



**INTERNATIONAL
STORMWATER BMP
DATABASE**
www.bmpdatabase.org

International Stormwater Best Management Practices (BMP) Database

Narrative Overview of BMP Database Study Characteristics

Prepared by

Wright Water Engineers, Inc.
Geosyntec Consultants

Under Support From

Water Environment Research Foundation
Federal Highway Administration
Environment and Water Resources Institute of the
American Society of Civil Engineers
U.S. Environmental Protection Agency

July 2012

Disclaimer

The BMP Database (“Database”) was developed as an account of work sponsored by the Water Environment Research Foundation (WERF), the American Society of Civil Engineers (ASCE)/Environmental and Water Resources Institute (EWRI), the American Public Works Association (APWA), the Federal Highway Administration (FHWA), and U.S. Environmental Protection Agency (USEPA) (collectively, the “Sponsors”). The Database is intended to provide a consistent and scientifically defensible set of data on Best Management Practice (“BMP”) designs and related performance. Although the individuals who completed the work on behalf of the Sponsors (“Project Team”) made an extensive effort to assess the quality of the data entered for consistency and accuracy, the Database information and/or any analysis results are provided on an “AS-IS” basis and use of the Database, the data information, or any apparatus, method, or process disclosed in the Database is at the user’s sole risk. The Sponsors and the Project Team disclaim all warranties and/or conditions of any kind, express or implied, including, but not limited to any warranties or conditions of title, non-infringement of a third party’s intellectual property, merchantability, satisfactory quality, or fitness for a particular purpose. The Project Team does not warrant that the functions contained in the Database will meet the user’s requirements or that the operation of the Database will be uninterrupted or error free, or that any defects in the Database will be corrected.

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The Project Team’s tasks have not included, and will not include in the future, recommendations of one BMP type over another. However, the Project Team’s tasks have included reporting on the performance characteristics of BMPs based upon the entered data and information in the Database, including peer reviewed performance assessment techniques. Use of this information by the public or private sector is beyond the Project Team’s influence or control. The intended purpose of the Database is to provide a data exchange tool that permits characterization of BMPs solely upon their measured performance using consistent protocols for measurements and reporting information.

The Project Team does not endorse any BMP over another and any assessments of performance by others should not be interpreted or reported as the recommendations of the Project Team or the Sponsors.

Acknowledgements

Report Preparation¹

Primary Authors:

Jane Clary, Wright Water Engineers, Inc.
Marc Leisenring, P.E., Geosyntec Consultants, Inc.

Reviewers:

Marcus Quigley, P.E. Geosyntec Consultants, Inc.
Jonathan Jones, P.E., D.WRE, Wright Water Engineers, Inc.
Eric Strecker, P.E. Geosyntec Consultants, Inc.

Project Information

WERF Project Director:

Jeff Moeller, P.E., Water Environment Research Foundation

Principal Investigators:

Eric Strecker, P.E., Geosyntec Consultants, Inc.
Jonathan Jones, P.E., D.WRE, Wright Water Engineers, Inc.

Project Steering Committee:

Susan Jones, P.E., Federal Highway Administration
Christopher Kloss, P.E., Office of Water/Office of Science & Technology, U.S. Environmental Protection Agency
Brian Parsons, P.E., Environmental and Water Resources Institute of American Society of Civil Engineers
Marcel Tchaou, Ph.D., P.E., P.H., MBA, Federal Highway Administration Office of Project Development and Environmental Review
Courtney Thompson, American Public Works Association

Project Subcommittee:

Michael E. Barrett, Ph.D., P.E., D.WRE, Center for Research in Water Resources, University of Texas
Bob Carr, P.E., O'Brien and Gere
David R. Graves, CPESC, Environmental Science Bureau, New York State Dept. of Transportation
Gregory E. Granato, U.S. Geological Survey
Jesse Pritts, P.E., Engineering and Analysis Division Office of Water/Office of Science & Technology, U.S. Environmental Protection Agency

¹ Contact Jane Clary (clary@wrightwater.com) with questions regarding this summary.

TABLE OF CONTENTS

1 INTRODUCTION..... 1

2 DATA SOURCES 1

3 GEOGRAPHIC DISTRIBUTION 2

4 BMP CATEGORY OVERVIEW..... 5

4.1 BIORETENTION 5

4.2 DETENTION BASIN 6

4.3 BIOFILTER - GRASS STRIP 6

4.4 BIOFILTER - GRASS SWALE 7

4.5 MANUFACTURED DEVICE..... 7

4.6 MEDIA FILTER..... 8

4.7 POROUS PAVEMENT 9

4.8 RETENTION POND..... 9

4.9 WETLAND BASIN..... 10

4.10 WETLAND CHANNEL..... 10

4.11 GREEN ROOF 11

4.12 INFILTRATION BASIN..... 11

4.13 PERCOLATION TRENCH/WELL..... 12

4.14 COMPOSITE (TREATMENT TRAIN)..... 12

4.15 LID (SITE SCALE) 13

4.16 RAINWATER HARVESTING..... 13

4.17 NONSTRUCTURAL PRACTICES/MAINTENANCE PRACTICE 13

4.18 OTHER..... 14

5 COST DATA 14

6 CONCLUSION..... 14



BMP DATABASE 2012 OVERVIEW

1 INTRODUCTION

The International Stormwater Best Management Practice (BMP) Database is a long-term project that has evolved over a 15-year time period. The BMP Database was originally released on a CD in 1999, containing 73 studies conducted in the 1980s and early 1990s. As of 2012, the Database is publically accessible on a project website (www.bmpdatabase.org) with multiple tools for accessing data for over 500 BMPs (Table 1), including an online search engine and web-based map interface, statistical summaries for individual studies and overall BMP categories, dynamic on-line tools to generate summaries for custom data queries, and a downloadable master database in Microsoft Access.

The purpose of this document is to provide a condensed overview of the types of studies and data contained in the BMP Database and identify some of the areas with data gaps. The audience for this document is primarily researchers who will find it useful to have a quick snapshot of basic information about various BMP categories such as how many studies are available, whether category-level data sets are adequately developed for purposes of analyses, the geographic distribution of the data, age of BMP designs, age and duration of the BMP monitoring period, and related information. This document is also intended to provide an initial framework for identifying data categories that may be appropriate for further in-depth analysis with regard to BMP design and watershed factorial analysis.

Background information on the BMP Database and BMP performance analyses are not provided in this document, but can be readily accessed at www.bmpdatabase.org.

2 DATA SOURCES

An ongoing goal of the BMP Database project is continued growth to enable compilation of a robust data set that is ultimately appropriate for evaluating BMP design parameters and site-

**Table 1. BMP Summary
(July 2012)**

BMP Category	# Studies
Bioretention	30
Detention Basin	39
Green Roof	13
Biofilter - Grass Strip	45
Biofilter - Grass Swale	41
Infiltration Basin	2
LID (Site Scale)	2
Manufactured Device	79
Media Filter	37
Percolation Trench/Well	12
Porous Pavement	35
Retention Pond	68
Wetland Basin	31
Wetland Channel	19
Composite (Treatment Train)	25
Maintenance Practice	28
Other	6
Total	512
Control Sites	19

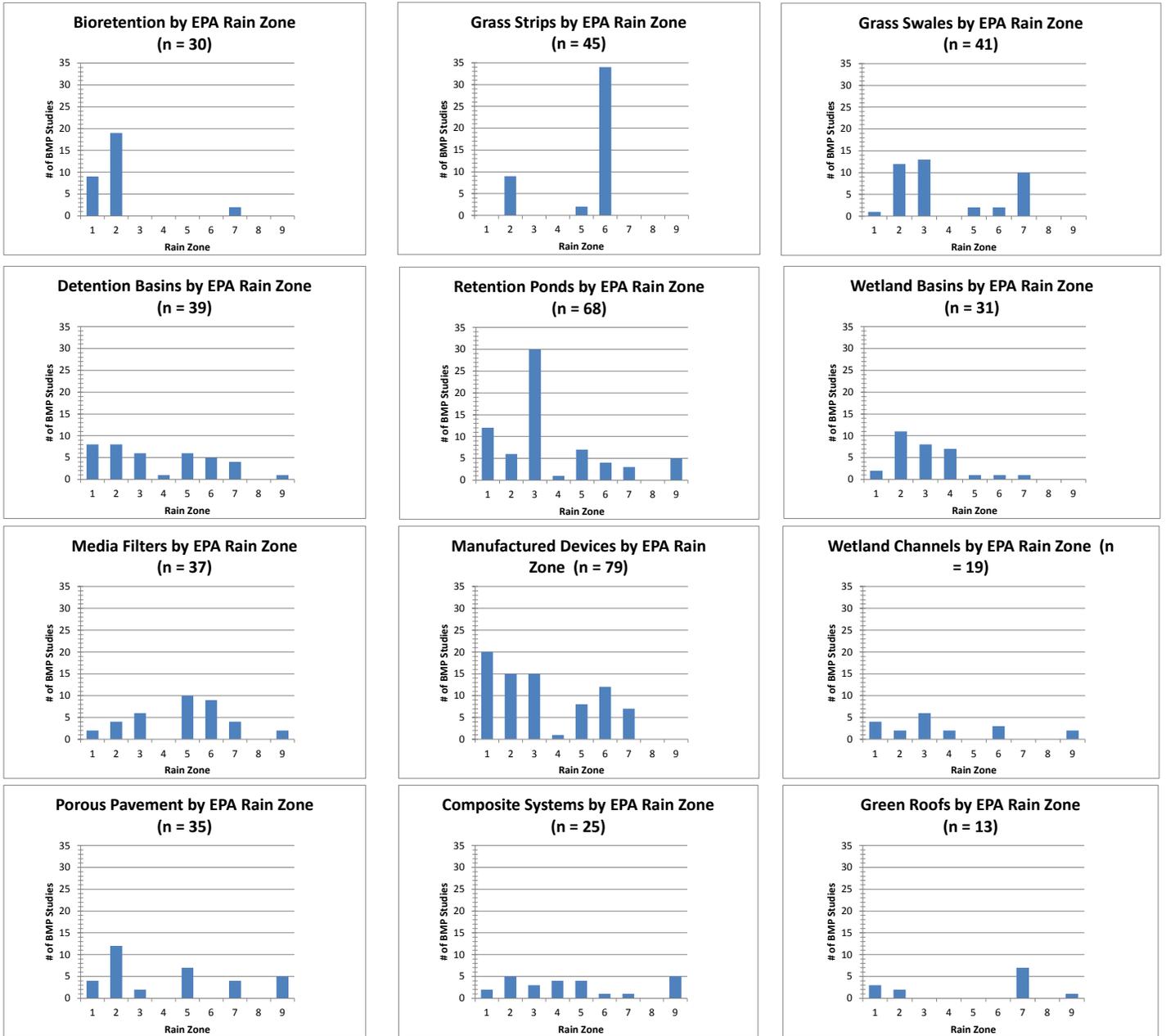
specific factors contributing to BMP performance. BMP studies contained in the BMP Database are obtained using a variety of approaches, generally including:

- **Literature Review:** The originally released BMP Database in 1999 included studies obtained through a literature review and electronic data transferred from studies associated with National Urban Runoff Program (NURP) in 1980s.
- **Major database transfers:** Several key sources of data have included electronic data transfers from independently maintained databases. Representative examples include the California Department of Transportation (CalTrans), the City of Austin, TX, the Florida Department of Environmental Protection, and Harris County Flood Control District (Texas).
- **Mini-grants:** In 1999, the U.S. Environmental Protection Agency (EPA) and the American Society of Civil Engineers (ASCE) facilitated a mini-grant program to partially compensate data providers for entering their studies into the BMP Database. A smaller scale mini-grant program was administered in 2011. The mini-grant program is subject to funding availability and has been best suited to data providers with batches of studies that can be efficiently uploaded as a group.
- **Ongoing data providers/university researchers:** The steady growth of the BMP Database over time has largely been accomplished through the support of individual university researchers, local governments and regional stormwater-related agencies that routinely submit their data sets on an annual or cyclical basis. Examples of these types of data providers include Urban Drainage Flood Control District (Denver, CO), Portland Bureau of Environmental Services, North Carolina State University, Villanova Urban Stormwater Partnership, and others. In some cases, researchers provide completely new studies, but in other cases provide additional years of monitoring data at existing sites, which is valuable for supporting analyses of BMP performance over the long-term. Database Project Team members also pursue contemporary data sets through review of journal papers, conference proceedings and other avenues.
- **Manufacturers:** In some cases, the Project Team is contacted directly by manufacturers who would like to submit studies for inclusion in the BMP Database. Provided that third party involvement requirements are met in accordance with the Database Proprietary Device policy, these studies can also be included in the BMP Database (see policy at <http://www.bmpdatabase.org/Docs/Proprietary%20Device%20Policy%2011-29-10.pdf>). In 2010-2011, a number of new manufactured devices studies were uploaded as a result of studies obtained through the New Jersey Corporation for Advanced Technology (NJCAT) Technology Verification Program.

3 GEOGRAPHIC DISTRIBUTION

The geographic distribution of studies in the BMP Database is dependent on the location of past and ongoing research and participation of data providers in various parts of the country. Study locations are also likely influenced by urban population distributions in the U.S. Figure 1 provides an overview of BMP test sites within the U.S., and Figure 2 provides a series of bar

Figure 2. Geographic Distribution of BMPs in the International Stormwater BMP Database by Rain Zone



EPA Rain Zone Key:	BR	CO	DB	GR	GS-BI	GS-BS	IB	LD	MD	MF	MP	OT	PP	PT	RP	WB	WC	Sum
NA/Outside U.S./Can.	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	4
1 Northeast/North Central	9	2	8	3	0	1	1	1	20	2	12	0	4	2	12	2	4	83
2 Midatlantic/ Upper Central	19	5	8	2	9	12	0	1	15	4	2	4	12	0	6	11	2	112
3 Southeast/East Gulf	0	3	6	0	0	13	0	0	15	6	0	1	2	9	30	8	6	99
4 South Central/ Central	0	4	1	0	0	0	0	0	1	0	0	0	0	0	1	7	2	16
5 Southwest/ West	0	4	6	0	2	2	0	0	8	10	0	0	7	1	7	1	0	48
6 Pacific Southwest/ West Inland	0	1	5	0	34	2	1	0	12	9	2	0	0	0	4	1	3	74
7 Pacific Northwest/ Pacific Central	2	1	4	7	0	10	0	0	7	4	12	0	4	0	3	1	0	55
8 Northwest Inland/ Rocky Mountain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 Northwest Inland/ Plains	0	5	1	1	0	0	0	0	0	2	0	0	5	0	5	0	2	21
Total	30	25	39	13	45	41	2	2	79	37	28	6	35	12	68	31	19	512

BMP Types: BR = bioretention; CO = composite/system; DB = detention basin; GR = green roof; GS-BI = grass buffer strips; GS-BS = grass swales; IB = infiltration basin; LD = low impact development; MD = manufactured device; MF = media filter; MP = maintenance practice; OT= other; PP = porous pavement; PT = infiltration trench; RP = retention pond; WB = wetland basin; WC = wetland channel.

Note: Only structural BMPs with > 12 studies are shown in the bar charts.

4 BMP CATEGORY OVERVIEW

This section provides a general overview of selected characteristics of each BMP category, including these general topics:

- **Category overview**— includes a basic overview of the data category, including major design subcategories and information on the design era (e.g., 1980s, 1990s or 2000s).
- **Geographic diversity and data sources**—summarizes information related to geographic distribution and dominant data sources.
- **Monitoring data set characteristics** —summarizes information related to time period over which the data set was monitored (e.g., 1980s, 1990s or 2000s) along with general characterization of the quantity of data available based on number of storm events monitored. Comments related to BMP category level analysis may also be included.

For additional background on BMP category definitions, the BMP Database User's Guide should be referenced for more information (<http://www.bmpdatabase.org/DataEntry.htm>).

4.1 Bioretention

Category Overview: As of July 2012, 30 bioretention BMPs are included in the BMP Database, with over 90% of the studies designed and monitored in the past decade. Bioretention was added to the BMP Database as a stand-alone reporting category in 2009. Prior to that time, a few bioretention practices were included in the Database, primarily under the media filter BMP type, due to similarities in unit treatment processes. Since addition of this category, the number of bioretention studies has grown rapidly and includes a variety of designs. Approximately 80% of the designs are characterized as bioretention cells (non-linear, not associated with conveyance), with other design variations such as in-line bioretention areas, planter boxes and other configurations. Design information for the bioretention category is relatively well developed and includes information on facilities with traditional underdrains, “internal water storage zone” underdrain configurations, as well as sites without underdrains. The majority of the studies in the BMP Database are equipped with underdrains; however, there are 8 studies without underdrains. Many of the bioretention BMPs have been monitored in pairs to assess design variations such as deep vs. shallow depth, clay vs. sandy soil, turf vs. native grasses, and other factors.

Geographic Diversity/Data Sources: Bioretention facilities are currently dominated by studies conducted in Rain Zones 1 and 2, with two studies in Rain Zone 7. No studies are currently located in arid or semi-arid climates or plains states. Half of the bioretention sites are located in North Carolina and have been conducted by North Carolina State University Biological and Agricultural Engineering Stormwater Engineering Group.

Monitoring Data Characteristics: For the 30 bioretention studies, over 95% of the studies monitored more than 12 storm events, with nearly 50% monitoring 25-75 storm events and nearly 30% monitoring over 75 events. Studies with particularly large numbers of events (150-380 events) include the Villanova Traffic Island in Pennsylvania, the Glencoe Rain Garden in Portland, Oregon, and four U.S. Geological Survey (USGS) studies in Wisconsin (the Owen and

Pumphouse rain gardens). Volume-related data tends to be relatively complete for this BMP type because surface runoff reduction is often a design objective for bioretention practices. Twenty of the bioretention studies in the BMP Database were considered appropriate for expanded analysis of volume reduction in bioretention BMPs completed in 2012 (Geosyntec and Wright Water Engineers 2012). These 20 studies had relatively complete design information and flow data sets, enabling more in-depth evaluation of volume reduction at these BMPs.

4.2 Detention Basin

Category History: Detention basins (dry ponds) have been included in the BMP Database since its inception. Out of the 39 detention basins currently included in the Database, 33 are surface-lined grass basins designed to empty after storm events, with the remaining six practices being concrete lined basins or underground concrete vaults. For purposes of category-level analysis, the focus of the analysis has been on the subset of above-ground, grass-lined practices with event mean concentration (EMC) data. About 10% of the grass-lined detention basin studies were designed in the 1980s timeframe, with 60% in the 1990s and 30% since 2000. Design data provided for these BMPs varies in terms of completeness.

Monitoring Data Characteristics: About 55% of the grass-lined detention basin monitoring was conducted since 2000, 35% was conducted in the 1990s and 10% was conducted in the 1980s. The concrete-lined detention basins in the BMP Database were designed and monitored beginning in the 1990s. Focusing on the grass-lined detention basin subset (which is considered more appropriate for water quality treatment than concrete-lined basins), about 50% of the studies spanned longer than one year. About half of the studies included more than 12 sampling events, whereas 20% of the studies had 6 to 12 storms and 30% had 5 or fewer storm events. Studies with small numbers of storm events or grab samples (only) are excluded from category level pollutant analysis (approximately 9 studies), but can be accessed as individual PDFs from www.bmpdatabase.org. Detention basins are well represented in category-level pollutant analyses conducted for the BMP Database project. For volume analysis, a smaller subset of 11 grass-lined detention basin studies was considered appropriate for analysis.

Geographic Diversity/Data Sources: The BMP Database contains detention basin studies in all rain zones except Rain Zone 8. Detention basin installations are distributed fairly evenly throughout the rain zones, with the exception of Rain Zone 4 and 9, which each have one study in Texas and Colorado, respectively.

4.3 Biofilter - Grass Strip

Category History: As of July 2012, 45 grass strip (buffer) BMPs are included in the BMP Database. Over 80% of the grass strip designs were completed since 2000. The majority of the grass buffer strips are located in highway settings. A number of studies in this category include multiple-length monitoring designs at one location (i.e., there may be strips of four different lengths, entered as four separate BMPs at the same site). In these cases, only the longest length is included for category-level BMP analysis. For this reason, the number of BMPs included for pollutant analysis is about half of the total number of grass strips in the Database.

Monitoring Data Characteristics: Nearly 95% of the monitoring for the grass buffer strip data set has occurred since 2000. Two-thirds of the studies include monitoring periods spanning over one year, 15% span 4 to 12 months, and 20% span periods shorter than 3 months. The majority of the data sets monitored over 12 events, with nearly 50% monitoring 25-75 events and 30% monitoring over 75 events. Grass strip studies are well represented in category-level pollutant analysis. Sixteen of the grass buffer strip studies were considered appropriate for volume analysis conducted in early 2011 (Geosyntec and WWE 2011).

Geographic Diversity/Data Sources: Approximately 75% of the grass buffer strip category is associated with highway-related applications provided by California Department of Transportation (Caltrans). The remaining studies include: North Carolina (8 studies, most of which were conducted by North Carolina State University), Texas (2 studies), and Virginia (1 study). The majority of the study locations in North Carolina and Texas are also highway applications. The majority of the data set includes studies in Rain Zones 6, which is relatively dry, followed by Rain Zone 2.

4.4 Biofilter - Grass Swale

Category History: As of July 2012, 41 grass swale BMPs are included in the BMP Database. Studies included in this category are typically dry swales, whereas swales with wetland vegetation (wet swales) are typically analyzed in the wetland channel category. The majority (70%) of the grass swales in the BMP Database were designed in the 1990s, with the remaining 30% of the studies conducted in the 1980s or earlier.

Monitoring Data Characteristics: The majority of the grass swale studies were monitored in the 1990s and 2000s, with about 20% of the studies conducted during the 1980s. About 60% of the studies monitored 6-24 storm events, 25% monitored more than 24 events and 15% monitored 6 or fewer events. Nearly 40% of the grass swale studies spanned longer than one year. Approximately 13 of the grass swale studies were considered appropriate for volume analysis in 2011. Grass swale studies are well represented in category-level pollutant analyses conducted for the BMP Database.

Geographic Diversity/Data Sources: In contrast to the grass buffer strip data set, the grass swale data set includes BMPs predominantly located in wetter climates (particularly Rain Zones 2, 3 and 7), with the remaining 10% located of studies located in drier climates in California and Texas (Rain Zones 6 and 5, respectively).

4.5 Manufactured Device

Category History: As of July 2012, 79 manufactured device BMPs are included in the BMP Database. The overall manufactured device data set is fairly evenly split between 1990s designs and designs since 2000. One oil/water separator study from the mid-1980s is also included in the data set. For a proprietary manufactured device study to be included in the BMP Database, third party involvement is required (see policy on www.bmpdatabase.org). In 2010, a number of manufactured devices that had been through the NJCAT verification process were added to the BMP Database. In 2012, an analysis of manufactured device performance was completed based on dominant unit treatment processes present in various manufactured devices. The general sub-

categories included: physical processes relying on gravitational settling (e.g., hydrodynamic devices), biological filtration (e.g., mimicking bioretention), physical filtration (e.g., sand filters), inlet inserts, multi-process devices, oil/grit separators and baffle boxes, physical processes with volume control features, and disinfection (1 study). Approximately 35% of the studies analyzed for manufactured devices are associated with physical processes relying on gravitational settling (e.g., hydrodynamic devices), about 15% are oil/grit separators, about 20% are inlet inserts, 15% provide filtration, 10% provide volume control (typically for peak flows), and 5% have multiple processes. The BMP Database does not provide endorsements or recommendations for specific products; therefore, analysis is focused on the performance of sub-categories of devices with similar unit treatment processes for removing various water quality pollutants, as opposed to specific proprietary devices.

Monitoring Data Characteristics: Approximately 60% of the manufactured device studies have been monitored since 2000. Approximately 70% of the studies monitored 6 to 24 storms, 20% monitored 25-75 storms and 10% monitored 5 or fewer. Approximately 40% of the studies spanned longer than one year. The manufactured device data set is generally well suited to analysis of water quality parameters, but less well suited for volume-related analysis. Most manufactured device studies assume inflow equals outflow because volume reduction is not typically an objective for the majority of the manufactured device designs currently in the Database. There are some exceptions to this generalization, including devices that mimic bioretention functions and devices that are designed to infiltrate runoff.

Geographic Diversity/Data Sources: In terms of geographic distribution, the manufactured device data set provides reasonably good representation in multiple rain zones, with 5 to 20 studies in six different rain zones. Rain Zones 8 and 9 do not have manufactured device data, and Rain Zone 4 has one study. The data set is weighted more heavily towards wetter climate conditions; approximately 75% of the studies are in wetter climates.

4.6 Media Filter

Category History: As of July 2012, 37 media filter BMPs are included in the BMP Database. Of these, 26 are sand filters, with the remaining 11 studies including various configurations with different types of filtration media (e.g., peat, perlite, zeolite, compost). Approximately 60% of the media filters in the BMP Database are of the 1990s design era, with 25% designed since 2000 and 15% in the 1980s.

Monitoring Data Characteristics: Nearly 50% of the monitoring data for media filters has been collected since 2000, 40% was collected in the 1990s and less than 15% in the 1980s. Approximately 75% of the studies monitored 6-24 storms, with the remaining 25% monitoring more than 24 storms. Approximately 70% of the studies lasted a year or longer. Media filters tend to have a strong water quality analysis data set, with the majority of studies suitable for analysis for most pollutant categories, but have a less useful volume-related data set. A common practice for media filter studies is to monitor inflow to the device and assume that outflow is similar. For this reason, media filters are not included in the volume-related analysis for the BMP Database.

Geographic Diversity/Data Sources: The media filter data set provides reasonably good representation of a range of climates. No studies are provided for Rain Zones 4 and 8. The data set is split relatively evenly between wet and dry climates.

4.7 Porous Pavement

Category History: As of July 2012, 35 porous pavement BMPs are included in the BMP Database. Of these, 11 are modular block (including various types interlocking pavers and 3 modular turf types), 6 are pervious concrete, 1 is porous aggregate, 8 are porous asphalt, 3 are porous turf and 6 are permeable friction course applications. Porous pavement has been included in the BMP Database since its inception, but permeable friction course was added as a sub-category to this data set in 2011. Additionally, 15 out of 19 of the control (“CX”) entries in the BMP Database are reference sites for paved areas used to evaluate porous pavement studies. Most porous pavement studies in the BMP Database are designed using a test site–control site (reference) study design, rather than an inflow-outflow design at a porous pavement installation. With the exception of permeable friction course applications, water quality samples at most porous pavement sites are collected from underdrains.

Monitoring Data Characteristics: The porous pavement data set has two distinct data quality/characteristic levels that result in data screening prior to analysis. Early-era porous pavement monitoring with only a few storms (e.g., 3-5 storms) was conducted in the 1980s in Austin, TX and one location in Dayton, OH. These data sets were extracted from early literature as part of the initial data upload in 1999. Most of these older studies are currently excluded from category-level BMP analysis, primarily due to the small number of monitored storms. The second group of studies includes installations from the mid-1990s and mid-2000s and has a minimum of 11 storm events, with quite a few studies in the 50-150 storm event range. The more recent permeable friction course studies were conducted in North Carolina and Texas in the late 2000s. Permeable pavement is moderately well represented in category-level performance analyses for water quality pollutants, but is not well suited for volume analysis as an overall category due to variations in study designs associated with use of reference sites.

Geographic Diversity/Data Sources: The porous pavement data set includes one or more studies in all Rain Zones except 4, 6 and 8. Studies tended to be conducted as tests of several types of porous pavement, with primary study locations including North Carolina, Texas, Washington and Colorado. (One or two studies were also located in other states and in New Zealand.)

4.8 Retention Pond

Category History: As of July 2012, 68 retention pond (wet pond) BMPs are included in the BMP Database. Of these, three applications are underground vaults and are not included in the category-level analysis for retention ponds. The vast majority of retention ponds in the BMP Database were designed in the 1980s (40%) and the 1990s (40%), with 15% since 2000. A wide range of retention pond sizes, volumes and designs are included in the BMP Database.

Monitoring Data Characteristics: Monitoring records for the retention pond data set are fairly evenly divided over time, with 30% in the 1980s, 40% in the 1990s and 30% since 2000. Over

half of the retention pond studies spanned longer than one year. Two-thirds of the studies included 13 or more storm events, with 25% monitoring 6-12 events, and the remaining 10% monitoring less than 6 events. The retention pond category has a relatively strong water quality data set, enabling analyses for many key water quality parameters. Volume-related analysis is not conducted for typically wet BMP types such as retention ponds and wetland basins since volume reduction is not usually a design objective and base flow rates are not always characterized for these BMPs.

Geographic Diversity/Data Sources: While all rain zones other than Rain Zone 8 are represented by one or more retention ponds in the BMP Database, the overall data set is dominated by studies in the Southeast (Rain Zone 3), with 27 of these studies located in Florida.

4.9 Wetland Basin

Category History: As of July 2012, 31 wetland basin BMPs are included in the BMP Database. Of these, 27 are wetland basins with open water surfaces, whereas 4 are wetland meadow types without open water surfaces. Nearly 60% of the wetland basins in the BMP Database were designed in the 1990s, with the remaining sites evenly split between the 1980s and the 2000s.

Monitoring Data Characteristics: About 85% of the wetland basin monitoring data set was collected in the 1990s and 2000s (evenly split between the two decades), with the remaining 15% collected in the 1980s. Approximately 40% of the studies monitored 13-24 storm events, 30% monitored more than 24 events, and 30% monitored less than 12 events. Over half of the studies spanned a year or longer. Wetland basin studies are relatively well represented in water quality pollutant analyses for the BMP Database, but are not included in volume reduction analyses. In recent analyses of the BMP Database, wetland basins and retention ponds have been analyzed both separately and as a combined data set, since many of the design attributes and unit processes for these BMPs are similar. (Some of the differences between these data sets may be a difference in nomenclature, as opposed to differences in unit treatment process function, particularly where open water surfaces are present in the wetland basin.)

Geographic Diversity/Data Sources: The majority (85%) of the wetland basins in the BMP Database are located in Rain Zones 2 through 4, although all rain zones other than 8 and 9 have at least one wetland basin.

4.10 Wetland Channel

Category History: As of July 2012, 19 wetland channel BMPs are included in the BMP Database. Approximately 90% of designs were completed in the 1980s and 1990s and are evenly split between these decades.

Monitoring Data Characteristics: Approximately 40% of the monitoring events occurred in the 1980s, with the remaining 60% evenly split between the 1990s and 2000s. Approximately 80% of the wetland channel studies monitored more than 12 storm events, with the remainder of studies typically monitoring 6-12 events. Over half of the studies monitored wetland channels for more than a year. A number of studies in the wetland channel data set relied on grab samples or had other unique study designs that results in screening of some studies from category level

analysis. As a result, this BMP category is less well represented in water quality pollutant analyses than some of the other BMP categories. At the BMP category level, wetland channels are generally not well suited for volume reduction analyses since they are typically wet BMPs with natural variation in flows from groundwater and non-stormwater sources.

Geographic Diversity/Data Sources: For rain zones with BMP studies, the wetland channel data set has fairly even representation among rain zones; however, no studies are included for Rain Zones 5, 7 and 8. Unlike wetland basins, wetland channels have reasonable representation in drier climates, with nearly one-third of the studies located in Rain Zones 6 and 9.

4.11 Green Roof

Category History: The green roof BMP category was added to the BMP Database in 2009 and is in an early stage of data population. A few of the older green roof data sets from Portland, Oregon, were temporarily stored in the media filter category prior to 2009. Although 13 BMP entries are included as of July 2012, the majority of the data has been collected at 7 test sites that have had various design modifications over time or consist of studies of various roof sections in the same building complex. Of these, approximately 5 of the data sets are adequately developed for pollutant related analyses.

Monitoring Data Characteristics: All of the green roofs in the BMP Database have been installed and monitored over the past 10-15 years. The oldest green roofs in the database are located in Portland, OR and have been monitored by Portland Bureau of Environmental Services, with three locations with over 100 storms. The other green roof sites generally have 20-70 storms. The majority of the studies collected data for more than one year. Although the number of green roof installations in the BMP Database is relatively limited, the quality of the data sets is good in terms of numbers of events monitored and use of contemporary monitoring methods and detection limits. The green roof data set includes a mixture of grab samples and EMC data. Some of the studies use reference roof locations for purposes of comparison. Green roof data sets have been included in a limited number of category-level analyses. Due to the complexities in conducting green roof volume-related analysis and the relatively small data set, green roofs have not been included in volume reduction analysis to date. Particularly in semi-arid and arid green roof installations where irrigation may be used on the roof, care is needed in carefully interpreting volume related data sets over time.

Geographic Diversity/Data Sources: Green roof data sets are available in Rain Zones, 1, 2, 7 and 9, although only one to three test sites are located in each zone. The 13 BMP entries include installations on EPA buildings located in Denver and Pennsylvania, the American Society of Landscape Architects (ASLA) green roof in Washington, D.C., the Herrity green roof in Virginia, and three green roofs in Portland, OR.

4.12 Infiltration Basin

Category History: The infiltration basin category has been included in the BMP Database since its initial release; however, as of July 2012, only two studies are currently included in this data category: the Villanova Infiltration Trench in Pennsylvania and the Sun Valley Infiltration Basin

in Los Angeles, California. The Villanova site is intentionally undersized for research purposes. The Los Angeles site is used for flood control and involves buried facilities beneath a park.

Monitoring Data Characteristics: Both studies were installed and monitored in mid-2000. The Villanova site includes data from approximately 140 storms monitored over several years. The Sun Valley site has also been monitored over a several year period and has 13 storms. Category level analysis is not conducted on this data set due to the small number of BMPs; however, analysis of individual studies is accessible in the on-line BMP Database search engine.

Geographic Diversity/Data Sources: As noted above, the Villanova Infiltration Trench in Pennsylvania and the Sun Valley Infiltration Basin in Los Angeles, California.

4.13 Percolation Trench/Well

Category History: As of July 2012, 12 infiltration trench BMPs are included in the BMP Database; however, the majority of these studies do not have adequate monitoring data for analysis. In particular, eight of the BMPs are associated studies at Anchor Key, Pelican Key and Indiatlantic projects in Florida (imported as part of the FDEP database) and cannot be evaluated as individual BMP types without additional information. Of the remaining four data sets, one is in Florida, one is in Texas and two are in Minnesota (Capital Region Watershed District).

Monitoring Data Characteristics: The Florida studies were designed and monitored in the late 1990s/early 2000s and typically included 3 to 4 storm events over a one-month period in the summer. The Texas study was monitored in the 1980s for three storms during one month. The two Minnesota studies included 22 storm events from April to October of 2007. As an overall BMP category, this data set is not yet adequately developed for category level analysis.

Geographic Diversity/Data Sources: This data set is not adequately developed for purposes of characterizing geographic diversity and would benefit from additional studies in all rain zones.

4.14 Composite (Treatment Train)

Category History: As of July 2012, 25 composite (or treatment train) BMPs are included in the BMP Database. When the Database was originally developed, BMPs in sequence could only be entered if both the inflow and outflow from each BMP was monitored. When the BMPs were entered, they were entered separately in a manner that made evaluation of the overall system difficult to reconnect. In 2009, structural changes were made to the BMP Database that enabled overall treatment systems to be more easily retrieved. For sites that have multiple BMPs in sequence, the individual BMPs are entered, along with a “composite” of the overall system. Approximately 60% of the composite systems were designed in the 1990s, with 25% designed in the 1980s. Of the remaining studies, 5% were designed before 1980 and 10% since 2000.

Monitoring Data Characteristics: Over 80% of the composite studies include more than 12 samples, with over 60% spanning more than a year. The monitoring period is distributed relatively evenly among the last three decades. The types of composite systems included in this category are diverse and generally warrant analysis at the individual study level. However, common types of composite system designs in the Database include the wetland-pond complex

and sedimentation-filtration systems. (Note that composite manufactured devices, such as the Multi-Chambered Treatment Train (MCTT), are included in the manufactured device category).

Geographic Diversity/Data Sources: Composite systems in the Database include studies in California, Colorado, Florida, Minnesota, North Carolina, Texas and Washington, providing a relatively diverse distribution among climates/rain zones. Each rain zone has one to five studies, except Rain Zone 8, which has no studies. Data sources range from the original literature review in 1999 to recent studies submitted by entities such as Urban Drainage and Flood Control District (Denver, CO); City of Austin, TX; Harris County Flood Control District, TX; North Carolina State University; and others.

4.15 LID (Site Scale)

Category History: As of July 2012, two development scale Low Impact Development studies are included in the BMP Database. One is the Providence LID study in Fairfax County, which included 16 storm events between June 2004 and March 2010 and was based on a before-and-after study design. The second study was conducted by the USGS in Cross Plains, WI and included 100 storms between 1998 and 2001 and is based on a concurrently monitored reference watershed. A third study in the BMP Database, Partridgeberry Place in Massachusetts is located at a site-scale LID development; however, the monitoring data included in the database are for individual practices within the development and the overall site performance was modeled instead of monitored.

Monitoring Data Characteristics: See above. Additional studies are needed for this category.

Geographic Diversity/Data Sources: See above.

4.16 Rainwater Harvesting

To date, no rainwater harvesting BMPs have been submitted to the BMP Database, although reporting protocols have been developed for this BMP type.

4.17 Nonstructural Practices/Maintenance Practice

Category History: As of July 2012, 28 non-structural entries are included in the BMP Database. Of these, 8 are catch basin cleaning studies and 20 are 1980s-era street sweeping practices.

Monitoring Data Characteristics: All of these studies were conducted in the late 1970s to early 1980s. Eight of the sites were entered from electronic NURP data sets as part of the initial BMP Database release in 1999. The remaining sites were provided by Dr. Robert Pitt under the mini-grant program. These studies have not been analyzed as part of the routine BMP Database analysis. Some of the street sweeping techniques in these studies are likely outdated due to changes in street sweeping technology.

Geographic Diversity/Data Sources: These studies were located in Washington, California, Illinois, North Carolina, Washington and Wisconsin.

4.18 Other

As of July 2012, six BMPs are categorized as “other” in the BMP Database due to unique characteristics of the BMP or the monitoring design. Brief descriptions of these BMPs include:

- Construction-phase sedimentation basins (3 sites) monitored for 12 storm events by Montgomery County, MD Department of Environmental Protection in the 2005-2009 timeframe. A fourth site was monitored for 6 events in a similar timeframe.
- Periphyton filter BMP—includes 50 storm events in the late 1990s and was included as part of the Florida Department of Environmental Protection Database upload.
- Flow Balancing Method— Lake Ronningesjon, Sweden. This is a 10-year study with annual data sets submitted by Dr. Robert Pitt, University of Alabama based on work conducted between 1981 and 1991.

5 COST DATA

As of 2012, approximately 129 studies provide cost data, with 85 of the cost records submitted since 2000. One of the common inquiries that the BMP Database project receives is related to why more cost-related information is not provided. BMP cost information is considered “nice to have” as part of BMP performance data submissions, but this information is not required in order for a study to be accepted. In some cases, researchers monitoring the BMPs were not involved in the design and may not have readily-accessible cost information. Because most BMP studies are submitted voluntarily, researching historical costs requires additional time that researchers may choose to forego. Future BMP Database work may include pursuing cost data for selected studies in the Database and encouraging data providers to input more of their BMP cost information.

6 CONCLUSION

Since its initial release in 1999, the BMP Database has grown substantially and contains many high quality data sets. This paper provides a summary that can be used by researchers to better understand the types of studies in the Database, including BMP categories with robust data sets that have been used in category-level analyses, as well as those that would benefit from additional high quality studies. In 2012, this summary will be expanded to “dig deeper” into watershed and design related considerations for BMP categories that have adequate data sets for analysis of factors that affect BMP performance. Because the BMP Database is a “living” document/tool, the descriptive information in this paper will change over time as the BMP Database grows.

7 REFERENCES

Geosyntec and Wright Water Engineers, 2011. International Stormwater Best Management Practices (BMP) Database Technical Summary: Volume Reduction. Prepared under Support from WERF, FHWA, EWRI/ASCE and EPA.

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