ATTACHMENT C – WATER QUALITY BENEFIT QUANTIFICATION

1 INTRODUCTION

This attachment summarizes the water quality benefit quantification approaches used in the scoring of the priority drainage areas (opportunity identification) and selection of priority projects (project prioritization).

2 OPPORTUNITY IDENTIFICATION

This section describes the water quality benefit opportunity screening and scoring approach utilized for the drainage areas evaluated in the GSCW Plan. The intent of this exercise was to prioritize drainage areas that would have the potential to provide the greatest pollutant load reduction if green streets BMPs were to be implemented and facilitate a more focused review of individual project opportunities within the narrower subset of prioritized drainage areas. This approach allows for green streets BMPs to be sited in areas most needing treatment, and likely to provide a significant benefit with regards to pollutant load reduction and TMDL compliance. The water quality score was combined with the community benefit score, as described in Section 3 of the GSCW Plan) to identify the drainage areas with optimized potential for both water quality and community benefits.

2.1 Approach

To form the basis of the relative scoring between drainage areas, pollutant contributions were area-weighted into a representative drainage area concentration with a simplified estimate for local runoff hydrology. This simplified method made use of land surface slivers with similar runoff-affecting characteristics. These slivers are referred to as Hydrologic Response Units (HRUs) and were determined by the geospatial intersection of soil type, land use, mean annual precipitation, and imperviousness. This simplified hydrology is meant to be broadly consistent with the County's guidance for estimating BMP sizing (County of San Diego, 2020a). This simplified hydrology is appropriate for making comparisons of annual runoff volume between BMP siting locations and not to be used to create or inform numerical estimates of whole-watershed hydrology.

The screening utilized the input data identified in the following sections, with a unique drainage area-relative pollutant concentration for each individual pollutant of concern.

2.1.1 Unit of Analysis

The unit of analysis for the water quality opportunity prioritization was the drainage area layer developed for the County through the 2018 Trash Amendment work. These drainage areas were developed using a combination of GIS and PCSWMM to perform typical automated delineation techniques. The resulting drainage areas were then refined based on a manual QA/QC procedure as outlined in the Inlet Mapping, Collection, and Drainage Area Mapping Report (County of San Diego, 2018a). The layer contains a total of 19,347 individual drainage areas, 7,813 of which fall within the study area and establish the analysis units for the water quality prioritization. The average area of the water quality prioritization drainage areas is 47 acres, with a number of significantly larger drainage areas within the lesser developed areas and significantly smaller drainage areas (less than an acre) within the well-defined village areas.

2.1.2 Pollutants of Concern

The water quality prioritization provided a score for each drainage area for each of the following eight pollutants: Total Suspended Solids (TSS), Total Phosphorous (TP), Total Nitrogen (TN), Total Copper (TCu), Total Lead (TPb), Total Zinc (TZn), Fecal coliform (FC), and trash. These pollutants of concern were selected in keeping with typical land use-based pollutant modeling and local practices as described in Appendix B of the Water Quality Equivalency (WQE) Guidance Document Region 9 (County of San Diego, 2018b). Trash was not included in the WQE but has been added to this analysis due to the implementation of the Statewide Trash Amendments and development of land use based annual trash generation rates for priority land uses developed since the publishing of the WQE.

Relative pollutant concentrations were assigned to each of the pollutants of concern (except for trash which was assigned an annual generation rate) based on the contributing land use category in Appendix B of the WQE (County of San Diego, 2018b). Relative pollutant concentrations were used in place of land use event mean concentration (EMC) values to mitigate for the orders of magnitude difference in concentrations between pollutants from different land uses (e.g., rural residential TSS concentration of 2,524 mg/l vs. transportation TSS concentration of 78 mg/l) non-uniform units between categories (i.e., FC and others). This is the same approach and same values that were proposed and used in the WQE (methodology outlined in Section B.12) and allows for a better comparison between pollutants and the development of a single combined score. Table 1 summarizes the relative pollutant concentrations used.

Table 1. Relative Pollutant Concentrations

Land Use Category	TSS	TP	TN	TCu	TPb	TZn	FC
Agriculture	0.45	1.00	1.00	1.00	1.00	0.59	1.00
Commercial	0.13	0.16	0.16	0.56	0.48	1.00	0.87
Education	0.13	0.2	0.11	0.14	0.25	0.39	0.13
Industrial	0.13	0.19	0.15	0.54	0.68	0.89	0.49
Multi-Family Residential	0.10	0.13	0.13	0.14	0.15	0.29	0.27
Orchard	0.18	0.17	0.67	1.00	1.00	0.59	0.11
Rural Residential	1.00	0.51	0.14	0.10	0.71	0.13	0.19
Single Family Residential	0.13	0.2	0.15	0.27	0.43	0.35	0.63
Transportation	0.11	0.26	0.12	0.53	0.31	0.62	0.12
Vacant / Open Space	0.16	0.10	0.10	0.12	0.10	0.10	0.10
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The WQE does not provide a relative pollutant concentration for trash, so for this analysis, the values were determined by normalizing the annualized loading rate by the maximum value (6 gallons/acre/year for commercial land uses). Table 2 summarizes the relative pollutant concentrations developed for the Trash used in this analysis.

Table 2. Relative Trash Concentration (Yield)

Land Use Category	Annual Yield (gallons/acre)	Relative Trash Yield Concentration
Commercial	6	1.00
High Density Residential	2.5	0.41
Industrial	2.6	0.43
Public Transportation Station	6	1.00
Alternative Land Use	1	0.16
Undeveloped	0	0.00

2.1.3 Receiving Water TMDLs and Impairments

Receiving water TMDLs and impairments on the 2014/2016 303(d) List (2014/2016 California Integrated Report[1]) were identified for the pollutants of concern and mapped to the corresponding drainage area based on HSA (see the GSCW Section 3, Figure 3). HSAs were used to trace TMDLs and impairments to upstream drainage areas such that all contributing drainage areas could be identified and included in the scoring.

The 2014/2016 California Integrated Report places each assessed waterbody segment into five categories based on the overall beneficial use of the water segment and the need for a TMDL. 303(d) listings for this analysis were filtered for Category 5 (listing requiring the development of a TMDL) and Category 4b (listing is being addressed by an action other than a TMDL). Category 4a 303(d) listings are addressed by USEPA approved TMDLs and are included under the receiving water TMDLs. Table 3 summarizes the TMDLs included in this evaluation (TMDLs with no contributing study areas have not been included).

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[1] State Board approved the 2014 303(d) List on October 3, 2017, by Resolution No. 2017-0059, and on April 6, 2018, USEPA approved the List. At the time of this analysis, the State Board had not yet released the 2018 Integrated Report.

Table 3. San Diego Region 9 TMDLs within Study Area

TMDL	Status	Adoption/ Approval Date	Pollutants of Concern	HSAs	
Revised Project I - Twenty Beaches and Creeks in San Diego Region (including Tecolote Creek)	TMDL Adopted	February 10, 2010	Indicator Bacteria (Fecal Coliform)	901.11 901.12 901.13 901.14 901.27 901.30 903.00 904.50	905.00 906.10 906.30 906.50 907.11 907.12 908.22
Rainbow Creek Watershed Nitrogen and Phosphorus TMDLs	TMDL Adopted	February 9, 2005	Total Nitrogen & Total Phosphorous	902.22 902.23	
Loma Alta Slough Phosphorus TMDL	Alternate Approach TMDL Approved	June 26, 2014	Total Phosphorus	904.10	

2.1.4 Other Data and Uses

Additional data and their respective use in the water quality prioritization are identified and summarized below, source information is included in GSCW Plan Attachment B, and graphical inputs are shown in Section 3.1 of the GSCW Plan.

- **Hydrologic Subareas (HSA)** – The HSA is one of the nested levels of watershed delineations developed and cataloged in the California Interagency Watershed Map of 1999 (California Interagency Watershed Mapping Committee, 1999, updated 2004) as the State's working definition of watershed boundaries. TMDLs are mapped to associated HSAs, which are used in this analysis to map downstream impairments to upstream contributing drainage areas.

- **Land Use** – This analysis uses two land use classifications to associate the relative concentrations from Table 1 and Table 2 to each of the drainage areas. The typical land use categories used for the WQE and WQIPs are used for pollutants, while the priority land uses categories from the Trash Amendments are used for Trash. Each drainage area is divided into separate land uses and assigned relative concentrations as shown for Pollutants and Trash.

- **Imperviousness and Hydrologic Soil Group (HSG)** – Impervious area and HSG are used to calculate the area weighed runoff coefficient of each drainage area. Percent Impervious from the CONUS Imperviousness National Land Cover Database (NLCD, 2016), which assigns a value to each 30-meter square grid cell, was resampled within the study area to five times resolution (i.e., each 30-meter grid was divided into 25 identical grid cells) which allowed for spatial averaging across watershed and land-use boundaries. Impervious surfaces were assigned a runoff coefficient of 0.9, consistent with guidance from the County of San Diego Best Management Practice Design Manual (County of San Diego, 2020a). Runoff coefficients of 0.10, 0.14, 0.23, and 0.30 were assigned to previous portions of the drainage areas by HSGs A, B, C, and D, respectively, consistent with guidance from the County of San Diego Best Management Practice Design Manual (County of San Diego, 2020a). Additionally, areas that were as classification of "Rock" or "Water" in the USGS data were assigned runoff coefficients of 0.9 (i.e., assumed impervious).

Table 4 summarizes the breakdown of land use and impervious area across the study area. Impervious area was determined by multiplying the aggregated % impervious value by the total area; these values are provided for general information only and were not used in the scoring analysis.

Table 4. Land Use Summary within Study Area

EMC Land Use	Area (Ac)	Impervious Area (Ac)	Percent Impervious (%)
Agriculture	26,392	1,348	5
Commercial	3,372	1,823	54
Education	6,851	1,763	26
Industrial	3,598	1,728	48
Multi-Family Residential	6,185	2,932	47
Orchard	23,983	326	1
Rural Residential	90,801	5,221	6

EMC Land Use	Area (Ac)	Impervious Area (Ac)	Percent Impervious (%)
Single Family Residential	47,693	14,819	31
Transportation	22,001	7,724	35
Vacant / Open Space	136,678	2,950	2
Water	1,380	50	3.6
Summary (Totals/Weighted)	**367,554**	**40,634**	**11**

- **County Maintained and Private Roads**- The County-maintained and private roads were determined using data from the County of San Diego Department of Public Works and identified based on the jurisdiction attribute. This data set was used to verify that the drainage areas within the study area, to potentially be considered for BMP siting, intersected a portion of County maintained right-of-way (ROW) (public or private). For the screening level intersect analysis, a ROW width of 106 ft. (corresponding to the "Boulevard with median" classification from the Road Registry) was selected. This selection was made to capture a larger number of drainage areas potentially draining to the ROW. A total of 1,485 drainage areas (19%) were identified that did not intersect with the ROW and were subsequently removed from the analysis.

- **Average Annual Precipitation-** At this broad stage of analysis, average annual precipitation was assumed constant across the study area so as not to bias the resulting scoring against portions of the study area with lower annual precipitation. High-resolution rainfall data from a number of gages throughout the County was used for the performance evaluation steps to be conducted for project prioritization (Section 3).

2.1.5 Hydrologic Response Units (HRUs)

The data above were combined to develop unique combinations of land use and land cover or Hydrologic Response Units (HRUs) within each of the study area drainage areas. Each of these HRUs was then evaluated and aggregated to the drainage area level as described in the scoring section below.

2.2 Scoring

Drainage area scores were calculated as the summation of the relative pollutant and trash concentrations for each drainage area using the equations presented below.

First, the area-weighted runoff coefficient is determined for each HRU and drainage area using Equation 1.

$$\mathbf{RC_{i,a\text{-}k}} = \frac{A_{i,imp}RC_{i,imp}+A_{i,perv}RC_{i,perv}}{\sum A_i} \qquad \textbf{(Eq. 1)}$$

Where,

A_i = Area of unique HRU "i" within drainage area (acres)

$RC_{i,imp}$ = Runoff coefficient for impervious land uses within HRU "i" of drainage area = 0.90 (County of San Diego, 2020a)

$RC_{i,perv}$ = Runoff coefficient for pervious land uses within HRU "i" of drainage area (see Table 6, Task 2 Memo) (County of San Diego, 2020a)

Then, the relative pollutant concentration is calculated for each pollutant of concern in each drainage area using Equation 2.

$$\mathbf{P_i} = \frac{\sum P_{1a}A_aRC_a+P_{1b}A_bRC_b+\ldots P_{1k}A_kRC_k}{\sum A_aRC_a+A_bRC_b+\ldots A_kRC_k} \qquad \textbf{(Eq. 2)}$$

Where,

P_i = Relative Pollutant Concentration for Drainage area (calculated for each pollutant),

P_{1a} - P_{1k} = Relative Pollutant Concentration for Land Use Category (See Table 1),

RC_a – RC_k = Runoff Coefficient for HRU (See Equation 1),

A_a – A_k = Area (ac) of Land Use Category

Next, the relative trash yield concentration is calculated for each drainage area using Equation 3. Note that since the trash yield is independent of the runoff coefficient, that term is removed from the equation.

$$\mathbf{P_{Trash}} = \frac{\sum P_{Ta}A_a + P_{Tb}A_b + \ldots P_{Tf}A_f}{\sum A_a + A_b + \ldots A_f} \qquad \textbf{(Eq. 3)}$$

Where,

P_{Trash} = Relative Trash Yield for Drainage area,

$P_{Ta} – P_{Tf}$ = Relative Trash Yield for Land Use Category (See Table 2),

$A_a – A_f$ = Area (ac) of Land Use Category

The Pollutant Score and Trash Score are then calculated using Equations 4 and 5.

$$\textbf{Pollutant Score}_{\textbf{Pollutant}} = P_i \times RC_i \times max(F_{TMDL}, F_{303(d)}) \times 20 \qquad \textbf{(Eq. 4)}$$

Where,

RC_i = Area weighted runoff coefficient for drainage area "i" calculated in Equation 1

F_{TMDL} = 3, a weighting factor applied if the drainage area drains to a receiving water with an existing TMDL for the pollutant of concern.

$F_{303(d)}$ = 2, a weighting factor applied if the drainage area drains to a 303(d) listed receiving water for the pollutant of concern.

Equation 4 applies the maximum of either the TMDL factor or 303(d) factor so that drainage areas points are not double-counted.

$$\textbf{Trash Score} = P_T \; x \; F_{PLU} \; x \; 20 \qquad \textbf{(Eq. 5)}$$

Where,

F_{PLU} =2, a weighting factor applied if the drainage area contains one of the following Priority Land Uses: Commercial, High-Density Residential, Industrial, and Public Transportation Station.

Finally, the overall Water Quality Benefit Score is determined by summing the individual pollutant and trash scores for each drainage area using Equation 6.

$$\textbf{Water Quality Benefit Score} = \sum Pollutant\ Score_{Pollutant} + Trash\ Score \qquad \textbf{(Eq. 6)}$$

The scoring approach represented above results in eight individual pollutant scores and one overall Water Quality Benefit Score for each drainage area. These results are presented in GSCW Plan Attachment D.1.

3 PROJECT PRIORITIZATION & MODELING ENGINE

This section identifies the water quality benefit quantification approach utilized for project-scale prioritization. Specifically, the section summarizes the modeling inputs and methods used to quantify the water quality benefits of each potential green streets project. Water quality benefits serve as inputs into a broader triple bottom line approach to project prioritization, as described in Section 5 of the GSCW Plan.

3.1 Approach

The water quality performance measures which were quantified for each project include:

- Annual wet and dry weather volume capture;
- Annual wet and dry weather pollutant load reduction;
- Peak flow mitigation (as a percent); and
- Annual trash load reduction.

The quantification leveraged the core water quality calculation engine used in the Orange County (OC) Stormwater Tools platform to support the volume capture and pollutant load reduction benefits. This open-source water quality modeling engine implements general algorithms for computing volume-weighted land surface runoff volume and runoff water quality for both wet weather and dry weather conditions and for determining the long-term volume capture performance and load reduction performance of BMPs. For this project, a San Diego County specific set of input files and reference datasets tailored to San Diego County hydrology, design standards, and the suite of specific BMP configurations assessed for the GSCW Plan effort were developed. Once configured, this calculation framework allowed for the rapid performance assessment of project sites located anywhere within the region for which complete reference data is available.

The following sections document the formation of the input reference data, how the calculation engine used these data to characterize BMP performance for volume and pollutant load reduction, and how other performance measures like trash load reductions and long-term peak flow mitigation were determined.

3.2 Land Surface Hydrology

3.2.1 Rainfall Data

The County provided records for 45 rainfall gauge locations distributed throughout the study area. Each dataset was analyzed to determine suitability for use as a reference gauge to support the long-term volume capture performance of the GSCW Plan BMP scenarios. Gauge suitability for supporting modeling volume-based facilities such as biofilters and infiltration trenches was based on the gauge having over 25 years of hourly measurements. Gauge suitability for flow-based BMP facilities such as HDS devices and swales was based on the gauge having over ten years of records with 5-minute measurements. Twelve gauges were identified as having met both criteria and were used to define rainfall reference zones covering the County's study area. The selected gauges are shown in Figure 1, with summary statistics in Table 5.

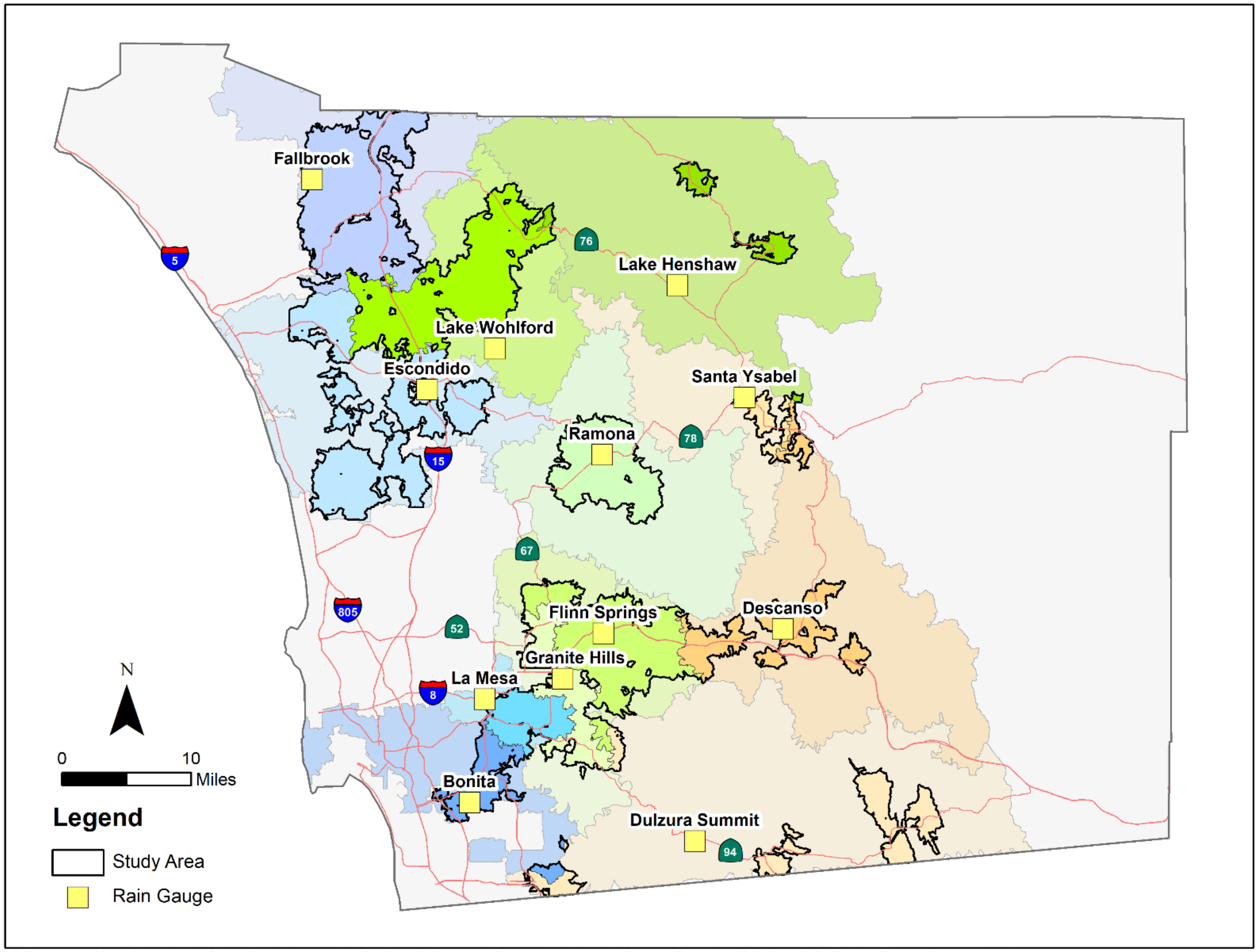

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Figure 1. Rainfall Zones

Table 5. Rainfall Summary

Gauge	Mean Annual Rainfall Depth (in)	85th Percentile 24-hr Storm Depth (in) – 2015 Isohyet
BONITA_27017	8.97	0.56
ESCONDIDO_27020	13.3	0.52
FALLBROOK_27019	13.96	0.82
LA MESA_27015	10.55	0.54
FLINN SPRINGS COUNTY PARK_27025	12.74	0.62
GRANITE HILLS_27026	11.37	0.50
LAKE HENSHAW RAIN_27028	22.09	0.78
LAKE WOHLFORD_27021	15.41	0.78
RAMONA CRS_27022	13.19	0.60
DESCANSO_27030	20.72	0.74
DULZURA SUMMIT_48	12.27	0.48
SANTA YSABEL_27029	20.51	0.82

The design storm depth defined by the SD County 85th percentile isohyet layer was used to determine the Design Capture Volume (DCV) for the project and to determine the normalized BMP volume when interrogating the relevant long-term volume capture nomograph for the site. This latter step is described in more detail in Section 3.5.

3.2.2 Stormwater Runoff Quantity

Stormwater runoff quantity was computed using site-specific conditions for every BMP project scenario considered for the GSCW Plan effort. Project site drainage areas were reviewed and adjusted (cut, trimmed, modified, etc.) based on BMP location within the larger prioritized drainage area and a desktop review of local topography and drainage networks where available was readily available. Each project site drainage area intersected a unique combination of on-site soils, land uses, imperviousness surfaces, and used the most representative rainfall record according to its rain zone.

Runoff coefficients were computed using the Hydrologic Response Unit (HRU) approach as described in Section 2.1.5. This approach subdivided a project drainage area into unique local-occurring combinations of rainfall zone, soil, and land use. Impervious surfaces are assigned a runoff coefficient of 0.9, consistent with guidance from the County of San Diego Best Management Practice Design Manual (County of San Diego, 2020a). Runoff coefficients of 0.10, 0.14, 0.23, and 0.30 are assigned to pervious portions of the project drainage area according to the underlying soil Hydrologic Soil Group (HSG) A, B, C, and D, respectively, consistent with guidance from the County of San Diego Best Management Practice Design Manual (County of San Diego, 2020a). Additionally, areas classified as "Rock" or "Water" in the USGS data were assigned runoff coefficients of 0.9 (i.e. assumed impervious).

Each individual HRU on the project thus had a characteristic area-weighted runoff coefficient formed by determining the underlying imperviousness of the HRU according to the imperviousness layer from the CONUS Imperviousness National Land Cover Database (NLCD, 2016). The characteristic runoff coefficient for each HRU was computed using Equation 7:

$$RC_{HRU} = A_{imp} * 0.9 + A_{perv} RC_{perv} \qquad \textbf{(Eq. 7)}$$

Where,

A = Area (acres)

RC_{perv} = Runoff coefficient for pervious land use varies by HSG.

The average annual stormwater runoff volume within a GSCW Plan drainage area was then calculated for each HRU using Equation 8:

$$Runoff\ Volume = Area * RC_{HRU} * Rainfall\ Depth \qquad \textbf{(Eq. 8)}$$

Where,

Area = Total area of HRU (sqft)

RC_{HRU} = Weighted runoff coefficient for the HRU.

Rainfall Depth = mean annual rainfall depth (ft)

This approach allows for separate runoff volume quantification for each HRU within a proposed green street BMP project drainage area. It thus supports appropriately volume-weighted pollutant loading estimates according to land use EMCs.

3.2.3 Dry Weather Discharge Quantity

Dry weather discharge volume was characterized using a steady-state discharge rate from certain developed land uses. For GSCW Plan project benefit quantification, the dry weather discharge rate was assumed to be 0.0003 cfs/developed acre. This value is the result of extensive regional monitoring in Orange County (2019, 2021) and is also used as the basis for other San Diego County benefit quantification efforts, such as the Rebates and Incentives program.

The land use categories for which unit dry weather discharges were applied are presented in Table 6 below.

Table 6. Land Uses Contributing to Dry Weather Discharges

Land Use Category	Contributes to Dry Weather Flow
Commercial	True
Education	True
Industrial	True
Multi Family Residential	True
Single Family Residential	True
Transportation	True
Rural Residential[1]	False
Agriculture	False
Orchard	False
Vacant / Open Space	False
Water	False

1. Rural residential land uses have been observed to be drained by pervious channels and ditches often leading field teams to observe dry/no flow conditions during dry weather observations.

Rural residential land use is the notable exclusion from the developed land use categories which was modeled as contributing to dry weather discharges. The rural residential land use category is characterized by very low development density, often pervious driveways, and typical drainage infrastructure and conveyances are unlined ditches. Field observations of MS4 outfalls in the San Luis Rey and San Diego River watershed have confirmed that dry weather observations made within 50 ft of the rural residential land use category were consistently observed to be dry for 95 observations out of 102, or 93%, during the 2019 monitoring season. This is much different from the observation locations that are not within 50 ft of rural residential land use, for which 285 of 370 (77%) monitored sites were consistently observed to be dry. For this reason, the Rural Residential land use category is not included in the list of land use categories that generate dry weather discharge volume for the GSCW Plan project benefits quantification effort.

Within each GSCW Plan treated drainage area, the acreages of the land use categories which contribute to dry weather discharges were used to scale the estimated steady-state dry weather discharge volumetric flowrate. The total annual volume of dry weather flow discharged from a given project area and treated by a BMP was calculated by combining the project area's steady-state volumetric flow rate with the number of dry days expected to occur during that year. This scaling is site-specific and varies based upon the rainfall gauge associated with the project.

The San Diego Region 9 MS4 Permit (CARWQCB 2015) provides the following definition for dry weather conditions:

> *"Weather is considered dry if the preceding 72 hours has been without measurable precipitation (>0.1 inch)."*

This definition was used to determine the average long-term number of dry days for each month for each of the modeled rainfall gauges.

Table 7. Water Quality Engine Reference Table: Average Number of Dry Days Per Month

	Average Number of Dry Days Per Month											
Rain Gauge	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
BONITA	21.2	18.1	21.5	24.3	29.2	29.4	30.5	30.4	29.1	27.7	23.8	22.6
ESCON	19.9	15.9	20.2	23.8	28.0	29.2	30.6	30.3	28.7	27.2	23.6	20.4
FALLBR	20.2	15.9	20.3	23.9	28.2	29.3	30.4	29.9	29.0	27.3	24.4	20.4
LAMESA	21.3	17.3	21.4	24.7	28.1	29.2	30.6	30.7	28.9	27.3	24.5	21.5
FLINN	20.7	17.0	20.9	23.6	27.1	29.1	30.1	30.1	28.6	27.3	23.9	20.6
GRANITE	20.7	17.0	20.9	24.4	28.0	28.7	30.5	30.5	29.2	27.9	23.3	21.0
HENSHAW	19.1	15.2	18.9	23.0	27.8	29.3	28.8	28.8	27.4	26.2	23.3	19.5
WOHLF	19.5	16.3	20.2	23.2	27.6	28.8	30.5	30.3	28.8	27.3	23.0	20.0
RAMONA	20.0	15.7	20.4	23.9	28.1	29.2	30.1	29.8	28.7	27.3	23.1	19.6
DESCANSO	18.4	15.3	19.2	22.7	26.9	29.1	28.5	29.1	27.5	26.8	22.6	18.3
DULZURA	20.7	16.2	21.3	23.7	28.2	29.5	30.4	30.3	29.1	27.6	23.9	21.0
YSABEL	19.2	15.3	18.5	21.4	26.7	28.8	28.9	28.4	27.7	26.4	22.6	18.8

The GSCW Plan modeling approach quantified dry weather discharge calculations occurring as summer season and winter season flows independently. This allows the option to use a different steady-state dry discharge rate for summer and winter flows, if justifiable pending further analysis of available County monitoring data. For this effort, April through September is defined as the summer season and October through March is defined as the winter season.

The overall discharge flow rate from a BMP drainage area composed of multiple types of land surfaces was calculated by multiplying the dry weather discharge rate by the total developed area. The calculation is shown in Equation 9:

$$Q_{season\,\&\,location} = q_{season\,\&\,location} * \ DWF\ Area \qquad \textbf{(Eq. 9)}$$

Where:

Q = dry weather discharge rate for a season and location (cfs)

Q = unit dry weather discharge rate for a certain season and location (cfs/developed acre)

DWF Area=Area contributing to dry weather flow (acres)

The total seasonal dry weather discharge volume from a drainage area was calculated using Equation 10 from the steady-state discharge rate and the long-term average number of dry weather days for the location.

$$V_{season\,\&\,location} = Q_{season\,\&\,location} * \ N_{season\ dry\ days} * 3600\ \frac{seconds}{hour} * 24\,\frac{hours}{day} \qquad \textbf{(Eq. 10)}$$

Where:

V = dry weather discharge volume for a certain season and location (cf)

Q = dry weather discharge rate for a certain season and location (cfs)

N = total number of dry days occurring for a certain season and location

These seasonal dry weather flow rates are compared to the treatment capacity of the BMP receiving the flow as discussed further in Section 3.5.2.

3.3 Land Surface Pollutant Loading

3.3.1 Stormwater Runoff Water Quality

The stormwater quality for each green street BMP project was quantified for each of the same pollutants of concern as described in Section 2. These pollutants of concern were selected for consistency with typical land use-based pollutant modeling and local practices as described in Appendix B of the Water Quality Equivalency (WQE) Guidance Document Region 9 (County of San Diego, 2018b). The specific event mean concentrations are listed in Table 8 below.

Table 8. Event Mean Pollutant Concentrations

Land Use Category	TSS mg/l	TP mg/l	TN mg/l	TCu ug/l	TPb ug/l	TZn ug/l	FC MPN/100ml
Agriculture	999.2	3.34	43.37	100.10	30.20	274.80	60,300
Commercial	127.68	0.32	5.20	54.84	14.40	483.70	51,600
Education	132.11	0.46	2.72	12.02	7.43	174.10	2,148
Industrial	125.18	0.45	4.34	53.54	20.52	428.39	26,703
Multi-Family Residential	39.90	0.23	3.81	12.10	4.50	125.10	11,800
Orchard	252.64	0.36	28.46	100.10	30.20	274.80	1,344
Rural Residential	2,523.76	1.59	4.26	8.36	21.38	39.19	6,684
Single Family Residential	123.41	0.49	4.58	25.96	13.03	153.29	35,557
Transportation	77.80	0.68	2.95	52.20	9.20	292.90	1,680
Vacant / Open Space	216.60	0.12	2.24	10.60	3.00	26.30	484
Water	0	0	0	0	0	0	0

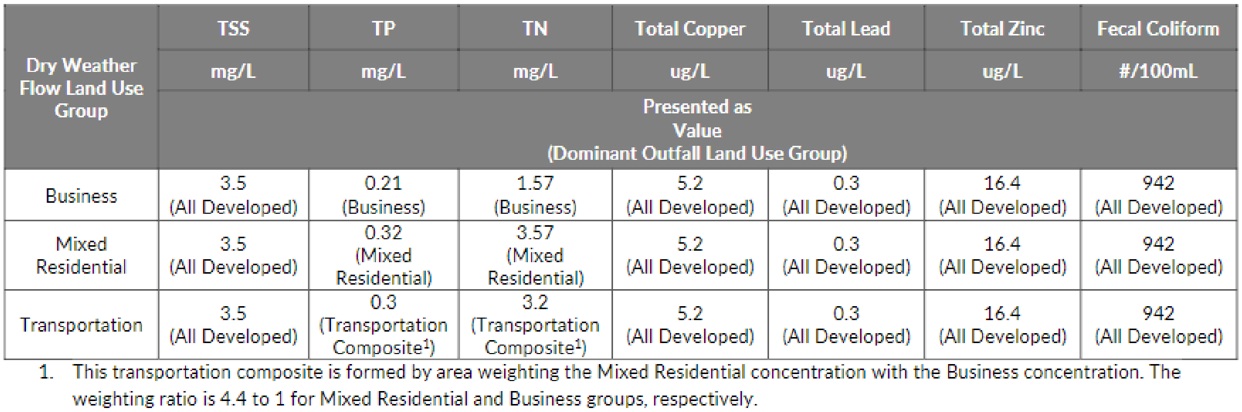
The load of each pollutant was calculated for each individual HRU comprising the project drainage area and accumulated to form the total load for each pollutant for the project. Each project area draining to a GSCW Plan BMP therefor had a characteristic volume-weighted pollutant concentration formed by the unique combinations of land use pollutant EMC and runoff coefficients.

3.3.2 Dry Weather Discharge Water Quality

Dry weather discharge parameters for water quality were used in quantifying dry weather load reductions (similar to EMCs for wet weather water quality). In lieu of County-specific data (which is available in raw format but has not been screened for groundwater influenced or otherwise processed for use in water quality modeling), dry weather discharge water quality parameters derived through analysis of public outfall monitoring data in South Orange County was used in this analysis. The parameters were developed to support the OC Stormwater Tools Modeling Module and are documented in the Dry Weather Average Pollutant Runoff Concentrations for the South Orange County WMA (Orange County, 2022), available via the South Orange County Regional Clearinghouse, OC Stormwater Tools Modeling Documentation.

As documented in the Modeling Module, five years of outfall monitoring data within the South Orange County Watershed Management Area collected between 2015 and 2020 were analyzed based on contributing land uses (dominant categories of mixed residential, business, or transportation). The geometric mean of the relevant data was then determined for constituents of concern as summarized in the table below (Table 2 from OC, 2022).

Table 9. Dry Weather Flow Concentrations by Major Land Use Grouping



Dry Weather Flow Land Use Group	TSS	TP	TN	Total Copper	Total Lead	Total Zinc	Fecal Coliform
	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	#/100mL
	Presented as Value (Dominant Outfall Land Use Group)						
Business	3.5 (All Developed)	0.21 (Business)	1.57 (Business)	5.2 (All Developed)	0.3 (All Developed)	16.4 (All Developed)	942 (All Developed)
Mixed Residential	3.5 (All Developed)	0.32 (Mixed Residential)	3.57 (Mixed Residential)	5.2 (All Developed)	0.3 (All Developed)	16.4 (All Developed)	942 (All Developed)
Transportation	3.5 (All Developed)	0.3 (Transportation Composite[1])	3.2 (Transportation Composite[1])	5.2 (All Developed)	0.3 (All Developed)	16.4 (All Developed)	942 (All Developed)

1. This transportation composite is formed by area weighting the Mixed Residential concentration with the Business concentration. The weighting ratio is 4.4 to 1 for Mixed Residential and Business groups, respectively.

3.3.3 For the GSCW Plan the Business category was chosen to represent dry weather flow quality for modeling purposes. This decision was based on the exclusion of rural residential land uses described in Section 3.2.3. Trash Loading

The total project trash loading was calculated similarly to the stormwater runoff pollutant loading. Annual trash loading was calculated and accumulated for each of the Priority Land Use categories existing within the project drainage area according to the annual trash yields (County of San Diego, 2020b) presented in Table 10.

Table 10. Trash Yield by Priority Land Use Category

Trash Priority Land Use Category	Annual Yield (gallons/acre)
Commercial	6
High Density Residential	2.5
Industrial	2.6
Public Transportation Station	6

Alternative Land Use	1
Undeveloped	0

3.4 BMP Types

BMP configurations considered for the GSCW Plan considered a variety of different in-situ conditions, and a variety of on-site constraints. For this reason, each of the BMP types detailed in the County of San Diego's Green Streets Standard Drawings had its water quality benefits quantified by the modeling approach. Where applicable, each of the design profiles defined by the Green Streets Standard Drawings document was modeled according to the underlying soil infiltration condition and the BMP underdrain design (see GS-1.05, GS-3.10, and GS-4.03).

The project team also considered three additional BMP types to broaden the number of stormwater treatment options available to high priority GSCW Plan project areas. These included dry wells, hydrodynamic separators, and vegetated swales. The stormwater BMP types considered for the GSCW Plan are presented below in 11.

Table 11. GSCW Plan Stormwater BMPs

Water Quality Treatment BMPs
Type 1 (Infiltration) Tree Well (GS-1) without underdrain Biofilter (GS-3) without underdrain Permeable Pavement (GS-4) without underdrain Dispersion Area (GS-2) Drywell
Type 2 (Partial Infiltration) Tree Well (GS-1) with underdrain Biofilter (GS-3) with underdrain Permeable Pavement (GS-4) with underdrain
Type 3 (Low/No Infiltration) Tree Well (GS-1) with underdrain Biofilter (GS-3) with underdrain and liner
Hydrodynamic Separator
Vegetated Swale

Each of the facility types and infiltration conditions identified for consideration in the GSCW Plan were sized and sited according to the characteristics and requirements of the facility's drainage area. The modeling engine required a minimum set of input parameters for each facility profile to express these physical design characteristics. The required facility design parameters and guidance for calculating and/or estimating them for use with the GSCW Plan modeling approach can be found in Attachment C.1 BMP Modeling Parameters.

In cases where multiple BMP types are identified as being likely suitable for the project, the BMP type that is expected to produce the greatest number of benefits, based on the County of San Diego BMP Design Manual and Green Streets Guidelines, was prioritized in the model (Figure 2). This hierarchy is based on maximizing retention where feasible. Additionally, when biofiltration type (Tree Wells and Biofilters) BMPs were compared, Tree Wells were preferred within each priority. Tree Wells are deeper than Biofilters and therefore more space efficient, resulting in more volume capture per available footprint. Furthermore, Tree Wells are typically preferable based on 1) community preference (survey results), 2) provide greater environmental and community benefit (shading).

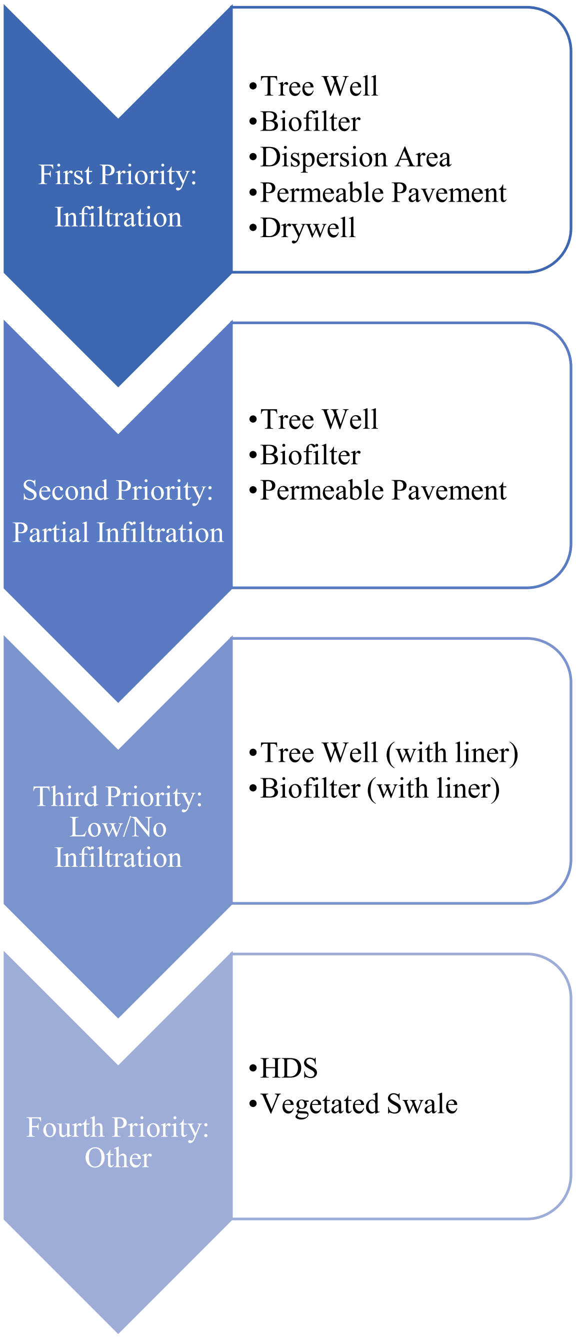


Figure 2. BMP Hierarchy for Modeling

1. Infiltration BMPs (Type 1) do not have impermeable liners or underdrains. Water quality treatment is maximized through retention and infiltration.

2. When full infiltration is not feasible, maximizing partial infiltration is preferred. Partial Infiltration BMPs (Type 2) BMPs do not have impermeable liners but do have underdrains. Water quality treatment is maximized through retention, infiltration, and biofiltration.

3. When partial infiltration is not feasible, Low/No Infiltration (Type 3) BMPs were preferred. These BMPs have impermeable liners and underdrains. Water quality treatment is predominately provided through biofiltration with a small component of retention.

4. When none of the BMPs are feasible, HDS units are selected. HDS units which provide mechanical filtration.

3.5 BMP Performance Quantification

3.5.1 Volume Capture Performance – Wet Weather

Long-term stormwater volume capture performances were modeled with the help of hundreds of long-term continuous modeling simulations performed for each rainfall gauge record. These simulations form nomographs tailored for use within San Diego County and represent the GSCW Plan BMP facilities. A nomograph is a chart that relates key sizing and design parameters of a BMP to the long-term performance of the BMP.

The stormwater BMPs considered for the GSCW Plan were sized according to either 1) the amount of volume capture they provide for purposes of retention and detention (volume-based, e.g., biofilter with an underdrain), or 2) their flow-through capacity for providing treatment (flow-based, e.g., HDS unit). To support the quantification of volume captured by BMPs for both design sizing paradigms, two complete sets of nomographs were prepared for each rainfall record. These nomographs were created by running batches of long-term continuous simulations for BMPs with various storage volumes and drawdown times (for volume-based BMPs) or various flow rates and watershed time of concentration (Tc) values (for flow-based BMPs). Drawdown time is the time required for a storm water BMP to drain and return to dry weather condition. For detention facilities, drawdown time is a function of basin volume and outlet orifice size. For infiltration facilities, drawdown time is a function of basin volume and infiltration rate (County of San Diego, 2020a).

Long-term simulations for volume-based BMPs span a 30-year period from October 1988 to October 2018 and use a 1-hour rainfall timestep. Each volume-based nomograph curve describes the relationship between a BMP's provided treatment capacity, its drawdown time (DDT), and its modeled long-term capture efficiency. Long-term simulations for flow-based BMPs span a 10-year period from October 2008 to October 2018 and use a 5-minute rainfall timestep. Each flow-based nomograph curve describes the relationship between a BMP's design flow rate, the Tc of the watershed, and the BMP's modeled long-term capture efficiency.

Hydraulic result summaries were extracted from each model run to evaluate the long-term BMP capture efficiency. The long-term capture efficiency is defined as the long-term volume treated (i.e., not bypassed) by the BMP divided by the long-term total volume received by the BMP, expressed as a percent. The results for each scenario were then plotted to obtain the nomographs. Example nomographs for the Bonita rainfall gauge are provided in Figure 3.

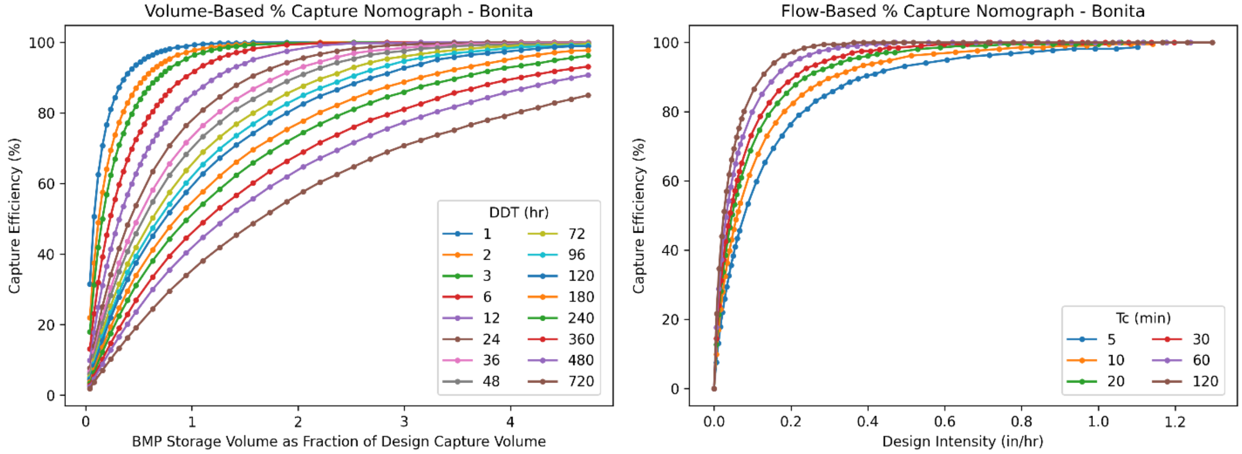


Figure 3. Bonita Gauge Volume Capture Nomographs for Volume-Based BMPs (left) and Flow-Based BMPs (right)

When used within the modeling framework, the volume-based capture nomograph storage volume values are normalized to be expressed as a fraction of the design capture volume. This allows the same nomograph to be used to estimate capture performance for two facilities that need to utilize the same reference rainfall gauge record, but which have different 85th percentile design storm depths according to the SD County 85th percentile isohyet. Equation 11 was used for normalizing the volume provided by the design capture volume.

$$DCV\ (cf) = RO\ Coeff * Drainage\ Area\ (sqft) * Design\ Storm\ Depth\ (inches) * \left(\frac{foot}{12\ inches}\right)$$

(Eq.11)

Similarly, the flow-based capture nomograph treatment rate values are normalized by the effective area of the drainage area to express the treatment rate provided by the facility in terms of design intensity. Equation 12 was used for the design intensity.

$$I_{design}(in/hr) = \frac{Treatment\ Rate\ (cfs)}{RO\ Coeff * Drainage\ Area\ (sqft)}\left(12\frac{inches}{foot}\right) * \left(3600\frac{seconds}{hr}\right)$$ **(Eq. 12)**

3.5.1.1 Nomograph Solution Approaches

Structural stormwater facility types that utilize nomographs to determine capture performance use the notion of 'compartments' to estimate their long-term volume capture. This allows the modeling engine to consult one nomograph curve for a slow draining storage compartment (e.g., gravel storage layer positioned below an underdrain which infiltrates into in-situ soils) and a different nomograph curve for the faster draining treatment and discharge compartment (e.g., the ponded volume which passes through the filter media before being discharged into the MS4). Each facility may be composed of one or two compartments, and the volume managed by each compartment is either counted as 'treated' and discharged downstream or it is counted as 'retained' and infiltrated. The remaining volume not captured by one of these compartments is considered bypass flow.

This compartment-based approach allows the system to calculate BMP capture for a very wide variety of facility configurations by combining one or two nomograph compartments. The compartments allowed for each of the stormwater BMP types considered for the GSCW Plan are shown in Table 12.

Table 12. Volume Capture Modeling Approaches for Structural Facility Type

Water Quality BMP Types	Volume-based Nomograph Compartments	Flow-based Nomograph Compartments
Type 1 (Infiltration) Tree Well (GS-1) without underdrain Biofilter (GS-3) without underdrain Permeable Pavement (GS-4) without underdrain Dispersion Area (GS-2) Drywell	Retention	--
Type 2 (Partial Infiltration) Tree Well (GS-1) with underdrain Biofilter (GS-3) with underdrain Permeable Pavement (GS-4) with underdrain	Retention Treatment	--
Type 3 (Low/No Infiltration)[1] Tree Well (GS-1) with underdrain Biofilter (GS-3) with underdrain and liner	Treatment	--
Hydrodynamic Separator	--	Treatment
Vegetated Swale	Retention[2]	Treatment

[1] Vegetated BMPs are also capable of performing retention via evapotranspiration. For this analysis, 1% of the long term capture of Type 3 facilities will be considered retained volume to account for retention via evapotranspiration.

[2] Vegetated Swales achieve incidental retention due to their un-lined design. Their volume capture performance benefits are calculated as a hybrid case of flow-based treatment and volume-based retention.

3.5.1.2 Single-Compartment Volume-Based Nomograph Traversal

The single-compartment BMP is the simplest case for facilities whose sizing and performance are most sensitive to the effective volume of the facility, such as with all infiltration facilities, low/no infiltration facilities, and drywells, as shown in Table 8. BMP input parameters are structured so that the total drawdown time can be inferred from commonly known design information like facility depth, total volume, and underlying infiltration rate, so that the correct curve can be chosen from the nomograph. Guidance on the drawdown time calculation is presented in Attachment C.1. For a single compartment BMP, the normalized BMP volume is determined as the ratio of the facility's total effective volume to the facility's drainage area DCV design volume.

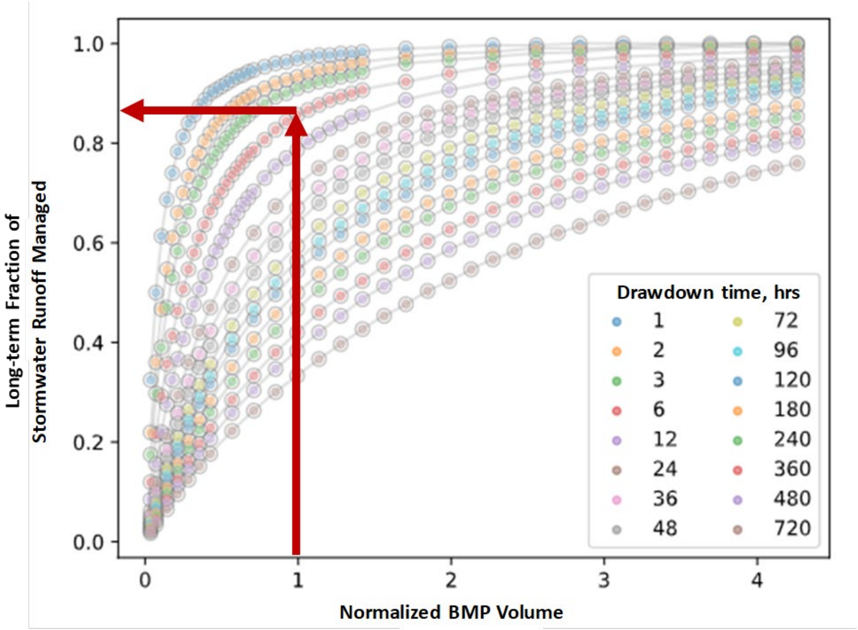


Figure 4. Single Compartment Volume-Based Nomograph Solution Example

Figure 4 above illustrates an example performance solution for an infiltration facility with a 6-hour drawdown time whose total volume is equal to the design volume of the tributary area. In this case, this modeling approach estimated that the facility achieves approximately 85% of long-term runoff volume retention.

3.5.1.3 Two-Compartment Volume-Based Nomograph Traversal

A two-compartment volume-based nomograph traversal is used for volume-based facilities that are capable of both retention and treatment of inflowing stormwater, such as the partial infiltration facilities shown in Table 8. These facility types will perform volume retention via infiltration through their gravel storage layers or soft-bottoms and will discharge treated flow into downstream infrastructure through their underdrains or outlet structures.

The first nomograph traversal is for the retention compartment since these facilities fill from the bottom and retention typically begins to occur before treated discharge. The following figure illustrates the traversal process for a two-compartment facility in which each compartment is sized to be 50% of the design volume. In this case, the drawdown time is 24 hours for the retention compartment and 3 hours for the treatment compartment. The following steps walk through the traversal process, which is illustrated in Figure 5.

1. Determined the retention capture performance by traversing 0.5 units along the x-axis and locate the correct trace for the 24-hour drawdown time of the retention compartment. The value is approximately 48% of long-term capture (shown in brown in the figure below).

2. Translated horizontally to the trace for the next compartment, which draws down in 3 hours (shown in green in the figure below).

3. Followed the green 3-hour drawdown trace up the nomograph for 0.5 units of x-axis distance.

4. In this example, about 83% of long-term capture is achieved by both compartments working in concert.

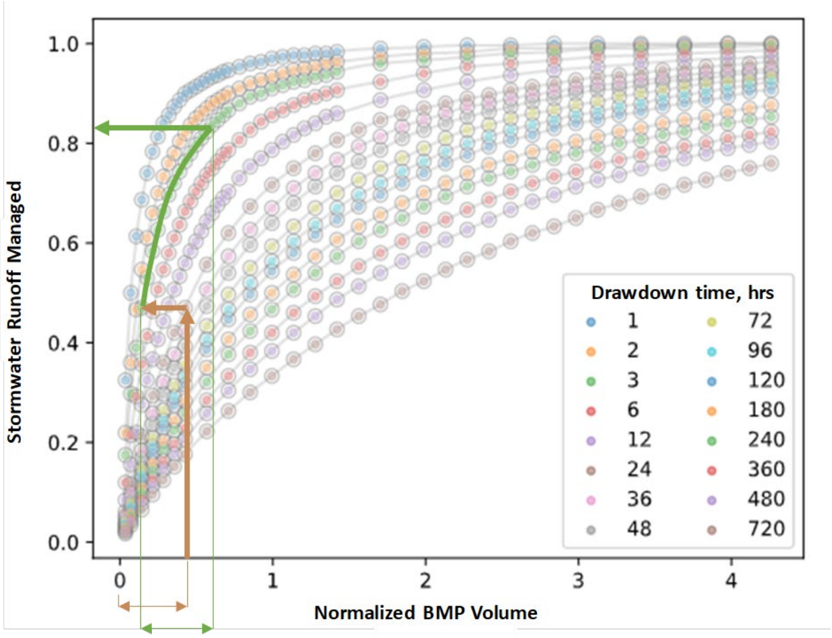


Figure 5: Two Compartment Volume-Based Nomograph Solution Example.

In this case, both compartments have the same volume capture capacity (0.5 design volumes), but they have different drawdown times.

3.5.1.4 Single-Compartment Flow-Based Nomograph Traversal

A single-compartment flow-based nomograph traversal is the simplest case for facilities whose sizing and performance are most sensitive to the design flow rate of the facility and the time of concentration of the treated land area. This nomograph is useful for modeling facilities such as an HDS unit. These facilities do not perform stormwater volume retention, only treatment and discharge.

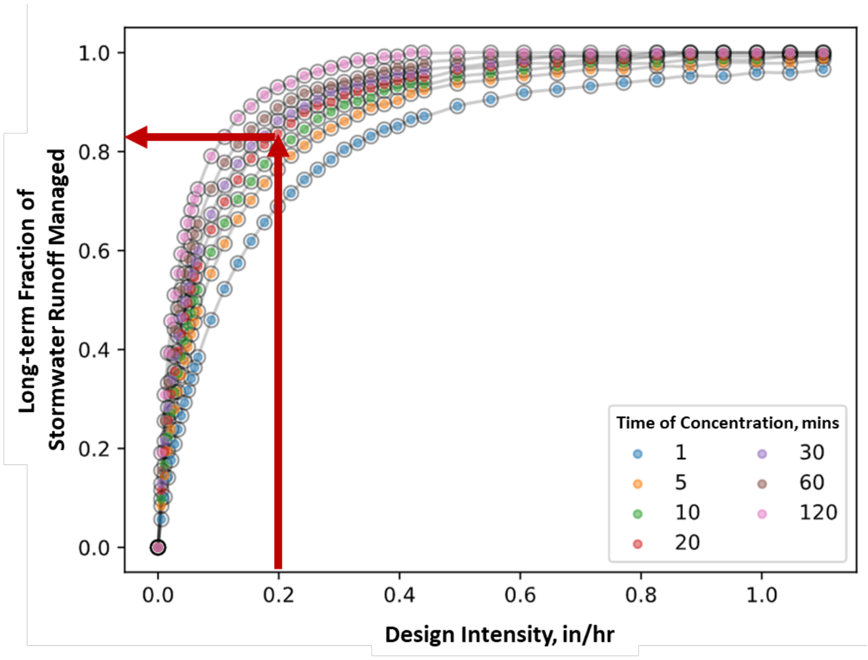


Figure 6. Single-Compartment Flow-Based Nomograph Solution

In the example nomograph shown above in Figure 6, a facility with a design treatment intensity of 0.2 inches/hr treats a drainage area with a 20-minute time of concentration and is expected to manage 83% of long-term runoff.

3.5.1.5 Hybrid Flow-Based Nomograph Traversal

This volume capture solution applies only to unlined flow-based facilities like a vegetated swale. These facilities are typically designed in a flow-based paradigm, but they may achieve incidental volume reduction via infiltration. For these facilities, the modeling module first computes the overall managed volume via the single-compartment flow-based approach, then uses the facility volume, depth, and underlying soil group to estimate the long-term retained volume using the volume-based nomograph. The treated volume discharged by the facility is then back-calculated as the difference between the overall facility captured volume and the retained volume.

3.5.2 Volume Capture Performance – Dry Weather

Dry weather BMP volume capture calculations were performed through steady-state comparison of the cumulative inflowing dry weather discharge rate (see Section 3.2.3 Dry Weather Discharge Quantity) and the rate at which the BMP can retain and/or treat inflows. The following procedure was used to determine what fraction of the dry weather flow is retained, treated, or bypassed for a given inflowing dry weather discharge rate.

1. Determined the retention rate of the BMP. If the facility has no retention compartment, this value is zero.
2. Compared the retention rate to the inflowing dry weather discharge rate. If the retention rate is higher, all dry weather discharge is retained. If the retention rate is lower, the retention rate is retained and subtracted from the inflowing dry weather discharge rate. The remaining inflowing dry weather discharge is released from the facility as either treated or untreated, depending on the treatment rate.
3. Determined the treatment rate of the BMP. If the facility has no treatment compartment, this value is zero.
4. Compared the treatment rate to the remaining inflowing dry weather discharge rate. If the treatment rate is higher, all the remaining inflowing dry weather discharge rate is discharged as treated volume. If the treatment rate is lower, the treatment rate is subtracted from the inflowing dry weather discharge rate, and the full treatment rate is considered treated and discharged. All remaining inflowing dry weather discharge is released from the facility as untreated dry weather flow.

This entire procedure was repeated and summarized by the modeling engine for both summer and winter season dry weather conditions.

3.5.3 BMP Load Reduction Performance Curves

In this modeling framework, BMP pollutant load reduction can be achieved in two ways:

1. Retain and infiltrate polluted inflows, and/or
2. Treat and discharge polluted inflows

Structural BMP facilities, such as partial infiltration and low/no infiltration facilities, HDS units, and vegetated swales are capable of treating and discharging a portion of their inflow volume. This modeling framework leveraged the influent-versus-effluent concentration curves developed based on monitoring studies in the International Stormwater BMP Database (http://bmpdatabase.org/) and prepared for the San Diego WQE (2018). An example plot representing the functional relationship between influent and effluent TSS concentration for several BMP types is shown below in Figure 7.

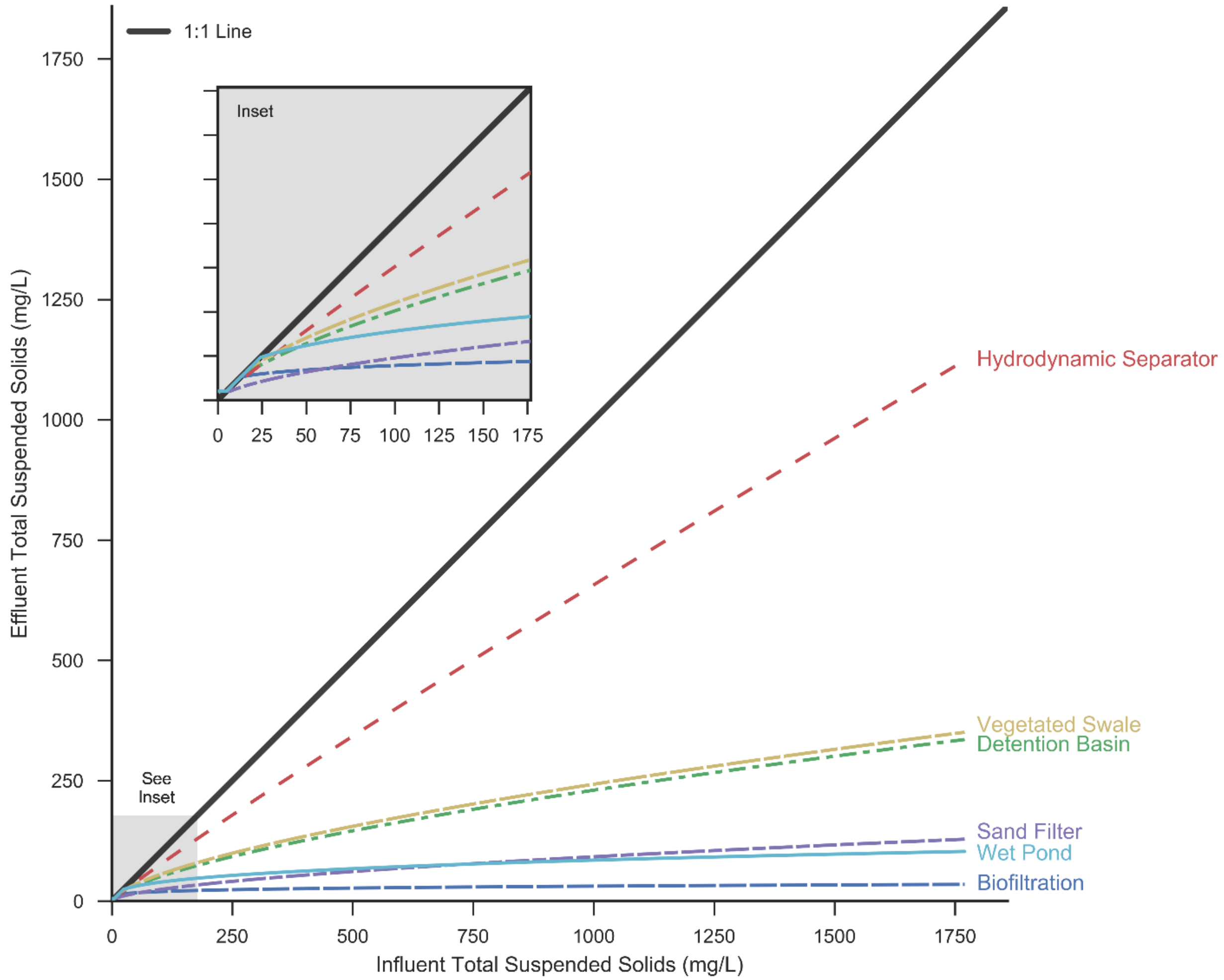


Figure 7. Influent vs Effluent Curve for TSS Removal by BMP Type

A significant amount of effort was invested into developing these characteristic BMP treatment performance curves for the SD WQE and a detailed report about the input data, statistical methods.

The overall load reduction quantification performed by the modeling engine was calculated for each of the three possible pollutant pathways through the BMP: retention, treatment and discharge, and untreated bypass. The total volume for each of these pathways was calculated as described in previous sections. The load present in the retained volume was considered fully treated & removed by the facility since this fraction of the inflow volume is infiltrated into the soil. The load for the treated discharge was calculated by determining the effluent concentration from the functional relationship and combining it with the volume treated and discharged. The facility bypass volume was assumed to be untreated and thus has the same pollutant concentrations as the inflowing runoff volume.

The load reduction processes and assigned treatment performance curve used for each structural stormwater facility type are listed below in Table 13.

Table 13. Load Reduction Mechanisms for GSCW Plan BMPs

Type	Water Quality BMP Types	Eliminates Load (Retained / Infiltrated)	Treatment & Discharge Performance Curve
Type 1 (Infiltration)	Tree Well (GS-1) without underdrain	Retention	--
	Biofilter (GS-3) without underdrain	Retention	--
	Permeable Pavement (GS-4) without underdrain	Retention	--
	Dispersion Area (GS-2)	Retention	--
	Drywell	Retention	--
Type 2 (Partial Infiltration)	Tree Well (GS-1) with underdrain	Retention	Biofiltration / Bioretention
	Biofilter (GS-3) with underdrain	Retention	Biofiltration / Bioretention
	Permeable Pavement (GS-4) with underdrain	Retention	--
Type 3 (Low/No Infiltration)	Tree Well (GS-1) with underdrain (no infiltration)	--	Biofiltration / Bioretention
	Biofilter (GS-3) with underdrain (no infiltration)	--	Biofiltration / Bioretention
--	Hydrodynamic Separator	--	Hydrodynamic Separator
--	Vegetated Swale	Retention	Vegetated Swale

3.5.4 BMP Peak Flow Mitigation Benefit

BMPs designed to retain or detain stormwater runoff volume may achieve the additional benefit of partially mitigating long-term peak runoff flowrates from their drainage areas. This benefit is quantified for volume-based BMPs by using the same long-term continuous SWMM simulations that produced the volume capture nomographs described in Section 4.1. For each of the SWMM simulation results, the long-term peak runoff flowrate and the long-term peak BMP discharge flowrate were compared to determine the percent reduction for each BMP size and drawdown time combination. As an example, the nomograph for peak flow mitigation is shown for the Bonita rainfall gauge in Figure 8.

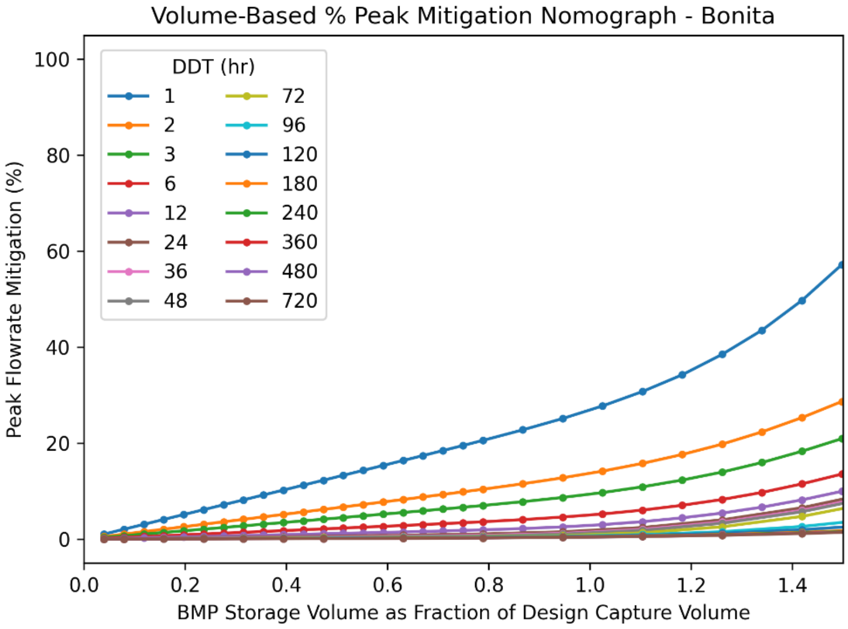


Figure 8. Bonita Rain Gauge Peak Flow Mitigation Nomograph

For peak flow mitigation benefits, larger facilities that provide more capture volume are expected to reduce long-term peak flows more effectively than smaller facilities. In addition, facilities that draw down more quickly, as by high underlying infiltration rates, are expected to reduce long-term peak flows more effectively than slowly draining facilities.

When scoring volume-based BMP facility with two compartments (e.g., partial infiltration BMPs), only the treat and discharge compartment will be considered for peak flow mitigation benefit. These BMPs are characterized by having a low infiltration rate and the contribution to long-term peak flow mitigation of the retention and storage pore volume is thus ignored during benefit quantification since it is de minimis compared to the treat and discharge compartment.

This methodology of ascribing long-term peak flow mitigation benefit was useful for determining the relative performance score for various BMP options across the County at the concept plan level that accounts for the varying rainfall patterns across the GSCW Plan study areas. Though it is useful for GSCW Plan project benefit scoring, this type of analysis cannot take the place of detailed hydraulic and hydrologic simulations that are necessary during future design phases.

3.5.5 BMP Trash Load Reduction Benefit

GSCW Plan stormwater BMP facility types that are approved as full trash capture BMPs will claim the benefits of eliminating all the trash load generated by their project drainage areas. Therefore, the trash benefit calculation for each applicable GSCW Plan BMP assessed for this effort was equal to the land-use area-weighted trash volume (gallons) generated by the project drainage area.

3.5.6 BMP Treatment Benefit Quantification Summary

The following steps summarize the performance metrics benefit quantification workflow that was used for each GSCW Plan proposed project:

1. Evaluated drainage areas for local opportunities and constraints to determine potential locations for Green Street BMPs.
2. Determined treatable drainage areas and delineated them in GIS.
3. Calculated the HRU characteristics for each drainage area that will be routed to a BMP for treatment. An ArcGIS toolbox performed the necessary intersections with reference data layers and produced a land surface characteristics table. This table was used as an input into the water quality modeling engine to determine the wet weather annual runoff volume and the dry weather annual discharge volume as described in Sections 3.2.1 and 3.2.2.
4. Calculated trash loading from the drainage area using the ArcGIS Toolbox.
5. Defined the input parameters for the on-site BMP(s), including facility type, location, and required input parameters defined in Attachment C.1.
6. Loaded the input tables from Steps 3 and 5 into the water quality analysis tool to evaluate the scenario for water quality performance benefits.
7. If the BMP was capable of full trash capture, computed the trash load reduction benefit.

The water quality benefit quantification methodology presented in this attachment has been selected to quantify BMP performance to the extent feasible with the data available at this time and is consistent with San Diego County BMP sizing design guidance (CoSD BMP DM, 2020). The methodology was used to quantify key project benefits, including wet and dry weather volume and pollutant load reduction, as well as peak flow mitigation for each of the BMPs sited within the top 85 drainage areas. These performance values were used to score the environmental portion of the triple bottom line project prioritization.

3.6 Limitations

The water quality benefit quantification and prioritization of the BMP projects were performed based on the available data and tailored to the characteristics of the study area. The methods, datasets, and assumptions used here may not be applicable to other areas or regions. The GSCW Plan study area is unique compared to many similar efforts due to the wide geographic region covered within the unincorporated County. Modeling inputs are presented for the suite of selected BMPs only.

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ATTACHMENT C.1 – BMP MODELING PARAMETERS

BMP Modeling Parameters

This document is intended to provide guidance to define the required modeling parameters necessary for the GSCWP Modeling Engine to correctly represent the structural BMP under analysis. These modeling parameters are required inputs for each facility to produce accurate estimates of water quality benefits using the GSCWP Modeling Engine.

These supported BMP types and their input parameters have been customized to support the County of San Diego’s Green Streets Clean Water effort. The following sections and tables provide guidance on how to specify the modeling input parameters for each of the GSCWP BMP facility types.

1 COMMON PARAMETERS FOR ALL BMPS

The following common parameters are required for most structural BMPs.

BMP Types	Parameter Name	Units	Field Description	Purpose in Modeling Engine
All BMPs	Delineation(s) or Upstream BMP	--	Assign a delineation to the BMP through the normal delineation options. **OR** Indicate that the BMP receives flow from an upstream BMP.	Determines what drains to the BMP, or if it receives flow that has already been treated by another BMP.
	Lat, Long	Degrees (WGS 1984)	Locate the BMP on the landscape	Assigns the 85th percentile storm depth according to the nearest isohyet (CoSD Hydrology Manual 2015). Assigns the relevant rainfall zone for selecting an appropriate nomograph.

2 PARAMETERS FOR INFILTRATION BMPS

The following parameters are required to model infiltration BMPs.

BMP Types	Parameter Name	Units	Description	Guidance and Defaults
Tree Well (GS-1) with no underdrain Biofiltration (GS-3) with no underdrain Permeable Pavement (GS-4) with no underdrain Dispersion Area (GS-2)	Total Effective BMP Volume	cu-ft	The volume of the BMP available for water quality purposes. This includes ponding volume and the volume available in subsurface layers. It does not include flow control volumes or other volume that is not designed for water quality purposes.	Total effective volume = ponded volume + pore volume Simple methods: - Ponded volume = WQ ponding depth * wetted area when ponded at half of WQ depth - Pore volume = media and gravel volume * respective porosity o Default media porosity = 0.25 o Default gravel porosity = 0.4
	Infiltration Surface Area	sq-ft	Surface area through which infiltration can occur in the system. If infiltration will occur into the sidewalls of a BMP, it is appropriate to include half of the sidewall area as part of the infiltration surface area.	Estimate the area of the BMP floor and sidewalls that are wetted when the BMP at half of its total effective volume. Sidewalls are typically negligible for permeable pavement and underground infiltration galleries.
	Underlying Infiltration Rate	in/hr	The underlying infiltration rate below the BMP. This refers to the underlying soil, not engineered media.	A design infiltration rate should be calculated when infiltration is the only means of treatment
	Drawdown time	hrs	The time required for a BMP to drain and return to the dry-weather condition. For infiltration facilities, drawdown time is a function of basin volume and infiltration rate.	The drawdown time can be estimated by dividing the effective retention depth within all layers of the BMP by the design infiltration rate of the underlying soil.

BMP Types	Parameter Name	Units	Description	Guidance and Defaults
Drywell	Total Effective BMP Volume	cu-ft	The volume of the BMP available for water quality purposes. This includes the volume in any pre-treatment chamber as well as the volume in the well itself.	Add the volume of the pre-treatment system and the drywell, including free water volume and pore volume.
	Infiltration Discharge Rate	cfs	Design or tested infiltration flowrate of the drywell. This is specified in cu-ft per second, rather than inches per hour.	This value varies based on boring depth, width, and site soil conditions.
	Drawdown time	hrs	The time required for a BMP to drain and return to the dry-weather condition. For infiltration facilities, drawdown time is a function of basin volume and infiltration rate.	Dry are typically designed to infiltrate within 96 hours. However they are sized and treated as flow-based systems in this engine and therefore drawdown time is not used in sizing.

3 PARAMETERS FOR BMPS WITH ELEVATED UNDERDRAINS

This BMP type discharges treated water and provides stormwater retention via infiltration. There are two distinct compartments: the retention compartment below the underdrain elevation and the biofiltration compartment above the underdrains (media + ponding). The following parameters are required to model this BMP type.

BMP Types	Parameter Name	OCST Units	Description	Guidance and Defaults
Biofiltration (GS-3) with underdrain Tree Well (GS-1) with underdrain Permeable Pavement (GS-4) with underdrain	Total Effective BMP Volume	cu-ft	The volume of the BMP available for water quality purposes. This includes ponding volume and the available pore volume in media layers and/or in gravel storage layers. It does not include flow control volumes or other volume that is not designed for water quality purposes.	Total effective volume = ponded volume + pore volume Simple methods: - Ponded volume = WQ ponding depth * wetted area when ponded at half of WQ depth - Pore volume = media and gravel volume * respective porosity o Default media porosity = 0.25 o Default gravel porosity = 0.4
	Storage Volume Below Lowest Outlet Elevation	cu-ft	The volume of water stored below the lowest outlet (e.g., underdrain, orifice) of the system.	Calculate the volume contained in gravel or soil pores that is below the lowest outlet from the system. See calculations and defaults above.
	Media Bed Footprint	sq-ft	Surface area of the media bed of the BMP.	This can be estimated based on the ponded volume divided by the ponding depth.
	Design Media Filtration Rate	in/hr	Design filtration rate through the media bed. This may be controlled by the media permeability or by an outlet control on the underdrain system.	If not known, a reasonable default is 2.5 in/hr.
	Underlying Hydrologic Soil Group (HSG)	[A, B, C, D]	Choose the soil group that best represents the soils underlying the BMP. This is used to estimate a default infiltration rate.	Default to D
	Drawdown time	hrs	The time required for a BMP to drain and return to the dry-weather condition. For facilities with elevated underdrains, drawdown time is a function of basin volume, outlet sizing, and infiltration rate.	For two compartment BMP types the drawdown time for the ponded volume is a function of the outlet and the underlying infiltration rate. The Drawdown time of the retention volume is a function of the infiltration rate.

4 PARAMETERS FOR BIOFILTRATION AND FILTRATION BMPS WITH LINER

The following parameters are needed to model biofiltration and filtration BMPs with a liner. This group of BMPs is “volume-based” which means they have a design capture volume and drawdown time.

BMP Types	Parameter Name	Units	Description	Guidance and Defaults
Biofiltration (GS-3) with underdrain and liner Tree Well (GS-1) with underdrain	Total Effective BMP Volume	cu-ft	The volume of the BMP available for water quality purposes. This includes ponding volume and the available pore volume in media layers. It does not include flow control volumes or other volume that is not designed for water quality purposes.	Total effective volume = ponded volume + pore volume Simple methods: - Ponded volume = WQ ponding depth * wetted area when ponded at half of WQ depth - Pore volume = media and gravel volume * respective porosity o Default media porosity = 0.25 o Default gravel porosity = 0.4
	Media Bed Footprint	sq-ft	Surface area of the media bed or sand bed of the BMP.	This can be estimated based on the ponded volume divided by the ponding depth.
	Design Media Filtration Rate	in/hr	Design filtration rate through the media/sand bed. This may be controlled by the media/sand permeability or by an outlet control on the underdrain system.	If not known, a reasonable default is 2.5 in/hr.

	Drawdown Time	hr	The time required for a BMP to drain and return to the dry-weather condition. For infiltration facilities, drawdown time is a function of basin volume and infiltration rate	Surface Ponding: The drawdown time can be estimated by dividing the WQ ponding depth by the design media filtration rate.

5 PARAMETERS FOR PROPRIETARY FLOW-BASED BMPS

The following parameters are needed to model BMPs the following flow-based treatment BMPs. These BMPs do not retain or detain significant volume. They treat water as it flows through them up to a certain design flowrate.

BMP Types	Parameter Name	Units	Description	Guidance and Defaults
Hydrodynamic Separator	Treatment Rate	cfs	The flowrate at which the BMP can provide treatment of runoff.	Obtain from manufacturer specifications.
	Time of Concentration	mins [5,10, 15,20, 30,45, 60]	The time required for the entire drainage to begin contributing runoff to the BMP. This value must be less than 60 minutes.	Default 10 mins is reasonable for most developed catchments with size of at least 0.2 acres. For smaller catchments, assume 5 minutes.

6 PARAMETERS FOR VEGETATED FLOW-BASED BMPS WITH INCIDENTAL INFILTRATION

This group of BMPs are typically sized with flow-based methods, but also typically have soft bottoms and may therefore provide incidental volume reduction via infiltration.

BMP Types	Parameter Name	Units	Description	Guidance and Defaults
Vegetated Swale	Treatment Rate	cfs	The flowrate at which the BMP can provide treatment of runoff.	Enter the design flowrate of the facility.
	Time of Concentration	mins [5,10, 15,20, 30,45, 60]	The time required for the entire drainage to begin contributing runoff to the BMP. This value must be less than 60 minutes. See TGD guidance.	A default of 10 mins is reasonable for most developed catchments with size of at least 0.2 acres. For smaller catchments, assume 5 minutes.
	Wetted Footprint	sq-ft	Wetted footprint when BMP is half full.	
	Effective Retention Depth	feet	Depth of water stored in shallow surface depression or media/rock sump for infiltration to occur. Must account for gravel porosity.	If there is an infiltration sump in the swale, then use this value. Most of this time this will be zero.
	Underlying Hydrologic Soil Group (HSG)	[A, B, C, D, Lined]	Choose the soil group that best represents the soils underlying the BMP. This is used to estimate a default infiltration rate.	If not known assume D soils as a conservative default.

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