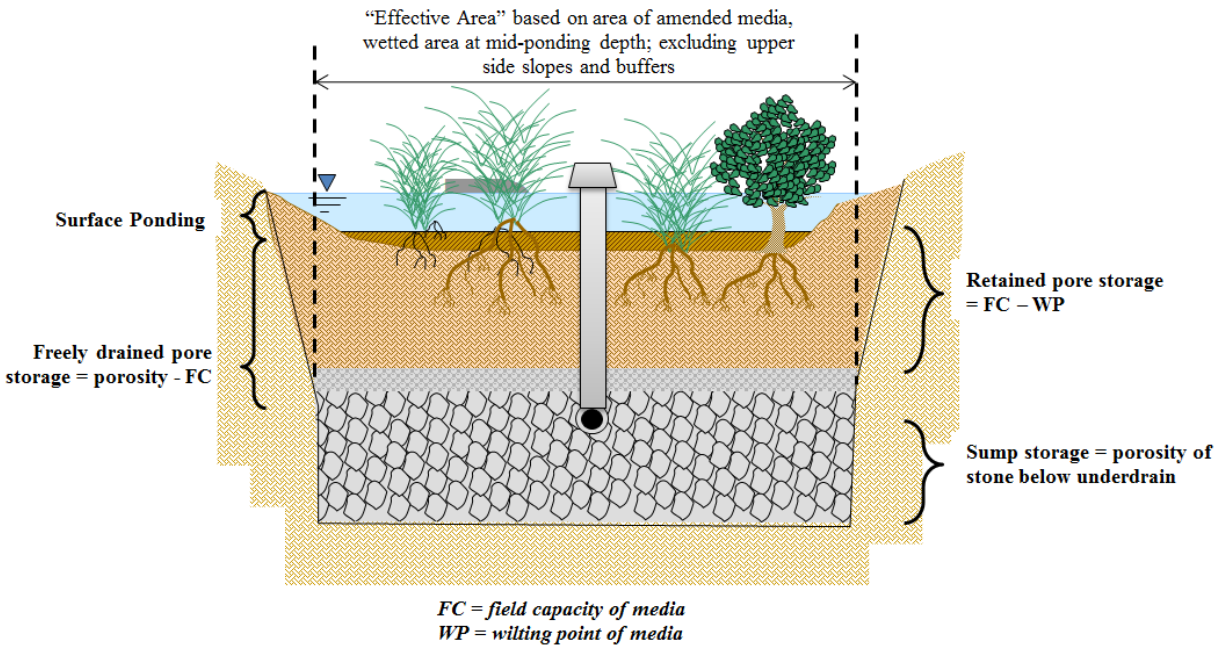
As such, this equivalency (between DCV draw down in 36-hours and 80 percent capture) has been utilized to provide a common currency between volume-based BMPs with a wide range of drawdown rates. This approach allows flexibility in the design of BMPs while ensuring consistent performance.

B.5 Biofiltration BMPs

Biofiltration BMPs must be sized by one of the following sizing methods:

Option 1: Treat 1.5 times the portion of the DCV not reliably retained onsite, OR

Option 2: Treat 1.0 times the portion of the DCV not reliably retained onsite; and additionally check that the system has a total static (i.e., non-routed) storage volume, including pore spaces and pre-filter detention volume, equal to at least 0.75 times the portion of the DCV not reliably retained onsite.



Explanation of Biofiltration Volume Compartments for Sizing Purposes

When using sizing option 1 a routing period of 6 hours is allowed. The routing period was estimated based on 50th percentile storm duration for storms similar to 85th percentile rainfall depth. It was estimated based on inspection of continuous rainfall data from Lake Wohlford, Lindbergh and Oceanside rain gages.

Worksheet B.5-1 on the following page provides a sizing method for biofiltration BMPs that do not incorporate any elements of retention. Alternatively Worksheet B.5-2 provides a sizing method for partial retention BMPs that incorporate elements of both retention and biofiltration. These worksheets require basic inputs for tributary and BMP characteristics and provide standardized calculations to determine associated drawdown times, biofiltration volumes, infiltration volumes, and BMP effectiveness. The result of these worksheets is a "deficit of effectively treated storm water". BMPs that are in compliance with performance standards have a deficit of zero. BMPs with a negative deficit value are not in compliance with performance standards and must be redesigned or augmented with flow-thru treatment and mitigated for through an offsite alternative compliance project.

Worksheet B.5-1: Sizing Biofiltration BMPs

Category	#	Description	Value	Units
BMP Inputs	0	Drainage Basin ID or Name		unitless
	1	Effective Tributary Area		sq-ft
	2	Minimum Biofiltration Footprint Sizing Factor		ratio
	3	Design Capture Volume Tributary to BMP		cubic-feet
	4	Provided Biofiltration Surface Area		sq-ft
	5	Provided Surface Ponding Depth		inches
	6	Provided Soil Media Thickness		inches
	7	Provided Gravel Storage Thickness		inches
	8	Hydromodification Orifice Diameter of Underdrain		inches
Biofiltration Calculations	9	Max Hydromod Flow Rate through Underdrain		CFS
	10	Max Soil Filtration Rate Allowed by Underdrain Orifice		in/hr
	11	Soil Media Filtration Rate	5.00	in/hr
	12	Soil Media Filtration Rate to be used for Sizing		in/hr
	13	Depth Biofiltered Over 6 Hour Storm		inches
	14	Soil Media Pore Space	0.30	unitless
	15	Gravel Pore Space	0.40	unitless
	16	Effective Depth of Biofiltration Storage		inches
	17	Drawdown Time for Surface Ponding		hours
	18	Drawdown Time for Entire Biofiltration Basin		hours
	19	Total Depth Biofiltered		inches
	20	Option 1 - Biofilter 1.50 DCV: Target Volume		cubic-feet
	21	Option 1 - Provided Biofiltration Volume		cubic-feet
	22	Option 2 - Store 0.75 DCV: Target Volume		cubic-feet
	23	Option 2 - Provided Storage Volume		cubic-feet
	24	Percentage of Performance Requirement Satisfied		ratio
Result	25	**Deficit of Effectively Treated Stormwater**		cubic-feet

Worksheet B.5-1 General Notes:

A. Applicants may use this worksheet to size Lined Biofiltration BMPs (BF-1). Applicants must provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Notes corresponding with each line item are provided below. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

Worksheet B.5-1 Line Item Notes:

0. User Input from stormwater plans
1. Populated per result of Worksheet B.1-1
2. Populated per result of Worksheet B.5-3 Default is 0.030.
3. Populated per result of Worksheet B.1-1
4. User Input, must satisfy minimum sizing factor specified in Line 2.
5. User Input
6. User Input, 18 inches minimum
7. User Input, use a value of zero if gravel does not cover entire bottom.
8. User Input, Select n/a if no hydromodification flow control is provided
9. If flow controls are provided, calculate per orifice equation: $Q=CA\sqrt{2gh}$
10. If flow controls are provided, calculate as [(Line 9 x 12 x 3600)/Line 4]
11. Default = 5.00
12. Minimum of Line 10 or Line 11
13. [Line 12 x 6 Hours]
14. Default = 0.30 for Biofiltration-Only BMPs
15. Default = 0.40
16. [Line 5 + (Line 6 x Line 14) + (Line 7 x Line 15)]
17. [Line 5 / Line 12]
18. [Line 16 / Line 12]
19. [Line 13 + Line 16]
20. [1.50 x Line 3]
21. [Minimum of Line 20 or [(Line 19/12) x Line 4]]
22. [0.75 x Line 3]
23 [Minimum of Line 22 or [(Line 16/12) x Line 4]]
24. [Maximum of (Line 21/Line 20) or (Line 23/Line 22)]
25. [Line 3 x Line 24] - Line 3

Worksheet B.5-2: Sizing Partial Retention BMPs

Category	#	Description	Value	Units
BMP Inputs	0	Drainage Basin ID or Name		sq-ft
	1	Effective Tributary Area		sq-ft
	2	Minimum Biofiltration Footprint Sizing Factor		ratio
	3	Design Capture Volume Tributary to BMP		cubic-feet
	4	Provided Partial Retention BMP Surface Area		sq-ft
	5	Provided Surface Ponding Depth		inches
	6	Provided Soil Media Thickness		inches
	7	Provided Depth of Gravel Above Underdrain Invert		inches
	8	Hydromodification Orifice Diameter of Underdrain		inches
	9	Provided Depth of Gravel Below the Underdrain		inches
	10	Native Soil Infiltration Rate		in/hr
Retention Calculations	11	Volume Infiltrated Over 6 Hour Storm		cubic-feet
	12	Soil Media Pore Space Available for Retention	0.10	unitless
	13	Gravel Pore Space Available for Retention	0.40	unitless
	14	Effective Retention Depth		inches
	15	Calculated Drawdown for Gravel Below Underdrain (Including 6 Hr Storm)		hours
	16	Volume Retained by BMP		cubic-feet
	17	Fraction of DCV Retained		ratio
	18	Portion of Retention Performance Standard Satisfied		ratio
	19	Equivalent Fraction of DCV Retained with 36-hr Drawdown		ratio
	20	Design Capture Volume Remaining for Biofiltration		cubic-feet
Biofiltration Calculations	21	Max Hydromod Flow Rate through Underdrain		CFS
	22	Max Soil Filtration Rate Allowed by Underdrain Orifice		in/hr
	23	Soil Media Filtration Rate per Specifications	5.00	in/hr
	24	Soil Media Filtration Rate to be used for Sizing		in/hr
	25	Depth Biofiltered Over 6 Hour Storm		inches
	26	Soil Media Pore Space Available for Biofiltration	0.20	unitless
	27	Effective Depth of Biofiltration Storage		inches
	28	Drawdown Time for Surface Ponding		hours
	29	Drawdown Time for Effective Biofiltration Depth		hours
	30	Total Depth Biofiltered		inches
	31	Option 1 - Biofilter 1.50 DCV: Target Volume		cubic-feet
	32	Option 1 - Provided Biofiltration Volume		cubic-feet
	33	Option 2 - Store 0.75 DCV: Target Volume		cubic-feet
	34	Option 2 - Provided Storage Volume		cubic-feet
	35	Portion of Biofiltration Performance Standard Satisfied		ratio
Result	36	Overall Portion of Performance Standard Satisfied		ratio
	37	**Deficit of Effectively Treated Stormwater**		cubic-feet

Worksheet B.5-2 General Notes:

A. Applicants may use this worksheet to size Partial Retention BMPs (PR-1). Applicants must provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Notes corresponding with each line item are provided on the following page. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

Worksheet B.5-2 Line Item Notes:

0. User Input from stormwater plans
1. Populated per result of Worksheet B.1-1
2. Populated per result of Worksheet B.5-3. Default is 0.030.
3. Populated per result of Worksheet B.1-1
4. User Input, must satisfy minimum sizing factor specified in Line 2.
5. User Input
6. User Input, 18 inches minimum
7. User Input, use a value of zero if gravel does not cover entire bottom.
8. User Input, select n/a if no hydromodification flow control is provided
9. User Input
10. User Input from Worksheet D.5-1
11. Minimum of Line 3 or [Line 4 x (Line 10/12) x 6.00]
12. Default = 0.10 for Retention Portion of Partial Retention BMP
13. Default = 0.40
14. (Line 6 x Line 12)+ (Line 9 x Line 13)
15. [(Line 9 x Line 13) / Line 10] + 6.0. If this equals 6 (ET only) use 36 hours.
16. [(Line 14/12) x Line 4] + Line 11
17. [Line 16/Line 3]
18. Look up value from Retention Percent Capture Curves, Maximum of 1.00.
19. Look up value from Retention Provided Capture Curves, Maximum of 1.00.
20. [Line 3 x (1.00 - Line 19)]
21. If flow controls are provided, calculate per orifice equation: $Q=CA\sqrt{2gh}$
22. If flow controls are provided, calculate as [(Line 21 x 12 x 3600)/Line 4]
23. Default = 5.00
24. Minimum of Line 22 or Line 23
25. [Line 24 x 6]
26. Default = 0.20 for Biofiltration Portion of Partial Retention BMP
27. [Line 5 + (Line 6 x Line 26) + (Line 7 x Line 13)]
28. Minimum of [Line 5/5.00] or [Line 5/(Line 10+ Line 24)]
29. Minimum of [Line 27/5.00] or [Line 27/(Line 10 + Line 24)]
30. [Line 25 + Line 27]
31. [1.50 x Line 20]
32. [Minimum of Line 31 or [(Line 30/12) x Line 4]]
33. [0.75 x Line 20]
34. [Minimum of Line 33 or [(Line 27/12) x Line 3]]
35. [Maximum of (Line 32/Line 31) or (Line 34/Line 33)]
36. [Line 18 + Line 35]. Maximum of 1.00.
37. [Line 36 x Line 3] - Line 3

B.5.1 Basis for Minimum Sizing Factor for Biofiltration BMPs

B.5.1.1 Introduction

MS4 Permit Provision E.3.c.(1)(a)(i)

The MS4 Permit describes conceptual performance goals for biofiltration BMPs and specifies numeric criteria for sizing biofiltration BMPs (See Section 2.2.1 of this Manual).

However, the MS4 Permit does not define a specific footprint sizing factor or design profile that must be provided for the BMP to be considered "biofiltration." Rather, the MS4 Permit specifies (Footnote 25):

> **As part of the Copermittee's update to its BMP Design Manual, pursuant to Provision E.3.d, the Copermittee must provide guidance for hydraulic loading rates and other biofiltration design criteria necessary to maximize storm water retention and pollutant removal.**

To meet this provision, this manual includes specific criteria for design of biofiltration BMPs. Among other criteria, a minimum footprint sizing factor of 3 percent (BMP footprint area as percent of contributing area times adjusted runoff factor) is specified. The purpose of this section is to provide the technical rationale for this 3 percent minimum sizing factor.

B.5.1.2 Conceptual Need for Minimum Sizing Factor

Under the 2011 Model SUSMP, a sizing factor of 4 percent was used for sizing biofiltration BMPs. This value was derived based on the goal of treating the runoff from a 0.2 inch per hour uniform precipitation intensity at a constant media flow rate of 5 inches per hour. While this method was simple, it was considered to be conservative as it did not account for significant transient storage present in biofiltration BMPs (i.e., volume in surface storage and subsurface storage that would need to fill before overflow occurred). Under this manual, biofiltration BMPs will typically provide subsurface storage to promote infiltration losses; therefore typical BMP profiles will tend to be somewhat deeper than those provided under the 2011 Model SUSMP. A deeper profile will tend to provide more transient storage and allow smaller footprint sizing factors while still providing similar or better treatment capacity and pollutant removal. Therefore a reduction in the minimum sizing factor from the factor used in the 2011 Model SUSMP is supportable. However, as footprint decreases, issues related to potential performance, operations, and/or maintenance can increase for a number of reasons:

1) As the surface area of the media bed decreases, the sediment loading per unit area increases, increasing the risk of clogging. While vigorous plant growth can help maintain permeability

of soil, there is a conceptual limit above which plants may not be able to mitigate for the sediment loading. Scientific knowledge is not conclusive in this area.

2) With smaller surface areas and greater potential for clogging, water may be more likely to bypass the system via overflow before filling up the profile of the BMP.
3) As the footprint of the system decreases, the amount of water that can be infiltrated from subsurface storage layers and evapotranspire from plants and soils tends to decrease.
4) With smaller sizing factors, the hydraulic loading per unit area increases, potentially reducing the average contact time of water in the soil media and diminishing treatment performance.

The MS4 Permit requires that volume and pollutant retention be maximized. Therefore, a minimum sizing factor was determined to be needed. This minimum sizing factor does not replace the need to conduct sizing calculations as described in this manual; rather it establishes a lower limit on required size of biofiltration BMPs as the last step in these calculations. Additionally, it does not apply to alternative biofiltration designs that utilize the checklist in Appendix F (Biofiltration Standard and Checklist). Acceptable alternative designs (such as proprietary systems meeting Appendix F criteria) typically include design features intended to allow acceptable performance with a smaller footprint and have undergone field scale testing to evaluate performance and required O&M frequency.

B.5.1.3 Lines of Evidence to Select Minimum Sizing Factor

Three primary lines of evidence were used to select the minimum sizing factor of 3 percent (BMP footprint area as percent of contributing area times adjusted runoff factor) in this manual:

1. Typical design calculations.
2. Sediment clogging calculations.

These lines of evidence and associated findings are explained below.

Typical Design Calculations

A range of BMP profiles were evaluated for different design rainfall depths and soil conditions. Worksheet B.5-1 was used for each case to compute the required footprint sizing factor. For these calculations, the amount of water filtered during the storm event was determined based on a media filtration rate of 5 inches per hour and a routing time of 6 hours. These input assumptions are considered to be well-supported and consistent with the intent of the MS4 Permit. These calculations generally yielded footprint sizing factors between 1.5 and 4.9 percent. In the interest of establishing a uniform County-wide minimum sizing factor, a 3 percent sizing factor was selected from this range, consistent with other lines of evidence.

Sediment Clogging Calculations

As sediment accumulates in a filter, the permeability of the filter tends to decline. The lifespan of the filter bed can be estimated by determining the rate of sediment loading per unit area of the filter bed. To determine the media bed surface area sizing factor needed to provide a target lifespan, simple sediment loading calculations were conducted based on typical urban conditions. The inputs and

results of this calculation are summarized in Table B.5-1.

Table B.5-1: Inputs and Results of Clogging Calculation

Parameter	Value	Source
Representative TSS Event Mean Concentration, mg/L	100	Approximate average of San Diego Land Use Event Mean Concentrations from San Diego River and San Luis Rey River WQIP
Runoff Coefficient of Impervious Surface	0.90	Table B.1-1
Runoff Coefficient of Pervious Surface	0.10	Table B.1-1 for landscape areas
Imperviousness	40% to 90%	Planning level assumption, covers typical range of single family to commercial land uses
Average Annual Precipitation, inches	11 to 13	Typical range for much of urbanized San Diego County
Load to Initial Maintenance, kg/m^2	10	Pitt, R. and S. Clark, 2010. Evaluation of Biofiltration Media for Engineered Natural Treatment Systems.
Allowable period to initial clogging, yr	10	Planning-level assumption
Estimated BMP Footprint Needed for 10-Year Design Life	2.8 to 3.3%	Calculated

This analysis suggests that a 3 percent sizing factor, coupled with sediment source controls and careful system design, should provide reasonable protection against premature clogging. However, there is substantial uncertainty in sediment loading and the actual load to clog that will be observed under field conditions in the San Diego climate. Additionally this analysis did not account for the effect of plants on maintaining soil permeability. Therefore this line of evidence should be considered provisional, subject to refinement based on field scale experience. As field scale experience is gained about the lifespan of biofiltration BMPs in San Diego and the mitigating effects of plants on long term clogging, it may be possible to justify lower factors of safety and therefore smaller design sizes in some cases. If a longer lifespan is desired and/or greater sediment load is expected, then a larger sizing factor may be justified.

B.5.1.4 Discussion

Generally, the purpose of a minimum sizing factor is to help improve the performance and reliability of standard biofiltration systems and limit the use of sizing methods and assumptions that may lead to designs that are less consistent with the intent of the MS4 Permit.

Ultimately, this factor is a surrogate for a variety of design considerations, including clogging and associated hydraulic capacity, volume reduction potential, and treatment contact time. A prudent design approach should consider each of these factors on a project-specific basis and identify whether site conditions warrant a larger or smaller factor. For example a system treating only rooftop runoff in an area without any allowable infiltration may have negligible clogging risk and negligible volume reduction potential – a smaller sizing factor may not substantially reduce

performance in either of these areas. Alternatively, for a site with high sediment load and limited pre-treatment potential, a larger sizing factor may be warranted to help mitigate potential clogging risks. County staff has discretion to accept alternative sizing factor(s) based on project-specific or jurisdiction-specific considerations. Additionally, the recommended minimum sizing factor may change over time as more experience with biofiltration is obtained.

Worksheet B.5-3 on the following page must be used to support a request for an alternative minimum footprint sizing factor. Based on a review of the submitted worksheet and supporting documentation, the use of a smaller footprint sizing factor may be approved at the discretion of County staff..

This worksheet includes the following general steps to calculate the minimum footprint sizing factor:

- Select a "load to clog" that is representative of the type of BMP proposed
- Select a target life span (i.e., frequency of major maintenance) that is acceptable to County staff. A default value of 10 years is recommended.
- Compile information about the DMA from other parts of the SWQMP development process.
- Determine the event mean concentration (EMC) of TSS that is appropriate for the DMA
- Perform calculations to determine the minimum footprint to provide the target lifespan.

Worksheet B.5-3: Alternate Minimum Biofiltration Footprint Ratio

Category	#	Description	Value	Units
Drainage Basin Inputs (Optional)	0	Drainage Basin ID or Name		unitless
	1	Total Tributary Area		sq-ft
	2	Final Adjusted Runoff Factor		unitless
	3	Average Annual Precipitation		inches
	4	Load to Clog (default =2.0)		lb/sq-ft
	5	Allowable Period to Accumulate Clogging Load (default =10)		years
	6	Pretreatment Measures Included?		yes/no
	7	Commercial: TSS=128 mg/L, C= 0.80		sq-ft
	8	Education: TSS=132 mg/L, C= 0.50		sq-ft
	9	Industrial: TSS=125 mg/L, C= 0.90		sq-ft
	10	Low Traffic Areas: TSS=50 mg/L, C= 0.50		sq-ft
	11	Multi-Family Residential: TSS=40 mg/L, C= 0.60		sq-ft
	12	Roof Areas: TSS=14 mg/L, C= 0.90		sq-ft
	13	Single Family Residential: TSS=123 mg/L, C= 0.40		sq-ft
	14	Transportation: TSS=78 mg/L, C= 0.90		sq-ft
	15	Vacant/Open Space: TSS=216 mg/L, C= 0.10		sq-ft
Minimum Footprint Calculations	16	Effective-Area Based on Specified Land Use Coefficients		sq-ft
	17	Average TSS Concentration for Tributary		mg/L
	18	Effective Tributary Area		sq-ft
	19	Average Annual Runoff		cubic-feet
	20	Average Annual TSS Load		lb/yr
	21	Average Annual TSS Load After Pretreatment Measures		lb/yr
Result	22	Minimum Allowable Biofiltration Footprint Ratio		ratio

Worksheet B.5-3 General Notes:

A. Applicants may use this worksheet to calculate Alternate Minimum Biofiltration Footprint Ratio. Applicants must provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Notes corresponding with each line item are provided on the following page. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

Worksheet B.5-3 Line Item Notes

0. User Input from stormwater plans
1. Automatically populated per user input on Worksheet B.1-1
2. Automatically populated per user input on Worksheet B.1-1
3. User Input
4. User Input, Default=2.0. See Table B.5-3 for guidance
5. User Input, Default=10. Provide maintenance justification if alternate value is used.
6. User Input, Default=No
7. User Input
8. User Input
9. User Input
10. User Input
11. User Input
12. User Input
13. User Input
14. User Input
15. User Input
16. ∑Lines 7-15 Area x Runoff Coefficient
17. [(∑Lines 7-15 Area x Runoff Coefficient x TSS Concentration) / Line 16]
18. Line 1 x Line 2
19. [(Line 3/12) x Line 18
20. Line 17 x 0.000062428 x Line 19
21. If Line 6=Yes, then Line 20 x 0.75. Otherwise Line 20
22. [(Line 21 x Line 5) / (Line 4 x Line 28)]. Maximum value of 0.030 is the default footprint ratio.

Table B.5-2 Typical land use total suspended solids (TSS) event mean concentration (EMC) values.

Land Use	TSS EMC[10], mg/L
Single Family Residential	123
Commercial	128
Industrial	125
Education (Municipal)	132
Transportation[11]	78
Multi-family Residential	40
Roof Runoff[12]	14
Low Traffic Areas[13]	50
Open Space	216

Table B.5-3 Guidance for Selecting Load to Clog (L_C)

BMP Configuration	Load to Clog, L_c, lb/sq-ft
Baseline: Approximately 50 percent vegetative cover; typical fine sand and compost blend	2
Baseline + increase vegetative cover to at least 75 percent	3
Baseline + include coarser sand to increase initial permeability to 20 to 30 in/hr; control flowrate with outlet control	3
Baseline + increase vegetative cover and include more permeable media with outlet control, per above	4

References

Charters, F.J., Cochrane, T.A., and O'Sullivan, A.D., (2015). Particle Size Distribution Variance in Untreated Urban Runoff and its implication on treatment selection. Water Research, 85 (2015), pg. 337-345.

[10] EMCs are from SBPAT datasets for SLR and SDR Watersheds – Arithmetic Estimates of the Lognormal Summary Statistics for San Diego, unless otherwise noted.

[11] EMCs are based on Los Angeles region default SBPAT datasets due to lack of available San Diego data.

[12] Value represents the average first flush concentration for roof runoff (Charters et al., 2015).

[13] Davis and McCuen (2005)

Davis, A.P. and McCuen, R.H., (2005). Storm Water Management for Smart Growth. Springer Science & Business Media, pg. 155.

Maniquiz-Redillas, M.C., Geronimo, F.K.F, and Kim, L-H. Investigation on the Effectiveness of Pretreatment in Storm Water Management Technologies. Journal of Environmental Sciences, 26 (2014), pg. 1824-1830.

Pitt, R. and Clark, S.E., (2010). Evaluation of Biofiltration Media for Engineered Natural Treatment Systems. Geosyntec Consultants and The Boeing Company.

B.5.2 Sizing Biofiltration BMPs Downstream of a Storage Unit

B.5.2.1 Introduction

In some cases, incorporation of upstream storage units (e.g. cisterns) may be used to regulate the flows through a downstream biofiltration BMP.

This methodology is **not** applicable when the minimum footprint factor is governed based on the alternative minimum footprint sizing factor calculated using Worksheet B.5-3.

B.5.2.2 Sizing Calculation

Sizing calculations for the biofiltration footprint must demonstrate that one of two equivalent performance standards is met:

1. Use continuous simulation and demonstrate one of the following is met based on the infiltration condition identified in Chapter 5.4.2:
    a. **No infiltration condition**: The BMP or series of BMPs biofilters at least 92 percent of average annual (long term) runoff volume. This can be demonstrated through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in Appendix G, as acceptable to County staff. The 92 percent of average annual runoff treatment corresponds to the average capture achieved by implementing a BMP with 1.5 times the DCV and a drawdown time of 36 hours.
    b. **Partial infiltration condition**: The BMP or series of BMPs biofilters at least 92 percent of average annual (long term) runoff volume. This can be demonstrated through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in Appendix G, as acceptable to County staff.
2. Use the simple sizing method in Worksheet B.5-4. This worksheet was developed to satisfy the following two criteria as applicable:
    a. Greater than 92 percent of the average annual runoff volume from the storage unit is routed to the biofiltration BMP through the low flow orifice and the peak flow from the low flow orifice can instantaneously be filtered through the biofiltration media. If the outlet design includes orifices at different elevations and an overflow structure, only flows from the overflow structure should be excluded from the calculation

(both for 92 percent capture and for peak flow to the biofiltration BMP that needs to be instantaneously filtered), unless the flows from other orifices also bypass the biofiltration BMP, in which case flows from the orifices that bypass should also be excluded.

Table B.5-4 Storage required for different drawdown times

Drawdown Time (hours)	Storage requirement (below the overflow elevation, or below outlet elevation that bypass the biofiltration BMP)
12	0.85 DCV
24	1.25 DCV
36	1.50 DCV
48	1.80 DCV
72	2.20 DCV
96	2.60 DCV
120	2.80 DCV

For drawdown times that are outside the range of values presented in Table B.5-4 above the storage unit should be designed to discharge greater than 92% average annual capture to the downstream Biofiltration BMP.

Worksheet B.5-4: Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit

Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit		Worksheet B.5-4	
1	Area draining to the storage unit and biofiltration BMP		sq-ft
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	Effective impervious area draining to the storage unit and biofiltration BMP [Line 1 x Line 2]		sq-ft
4	Remaining DCV after implementing retention BMPs		cubic-feet
5	Infiltration rate from Worksheet D.5-1 if partial infiltration is feasible		ft/hr.
6	Media Thickness [1.5 feet minimum], also add mulch layer thickness to this line for sizing calculations		ft
7	Media filtration rate to be used for sizing (0.42 ft/hr. with no outlet control; if the filtration rate is controlled by the outlet use the outlet controlled rate)		ft/hr
8	Media retained pore storage	0.1	ft/ft
Storage Unit Requirement			
9	Drawdown time of the storage unit, minimum(from the elevation that bypasses the biofiltration BMP, overflow elevation)		hours
10	Storage required to achieve greater than 92 percent capture (see Table B.5-4)		fraction
11	Storage required in cubic feet (Line 4 x Line 10)		cubic-feet
12	Storage provided in the design, minimum(from the elevation that bypasses the biofiltration BMP, overflow elevation)		cubic-feet
13	Is Line 12 ≥ Line 11. If no increase storage provided until this criteria is met	☐ Yes	☐ No
Criteria 1: BMP Footprint Biofiltration Capacity			
14	Peak flow from the storage unit to the biofiltration BMP (using the elevation used to evaluate the percent capture)		cfs
15	Required biofiltration footprint [(3,600 x Line 14)/Line 7]		sq-ft
Criteria 2: Alternative Minimum Sizing Factor (Clogging)			
16	Alternative Minimum Footprint Sizing Factor [Worksheet B.5-3]		Fraction
17	Required biofiltration footprint [Line 3 x Line 16]		sq-ft
Optimized Biofiltration Footprint			
18	Optimized biofiltration footprint, maximum(Line 15, Line 17)		sq-ft

Note: Biofiltration BMP smaller than the alternative minimum footprint sizing (Line 17) is considered compact biofiltration BMP and may be allowed at the discretion of County staff if the BMP meets the requirements in Appendix F and Option 1 or Option 2 sizing in Worksheet B.5-1.

B.6 Flow-Thru Treatment Control BMPs (for use with Alternative Compliance)

The following methodology must be used for selecting and sizing onsite flow-thru treatment control BMPs. These BMPs are to be used only when the project is participating in an alternative compliance program. This methodology consists of three steps:

1) Determine the PDP most significant pollutants of concern (Appendix B.6.1).
2) Select a flow-thru treatment control BMP that treats the PDP most significant pollutants of concern and meets the pollutant control BMP treatment performance standard (Appendix B.6.2).
3) Size the selected flow-thru treatment control BMP (Appendix B.6.3).

B.6.1 PDP Most Significant Pollutants of Concern

The following steps must be followed to identify the PDP most significant pollutants of concern:

1) Compile the following information for the PDP and receiving water:
    a. Receiving water quality (including pollutants for which receiving waters are listed as impaired under the Clean Water Act section 303(d) List; refer to Section 1.9);
    b. Pollutants, stressors, and/or receiving water conditions that cause or contribute to the highest priority water quality conditions identified in the WQIP (refer to Section 1.9);
    c. Land use type(s) proposed by the PDP and the storm water pollutants associated with the PDP land use(s) (see Table B.6–1).
2) From the list of pollutants identified in Step 1 identify the most significant PDP pollutants of concern. A PDP could have multiple most significant pollutants of concerns and must include the highest priority water quality condition identified in the watershed WQIP and pollutants anticipated to be present onsite/generated from land use.

TABLE B.6–1: Anticipated and Potential Pollutants Generated by Land Use Type

Priority Project Categories	General Pollutant Categories								
	Sediment	Nutrients	Heavy Metals	Organic Compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticides
Detached Residential Development	X	X			X	X	X	X	X
Attached Residential Development	X	X			X	P(1)	P(2)	P	X
Commercial Development >one acre	P(1)	P(1)	X	P(2)	X	P(5)	X	P(3)	P(5)
Heavy Industry	X		X	X	X	X	X		
Automotive Repair Shops			X	X(4)(5)	X		X		
Restaurants					X	X	X	X	P(1)
Hillside Development >5,000 ft2	X	X			X	X	X		X
Parking Lots	P(1)	P(1)	X		X	P(1)	X		P(1)
Retail Gasoline Outlets			X	X	X	X	X		
Streets, Highways & Freeways	X	P(1)	X	X(4)	X	P(5)	X	X	P(1)

X = anticipated
P = potential
(1) A potential pollutant if landscaping exists onsite.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves food or animal waste products.
(4) Including petroleum hydrocarbons.
(5) Including solvents.

B.6.2 Selection of Flow-Thru Treatment Control BMPs

The following steps must be followed to select the appropriate flow-thru treatment control BMPs for the PDP:

1) For each PDP most significant pollutant of concern identify the grouping using Table B.6-2. Table B.6-2 is adopted from the Model SUSMP.

2) Select the flow-thru treatment control BMP based on the grouping of pollutants of concern that are identified to be most significant in Step 1. This section establishes the pollutant control BMP treatment performance standard to be met for each grouping of pollutants in order to meet the standards required by the MS4 permit and how an applicant can select a non-proprietary or a proprietary BMP that meets the established performance standard. The grouping of pollutants of concern are:

    a. Coarse Sediment and Trash (Appendix B.6.2.1)
    b. Pollutants that tend to associate with fine particles during treatment (Appendix B.6.2.2)
    c. Pollutants that tend to be dissolved following treatment (Appendix B.6.2.3)

TABLE B.6–2: Grouping of Potential Pollutants of Concern

Pollutant	Coarse Sediment and Trash	Suspended Sediment and Particulate-bound Pollutants[1]	Soluble-form Dominated Pollutants[2]
Sediment	X	X	
Nutrients		X	X
Heavy Metals		X	
Organic Compounds		X	
Trash & Debris	X		
Oxygen Demanding		X	
Bacteria		X	
Oil & Grease		X	
Pesticides		X	

[1] Pollutants in this category can be addressed to Medium or High effectiveness by effectively removing suspended sediments and associated particulate-bound pollutants. Some soluble forms of these pollutants will exist, however treatment mechanisms to address soluble pollutants are not necessary to remove these pollutants to a Medium or High effectiveness.

[2] Pollutants in this category are not typically addressed to a Medium or High level of effectiveness with particle and particulate-bound pollutant removal alone.

One flow-thru BMP can be used to satisfy the required pollutant control BMP treatment performance standard for the PDP most significant pollutants of concern. In some situations it

might be necessary to implement multiple flow-thru BMPs to satisfy the pollutant control BMP treatment performance standards. For example, a PDP has trash, nutrients and bacteria as the most significant pollutants of concern. If a vegetated filter strip is selected as a flow-thru BMP then it is anticipated to meet the performance standard in Appendix B.6.2.2 and B.6.2.3 but would need a trash removal BMP to meet the pollutant control BMP treatment performance standard in Appendix B.6.2.1 upstream of the vegetated filter strip. This could be achieved by fitting the inlets and/or outlets with racks or screens on to address trash.

B.6.2.1 Coarse Sediment and Trash

If coarse sediment and/or trash and debris are identified as a pollutant of concern for the PDP, then BMPs must be selected to capture and remove these pollutants from runoff. The BMPs described below can be effective in removing coarse sediment and/or trash. These devices must be sized to treat the flow rate estimated using Worksheet B.6-1. Applicant can only select BMPs that have High or Medium effectiveness.

Trash Racks and Screens [Coarse Sediment: Low effectiveness; Trash: Medium to High effectiveness] are simple devices that can prevent large debris and trash from entering storm drain infrastructure and/or ensure that trash and debris are retained with downstream BMPs. Trash racks and screens can be installed at inlets to the storm drain system, at the inflow line to a BMP, and/or on the outflow structure from the BMP. Trash racks and screens are commercially available in many sizes and configurations or can be designed and fabricated to meet specific project needs.

Hydrodynamic Separation Devices [Coarse Sediment: Medium to High effectiveness; Trash: Medium to High effectiveness] are devices that remove coarse sediment, trash, and other debris from incoming flows through a combination of screening, settlement, and centrifugal forces. The design of hydrodynamic devises varies widely, more specific information can be found by contacting individual vendors. A list of hydrodynamic separator products approved by the Washington State Technology Acceptance Protocol-Ecology protocol can be found at:

http://www.ecy.wa.gov/programs/wq/storm water/newtech/technologies.html.

Systems should be rated for "pretreatment" with a General Use Level Designation or provide results of field-scale testing indicating an equivalent level of performance.

Catch Basin Insert Baskets [Coarse Sediment: Low effectiveness; Trash: Medium effectiveness, if appropriately maintained] are manufactured filters, fabrics, or screens that are placed in inlets to remove trash and debris. The shape and configuration of catch basin inserts varies based on inlet type and configuration. Inserts are prone to clogging and bypass if large trash items are accumulated, and therefore require frequent observation and maintenance to remain effective. Systems with screen size small enough to retain coarse sediment will tend to clog rapidly and should be avoided.

Other Manufactured Particle Filtration Devices [Coarse Sediment: Medium to High effectiveness; Trash: Medium to High effectiveness] include a range of products such as cartridge filters, bag filters, and other configurations that address medium to coarse particles. Systems should be rated for "pretreatment" with a General Use Level Designation under the Technology Acceptance Protocol-Ecology program or provide results of field-scale testing indicating an equivalent level of performance.

Note, any BMP that achieves Medium or High performance for suspended solids (See Section B.6.2.2) is also considered to address coarse sediments. However, some BMPs that address suspended solids do not retain trash (for example, swales and detention basins). These types of BMPs could be fitted with racks or screens on inlets or outlets to address trash.

BMP Selection for Pretreatment:

Devices that address both coarse sediment and trash can be used as pretreatment devices for other BMPs, such as infiltration BMPs. However, it is recommended that BMPs that meet the performance standard in Appendix B.6.2.2 be used. A device with a "pretreatment" rating and General Use Level Designation under Technology Acceptance Protocol-Ecology is required for pretreatment upstream of infiltration basins and underground galleries. Pretreatment may also be provided as presettling basins or forebays as part of a pollutant control BMP instead of implementing a specific pretreatment device for systems where maintenance access to the facility surface is possible (to address clogging), expected sediment load is not high, and appropriate factors of safety are included in design.

B.6.2.2 Suspended Sediment and Particulate-Bound Pollutants

Performance Standard

The pollutant treatment performance standard is shown in Table B.6-3. This performance standard is consistent with the Washington State Technology Acceptance Protocol-Ecology Basic Treatment Level, and is also met by technologies receiving Phosphorus Treatment or Enhanced Treatment certification. This standard is based on pollutant removal performance for total suspended solids. Systems that provide effective TSS treatment also typically address trash, debris, and particulate bound pollutants and can serve as pre-treatment for offsite mitigation projects or for onsite infiltration BMPs.

Table B.6-3: Performance Standard for Flow-Thru Treatment Control

Influent Range	Criteria
20 – 100 mg/L TSS	Effluent goal ≤ 20 mg/L TSS
100 – 200 mg/L TSS	≥ 80% TSS removal
>200 mg/L TSS	> 80% TSS removal

Selecting Non-Proprietary BMPs

Table B.6-4 identifies the categories of non-proprietary BMPs that are considered to meet the pollutant treatment performance standard if designed to contemporary design standards[14]. BMP types with an "High" ranking should be considered before those with an "Medium" ranking. Statistical analysis by category from the International Storm Water BMP Database (also presented in Table B.6-4) indicates each of these BMP types (as a categorical group) meets or nearly meets the performance standard. The International Storm Water BMP Database includes historic as well as contemporary BMP studies; contemporary BMP designs in these categories are anticipated to meet or exceed this standard on average.

[14] Contemporary design standards refers to design standards that are reasonably consistent with the current state of practice and are based on desired outcomes that are reasonably consistent with the context of the MS4 Permit and this manual. For example, a detention basin that is designed solely to mitigate peak flow rates would not be considered a contemporary water quality BMP design because it is not consistent with the goal of water quality improvement. Current state of the practice recognizes that a drawdown time of 24 to 72 hours is typically needed to promote settling. For practical purposes, design standards can be considered "contemporary" if they have been published within the last 10 years, preferably in California or Washington State, and are specifically intended for storm water quality management.

Table B.6-4: Flow-Thru Treatment Control BMPs Meeting Performance Standard

List of Acceptable Flow-Thru Treatment Control BMPs	Statistical Analysis of International Storm Water BMP Database				Evaluation of Conformance to Performance Standard		
	Count In/Out	TSS Mean Influent, mg/L	TSS Mean Effluent[1], mg/L	Average Category Volume Reduct.	Volume-Adjusted Effluent Conc[2], mg/L	Volume-Adjusted Removal Efficiency[2]	Level of Attainment of Performance Standard (with rationale)
Vegetated Filter Strip	361/ 282	69	31	38%	19	72%	Medium, effluent < 20 mg/L after volume adjustment
Vegetated Swale	399/ 346	45	33	48%	17	61%	Medium, effluent < 20 mg/L after volume adjustment
Detention Basin	321/ 346	125	42	33%	28	77%	Medium, percent removal near 80% after volume adjustment
Sand Filter/ Media Bed Filter	381/ 358	95	19	NA[3]	19	80%	High, effluent and % removal meet criteria without adjustment
Lined Porous Pavement[4]	356/ 220	229	46	NA[3,4]	46	80%	High, % removal meets criteria without adjustment
Wet Pond	923/ 933	119	31	NA[3]	31	74%	Medium, percent removal near 80%

Source: 2014 BMP Performance Summaries and Statistical Appendices; 2010 Volume Performance Summary; available at: www.bmpdatabase.org

1 - A statistically significant difference between influent and effluent was detected at a p value of 0.05 for all categories.

2 - Estimates were adjusted to account for category-average volume reduction.

3 - Not Applicable as these BMPs are not designed for volume reduction and are anticipated to have very small incidental volume reduction.

4 - The category presented in this table represents a lined system for flow-thru treatment purposes. Porous pavement for retention purposes is an infiltration BMP, not a flow-thru BMP. This table should not be consulted for porous pavement for infiltration.

Selecting Proprietary BMPs

Proprietary BMPs can be used if the BMP meets each of the following conditions:

(1) **The proposed BMP meets the performance standard in Appendix B.6.2.2 as certified through third-party, field scale evaluation.** An active General Use Level Designation for Basic Treatment, Phosphorus Treatment or Enhanced Treatment under the Washington State Technology Acceptance Protocol-Ecology program is the preferred method of demonstrating that the performance standard is met. The list of certified technologies is updated as new technologies are approved (link below). Technologies with Pilot Use Level Designation and Conditional Use Level Designations are not acceptable. Refer to:

http://www.ecy.wa.gov/programs/wq/storm water/newtech/technologies.html. Alternatively, other field scale verification of 80 percent TSS capture, such as through Technology Acceptance Reciprocity Partnership or New Jersey Corporation for Advance Testing may be acceptable. A list of field-scale verified technologies under Technology Acceptance Reciprocity Partnership Tier II and New Jersey Corporation for Advance Testing can be accessed at: http://www.njcat.org/verification-process/technology-verification-database.html (refer to field verified technologies only).

(2) **The proposed BMP is designed and maintained in a manner consistent with its performance certifications (see explanation below).** The applicant must demonstrate conclusively that the proposed application of the BMP is consistent with the basis of its certification/verification. Certifications or verifications issued by the Washington Technology Acceptance Protocol-Ecology program and the Technology Acceptance Reciprocity Partnership or New Jersey Corporation for Advance Testing programs are typically accompanied by a set of guidelines regarding appropriate design and maintenance conditions that would be consistent with the certification/verification. It is common for these approvals to specify the specific model of BMP, design capacity for given unit sizes, type of media that is the basis for approval, and/or other parameters.

(3) **The proposed BMP is acceptable at the discretion of the County.** The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met. While the County has no obligation to accept the use of any proposed proprietary BMP, applicants will be provided a written explanation describing the rationale for the rejection of any proposed devices.

B.6.2.3 Soluble-form dominated Pollutants (Nutrients)

If nutrients are identified as a most significant pollutant of concern for the PDP, then BMPs must be selected to meet the performance standard described in Appendix B.6.2.2 **and** must be selected to provide medium or high level of effectiveness for nutrient treatment as described in this section. The most common nutrient of concern in the San Diego region is nitrogen, therefore total nitrogen (TN) was used as the primary indicator of nutrient performance in storm water BMPs.

Selection of BMPs to address nutrients consists of two steps:

1) Determine if nutrients can be addressed via source control BMPs as described in Appendix E and Chapter 4. After applying source controls, if there are no remaining source areas for soluble nutrients, then this pollutant can be removed from the list of pollutants of concerns for the purpose of selecting flow-thru treatment control BMPs. Particulate nutrients will be addressed by the performance standard in Appendix B.6.2.2.

2) If soluble nutrients cannot be fully addressed with source controls, then select a flow-thru treatment control BMPs that meets the performance criteria in Table B.6-5 or select from

the nutrient-specific menu of treatment control BMPs in Table B.6-6.

a. The performance standard for nitrogen removal (Table B.6-5) has been developed based on evaluation of the relative performance of available categories of non-proprietary BMPs.

b. For proprietary BMPs, submit third party performance data indicating that the criteria in Table B.6-5 are met. The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met. While the County has no obligation to accept the use of any proposed proprietary flow-thru BMP, applicants will be provided a written explanation describing the rationale for the rejection of any proposed devices.

Table B.6-5: Performance Standard for Flow-Thru Treatment Control BMPs for Nutrient Treatment

Basis	Criteria
Treatment Basis	Comparison of mean influent and effluent indicates significant concentration reduction of TN approximately 40 percent or higher based on studies with representative influent concentrations
Combined Treatment and Volume Reduction Basis	Combination of concentration reduction and volume reduction yields TN mass removal of approximately 40 percent or higher based on studies with representative influent concentrations

Table B.6-6: Flow-Thru Treatment Control BMPs Meeting Nutrient Treatment Performance Standard

List of Acceptable Flow-Thru Treatment Control BMPs for Nutrients	Statistical Analysis of International Storm Water BMP Database				Evaluation of Conformance to Performance Standard		
	Count In/Out	TN Mean Influent, mg/L	TN Mean Effluent[1], mg/L	Average Category Volume Reduct.	Volume-Adjusted Effluent Conc[2], mg/L	Volume-Adjusted Removal Efficiency[2]	Level of Attainment of Performance Standard (with rationale)
Vegetated Filter Strip	138/ 122	1.53	1.37	38%	0.85	44%	Medium, if designed to include volume reduction processes
Detention Basin	90/ 89	2.34	2.01	33%	1.35	42%	Medium, if designed to include volume reduction processes
Wet Pond	397/ 425	2.12	1.33	NA	1.33	37%	Medium, best concentration reduction among BMP categories, but limited volume reduction

Source: 2014 BMP Performance Summaries and Statistical Appendices; 2010 Volume Performance Summary; available at: www.bmpdatabase.org

1 - A statistically significant difference between influent and effluent was detected at a p value of 0.05 for all categories included.

2 - Estimates were adjusted to account for category-average volume reduction.

B.6.3 Sizing Flow-Thru Treatment Control BMPs:

Flow-thru treatment control BMPs must be sized to filter or treat the maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of every storm event. The required flow-thru treatment rate should be adjusted for the portion of the DCV already retained or biofiltered onsite as described in Worksheet B.6-1. The following hydrologic method must be used to calculate the flow rate to be filtered or treated:

$$Q = C \times i \times A$$

Where:

Q = Design flow rate in cubic feet per second

C = Runoff factor, area-weighted estimate using Table B.1-1.

i = Rainfall intensity of 0.2 in/hr.

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drain to the BMP. Refer to Section 3.3.3 for additional guidance. Street projects consult Section 1.4.3.

Worksheet B.6-1: Flow-Thru Design Flows

Category	#	Description	Value	Units
Flow-Thru BMP Inputs	0	Drainage Basin ID or Name		unitless
	1	Total Tributary Area		sq-ft
	2	Final Adjusted Runoff Factor		unitless
	3	Design Capture Volume		cubic-feet
	4	Volume Effectively Retained and/or Biofiltered		cubic-feet
	5	Deficit of Effectively Treated Stormwater Requiring Flow-Thru Treatment		cubic-feet
	6	Maximum Rated Water Quality Flow Rate of Proposed BMP		CFS
Flow Rate Calculations	7	Adjustment Factor		unitless
	8	Design Rainfall Intensity for Flow-Thru BMPs	0.20	in/hr
	9	Water Quality Flow Rate Requiring Flow-Thru Treatment		CFS
Result	10	Is Flow-Thru BMP Adequately Sized?		unitless

Worksheet B.6-1 General Notes:

A. Applicants may use this worksheet to size flow-thru BMPs. Applicants must provide inputs for yellow shaded cells and calculate appropriate values for unshaded cells. Note that applicants proposing on-site flow-thru BMPs must also implement an offsite alternative compliance project to offset the deficit of effectively treated stormwater volume. An automated version of this worksheet is available for download at the County of San Diego Department of Public Works website.

Worksheet B.6-1 Line Item Notes:

0. Populated per Worksheet B.1-1.
1. Populated per Worksheet B.1-1.
2. Populated per Worksheet B.1-1.
3. Populated per Worksheet B.2-1.
4. Populated per Retention and/or Biofiltration treatment determined in Worksheets B.3-1 through B.5-3.
5. Line 4 - Line 3
6. User input per manufacturer's specification sheet.
7. -Line 5 / Line 3
8. Default value of 0.20 inches per hour
9. (Line 1/43,560) x Line 2 x Line 7 x Line 8
10. If Line 6 ≥ Line 9 then "Yes". If Line 6 < Line 9 then "No".

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