Chapter 2

Watershed Flow Regime Restoration Evaluaton Process

Developing Stormwater BMP Quality Gallon Metrics

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CH2MHILL

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Developing Stormwater BMP Quality Gallon Metric

Introduction

Stormwater best management practices (BMPs) for flow management are installed for the primary purpose of controlling runoff coming from a given drainage area. It is evident, however, that BMPs also have varying effects upon the environment whether positive or negative. BMPs can provide additional environmental benefits including pollutant removal, habitat creation, improved water quality; or have negative impacts on the environment such as increasing temperature or causing an obstruction to fish passage.

The concept of stormwater flow management is that a BMP provides water storage under certain design precipitation events to protect or restore the flow regime in the watershed. For a given precipitation event under the design criteria, the BMP provides a storage or infiltration volume in gallons. As discussed in Chapter 1 of this report, the flow duration curves help determine the storage or infiltration required at the subwatershed level to meet target flow conditions.

The contribution that individual BMPs make to the overall subwatershed targets can be tracked through an accounting system. The accounting system can quantify the storage or infiltration gallons provided by an individual BMP, and track the relative contribution of individual BMPs to other environmental benefits. Tracking both gallons and additional environmental benefits provides the opportunity to create a metric that ranks the individual BMPs in terms of their quantifiable flow regime contribution and their relative influence on habitat and other beneficial factors.

The following section summarizes the different types of BMPs used for flow control and introduces a “Quality Gallon” accounting approach that quantifies the overall impact that specific BMPs have on the watershed in terms of flow regime restoration and other environmental effects.

This chapter is one of a series of related documents[1] developed under a study to address Great Lakes flow regime-based ecosystem improvement projects. These chapters are presented individually because different applications are anticipated depending upon end users’ goals. Chapters may be useful to users individually or collectively.[2]

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[1] Executive Summary, Chapter 1: Watershed Flow Regime Restoration Evaluation Process, Chapter 2: Developing Stormwater BMP Quality Gallon Metric, Chapter 3: BMP Evaluation Process, Chapter 4: Quality Gallon Accounting System Protocol, Chapter 5: Facilitating and Funding Stormwater Management for Ecosystem Improvement, Chapter 6: Ecosystem Improvement Transaction Example Contracts, Chapter 7: Study Evaluation, Chapter 8: Study Communication Summary

[2] The project team members (CH2M HILL in association with The Conservation Fund, Cook and Franke, Public Sector Consultants, and Stormtech) acknowledge the generous support from the Great Lakes Protection Fund as part of their Growing Water suite of research projects.

Stormwater BMPs

With the relatively recent interest in low impact development (LID) stormwater management from many states and local regulatory agencies, there has been a rapid growth in various types of BMPs in addition to conventional detention or retention systems. Table 2-1 synthesizes the range of stormwater BMPs into 12 categories. The categories were developed by the project team based upon its stormwater management experience and in consultation with other industry experts. Nevertheless, there are many other BMPs that are not listed in the table but that can be incorporated in this analysis in a similar manner.

TABLE 2-1
Categories and Examples of Stormwater BMPs

BMP Categories	Example BMPs
Stormwater Wetlands	Constructed wetlands used to treat stormwater.
Bioretention	Decentralized stormwater controls, primarily based on engineered soils, that use plants, microbes, and soil filtration to remove pollutants from runoff. Implementations include bioretention swales, rain gardens, and median storage and detention.
Grassed Swale	Broad and shallow earthen channel vegetated with erosion resistant and flood-tolerant grasses. Check dams or engineered soil mixtures may be used to encourage infiltration and sedimentation.
Sand Filter	Device to filter runoff through a sand layer (with or without underdrain) prior to the ultimate point of discharge. Typical systems may consist of an inlet structure, sedimentation chamber, sand bed, and underdrain piping.
Riparian Buffer	Forested or grassed areas along the sides of a stream. Level spreaders may be used to distribute flow from pipes and ditches across the buffer and prevent short-circuiting.
Offline Wet Detention Basin	Traditional detention basin with a permanent pool of water to trap sediments and provide peak flow attenuation. The facility is located in an upland area and does not obstruct stream flow.
Inline Wet Detention Basin	A storage facility constructed by damming a stream.
Dry Detention Basin	A detention basin without a permanent pool that drains completely after a storm.
Rooftop Runoff Management	A BMP to manage runoff generated by rooftops, for example a green roof or a cistern or rain barrel for rain water capture and reuse.
Underground storage	A detention facility located underground to maximize usability of surface space. Underground storage can take multiple forms including concrete vaults, corrugated steel pipe systems, or commercially manufactured systems.
Permeable Pavement and Infiltration Devices	Nonvegetated infiltration systems, such as infiltration trenches, dry wells, and permeable paving materials including porous asphalt, porous concrete, and permeable pavers.
Land Use Conversion	Changing land use to reduce runoff generation, improve water quality, and enhance aquatic and terrestrial habitat. For example, conversion of an impervious area, such as a parking lot or building, to a forest or prairie.
Floodplain Enhancement	Projects that restore or create floodplains to provide temporary storage for floodwaters and sediment produced by the watershed.
Direct Discharge/Baseflow Augmentation	Augmentation of stream baseflow in a watershed with discharge sources such as treated effluent from a municipal wastewater treatment plant, industrial plant, or power plant.

The type of BMP selected and its location within the watershed determine how effective it is in the control of pollutants, prevention of downstream flooding, and protection and enhancement of surface and groundwater flow regimes. For example, a stormwater wetland can improve water quality by filtering nutrients and suspended solids, and provide fish spawning habitat. A rain garden reduces runoff volumes through infiltration and provides water quality benefits, however it does not provide aquatic habitat. In some cases, BMPs may provide benefits in one area like flow control while at the same time creating impairments to other ecosystem values. For instance, dams constructed for flood control may have detrimental impacts on the downstream ecosystem by increasing temperatures, interfering with natural sediment transport, and blocking fish migration.

Table 2-2 groups the ecosystem effects of BMPs into nine parameters. For each of the nine parameters, examples outline the potential effects on the ecosystem of specific types of BMPs.

TABLE 2-2
Summary of BMP Effects on the Ecosystem

Ecosystem Parameters	Examples
Temperature Moderation	If the overall water body temperature of a system is altered, an aquatic community shift can be expected. Cold water fish, such as trout and salmon, may disappear and be replaced by warm water fish, such as sunfish and carp. Higher temperatures also exacerbate low dissolved oxygen level problems in lakes and reservoirs. The increased storage time and surface area in detention ponds contributes to temperature increases, while infiltration-based BMPs contribute to maintaining or decreasing temperature.
Physical Aquatic Habitat Improvement	Aquatic organisms require adequate channel substrate, pool frequency, and available cover (for example, large woody debris) to feed, reproduce, and hide from predators. An underground storage device would have a lower habitat value than a treatment wetland.
Nutrient Control	The increase of nutrients in stormwater runoff such as phosphorus and nitrogen accelerates eutrophication of receiving waters. As eutrophication progresses, water bodies can experience algal blooms, decreased dissolved oxygen levels, and fish kills. A bioretention facility would be expected to remove more nutrients than a dry detention pond.
Bacteria Control	In urban developed areas, high levels of bacteria can be found in stormwater. Receiving waters can be contaminated with bacteria to the point where recreation and public water supplies are impaired. BMPs that promote filtration can be effective at removing bacteria.
Solids Control	Sediment deposition can cover plants and animals and fill in rivers and lakes. Very fine suspended sediment causes the water to become cloudy, reducing the distance that light can penetrate into the water body. BMPs that encourage settling or filtration can be effective at controlling solids.
Improved Dissolved Oxygen	Both aquatic plants and animals depend on dissolved oxygen for survival. Different aquatic organisms have different oxygen needs. Trout, for example require more dissolved oxygen than other aquatic organisms. Dissolved oxygen levels are affected by temperature, rate of photosynthesis, the degree of turbulence, and the amount of organic matter. BMPs that promote cooler temperatures provide dissolved oxygen benefits.
Erosive Energy Control	Increased velocities can cause scouring, channel widening, stream incisement, and increased sedimentation. BMPs that slow stream velocity, such as a floodplain enhancement, provide more erosion control than BMPs that do not directly affect stream velocity. BMPs that reduce runoff volume through infiltration also help control erosion.
Baseflow Enhancement	Lower stream flows are more susceptible to seasonal temperature extremes in both winter and summer. The dewatering of reaches can block fish passage. BMPs that add water through infiltration enhance baseflows. Direct discharges can also be considered as baseflow enhancements.
Terrestrial Habitat Improvement	Restoration of native vegetation communities fosters diverse plant and animal populations in addition to the in-stream ecosystem. For example, a stormwater wetland BMP provides more habitat than an underground detention facility.

There are other important considerations for the selection of BMPs including social/political, land control, and costs associated with construction and maintenance. These factors can be taken into account as part of a formal ranking and prioritization procedure. However, for the purposes of this study, only the factors related to the goal of flow regime and ecosystem restoration are taken into account.

Quality Gallons

The “additional” benefits or impacts to the ecosystem that may result from a stormwater BMP are taken into account through a concept termed *Quality Gallons*. The environmental impacts of the BMPs, whether they are positive or negative, are taken into account by the use of multipliers that modify the BMP volume into a “quality”-based volume. As discussed in Chapter 1, the water stored or infiltrated by a BMP is a measure of the BMP’s contribution to the flow restoration target. The stormwater BMP volume is then converted into a “quality” volume by the use of three multipliers that account for the BMP environmental impacts. These multipliers include the following:

- **BMP Type.** This multiplier quantifies the impact, either positive or negative, that a specific stormwater BMP (Table 2-1) has on different ecosystem parameters (Table 2-2).
- **BMP Location.** This multiplier quantifies the benefit associated with constructing a stormwater BMP at a location that will have the greatest benefit on the receiving stream and downstream aquatic resources.
- **Watershed Priority.** This multiplier quantifies the benefit achieved by locating a stormwater BMP in an area and for a purpose that is identified as a restoration priority by watershed stakeholders.

The combination of these three multipliers is used to convert the stormwater BMP storage or infiltration volume from gallons to a *Quality Gallons*, which recognizes the impacts of specific BMPs on the ecosystem both in terms of flow restoration and other critical factors. The multipliers value the relative amount of improvement provided to the environment with respect to BMP type, and its location and relationship to watershed priorities. It is important to note that while the *gallons* metric provides a quantitative measure towards restoring the flow regime (meeting the flow regime target condition), the *Quality Gallons* metric will only measure the relative impact on the ecosystem (positive or negative) of the BMPs selected as compared with other BMPs. *Quality Gallons* are not intended to measure progress towards any water quality or habitat ecosystem improvements since the *Quality Gallon* multipliers are not based upon other impairments in the watershed. Instead, because the *gallons* metric can be achieved by any number of BMPs, the *Quality Gallons* metric attempts to steer the choice of a BMP toward maximizing total ecosystem benefits.

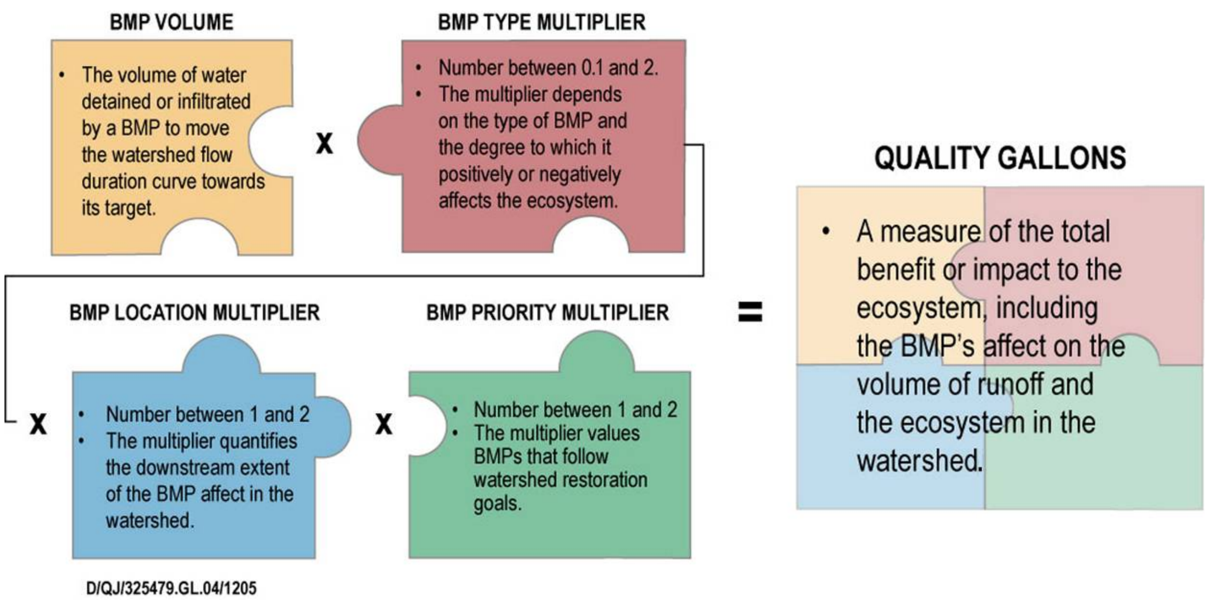
The BMP gallons are determined through the design criteria as described in Chapter 1. To convert gallons to *Quality Gallons*, the multipliers identified above are incorporated in the equation below, which is graphically illustrated in Figure 2-1. The *Quality Gallons* equation takes into account the positive and negative impacts on the ecosystem that selected BMPs can have by adjusting the BMP volume with multipliers that place a value on the design and location of the stormwater BMP as well as the watershed restoration priorities. The *Quality*

Gallon approach accounts for the fact that not all BMPs have the same value to the ecosystem.

$$QG_{BMP} = V_{BMP}\, T_{BMP}\, L_{BMP}\, P_{BMP}$$

Where V_{BMP} is the stormwater control volume, storage or infiltration, provided by the BMP, in gallons; T_{BMP} is the BMP type multiplier; L_{BMP} is the BMP location multiplier; and P_{BMP} is the BMP watershed priority multiplier.

FIGURE 2-1
Equation to Calculate Quality Gallons

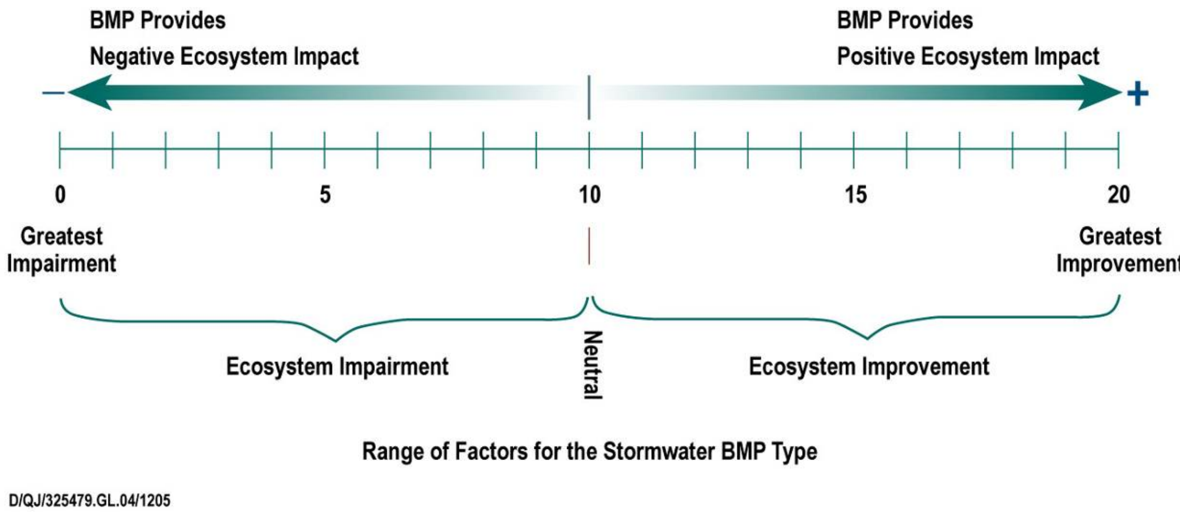


Because its primary focus is individual BMPs, the *Quality Gallon* concept does not account for system-wide impairments such as fish passage barriers, toxics, or invasive species that would affect fish populations and cannot be addressed through stormwater management controls. Nevertheless, it is possible to use the location or watershed priority multipliers to consider these effects. For example, a watershed that has significant barriers could be given a low priority until the barriers are removed.

BMP Type Multiplier

The stormwater BMPs identified in Table 2-1 will affect the ecosystem parameters identified in Table 2-2 in different ways. A BMP may improve some ecosystem parameters while negatively impacting others as a result of how the BMP manages the stormwater. For example, a detention pond can provide beneficial nutrient, solids, and erosive energy control, but may negatively affect water temperature. The degree to which a BMP affects the ecosystem is scaled with a numerical factor between 1 and 20, with 10 being a neutral value. If a BMP has negative impacts on an ecosystem parameter, a factor between 1 and 9 would be assigned. A BMP that has a significant negative impact may be assigned a numerical factor of 1, while a BMP with a slightly negative impact on the ecosystem may receive a numerical factor of 9. Positive effects on the ecosystem are accounted for with a numerical factor between 11 and 20. A BMP with a significant beneficial impact on the ecosystem may receive a value of 20, while a BMP that provides a small improvement to the ecosystem may receive a factor of 11. Figure 2-2 illustrates the factor scale and the range of the positive and negative ecosystem impacts.

FIGURE 2-2
Range of Positive and Negative Impacts on the Ecosystem that Result from Different BMPs



This approach of using factors to quantify the impact that BMPs have on the ecosystem is modeled after similar methods developed by the U.S. Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers (USACE) for wetland and stream assessments (USACE 2004, Barbour et al. 1999).

Table 2-3 is a matrix of BMP types compared to ecosystem effects of the BMPs outlined in Tables 2-1 and 2-2. Numerical values were assigned to quantify the known relative impacts that specific BMPs have on the ecosystem parameters described. The values were assigned based upon a review of the literature, project experience of the firm's involved in this research project and through consultation with other experts in the field. It is important to note that the values in Table 2-3 can be adjusted for site-specific designs or based on expert opinion specific to the target watershed. The values shown in Table 2-3 are a general starting place for a watershed and the BMPs listed but it is expected that the multipliers will be defined through a consensus-based process among watershed stakeholders and experts.

TABLE 2-3
BMP Type Factors

	Factor [a]								
BMP	Temperature Moderation	Physical Aquatic Habitat Improvement	Nutrient Control	Bacteria Control	Solids Control	Improved Dissolved Oxygen	Erosive Energy Control	Baseflow Enhancement	Terrestrial Habitat Improvement
Stormwater Wetlands	15	17	20	15	20	13	20	15	20
Bioretention	20	10	15	20	20	13	13	20	10
Grassed Swale	10	10	13	15	15	13	13	13	10
Sand Filter	20	10	13	20	20	13	13	15	10
Riparian Buffer	15	17	15	15	15	10	15	13	20
Offline Wet Detention Basin	5	10	13	5	20	10	15	10	10
Inline Wet Detention Basin	5	5	13	5	5	10	15	10	10
Dry Detention Basin	5	10	15	10	13	10	15	10	10
Rooftop Runoff Management	15	10	10	10	10	10	13	10	13
Underground storage	20	10	8	3	13	5	13	10	10
Permeable Pavement and Infiltration Devices	20	10	13	15	15	10	13	15	10
Land Use Conversion	15	10	15	10	15	10	15	15	20
Floodplain Enhancement	15	20	13	15	20	10	20	10	20
Direct Discharge/Baseflow Augmentation	15	10	5	10	10	13	10	20	10

[a] Factor values indicate the following:
1 to 9 = negative impact
10 = neutral
11 to 20 = positive impact

Ecosystem Value Weights

Some individual ecosystem parameters identified in Table 2-2 may be more important than others to watershed stakeholders or to achieve priorities established in a watershed master plan. In some watersheds restoration of impairments associated with water quality may be more important or equally important as restoration of target flow regimes. For example, if a watershed master plan has identified physical habitat and nutrients as the limiting factors, a flow regime enhancement BMP that provides additional habitat and nutrient improvement would be valued higher in the watershed than a BMP that does not address these watershed priorities. Therefore, BMPs that target watershed goals are valued more than BMPs that do not.

By assigning a value to the ecosystem components, watershed stakeholders are able to weigh ecosystem parameters that are most important to the restoration of their watershed. The weight assigned to an ecosystem parameter is specific to a watershed and may change as additional information within the watershed is collected and analyzed. Table 2-4 provides an example of weighting the ecosystem parameters.

TABLE 2-4
Example of Weights for Ecosystem Parameters

	Temperature Moderation	Physical Aquatic Habitat Improvement	Nutrient Control	Bacteria Control	Solids Control	Improved Dissolved Oxygen	Erosive Energy Control	Baseflow Enhancement	Terrestrial Habitat Improvement
Sample Ecosystem Value Weight [a]	1	2	2	1	1	1	1	0	1

[a] Ecosystem Weight Scale:
0 = Ecosystem component not a concern in the watershed
1 = Ecosystem component is important to the health, function, and restoration of the watershed
2 = Ecosystem component is very important to the health, function, and restoration of the watershed

The sample ecosystem value weights from Table 2-4 and BMP type factors shown in Table 2-3 are combined to yield a hypothetical *BMP Type Multiplier* found in Table 2-5, where the ecosystem parameters are weighted with respect to the restoration goals of the watershed. BMPs that move the watershed towards flow and ecosystem improvement consistent with management goals have a larger multiplier and are thus given more “credit” in calculating the *Quality Gallons*. For example, the weights in Table 2-4 indicate that in this hypothetical example, habitat restoration and nutrients are very important but that baseflow is not an issue in restoring the ecosystem.

The last column of Table 2-5 is the *BMP Type Multiplier* T_{BMP}, the first of the three multipliers that are used to calculate *Quality Gallons* and is computed from

$$T_{BMP} = \frac{\sum_{i=1}^{9} w_i F_i}{10 \sum_{i=1}^{9} w_i}$$

Where F_i is the value and w_i is the weight for ecosystem factor i. The normalizing factor of 10 in the denominator maintains the value of T_{BMP} between 0 and 2.

TABLE 2-5
Example of BMP Type Multiplier Calculation Including Ecosystem Factors and Weights

	Temperature Moderation	Physical Aquatic Habitat Improvement	Nutrient Control	Bacteria Control	Solids Control	Improved Dissolved Oxygen	Erosive Energy Control	Baseflow Enhancement	Terrestrial Habitat Improvement	Sum of Weights	Value Adjustment (Sum×10)
Sample Ecosystem Value Weights	1	2	2	1	1	1	1	0	1	10	100
BMP	**Hypothetical Weighted Factors [a]**									**Sum of Factors**	**BMP Type Multiplier [b]**
Stormwater Wetlands	15	34	40	15	20	13	20	0	20	177	1.77
Bioretention	20	20	30	20	20	13	13	0	10	146	1.46
Grassed Swale	10	20	26	15	15	13	13	0	10	122	1.22
Sand Filter	20	20	26	20	20	13	13	0	10	142	1.42
Riparian Buffer	15	34	30	15	15	10	15	0	20	154	1.54
Offline Wet Detention Basin	5	20	26	5	20	10	15	0	10	111	1.11
Inline Wet Detention Basin	5	10	26	5	5	10	15	0	10	86	0.86
Dry Detention Basin	5	20	30	10	13	10	15	0	10	113	1.13
Rooftop Runoff Management	15	20	20	10	10	10	13	0	13	111	1.11
Underground storage	20	20	16	3	13	5	13	0	10	100	1.00
Permeable Pavement and Infiltration Devices	20	20	26	15	15	10	13	0	10	129	1.29
Land Use Conversion	15	20	30	10	15	10	15	0	20	135	1.35
Floodplain Enhancement	15	40	26	15	20	10	20	0	20	166	1.66
Direct Discharge/Baseflow Augmentation	15	20	10	10	10	13	10	0	10	98	0.98

[a] Weighted Factor = Ecosystem Value Weight × BMP Type Factor in Table 2-3
[b] BMP Type Multiplier = Sum of Weighted Factors/(10 × Sum of Weights)

BMP Location Multiplier

The location of a stormwater BMP can influence the amount of improvement that the BMP provides to the watershed. For example, a BMP that is next to the mouth of a river only provides a small benefit to the overall watershed while a BMP that is located in the headwaters has the potential to provide benefits for a much larger downstream area. Consequently, a stormwater *BMP Location Multiplier* was developed to account for the influence that a BMP's location has on ecosystem benefits.

A BMP located in headwater areas will likely propagate along more stream miles of flow and thus provide more ecosystem benefits than a BMP with the same storage or infiltration capacity located in the lower portions of the watershed. In larger streams or rivers, the volume of water treated by the stormwater BMP could be a small fraction of the volume of water in the stream or river, and therefore the BMP may not individually have a significant influence on the hydrology in the lower portions of a watershed. In general, watershed and flow regime restoration BMPs providing the same storage or infiltration capacity have greater influence on watershed flows in upstream locations compared to those located in areas further downstream. The *BMP Location Multiplier* is intended to account for these location differences in determining *Quality Gallons*.

Table 2-6 shows how the *BMP Location Multiplier* is established for three areas that include headwaters, middle reaches, and lower reaches of the watershed. The magnitude of the multiplier promotes headwater flow restoration with lower numerical values applied to BMPs located further downstream.

TABLE 2-6
Multipliers Based on the Location of the BMP in the Watershed.

Location	BMP Location Multiplier
Headwater	1.6
Middle Reach	1.3
Lower Reach	1.0

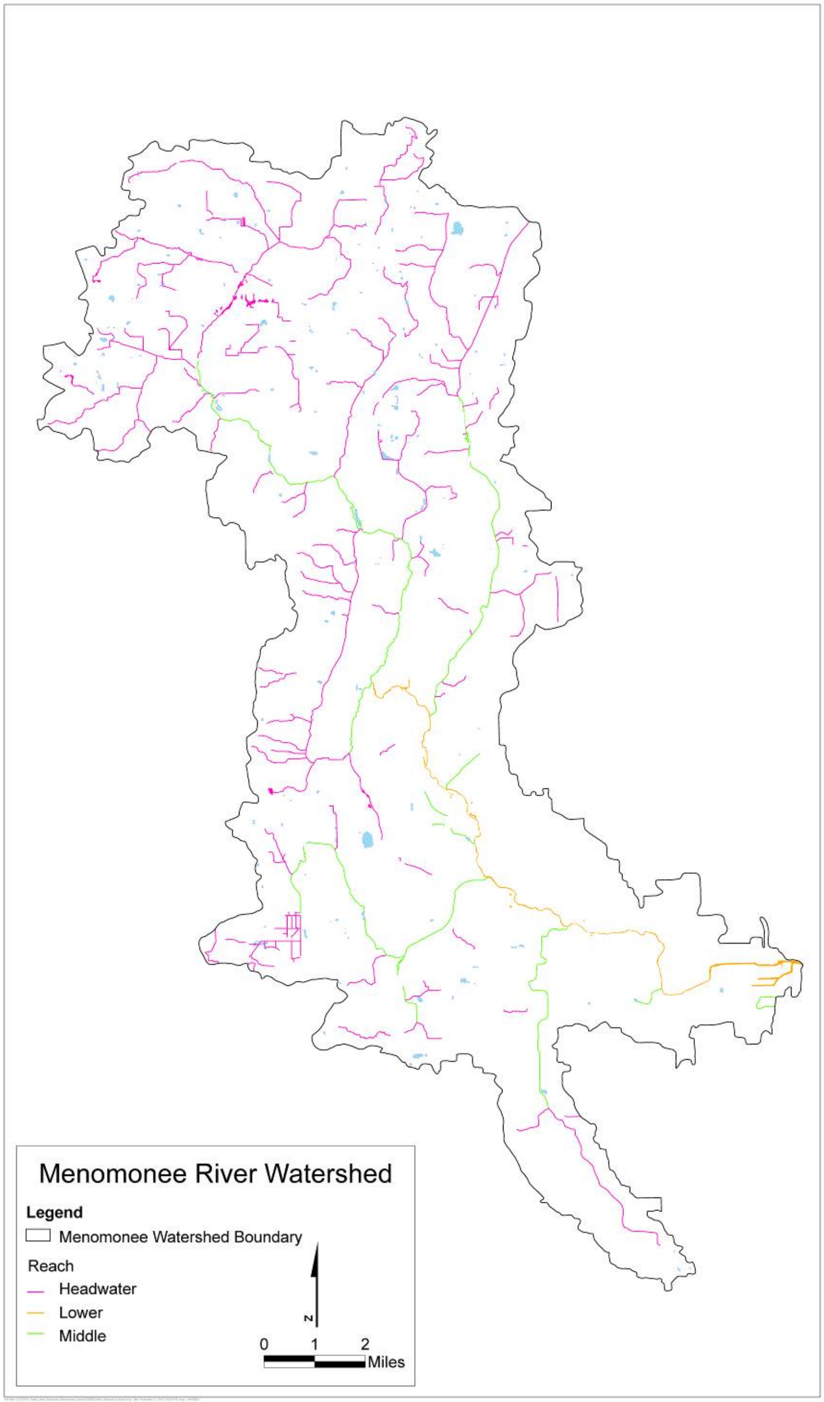
The multiplier numbers are between 1.0 and 1.6, consistent with the scale of the *BMP Type Multiplier* used in Table 2-5. A value of 1 is used as the lowest value and represents a neutral value. The location of a BMP does not provide a negative impact on the ecosystem because in a watershed that requires flow restoration, a BMP is always preferred over no flow enhancement. The *BMP Location Multiplier* will promote locating a BMP at a site within the watershed that provides the highest potential for improving the largest number of stream miles.

The multiplier values associated with the BMP locations as well as the criteria to define headwaters, middle, and lower reaches can be determined from informed watershed stakeholder feedback. This knowledgeable stakeholder approach relies upon expert opinion and has minimal data requirements. Alternative approaches, such as using modeling results, could also be used where available, but may not be worth the effort of building new models specifically for this purpose.

Definition of the BMP *Location Multiplier* could include a number of considerations. For example, a headwater stream may include what are typically considered first and second order streams. A middle reach may include small to moderate sized streams in the middle of the watershed and could typically include second-, third-, or small fourth-order streams. A middle reach stream may also include first order tributary streams that discharge to a large river, thus recognizing that a BMP may have a small effect on a small stream that discharges to a large river. A lower reach river would generally include rivers greater than third order that discharge to large bodies of water, including lakes, major rivers, or oceans. These classifications need to be customized through a consensus based process among watershed stakeholders.

A watershed map can be generated to define headwater, middle reach, and lower reach areas. An example map for the Menomonee River watershed in southeastern Wisconsin is shown in Figure 2-3. Stormwater BMPs tributary to a headwater stream (pink lines) would receive a multiplier of 1.6, and stormwater BMPs tributary to middle reaches (green lines) and lower reaches (orange lines) would receive multiplier values of 1.3 and 1.0, respectively.

FIGURE 2-3
Example BMP Location Multiplier Categories for the Menomonee River Watershed



BMP Priority Multiplier

Many watersheds have management plans that prioritize restoration opportunities to achieve the greatest environmental, political, or social improvements in the watershed. Installation of stormwater BMPs that meet watershed priorities or target the highest priority improvements would provide greater community support and therefore should be encouraged over BMPs that do not contribute to the restoration goals of a watershed. Many watersheds do not have management plans that identify restoration priorities, however watershed stakeholders and experts could develop priorities to achieve a similar goal. In either case, BMPs that achieve the goals of a management plan should be encouraged.

The *BMP Priority Multiplier* is the third multiplier used to calculate *Quality Gallons* and it incorporates the benefits provided by a stormwater BMP related to restoration priorities in the watershed that are identified in a management plan or by watershed stakeholders and experts. The *BMP Priority Multiplier* is separated into three categories, including a high, medium, and low priority, with multipliers of 1.6, 1.3, and 1.0, respectively. Similarly to the *BMP Location Multiplier*, the *BMP Priority Multiplier* cannot be less than 1, which recognizes that the BMP cannot negatively affect the ecosystem regardless of its priority. The numerical values of the *BMP Priority Multiplier* would be established using consensus from watershed stakeholders. The scale of the numbers is consistent with the *BMP Type Multiplier* and *BMP Location Multiplier* so that the three multipliers have equal weight in determining the *Quality Gallons* provided by a specific BMP.

A BMP that targets high priority streams for restoration would receive the most credit through a multiplier of 1.6, and a BMP that targets improvements that are a low priority in the watershed would have a neutral multiplier of 1.0. For example, if a public recreation area located on the river was identified as a high priority for flow regime enhancements, a BMP located in the recreation area would provide more value than a BMP located somewhere else in the watershed. A description of the application of the *BMP Priority Multiplier* is shown in Table 2-7. The table shows how the multiplier can be used to account for the effects of obstructions to fish passage.

TABLE 2-7
Multiplier to Account for BMP Location to Meet Watershed Restoration Priorities

Local Watershed Priority	Multiplier
High Priority: The BMP is located in a high priority area of the watershed. No downstream fish passage or obstructions exist	1.6
Medium Priority: The BMP is located in a medium priority area of the watershed. No downstream fish passage or obstructions exist	1.3
Low Priority: The BMP is located in a low priority area of the watershed or downstream fish passage or obstructions exist	1.0

Quality Gallon Computation Example

This section provides an example of how the concept of *Quality Gallons* is applied. Additional information on this and other examples can be found in Chapter 3, *BMP Evaluation Process*.

Case Study: Constructed Wetland Retrofit—Menomonee River

The potential to implement flow restoration principles into a proposed floodplain improvement near State Street and Hwy 41 in Milwaukee, Wisconsin, was evaluated. The site is a tributary to the Menomonee River.

Proposed Design

The proposed facility is a 3.5-acre constructed wetland located within the 4-acre proposed site outline shown in the aerial photograph in Figure 2-4. The facility would be designed to capture and treat runoff from the storm sewer system tributary to the site before ultimately releasing it into the Menomonee River. The runoff currently receives no treatment. This system collects stormwater from a 51-acre area with a mix of commercial, residential, and woodland land uses. The hypothetical design assumes an overflow weir set at bank elevation with a sediment forebay to trap incoming sediment. It is also assumed that an easement restricting the use of the area occupied by the BMP would be enforced. Figure 2-4 outlines the drainage area.

FIGURE 2-4
Aerial View of a Hypothetical Constructed Wetland
The drainage area is outlined in red. BMP implementation area is shaded green. Yellow denotes existing storm sewers.

Source: SEWRPC

BMP Flow Restoration Performance

HEC-HMS was used to calculate runoff from the design storm over the tributary area and route it through the constructed wetland. The design storm used the precipitation associated with the 5 percent exceedence flow for the flow duration curve along the Menomonee River (see Chapter 1). The volume of storage necessary to control the storm was then used to assign flow restoration gallons to the BMP.

Releasing water at the target yield for the watershed required a 120-hour drawdown time to completely drain the wetland. It should be noted, however, that at 72 hours post-storm the modeled water depth was less than 2 inches. In practice, water depths would likely recede more quickly due to evapotranspiration and infiltration, especially if the constructed wetland is well vegetated. The maximum depth in the wetland is about 6 inches, which yielded a maximum storage of 1.9 acre-feet. The volume of flow restoration storage provided by this BMP is 619,000 gallons.

Quality Gallons Calculation

The number of quality gallons for a constructed wetland is related to the BMP Type, BMP Location, and BMP Priority. For this example, it is assumed that, when a wetland is to be located in a lower reach and the area is a high priority for restoration. The quality gallon multipliers are shown in Table 2-8.

TABLE 2-8
Quality Gallon Calculation—Constructed Wetland Retrofit Case Study

Multiplier	Value
BMP Type Multiplier (stormwater wetland, Table 2-5)	1.77
BMP Location Multiplier (Lower Reach, Table 2-6)	1.0
BMP Priority Multiplier (High Priority, Table 2-7)	1.6
Quality Gallons (619,000 x 1.77 x 1.0 x 1.6)	**1,753,000**

The quality gallon *credit* for this example is 2.8 times the storage volume assigned to the BMP or 1,753,000 gallons.

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