Chapter 1
INTRODUCTION

1.1 Purpose of this Manual

Over the past three decades, both public and private entities have monitored urban stormwater Best Management Practices (BMPs) for many purposes, often related to efforts to comply with the continually evolving federal Clean Water Act. In 1996, the U.S. Environmental Protection Agency (EPA) entered into a cooperative agreement with the American Society of Civil Engineers (ASCE), led by members of the Urban Water Resources Research Council (UWRRC), to initiate the International Stormwater BMP Database project ("BMP Database"). The BMP Database goals were multi-faceted, with key goals including development of a standardized set of monitoring and reporting protocols for urban stormwater BMP performance studies and assembling and summarizing historical and on-going BMP study data into a standardized format to facilitate performance analysis. During the initial stages of the BMP Database project, it became clear that better guidance was needed regarding stormwater BMP monitoring, particularly if monitoring results were to be valuable to the broader technical, management, and regulatory community. As a result, the 2002 version of this monitoring manual was developed to promote collection of more useful and representative data associated with BMP studies, as well as more consistent reporting of monitoring results appropriate for inclusion in the BMP Database. Since that time, both the BMP Database project and stormwater management practices have continued to evolve, prompting this second release of the manual.

The purposes of this updated Manual are primarily two-fold:

1) Improve the state of the practice by providing and enhancing a recommended set of protocols and standards for collecting, storing, analyzing, and reporting stormwater BMP monitoring data that will lead to better understanding of the function, efficiency, and design of urban stormwater BMPs.

2) Provide monitoring guidance for "Low Impact Development" (LID) strategies at the overall site level (e.g., monitoring overall sites with multiple distributed stormwater controls).

The remainder of this introduction provides a brief synopsis of the organization and content of this Manual, and provides some basic information on stormwater, BMPs, the BMP Database project, and regulatory drivers related to BMP implementation and monitoring. Several key terms used throughout this manual are defined, and links to other monitoring resources are also provided.

1.2 Manual Overview

This Manual provides guidance for all stages of BMP monitoring programs ranging from the early stages of study design to the end stages of data interpretation and reporting. Guidance is provided for monitoring a broad range of individual BMPs as well as overall site monitoring with multiple distributed BMPs, such as is the case with LID sites. The Manual addresses these topics:

1) Designing the Monitoring and Reporting Program (Chapter 2): A well-thought out and systematically designed monitoring program is essential to a cost-effective study design that yields meaningful results. The Manual builds upon guidance provided by EPA (2002) in its *Guidance for Quality Assurance Project Plans*, providing additional guidance specific to stormwater BMP monitoring and the BMP Database protocols.

2) Methods and Equipment for Stormwater BMP Monitoring (Chapters 3 and 4): In order to obtain high-quality data in BMP monitoring studies, it is necessary to select the proper precipitation, flow, and water quality sample collection and monitoring equipment and procedures. Chapter 3 provides information and guidance related to flow and precipitation monitoring in the context of BMP monitoring, and Chapter 4 focuses on water quality sample collection and analysis methods.

3) Implementing the Monitoring Program (Chapter 5): In order for well designed monitoring programs to result in high quality data, personnel must be properly trained, equipment be properly installed, calibrated and maintained, samples be correctly collected and analyzed, and data properly reported. Failures at this stage of the monitoring program can result in data that cannot be used to draw valid conclusions regarding BMP performance.

4) Data Management, Evaluation and Reporting of Results (Chapter 6): Once data have been collected from a monitoring program, the data need to be compiled and managed in a manner that reduces introduction of errors and enables ready access for future reference, and ideally, facilitates incorporation into the BMP Database (http://www.bmpdatabase.org). A strong data management and reporting system helps to ensure that studies are documented in a manner that enables long-term use of the data and transferability to the local, regional, national, and international state of the practice. As part of this chapter, an overview of data reporting requirements for the BMP Database is provided, describing study features such as test site, watershed, and BMP design characteristics, instrumentation, and monitoring data (precipitation, flow, water quality).

5) BMP Performance Analysis (Chapter 7): Over the past decade, the BMP Database project has developed recommended performance analysis approaches for BMP studies. This chapter describes these methods, as well as pitfalls to avoid misleading interpretation of data.

6) LID/Distributed Controls Monitoring (Chapter 8): Building upon the concepts introduced for monitoring individual BMPs, this chapter provides guidance on specific challenges associated with monitoring distributed controls at the site level, particularly focused on LID. In these types of studies, a variety of practices such as disconnecting impervious areas, use of pervious paving materials, implementation of rain gardens on multiple lots, use of swales instead of curb and gutter, and other runoff reduction practices may be implemented. As a result, unique challenges exist in collecting and analyzing the performance of such sites. Although the state of the practice continues to evolve on this topic, this chapter provides basic guidance on properly designing such studies.

7) Data Interpretation and Performance Evaluation of LID Studies (Chapter 9): The careful interpretation and evaluation of data is critical in reaching appropriate conclusions about volume reduction and the water quality benefits of LID. Chapter 9 suggests approaches to interpret and evaluate hydrologic and water quality data, both absolutely and in comparison to conventional BMP implementations. Although LID and conventional BMP studies have some similarities, there are also some key differences that warrant LID-specific guidance. A few representative differences include: LID strategies tend to emphasize reduction in volume rather than reduction in concentration; LID studies are less likely to have an "influent stream" conducive to inflow-outflow comparisons; and the time scale of monitoring required to obtain representative data may be much longer than for a conventional studies.

8) LID Case Studies (Chapter 10): This chapter summarizes key aspects of site-level LID studies conducted in Cross Plains, WI; Burnsville, MN; Jordan Cove, CT and Somerset, MD. All of these studies are based on a paired watershed approach incorporating a reference and test watershed, either geographically or over time.

9) Supplemental Resources on Key Topics (Appendices): Many of the topics addressed in this manual are complex and/or require considerable detail for proper discussion. For this reason, supplemental appendices are provided as follows:

   - Appendix A: Data Entry Forms for International Stormwater BMP Database: Forms useful for recording BMP monitoring study information, key watershed and BMP design criteria, instrumentation and monitoring data for precipitation, flow, and water quality are provided in Appendix A, corresponding to the data entry spreadsheets used in the BMP Database.

   - Appendix B: Comparison of Data Analysis Approaches: This appendix contains a discussion of the various BMP performance analysis approaches that have been commonly used historically, but are not currently recommended by the BMP Database project. Nonetheless, some of these techniques are used by others, so comments are provided regarding the strengths and weaknesses of each approach.

   - Appendix C: Determining Required Number of Samples: Depending on the objectives established for the monitoring program, the number of samples required for meaningful interpretation of the data can vary substantially. This

appendix provides guidance in determining the number of samples needed to obtain statically significant monitoring data. It also includes charts for estimating the number of samples required to observe a statically significant difference between two populations for a various levels of confidence and power.

- Appendix D: Error Analysis: Properly accounting for errors and uncertainty in BMP monitoring data is important to avoid erroneous conclusions regarding BMP performance. This appendix describes methods for calculating expected errors in field measurements.

- Appendices E and F: Statistical Information: Although this manual does not provide a primer on statistics, Appendices E and F provide some basic information needed to properly apply statistics in the context of stormwater BMP monitoring.`

1.3 Stormwater Basics

1.3.1 Physical and Chemical Characteristics of Stormwater Runoff

Numerous studies conducted since the late 1970s show that stormwater runoff from urban and industrial areas is a potentially significant source of pollution (EPA 1983; Driscoll et al. 1990; Pitt et al. 2008). As a result, federal, state, and local regulations have been promulgated to address stormwater quality and many communities have implemented structural and non-structural stormwater BMPs to minimize the potential adverse impacts of urban runoff and comply with these regulations. Although the historical focus of many monitoring programs was primarily stormwater quality (chemical), more recently, the hydrologic and hydraulic (physical) changes in watersheds associated with urbanization are increasingly being recognized as significant contributors to receiving water degradation. Representative physical impacts include stream channel changes (e.g., erosion, sedimentation, temperature changes), as well as wetland water level fluctuations. As a result, site designs such as LID that seek to mimic predevelopment site hydrology are being encouraged or mandated by more communities.

Some of the challenges associated with proper characterization of stormwater quality are related to its highly variable nature (EPA 1983; Driscoll et al. 1990). For example, the intensity of rainfall often varies irregularly and dramatically. These variations in rainfall intensity affect runoff rate, pollutant washoff rate, in-channel flow rate, pollutant transport, sediment deposition and resuspension, channel scour, and numerous other phenomena that collectively determine the pollutant concentrations, pollutant forms, and stormwater flow rate observed at a given monitoring location at any given moment. In addition, the transitory and unpredictable nature of many pollutant sources and release mechanisms (e.g., spills, leaks, dumping, construction activity, landscape irrigation runoff, vehicle washing runoff), and differences in the time interval between storm events also contribute to inter-storm variability. As a result, pollutant concentrations and other stormwater characteristics at a given location often fluctuate greatly during a single storm runoff event and from event to event. It is important that those involved with stormwater monitoring not underestimate the complex variables affecting stormwater BMP monitoring.

Exhibit 1-1. Defining "Stormwater"

Although in the simplest sense, stormwater can be defined as runoff resulting from rainfall or snowmelt, a more inclusive definition is used in this Monitoring Manual. In the context of stormwater BMP monitoring, stormwater also includes base flows or dry weather flows occurring prior to, during and following storm runoff events, as well as other discharges affecting the BMP such as materials that are dumped, leaked, spilled, or otherwise discharged into the conveyance system.

Representative dry weather flows include pavement washing, pavement cutting wash water, or irrigation water, including the pollutants transported in such flows. In some cases, dry weather loads can greatly exceed wet weather loads over the course of a year and must be taken into account in BMP monitoring programs.

Stormwater may also contain materials that settled out in the system toward the end of previous storms and are flushed out by high flows during the event being sampled.

1.3.2 Best Management Practices

In the context of post-construction urban stormwater runoff management, Best Management Practices (BMPs) include a variety of measures intended to prevent or reduce the discharge of pollutants to waters of the United States. BMPs can be discussed in terms of individual structural practices and non-structural practices, as well as in terms of overall site designs such as LID that combine a variety of structural and non-structural practices. Structural BMPs include a variety of practices that rely on a wide range of hydrologic, physical, biological, and chemical processes to improve water quality and manage runoff. (See Exhibit 1-2 and *Critical Assessment of Stormwater Treatment and Control Selection Issues* [WERF 2005] for more information on these processes.) Non-structural BMPs such as education and source control ordinances typically depend on a combination of behavioral change and enforcement.

Due to the variation in BMP designs and features, as well as rainfall distributions, there is not a one-size-fits-all monitoring strategy. For example, Philadelphia, PA, receives approximately 45 inches of rainfall a year, primarily in small storms, whereas Austin receives approximately 35 inches of rainfall, but primary in large storms, whereas Denver receives approximately 14 inches per year. These differences in rainfall distributions affect both the design of BMPs and the design of monitoring programs. Many BMPs and LID sites are designed to treat runoff from small storms, rather than large storms, so it is important to understand the basis of design for BMPs when developing monitoring programs and evaluating performance of BMPs. In this Manual, five general categories of BMPs will be used to assist in monitoring strategy design and BMP performance analysis. These general categories include:

Type I BMPs with well-defined inlets and outlets (e.g., detention basins, vegetated swales, catch basin inserts). These are the “easy” BMPs to monitor where inflow and outflow can typically be paired to assess performance. In the case of systems such as wet ponds with substantial residence times or storage volumes, data may be straightforward to collect, but challenging to evaluate for individual storms. In such cases, a seasonal mass balance approach is often more appropriate than a storm-based, paired influent-effluent approach because it is likely that the effluent sample for small storms is displaced water originating from prior events.

Type II BMPs with well-defined inlets, but not outlets (e.g., infiltration basins, infiltration trenches, bioretention cells). Monitoring strategies for these BMPs are more complex and may involve sampling of underdrains, vadose (unsaturated) zone monitoring, groundwater monitoring, measuring infiltration rates and surface overflow. At a minimum, the influent and surface overflow must be quantified, since the difference between the two should represent the volume infiltrated. If an underdrain is used to direct partially treated water back to the surface drainage, then it should also be monitored. Evaluation of data from these types of studies should focus on mass balance approaches.

Type III BMPs with well-defined outlets, but not inlets (e.g., grass swales where inflow is overland flow along the length of the swale, buffer strips, green roofs).

Type IV BMPs without any well-defined inlets or outlets and/or institutional BMPs (e.g., buffer strips, basin-wide catch basin retrofits, education programs, source control programs, disconnected impervious area practices).

Type V LID/Distributed Controls/Overall Site Designs where some defined monitoring locations are available that may include monitoring of individual practices within a development, in combination with an overall site monitoring mechanism.

In addition to understanding the complexities associated with monitoring the various types of BMPs, it is also important to recognize that there is a difference between reporting performance based on the flows treated by the BMP and the flows associated with the overall BMP system, which includes bypassed flows and overflows. These types of considerations are also important when assessing the performance of the BMP, the effectiveness of the overall BMP system and the efficiency of the BMP or BMP system in removing pollutants. Definitions of several BMP-related terms used throughout this document are provided in Exhibit 1-3.

Exhibit 1-2. Structural Stormwater Controls and Associated Fundamental Process Categories

(Source: WERF 2005. *Critical Assessment of Stormwater Treatment and Control Selection Issues*. 02-SW-1.)

Fundamental Process Category (FPC)	Unit Operation or Process (UOP) *Target Pollutants*	Typical Treatment System Components (TSCs)
Hydrologic Operations	Flow and Volume Attenuation	Extended detention basins Retention/detention ponds Wetlands Tanks/vaults Equalization basins
	Volume Reduction *All pollutant loads*	Infiltration/exfiltration trenches and basins Permeable or porous pavement Bioretention cells Dry swales Dry well Extended detention basins
Physical Treatment Operations	Particle Size Alteration *Coarse sediment*	Comminutors (not common for stormwater) Mixers (not common for stormwater)
	Physical Sorption *Nutrients, metals, petroleum compounds*	Engineered media, granular activated carbon, and sand/gravel (at a lower capacity)
	Size Separation and Exclusion (screening and filtration) *Coarse sediment, trash, debris*	Screens/bars/trash racks Biofilters Permeable or porous pavement Infiltration/exfiltration trenches and basins Manufactured bioretention systems Engineered media/granular/sand/compost filters Hydrodynamic separators Catch basin inserts (i.e., surficial filters)
	Density, Gravity, Inertial Separation (grit separation, sedimentation , flotation and skimming, and clarification) *Sediment, trash, debris, oil and grease*	Extended detention basins Retention/detention ponds Wetlands Settling basins, Tanks/vaults Swales with check dams Oil-water separators Hydrodynamic separators
	Aeration and Volatilization *Oxygen demand, PAHs, VOCs*	Sprinklers Aerators Mixers (not common for stormwater)
	Physical Agent Disinfection *Pathogens*	Shallow detention ponds Ultra-violet systems
Biological Processes	Microbially Mediated Transformation (can include oxidation, reduction, or facultative processes) *Metals, nutrients, organic pollutants*	Wetlands Bioretention systems Biofilters (and engineered bio-media filters) Retention ponds Media/sand/compost filters
	Uptake and Storage *Metals, nutrients, organic pollutants*	Wetlands/wetland channels Bioretention systems Biofilters Retention ponds
Chemical Processes	Chemical Sorption Processes *Metals, nutrients, organic pollutants*	Subsurface wetlands Engineered media/sand/compost filters Infiltration/exfiltration trenches and basins
	Coagulation/Flocculation *Fine sediment, nutrients*	Detention/retention ponds Coagulant/flocculant injection systems
	Ion Exchange *Metals, nutrients*	Engineered media, zeolites, peats, surface complexation media
	Chemical Disinfection *Pathogens*	Custom devices for mixing chlorine or aerating with ozone Advanced treatment systems

Exhibit 1-3. Key Terms Used in the Manual

A common understanding of terms used in this manual includes the following:

- Best Management Practice (BMP) – A device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters. (Some entities use the terms "Stormwater Control Measure", "Stormwater Control", or "Management Practice", but BMP is used in this manual for consistency with the International Stormwater BMP Database.) BMPs include both LID and non-LID practices,

- BMP System – A BMP system includes the BMP and any related bypass or overflow. For example, the efficiency (see below) can be determined for an offline retention pond either by itself (as a BMP) or for the BMP system (BMP including bypass).

- Low Impact Development (LID) – LID is an overall land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to mimic the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. LID is similar to Sustainable Urban Drainage Systems (SUDS), a term used in the United Kingdom, and Water Sensitive Urban Design (WSUD), a term used in Australia. The term Green Infrastructure may also be used, particularly in areas with combined sewer overflow (CSO) issues.

- LID Practice – Individual practices used as part of overall LID developments or integrated into traditional developments include practices such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, permeable pavements and other infiltration-oriented practices. In some cases, LID terminology and traditional BMP terminology vary for the same basic practice. For example, the LID term "bioretention" may also be called porous landscape detention; the LID term "bioswale" may also be called grass swale.

- Performance – measure of how well a BMP meets its goals for stormwater that the BMP *is designed to treat*.

- Effectiveness – measure of how well a BMP *system* meets its goals in relation to *all* stormwater flows.

- Efficiency – measure of how well a BMP or BMP system *removes or controls pollutants*.

1.4 Stormwater BMP Monitoring

Purposes of BMP monitoring vary significantly and the monitoring program must be designed in the context of the objectives of the program. For example, a monitoring program for an industry seeking to comply with monitoring requirements under its National Pollutant Discharge Elimination System (NPDES) permit may be relatively straight-forward, whereas more in-depth monitoring research related to factors affecting BMP performance will be more complex. Key principles include:

- Dedicate the time and resources to develop a sound monitoring plan. Complexities of plans will vary depending on monitoring objectives.

- Be sure to plan and budget for an adequate number of samples to enable proper data interpretation.

- Be aware of the many static and state variables that need to be documented as part of a monitoring program. Exhibit 1-4 provides a brief overview of some key variables.

- Be sure that the monitoring design properly identifies the relationship between storm characteristics and the design basis of the BMP. (For example, is the intent of the monitoring program to assess performance over all storm conditions or only design conditions? What types of storms are considered to be adequately representative for purposes of monitoring?)

- Properly implement and follow the monitoring plan, clearly documenting any adjustments to the program. Particularly important are proper equipment installation and calibration, proper sample collection techniques and analysis, and maintenance of equipment for longer term programs.

- Expect the unexpected: rodents building nests in monitoring equipment, vandalism, battery/power failures, etc. Monitoring programs require attention and ongoing adjustment.

- Maintain data in an organized and well-documented manner, including not only monitoring data, but also BMP design and maintenance practices and site characteristics.

- Clearly report study limitations and other caveats on use of the data.

The remainder of this Manual provides detailed guidance on many of these issues.

Exhibit 1-4. Examples of Static and State Variables to Report in BMP Monitoring Programs (*See Appendix A for a complete list specified by BMP type in the BMP Database.*)

Example Static Variables	Example State Variables
Tributary watershed conditions: Geographical location Watershed size and slope Land use type and characteristics (e.g., curb/gutter, imperviousness) Vegetative canopy/condition (*may also be a state variable*) Soil types and condition BMP design (e.g., length, width, height, storage volume, outlet design, upstream bypass, model number)	Rainfall intensity Storm Size Flow rate Season Upstream non-structural controls Inter-event timing Settings for control structures such as gates, valves, and pumps Modifications to BMP design over time Maintenance of the BMP

1.5 The International Stormwater BMP Database

As noted earlier in this chapter, a primary driver for the development of this Manual is the BMP Database project, which began in 1996 with the long-term goal of gathering transferable technical design and performance information to improve BMP selection and design so that local stormwater problems can be effectively addressed. In 2004, the project transitioned from a USEPA funded grant project to a more broadly supported coalition of partners including the Water Environment Research Foundation (WERF), ASCE Environmental and Water Resources Institute (EWRI), Federal Highway Administration (FHWA) and the American Public Works Association (APWA). These entities continue to provide long-term support of the project. The cornerstones of the project are the BMP monitoring and reporting protocols and the BMP Database itself, which were developed based on the input and intensive review of many experts for the purpose of developing standardized reporting parameters necessary for more accurate BMP performance analysis. The database encompasses a broad range of parameters including test site location, watershed characteristics, climate data, BMP design and layout characteristics, monitoring instrumentation, and monitoring data for precipitation, flow and water quality.

The database is available for download from the project website (http://www.bmpdatabase.org) and has evolved from its original 1999 release on CD to a more flexible and user-friendly structure. The three key component of the BMP Database include:

1) Data Entry Spreadsheets: These are forms for use by researchers and data providers to track BMP monitoring data, both for their own purposes, as well as for submitting data to the BMP Database. These spreadsheets are consistent with the structure and

data elements contained in the original database release on CD, but allow more flexibility for database users in a familiar Excel format.

2) BMP Database: This is the master database itself, which is loaded with over 350 BMP studies and continues to grow through submission of studies from researchers and many entities regulated under the stormwater NPDES program.

3) BMP Performance Summaries: Data submitted to the database are analyzed on approximately an annual basis, with results reported in several different formats. Cumulative performance across BMP categories is provided in summary tables and brief reports, as well as in "flat file" spreadsheets containing a summary of analysis data. Additionally, BMP performance results for individual submitted studies in PDF format can be downloaded using the on-line search engine at http://www.bmpdatabase.org.

Following the guidance provided in this Manual should typically result in studies being compatible for inclusion in the BMP Database and facilitate progress towards the BMP Database project's long-term goals, both with regard to traditional stormwater BMPs and LID approaches.

1.6 Regulatory Environment

Although BMP monitoring is conducted for both regulatory and non-regulatory purposes, in many cases, it is driven by regulations, even if the regulation itself does not "require" monitoring. As general background for BMP monitoring, it is important to be aware of several key regulatory drivers related to BMP monitoring programs, including:

- The Clean Water Act (CWA) of 1972: Section 208 of 1972 CWA requires every state to establish effective BMPs to control nonpoint source pollution. The 1987 Water Quality Act (WQA) added Section 402(p) to the CWA, which requires that urban and industrial stormwater be controlled through the NPDES permit program. As a result, urban areas must meet requirements of Municipal Separate Storm Sewer System (MS4) permits, and many industries and institutions such as state departments of transportation must also meet NPDES stormwater permit requirements. Even if monitoring is not required under the NPDES permit, operators of regulated MS4s are required to develop a Stormwater Management Plan (SWMP) that includes measurable goals and to implement needed stormwater management controls (BMPs). MS4s are also required to assess controls and the effectiveness of their stormwater programs and reduce the discharge of pollutants to the "maximum extent practicable."

  Section 303(d) of WQA requires the states to list those water bodies that are not attaining water quality standards including designated uses and identify relative priorities among the impaired water bodies. States must also develop Total Maximum Daily Loads (TMDLs) to assign allowable pollutant loads to various sources to enable the waterbody to attain designated uses in the future. (For more information about the TMDL program, see http://www.epa.gov/owow/tmdl.) Implementation plans to

achieve the loads specified under TMDLs commonly rely on BMPs to reduce pollutant loads associated with stormwater sources.

- Coastal Zone Act Reauthorization Amendments (CZARA) of 1990: CZARA was passed to help address nonpoint source pollution in coastal waters. Each state with an approved coastal zone management program must develop and submit to the USEPA and National Oceanic and Atmospheric Administration (NOAA) a Coastal Nonpoint Pollution Control Program (CNPCP), which provides for the implementation of the most economically achievable management measures and BMPs to control the addition of pollutants to coastal waters.

  CZARA does not specifically require that states monitor implementation of management measures and BMPs. They must, however, provide technical assistance to local governments and the public in the implementation of the management measures and BMPs, which may include assistance to predict and assess the effectiveness of such measures.

  CZARA also states that the EPA and NOAA shall provide technical assistance to the states in developing and implementing the CNPCP, including methods to predict and assess the effects of coastal land use management measures on coastal water quality and designated uses.

- The National Environmental Policy Act (NEPA): NEPA establishes judicially enforceable obligations that require all federal agencies to identify the environmental impacts of their planned activities. The NEPA legislation and its requirements provide the framework under which environmental impacts of all substantial federal projects are evaluated, and have been the starting point from which many other environmental regulations are applied and enforced. Any major effort that involves federal funding, oversight, or permits, such as highway operations and projects, is subject to the NEPA process to ensure environmental concerns are considered and documented in an Environmental Impact Statement (EIS) before implementation.

- The Endangered Species Act: The Endangered Species Act of 1973 protects animal and plant species currently in danger of extinction (endangered) and those that may become endangered in the foreseeable future (threatened). It provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend, both through federal action and by encouraging the establishment of state programs.

- State, Regional and Local Regulations: Increasingly, state and local governments and regional agencies may also develop their own rules and regulations requiring BMPs to protect drinking water supplies, recreational values, aquatic life and other beneficial uses. In some cases, such regulations focus primarily on water quality; however, more recently, such ordinances also focus on volume reduction through implementation of LID strategies that seek to mimic pre-development hydrology.

Because regulations are continually evolving and may vary by location, it is always prudent to check with key federal, state, regional, and local sources for the most up-to-date regulatory requirements that could affect BMP monitoring programs.

1.7 Manual Scope Limitations

The audience for this Manual is targeted primarily to those who possess a basic level of knowledge regarding stormwater quality, hydrology, and regulatory issues. The EPA website (http://www.epa.gov) and other state and local websites can be referenced for additional guidance and background information.

This Manual focuses primarily on the collection, reporting, and analysis of water quantity and quality measurements at the heart of quantitative BMP efficiency projects. It does not address, in detail, sediment sampling methods and techniques, biological assessment, monitoring of receiving waters, monitoring of groundwater, streambank erosion, channel instability, channel morphology, or other activities that in many circumstances may be as, or more, useful for measuring and monitoring water quality for assessing BMP efficiency.

This Manual addresses methods that were in use at the time it was written. As the state of the practice and the design of monitoring equipment progress, new monitoring approaches and techniques, more sensitive devices, and equipment based on new technologies will likely be employed. Although the technology may change somewhat from that described herein, most of the basic flow and water quality monitoring methods discussed in this document have a long history of use and will most likely remain viable even as new and different technologies emerge.

Exhibit 1-5. Other Resources for More Information on Stormwater Monitoring

Burton and Pitt. 2001. *Stormwater Effects Handbook: A Toolbox for Watershed Managers, Scientists, and Engineers*. Lewis Publishers. http://www.epa.gov/ednnrmrl/publications/books/handbook/index.htm

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1.8 References

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