EXHIBIT "31"

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF WATER

November 17, 2008

Dear Colleague:

Today we are making available the draft technical document *TMDLs to Stormwater Permits Handbook* for your review and comment. Stormwater runoff is a significant contributor to water quality impairments across the country, particularly runoff from developing and urbanized areas. Currently there are thousands of Clean Water Act section 303(d) waters listed as impaired for stormwater-source pollutants such as pathogens, nutrients, sediments and metals. To effectively address these impairments it is important to strengthen connections between two key federal programs under the Clean Water Act – the TMDL program and the NPDES stormwater permitting program.

This Handbook provides a reference for TMDL practitioners and permit writers on current methods being used to develop more detailed stormwater-source TMDL allocations, TMDL implementation plans including best management practices, and methods for translating TMDL allocations into NPDES stormwater permit requirements. The Handbook assumes that the reader has a working knowledge of both TMDLs and NPDES stormwater permits, and provides background information on the components of these programs. Please note that last month the National Research Council released a lengthy report, *Urban Stormwater Management in the United States* (NRC, the National Academies Press, October 15, 2008). We intend to review the publication for consideration in producing the final version of the Handbook.

Please provide us feedback on the methods and approaches presented in this Draft Handbook, as well as additional TMDL-stormwater case studies, implementation plans, other valuable resources, or permits and/or permit language that would be useful to include. Comments on the document should be sent to Christine Ruf (ruf.christine@epa.gov), Dean Maraldo (maraldo.dean@epa.gov) and Jack Faulk (faulk.jack@epa.gov) by February 27, 2009.

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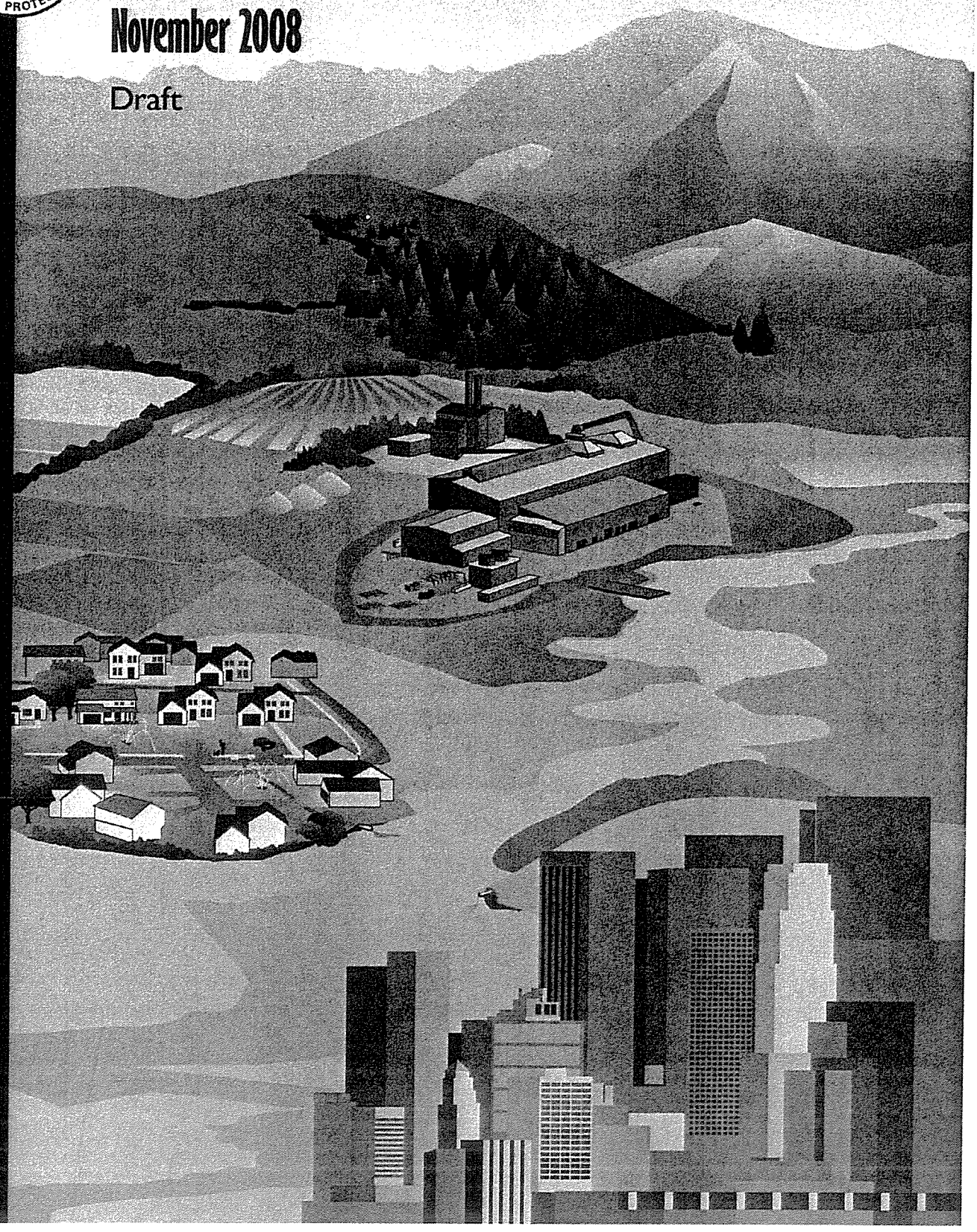
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TMDLs to Stormwater Permits Handbook

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DISCLAIMER

This document provides technical information to TMDL and NPDES practitioners who are familiar with the relevant technical approaches and legal requirements pertaining to developing TMDLs and NPDES stormwater permits, and refers to statutory and regulatory provisions that contain legally binding requirements. This document does not substitute for those provisions or regulations, nor is it a regulation itself. Thus, it does not impose legally binding requirements on EPA or States, who retain the discretion to adopt approaches on a case-by-case basis that differ from this information. Interested parties are free to raise questions about the appropriateness of the application of this information to a particular situation, and EPA will consider whether or not the technical approaches are appropriate in that situation.

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Preface

Thousands of impaired waterbodies require total maximum daily loads (TMDLs) for pollutants, such as pathogens, nutrients, sediments, and metals – pollutants commonly associated with urban stormwater discharges. As a result, it is important for the TMDL program and the National Pollutant Discharge Elimination System (NPDES) Stormwater program to identify opportunities and approaches for promoting TMDL implementation through stormwater permits. The U.S. Environmental Protection Agency (EPA) developed this *TMDLs to Stormwater Permits Handbook* (Handbook) to address challenges that are unique to TMDL development and implementation involving permitted stormwater discharges from municipal separate storm sewer systems (MS4s), industrial facilities, and construction activities.

The Handbook is intended for federal and state TMDL writers and NPDES stormwater permit writers responsible for addressing waterbodies impaired by discharges from stormwater sources. The Handbook assumes that the reader has a working knowledge of both the TMDL and the NPDES stormwater programs and provides limited background information on the basic regulatory and programmatic aspects of these programs.

The Handbook contains information to give TMDL and stormwater permit writers a better understanding of (1) cross-program regulatory requirements and programmatic processes; (2) current efforts to establish better cross-program connections; and (3) opportunities to further improve how the TMDL and NPDES Stormwater programs interact to address stormwater-related water quality impairments. Real-world examples are the predominant mechanism to illustrate concepts and approaches for promoting improved implementation of TMDLs through stormwater permits. The information contained in this Handbook represents an initial step in identifying and comprehensively addressing these issues. The issues and challenges surrounding TMDL implementation through stormwater permits will continue to evolve as EPA and state TMDL practitioners and stormwater permit writers consider and test new approaches and strategies.

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Acronyms and Abbreviations

303(d)	Section 303(d) of the Clean Water Act
AnnAGNPS	Annualized Agricultural Non-Point Source model
ASCE	American Society of Civil Engineers
BAT	best available technology economically achievable
BMP	best management practice
BOD5	five-day biochemical oxygen demand
CADDIS	Causal Analysis/Diagnosis Decision Information System
CASQA	California Stormwater Quality Association
CBOD5	five-day carbonaceous biochemical oxygen demand
CFB	commercial fishing ban
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CGP	Construction General Permit
CWA	Clean Water Act
DA	drainage area
DMR	discharge monitoring report
DO	dissolved oxygen
DRSCW	DuPage River Salt Creek Workgroup
DURMM	Delaware Urban Runoff Management Model
EFDC	Environmental Fluid Dynamics Code
EMAP	Environmental Monitoring and Assessment Program
eNOI	Electronic Notice of Intent
EPA	U.S. Environmental Protection Agency
FCG	fish consumption guidelines
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GI	green infrastructure
GIS	geographic information system
GWLF	Generalized Watershed Loading Functions
HSPF	Hydrologic Simulation Program in Fortran

IC	impervious cover
ICIS	Integrated Compliance Information System
IDDE	Illicit Discharge Detection & Elimination
IDEAL	Integrated Design and Evaluation Assessment of Loadings
LA	load allocation
LID	low impact development
LSPC	Loading Simulation Program in C++
MASTEP	Massachusetts Stormwater Technology Evaluation Project
MDAS	Mining Data Analysis System
MEP	maximum extent practicable
mg/L	milligram per liter
MOS	margin of safety
MRLC	multi-resolution land characteristics
MS4	municipal separate storm sewer system
MSGP	Multi-Sector General Permit
MUSIC	Model for Urban Stormwater Improvement Conceptualization
NAWQA	National Water-Quality Assessment (Program)
NLCD	National Land Cover Dataset
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSPS	New Source Performance Standards
NTU	nephelometric turbidity units
NURP	Nationwide Urban Runoff Program
NWIS	National Water Information System
O&M	operation and maintenance
P8-UCM	Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds—Urban Catchment Model
PCS	Permit Compliance System
PCB	polychlorinated biphenyl
PG BMP-DSS	Prince George's County Best Management Practice Decision Support System
QAPP	quality assurance project plan

SB	shellfishing ban
SET	Site Evaluation Tool
SI	stressor identification
SIC	standard industrial classification
SLAMM	Source Loading and Management Model
STORET	Storage and Retrieval (database)
SWAT	Soil and Water Assessment Tool
SWMM	Storm Water Management Model
SWMP	stormwater management program
SWPPP	stormwater pollution prevention plan
TARP	Technology Acceptance and Reciprocity Partnership
TMDL	total maximum daily load
TSS	total suspended solids
TWR	trophic weighted residue value of mercury in fish tissue
UNRBA	Upper Neuse River Basin Association
UOD	ultimate oxygen demand
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VAFSWM	Virginia Field Scale Wetland Model
VFSMOD	Vegetative Filter Strip Model
WLA	wasteload allocation
WQBEL	water quality-based effluent limitations
WQ_v	water quality volume

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INTRODUCTION

Across the country, stormwater runoff is a significant contributor to water quality impairments, particularly in developing and urbanized areas. There are thousands of impaired waterbodies requiring total maximum daily loads (TMDLs) for pollutants associated with stormwater sources, such as pathogens, nutrients, sediments, and metals. Developing TMDLs that include stormwater sources can present unique challenges because of the variety and number of sources, the variability of the pollutants discharged by these sources, the limited availability of monitoring data, and the complexity of the mechanisms by which pollutants in stormwater discharges affect ambient water quality criteria. Implementing TMDLs via National Pollutant Discharge Elimination System (NPDES) stormwater permits can also present challenges because of difficulties in translating the numeric, water quality-based TMDL wasteload allocations (WLAs) into permit requirements.

The purpose of this Handbook is to provide information to TMDL practitioners and NPDES stormwater permit writers (referred to as *TMDL writers and permit writers* throughout this Handbook) on the following:

- Current methods and other potential options for developing more precise WLAs for stormwater sources (referred to simply as *sources* throughout this Handbook)
- TMDL implementation plans including best management practice (BMP) and other stormwater management strategy recommendations
- Approaches for translating TMDL WLAs and implementation recommendations into NPDES stormwater permit requirements and implementation strategies

Information contained in this Handbook specifically addresses the following:

- TMDL WLAs for stormwater sources that clearly express and assign the targeted loading reductions necessary to attain and maintain water quality standards
- TMDL implementation plans that connect WLAs and stormwater permits by either (1) including specific recommendations (e.g., performance standards, management measures) for implementing WLAs, or (2) providing technical information for permit writers and permittees on how to analyze, select, and implement provisions to implement the WLAs
- Stormwater permits that are consistent with the WLAs by identifying specific elements, including management measures, that implement the WLA and, if available, TMDL implementation plan recommendations or specifying approaches for demonstrating that specific provisions will implement WLAs

In addition, the goal is to provide TMDL and permit writers a better cross-program understanding of regulatory requirements and programmatic processes and a better understanding of opportunities to further improve how the TMDL and NPDES Stormwater programs should interact to address stormwater-related water quality impairments. The real-world examples provided in this Handbook are intended to provide a range of options for TMDL and permit writers to consider. Where real-world examples do not exist to illustrate a concept, the Handbook provides a hypothetical example for TMDL and permit writers to consider, and the writers hope that it provides insight into future directions to improve this linkage.

This Handbook is organized as follows:

- **Chapter One: Understanding the connections between TMDLs and stormwater permits.** Provides overviews of TMDL and NPDES Stormwater programs and summarizes the challenges of developing TMDLs and implementing WLAs through stormwater permits.
- **Chapter Two: Identifying opportunities to coordinate TMDLs and stormwater permits.** Identifies ideas and opportunities for TMDL and permit writers to coordinate at various points throughout the TMDL and stormwater permitting processes.
- **Chapter Three: Characterizing impairments and stormwater sources.** Provides a detailed discussion of the type of information that TMDL and permit writers can use to generate a detailed stormwater source characterization, including data on water quality and watershed conditions, as well as data generated by stormwater permittees and where to obtain this information.
- **Chapter Four: Developing TMDLs with Stormwater Sources.** Addresses key stormwater-specific issues that TMDL writers can consider when developing TMDLs using a specific technical approach. It also discusses options for categorizing stormwater WLAs to facilitate their implementation in permits.
- **Chapter Five: Promoting effective stormwater management.** Presents an adaptive management framework for selecting, implementing, assessing, and modifying stormwater management strategies using information and tools that predict potential BMP performance
- **Chapter Six: Coordinating TMDLs and stormwater permit requirements.** Provides a variety of options for effectively tying together TMDLs and associated permit requirements through the development of TMDL reports, stormwater permit language, and fact sheets, as well as TMDL implementation planning documents.
- **Appendix.** Provides excerpts of TMDLs, implementation plans, and stormwater permit requirements to illustrate how states connect permitted stormwater source requirements among programmatic documents.
- **Bibliography.** Provides a comprehensive list of documents, Web sites, and databases that are included in the Resources section of each chapter or cited in the Handbook.
- **Glossary.** Defines key terms introduced throughout the Handbook.

1. **Understanding the Connections Between TMDLs and Stormwater Permits**
2. Identifying Opportunities to Coordinate TMDLs and Stormwater Permits
3. Characterizing Impairments and Stormwater Sources
4. Developing TMDLs with Stormwater Sources
5. Promoting Effective Stormwater Management
6. Coordinating TMDLs and Stormwater Permits

Chapter One
Understanding the Connections Between TMDLs and Stormwater Permits

What's included in this chapter

- ✓ Overview of the TMDL and stormwater programs.
- ✓ Discussion of the challenges associated with connecting TMDLs and stormwater permit requirements.

What you should know after reading this chapter

- ✓ Basic components of a TMDL and why stormwater sources receive WLAs.
- ✓ The three categories of permitted stormwater sources, the two types of stormwater permits, and a general understanding of stormwater permit requirements.
- ✓ Why development of this Handbook was necessary to help connect TMDLs and stormwater permits.

Potential roles and responsibilities under this activity

If you are a TMDL writer

1. Develop a basic understanding of who the stormwater program covers, the types of permits and requirements to which stormwater sources are subject, and factors affecting the role of the stormwater permit writer.
2. Understand how TMDL development relates for permit writers.

If you are a stormwater permit writer

1. Develop a basic understanding of when TMDLs are necessary, the TMDL development process, and factors affecting the role of TMDL writers.
2. Understand how stormwater permitting relates to developing and implementing TMDLs.

1. UNDERSTANDING THE CONNECTIONS BETWEEN TMDLS AND STORMWATER PERMITS

Understanding the regulatory, programmatic, and technical issues associated with the TMDL and NPDES Stormwater programs can help TMDL and permit writers improve cross-program connections, leading to better TMDLs and stormwater permits. This chapter briefly summarizes the key statutory and regulatory elements of these two programs.

1.1. What Every Permit Writer Should Know about the TMDL Program

> ***Resources:*** For more information on the TMDL program, refer to the Resources list at the end of this chapter in Section 1.4.1, including EPA's TMDL Web site at www.epa.gov/owow/tmdl/.

A TMDL reflects the total pollutant loading a waterbody can receive and still meet water quality standards. TMDLs are one of the many tools Congress authorized in the Clean Water Act (CWA) to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." (CWA section 101(a)). Section 303(d) of the CWA requires states, territories, and authorized tribes to identify and establish a priority ranking for waters for which technology-based effluent limitations required by section 301 are not stringent enough to implement applicable water quality standards, establish TMDLs for the pollutants causing impairment in those waters, and submit to the U.S. Environmental Protection Agency (EPA), from time to time, the list of waters in which water quality standards are not attained or maintained and for which TMDLs are required, as well as their associated TMDLs. EPA must review and approve or disapprove lists and TMDLs within 30 days. If EPA disapproves a list or a TMDL submitted by states, territories, and authorized tribes, EPA must establish the list or TMDL. In addition, some courts have interpreted the statute as requiring EPA to establish lists and TMDLs when a state fails to do so. EPA's TMDL regulations can be found at Title 40 of the *Code of Federal Regulations* (CFR) sections 130.7 and 130.2.

Listing impaired waters and establishing TMDLs for waters impaired by pollutants from point and nonpoint sources does not, by itself, create any new or additional implementation authorities to control point or nonpoint sources. Permitting authorities implement WLAs included in a TMDL through enforceable water quality-based discharge limits in NPDES permits authorized under section 402 of the CWA (see next section, "What every TMDL Writer Should Know about the NPDES Stormwater Program"). Mechanisms for implementing nonpoint source load allocations (LAs) within TMDLs include state section 319 nonpoint source management programs, coupled with a wide variety of other state, local, tribal, and federal programs—which may be regulatory, nonregulatory, or incentive-based, depending on the program—as well as voluntary action by committed citizens. To date, no tribe has sought or received CWA authority to establish TMDLs.

A brief summary of the key aspects of the TMDL program is provided below.

- **Section 303(d) Lists of Impaired Waterbodies.** Each state is required to identify "water quality limited segments," or impaired waterbodies, for which federal technology-based controls, state, tribal, or local effluent limitations or other pollution control requirements (e.g., BMPs) required by local, state, tribal, or federal authority are not stringent enough to achieve water quality standards, including waters not meeting standards due to thermal discharges (40 CFR 130.7 (b)). The list that

identifies these water quality limited segments is known as the Section 303(d) list. States are required to submit Section 303(d) list updates every 2 years. The information that the Section 303(d) list must contain (40 CFR 130.7) is as follows:

- ✓ The pollutant(s) causing (or expected to cause) the violation of water quality standards for each listed water
- ✓ A priority ranking of all listed waters and waters targeted for TMDL development within the next 2-year listing cycle
- ✓ Documentation to support listing decisions, including a description of the methodology used, data evaluated, rationale for not using any readily available data, and any other reasonable information requested by EPA to evaluate the listing decisions

New Location for 303(d) Lists

States are now integrating Section 303(d) lists of impaired waters and Section 305(b) water quality assessment reports to produce Integrated Reports. The Integrated Report groups a state's waters into five categories, depending on a determination of whether a waterbody is impaired or is in attainment of water quality standards. Category 5 of the Integrated Report contains the list of waterbodies that do not meet water quality standards and require a TMDL. Therefore, Category 5 represents the Section 303(d) list of impaired waters. For more information on Integrated Reports, visit EPA's Web site: www.epa.gov/owow/tmdl/2008_ir_memorandum.html

- **Components of a TMDL.** EPA's regulations at 40 CFR 130.2(i) define a TMDL as the sum of WLAs plus load LAs plus a margin of safety (MOS) to account for uncertainty between pollutant sources and resulting water quality. Allocations to pollutant sources vary on the basis of the type of pollutant sources—WLAs are loads allotted to existing and future point sources, and LAs are loads attributed to existing and future nonpoint sources, plus loads from natural background. Future growth allowances in TMDLs account for increased pollutant loadings and can be included as an allocation of pollutant loads from new sources expected in the future. For instance, in areas where land use changes are anticipated, TMDLs can include a reserve for future growth, which can be a separate component of the TMDL or included in WLAs or LAs.

Characteristics of a TMDL

- Addresses a variety of pollutants
- Contains quantified targets
- Considers all significant sources
- Expresses pollutant loads in relationship to water quality standards
- Provides allocations for known sources
- Considers a MOS and future growth
- Focuses on temporal nature of allocations to achieve standards
- Requires sound data
- Involves stakeholders

- **TMDL implementation plans.** Although not required by federal law or regulation, many states include (and some state regulations do require) TMDL implementation plans, which are typically developed in coordination with relevant stakeholders. A TMDL implementation plan typically identifies recommended management practices that major sources in the watershed are expected to implement, along with a general time frame and strategy for funding and monitoring. Factors such as waterbody ranking, data availability, court-ordered schedules, and anticipated management activities can affect the timing of TMDL development and implementation.

As illustrated in Figure 1, the process for developing a TMDL typically includes the following steps:

- Stakeholder involvement and public participation to engage affected parties and solicit input, feedback and buy-in for a successful TMDL. This process can occur throughout the TMDL development (and implementation) process.
- Watershed characterization to identify the waterbody, watershed, and impairment conditions; TMDL targets; and potential sources.

- Linkage analysis to calculate the loading capacity.
- Allocation analysis to evaluate and assign WLAs to point sources and LAs to nonpoint sources.
- Developing the TMDL report and administrative record for submittal to EPA.
- TMDL implementation to identify management activites to implement WLAs and LAs.

Figure 1 also illustrates where to find a discussion of each activity in the Handbook. At the beginning of each chapter, you will find a modified version of Figure 1 that highlights the TMDL activities discussed in that chapter.

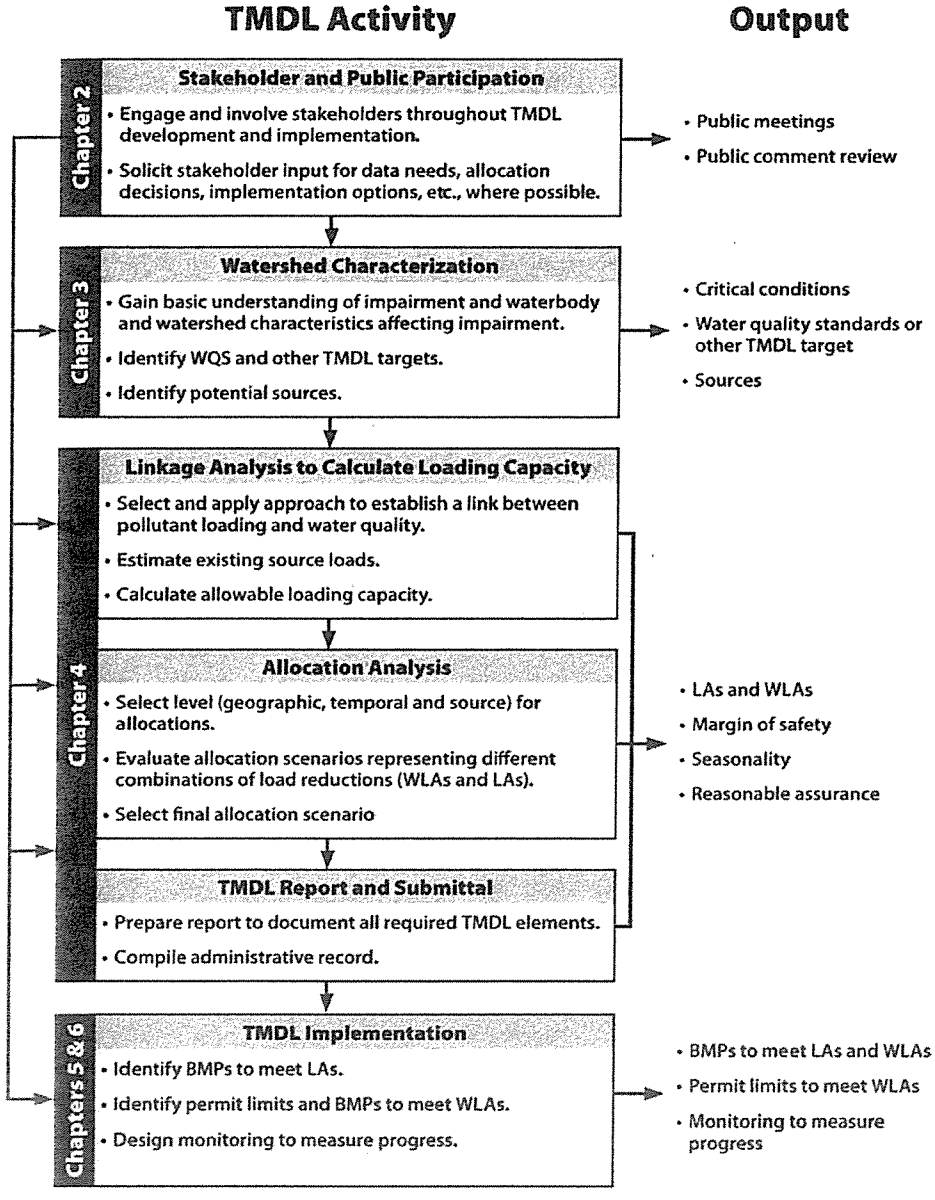


Figure 1. Typical steps in the TMDL development process.

1.2. What Every TMDL Writer Should Know about the NPDES Stormwater Program

To understand the NPDES Stormwater program, it is important to have an understanding of the NPDES program framework. This section provides a brief overview of the NPDES program to introduce basic permitting concepts and then provides details about the NPDES Stormwater program.

1.2.1. NPDES Program Framework

The CWA enacted in 1972 established the NPDES program and provides that either EPA or the state can administer (i.e., issue permits, assess compliance, take enforcement) the program. EPA, however, must first authorize a state to do so. Authorization requires that a state demonstrate to EPA's satisfaction that it has the necessary legal authority, technical skills, and resources to administer the program. Once authorized, a state becomes the *permitting authority*, taking on the responsibility of administering the NPDES program, including issuance of NPDES stormwater permits. As of 2008, 45 states (excluding Alaska, Idaho, Massachusetts, New Hampshire, and New Mexico) and one territory (U.S. Virgin Islands) are authorized to administer the NPDES program.[1] Where a state is not authorized to administer the NPDES program, the EPA Regional office is the permitting authority. For the purpose of this Handbook, the term *permit writer* is intended to convey a state or EPA staff person responsible for acting on behalf of the state agency or EPA regional office serving as the NPDES permitting authority in that area.

The NPDES regulations provide for two basic types of permits: individual and general. Dischargers requesting to be covered under an individual permit are required to submit an individual permit application, which the permit writer uses as the basis for developing site-specific permit requirements. The individual permit is then issued to that discharger for a period not to exceed 5 years, with a requirement to reapply before the expiration date. An individual permit is tailored specifically for an individual facility.

Five Basic Components of General and Individual NPDES Permits

- Cover page
- Effluent limits (numeric or narrative; technology-based or water quality-based)
- Monitoring and reporting requirements
- Standard conditions
- Special conditions

When the permitting authority expects that many dischargers with similar types of activities will require coverage under an NPDES permit, the permitting authority may choose to issue a general permit in lieu of issuing individual permits to each of these dischargers. After a general permit is issued, dischargers wishing to be covered under the general permit submit a Notice of Intent (NOI) to the permitting authority. These dischargers, consistent with procedures specified in the general permit, are then authorized to discharge under the terms of that general permit. The CWA requires that NPDES permits, both individual and general, be made available to the public for at least 30 days for review and comment before final issuance.

NPDES permits, with the exception of municipal separate storm sewer system (MS4) permits, must include technology-based effluent limitations based on best available technology economically achievable (BAT), or New Source Performance Standards (NSPS) for new sources, and any other more

[1] EPA Regions retain permitting authority for most Indian lands, federal facilities in four states (Colorado, Deleware, Vermont, and Washington) certain oil and gas activities (Texas and Oklahoma) and agricultural activities (Oklahoma).

stringent limitations as necessary to ensure that the discharge does not cause or contribute to in-stream exceedances of water quality standards. MS4s defined by the regulations as needing NPDES permit coverage are required to implement stormwater management programs (SWMPs) designed to control pollutants to the maximum extent practicable (MEP) to protect water quality rather than meeting a BAT requirement as for other NPDES permittees. NPDES-authorized states and territories may impose more stringent permit requirements than those set forth in federal regulations.

1.2.2. NPDES Stormwater Program

Resources: For more information on the NPDES Stormwater program, refer to the Resources list at the end of this chapter in Section 1.4.3, including EPA's NDPES Web site at www.epa.gov/npdes/stormwater.

In 1987 Congress amended the CWA to require EPA to regulate certain stormwater discharges through the NPDES program. After promulgating stormwater rules in 1990 and 1999 (known as the Phase I and Phase II stormwater rules, respectively), NPDES permitting authorities now issue permits to control stormwater discharges from (1) MS4s, (2) industrial activities, and (3) construction activities as follows:

(1) Medium, large, and regulated small MS4s: MS4s, generally, are public storm sewer systems (including roads with drainage systems and municipal streets) that are owned or operated by a public body and not part of a combined sewer (i.e., storm and sanitary sewers combined). Incorporated places and counties meeting EPA's definitions of medium and large MS4s are identified in the NPDES regulations in 40 CFR Part 122, Appendices F through I. In general, these are separate storm sewer systems that serve populations over 100,000 people. Regulated small MS4s are identified according to the U.S. Census Bureau definition of urbanized area as established every 10 years in its decennial census. Populations served by these regulated small MS4s range from several hundred to tens of thousands of people, but in most instances these systems serve fewer than about 30,000–50,000 people.

Types of MS4 Infrastructure and Permittees

The NPDES Stormwater program uses the term MS4 to describe the type of stormwater conveyance infrastructure, as well as the permittee required to obtain stormwater permit coverage. As a type of infrastructure, MS4s are not merely a system of pipes. As defined by regulations, an MS4 can also include drainage systems for roadways, gutters, and ditches.

An MS4 permittee does not just include municipally owned storm sewer systems. The term MS4 can also apply to a variety of entities that own and operate MS4 infrastructure, such as departments of transportation, military bases, universities, hospitals, and prisons.

(2) Industrial facilities that fall under 11 categories of industrial activities that discharge to an MS4 or to waters of the United States (construction activity disturbing 5 acres or more is one of these 11 categories, but because of the nature of its operations, it is addressed separately from the other 10 categories.). Industrial facilities (except construction) may certify to a condition of *no exposure* in lieu of obtaining NPDES permit coverage if their industrial materials and operations are not exposed to stormwater.

11 Categories of Industrial Activity

Category One (i): Facilities subject to national effluent limitations

Category Two (ii): Heavy Manufacturing

Category Three (iii): Mining and Oil and Gas

Category Four (iv): Hazardous Waste Storage, Treatment, or Disposal Facilities

Category Five (v): Landfills

Category Six (vi): Recycling Facilities

Category Seven (vii): Steam Electric Plants

Category Eight (viii): Transportation Facilities

Category Nine (ix): Wastewater Treatment Works

Category Ten (x): Construction Activity disturbing 5 acres or more

Category Eleven (xi): Light Industrial Activity

(3) Construction activity that disturbs one or more acre of land and less than one acre if the activity is part of a larger common plan of development or sale (USEPA 2004). The Phase I stormwater rule regulates construction activities 5 acres and above. The Phase II stormwater rule added sites between one and 5 acres.

Figure 2 illustrates how the regulation of these stormwater sources affected the universe of regulated NPDES dischargers over time. From the beginning of the NPDES program, permit writers across the country developed and issued permits for approximately 60,000 facilities with wastewater discharges. The NPDES Phase I Stormwater program required stormwater discharges from large and medium MS4s, large construction activities, and industrial facilities to obtain NPDES permit coverage; bringing approximately 300,000 stormwater sources into the NPDES program. The NPDES Phase II Final Rule covering regulated small MS4s and construction sites between one and 5 acres added approximately 200,000 additional stormwater sources to the NPDES program universe.

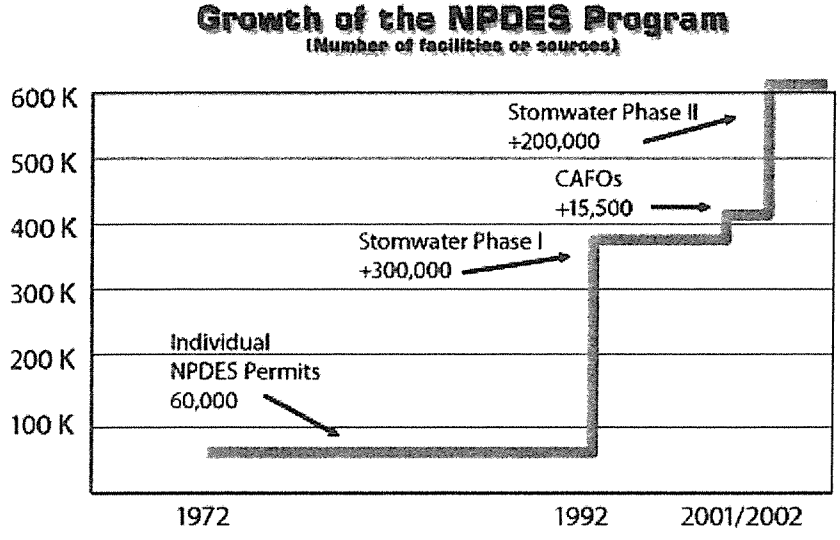


Figure 2. Number of facilities or sources permitted under various programs of the NPDES program over time.

A brief summary of key aspects of the NPDES Stormwater program is provided below.

1.2.2.1. Types of NPDES Stormwater Permits

To regulate the approximately 500,000 stormwater sources, the NPDES Stormwater program uses both individual and general permits.

- **Individual permits**, issued to most medium and large MS4s and small MS4s in a few states, require the initial submission of a comprehensive permit application. However, because most MS4s have already been permitted, the content of future applications is expected to contain less information than the original submission. Applications will contain available data or a summary of that data and the permittee's plans for future activities and controls to address any identified concerns. NPDES permitting authorities use the detailed permit application information to develop site-specific requirements.

- **General permits**, issued for most stormwater discharges associated with industrial and construction activities and small MS4s in most states, contain more widely applicable requirements. Stormwater dischargers submit an NOI to the permitting authority to obtain coverage under a general permit. The information necessary to complete an NOI for coverage under a general permit is usually (depending on state requirements) less burdensome than the information required for an individual permit. Coverage under a general permit is often relatively automatic when the discharger meets the eligibility requirements for coverage. Stormwater permittees that are unable to meet eligibility conditions for general permits must obtain coverage under an individual permit. Table 1 highlights the estimated number of stormwater permittees across the country by type of stormwater discharge and the number of general and individual permits issued to these permittees.

Table 1. Estimated number of stormwater permittees and permits by type of stormwater discharge

Type of stormwater discharge	Permittees	General permits	Individual permits
MS4	7,000	50	500
Industrial	100,000	120	Unknown*
Construction	250,000	60	Unknown*

* These permits are not tracked separately under the stormwater program. EPA estimates that several hundred entities are permitted with individual permits each year.

1.2.2.2. Standards and Limits in Stormwater Permits

The CWA requires, with the exception of MS4s, that NPDES permits contain technology-based effluent limits and water quality-based effluent limits (WQBELs) when the technology-based limits alone do not adequately protect water quality. The CWA standard for MS4s is that the permit must require controls to reduce the discharge of pollutants to the MEP to protect water quality. Stormwater permits use a variety of approaches to incorporate these concepts into NPDES permit conditions. Generally, stormwater permits require implementation of BMPs, identified as narrative effluent limits, deemed by the permitting authority to be appropriate to meet the intent of the CWA. These narrative effluent limits include practices such as source control and pollution prevention BMPs. Stormwater permits typically stipulate general categories of controls, and charge the permittee to articulate the details in a stormwater plan. Occasionally, stormwater permits will establish numeric effluent limits that must be met at the discharge point.

MEP Pollutant Reduction Standard for MS4s

Operators of regulated MS4s must develop and implement SWMPs that reduce the discharge of pollutants to the MEP to protect water quality. While MEP is a pollutant reduction standard that applies to all permitted MS4s, the practical aspects of MEP varies from location to location depending on factors such as pollutant sources and local receiving water conditions and concerns. EPA's *Measureable Goals Guidance for Phase II MS4s* (http://cfpub.epa.gov/npdes/stormwater/measurablegoals/part1.cfm) states the following:

> The definition of "MEP" should adapt continually to both current conditions and BMP effectiveness, but ultimately, successive iterations of the mix of BMPs and measurable goals should be made to achieve the objective of meeting water quality standards. If, after implementing the minimum control measures, there is still water quality impairment associated with discharges from the MS4, you will need to expand or better tailor your BMPs (USEPA 2001).

Stormwater permitting authorities must review MS4 SWMPs to determine if implementation of the plan is likely to reduce the discharge of pollutants to the MEP. Where the permitting authority identifies deficiencies, the MS4 must modify its SWMP.

1.2.2.3. Basic Stormwater Management Program and Pollution Prevention Plan Requirements

The primary requirement of NPDES stormwater permits is the development and implementation of a plan that describes how the permittee will control the discharge of pollutants in stormwater to meet permit requirements. Operators of regulated MS4s develop and implement SWMPs that cover a variety of activities discharging to the MS4, while operators of industrial facilities and construction activities must develop and implement facility-specific stormwater pollution prevention plans (SWPPPs). A brief overview of the type of management activities required in MS4 (Phase I and Phase II), industrial, and construction permits is provided below.

- **Phase I MS4 Permits.** Phase I MS4s, all of which were identified by incorporated place or county names in the 1990 Phase I Rule, were required to apply for permit coverage in the early 1990s with the application including the MS4s proposed SWMP to address programmatic, structural, and source control measures for stormwater discharges from commercial and residential areas, including discharges from areas of new development or redevelopment; illicit discharges; priority industrial facilities; and construction sites. Individual permits issued to Phase I MS4s specified the required SWMP activities and included other provisions to ensure effective implementation, such as monitoring and annual reporting.
- **Phase II MS4 Permits.** Regulated, small MS4s are required to obtain individual or general permit coverage and implement an SWMP that addresses the six minimum control measures: (1) public education and outreach; (2) public participation and involvement; (3) illicit discharge detection and elimination (IDDE); (4) construction site stormwater runoff control; (5) post-construction stormwater management in new and redevelopment; (6) pollution prevention/good housekeeping for municipal operations. In addition, Phase II MS4s must also develop and specify measurable goals for each of the six minimum control measures in the SWMP. The Phase II Final Rule does not require monitoring data as part of the application or as a requirement of the permit, although permitting authorities may decide otherwise. Regulated small MS4s are required to submit periodic reports to the permitting authority ranging from annually to twice every 5-year permit cycle.
- **Construction Stormwater Permits.** NPDES permits for stormwater discharges associated with construction activities require control measures (i.e., BMPs) to address pollutants in stormwater discharges. These requirements, almost always addressed through the issuance of statewide general permits, include erosion and sediment control BMPs to prevent the discharge of sediment and measures to prevent the discharge of non-sediment materials such as construction debris, vehicle fluids, concrete washout, and trash. In addition, some permitting authorities require post-construction stormwater management measures to minimize pollutant discharges after construction is complete. SWPPPs prepared by site operators describe activities to be performed and how the operator intends to comply with permit requirements (e.g., a description of controls to minimize

> ***Tip: Read SWMPs and SWPPPs—not just stormwater permits—to get implementation details.***
>
> TMDL writers often go to NPDES stormwater permits looking for information on stormwater discharges that will assist in the TMDL development process. Reviewing stormwater permits will provide an understanding of what permittees must include in the required SWMPs and SWPPPs, but the permits rarely provide complete details on this information. TMDL writers might need to obtain and review SWMPs and SWPPPs to gather information to support TMDL activitites, such as pollutant source characterization and pollutant load allocation. Chapter 3 of this Handbook provides an in-depth discussion of what information is available through SWMPs and SWPPPs and how TMDL writers can use this information to characterize stormwater sources.

exposure of the materials to stormwater and spill prevention and response practices). NPDES construction permits also typically require the site operator to document in an SWPPP any interim and permanent stabilization practices for the site, including a schedule of when the practices will be implemented.

- **Industrial Stormwater Permits.** Industrial stormwater permits typically focus on the implementation of BMPs to reduce stormwater pollutants. NPDES stormwater permits for industrial facilities typically require SWPPPs to document the facility's pollution prevention team, describe the site, identify the receiving waters, and describe the BMPs that will be implemented to meet permit requirements. An SWPPP should also contain a summary of potential pollutant sources, including spills and leaks, and a summary of existing stormwater discharge sampling data. The focus of the SWPPP is the description of the existing and planned BMPs to reduce stormwater pollutants. BMPs may be procedural such as good housekeeping activities, spill prevention and response planning, preventative maintenance, routine facility inspections, and employee training or structural systems, such as containment systems or sediment basins.

1.3. Key Challenges Associated with Connecting the TMDL and NPDES Stormwater Programs

> ***Resources:*** For more information on research and policy related to TMDLs and stormwater, refer to the Resources list at the end of this chapter in Section 1.4.2.

Improving the ways in which water quality programs work together and relate to one another often presents challenges because of programmatic, regulatory, and technical differences. Improving connections between the TMDL and NPDES Stormwater programs highlights challenges such as conflicting program priorities, and unsynchronized development schedules, lack of sufficient data, inadequate cross-program communication, and lack of adequate staff and resources. EPA and state TMDL and permit writers working to improve connections between the TMDL and NPDES Stormwater programs have identified some key challenges facing each program. EPA's *Total Maximum Daily Loads and National Pollutant Discharge Elimination System Storm Water Permits for Impaired Water Bodies: A Summary of State Practices* (USEPA 2007) provides a detailed discussion of these key challenges and possible solutions. These key challenges are briefly summarized below and discussed in greater detail in subsequent chapters.

1.3.1. Challenge 1: Addressing Differences in Organizational Structure

Strengthening the connections between TMDLs and stormwater permits begins with communication and coordination among internal programmatic staff. Often this is challenging for a variety of reasons. In most instances, TMDL and NPDES permitting staff function not only in different programs, but in different organizational groups. In some states, the separation between programs is more drastic, with TMDL and NPDES staff functioning under different agencies. These organizational differences can create real and perceived obstacles for effective staff coordination. In addition, agency staff can face programmatic pressures (e.g., court ordered deadlines, permit reissuance schedules) that limit timely coordination.

1.3.2. Challenge 2: Developing Consistent Stormwater Allocations in TMDLs

Approaches for developing and expressing TMDLs that include stormwater sources can vary within and among states. For example, some TMDLs assign aggregated stormwater WLAs to all permitted stormwater sources within a watershed or to each type of permitted stormwater source. Collecting additional dataor information on the permitted stormwater sources within a watershed might allow TMDL writers to generate more detailed WLAs that could facilitate the development of permit requirements.

1.3.3. Challenge 3: Translating Numeric TMDL WLAs into Implementation Strategies and Permit Requirements

One way for TMDL and permit writers to facililitate the implementation of TMDLs is to provide permittees with information on specific types of management strategies that could be used to implement the WLAs. In most cases, this means facilitating efforts so that the WLA, the TMDL implementation plan (if applicable), and the stormwater permit requirements are developed to coordinate with each other in a meaningful way, particularly when stormwater sources are covered exclusively by general permits.

1.3.4. Challenge 4: Reconciling Spatial Boundaries of TMDLs with Boundaries of NPDES Stormwater Permits

The TMDL program often provides information on impaired waters by waterbody or watershed. The majority of actions under the NPDES Stormwater program focus on site-specific activities (e.g., construction sites and industrial facilities) and large stormwater conveyances systems (e.g., MS4s). The different spatial scales at which regulatory agencies provide information to, and require information from, permittees can create challenges as permittees attempt to identify applicable requirements and determine the appropriate locations to implement the requirements.

1.3.5. Challenge 5: Incorporating Monitoring, Tracking, and Adaptive Management Elements into TMDL WLAs and Stormwater Permits

Monitoring and evaluation are key components to determining if stormwater management efforts are producing the necessary pollutant load reductions identified in the TMDLs, thereby making progress toward attainment of water quality standards. Because it is not required, most TMDLs do not address monitoring or, if the need is mentioned, the type and frequency of monitoring necessary to demonstrate progress towards attaining and maintaining water quality standards. Stormwater permits require all stormwater permittees to evaluate the efficacy of their SWMP or SWPPP. However, the evaluation process does not usually involve end-of-pipe or in-stream analytical monitoring to directly evaluate stormwater discharge or ambient water quality. To more effectively connect TMDLs and stormwater permits, the TMDL could include recommendations regarding monitoring, tracking, and adaptive management activities, and the relevant stormwater permits could either reference the recommended activities or adopt these recommendations. Permit writers can consider permittees to identify milestones on the basis of criteria (water quality- or technology-based) that use the monitoring and tracking information to drive adaptive management efforts.

1.4. Resources

1.4.1. TMDL Program

1. EPA's TMDL Web site: www.epa.gov/owow/tmdl/

2. USEPA (U.S. Environmental Protection Agency). 2005. *Guidance for 2006 Assessment, Listing, and Reporting Requirements Pursuant to Sections 303(d), 305(b), and 314 of the Clean Water Act [2006 Integrated Report Guidance (IRG)].* U.S. Environmental Protection Agency, Office of Water, Office of Wetland, Oceans and Watersheds, Washington, DC. www.epa.gov/owow/tmdl/2006IRG/#documents

   This document provides a recommended reporting format and suggested content to be used in developing a single document that integrates the reporting requirements of the CWA sections 303(d), 305(b), and Part 314. The report also provides a comprehensive compilation of EPA's previous guidance related to integrated reporting.

3. USEPA (U.S. Environmental Protection Agency). 2006. *Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Listing and Reporting Decisions.* Memorandum from Diane Regas, Director, Office of Wetlands, Oceans and Watersheds to Regions 1-10 Water Division Directors. www.epa.gov/owow/tmdl/2008_ir_memorandum.html

   This EPA memorandum dated October 12, 2006, provides information to assist in the preparation and review of 2008 integrated water quality reports to supplement the information provided in the 2006 Integrated Report Guidance.

4. USEPA (U.S. Environmental Protection Agency). 1991. *Guidance for Water-Quality-based Decisions: The TMDL Process.* EPA 440/4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/OWOW/tmdl/decisions/

   This guidance document explains the programmatic elements and requirements of the TMDL process as established by CWA section 303(d) and by EPA's Water Quality Planning and Management Regulations (40 CFR Part 130). It discusses the process for developing a TMDL, roles of EPA and the states in the process, and supporting or related water programs.

5. Best-Wong, B. 2006. *Clarification Regarding "Phased" Total Maximum Daily Loads.* Memorandum from Benita Best-Wong, Director, Assessment and Watershed Protection Division, to Water Division Directors, Regions 1–10, August 2, 2006. www.epa.gov/owow/tmdl/tmdl_clarification_letter.html

   This memorandum clarifies the *Guidance for Water Quality-Based Decisions: The TMDL Process*, issued in 1991, by explaining EPA's interpretation of the term *phased TMDL* as used in EPA guidance and explaining the distinction between *phased TMDLs*, *staged implementation*, and *adaptive implementation.*

6. EPA's *Guidelines for Reviewing TMDLs Under Existing Regulations Issued in 1992*: www.epa.gov/owow/tmdl/guidance/final52002.html

This Web document provides guidance on the required elements of a TMDL report for use in reviewing and approving TMDLs.

1.4.2. TMDLs and Stormwater

1. EPA's TMDL and Stormwater Resources Web site: www.epa.gov/owow/tmdl/stormwater

2. USEPA (U.S. Environmental Protection Agency). 2007. *Total Maximum Daily Loads with Stormwater Sources: A Summary of 17 TMDLs*. EPA 841-R-07-002. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, DC. www.epa.gov/owow/tmdl/17_TMDLs_Stormwater_Sources.pdf

   This document summarizes 17 TMDLs that have been developed for stormwater-source pollutants in 16 states, representing a range of pollutants, models used, and different allocation and implementation methods.

3. USEPA (U.S. Environmental Protection Agency). 2007. *Total Maximum Daily Loads and National Pollutant Discharge Elimination System Storm Water Permits for Impaired Water Bodies: A Summary of State Practices*. U.S. Environmental Protection Agency, Region 5, Chicago, IL. www.epa.gov/region5/water/wshednps/pdf/state_practices_report_final_09_07.pdf

   This report summarizes information on TMDL-stormwater practices in 10 states, provides specific TMDL and permit language, and identifies some specific technical and programmatic challenges.

4. Wayland, R.H., and J.A. Hanlon. 2002. *Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs*. Memorandum from Robert H. Wayland, III, Director, Office of Wetlands, Oceans and Watersheds, and James A. Hanlon, Director, Office of Wastewater Management, U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/npdes/pubs/final-wwtmdl.pdf

   This memo clarifies existing EPA regulatory requirements for, and provides guidance on, establishing WLAs for stormwater discharges in TMDLs approved or established by EPA.

5. NRC (National Research Council). 2008. *Urban Stormwater Management in the United States*. Committee on Reducing Stormwater Discharge Contributions to Water Pollution, Water Science and Technology Board, Division on Earth and Life Studies, National Research Council of the National Academies. National Academies Press, Washington, D.C.

   The report provides a description of the history of stormwater management in the United States; an overview of stormwater regulations and the federal regulatory program; and information on a number of relevant scientific and technological issues such as hydrology, geomorphology, biology, monitoring and modeling. The report also provides a number of significant findings and recommendations on how stormwater management in the United States should be improved to achieve better environmental outcomes

1.4.3. NPDES Stormwater Program

1. EPA's NPDES Stormwater program Web site: http://cfpub.epa.gov/npdes/home.cfm?program_id=6

2. EPA's NPDES Stormwater Program Authorization Status: http://cfpub.epa.gov/npdes/stormwater/authorizationstatus.cfm

3. NRC (National Research Council). 2008. *Urban Stormwater Management in the United States.* Committee on Reducing Stormwater Discharge Contributions to Water Pollution, Water Science and Technology Board, Division on Earth and Life Studies, National Research Council of the National Academies. National Academies Press, Washington, D.C.

   The report provides a description of the history of stormwater management in the United States; an overview of stormwater regulations and the federal regulatory program; and information on a number of relevant scientific and technological issues such as hydrology, geomorphology, biology, monitoring and modeling. The report also provides a number of significant findings and recommendations on how stormwater management in the United States should be improved to achieve better environmental outcomes.

1.4.3.1. MS4s

1. EPA's NPDES Stormwater Discharges from Municipal Separate Storm Sewer Systems Web site: http://cfpub.epa.gov/npdes/stormwater/munic.cfm

2. USEPA (U.S. Environmental Protection Agency). 2007. *Municipal Separate Storm Sewer System (MS4) Program Evaluation Guidance.* EPA-833-R-07-003. U.S. Environmental Protection Ageny, Office of Wastewater Management, Water Permits Division, Washington, DC. www.epa.gov/npdes/pubs/ms4guide_withappendixa.pdf and www.epa.gov/npdes/pubs/ms4guide_appendicesb-d.pdf

   This guide is primarily for use by NPDES authorities to evaluate the quality of Phase I and Phase II MS4 programs for permit compliance, technical assistance, and other purposes. It can be used for comprehensive program evaluations or for certain components. MS4 program managers can also use it to evaluate their own programs.

3. USEPA (U.S. Environmental Protection Agency). 2005. *Stormwater Phase II Final Rule Fact Sheet: Small MS4 Stormwater Program Overview.* EPA 833-F-00-002. U.S. Environmental Protection Agency, Office of Water. www.epa.gov/npdes/pubs/fact2-0.pdf

   This three-page fact sheet provides the definition of regulated small MS4s and associated permit requirements for regulated small MS4s.

1.4.3.2. Industrial Activities

1. EPA's NPDES Stormwater Discharges from Industrial Facilities Web site: http://cfpub.epa.gov/npdes/stormwater/indust.cfm

2. List of sectors of industrial activity that require permit coverage: http://cfpub.epa.gov/npdes/stormwater/swcats.cfm

3. USEPA (U.S. Environmental Protection Agency). 1992. *Stormwater Management for Industrial Activities: Summary Guidance on Developing Pollution Prevention Plans and Best Management*

Practices. EPA 833-R-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/npdes/pubs/owm0236a.pdf

This document provides guidance on the SWPPP requirements and includes a set of worksheets, a checklist, and a sample SWPPP.

1.4.3.3. Construction Activities

1. EPA's NPDES Stormwater Discharges from Construction Activities Web site: http://cfpub.epa.gov/npdes/stormwater/const.cfm

2. USEPA (U.S. Environmental Protection Agency). 2007. *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites*. EPA 833-R-060-04. U.S. Environmental Protection Agency, Washington, DC. http://cfpub.epa.gov/npdes/stormwater/swppp.cfm

   This guidance document is a reference for construction site operators who must comply with an NPDES stormwater permit. Through its description of the SWPPP development process, this guidance addresses the type of information required in an SWPPP and could help TMDL writers determine if SWPPPs will provide information and data useful to the TMDL development process.

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1. Understanding the Connections Between TMDLs and Stormwater Permits
2. **Identifying Opportunities to Coordinate TMDLs and Stormwater Permits**
3. Characterizing Impairments and Stormwater Sources
4. Developing TMDLs with Stormwater Sources
5. Promoting Effective Stormwater Management
6. Coordinating TMDLs and Stormwater Permits

Chapter Two
Identifying Opportunities to Coordinate TMDLs and Stormwater Permits

What's included in this chapter

- ✓ Overview of activities used by various state agencies to promote better coordination and communication among TMDL and permit writers.
- ✓ Discussion of opportunities to promote better coordination between TMDLs and stormwater permits at different stages of the development process.

What you should know after reading this chapter

- ✓ Internal reorganization efforts can help to promote better coordination between TMDL and stormwater permitting programs.
- ✓ Options exist for coordinating TMDLs and stormwater permits, even if development schedules are not synchronized.
- ✓ Communication between program staff, as well as affected stakeholders, is key to improving connections between TMDLs and stormwater permits.

Potential roles and responsibilities under this activity

If you are a TMDL writer

1. Find out the names of stormwater permit staff and talk to them about the state's stormwater permitting program.
2. Identify TMDLs on the 303(d) list that might have a stormwater component and share the list of watersheds and municipalities with stormwater permitting staff, along with the associated TMDL development schedule.

If you are a stormwater permit writer

1. Find out the names of TMDL program staff and talk to them about the state's TMDL program.
2. Submit list of permits to be issued or reissued categorized by watershed to TMDL staff to determine status on the 303(d) list and TMDL development schedule.

2. IDENTIFYING OPPORTUNITIES TO COORDINATE TMDLS AND STORMWATER PERMITS

Improving the connection between TMDLs and stormwater permits can start with TMDL and permit writers taking steps to improve communication through efforts such as (1) coordinating programmatic schedules and activities and (2) developing institutional and organizational communication mechanisms. Improved communication at the programmatic level can lead to improved coordination of technical activities, such as assessment and monitoring. Improving internal coordination and communication among TMDL and permit writers can foster good communication and information sharing with key stakeholders, including stormwater sources. As shown in Figure 3, stakeholder and public involvement is an important element of the overall TMDL process. Engaging and involving stakeholders is required under both the TMDL and NPDES Stormwater programs and provides stakeholders with the opportunity to share stormwater related data and information to strengthen and focus the overall TMDL analysis and related implementation efforts. This chapter addresses opportunities to improve coordination and communication both internally and with key stakeholders that affect stormwater management decisions and activities.

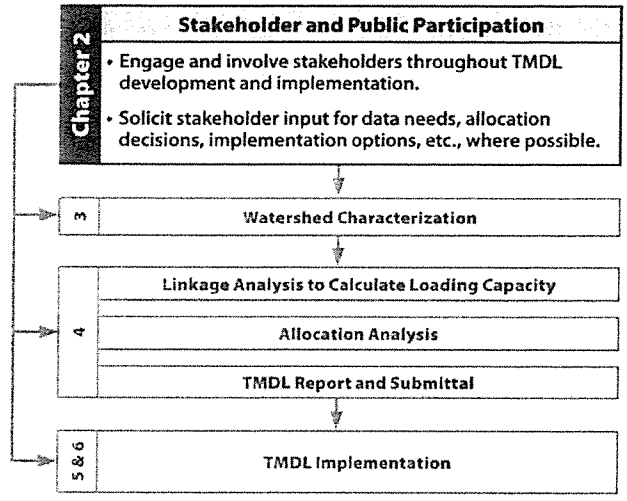


Figure 3. Illustration of the steps in the TMDL process, including the step of stakeholder involvement and public participation.

2.1. Improving Internal Communication and Coordination

Schedules and priorities for the TMDL program are driven by factors such as court-ordered deadlines, waterbody rankings under the section 303(d) list, rotating watershed basin planning approaches, as well as available staff and resources. Factors such as regulatory requirements, permit expiration dates, rotating watershed basin planning and assessment approaches, as well as available staff and resources, affect NPDES stormwater permit development schedules. Regardless of how internal program schedules and priorities are set, it could prove beneficial for TMDL and permit writers to participate in some type of internal planning to determine short-term and long-term schedules for TMDLs and stormwater permit development. Examining internal program schedules is a good starting point for identifying opportunities for coordination and collaboration between the programs.

> ***Resources:*** For more information on approaches states and EPA Regions use to improve coordination between the TMDL and Stormwater programs, refer to the Resources list at the end of this chapter in Section 2.3.

TMDL and permit writers should collectively examine each program's schedule to determine the timing for (1) waterbodies and watersheds with *ongoing* TMDL development activities for impairments with known or suspected stormwater sources; (2) waterbodies and watersheds with *planned* TMDL

development activities for impairments with known or suspected stormwater sources; and (3) general and individual stormwater permits nearing expiration, expired, or administratively continued discharging to impaired waterbodies or within impaired watersheds that have ongoing or planned TMDL development activities. Ultimately, the goal is to identify stormwater source TMDLs and stormwater permits that fall into the following categories: impending, in progress, and developed.

As illustrated in Table 2, there are a variety of ways that TMDL and permit writers can promote better connections between TMDLs and stormwater permits regardless of the development status. Significant opportunities for coordination include activities such as data collection and sharing, stakeholder involvement, permit and TMDL language development, and process administration. It is important to note that coordination opportunities might vary depending on the type of permit used to implement the TMDL. Table 2 highlights where differences in opportunities exist according to permit type.

Planning and scheduling is only one factor affecting internal TMDL and NPDES Stormwater program coordination and collaboration. Organizational structures that affect how easily staff from the two programs can work together also influence TMDL and permit writer coordination and collaboration. Several EPA Regions and state agencies have reorganized to bring the TMDL and NPDES Stormwater programs under a common management unit (e.g., branch, division, group). Some have gone beyond bringing the programs together and have taken steps to ensure further integration either by developing TMDL-stormwater teams or specific positions tasked with promoting stormwater-source TMDL implementation.

Table 2. Potential opportunities for coordination based on status of TMDL and stormwater permit development

Status of TMDL	Status of stormwater permit	Potential opportunities for coordination	
		Individual permit	General permit
Impending	Impending (New or Anticipated Reissuance)	▪ Identify available data, data gaps, and develop integrated approach for collecting additional data ▪ Attempt to synchronize schedules for coordinated development ▪ Develop coordinated TMDL and permit stakeholder involvement process ▪ Conduct collaborative kick-off meeting among TMDL and permit writers and permittee(s) that integrates discussion of TMDL development issues and implementation considerations ▪ Determine how the permit can address future TMDLs	▪ Conduct internal collaborative kick-off meeting among TMDL and permit writers ▪ Determine if TMDL will recommend specific stormwater BMPs recommended to implement the WLA ▪ Coordinate development of TMDL and permit language to ensure consistency ▪ Determine how the permit can address future TMDLs
	In Progress	▪ Consider adjusting permit development schedule to track with TMDL development ▪ Share data and information collected through permit application process with TMDL writers to inform TMDL development ▪ Discuss potential TMDL data needs and incorporate permit requirements that focus on monitoring and other types of data collection that will inform TMDL development	▪ Tailor permit language to acknowledge the need for permittees to review and modify SWMP/SWPPP to achieve consistency with WLAs upon approval of the TMDL

Status of TMDL	Status of stormwater permit	Potential opportunities for coordination	
		Individual permit	General permit
	Developed	▪ Discuss options for modifying the permit to be consistent with TMDL WLA assumptions. ▪ Share data and information collected through permit application process with TMDL writers to inform TMDL development	▪ Determine if the permit will be consistent with TMDLs approved at the time of permit issuance or at the time of NOI submission ▪ Evaluate existing permit language regarding consistency with approved WLAs to determine if it is adequate or requires revision during permit reissuance process ▪ Consider developing a technical appendix/amendment to update existing stormwater permit, without triggering permit modification requirements, to compile and present TMDL requirements upon completion
In-Progress	Impending (New or Anticipated Reissuance)	▪ Discuss TMDL development process and options for WLA categorization to enable sources to implement them through planned permit requirements ▪ Develop specific requirements that directly relate to implementation of the proposed WLAs, such as monitoring and SWMP/SWPPP assessment and modification	▪ Consider including any implementation planning information from the TMDL into the permit either directly or by reference ▪ Identify data gaps discovered through the TMDL development process and determine what type of permit requirements are appropriate to include to facilitate filling data gaps for potential future revision of the TMDL or to support adaptive management activities
	In Progress	▪ Compare information collected to date under each program to ensure that each process is working with the same data and information and to determine if one program can fill any data gaps identified by the other program ▪ Attempt to streamline interaction with stakeholders by conducting joint meetings or consolidating data requests ▪ Identify activities under each process to determine if there is any overlap and any opportunity for integrating remaining activities ▪ Ensure that any language used in both the TMDL and the permit are consistent; provide updates on changes to language as necessary	▪ Identify activities under each process to determine if there is any overlap and any opportunity for integrating remaining activities ▪ Ensure that any language used in both the TMDL and the permit are consistent; provide updates on changes to language as necessary
	Developed	▪ Review existing permit requirements and required permit documents (e.g., SWMPs and SWPPPs) to determine if existing permittee-generated data and information can facilitate remaining TMDL development activities ▪ Discuss options for modifying the permit to be consistent with TMDL WLA assumptions and requirements	▪ Determine if the permit will be consistent with TMDLs approved at the time of permit issuance or at the time of NOI submission ▪ Evaluate existing permit language regarding compliance with proposed WLAs to determine if it is adequate or requires revision during permit reissuance process ▪ Consider developing a technical appendix/amendment to update existing stormwater permit, without triggering permit modification requirements, to compile and present TMDL requirements upon completion

Status of TMDL	Status of stormwater permit	Potential opportunities for coordination	
		Individual permit	General permit
Developed	Impending (New or Anticipated Reissuance)	▪ Review the approved WLA to determine how best to reflect the input factors and pollutant loads established in the WLA for implementation into new or reissued permit requirements ▪ Identify any TMDL implementation planning activities or information that the permit could incorporate or reference to help permitted stormwater sources implement the approved WLA	▪ Determine most feasible and appropriate requirements to include in the permit to demonstrate SWMP or SWPPP progress toward implementing the WLA ▪ Consider developing a technical appendix/amendment to compile and present TMDL information
	In Progress	▪ Review draft permit conditions to ensure consistency with the approved WLA and any TMDL implementation plan recommendations ▪ Develop and incorporate tailored monitoring requirements to assess progress toward implementing the WLA	▪ Review draft permit conditions to ensure requirements related to impaired waterbodies with approved TMDLs reflect WLAs and , if applicable TMDL implementation plan recommendations ▪ Ensure that draft permit conditions include meaningful monitoring and assessment requirements that will support adaptive management activities
	Developed	▪ Assess if current permit conditions are consistent with approved WLA ▪ Determine if mechanisms exist to assess progress toward implementing WLAs ▪ Plan potential changes to future versions of the permit	▪ Assess if current permit conditions are consistent with approved WLA ▪ Determine if mechanisms exist to assess progress toward implementing WLAs ▪ Plan potential changes to future versions of permit conditions

In Practice: Efforts to Promote Improved Coordination Between TMDL and Permit Activities

States and EPA are making strides to promote improved coordination between TMDL and permit writers. A few examples of internal efforts are provided below.

Consolidating stormwater-source TMDL development with one group. The Vermont Department of Environmental Conservation has a Stormwater Management Section that focuses on administering the state's stormwater program—both the federal NPDES Stormwater program and the state-authorized SWMP. Although staff in this section address stormwater permitting issues, they also tackle TMDL development if the impairment involves stormwater. TMDL staff hand off stormwater-related TMDL development and implementation to staff in the Stormwater Management Section that have expertise both in permitting issuance and stormwater BMP implementation.

Assigning staff to coordinate and promote implementation. In Minnesota and Tennessee, the state agencies have recently created new positions intended to promote successful stormwater management implementation and connection to the TMDL program, as well as other related requirements. Oregon assigns one person to coordinate TMDL development and permitting within one watershed, although that one person might not necessarily be responsible for actually developing the TMDLs or crafting permit language.

Bringing staff physically and organizationally together. Promoting more effective communication and data sharing often requires reorganizing staff to share physical space or space on an organizational chart. EPA Region 2 reorganized TMDL and permit staff to bring them together under one branch. EPA Region 10 physically moved TMDL and permit staff to share a common area. EPA Region 4 is reorganizing to include TMDL development, permits, and nonpoint sources together in one branch

Facilitating regular communication. EPA headquarters works with EPA Regional Offices to host monthly TMDL and Stormwater Workgroup conference calls. These internal calls provide EPA TMDL and permit staff from every region with the opportunity to exchange information and ideas related to TMDL development and implementation through stormwater permits. The group participates in developing technical resources and

shares information on TMDL and stormwater projects. EPA Region 4 conducts bimonthly conference calls with state TMDL and stormwater permit staff to exchange information and ideas on issues affecting coordination between the two programs.

2.2. Improving Stakeholder Communication and Coordination

Another reason to promote coordination between TMDL and permit writers is to enable key stakeholders, including stormwater sources, to participate in the TMDL development process. Permit writers can help to encourage stormwater sources to participate in the TMDL development process and facilitate information sharing. Although TMDL writers are likely to work with permit writers to obtain permit-related information from stormwater sources, there might be instances when TMDL writers have to go directly to stormwater sources to obtain information and data. Stormwater sources might have an additional level of comfort and willingness to share information knowing their permit writer is involved in the process.

Stakeholder involvement is an essential component of both the TMDL development and NPDES permitting process. Both the TMDL and the NPDES programs contain regulatory requirements for public participation that involve activities such as public review, public notice, public hearings, and public comment periods Ideally, TMDL and permit writers should identify and involve stakeholders early in both the TMDL development and NPDES permitting processes. The primary stakeholders in the TMDL and NPDES processes are parties directly affected by the TMDL allocations or the permit requirements. In the case of stormwater source TMDLs, the primary stakeholders are permitted stormwater sources that will receive a WLA under the TMDL and must implement the WLA through stormwater permits. In addition to permitted stormwater sources, other stakeholders include those affected by the TMDL and permitting decisions or have information to contribute to the process, such as local environmental organizations, homeowner associations, universities, local developers, and city planners.

Resources: For more ideas and strategies to involve stakeholders, refer to the Resources list at the end of this chapter in Section 2.3.2.

Providing data and information is one of the most significant contributions that stakeholders can make to the stormwater source TMDL development process. TMDL and permit writers can consider opportunities and approaches to facilitate information exchanges and technical participation in the TMDL development process. These opportunities could include face-to-face information exchange meetings, facility visits, focus group meetings for feedback on technical issues pertaining to stormwater source WLA development and associated permit requirements, or regular group conference calls to discuss ideas and progress. As mentioned in the previous section, permit writers might have access to much of the data and information generated by stakeholders through compliance with existing stormwater permit requirements. (Chapter 3 of this Handbook provides a discussion of the types of information sources generate through stormwater permit requirements and how TMDL writers can use this information in the stormwater source TMDL development process.)

In Practice: Using Stakeholder Data and Information to Identify High-Priority Stormwater Sources

The 2007 Charles River watershed (Massachusetts) pathogen TMDL relies on data from the Charles River Hot Spot monitoring effort to identify and prioritize bacterial sources of pollution. This monitoring effort, crucial to the TMDL development process, is the result of a single watershed stakeholder dedicated to voluntarily kayaking the Lower Charles River shoreline to conduct sampling after rain events. From 2002 through 2005, this dedicated watershed stakeholder followed sampling procedures detailed in the approved Charles River Watershed Association Quality Assurance Project Plan (QAPP) for fecal coliform. He was able to collect samples from several hundred storm drain outfalls during this period. Data from this stakeholder-based monitoring effort allowed the Massachusetts Department of Environmental Protection to identify and prioritize 31 stormwater outfalls along the Lower Charles River as high-priority bacterial sources in the TMDL analysis. Ultimately, the data collected by this dedicated watershed stakeholder will help the Massachusetts Department of Environmental Protection and other key stakeholders target future bacterial source tracking efforts and implementation activities.

In Practice: Locally Led TMDL Implementation

The DuPage River Salt Creek Workgroup (DRSCW) is a collaborative stakeholder effort by sanitary districts, municipalities, counties, forest preserve districts, state and federal agencies, and private environmental organizations to address the water quality impairments identified in chloride and dissolved oxygen TMDLs for branches of the DuPage River and Salt Creek (Illinois). Although Illinois EPA held public meetings during the development of the TMDL reports, a watershed-based stakeholder group did not exist in the area when the TMDL reports were written. Stakeholders affected by the TMDL allocations wanted an opportunity to *substantiate* implementation strategies and determine whether there were other cost-effective options for achieving water quality standards (DRSCW 2004). Representatives from municipalities affected by the TMDL reports discussed forming the workgroup to collect data and carry out other technical activities to move forward with implementing the TMDLs. It was also envisioned that the DRSCW could help stakeholders establish a solid foundation for future TMDLs, contribute to developing nutrient criteria, and address other water quality or regulatory issues in the watersheds. A core group of municipalities generated support for the workgroup concept by emphasizing the importance of locally led decisions on where and how to spend local money to address water quality issues.

2.3. Resources

2.3.1. TMDL and Stormwater Permitting

1. EPA's TMDL and Stormwater Web site: www.epa.gov/owow/tmdl/stormwater/

2. USEPA (U.S. Environmental Protection Agency). 2007. *Total Maximum Daily Loads and National Pollutant Discharge Elimination System Storm Water Permits for Impaired Water Bodies: A Summary of State Practices*. U.S. Environmental Protection Agency, Region 5, Chicago, IL. www.epa.gov/region5/water/wshednps/pdf/state_practices_report_final_09_07.pdf

   This EPA report summarizes information on TMDL-stormwater practices in 10 states, provides specific TMDL and permit language, and identifies some specific technical and programmatic challenges.

2.3.2. Identifying and Involving Stakeholders

1. USEPA (U.S. Environmental Protection Agency). 2008. *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. EPA 841-B-08-002. U.S. Environmental Protection Agency, Office of Water, Nonpoint Source Control Branch, Washington, DC. www.epa.gov/nps/watershed_handbook/

   Chapter Three: Building Partnerships (www.epa.gov/nps/watershed_handbook/pdf/ch03.pdf): This chapter provides guidance on initial activities to organize and involve interested parties in watershed-based water quality protection activities. Topics include identifying stakeholders, integrating other key programs, and conducting outreach.

2. Conservation Technology and Information Center Web site, *Know Your Watershed: Building Local Partnerships*: www2.ctic.purdue.edu/KYW/Brochures/BuildingLocal.html

1. Understanding the Connections Between TMDLs and Stormwater Permits
2. Identifying Opportunities to Coordinate TMDLs and Stormwater Permits
3. **Characterizing Impairments and Stormwater Sources**
4. Developing TMDLs with Stormwater Sources
5. Promoting Effective Stormwater Management
6. Coordinating TMDLs and Stormwater Permits

Chapter Three
Characterizing Impairments and Stormwater Sources

What's included in this chapter

- ✓ General description of the types of impairments resulting from stormwater.
- ✓ Description of the commonly used types of data analyses to understand the impairment being addressed in a TMDL.
- ✓ Discussion of setting TMDL targets for TMDLs with stormwater sources.
- ✓ Discussion of identifying potential sources to include in the TMDL analysis.
- ✓ Description of the types of data generated by stormwater dischargers that TMDL writers can use to better understand the relative contribution of stormwater sources to a waterbody impairment.

What you should know after reading this chapter

- ✓ What data and information can help to characterize the impairment to support identification of TMDL targets and potential sources.
- ✓ What information is available to accurately and comprehensively include stormwater sources in the watershed characterization for TMDL development.
- ✓ How TMDL writers can work with permit writers to determine the availability and the value of the stormwater discharger information before investing time and energy into data collection.

Potential roles and responsibilities under this activity

If you are a TMDL writer

1. Analyze waterbody and watershed data to characterize the impairment related to the stormwater impacts.
2. Identify whether stormwater sources are contributing to the impairment addressed in your TMDL.
3. Coordinate with stormwater permit staff to obtain existing data and information from stormwater permittees.
4. Use available data to characterize stormwater sources and their potential contribution to water quality impairments.

If you are a stormwater permit writer

1. Share existing stormwater discharger generated data available in-house with TMDL writers.
2. Serve as a liaison between TMDL writers and stormwater permittees to streamline the data sharing process.

3. CHARACTERIZING IMPAIRMENTS AND STORMWATER SOURCES

The general process for developing a TMDL including stormwater sources is much the same as that for developing any TMDL, including the following typical steps:

- Watershed characterization to identify the watershed, waterbody, and impairment conditions; TMDL targets; and potential sources
- Linkage analysis to calculate the loading capacity
- Allocation analysis to evaluate and assign WLAs to point sources and LAs to nonpoint sources
- Development of the TMDL report and administrative record for submittal to EPA

While these steps are common to all TMDL development projects, there are a number of considerations for each step when developing TMDLs that address stormwater sources. As shown in Figure 4, this chapter discusses the step of watershed characterization, and the remaining steps to calculate the loading capacity, establish allocations and document the TMDL report are discussed in Chapter 4.

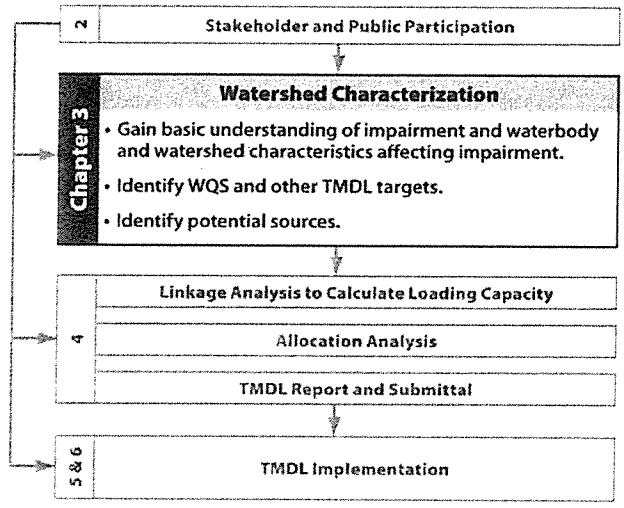


Figure 4. Illustration of the steps in the TMDL process, including the step of watershed characterization discussed in this chapter.

The TMDL process requires a thorough understanding of the waterbody and watershed characteristics, available data, causes of impairment, sources, water quality standards, and potential targets. Some of this information will be available through a state's 303(d) list and waterbody assessment documentation, but much of the information will be gathered and summarized while completing the TMDL. Collectively, this is referred to here as the *watershed characterization* step of the TMDL. Watershed characterization serves as the foundation of the TMDL analysis, providing a basic understanding of the impairments of concern, the desired levels for restoration (e.g., water quality standards and TMDL targets) and the likely sources contributing to the impairment. Characterizing the waterbody and the associated impairments as well as the sources and other watershed characteristics provides the necessary background information to support decisions regarding the approach used for calculating the TMDL, the level of detail or focus of the analysis, and ultimately TMDL implementation. The following sections describe the major elements of the watershed characterization:

- Understanding the impairment
- Identifying TMDL targets
- Identifying and assessing potential sources

At the end of the watershed characterization step for a TMDL addressing stormwater sources, the TMDL writer should understand how stormwater is affecting the impaired waterbody, what stormwater sources exist in the watershed, and what data and information are available to characterize the sources.

3.1. Understanding the Impairment

Understanding the impairment(s) being addressed by a TMDL is critical to establishing appropriate TMDL targets, identifying potential sources and eventually selecting a technical approach for calculating the loading capacity. The main objective of this step is to identify the nature of the impairment(s) being addressed by the TMDL, including location, timing, and magnitude of impairment. A state or tribe's 303(d) list identifies the basic information regarding the impaired waterbody and the observed impairment, usually including the waterbody characteristics (e.g., name, location, size), the water quality standard that was violated, the pollutant of concern (if known), and the suspected causes and sources contributing to the impairment. It is usually necessary to analyze available monitoring data to further characterize and understand the impairments. This section first introduces the commonly observed impairments associated with stormwater and discusses how stormwater can affect waterbody conditions. The section then describes the types of data analyses that are typically used to support characterization of impairments for TMDL development, highlighting the issues unique to developing stormwater TMDLs.

It is important to note that flow is a key component in characterizing, developing and implementing TMDLs for stormwater sources and is discussed throughout this Handbook. Quantity of flow and variation in flow regimes are important factors in transporting stormwater pollutants such as metals, pathogens or sediments that violate water quality standards. Flow is taken into account when developing loading analyses, and flow is specifically considered when calculating seasonal variation and critical conditions in a TMDL. The TMDL regulations specify that TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure, and flow has been used as a surrogate for stormwater pollutants, as discussed in Section 3.2. Flow is also a critical component to consider when TMDLs are being implemented. Additonal information on this is presented in Chapter 5 and Chapter 6.

> ***Resources:*** Several EPA documents include discussion of flow in developing TMDLs and are included in the Resource section at the end of this chapter in Section 3.4.2. In addition, Resource sections at the end of other chapters include TMDL documents available for further information.

3.1.1. Stormwater Effects on Receiving Waterbodies

The purpose of this section is to briefly summarize the effects that stormwater has on streams and lakes and other receiving waterbodies. Stormwater can affect waterbodies in a number of ways depending on the type of stormwater source and the waterbody characteristics. While stormwater sources can include illicit discharges and dry-weather flows, most stormwater sources represent precipitation-driven runoff from impervious and pervious surfaces. The effects of stormwater runoff have been well documented in multiple journal aricles, books and other publications. Most recently, the National Research Council has issued a report, *Urban Stormwater Management in the United States* (NRC 2008), that describes in detail the hydrologic, geomorphic, and biological effects of urbanization on watersheds. The conclusions derived from these reports are that increased imperviousness and stormwateer discharges can lead to the following effects:

- Altered stream hydrology, including higher peak flows, higher peak flow duration, lower base flows, and decreased groundwater recharge
- Increased pollutant loadings associated with higher runoff volumes (from increased imperviousness)

These two processes—flow alterations and increased pollutant loading—are the primary causes of stormwater effects on receiving waters. These effects on both water quantity and water quality can in turn cause impairment to a number of designated uses, as shown in Table 3. For example, flow alterations can cause impairments, especially to aquatic life, by altering habitat, increasing channel instability, causing stream incision, increasing bank erosion, causing riparian degradation, and altering sediment supply and transport (Burton and Pitt 2001). Increases in pollutant loading from stormwater sources can create conditions that are harmful to human health, fish, and other aquatic life. Pollutants that are typically associated with stormwater runoff include pathogens, metals, sediment, nutrients, chlorides, pesticides, oil and grease, toxic organics, and polychlorinated biphenyls (PCBs) (Burton and Pitt 2001). The type of pollutant varies for each area depending on the specific sources within a watershed. In addition, permitted stormwater includes unique sources that are not necessarily precipitation-driven such as illicit discharges and dry-weather flows (e.g., from lawn watering or car washing). These types of stormwater sources are typically associated with effects due to water quality rather than water quantity.

> ***Resources:*** For more information on stormwater impacts to receiving waters, refer to the Resources list at the end of this chapter in Section 3.4.1.

Table 3. Examples of the effect of stormwater runoff on common designated uses

Designated use	Water quantity effects	Water quality effects
Aquatic Life	Change in stream hydrology resulting in habitat modification and degradation (e.g., change in riffle/pool ratio, streambed alteration, stream incision and streambank erosion, change in sediment transport)	▪ Degradation of receiving water quality that can be detrimental to aquatic life (e.g., increased turbidity, increased temperature, eutrophic effects from increased nutrients)
Recreation	Alteration of stream channel or lake bathymetry impairing swimming or boating uses	▪ Increased pollutant levels that pose a risk to human health (e.g., bacteria, metals) ▪ Increased pollutants that degrade aesthetics (e.g., nutrients resulting in algal growth, oil and grease and litter causing odors or floatables)
Drinking Water	Less opportunities for infiltration to recharge groundwater supplies that serve as public drinking water	▪ Increased pollutant levels that pose a risk to human health (e.g., bacteria, metals) ▪ Increased pollutants that impede function of drinking water intakes (e.g., nutrients resulting in algal growth, blocked intakes from litter or increased sediment)

3.1.2. Data Analysis to Characterize Impairment

The analysis of waterbody monitoring data (e.g., flow, water quality, biological) supports an understanding of impairments by determining when, where, and under what conditions the problems are evident. These answers help to define many of the

> ***Resources:*** For more information on where to obtain water quality and flow data, refer to the Resources list at the end of this chapter in Section 3.4.3.

technical aspects of the TMDL, including what targets are appropriate, what sources are quantified, what approaches can be used, how allocations are determined, and on what time and spatial scale the analysis is conducted. Important aspects of the data analysis to understand the impairments for a TMDL include the following:

> ***Tip: Using data analysis to support source identification***
>
> Data analysis to understand the impairment is typically conducted in tandem with source identification activities (as discussed in Section 3.3). Analysis of waterbody data along with review of watershed land uses, source locations, and other source information helps to determine what sources exist and whether they are affecting impairment.

- Data analysis to identify pollutant of concern or expected causes of impairment in cases of a listing based on general or biological impairment
- Spatial analysis to identify spatial variations in waterbody and watershed conditions to identify environmental conditions or sources that affect impairment
- Temporal analysis to evaluate the timing of impairment and potential source loading or other conditions contributing to impairment
- Analysis of the relationships among multiple parameters or waterbody measures (e.g., pollutant concentration and flow) to understand impairment conditions and identify potential sources
- Review of results of data analyses to identify critical conditions to support identification of TMDL targets and select appropriate TMDL development approach

The following sections provide more detail on these common types of data analyses to support the characterization of impairments. These analyses also help to identify potential sources and evaluate their effect on impairment. Section 3.3 will discuss other activities and information that can help to identify sources and can be evaluated concurrently with the waterbody data to assess sources.

3.1.2.1. Identifying Pollutants or Other Causes of Impairment

Impaired waterbodies affected by stormwater sources are often listed as impaired due to such things as *biological impairment* or *habitat alteration* rather than for specific pollutants (e.g., metals, sediment). These listings are typically based on biological assessments or violations of biocriteria. Biological communities can show a response from multiple stressors or from a series of combined stressors such as water column pollutants, flow alterations, channel alterations, and other habitat alterations. Therefore, it might be difficult to identify the pollutant or suite of pollutants affecting the biological community.

EPA developed the *Stressor Identification Guidance Document* (USEPA 2000c) to help practitioners determine which pollutants might be affecting biological communities. The stressor identification (SI) document covers the organization and analysis of available evidence to determine the cause of biological impairment. The general SI process entails critically reviewing available information, forming possible stressor scenarios that might explain the impairment, analyzing those scenarios, and producing conclusions about which stressor(s) are causing the impairment. The SI process is iterative, usually beginning with a retrospective analysis of available data, and the accuracy of the identification depends on the quality of data and other information used in the process. If the SI process identifies specific pollutant parameters (e.g., sediment, nutrients, temperature) that are causing the biological impairment, TMDL writers can establish targets for the pollutant(s) and use additional waterbody

> ***Resources:*** For more information on conducting biomonitoring, bioassessment, biocriteria or where to obtain biological data, refer to the Resources list at the end of this chapter in Section 3.4.4.

and watershed information (e.g., analysis of ambient in-stream data, field reconnaissance) to identify potential sources.

However, because biological impairments often represent the cumulative effects of a number of stressors, it might not be possible to isolate a pollutant or even multiple pollutants as the primary cause of impairment. The impairment might be the result of hydrological and physical changes from the change in flow patterns often associated with impervious areas as well as the increase in pollutant loading. In these instances, the TMDL might be developed for a surrogate target that represents the combined effects from stormwater. Identifying TMDL targets, including the use of surrogates, is discussed in Section 3.2.

3.1.2.2. Identifying Spatial Patterns

> ***Tip: Use data analysis to support approach selection***
>
> The conclustions drawn during data analyses will help to define the technical needs of the TMDL development approach. Chapter 4 discusses selecting a TMDL approach.

Analyzing waterbody data to identify spatial variations in waterbody conditions and impairment can help to identify sources or waterbody or environmental conditions that are contributing to impairment. For instance, evaluating the data to identify spatial variations in water quality can identify *hot spots* where sources are affecting a greater impact on water quality. A hot spot downstream of an urban area might indicate that stormwater is a potentially significant source. Spatial evaluation can also be useful in evaluating the effects of different land uses or stormwater source types. For example, comparing monitoring data from sites representative of heavily developed commercial or industrial areas to data representative of residential or undeveloped areas can help to evaluate the relative significance of the different land use types discharging to an MS4.

Although the data might not always be available to support it, evaluation of conditions upstream and downstream of a suspected source can help to determine whether it has an effect on water quality. Figure 5 presents paired (i.e., collected at the same time) total suspended solids (TSS) readings from stations upstream and downstream of a landfill that discharges runoff into a small stream. It was expected that the landfill might be a source of nutrients and sediment to the stream. Data were plotted together to evaluate the corresponding conditions upstream and downstream. Also plotted in Figure 6 is a line representing a 1:1 linear relationship, where the values upstream would be equal to those downstream. As shown in the figure, the downstream measurements are typically higher than those upstream of the landfill, suggesting that the landfill could be a significant source of TSS to the stream.

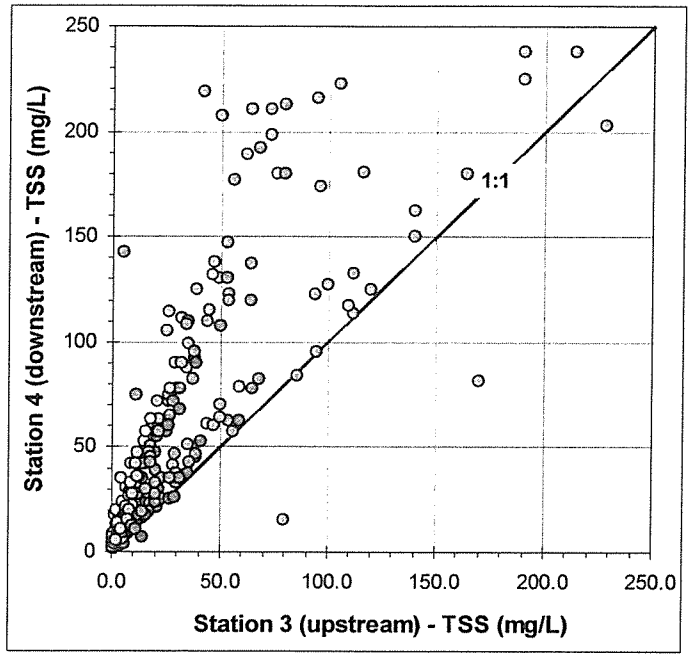


Figure 5. Analysis of upstream and downstream data to evaluate potential impact of an expected source.

3.1.2.3. Identifying Temporal Trends

TMDL writers can also assess data for temporal trends to better understand the impairment and identify potential sources. Temporal variations in water quality, whether from month to month or year to year, can be the result of trends in environmental conditions, such as weather and resulting runoff and flows, or from variations in loading because of schedules or variations in source activities. For example, open areas or parks that drain to MS4s can experience increased wildlife activity or dog walking during summer months, potentially increasing pathogen loads. Similarly, increased loads of sediment or chlorides can occur during winter months from use of sand and deicers on roadways during winter weather.

Longer-term, temporal variations such as trends over a decade rather than across seasons can also provide clues about watershed sources. Figure 6 illustrates a data analysis that evaluates both spatial and temporal variations using data from two stations on the same stream and collected over a 4-year period. The graph of time-series turbidity data shows that a significant increase in turbidity occurred in 2001 at the downstream station; since then, the levels have been consistently higher than upstream. Because upstream levels were measured at comparable levels before and after 2001, the data at the downstream station might suggest the introduction of a new source discharging between the two stations and contributing to the turbidity levels in the stream.

While source activity can affect temporal variations in water quality, they are more often related to environmental conditions such as flow. Evaluating the relationship among water quality, flow, and seasonality can be done using a variety of techniques including simple visual comparison of graphed time-series data, regression analyses, or the use of flow duration curves. Figure 7 includes examples of

each of these types of data representation using the same data set. As shown in the figure, all the figures can be used to show the relationship between bacteria and flow. While the regression plot does not show a strong correlation between flow and bacteria, the chronological and flow duration graphs show that they do tend to follow similar patterns, with elevated bacteria typically occurring during higher flows.

Because discharges from certain types of stormwater sources are typically observed during particular flow conditions, evaluations of flow and corresponding water quality can be a helpful tool in identifying potential sources of impairment. Many stormwater sources are related to increased runoff that can carry pollutants from impervious surfaces, such as parking lots and rooftops, and also lead to streambank or surface erosion, especially in areas of land-disturbing activities such as construction. Therefore, a waterbody influenced by stormwater would likely have observed water quality problems occurring at higher flows. However, waterbodies exhibiting the inverse relationship, with higher pollutant concentrations at lower flows, can also indicate MS4 sources such as illicit discharges to the storm sewer. Figure 8 depicts an example of pollutant loadings observed during low-flow conditions, possibly indicating illicit discharges entering the MS4 through either direct connections (e.g., sanitary sewer piping connected to storm drains, failing septic drain fields connected to ditches that are part of an MS4 conveyance system) or indirect connections (e.g., infiltration into the MS4 pipes from cracked sanitary systems).

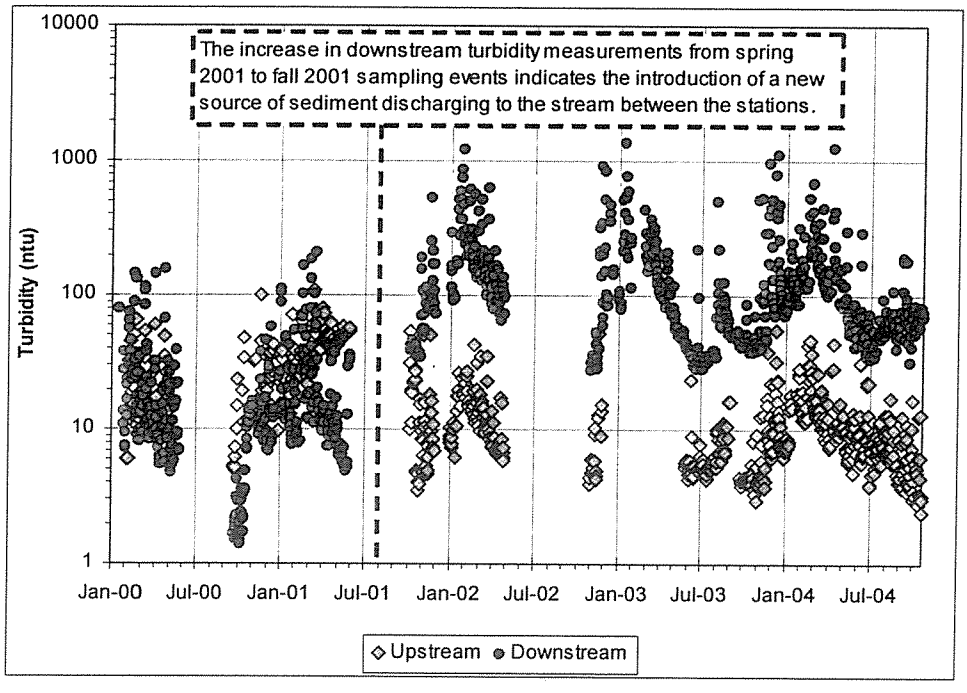
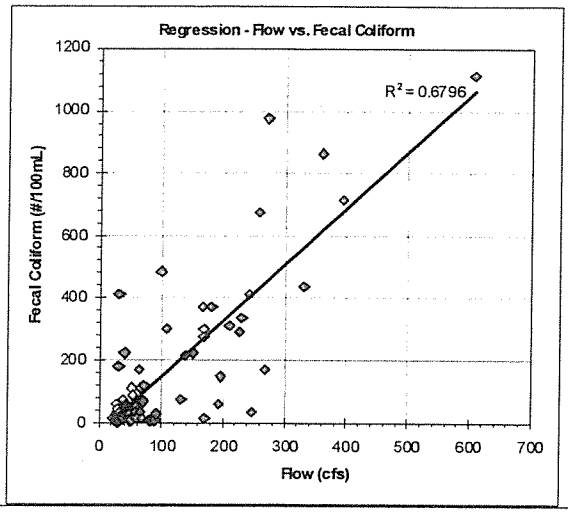
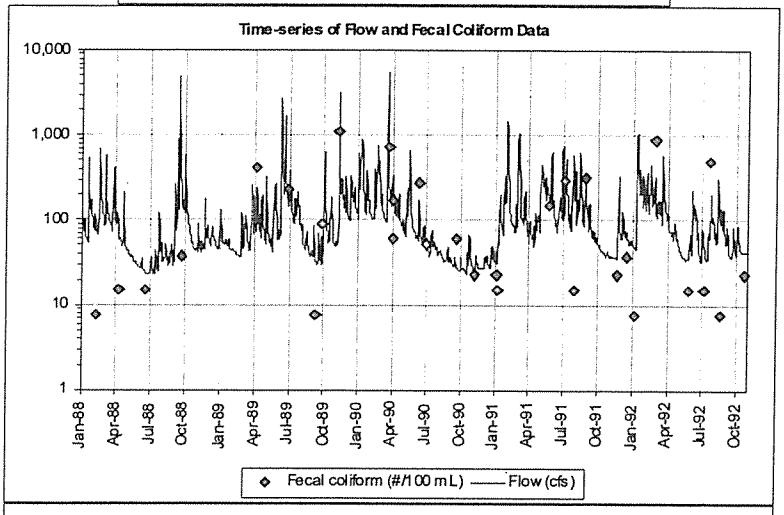


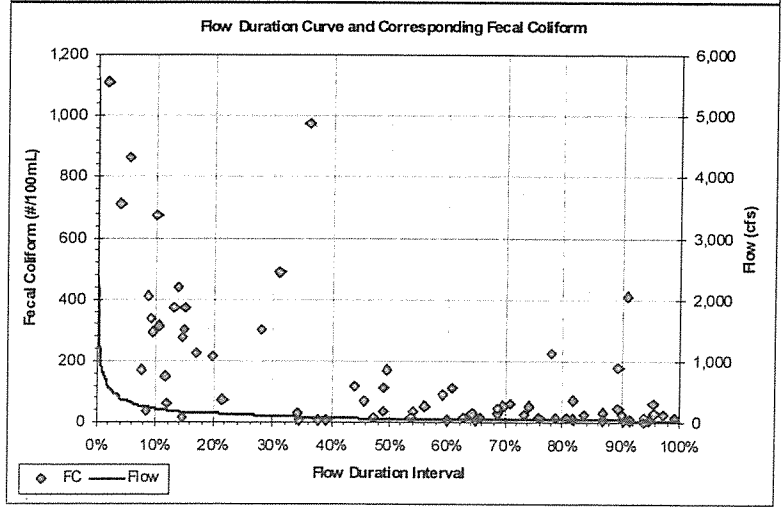
Figure 6. Evaluation of spatial variations in turbidity data to identify locations of potential sources.



Regression of matching measurements of fecal coliform and flow. R^2 of 0.7 might not indicate a strong correlation, but plot does show that the highest fecal coliform measurements occurred during high flows.

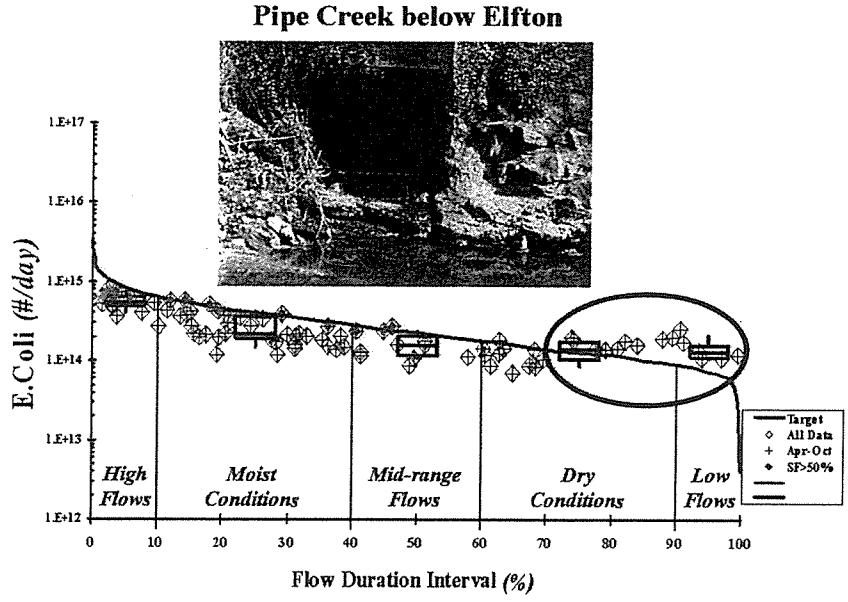


Chronological graph showing continuous flow data and instantaneous fecal coliform measurements. Plot indicates that higher measurements of fecal coliform generally correspond to times of higher flows.



Flow duration curve for continuous flow dataset shown above. Instantaneous fecal coliform measurements are plotted based on the corresponding flow duration interval of the flow measured on the sample date. Plot indicates that higher measurements of fecal coliform generally correspond to higher flows.

Figure 7. Examples of different data representations to evaluate the relationship between flow and fecal coliform.



Stormwater Source: *Illicit Discharges*

Figure 8. Duration curve analysis indicating illicit discharges as stormwater source. Circled data points represent those exceeding the target for *Escherichia coli*.

3.1.2.4. Evaluating Relationships among Parameters

Evaluating the relationship among pollutants can also help TMDL writers to understand observed impairments and identify the types of sources in the watershed. Many pollutants causing impairments can originate from common watershed sources. If a waterbody is impaired by multiple pollutants, evaluating trends or patterns in all pollutants can investigate the potential of common sources among pollutants. For example, sediment, chlorides, and litter are often associated with road maintenance for snow and ice removal. Observed impairments by these parameters in the same waterbody segment might indicate snow removal activities as a source. Similarly, pathogens and nutrients often share common sources that could be contributing to stormwater loads, such as landfills, sanitary sewer breaks, and wildlife or domestic pet waste.

In addition, some pollutants might be associated with other pollutants. For example, some pollutants (e.g., nutrients, metals) can be delivered to receiving waters adsorbed to sediment particles. Fertilizer or pesticide application in residential, commercial, or industrial areas can experience an accumulation of contaminants (e.g., nutrients, pesticides) that have adsorbed to sediment. Soil erosion and washoff in these areas can result in the delivery of loads of sediment and associated contaminants. Identifying a relationship between increased sediment concentrations and other pollutants can help to identify these situations to understand the nature of the impairment and identify potential sources.

3.1.2.5. Identifying Critical Conditions

EPA regulations require that the TMDL writer consider critical conditions while developing a TMDL. Evaluating the critical conditions builds on the previous analyses of spatial and temporal trends and

relationships among pollutants and processes and identifies the combination of environmental conditions (physical, chemical, and biological) under which impairment occurs. When addressing stormwater sources, understanding the critical conditions can be crucial when identifying a TMDL target. Especially without an applicable numeric water quality criterion or when dealing with a biological impairment, evaluation of the critical conditions will help determine the causes and conditions associated with the impairment, such as times of elevated pollutant concentrations or high flows. As with all the other analyses discussed, understanding critical conditions can provide clues about the location, timing, and type of sources affecting impairment and guides selection of an appropriate TMDL development approach (as discussed in Section 4.2.3).

3.2. Identifying TMDL Targets

Impaired waterbodies requiring TMDLs are included on state 303(d) lists because of violations of water quality standards. Water quality standards include the designated use of a waterbody, the water quality criteria established to protect that use, and an antidegradation policy. Water quality criteria can be expressed as numeric or narrative criteria, affecting both the nature of the listing and developing the resulting TMDL. All TMDLs must have a numeric target for which to calculate a loading capacity. Figure 9 illustrates the potential steps or options for developing targets for TMDLs that include stormwater sources. When developing a TMDL for a waterbody listed for a specific pollutant that has an associated numeric criterion, the criterion serves as the target for the TMDL. However, many impaired waterbodies affected by stormwater sources are listed as impaired by pollutants with narrative criteria (e.g., sediment, nutrients) or due to biological impairments (e.g., biological assessments indicate poor benthic communities, increase in *tolerant* species, or decrease in fish populations). In such cases, it is necessary for the TMDL writer to identify a numeric TMDL target that can be used for calculating the loading capacity. When waters are listed for biological impairments, sometimes a TMDL writer will use data analysis and SI to identify a specific pollutant(s) (e.g., sediment) contributing to the impairment (as discussed in Section 3.1). If a specific pollutant is identified relating to a biological impairment, the TMDL writer can identify a numeric target based on data analysis (e.g., reference conditions, historical conditions) or appropriate site-specific or regional literature values. Similarly, a numeric target can be identified for a pollutant that does not have associated numeric criteria.

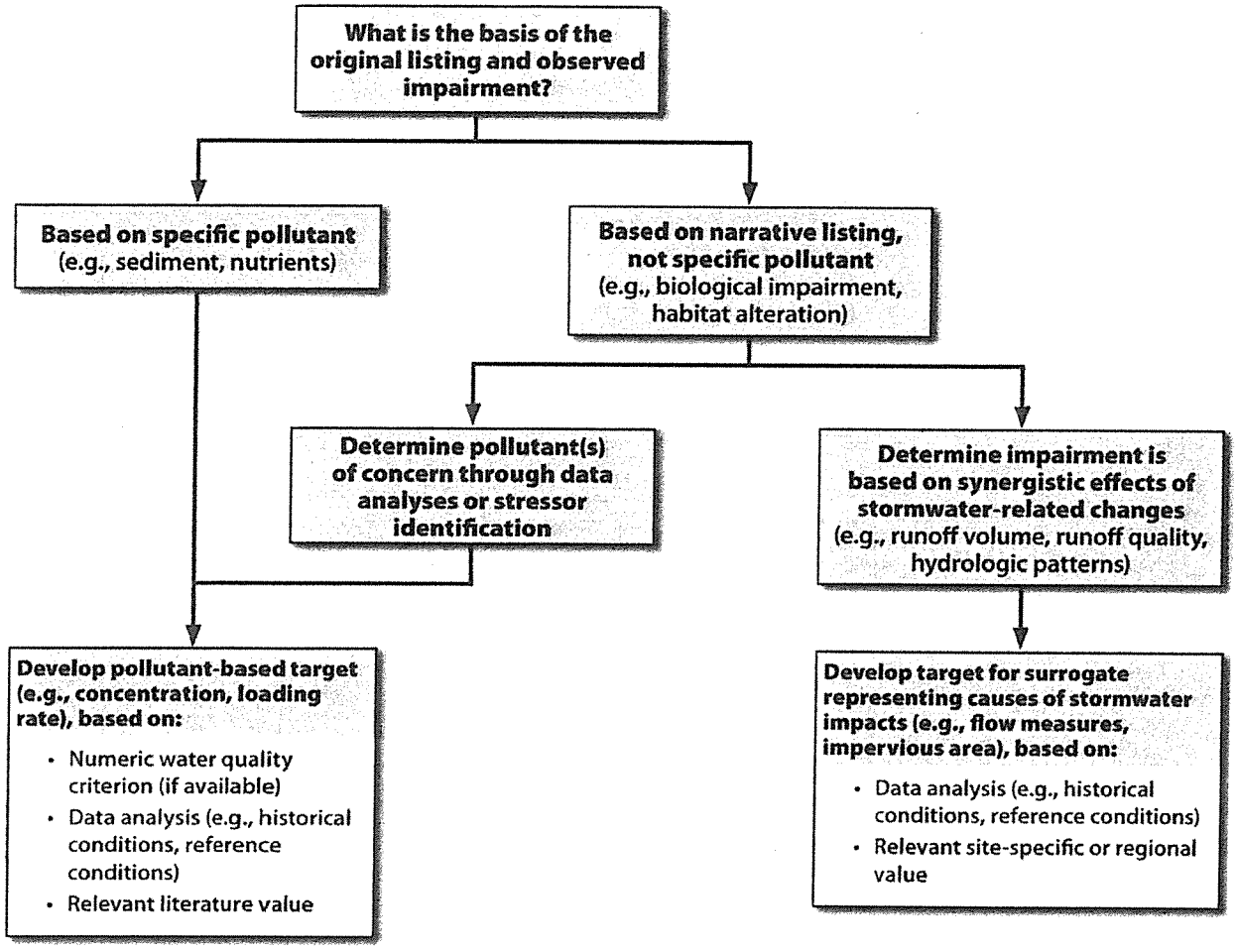


Figure 9. Options for identifying targets for TMDLs that include stormwater sources.

However, when dealing with stormwater effects on an impaired waterbody, it might be difficult to identify all the specific pollutants that are related to the impairment. The underlying problem might be due to hydrologic changes such as quantity of flow and variation in flow regimes that are important factors in transporting pollutants (e.g., metals, pathogens, sediment) that can violate water quality standards. For instance, the impairment might be the result of pollutant loads from flow-related in-stream scouring and and also increased pollutant loads being transported from specific activities within the stormwater source's drainage area (e.g., road sanding, pesticide treatments to lawns) or more generally because of the increased runoff from impervious surfaces. Therefore, when developing a stormwater TMDL, a TMDL writer might use a surrogate measure (e.g., flow) to represent the impairment and establish a numeric target for the surrogate to represent attainment of water quality standards. (The TMDL regulations specify that TMDLs can be expressed in terms of mass per time, toxicity or other appropriate measure). Rather than representing a specific pollutant, the surrogate would represent the suite of pollutants contributing to the impairment. Examples of surrogates for use in stormwater TMDLs based on biological listings include the percent of impervious cover (IC) in the watershed of the impaired water and the flow volume in the impaired stream. The TMDL developed for Eagleville Brook, Connecticut, provides an example of a TMDL using IC as a surrogate and provides

information on how the target represents the impairment and how an appropriate target was established. The TMDL developed for Potash Brook, Vermont, illustrates the use of flow volume as a surrogate for stormwater-related impairments. The TMDL establishes a target for high flow in the brook on the basis of hydrologic conditions of two reference streams where aquatic life criteria are met.

In Practice: Using Impervious Cover as a Surrogate for Water Quality Standards in Eagleville Brook, Connecticut

Eagleville Brook does not meet water quality criteria and designated uses for aquatic life. The relevant criteria are based on distribution and abundance metrics for benthic invertebrates that inhabit lotic waters and are described in the state's narrative water quality standards. An SI analysis concluded that the biological impairments are most likely due to a combination of pollutants related to stormwater runoff from developed areas and other related stressors (such as the physical impacts of stormwater flows). Because the major source of stormwater is runoff from the impervious surfaces in the watershed, the Connecticut Department of Environmental Protection selected iIC as a surrogate to represent attainment of aquatic life criteria and to establish the loading capacity. The IC target is set at 12 percent IC. This threshold is based on Rapid Bioassessment Protocol data from 125 small (< 50 square mile) watersheds indicating that no stream monitoring location with more than 12 percent IC in its watershed met criteria for full support of aquatic life use.

The TMDL loading capacity of 12 percent was reduced 1 percent to provide for an MOS, yielding an overall allocation target of 11 percent. The TMDL applies the 11 percent IC target to all stormwater drainage areas and affects all sources subject to LAs and WLAs in the watershed. The percent IC TMDL and WLA/LA targets apply at all times (instantaneously, daily, monthly, seasonal, and annual). The final TMDL (2007) is at: www.ct.gov/dep/lib/dep/water/tmdl/tmdl_final/eaglevillefinal.pdf.

3.3. Identifying and Assessing Potential Sources

The step of identifying sources for TMDL development should be an extension of the data analyses conducted to understand the impairment and serves to further characterize the important sources and better define their location, behavior, magnitude, and influence. The source assessment should result in an understanding of what major sources are contributing to impairment and how (e.g., pollutants, delivery pathways). This can affect what approach is selected and how it is applied for TMDL development and helps to focus the allocation analysis as well as future implementation.

While the pollutant loads originating with each source are typically quantified during the linkage analysis (Chapter 4), the information necessary to understand their location and discharge behavior and characteristics is compiled and reviewed during this step. In general, the methods that are used to complete a source assessment do not differ between a TMDL addressing stormwater sources and any other TMDLs, and they involve identification and characterization of point sources (e.g., stormwater, wastewater treatment plants, industrial facilities) and nonpoint sources (e.g., grazing, timber harvest, septic systems). The methods for completing a source assessment vary with the type of watershed, pollutants, and sources but typically rely on information from state or national databases, literature reviews, and local knowledge from state or local contacts. It is important to correlate the assessment of both point and nonpoint sources with the data analysis to characterize source impacts and behavior. For example, land use, locations of stormwater outfalls or facility discharges, and other source information should be evaluated along with water quality data analyses (e.g., spatial analysis) to understand potential effects from the various sources or explore unknown sources. The following are examples of information typically reviewed to identify sources for TMDL development:

- Query EPA's NPDES databases to identify permitted facilities or sources discharging to the impaired water or its tributaries
- Coordinating with state permitting staff to identify the number, type, and location of NPDES permitted point sources in a watershed (including stormwater sources)
- Review geographic information system (GIS) coverages (e.g., land use, soils), satellite images, and aerial photos to identify potential nonpoint sources (e.g., agriculture, silviculture)
- Conduct field or *windshield* surveys of the watershed to identify potential nonpoint sources (e.g., livestock operations, illegal dumping, failing septic systems)
- Review previous watershed, local, or regional studies or reports to identify potential nonpoint sources

Identifying and understanding the effect of stormwater sources might require additional investigation or information to support TMDL development. This section discusses the information available to support the following activities to further define and characterize stormwater sources:

- Identify type and general location of stormwater sources
- Delineate drainage area for stormwater sources
- Characterize discharge from stormwater sources

Tip: Maximize resources when characterizing stormwater sources

A thorough characterization of stormwater sources can require a significant amount of time and resources. Therefore, it is important for TMDL and permit writers to work together to determine the significance of stormwater sources to the TMDL and, if it is determined that further characterization of stormwater sources is necessary, what type and amount of data are necessary to complete the characterization.

3.3.1. Identifying the Type and Location of Stormwater Sources

Stormwater sources will fall within one of three categories—MS4, construction or industrial—but there can be a number of sources or activities within those permitted areas that might contribute to an impairment. Common stormwater-related pollutants of concern that cause water quality impairment include pathogens, metals (other than mercury), sediment, nutrients, and chlorides. Table 4 illustrates the range of permitted stormwater sources and related activities typically associated with certain pollutants or impairments.

Table 4. Examples of sources within regulated stormwater areas associated with common pollutants and impairments

Pollutant/stressor of concern	Potential source(s) within permitted area		
	MS4	Construction	Industrial
Pathogens	▪ Sanitary sewer breaks and cross-connections ▪ Restaurant trash areas and mat washing ▪ Landfills and transfer stations ▪ Pet and wildlife waste		▪ Sanitary sewer breaks and cross-connections ▪ Food trash areas ▪ Landfills and transfer stations ▪ Improper disposal of sanitary waste (e.g., dumping from boats at marinas) ▪ Wildlife waste (sea gulls)
Metals	Vehicular emissions build up on impervious surfaces ▪ Roadways ▪ Driveways ▪ Parking lots	▪ Vehicle and equipment use on-site ▪ Materials storage/handling	Varies with industry type* ▪ Materials storage and handling ▪ Outdoor processing ▪ Legacy pollutants in soil

Pollutant/stressor of concern	Potential source(s) within permitted area		
	MS4	Construction	Industrial
	Industrial activities and materials storage ▪ NPDES permitted industrial facilities ▪ Corporation yards (i.e., municipal) ▪ Unpermitted industrial facilities		
	Commercial activities and materials storage ▪ Automotive repair facilities ▪ Gas stations ▪ Car washes ▪ Auto dealerships		
Sediment	▪ Active construction ▪ NPDES permitted active construction ▪ Non-permitted active construction (<1 acre) ▪ Hillside development ▪ Roads and highways ▪ Snow/ice management	▪ Erosion on-site causing off-site discharge ▪ Road tracking	▪ Debris from materials storage ▪ Runoff from parking lots ▪ Snow/ice management
Nutrients	▪ Residential fertilizer application ▪ Industrial/commercial fertilizer application ▪ Municipal fertilizer application ▪ Pet and wildlife waste		▪ Fertilizer application
Chlorides	▪ Snow/ice removal activities and storage		▪ Snow/ice management
Habitat Alteration	▪ New development in greenspaces ▪ Building roads and highways ▪ Development in sensitive areas (i.e., near waterways, on hillsides)	▪ Sediment discharge from site	
Flow Alteration	▪ Increased, unmitigated imperviousness due to new development or redevelopment ▪ Increased, unmitigated imperviousness due to new roads and highways ▪ Increased connection of existing imperviousness	▪ Change in drainage patterns due to removal of vegetation and changing grade	
Pesticides	▪ Residential pesticide application ▪ Industrial/commercial pesticide application ▪ Municipal pesticide application ▪ Fuel stations		
Oil and grease	▪ Vehicle leaks on parking lots and roadways ▪ Spills ▪ Illegal dumping	▪ Spills ▪ Equipment maintenance and fueling	Varies with industry type* ▪ Materials storage and handling ▪ Outdoor processing ▪ Legacy pollutants in soil
Toxic Organics			Varies with industry type* ▪ Materials storage and handling ▪ Outdoor processing ▪ Legacy pollutants in soil
PCBs	▪ Landfills		Varies with industry type* ▪ Materials storage and handling ▪ Outdoor processing ▪ Legacy pollutants in soil

* The federal Multi-Sector General Permit for Industrial Activities (MSGP 2000) covers 30 industrial sectors that fall into one or more of the 10 categories of stormwater discharges associated with industrial activity (and construction activities) described in 40 CFR 122.26(b)(14)(i)-(xi). The 30 sectors are defined by either the facility's Standard Industrial Classification (SIC) code or a general description of the facility's industrial activities. MSGP 2000 expired at midnight on October 30, 2005. A new permit has not been issued.

Compiling a list of all stormwater sources in the watershed of an impaired water should be, in theory, relatively easy because stormwater sources are covered under NPDES general and individual stormwater permits, and coverage under these permits is tracked by state and EPA NPDES permitting authorities.

Each state has a stormwater permit program coordinator or multiple coordinators that TMDL writers can contact for information. NPDES-authorized states issue NPDES permits for MS4s and stormwater discharges associated with construction and industrial activities. The amount of information available online varies from state to state, but generally, it is a good idea to speak with the permitting authority directly to assess the adequacy of online resources. TMDL writers should be aware that in many states stormwater permittees are tracked in different data systems than other NPDES permittees. For example, EPA's Permit Compliance System (PCS) and Integrated Compliance Information System (ICIS) data systems include permit information for a very small percentage of stormwater permittees regulated under the NPDES program.

> ***Resources:*** For links to online resources for identifying permitted stormwater sources in your watershed, refer to the Resources list at the end of this chapter in Section 3.4.5. Resources include links to state and regional stormwater contacts and EPA's PCS/ICIS and eNOI systems.

In nonauthorized states, TMDL writers should contact the individual EPA Regional office for information about dischargers within a watershed boundary and use the Electronic Notice of Intent (eNOI) system EPA has developed to track construction sites and industrial facilities that need to apply for coverage under EPA's Construction General Permit (CGP) or Multi-Sector General Permit (MSGP). This system can be used to search, sort, and view NOIs and can be searched by city, county, or ZIP Code. The NOIs include location and receiving water name and for construction sites, the size of the disturbed area.

It is important to work with the permitting authority to identify stormwater sources in the watershed of an impaired water. Regulatory definitions of permitted stormwater sources can result in challenges in identifying the boundaries of regulated (i.e., permitted) stormwater sources versus and unregulated stormwater sources. This is particularly true for MS4s. Figure 10 illustrates the complexities of identifying regulated versus unregulated MS4s within a watershed boundary. As Figure 10 shows, it is possible to have both regulated and unregulated MS4s within the watershed boundary of an impaired waterbody. Phase I MS4s are defined as large and medium MS4s on the basis of population served, while Phase II regulated small MS4s are defined as small MS4s (i.e., any MS4 not regulated under Phase I) within an urbanized area. Any portion of a small MS4 within the urbanized area is considered a Phase II regulated small MS4 and is subject to Phase II MS4 permit requirements. Small MS4s outside the urbanized area are not subject to Phase II MS4 permit requirements; however, TMDL writers should take into account pollutant contributions from these stormwater discharges in a manner similar to regulated, small MS4s.

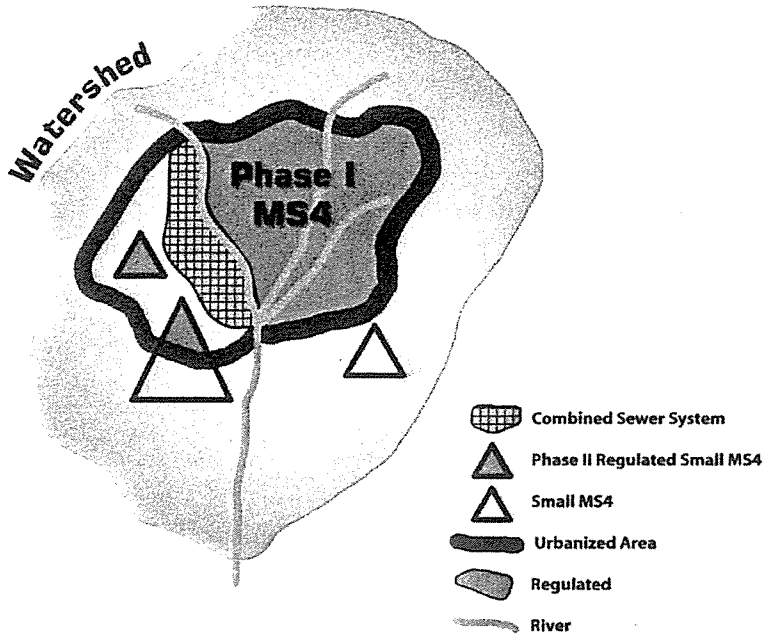


Figure 10. Potential spatial complexities of regulated and unregulated stormwater sources.

While land use is often an indicator for the existence of MS4s within the watershed of an impaired waterbody, it is important to remember that not all MS4s are municipal entities (e.g., cities, counties, or towns). Other entities such as departments of transportation, irrigation districts, sanitary districts, universities, hospitals, federal facilities and other entities that own and operate separate storm sewer systems can also fall into the category of regulated MS4s. These *nontraditional* MS4s have the potential to add another layer of MS4 boundaries for TMDL writers to consider. In addition, TMDL writers might focus on MS4s as the primary stormwater sources, but it is important to remember that regulated construction activities and industrial facilities both inside and outside the boundaries of regulated MS4s can also contribute stormwater discharges. Permit information on all types of regulated stormwater sources should be readily available in PCS. Identifying unregulated stormwater sources, such as other small MS4s, will require an understanding of local land uses and communication with the entities that own and operate these systems.

Field reconnaissance can also be used to identify any potential unknown stormwater sources as well as nonpoint sources. Field reconnaissance involves visiting the watershed and can range from a *windshield* survey while driving to a more comprehensive survey such as *walking the stream* to identify and geo-locate potential sources or identify potential monitoring sites to fill information gaps. Field reconnaissance is also useful to ground-truth available information used in characterizing the waterbody and its surrounding watershed, including areas within an MS4 boundary. For example, land use and land cover data are sometimes out of date and might include open space areas that have since been converted to residential, commercial, or industrial uses. Field reconnaissance is also helpful in identifying or better characterizing certain types of sources that might not be identifiable in the typical watershed coverages or information; for example,

> ***Resources:*** For more information on obtaining land use and coverage information and conducting field reconnaissance and visual surveys, refer to the Resources list at the end of this chapter in Sections 3.4.6 and 3.4.7.

field investigations are an essential tool for MS4 communities to detect illicit discharges and connections, which can be significant sources of contaminants. Field reconnaissance can also help identify areas where stormwater volumes and velocities are affecting stream morphology and contributing to impairment by noting streambank, channel and habitat conditions (e.g., embeddedness, number of pools and riffles).

3.3.2. Delineating the Drainage Areas of Stormwater Sources

To include a stormwater source in the TMDL analysis, it is necessary to identify its regulated area and if possible isolate the specific area drained by its sewer system and discharged to the receiving waterbody. Differences in spatial scale between the geographic focus of a TMDL (e.g., waterbody or watershed) and stormwater sources (e.g., regulated MS4s, construction sites, and industrial facilities) can create unexpected challenges for TMDL writers at this stage of TMDL development. To identify stormwater source areas, it is important that the TMDL writers fully understand the types of sources and how they are regulated. For example, it might be assumed that identifying jurisdictional boundaries is a straightforward way to identify regulated MS4s. However, the jurisdictional boundary is not necessarily the same as the regulated MS4 boundary. For example, combined sewer system portions of storm sewer infrastructure are not regulated by the NPDES MS4 program. As another example, regulated small MS4s typically are only the portion of the MS4 system that is actually within the urbanized area boundary (Figure 10). These distinctions can affect how the stormwater sources are included in the analysis and how their respective WLAs are subsequently developed and assigned.

It is also important to understand the stormwater conveyance methods for each stormwater source in a watershed to determine whether the source is discharging to or affecting the impaired waterbody and to delineate the boundary and drainage area. Stormwater can be conveyed to a waterbody through direct surface flow or through a pipe, ditch, or other conveyance. In addition, stormwater might be recharged to groundwater, which might or might not affect a stream. The type and location of these conveyance methods will help a TMDL writer to assess the potential effects that a stormwater source is having on a stream. For example, a concrete-lined channel that discharges stormwater directly to a receiving stream will likely have a greater effect than a discharge from a well-maintained wet pond designed to capture and treat 80 percent of the received water quality volume. Because of these issues, the outfall location and conveyance method for each stormwater source should be documented and summarized before completing a TMDL. This could be as simple as plotting the outfall locations in a GIS and comparing those locations to observed in-stream impacts, or it might require a more comprehensive analysis.

TMDL writers should work with the permitting authority to identify the information available to delineate the areas and drainage boundaries for stormwater sources. Individual NPDES permit application requirements for Phase I MS4s [40 CFR 122.26(d)(1)(iii)(B)] include the submittal of a map showing the service boundaries of the MS4 covered by the application as well as the location of all outfalls that discharge into a water of the United States. Phase II MS4s applying for individual permit coverage are required to submit the same information. Phase II MS4s regulated under general permits submit NOIs that might have a map, a description of the regulated MS4 boundary, or both and should be available from the permitting authority. However, those MS4s are required to develop such maps as part as permit implementation, not at the time of application. Industrial and construction SWPPPs should include site descriptions or maps to identify the facility or site location and locations of outfalls or surface water discharges.

If this information is not readily available or not sufficient to determine the area draining a stormwater source, a TMDL writer should work with the permitting authority to determine if additional information is necessary to locate and delineate all the stormwater sources in the watershed of the impaired waterbody. City and county planning departments often have information on the location and extent of stormwater infrastructure and controls, and in some cases, detailed sewer and boundary maps or stormwater facility plans might be available. This information should be obtained, where available, because it is often the most detailed and accurate information about stormwater sources. Similarly, industrial facilities and construction sites will have, and might submit to the city, county, or permitting authority, plans that document stormwater sources and management practices. Stormwater facilities are often required to submit a facility plan that documents the characteristics of the facility. However, additional investigations might still be needed to locate all potential stormwater sources.

3.3.3. Characterizing Discharges from Stormwater Sources

To better understand the quality and quantity of discharge being delivered to an impaired waterbody from a stormwater source, it is useful to evaluate data and information generated by the source to satisfy permit requirements. Table 5 outlines the types of data and information generated by the three types of stormwater sources—MS4s, industrial facilities, and construction activities—and the following sections briefly describe the information.

Table 5. Data and information generated by stormwater sources through the permitting process

Stormwater permit document or activity	Specific type of data generated by permittee
MS4 discharger generated data	
Phase I MS4 permit application	▪ Description of land use and 10-year growth projections ▪ Outfall characterization sampling data ▪ Receiving waters
Phase II MS4 general permit NOI	▪ MS4 location and boundaries ▪ Receiving waters
Industrial facility inventory and inspections (Phase I MS4s)	▪ Location of industrial facility to determine the watershed ▪ Activities, materials, and physical features of the industrial facility that might be sources of pollutants of concern during dry or wet weather ▪ Prioritization based on location, pollutants of concern, etc. ▪ Compliance history of industrial facility ▪ Location and pollutants of concern from nonregulated industrial (and perhaps commercial) facilities
Construction activities inventory and inspections	▪ Location of construction activity ▪ Size of disturbed area ▪ Receiving water/watershed ▪ Prioritization based on size, location, compliance history, etc. ▪ Compliance history of project ▪ Number and location of nonregulated (less than one acre) construction projects
IDDE and tracking	▪ Outfall map with receiving waters ▪ Dry weather screening ▪ Tracking of citizen complaints, dumping, spills, restaurant inspections, etc.
Post-construction BMP implementation and tracking	▪ Types of BMPs required ▪ Locations of BMPs ▪ Operation and maintenance (O&M) records/agreements ▪ Inspection results

Stormwater permit document or activity	Specific type of data generated by permittee
Outfall and ambient water quality monitoring data	▪ Characterization of discharges from particular land use types, subwatersheds, etc. ▪ Ambient data could provide baseline information before installing BMPs ▪ Habitat assessments might be part of monitoring program
Annual reports	▪ Location and type of identified illicit discharges ▪ Location of approved erosion and sediment control plans ▪ Compiled post-construction BMP inspection results ▪ Compiled monitoring results ▪ Planned SWMP changes
Industrial discharger generated data	
Industrial individual permit application	▪ Location of outfalls ▪ Site drainage map ▪ Impervious area calculation ▪ Description of proposed activities, spills and leaks, on-site materials ▪ Sampling data (if available)
Industrial general permit NOI	▪ Location of facility ▪ Receiving water/MS4 ▪ Applicable industrial sector
Industrial SWPPP	▪ Location of industrial facility to determine the receiving water(s) and if the facility is within an MS4 boundary ▪ Activities, materials, and physical features of the industrial facility that might be sources of pollutants of concern during dry or wet weather ▪ Map that shows outfalls into receiving waters
Monitoring data	▪ Loading from facility for benchmark discharge monitoring parameters
Industrial compliance evaluations and inspections	▪ Assess any compliance or BMP implementation issues on-site which may contribute to loading
Industrial sampling data	▪ Loading from particular facilities ▪ Assess general loading from types of industrial facilities ▪ Assess industrial loading from an MS4
Construction project generated data	
Construction individual permit application	▪ Location of construction activity ▪ Total area and total disturbed area ▪ Proposed BMPs ▪ Runoff coefficient ▪ Imperviousness created ▪ Receiving water
CGP NOI	▪ Location of construction activity ▪ Start/end dates ▪ Total disturbed area ▪ Receiving water
Construction activity SWPPP	▪ Location and size of disturbance as well as a location with associated surface water discharges. ▪ A description of any discharge associated with industrial activity other than construction and the location of that activity on the construction site. ▪ Type and location of any post-construction BMPs to be implemented on-site
Monitoring data	▪ Loading from project

The list of data types in Table 5 is based on the minimum federal permit requirements and assumed implementation strategies. Permitting authorities can choose to develop more stringent permit requirements; therefore, TMDL writers might want to take some time to carefully review individual and general permits issued by state permitting authorities to identify state or regional specific data and

information requirements. If a TMDL writer identifies potentially useful data generated by stormwater sources, the TMDL writer can work through the permitting authority to obtain this information. The permitting authority will have some information readily available on file (e.g., applications, NOIs, annual reports) or can make official requests to permittees for other types of information that the permitting authority might not have on file. It is important for TMDL writers to coordinate with permitting authorities to obtain this information, rather than directly contacting stormwater sources without the permitting authority's knowledge. This will ensure efficient use of time and resources and maintain clear communication with stormwater sources.

3.3.3.1. MS4-Generated Data

Both individual and general MS4 permits require Phase I and Phase II MS4s to develop specific types of documents that contain information and data potentially useful to the TMDL development process. Figure 11 illustrates the type of documents that MS4s must develop to comply with either individual permit requirements or general permit requirements. Under individual permits, Phase I MS4s must complete a two-part application, develop an SWPPP, conduct monitoring, and generate an annual report that compiles information and data on from SWPPP implementation from the previous year. As shown in Figure 11, Phase II MS4s have the option of obtaining permit coverage under either an individual permit or a general permit, depending on which type of permit the permitting authority makes available. Under an individual permit, a Phase II MS4 would likely have the same requirements to generate an SWPPP and prepare annual reports as a Phase I MS4. Although Phase II MS4s covered under a general permit must prepare the same type of documents, the information required in each document might vary. For example, the permit application for a general permit, the NOI, does not have the same extensive information requirements as the two-part application for an individual permit. In addition, not all general permits require monitoring. The Phase II MS4 general permit does require development of an SWPPP and annual reports, although the content might vary from those developed under an individual permit.

> ***Tip: Understanding the potential types of data not required by permits***
>
> Municipal MS4s might have data valuable to the TMDL development process that is not required by NPDES permits. For example, comprehensive planning or zoning documents could provide information regarding land use distribution. In addition, municipalities might coordinate or support volunteering monitoring or *watch* groups that could provide valuable input (e.g., stream monitoring, cleanups).

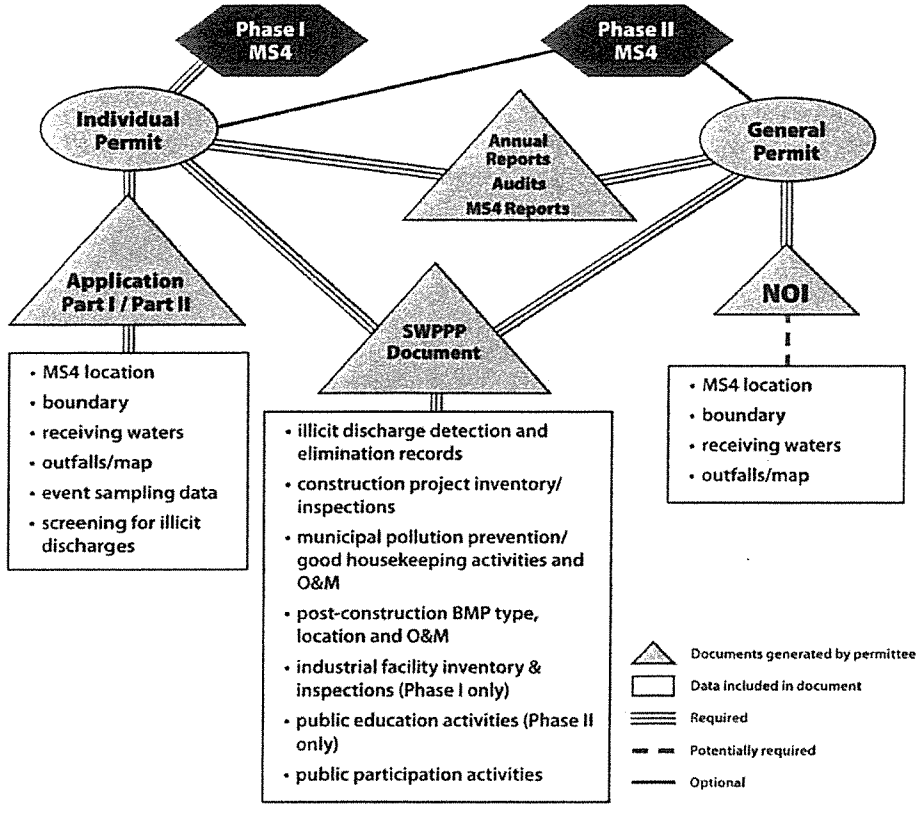


Figure 11. Required MS4 permit documents and associated information and data.

3.3.3.2. Industrial Discharger Generated Data

Most stormwater discharges associated with industrial activity have permit coverage under an NPDES general permit rather than an individual permit. However, significant industrial dischargers might have stormwater discharges covered under the facility's overall NPDES permit, which covers process wastewater, non-process wastewater, and stormwater. Figure 12 shows the type of documents required under both individual and general permits for industrial facilities.

Where an EPA Region is the permitting authority, rather than the state, regulated industrial facilities obtain permit coverage under EPA's MSGP. State permitting authorities often use EPA's MSGP as a template for developing and issuing their state-specific industrial stormwater general permit, with modifications necessary to address state-specific issues. All industrial stormwater general permits require industrial facilities to submit NOIs, and most require these permittees to develop and implement SWPPPs and conduct comprehensive site compliance evaluations and periodic inspections. Also, most of these industrial stormwater general permits require at least some sectors to conduct analytical monitoring of stormwater runoff. Figure 12 illustrates the types of data and information generated by an industrial discharger as a result of complying with permit requirements. This information can assist TMDL writers in characterizing stormwater discharges from industrial stormwater sources during the TMDL development process. .

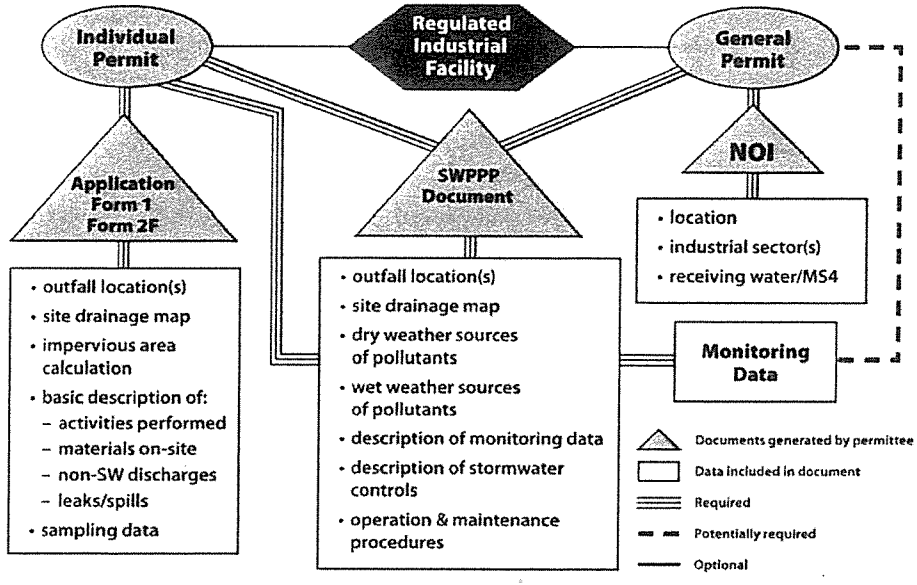


Figure 12. Required industrial stormwater permit documents and associated information and data.

3.3.3.3. Construction Project Generated Data

Construction projects disturbing one acre or more are required to obtain NPDES permit coverage for stormwater discharges. Figure 13 illustrates the data generated by construction stormwater sources as a result of complying with individual and general construction permit requirements. Construction stormwater discharges are most often permitted under an NPDES CGP, issued either by the state permitting authority or by an EPA Regional office. To obtain general permit coverage, the construction site operator must complete the required NOI and provide information such as project location and receiving waters. Construction stormwater general permits require operators of construction projects to develop and implement SWPPPs and conduct routine self-inspections. SWPPPs contain the majority of site-specific documentation of stormwater management activities performed. In limited instances, the state or EPA permitting authority may require certain construction projects (e.g., due to impaired receiving waters or to protect high-quality streams) to obtain coverage under an individual permit. When required, individual permits for construction activity typically contain requirements similar to those found in general permits; however, it is likely that the permittee will have specific monitoring requirements. Some construction stormwater permits (i.e., both individual and general) include effluent limits or *action levels* and associated effluent or receiving stream monitoring.

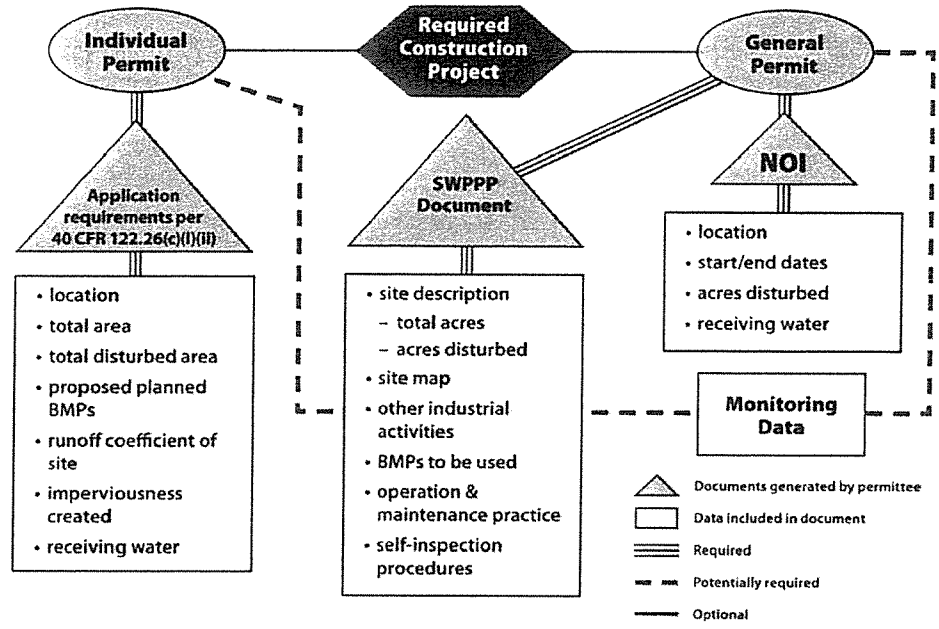


Figure 13. Required construction stormwater permit documents and associated information and data.

3.4. Resources

3.4.1. Stormwater Effects on Receiving Waters

1. USEPA (U.S. Environmental Protection Agency). 1983. *Results of the Nationwide Urban Runoff Program – Volume I Final Report.* U.S. Environmental Protection Agency, Water Planning Division, Washington, DC. www.epa.gov/npdes/pubs/sw_nurp_vol_1_finalreport.pdf

   The 5-year Nationwide Urban Runoff Program (NURP) was designed to examine the quality of urban runoff at different urban locations; whether urban runoff is a significant contributor to water quality problems in the United States; and the performance, effectiveness, and utility of management practices for controlling pollutant loads from urban runoff. This report presents the findings of the program.

2. USEPA. Undated. *Urbanization and Streams: Studies of Hydrologic Impacts.* U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, DC. http://epa.gov/owow/nps/urbanize/report.html. Accessed July 2008.

   This Web-based report summarizes the findings of a literature search to document physical impacts and indications of water quality problems associated with stormwater runoff. The report summarizes the review documents, articles and reports, and provides citations for further information.

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

   This handbook is intended to be a working document that assists scientists, engineers, consultants, regulators, citizen groups, and environmental managers in determining if stormwater runoff is causing adverse effects and beneficial use impairments in local receiving waters. The handbook provides an extensive discussion of the effects of stormwater (based on information documented in a number of other studies and documents) and focuses on providing information to support the design of a sampling program to assess stormwater impacts.

4. Center for Watershed Protection. 2003. *Impacts of Impervious Cover on Aquatic Systems*. Center for Watershed Protection, Ellicott City, MD. www.cwp.org/Store/guidance.htm

   This report examines more than 225 multidisciplinary studies documenting the hydrological, physical, water quality, and biological effects of urbanization and its accompanying IC.

5. Center for Watershed Protection's Stormwater Manager's Resource Center Web site: www.stormwatercenter.net/

3.4.2. Understanding Flow in TMDL Development

1. USEPA (U.S. Environmental Protection Agency). 2007. *An Approach for Using Load Duration Curves in the Development of TMDLs*. EPA 841-B-07-006. U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC. www.epa.gov/OWOW/tmdl/duration_curve_guide_aug2007.pdf

   This document provides an overview on the use of duration curves for TMDLs, describing the basic steps needed to develop duration curves and subsequently identify loading capacities, LAs, WLAs, MOS, and seasonal variations. The guide also discusses some considerations and limitations in using the approach and includes several case examples.

2. USEPA (U.S. Environmental Protection Agency). 1999. *Protocol for Developing Sediment TMDLs*. EPA 841-B-99-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/owow/tmdl/sediment/pdf/sediment.pdf

   This technical guidance document provides information to support TMDL writers in developing TMDLs for sediment. The document includes information on how to complete each step of the TMDL process, including problem identification, source assessment, linkage of water quality targets and sources, allocation analysis, and monitoring.

3. USEPA. 2005. *TMDL Model Evaluation and Research Needs*. EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH. www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm

   This report documents the review of more than 60 available watershed and receiving water models for their applicability to TMDL development and implementation. It discusses model selection on the basis of model capabilities and provides a series of tables rating the capabilities

or applicability the models using the categories of TMDL endpoints, general land and water features, special land processes, special water processes, and application considerations. The document also provides individual fact sheets for each reviewed model.

4. USEPA (U.S. Environmental Protection Agency). 2008. *Incorporating Green Infrastructure Concepts into Total Maximum Daily Loads.* U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/owow/tmdl/stormwater/

   This 11 page fact sheet provides recommendations for incorporating GI and LID concepts into various elements of a TMDL and provides two TMDL case studies.

3.4.3. Chemical, Physical and Biological Data

1. EPA's Storage and Retrieval Database (STORET): www.epa.gov/storet/
2. USGS's National Water Information System Web site (NWISWeb): http://waterdata.usgs.gov/nwis
3. EPA's Environmental Monitoring and Assessment Program (EMAP) database: www.epa.gov/emap/index.html
4. USGS's National Water-Quality Assessment (NAWQA) Program: http://water.usgs.gov/nawqa/
5. USDA's PACFISH/INFISH Biological Opinion Program: http://fsgeodata.fs.fed.us/pibo/

3.4.4. Biological Assessment and Guidance

1. EPA's Biocriteria Web site: www.epa.gov/waterscience/biocriteria/
2. USEPA (U.S. Environmental Protection Agency). 2000. *Stressor Identification Guidance Document.* EPA 822-B-00-025. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC. www.epa.gov/waterscience/biocriteria/stressors/

   This document describes EPA's process for identifying any type of stressor or combination of stressors that cause biological impairment. The SI Guidance is intended to lead water resource managers through a formal and rigorous process that identifies stressors causing biological impairment in aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions.

3. EPA's CADDIS Web site: http://cfpub.epa.gov/caddis/

   The Causal Analysis/Diagnosis Decision Information System (CADDIS) is an online application based on the process developed in EPA's SI Guidance Document. It uses a step-by-step guide, worksheets, and examples to help scientists and engineers find, access, organize, share, and use environmental information to evaluate causes of biological effects observed in aquatic systems such as streams, lakes, and estuaries.

4. EPA's list of bioassessment publications from EPA and other federal agencies (e.g., U.S. Geological Survey [USGS], U.S. Department of Agriculture [USDA]): www.epa.gov/bioindicators/html/publications.html

3.4.5. Permitted Stormwater Sources in a Watershed

1. EPA's list of state stormwater contacts: http://cfpub.epa.gov/npdes/contacts.cfm?program_id=6&type=STATE
2. EPA's list of Regional stormwater contacts: http://cfpub.epa.gov/npdes/contacts.cfm?program_id=6&type=REGION
3. EPA's PCS: www.epa.gov/enviro/html/pcs/index.html
4. EPA's eNOI system: http://cfpub.epa.gov/npdes/stormwater/enoi.cfm
5. Authorization Status for EPA's Stormwater Construction and Industrial Programs by State: http://cfpub.epa.gov/npdes/stormwater/authorizationstatus.cfm
6. USEPA (U.S. Environmental Protection Ageny). 2007. *MS4 Program Evaluation Guidance*. EPA-833-R-07-003. U.S. Environmental Protection Ageny, Office of Wastewater Management, Water Permits Division, Washington, DC. http://cfpub.epa.gov/npdes/docs.cfm?program_id=6&view=allprog&sort=name#ms4_guidance

   The MS4 Evaluation Guide is primarily for use by NPDES authorities to evaluate the quality of Phase I and Phase II MS4 programs, for permit compliance, technical assistance, and other purposes. It can be used for comprehensive program evaluations or for certain components. MS4 program managers can also use it to evaluate their own programs.

3.4.6. Land Use and Impervious Surface Coverages

1. Multi-Resolution Land Characteristics (MRLC) Consortium's National Land Cover Database (NLCD): www.epa.gov/mrlc/
2. National Agriculture Imagery Program (NAIP) Aerial Photos: http://165.221.201.14/NAIP.html
3. USGS's Earth Explorer: http://edcsns17.cr.usgs.gov/EarthExplorer/
4. USGS's Land Cover Institute: http://landcover.usgs.gov/
5. Google Earth: http://earth.google.com/

3.4.7. Field Reconnaisance and Illicit Discharge Detection

1. Kitchell, A., and T. Schueler. 2005. *Unified Stream Assessment: A User's Manual*. Version 2.0. Center for Watershed Protection, Ellicott City, MD. www.cwp.org/Store/usrm.htm#10

   This document outlines how to perform a Unified Stream Assessment, a rapid technique to locate and evaluate problems and restoration opportunities within the urban stream corridor. It also describes how to interpret the data collected to determine the stream corridor restoration potential.

2. Wright, T., C. Swann, K. Cappiella, and T. Schueler. 2005. *Unified Subwatershed and Site Reconnaissance: A User's Manual.* Version 2.0. Ellicott City, MD. www.cwp.org/Store/usrm.htm#11

   The manual provides detailed guidance on how to perform each of its four components: the Neighborhood Source Assessment, Hotspot Site Investigation, Pervious Area Assessment, and the analysis of Streets and Storm Drains. Together, these rapid surveys help identify upland restoration projects and source control to consider when devising subwatershed restoration plans.

3. Brown, E., D. Caraco, and R. Pitt. 2004. *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments.* Prepared for the U.S. Environmental Protection Agency, Office of Water and Wastewater, Water Permits Division, Washington, DC, by Center for Watershed Protection and the University of Alabama. www.epa.gov/npdes/pubs/idde_manualwithappendices.pdf

   Chapter 7 of this document describes the use of watershed reconnaissance to search for illicit discharge problems in the field, with the process consisting of rapid screening of priority outfalls in priority subwatersheds followed by indicator monitoring at suspect outfalls to characterize flow types and trace sources.

1. Understanding the Connections Between TMDLs and Stormwater Permits
2. Identifying Opportunities to Coordinate TMDLs and Stormwater Permits
3. Characterizing Impairments and Stormwater Sources
4. **Developing TMDLs with Stormwater Sources**
5. Promoting Effective Stormwater Management
6. Coordinating TMDLs and Stormwater Permits

Chapter Four
Developing TMDLs with Stormwater Sources

What's included in this chapter

- ✓ Discussion of considerations for selecting an approach for developing TMDLs with stormwater sources.
- ✓ Description of common analytical approaches that can be used for developing stormwater source TMDLs.
- ✓ Identification of factors that affect how stormwater sources are addressed in the TMDL analysis.
- ✓ Discussion of and examples illustrating options for calculating and expressing stormwater WLAs.

What you should know after reading this chapter

- ✓ The unique considerations for incorporating stormwater sources and calculating associated WLAs in a variety of commonly used TMDL development approaches.
- ✓ The advantages and disadvantages of different methods for developing stormwater-source TMDLs.
- ✓ Options for developing stormwater WLAs.

Potential roles and responsibilities under this activity

If you are a TMDL writer

1. Evaluate the potential approaches for developing your stormwater-source TMDL based on your technical and programmatic needs.
2. Select an approach for developing your stormwater-source TMDL.
3. Decide how to represent and include stormwater sources in your TMDL analysis.
4. Calculate WLAs for stormwater sources that will facilitate effective permit development.

If you are a stormwater permit writer

1. Coordinate with TMDL writer to support accurate and appropriate representation of stormwater sources in the TMDL analysis.
2. Provide input on WLA analysis to support development of equitable and feasible WLAs.

4. DEVELOPING TMDLS WITH STORMWATER SOURCES

The TMDL analysis establishes a quantitative link between pollutant sources and receiving water response to identify the loading capacity of an impaired waterbody that will result in meeting water quality standards. There are a number of approaches to support this analysis and selecting which to use for any given TMDL is often guided by a number of technical and practical factors. Developing stormwater-source TMDLs can present some unique technical considerations that affect what approaches can be used and how they are applied. As shown in Figure 4, this chapter discusses the activities related to calculating the TMDL and its associated allocations. To address these activities as related to stormwater-source TMDLs, the chapter first introduces a number of approaches for developing stormwater-source TMDLs and then discusses the following:

- Selecting an approach for developing the stormwater-source TMDL
- Applying that approach to develop the TMDL
- Expressing stormwater WLAs

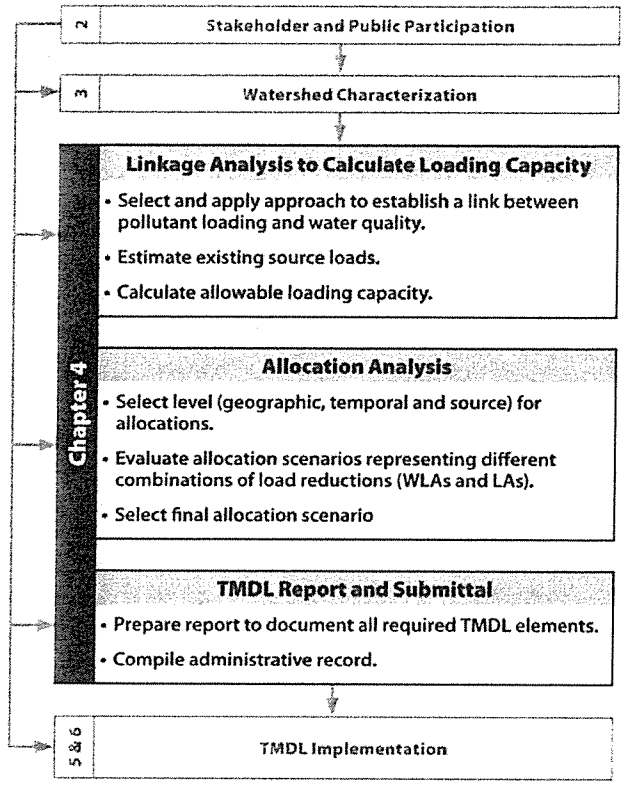


Figure 14. Illustration of the steps in the TMDL process, including activities related to calculation and documentation of the TMDL and its allocations.

4.1. Overview of Approaches for Developing TMDLs

There are a handful of approaches that are commonly used for developing TMDLs. This section briefly introduces these approaches, and Sections 4.2 and 4.3 describe the considerations for their selection and application when dealing with stormwater sources.

The types of TMDL approaches discussed fall into to two major categories—modeling approaches and non-modeling approaches. The term *model* describes the set of equations or algorithms that are used to simulate a physical system. In this report, model refers to the available software tools that automate the calculation of equations or groups of equations representing the system. These can include watershed models that simulate the processes related to surface runoff and receiving water models that simulate a range of waterbody conditions and processes. *Non-modeling* approaches include those approaches that are not based on a standardized, automated software that simulates watershed or waterbody processes. They

Resources: For more information the general approach for calculating TMDLs, refer to the Resources list at the end of this chapter in Section 4.5.1.

include those approaches that are based on monitoring data, empirical equations or other statistical or site-specific calculations. Examples include load duration curves developed using observed flow and water quality data and simple mass-balance calculations.

Within those categories, there are various types of approaches, all of which can be further characterized according to the type of simulation or calculation they perform. The approaches either calculate land-based loads or the resulting waterbody loads. Table 6 presents the types of approaches discussed in this section and their respective categories of modeling vs. non-modeling and land-based vs. waterbody-based. The *land-based* approaches calculate loading from land-based runoff processes assuming some measure of precipitation and characteristics representative of the watershed (e.g., soils, imperviousness). The *waterbody-based* approaches calculate the *delivered* load in the waterbody on the basis of in-stream conditions, either using observed monitoring data (i.e., concentration and flow) or assuming some user-defined load inputs and outputs. Many of these approaches are applied in combination to represent both source loading and waterbody response to establish a loading capacity and associated WLAs and LAs to meet water quality standards.

Table 6. Commonly used TMDL approaches

Calculation process	Type of TMDL approach	
	Modeling	Non-modeling
Land-based	▪ Watershed models (simple to complex)	▪ Export coefficients ▪ IC method ▪ Simple Method
Waterbody-based	▪ Receiving water models (simple to complex, hydrodynamic and water quality)	▪ Load duration method ▪ Percent reduction method ▪ Mass balance or steady-state analysis

The following discussion provides a brief description of these common TMDL approaches. More detail on their application in stormwater-source TMDLs is then provided, with examples, in Section 4.3.

4.1.1. Land-based Approaches

The following are brief descriptions of several land-based approaches used for TMDL development:

- **Watershed Model.** Many TMDLs use watershed models to evaluate existing and allowable pollutant loads to identify allocations, load reductions, and management scenarios. This group of models emphasizes description of watershed hydrology and water quality, including runoff, erosion, and washoff of sediment and pollutants. Some models simulate only the land-based processes, while some can also include linked river segments and simulate in-stream transport and water quality processes. Watershed models vary in the level of detail, including what processes they simulate and the simulation timestep (e.g., daily vs. monthly). The complexity of watershed models can range from the use of loading functions—empirically based estimates of load based on generalized meteorologic factors (e.g., precipitation, temperature)—to physically based simulations—scientifically based equations to represent the physical, chemical, and biological processes associated with runoff, pollutant accumulation and washoff, and sediment detachment and transport. An example of a loading function model is Generalized Watershed Loading Functions (GWLF), which simulates basic watershed processes related to weather, erosion, and runoff and pollutant washoff and does not include waterbody response or in-stream fate and transport. GWLF provides watershed load and flow estimates on a monthly basis. Alternatively, Hydrologic Simulation

Program – Fortran (HSPF) combines watershed processes with in-stream fate and transport to simulate watershed hydrology, land and soil contaminant runoff, and sediment-chemical interactions. HSPF can generate time series results of any of the simulated processes on a daily or even sub-daily timestep.

- **Export Coefficients/Pollutant Budgets.** This category encompasses a number of approaches built on empirical relationships among watershed processes and pollutant loading as well as the use of literature values of typical watershed loading rates. Examples include using monthly load rates from various land uses to calculate allowable loading from an impaired watershed. Another example is using an empirical relationship that allows a user to calculate an allowable load depending on desirable conditions (e.g., target runoff/waterbody concentration or indicator levels). This approach would typically be used to calculate existing loads and would often be combined with a supplementary approach that calculates an allowable load on the basis of in-stream targets (e.g., percent reduction). Another approach that could fall within this category is a Vollenweider type approach where an empirical equation relating reservoir tropic status to allowable phosphorus loading is used to identify an allowable load corresponding to the desired reservoir condition.
- **IC Method.** This emerging method calculates a target of percent IC in a watershed to represent attainment of water quality standards. Available data are used to relate the percent IC with the resulting runoff, pollutant loading, and waterbody response to calculate the loading capacpity.
- **Simple Method.** The Simple Method is an empirical equation used to calculate pollutant loading on the basis of drainage area, pollutant concentrations, a runoff coefficient, and precipitation. In the Simple Method, the amount of rainfall runoff is assumed to be a function of the imperviousness of the contributing drainage area. When using the Simple Method, the TMDL loading capacity would typically be calculated using a combination approach with a waterbody-based approach such as the percent reduction method.

4.1.2. Waterbody-based Approaches

The following are brief descriptions of several waterbody-based approaches used for TMDL development:

- **Receiving Water Model.** Receiving water models simulate conditions within a receiving waterbody (e.g., lake, stream, estuary) on the basis of a representation of physical, chemical and biological processes. Inputs to the waterbody are often defined as user-defined boundary conditions or using linked dynamic output from a watershed model. Receiving water models are typically either steady-state or dynamic models. Steady-state models operate under a single, nonvariable flow condition with constant inputs, typically used to evaluate conditions for a design or critical flow. Dynamic models allow for variations in both flow and meteorologic conditions on a small timestep, typically shorter than daily. Level of complexity in receiving water models is also determined by spatial detail described as one, two, or three dimensions.
- **Load Duration.** The load duration methodology relies on using observed flows and water quality criteria to establish a curve of loading capacities for various flow conditions. This builds on using flow duration curves, which use hydrologic data from stream gages to evaluate the cumulative frequency of historic flow data over a specified period. A water quality criterion or other target concentration can then be multiplied by the observed flows to create a curve representing the distribution of allowable loads as a function of daily flow, representing the loading capacity of the stream. The entire curve can be used to represent flow-variable loading capacities, or allowable loads

can be identified for specified flow intervals, which can be used as a general indicator of hydrologic condition (e.g., wet versus dry).

- **Percent Reduction.** This method assumes a 1:1 relationship between surface water concentrations and pollutant loading. The existing pollutant concentrations are compared to applicable water quality criteria to calculate a necessary reduction. This reduction is then applied to an estimate of *existing* loading to calculate the loading capacity to meet water quality standards. Existing loads are often calculated using ambient monitoring data (e.g., concentration and flow) or some estimation of land-based loading (e.g., export coefficients).
- **Mass Balance or Steady-State.** These approaches rely on the assumption of conservation of mass into a waterbody. The analysis might calculate loads entering a waterbody using export coefficients or observed data and calculate the resulting waterbody concentrations on the basis of estimated losses (e.g., settling, decay) and inputs. The approach relies on identifying the necessary loads entering a waterbody that will meet the desired waterbody target after considering all inputs and losses. These approaches can be applied for a steady-state critical condition or longer time periods, such as average monthly loading rates.

4.2. Selecting an Approach for Developing Stormwater-Source TMDLs

TMDL writers often consider a number of factors when deciding which approach to use to calculate the loading capacity and associated LAs and WLAs for TMDLs. As shown in Figure 15, these can include user needs or requirements, programmatic considerations, and technical needs. While user needs and programmatic considerations often guide the general type of approach (e.g., simple vs. complex, modeling vs. non-modeling), the technical considerations often guide the selection of a specific approach or methodology. The technical considerations define the following needs for the TMDL analysis:

- Spatial scale/resolution
- Temporal resolution/time scale
- Processes or features that need to be included (e.g., pollutant type, surface runoff, in-stream transport)

The watershed characterization step of TMDL development (Chapter 3) should generate the necessary information to define these needs by providing an understanding of the impaired waterbodies, the surrounding watershed and the associated impairments. Specifically, the major considerations or questions that were addressed during the watershed characterization that can support selection of an appropriate approach for TMDL development include the following:

- What are the applicable water quality criteria?
- What are the sources?

Tip: Evaluating Stormwater Issues when Selecting a TMDL Approach

Stormwater-source TMDLs can present unique considerations affecting selection and application of a TMDL approach. TMDL writers should evaluate stormwater-specific considerations within the context of *all* the issues and characteristics of the TMDL, waterbody, and associated watershed. If stormwater is a significant source affecting water quality, these considerations might carry more weight in the decision-making process; however, they should be evaluated with all watershed-specific issues when selecting the most appropriate approach.

- What are the impairments and associated critical conditions?

Table 7 summarizes the considerations related to each of the three technical needs for these defining topics of water quality standards, impairment, and sources. The answers to the questions outlined in Figure 15 and more specifically in Table 7 will guide approach selection for TMDL development. While these questions and considerations will not be much different for a stormwater-source TMDL than for any other TMDL, there might be some unique issues related to stormwater that will affect the selection of an appropriate approach for TMDL development. The following section discusses these stormwater-specific issues to be considered when selecting an approach for TMDL development.

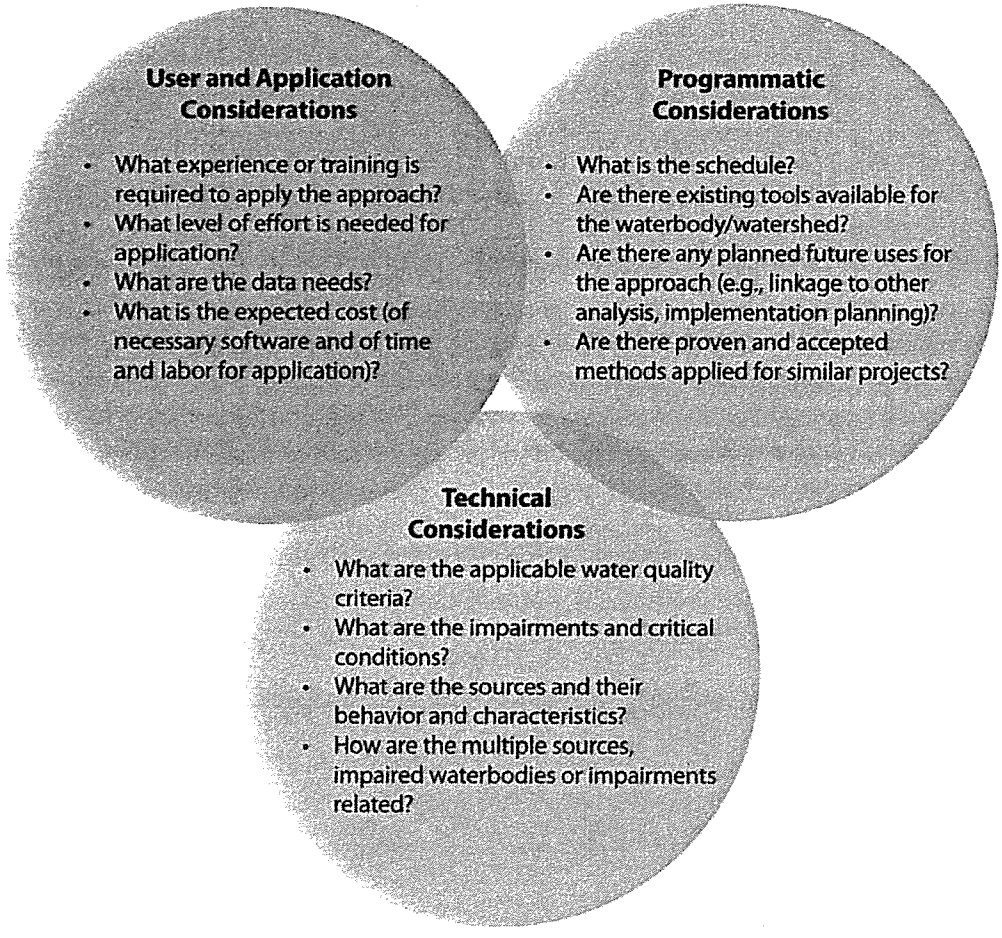


Figure 15. Considerations for selecting a TMDL development approach.

Table 7. Summary of technical considerations for selecting a TMDL development approach

Technical needs of approach	Technical considerations for approach selection		
	Water quality criteria and TMDL targets	**Impairments and critical conditions**	**Sources**
Spatial Needs	▪ Are different criteria or TMDL targets applicable in different locations within the watershed?	▪ How many impaired segments are being addressed? ▪ What are the location and distribution of impaired segments?	▪ What type of sources/land uses exist in the watershed? ▪ What are the location and distribution of sources? ▪ At what level do the sources need to be isolated (e.g., gross loading vs. land use specific loading)?
Time-scale Needs	▪ What are the duration and frequency of applicable criteria or targets?	▪ What is the timing associated with impairment (e.g., instantaneous vs. chronic or cumulative effects)? ▪ Are there any temporal trends to capture (e.g., seasonality in waterbody conditions)?	▪ Are the effects due to cumulative or acute loading conditions? ▪ Are there temporal variations in source loading (e.g., due to weather patterns, seasonal activities)? ▪ At what temporal scale do the sources need to be estimated?
Processes to Include	▪ Is criterion based on pollutant level (e.g., concentration) or a measure of response or condition (e.g., flow, habitat quality, eutrophication)? ▪ What are the pollutants?	▪ Is impairment based on a specific pollutant (e.g., sediment, metals) or based on cumulative effects of stressors (e.g., flow, habitat quality, pollutants)? ▪ Is meeting the target dependent on or affected by multiple waterbody measures (e.g., nutrient levels, temperature, pH)? ▪ What are the waterbody critical conditions for loading response (e.g., dynamic, flow variable vs. steady-state)? ▪ If dealing with multiple pollutants, how are they related?	▪ What is the source loading behavior (e.g., precipitation-driven, direct discharge)? ▪ Do sources impact multiple impaired segments (i.e., need for in-stream routing and transport)? ▪ Does the analysis need to evaluate individual and/or cumulative impact of sources?

4.2.1. How Are Water Quality Criteria or TMDL Targets Expressed?

The ultimate goal for any TMDL is to restore the impaired waterbody to meet water quality standards. As discussed in Section 3.2, identifying a TMDL target is typically based on using a numeric water quality criterion or interpreting narrative criteria. The expression of the resulting TMDL target can influence what types of TMDL development approaches are appropriate and how a TMDL analysis considers and represents water quality standards attainment. In many respects, considering the TMDL target for selecting an approach for a stormwater-source TMDL is no different than for any other TMDL. For example, numeric water quality criteria (or a numeric target representing narrative criteria) have an associated magnitude, duration, and frequency. The applicability of an approach can be affected by its ability to simulate at a time-scale necessary for comparison to the water quality target's magnitude, duration and frequency. Targets designed to address acute (short-term) impairments are typically based on instantaneous maximums or daily averages while chronic (long-term) problems (e.g., eutrophication, sediment loading and deposition) can be represented by targets with longer durations (e.g., monthly average concentration, annual loading).

> ***Tip: Select an approach consistent with water quality standards***
>
> Regardless of the significant pollutant sources, the TMDL writer should select a technical approach that is suitable for the pollutant of concern. For example, some models do not simulate certain pollutants and, therefore, are not appropriate for certain types of TMDLs. The approach should also provide the necessary output to allow for a direct comparison to the temporal duration specified in water quality criteria.

As discussed in Section 3.2, an issue unique to stormwater-source TMDLs is the use of surrogate targets (e.g., flow volume, percent IC) to represent the combined effects of stormwater quantity and quality on maintenance of water quality standards. In these situations, the use of a surrogate target will have a direct bearing on the choice of the technical approach. For example, if using an IC target, the approach chosen must be able to calculate flows from varying levels of imperviousness. Similarly, an analysis that uses peak flow as a target and identification of TMDL allocations and subsequent controls will depend on controlling flow volumes and peak flows, it will be necessary to use an approach that can either simulate the hydrology and hydraulics of a system in response to watershed characteristics or one that can otherwise relate in-stream flow conditions to watershed characteristics (e.g., imperviousness).

In Practice: Integrating Stormwater Runoff Volume as a Surrogate for Water Quality Standards into a TMDL Approach in Potash Brook, Vermont

Vermont's water quality standards provide for the use of numeric biological indices to determine the condition of fish and aquatic life based on reference conditions for different waterbody types. Potash Brook, near Burlington, is on Vermont's section 303(d) list as a result of biological impairments, including loss of sensitive taxa, and a compositional shift toward more tolerant species in macroinvertebrate communities. Data suggests that degraded habitat and increased sedimentation are the highest concerns, most likely caused by changes in water flow and increases in sediment erosion and deposition. To effectively address biological impairments in Potash Brook, the Vermont Department of Environmental Conservation selected stormwater runoff volume as a surrogate TMDL measure to represent issues associated with the following:

- Sediment delivered through erosion processes
- Physical effects on the stream channel such as sediment release from channel erosion and scour from increased flows
- Diminished base flow (e.g., decreased groundwater recharge)
- Amount of other potential pollutants (e.g., nutrients, toxics) delivered to Potash Brook is a function of the amount of storm water runoff generated within the watershed.

A high-flow reduction target was established on the basis of the hydrologic conditions of two reference watersheds where aquatic life criteria are attained. Flow duration curves were used to evaluate existing and target conditions for the stream and establish the TMDL. Flow duration curves were developed for both Potash Brook and the reference watersheds, and the difference between the 0.3 percent duration point on the curves was used to derive the reduction target. The 0.3-percentile flow represents the flow that is exceeded by only 0.3 percent of the measured flows and was selected because it approximately equals the one-year flow and the channel forming flow for this stream. The vast majority of reductions are assigned to the WLA, which applies to runoff from urban and developed portions of the watershed, and includes an allocation for future growth. The LA applies to the limited agricultural and open space portions of the watershed.

More information on the Potash Brook TMDL (2006), as well as other hydrology-based TMDLs approved in Vermont, is available at www.anr.state.vt.us/dec//waterq/stormwater/htm/sw_impairedwaters.htm. Other examples of hydrology-based TMDLs include Maine's Barberry Creek (2007) available at www.maine.gov/dep/blwq/docmonitoring/impairedwaters/TMDL/2007/barberry_ck_rep.pdf and Connecticut's Eagleville Brook (2007) available at www.ct.gov/dep/lib/dep/water/tmdl/tmdl_final/eaglevillefinal.pdf.

4.2.2. What Are the Stormwater Sources Affecting Impairment?

Analysis during the previous activity of characterizing the impairment and pollutant sources (Chapter 3) identified the regulated stormwater sources in the watershed that contribute to the impairment of concern. The TMDL writer should also have a general understanding of the relative importance of each source, which can guide decisions regarding technical approaches for TMDL development. It is important that a TMDL approach be able to represent important sources in a way that captures the sources' effect on water quality to calculate appropriate allocations. This is no different for stormwater sources than for other types of point or nonpoint sources. Therefore, when stormwater is a major source affecting impairment, it is important to consider its characteristics when selecting an approach. As discussed in the followings sections, which type of approach is selected for stormwater-source TMDLs will be influenced by the type of sources, size of the source area, and how the source generates and delivers pollutants of concern.

Characteristics of Stormwater Sources that Can Affect Approach Selection

- Type and distribution of sources
  - Pollutant generating activities
  - Spatial coverage
- Pollutant Delivery
  - Timing of loading
  - Delivery mechanism

4.2.2.1. Type and Distribution of Sources

If regulated stormwater sources are within the watershed of the impaired waterbody and discharge the pollutant of concern, they will be included in the TMDL analysis. However, there are varying levels of detail at which the sources can be characterized and quantified in the analysis, affecting both the selection and application of a TMDL approach. Decisions regarding the level of detail for including stormwater sources can include not only the spatial resolution at which sources are represented within the analysis, but also the types of spatial units (e.g., subwatershed, land use types) that can be included and how they are spatially related and represented in the analysis. These decisions will depend primarily on the significance of each source in their effect on the impairment of concern. For example, perhaps an MS4 in an impaired watershed is expected to be a minimal source of the pollutant of concern, whether because it covers a small portion of the watershed, it has already installed a number of effective controls minimizing its effect, or other active sources in the watershed (e.g., agriculture, mining, forestry) contribute significantly more pollutant load. In such a case, it might be appropriate to choose an approach that does not specifically include or calculate loads originating with individual stormwater sources but rather evaluates a cumulative load from all sources (e.g., load duration) and then distributes the total load among sources. Alternatively, if there are multiple regulated stormwater sources in the watershed, including MS4, construction, and industrial, that all represent major contributions of pollutant loading to the system, it will likely be necessary to choose an approach (e.g., watershed model) that can evaluate the watershed at a finer scale, both temporally and spatially, to isolate the source-specific loadings and evaluate their effect on water quality.

One of the first considerations regarding sources is how well they are understood. The analysis of impairment conditions and sources discussed in Chapter 3 helps the TMDL writer understand what and how sources are affecting impairment. This can help to identify the type of information that the technical approach will need to include and also produce, thereby narrowing the range of approach options. If sources and their impacts are well understood based on available data and local knowledge, it might not be necessary to use an approach that evaluates individual sources or provides the ability to predict effects from existing and future source inputs. Some approaches, such as receiving water modeling, can

potentially provide a great deal of information on how known sources will affect receiving water quality but will not provide much information on unknown sources. Land-based watershed modeling, on the other hand, can help to quantify the relative significance of various sources such as urban runoff compared to point source discharges. Data-driven approaches, such as load duration curves, that rely on evaluation of in-stream loads based on monitoring data are very useful when significant observed data are available and the impairments predominantly occur during certain flow conditions. However, they do not typically support direct calculation of loads originating from individual sources and require a supplementary analysis to do so.

Also affecting approach selection is the decision of the spatial resolution for representing the individual stormwater sources in the approach. Stormwater sources can have a variety of activities within their boundaries that contribute to pollutant loads. For example, within an MS4 different land uses (e.g., residential vs. commercial) and areas can contribute varying magnitudes of loads. It might be important to capture those variations in pollutant loading and evaluate subareas within the MS4 boundary, such as areas that drain to certain outfalls or different land uses, to more effectively target BMP implementation. Therefore, it would be appropriate to use an approach that can isolate and calculate pollutant loading from specified *sub-sources*. For example, using a watershed model allows for the inclusion of multiple types of land areas that are represented by characteristics (e.g., soils, pollutant accumulation, imperviousness) that can vary by land use or type, allowing a TMDL writer to not only isolate loads generated within a stormwater source boundary but also by other characteristics such as land use. However, approaches that do not specifically calculate loads from individual sub-sources can still accommodate and capture these variations depending on how they are applied. For example, while a load duration approach calculates a total allowable in-stream load without direct calculation of source-based loads, it can be applied at multiple strategic locations to capture the variability in loading from different sources.

Alternatively, an area within a source's boundary might be small or fairly homogenous, without much variation in pollutant generation. For example, regulated construction sites are relatively small in area and would not likely require further division within their boundaries. As another example, depending on the overlap of an MS4 and the watershed of an impaired water, the portion of the MS4 within the watershed might represent similar land uses and activities (e.g., all residential areas). In these cases, it is likely appropriate to use an approach that evaluates loading on a coarser level, possibly evaluating the cumulative load to an impaired waterbody rather than area-specific inputs.

If regulated construction stormwater sources are important in your watershed, they might present a different set of considerations and challenges for the TMDL analysis than MS4s or industrial sites. Again, there is the question of spatial coverage but also one of temporal effects. MS4s and industrial are static with a definable boundary, while regulated construction sites represent a *moving target* in that they have definable boundaries, but their existence and effects are more intermittent. The temporal aspect of the locations, magnitudes, and activities related to stormwater from construction sites makes it difficult to include in a TMDL analysis. Through the stormwater source characterization and the impairment analysis, the TMDL writer should determine whether construction is an important potential source given the characteristics of the watershed and the impairment. For example, if the watershed is experiencing rapid growth and expansion, construction could be a significant current or future source and might require specific representation in the TMDL analysis. Or perhaps the watershed had a number of construction sites that were active during the time the waterbody was identified as impaired, but the sites are no longer active or contributing to the impairment. In such cases, it might be necessary to select an

approach that can evaluate the temporal variations in waterbody conditions on the basis of time-variable source inputs and other watershed factors (e.g., weather). This type of evaluation is most directly accomplished using a time-variable watershed model. However, other non-modeling approaches can be applied to represent different time frames and source inputs to more generally evaluate the variable effects over time. This can allow the TMDL writer to evaluate past, current, and future conditions related to construction impacts.

Another level of detail in spatial resolution when representing stormwater sources is the potential for including loadings from individual outfalls. While the location of outfalls should be known, it is not always feasible to include or analyze loadings from individual outfalls in a TMDL analysis. To evaluate outfall-specific loads and effects, it is necessary to have data to characterize the outfall discharge (e.g., flow, pollutant concentrations) for at least the critical conditions (e.g., high flows) but preferably under a range of conditions. Data to support this level of detail are often not available. However, if sufficient data are available, it is important to consider the added benefit as well as the added effort in conducting the analysis. The TMDL writer along with the permit writer should identify the benefits of evaluating loading at the outfall level and whether those same benefits could be achieved by conducting the analysis at a broader scale (e.g., subwatershed level) and likely with less expended effort and resources.

4.2.2.2. Pollutant Delivery

How and when a pollutant is delivered to a receiving waterbody is an important consideration in selecting an appropriate TMDL approach. For stormwater-related sources, the typical pathway for pollutants is accumulation and washoff, where overland runoff transports pollutants deposited on land surfaces to stormwater conveyances and eventually receiving waterbodies. However, depending on the type of pollutant, the timing of delivery or mode of transport can present unique needs for a TMDL development approach. For example, many pollutants are delivered in dissolved form in stormwater runoff, while others can be transported adsorbed to sediment particles. Waterbodies that are impaired by sediment-associated pollutants such as phosphorus or organics can therefore require an approach that simulates the processes of sediment erosion and transport to fully evaluate the pollutant loading and impacts.

In addition to the delivery pathway, the timing of pollutant loading is another consideration for the evaluation of stormwater. Stormwater is typically driven by precipitation events and subsequent runoff and discharge. However, dry-weather flows delivered through MS4 infrastructure caused by such things as automobile washing and lawn watering also might be a source of loading to a waterbody, especially in arid regions. This situation might require a TMDL approach that can evaluate both precipitation-driven sources during wet weather and also direct inputs occurring during dry weather. For example, load duration curves and watershed models can be applied to evaluate loads for different flow conditions.

Regardless of the conditions of delivery, stormwater source activity can also occur during different times of year. For example, pollutants associated with deicing and winter road maintenance are more likely to be deposited and delivered during winter months while pollutant runoff from residential car washing might be more frequent during warmer summer months. These situations might warrant a TMDL approach that can evaluate and capture the variations in pollutant loading across months and seasons. For example, many watershed models can produce either daily continous loads or monthly loads that would capture the variations in loading during different seasons.

4.2.3. What Are the Critical Conditions?

As discussed in Chapter 3, the critical conditions for a TMDL represents the combination of environmental conditions (physical, chemical and biological) under which impairment occurs. This can include such things as the environmental processes that affect impairment (e.g., nutrient dynamics affecting dissolved oxygen levels, flow modification due to increased development affecting in-stream habitat) and the timing of impairment (e.g., certain months or times of day). From the characterization step discussed in Chapter 3, the TMDL writer should understand the impairment and the effect of stormwater sources on receiving water quality and can now evaluate how to capture that in the selected approach.

For example, some stormwater-related impairments are not associated with specific pollutants and therefore require the analysis of a variety of pollutants and processes to capture the impairment conditions. Evaluating the effects of stormwater and identifying necessary allocations might require the evaluation of such things as sediment delivery and deposition, peak flows, and nutrient loading and resulting eutrophication dynamics. Another example is critical conditions related to low dissolved oxygen that can be affected by the timing and availability of nutrient loads and also on seasonal factors such as temperature, resulting algal growth, and flow. The TMDL writer should evaluate the processes that need to be included to sufficiently represent the critical conditions when selecting an approach for developing the TMDL.

In Practice: Selecting a TMDL Approach to Capture Critical Conditions in Ballona Creek, California (2005)

Segments of Ballona Creek and Sepulveda Canyon Channel were included on 1996, 1998, and 2002 303(d) lists for cadmium, copper, lead, selenium, silver, zinc and toxicity. Data analysis indicates differences in waterbody conditions (e.g., water quality, flow) and sources between dry and wet weather. To capture the varying critical conditions and source loading, two distinct approaches were used to develop the TMDL.

Because the metals criteria are based on hardness, separate wet- and dry-weather targets were developed to reflect the different hardness values and flow conditions in the creek and its tributaries. For the purpose of this TMDL, wet weather is defined in terms of flow rather than rainfall. Wet weather is defined as any day in which the maximum daily flow is equal to or greater than 40 cubic feet per second (cfs) based on the 90th percentile of flows measured over a 10-year period.

The dry-weather loading capacity for each metal was derived by multiplying the hardness-adjusted, dry-weather numeric targets by the critical flow assigned to these two waterbodies. The wet-weather TMDL calculation was based on the simulation of the hydrologic processes and watershed metals loading using a watershed model (HSPF). Using simulated flows and metals concentrations, a load duration curve approach was used to establish the wet-weather loading capacity. Loading capacities were calculated by multiplying the daily storm volume by the appropriate numeric water quality target.

A grouped mass-based WLA was developed for stormwater permittees (Los Angeles County MS4, Caltrans, General Industrial and General Construction) for both dry weather and wet weather. Because there are no identified areas in the watershed that discharge directly to Ballona Creek or a tributary rather than through the storm drain system, the WLA was equal to the calculated loading capacity minus the estimated loads from atmospheric deposition. The grouped stormwater WLA was partitioned among the MS4 permittees (77,546 acres) and Caltrans (1,080 acres) using an estimate of the percentage of land area covered under each permit.

The Ballona Creek metals TMDL report is at www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/2005-007/05_0831/StaffReport.pdf.

4.3. Applying Approaches for Stormwater-Source TMDLs

Once an approach is selected for TMDL development, the TMDL writer will apply the approach to calculate the loading capacity and associated allocation for sources. While all sources present challenges in deciding how to accurately represent their inputs and effects, stormwater sources can require some unique considerations when applying a TMDL approach. The two key issues to address when developing TMDLs with stormwater sources are

1. How to represent stormwater source characteristics (e.g., discharge flows and concentrations)
2. How to isolate and estimate the loads transported and discharged through the stormwater system

Several commonly used TMDL approaches were introduced previously in Section 4.1. This section discusses the considerations for developing TMDLs with stormwater sources using these different methods and is organized according to whether the approach is land-based or waterbody-based, as identified in Table 6. Table 8 summarizes the advantages and disadvantages of each method, and the following sections provide more detail on their application for stormwater-source TMDLs.

Table 8. Summary of commonly used TMDL development approaches

Approach	Can be combined with...	Advantages	Disadvantages
Land-based Approaches			
Watershed Models	▪ Receiving Water Model ▪ Load Duration Curves	▪ Can directly simulate regulated stormwater sources as distinct hydrologic units to facilitate better representation of source inputs. ▪ Enables source-level allocations ▪ Provides flexibility in expression of allocations, from gross to detailed, site-level (if detailed model is used). ▪ Provides time-variable simulation and results to better represent varying conditions for regulated stormwater source inputs and impacts (if dynamic model is used). ▪ Flexibility in how model is set up to represent land units allows for simulation of subareas or land uses within regulated stormwater source boundaries to define spatial inputs and impacts for targeting implementation. ▪ Allows users to simulate potential changes in water quality conditions that might result from implementation activities.	▪ Requires significant data and analysis if outlet-level allocation is necessary. ▪ Direct simulation of stormwater sources is dependent on accurate information on drainage areas and runoff. ▪ Moderate or general watershed models (e.g., those with monthly time-steps) have limited capabilities for temporal evaluation or highly variable stormwater sources. ▪ Model accuracy dependent on having sufficient water quality data for calibration. ▪ Requires trained or experienced staff to run the model and understand model assumptions and limitations.
IC Method	▪ Watershed Models ▪ Load Duration Curves	▪ Because area of impervious surfaces is easily explained and tangible, can be more understandable to the public. ▪ Is translated more easily into management actions.	▪ Requires supplemental analysis and data to support linkage to a load . ▪ Requires sufficient data to support the link between IC and water quality standards. ▪ Is not appropriate for waterbodies affected by a mix of sources other than urban runoff.

Approach	Can be combined with...	Advantages	Disadvantages
Export Coefficients	▪ Percent Reduction ▪ Load Duration Curves	▪ Is simple to apply.	▪ Is usually based on regional or national literature values that might not be representative of local conditions. ▪ Does not provide a direct link to waterbody conditions and use support.
Simple Method	▪ Percent Reduction ▪ Load Duration Curves	▪ Is useful in watersheds lacking flow data. ▪ Is specifically designed to evaluate stormwater pollutant loads from impervious areas.	▪ Assumes all loading originates on impervious surface during storm events, not accounting for runoff from impervious areas or subsurface inputs and baseflow loading. ▪ Because it uses a static runoff concentration, does not account for variability in loading or in-stream levels. ▪ Not appropriate for large watersheds (>1 mi^2) or non-urban areas.
Waterbody-based Approaches			
Receiving Water Models	▪ Watershed Model ▪ Mass Balance	▪ Represents a high level of spatial variability within a waterbody, allowing for detailed outfall-based allocations ▪ Provides time-variable simulation and results to better represent varying conditions for regulated stormwater source inputs and impacts (if dynamic model is used).	▪ When applied independently, is limited to allocations set for specific input points; requires combination with a watershed model for land-based allocation analysis. ▪ Provides limited allocation opportunities when source is not discharging directly to the receiving water (e.g., for construction sites in upland locations). ▪ Provides limited allocation options when applied as a steady-state (non-dynamic) modeling application.
Load Duration	▪ Watershed Models ▪ Simple Method	▪ Is based on observed monitoring data, providing a data-based representation of existing conditions. ▪ Identifies the allowable and existing loads for all flow conditions, providing insight into the critical conditions and accounting for the natural variations in loading and in-stream conditions. ▪ Because it is based on observed in-stream conditions, can capture the effects of unknown sources (e.g., failing septic systems, illicit connections).	▪ Provides limited information regarding the relative magnitude of source loads. ▪ Requires supplemental analysis to distribute loading capacity into source-based allocations. ▪ Requires robust and consistent records of flow and in-stream water quality data. ▪ Is applicable only to non-tidal streams or rivers.
Percent Reduction Method	▪ Simple Method ▪ Export Coefficients	▪ Is simply and quickly applied. ▪ Easy for the public to understand.	▪ Assumes a 1:1 relationship between reductions in pollutant loading and resulting reductions in concentration. ▪ Does not calculate source-based loads, requiring supplementary analysis to identify stormwater WLAs.

Approach	Can be combined with...	Advantages	Disadvantages
Mass Balance or Steady-state Analysis	▪ Receiving Water Models	▪ Relatively simple to apply. ▪ Is based on observed monitoring data, providing a data-based representation of existing conditions.	▪ Typically focuses on a single critical condition (e.g., critical flow) or long-term average conditions (e.g., monthly loading and concentration), not allowing for evaluation of variability in pollutant loading or waterbody conditions. ▪ Simple representative of pollutant fate and transport.

4.3.1. Land-based Approaches

This section discusses the modeling and non-modeling TMDL approaches that evaluate land-based loading or conditions and issues related to their use in stormwater TMDLs.

4.3.1.1. Watershed Models

Watershed models are commonly applied to provide a quantitative linkage between source contributions and waterbody response for TMDL development. This category of models loosely refers to numerical frameworks that address a combination of land-based rainfall/runoff and contaminant loading processes and conveyance of flow and contaminants within a stream, impoundment, or some other type of receiving waterbody. Commonly available data used to drive watershed models and accurately simulate conditions within receiving waters include land cover, soil type, meteorological characteristics, and stream/impoundment dimensions. The level of complexity associated with each of these models varies widely from annual flow and contaminant load delivered from a watershed to sub-hourly prediction of detailed hydrologic processes at the land use or site level.

While structure and simulated processes vary from one model to the next, watershed models provide a useful basis for allocation to watershed sources contributing to waterbody impairment, including permitted stormwater sources. Most watershed models perform calculations on a land unit basis. That is, the modeler divides a drainage area into smaller land units to enhance representation of heterogeneities. These land units can represent variable soil characteristics, political boundaries, or more commonly, land use or cover. Many models take this land cover breakdown one step further and represent impervious and pervious land cover types using different mathematical formulations. Impervious land, for example, is not subject to infiltration and associated subsurface processes. Figure 16 illustrates how a typical watershed model categorizes each area of land by land use type (e.g., residential, forest, agriculture) and then routes flow and loads delivered from those within each watershed to the receiving waterbody. Watershed models typically have the capability to separate the watershed into a number of smaller subwatersheds. Some then have the added capability to route the flow and load contributed from each subwatershed to the corresponding stream reach to the downstream reach, creating a system of connected waterbody segments. Dividing a watershed into land cover-based units typically provides a logical basis for developing source-based allocations in a TMDL. For example, specific allocations (in terms of time-variable flow and contaminant loads) can be made to each land cover category represented in a watershed model. A watershed model might, for example, represent the following five land cover categories: forest, pasture, crop, residential–pervious, residential–impervious. In this situation each

category might receive independent allocations, which collectively result in the receiving water for the drainage area to attain and maintain water quality criteria.

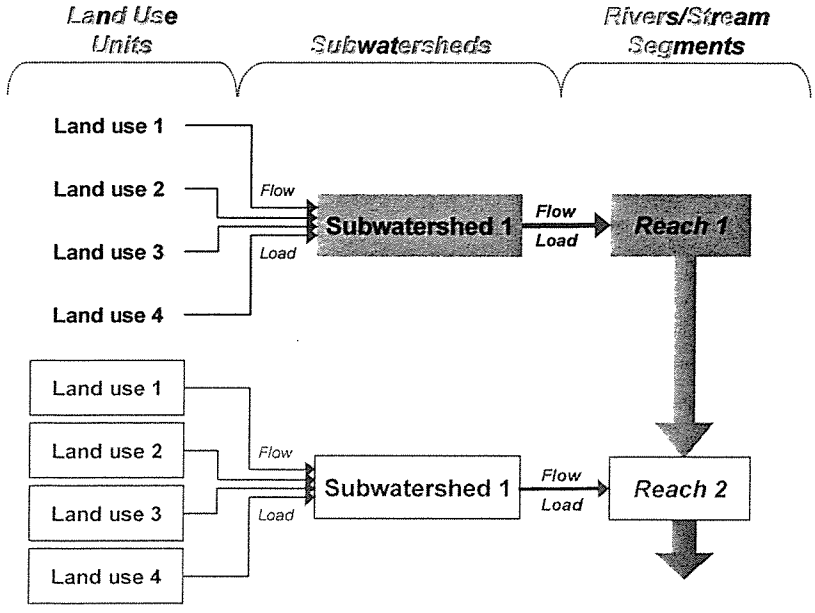


Figure 16. Typical watershed model elements for simulating runoff and pollutant loading from watershed land uses to receiving waterbodies.

Of the approaches presented in this section, watershed models can have the greatest variation in the type and method of application of the approach. Watershed models can vary widely in their capabilities, influencing their applicability for a particular TMDL application. The applicability of a model for simulating stormwater sources in a TMDL analysis can be affected by the model's capabilities, including the following:

- Timestep (temporal resolution)
- Ability to represent spatial variations (spatial resolution)
- Processes that are simulated

The temporal resolution can affect the model's ability to capture the variations in stormwater loading and the waterbody response. Its spatial scale can determine how watersheds are divided and represented, including how stormwater sources are isolated. The processes simulated by a model will often be a primary determining factor in model selection for TMDL development. A model's ability to simulate certain land-based processes (e.g., pollutant accumulation, runoff, erosion), waterbody processes (e.g., in-stream transport, nutrient dynamics, die-off), and management processes (e.g., stormwater detention) can determine whether it is appropriate for use in a certain TMDL project and also how the model will be applied. Table 9 identifies several model capabilities that can affect how it can be used to evaluate and estimate stormwater source loads. For each capability, the table rates a number of watershed models used for TMDL development, including:

Resources: For more information on selecting watershed models based on needs for a given TMDL, refer to the Resources list at the end of this chapter in Section 4.5.2.

- Annualized Agricultural Non-Point Source (AnnAGNPS)
- GWLF
- HSPF
- Loading Simulation Program in C++ (LSPC)
- Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds—Urban Catchment Model (P8-UCM)
- Source Loading and Management Model (SLAMM)
- Soil and Water Assessment Tool (SWAT)
- Storm Water Management Model (SWMM)

Table 9. Commonly used watershed models and select capabilities for evaluating stormwater sources in TMDLs

Simulation capability	AnnAGNPS	GWLF	HSPF	LSPC	P8-UCM	SLAMM	SWAT	SWMM
Simulates land-based pollutant accumulation and runoff	●	⊙	●	●	⊙	●	●	●
Simulates dynamic daily conditions (variable precipitation/flow)	⊙	○	●	●	⊙	●	⊙	●
Simulates conveyance systems	○	○	⊙	⊙	○	⊙	○	●
Simulates sediment erosion and transport	●	⊙	●	●	⊙	●	⊙	⊙
Simulates in-stream fate and transport	○	○	●	●	○	○	⊙	⊙
Simulates BMPs	●	○	⊙	⊙	●	●	●	⊙
Is appropriate for urban watersheds	○	○	⊙	⊙	●	●	○	●
Is appropriate for mixed land uses	⊙	⊙	●	●	○	⊙	⊙	⊙

○ = Low

⊙ = Medium

● = High

Other modeling references (USEPA 1997, 2005c) include summaries of model applicability for more general considerations, such as land uses simulated, pollutants simulated, and waterbody types simulated as well as for considerations related to their application. For example, *TMDL Model Evaluation and Research Needs* (USEPA 2005c) provides a series of tables rating the capabilities or applicability of more than 60 available watershed and receiving water models in the following categories:

- **TMDL Endpoints.** Considers the model's ability to simulate typical TMDL target pollutants (e.g., nutrients, toxics, bacteria) and expressions (e.g., load vs. concentration). Characterizes the models depending on the timestep of the simulation for the target (e.g., steady state, annual, daily, hourly).
- **General Land and Water Features.** Rates models according to their ability to simulate general land uses (e.g., urban, agricultural) and waterbody types (e.g., river, lake, estuary).
- **Special Land Processes.** Rates models on their ability to simulate more than 15 special land processes such as wetlands, hydrologic modification, urban BMPs (e.g., street sweeping, detention ponds), and rural BMPs (e.g., nutrient control practices, irrigation practices).

- **Special Water Processes.** Rates models on their ability to simulate special processes occurring in receiving waterbodies such as air deposition, stream bank erosion, algae, and fish.
- **Application Considerations.** Rates models on the following practical considerations affecting their application—experience required, time needed for application, data needs, support available, software tools, and cost.

Regardless of what type of watershed model is used, TMDL writers can calculate WLAs for permitted stormwater sources (e.g., MS4s, industrial facilities, and construction sites) in a number of ways using watershed models. The primary issues with modeling approaches that include stormwater sources are similar to those for other approaches, i.e., how to most accurately represent the sources and how to isolate and calculate their pollutant load contributions. Because models typically provide continuous simulation of multiple land- and waterbody-based processes, they can provide more flexibility than non-modeling approaches in representing stormwater sources.

An essential part of defining the contributions from permitted stormwater sources depends on isolating the *regulated boundary* of the source, or the drainage area that delivers stormwater runoff to the source's system. (See Chapter 3 about delineating the regulated area of a stormwater source.) Stormwater permits require all permittees to have documentation of the system configuration, its outfalls and boundaries. The level of detail of this information, however, will vary by permittee. Some might have detailed GIS-based coverages of storm sewer outlets and the areas they drain. Others might have coarse, hand-drawn maps roughly identifying their outlet locations and property boundaries. Once the TMDL writer delineates source areas, the issue becomes how to account for the delineated source area in the modeling analysis. The selection of an approach to include permitted stormwater sources in a modeling analysis for load calculation and allocation primarily depends on the available data and the importance or magnitude of the types of permitted stormwater sources. The two primary approaches include the following:

1. Including the permitted stormwater sources as discrete land units within the model—units that produce flows and loads separate from other watershed land areas and are hydrologically connected to the stream system
2. Calculating the load from the regulated stormwater source in a supplementary analysis using the model results of loads generated by watershed land uses

Which approach is used might depend on the significance of permitted stormwater sources to the impairment and the level of detail needed to characterize each source (e.g., evaluate as a whole vs. evaluate subareas within the regulated boundary). The first approach is most suitable for watersheds where stormwater sources are considered significant sources of impairment and sufficient data exist to define and isolate their regulated boundary, as well as discharge quality and quantity. The second approach can be used when regulated boundaries are not easily defined or because it is more important to evaluate the land use-specific effects on water quality rather than the effect of the cumulative contributions from a stormwater source (e.g., a regulated MS4) as a whole. For example, the regulated boundary of an MS4 might cover the majority of the watershed of the impaired waterbody. In such a case, it might be more efficient to set up the watershed model to evaluate the entire watershed area and the specific land uses or activities and then estimate and subtract the small portion that is delivered to the waterbody through nonpoint source runoff rather than the MS4. Both approaches are discussed in greater detail in the following sections.

4.3.1.1.1 Including Stormwater Sources as a Modeled Land Unit

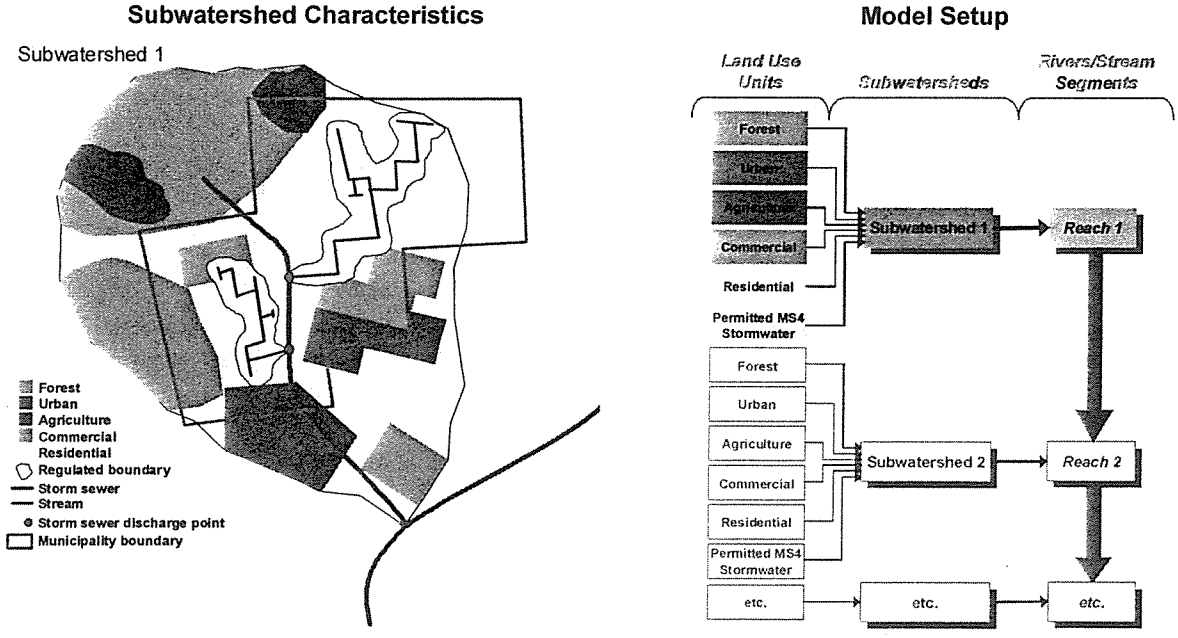
The most direct approach for calculating stormwater source allocations is to develop a watershed model including the regulated boundary. This means that the TMDL writer can isolate and represent the regulated area in the watershed model as a separate land unit—representing the area that produces stormwater runoff that is delivered to the receiving waterbody through the permittee's stormwater conveyance system. Using this approach, the model would internally calculate flow and pollutant loading separately for each stormwater source's area. For example, the TMDL writer could separate land covering each permitted industrial facility into individual land units to independently determine flow and contaminant contributions from each permitted industrial facility. The TMDL writer can use the same approach for construction sites (or areas expected to undergo construction) and areas covered by an MS4 permit.

> ***Tip: Modeling surface runoff vs. baseflow loads in MS4s***
>
> The use of watershed models allows a TMDL writer to estimate both surface runoff and baseflow loads from all sources, including MS4s. A strict reading of the MS4 definition would suggest that only groundwater that enters the stream by reemerging or infiltrating into the conveyance system should be covered by the MS4 permit, while groundwater that discharged directly to the stream would not be covered. However, in some situations groundwater discharge can be included within the WLAs because the entire watershed is within the MS4 boundary and much of the groundwater load (e.g., for bacteria) was assumed to derive from leaky sewer systems which are also covered by NPDES permit. In the case of fecal coliform and a watershed entirely within MS4 boundaries it is probably safe (and easier) to include all the load within the WLAs. For other parameters, however, it might not be so clear. For example, for TDS the natural geologic background in groundwater would be inappropriate to lump into the MS4 WLA.

Figure 17 illustrates this process for calculating the WLA for an MS4. The example assumes that the overlay of the storm sewer system is available, along with the corresponding areas that drain to that system for delivery to watershed streams (i.e., the regulated boundary), as shown in the *Subwatershed Characteristics* panel of the figure. Therefore, the TMDL writer can isolate areas drained by the system and include these areas in the model as discrete units. As shown in the *Model Setup* panel, the model then simulates flow and loads contributed by the discrete MS4 units within each subwatershed to the respective stream segment. Because of this setup, the TMDL writer can directly calculate WLAs within the model, similar to the approach for other simulated land units (e.g., urban, agriculture), as shown in the *Allocations based on Model Output* panel.

If the individual stormwater resources are represented in the model by their regulated boundaries, it will be necessary to characterize their land areas for simulation of runoff and loading. For example, when a watershed model is set up, the individual land use or other source areas are characterized by things such as soil type and characteristics (e.g., erodibility), perviousness, and measures of pollutant accumulation and generation. If available, monitoring data from the stormwater source should be used to characterize the source area and their associated runoff. If such data are not available, the areas included within the stormwater boundaries can be characterized in the same manner as other land uses. This is typically done by using GIS coverages such as land use, soil type, and topography to characterize the physical conditions of the land areas and site-specifc calculations or default values to represent pollutant accumulation for certain land use types.

The extent to which TMDL writers can use this approach of including stormwater sources as modeled land units depends primarily on the level of detail available geographically for each stormwater source, the data available to characterize pollutant generation and washoff from the source area and, in some cases, the capabilities of the watershed model.



Allocations based on Model Output

Sub.	Land Use	Allocated Load (kg/yr)
1	Forest	3.87
1	Urban	15.37
1	Agriculture	15.43
1	Commercial	3.6
1	Residential	29.16
1	MS4	29.57
1	Total	97
etc.	etc.	x

Figure 17. Process for calculating MS4 allocation when the MS4 drainage area is included in the model as a discrete land unit.

In Practice: Modeling Sediment Loads from Permitted Construction in the Potomac Direct Drains, West Virginia, TMDL (2008)

West Virginia's 2006 section 303(d) list includes 29 impaired streams in the 927-square-mile Potomac Direct Drains watershed in Berkeley and Jefferson counties. Many of the listed waters are biologically impaired on the basis of a narrative water quality criterion that prohibits the presence of wastes in state waters that cause or contribute to significant adverse effects on the chemical, physical, hydrologic, and biological components of aquatic ecosystems. SI analyses indicated sedimentation as a causative stressor in many of the streams, and sediment TMDLs were developed.

In recent years, the eastern panhandle of West Virginia has undergone significant development, with agricultural land and open space being converted to roads and housing subdivisions. The increased

construction activity is a potential source of sediment to the impaired waterbodies. At the time the TMDLs were developed, 297 construction sites encompassing 8,470 acres were registered, or had registrations pending, under the general permit.

The Mining Data Analysis System (MDAS) was used to represent the source-response linkage for sediment. Sediment TMDLs were developed using a reference watershed approach where MDAS was used to model sediment loading from a reference watershed. The reference loading rate was normalized for the Potomac Direct Drains watershed to establish the numeric TMDL target for sediment.

Sites subject to the Construction Stormwater General Permit were represented in the model using precipitation and runoff from the registered disturbed area and an assumption that proper installation and maintenance of required management practices would achieve an approximate 60 percent reduction of the sediment loading contributed by barren land. All registered sites and sites with registrations pending as of October 2006 were incorporated. All active registered sites and pending site registrations as of October 2006 were provided individual WLAs in the TMDL.

The Potomac Direct Drains TMDL reports are at www.wvdep.org/alt.cfm?asid=140.

4.3.1.1.2 Calculating Stormwater Source Loads Outside of the Model

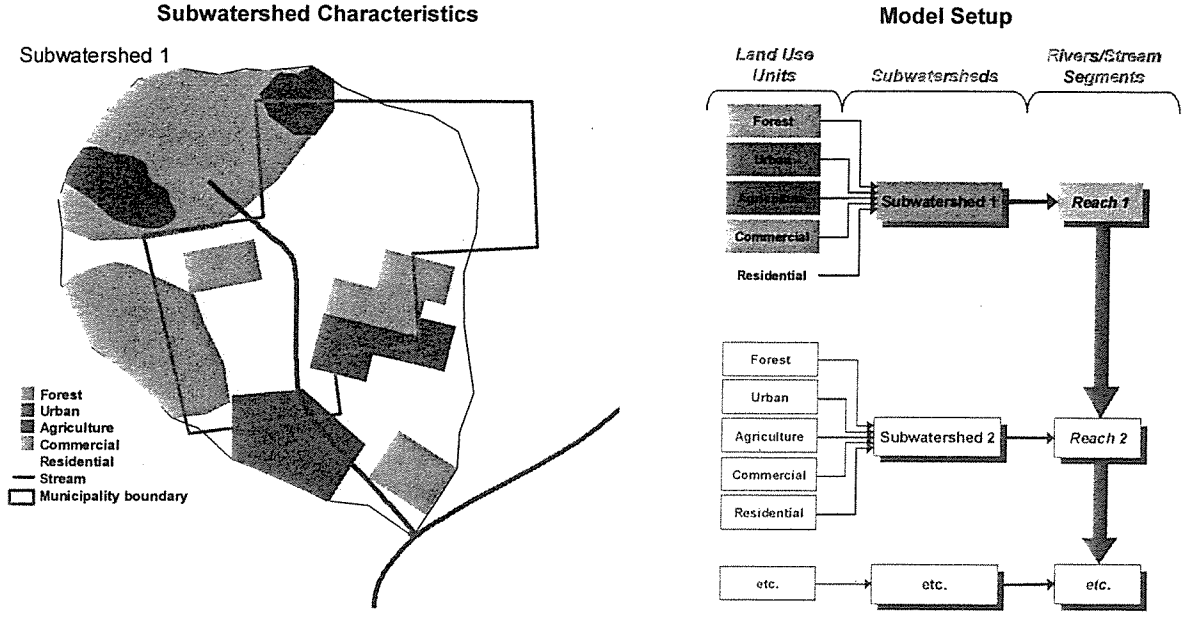
More commonly, the TMDL writer develops the watershed model based on typical land cover categories, without specifically including the regulated boundaries of stormwater sources. This is typically done because the boundaries of the area draining to the source's MS4 are not yet available or it is decided to focus on the land-use specific effects in more detail. In such situations, the TMDL writer will develop, calibrate, and apply the watershed model to TMDL development first, and then subsequently make allocations to permitted stormwater sources on the basis of their respective boundaries, whether represented by the regulated boundary or some alternative boundary (e.g, jurisdictional area) in the absence of the regulated boundary. The TMDL writer makes this allocation by overlaying the land cover represented in the model with applicable stormwater source area boundaries, such as the areas of an industrial facility exposed to stormwater runoff or the regulated MS4 boundary. The TMDL writer then determines the flow and pollutant load contribution associated with the various land cover categories that fall within the permitted stormwater source area boundary. This is often done by determining the unit area flow and pollutant loading for each land cover category on the basis of model results. The TMDL writer can then multiply the unit area rates by the corresponding area of the stormwater source that falls within that land cover category to calculate the portion of the land-use load that originates within the stormwater source boundary. To find the total load for the permitted stormwater source, the TMDL writer can then sum the land use-specific loads.

Figure 18 illustrates this type of process for calculating the WLA for an MS4 when the regulated boundary for the stormwater source is not included as a discrete area in the model. Unlike the example in Figure 17, the exact coverage of the storm system and the regulated boundary draining to the system has not yet been delineated by the permittee. Therefore, the model is set up to include only watershed land uses (see *Model Setup* panel in the figure), regardless of the MS4's boundary. The land-use loads are then used as the basis for calculating the load allocated to the MS4. This is done using an alternate boundary representing

Tip: Regulated Boundary vs. Jurisdictional Boundary

The most accurate way to represent a stormwater source's runoff and pollutant load contributions in a watershed model is to use the *regulated boundary*—the area actually generating and delivering runoff to the storm sewer system. However, many TMDLs represent the regulated stormwater source simply using the jurisdictional boundary (e.g., the municipal boundary for a small MS4) rather than the regulated boundary. As discussed in Chapter 3, the TMDL writer should work with the permitting authority to identify and obtain the regulated boundary to include in the modeling analysis or identify an appropriate alternative boundary if it does not exist.

the MS4 (e.g., jurisdictional boundary) rather than the actual area draining to the system. As shown in the *Allocations based on Model Output* panel of the figure, the areas of each land use that fall within the regulated MS4 boundary is calculated and multiplied by the loading rate for that land use. These loads are then totaled to calculate the total load attributed to the MS4.



Allocations based on Model Output

Sub.	Land Use	Modeled Load (kg/yr)	Area (acre)	Unit Area Loading (kg/acre/yr	MS4 Area in Land Use (acres)	MS4 Load (kg/yr)	Allocated Load (kg/yr)*
1	Forest	5	110	0.045	25	1.13	3.87
1	Urban	25	65	0.385	25	9.63	15.37
1	Agricultural	20	35	0.571	8	4.57	15.43
1	Commercial	12	40	0.300	28	8.40	3.6
1	Residential	35	120	0.292	20	5.84	29.16
1	MS4	-	106	-	-	-	29.57
1	Total	97	476	-	106	29.57	97
etc.	etc.	x	x	x	x	x	x

* Allocated load = modeled load – MS4 load

Figure 18. Process for calculating MS4 allocation when the specific stormwater drainage boundary is not included in the model and MS4 load is calculated based on percent of area within each modeled land use.

In Practice: Using watershed model-based approach for MS4 WLAs in the Christina River Basin

The Christina River Basin High-Flow Nutrient TMDL (www.epa.gov/reg3wapd/tmdl/pa_tmdl/ChristinaMeetingTMDL/index.htm), established by EPA in conjunction with Pennsylvania, Delaware, and Maryland, demonstrates the approach of calculating MS4 WLAs on the basis of watershed model output and jurisdictional boundary. TMDLs were determined for the Christina River and its tributaries using a watershed model (HSPF) combined with a receiving water model (Environmental Fluid Dynamics Code [EFDC]). The HSPF model represented contributions from 10 land cover categories: residential-septic, residential-sewer, agricultural-livestock, agricultural-rowcrop, agricultural-mushroom, open land, forested, wetlands/water, undesignated, and urban.

After determining the allowable nutrient load contributions from each land cover category for each subwatershed, the allowable loading was summarized for each township/municipality covered under the MS4 permit. To do this, the municipality boundary GIS layer was overlaid with the land use coverage. Nutrient loadings were then estimated for each land cover category within each municipality boundary within each of the modeled subwatersheds.

Because data were not readily available to determine stormwater outfall locations or to distinguish between areas within the municipalities that collected/conveyed stormwater and those that are truly nonpoint sources, the WLAs were based on jurisdictional boundaries. It was assumed that as part of the Phase II process more detailed stormwater information would be collected. This would enable the LA portion (i.e., that representing the truly nonpoint sources not delivered to receiving waters through stormwater collection/conveyance) to be extracted from the initial MS4 WLA allocations.

4.3.1.1.3 Modeling Specific Stormwater Conveyances and Discharges

Detailed stormwater conveyance models might be available in urbanized areas to support identification of allocations to regulated stormwater sources, particularly MS4 infrastructure. Stormwater models, often developed using the SWMM modeling framework, are implemented to support engineering design. They are generally capable of representing the effects of different storm events on flow throughout surface and subsurface components of a stormwater network. Thus, they are able to predict flow at individual stormwater discharge points to a receiving water.

It is possible to modify these models so that they also represent long-term conditions and contaminant loading. Employing this approach would provide the greatest level of detail for stormwater allocation in TMDLs (particularly for regulated MS4s and permitted industrial facilities and construction sites within regulated MS4 boundaries); however, it can be cost-prohibitive for TMDL development because of the time and effort needed to set up and calibrate a model at that level of detail. The number of outfalls to include could require the model be set up at a spatial level that is not supported by available data. For example, to include inputs from individual outfalls, it is necessary to have monitoring data to characterize the discharge from each outfall.

4.3.1.2. Impervious Cover Method

The IC method for stormwater TMDL development involves setting a target of percent IC for the watershed of the impaired waterbody to represent attainment of water quality standards. As discussed in Chapter 3, many areas affected by stormwater sources experience impairments due to the increase in the frequency and volume of surface runoff from impervious surfaces as well as the degraded quality of surface runoff. Therefore, the use of a target based on IC relates the amount of impervious surface to the resulting runoff volume and pollutant loading. This approach has been used in areas where waters are listed on the basis of biological impairment, and stormwater runoff has been determined to be the

primary cause of impairment. The approach should focus on effective imperviousness (i.e., a calculation of imperviousness that reflects the extent to which water falling on impervious areas is infiltrated, evapotranspired or reused) rather than total imperviousness. The target can represent the cumulative effects of both flow quantity and flow quality or the runoff and loading of a particular pollutant (e.g., metals, sediment, nutrients). The target should be used with available data to establish a link between IC, associated pollutant loading, and resulting waterbody conditions to calculate the loading capacity for the TMDL. Because the approach relies on a linkage between IC and the resulting runoff and waterbody effects, the approach is not be appropriate in areas where multiple sources other than urban runoff (e.g., wastewater treatment plant discharging nutrients) are affecting biological impairment.

In Practice: Using the Impervious Cover Method to Develop TMDLs in the State of Connecticut

To support TMDL development for waters impaired by stormwater, the state of Connecticut evaluated the relationship among IC and stream biological health to establish a statewide target using the surrogate measure of IC to represent attainment of water quality standards and support for aquatic life uses. The evaluation of statewide GIS-derived estimates of IC and macroinvertebrate data to identify a relationship among the parameters showed that measures of biological community (e.g., taxa richness) decreased with increasing IC. Using this analysis Connecticut Department of Environmental Protection established a target of 12 percent IC as representing maintenance of the state's aquatic life criteria.

4.3.1.3. Export Coefficients

Export coefficients are measures of typical loading rates from certain land uses or sources. In TMDLs they would typically be used to calculate existing loads on the basis of the land use distribution in a watershed and would often be combined with a supplementary approach that calculates an allowable load on the basis of in-stream targets (e.g., percent reduction). Export coefficients can be obtained from literature values from regional or national studies (e.g., EPA's NURP study [USEPA 1983]) or based on site-specific sampling of stormwater from individual land uses. The TMDL writer should evaluate the applicability of the coefficients to the watershed of the impaired waterbody and decide whether they are representative and appropriate. In addition, it is important to use the export coefficients in conjunction with some type of analysis of in-stream conditions to support calculation of a loading capacity.

4.3.1.4. Simple Method

The Simple Method calculates pollutant loading on the basis of stormwater runoff and typically is used in combination with another waterbody-based approach to support TMDL calculations to meet a waterbody target. For example, the Simple Method can be used to calculate the existing loading and then the percent reduction method would be applied to calculate the corresponding loading capacity. In other instances, the Simple Method equation can be applied to represent conditions assumed to meet water quality standards, such as using the applicable criteria as the allowable runoff pollutant concentration or using impervious targets to calculate the runoff and resulting loads. Regardless of how it is applied, the Simple Method will likely result in a gross pollutant load for the drainage area of an impaired waterbody. It would be necessary to distribute that load among the sources to set WLAs and LAs using such characteristics as land use areas

Resources: For more information on the Simple Method, refer to the Resources list at the end of this chapter in Section 4.5.3.

or jurisdictional areas. Alternatively, the Simple Method can be applied for delineated source areas to calculate loads from the different sources in the watershed.

In Practice: Using the Simple Method to Support Development of the Swamp Creek Fecal Coliform TMDL (2006)

Washington's Swamp Creek, north of Seattle, does not meet state water quality criteria for primary contact recreation due to high levels of fecal coliform bacteria. Data analysis using ambient monitoring and source inventories identified urban stormwater and nonpoint sources as the primary problem. The Washington State Department of Ecology developed a TMDL for Swamp Creek, including separate loading capacities for the wet season (October–April) and the dry season (May–September) to capture significant variations in in-stream concentrations and expected source loading. Daily dry-season and wet-season loading capacities were calculated at three points in the watershed by multiplying the average seasonal flows by the water quality criteria of 100 cfu/100 mL, representing the allowable 90th percentile concentration. To compare with the loading capacities and identify necessary load reductions, existing loads were estimated by multiplying the same season average flows by the observed 90th percentile bacteria concentration based on data collected at the respective station. The Simple Method was used to estimate the relative stormwater loading from each MS4 to assign WLAs to the multiple MS4s in the watershed. WLAs were then assigned on the basis of the total loading capacity and each MS4's proportional loading contribution at that station. Washington's Swamp Creek TMDL is at www.ecy.wa.gov/biblio/0610021.html.

4.3.2. Waterbody-based Approaches

Waterbody-based approaches rely on calculating an overall in-stream load, sometimes reflecting drainage areas with multiple sources. Therefore, it is necessary to use some supplementary analysis to distribute the calculated loading capacity among the identified sources, including permitted stormwater sources. To divide a cumulative load among watershed sources, it is necessary to gain a general understanding of the relative magnitude of the sources. The source characterization discussed in Chapter 3 should provide a TMDL writer with enough information to identify the sources of concern and at least generally delineate their location. The TMDL writer should be able to list the sources requiring LAs and WLAs and should know what data or information is available to characterize that source. For example, are there outfall or stormwater monitoring data for any of the stormwater sources? If so, such data (e.g., flow and concentration) can be evaluated and used to calculate a representative load attributed to the source. Or can the approach (e.g., load duration) be applied at a location that represents a drainage area from only one source? If so, the calculations at this point can be allocated to that individual source.

With any of the waterbody-based approaches, if stormwater source monitoring data are available, the TMDL writer should try to incorporate the data to most accurately represent the source inputs and calculate existing loads and subsequently distribute allowable loads. For example, storm event sampling can be used to estimate source loads, either through collecting data at major stormwater outfalls or through ambient monitoring at key locations representative of certain land use categories. However, monitoring data are not always available to characterize the discharge characteristics of individual sources. In such cases, common methods used to divide the total load into WLAs for stormwater include consideration of a stormwater source regulated area, jurisdictional area, land use, or IC:

- *Stormwater regulated boundary:* loading capacity is allocated to permitted stormwater sources (and other land-based sources) based on the proportion of the total drainage area they represent. For

example, if the loading capacity is 100 lbs/day and an MS4 conveyance system drains and transports runoff from 20 percent of the area draining to the assessment location, the MS4 WLA is specified as 20 lbs/day. To use this approach, it is necessary to be able to delineate the area draining to the source's stormwater conveyance system. Otherwise, an alternate estimate of the stormwater source's *drainage* area can be used, such as jurisdictional area. (For information on delineating the area of a stormwater source, see Chapter 3.)

- *Jurisdictional area:* loading capacity is allocated to permitted stormwater sources (and other land-based sources) on the basis of the portion of the drainage area included within their physical boundary. Without knowing the specific area draining to a stormwater conveyance system, the stormwater source area can be represented by the jurisdictional or operational area of the source (e.g., urbanized area for an MS4). For example, if the loading capacity is 100 lbs/day and the *urbanized area* of an MS4 represents 30 percent of the area draining to the assessment location, the MS4 WLA is specified as 30 lbs/day.
- *Land use:* loading capacity is allocated to permitted stormwater sources on the basis of expected land use unit area loads derived from literature values. For example, if the loading capacity is 100 lbs/day and an MS4 is estimated to contribute 25 percent of the load on the basis of the land uses within its boundary, the MS4 WLA is specified as 25 lbs/day.

> ***Resources:*** For more information on obtaining land use and coverage information, refer to the Resources list at the end of Chapter 3 in Sections 3.4.6 and 3.4.7.

- *IC:* loading capacity is allocated to permitted stormwater sources on the basis of the proportion of the drainage area they represent modified to reflect the amount of IC.

While the issue of how to distribute the cumulative loading capacity among sources is relevant to all the waterbody-based approaches, the following discussion identifies some issues and considerations specific to each approach.

4.3.2.1. Receiving Water Models

> ***Resources:*** For more information on selecting receiving water models based on needs for a given TMDL, refer to the Resources list at the end of this chapter in Section 4.5.4.

In some situations, the TMDL writer might use receiving water models alone to support TMDL development. Receiving water models differ from watershed models in that they only represent conditions within a receiving water, such as a stream or reservoir. Land-based contributions are typically addressed through designation of boundary conditions (which are often based on monitoring data) or through development of a separate watershed model. While these models provide many benefits for water column analysis, they pose limitations for stormwater allocation when applied independently from a land-based loading or watershed model. The inherent limitation is that they do not explicitly represent land-based sources (i.e., land units). This limitation is most pronounced when only limited geographical data are available for regulated MS4s, industrial facilities, and construction sites.

In situations where detailed geographic data are available, they can potentially provide a level of stormwater allocation commensurate with that of a watershed model application. Receiving water models are robust in their ability to provide a high level of detail laterally, vertically, and longitudinally. They can represent a stream, lake, or estuary using numerous analytical elements—in some cases tens of thousands. Thus, model predictions can be very accurate at many locations along the length of a receiving water. With this capability, receiving water models can be used to most accurately determine

the specific amount of a pollutant that can enter a receiving water at different locations while still attaining and maintaining water quality criteria throughout. Thus, allocations can potentially be made at the very detailed stormwater discharge level. This assumes that very detailed stormwater discharge location (i.e., outfall) and contribution (flow and contaminant levels) are available to support the receiving water analysis. Without this level of detail, a receiving water model is limited.

In practice, TMDLs employing receiving water models often also employ a watershed model to support source-based allocations, including those to regulated stormwater sources.

4.3.2.2. Load Duration Approach

TMDLs developed using the load duration approach most often identify the portion of the loading capacity for the stormwater WLA(s) on the basis of jurisdictional area. However, because the duration curve framework establishes a series of individual flow-variable loading capacities, the portion of each loading capacity attributed to individual sources typically will also vary by flow. Figure 19 illustrates a TMDL that was developed using a duration curve framework. WLAs are specified for municipal treatment plants that reflect NPDES permit limits. In the case of Figure 19, these WLAs are based on technology-based effluent limits at facility design flows. The treatment plant WLAs are constant across all flow conditions and ensure that water quality standards will be attained. WLAs are also identified for MS4s, which reflect increased loads under higher flow conditions. In the Figure 19 example, stormwater WLAs for MS4 communities are based on the percent jurisdictional area approach. In this case, 3 percent of the watershed falls within the jurisdiction of MS4 communities. Thus, the MS4 WLA is 3 percent of the available allocation for each flow zone. The remaining 97 percent is designated for nonpoint sources and natural background as the LA for each zone.

Resources: For more information on the load duration approach, refer to the Resources list at the end of this chapter in Section 4.5.5.

Because a load duration curve establishes a flow-variable loading capacity, the framework allows for source-specific allocations to be adjusted by flow zone. To target loading controls and put the load duration results in a more *digestible* format, the load duration curve is usually divided into different flow zones representing different conditions (e.g., low flow, high flow). Representative existing loads and allowable loads can then be identified for each of those intervals. Because some sources tend to produce pollutant loads and affect the stream under certain flow conditions, this can help to distribute the allowable load among expected sources specific to a flow zone. This can account for different source areas and delivery mechanisms that might dominate under different flow conditions. For example, some TMDLs developed using the load duration approach allocate WLAs to stormwater sources for only certain flow zones (e.g., a WLA of zero is specified for the low-flow zone under the assumption that no load is generated from this source during those periods; see Table 10 for example). During the characterization activity discussed in Chapter 3, the TMDL writer should have an understanding of the types of stormwater sources and under what conditions they are affecting the stream. Within the load duration framework, allocations within the TMDL can be set in a way that reflects dominant concerns associated with appropriate hydrologic conditions.

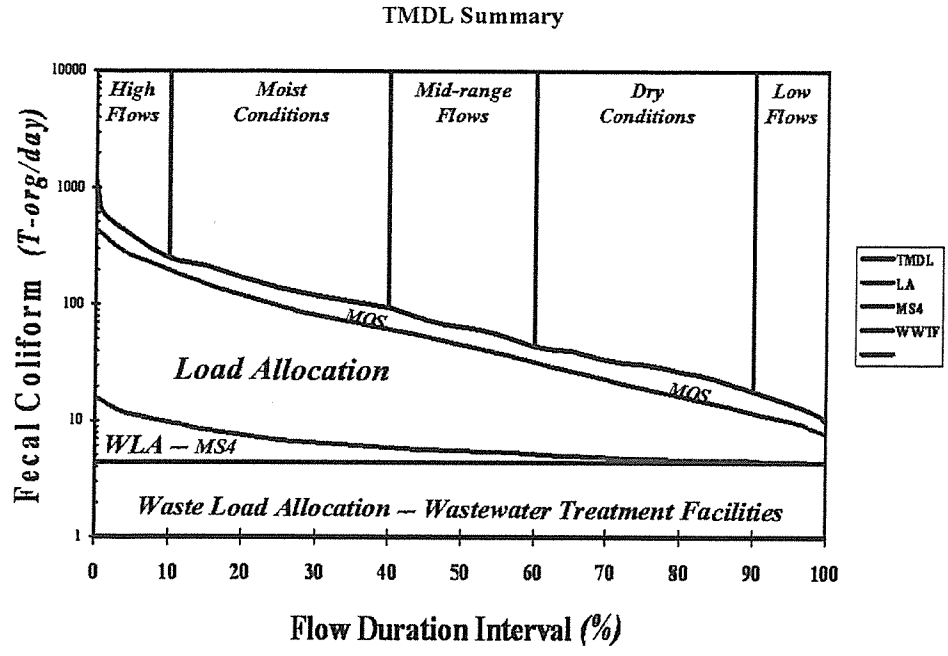


Figure 19. Example TMDL using duration curve framework

Table 10. Example summary of allocations calculated for a TMDL using the load duration framework

Name	TMDL Component	Duration Curve Zone (Phosphorus expressed as pounds/day)				
Redrock River—Phosphorus		High	Moist	Mid	Dry	Low
	TMDL	19.93	10.84	8.53	6.53	3.44
	MOS	5.63	1.47	0.72	0.57	0.43
	LA	11.79	7.62	6.28	4.72	2.59
Douglton (WWTP)	WLA	0.38	0.38	0.38	0.38	0.38
Guilaine (Industrial)	WLA	0.04	0.04	0.04	0.04	0.04
Douglton (MS4 / Phase 1)	WLA	1.39	0.89	0.74	0.55	0.00
Westerbridge (MS4 / Phase 2)	WLA	0.49	0.31	0.26	0.19	0.00
Thompath (MS4 / Phase 2)	WLA	0.21	0.13	0.11	0.08	0.00
Stormwater Source Areas of Concern		CSOs				
		Riparian Areas				
		Impervious Surfaces				
				Illicit Discharges		

4.3.2.3. Percent Reduction Method

The Percent Reduction method typically involves comparing ambient water quality data to applicable water quality criteria to identify a necessary percent reduction in observed concentrations to meet WQS. That percent reduction is then applied to an *existing* load to calculate the loading capacity. Depending on how the existing loads were calculated, that analysis can help to support distributing the loading capacity among the sources and identifying any stormwater WLAs. For example, if the existing load is based on export coefficients or literature values for watershed land uses or sources, the TMDL writer will already

have calculated the source-specific existing loads and can target percent reductions to individual sources to meet the overall loading capacity goal. If the existing load did not include specific calculation for stormwater sources, it will be necessary to use one of the approaches discussed previously to distribute the loading capacity (e.g., source drainage area, jurisdictional area) into LAs and WLAs.

4.3.2.4. Mass Balance or Steady-State Analysis

Like the Percent Reduction method, applying a mass balance or steady-state analysis to calculate a loading capacity relies on some calculation of the incoming existing pollutant load. This might be done by *back-calculating* an existing load on the basis of observed concentrations and stream flow (or volume for lakes and reservoirs) and accounting for any expected losses (e.g., die-off, settling). If this is the case, the existing load represents a cumulative load from all the sources contributing to the pollutant of concern. If there are no data available to directly calculate loads from individual sources, the most likely approach for distributing the loading capacity and identifying stormwater WLAs will be to use some measure of source area (e.g., jurisdiction, drainage area) as discussed previously. Another option for calculating the existing load for a mass-balance analysis is the use of export coefficients. Similar to the Percent Reduction method, this would produce source-specific existing loads that could be multiplied by an estimated load reduction to calculate LAs and WLAs that meet the overall loading capacity.

4.4. Categorizing WLAs for Stormwater Sources

This section provides a description of the various ways that TMDL writers can categorize and assign WLAs to permitted stormwater sources. The manner in which TMDL writers choose to calculate the WLAs for permitted stormwater sources can vary depending on data availability and quality, stormwater source characteristics, and permit implementation considerations. Four basic options for categorizing stormwater source WLAs include the following:

1. Aggregated for all stormwater sources (i.e., one overall WLA that represents total allocation to all MS4s, construction activities, and industrial facilities)
2. Aggregated by each type of stormwater source (i.e., one WLA for all permitted MS4s; one WLA for all permitted construction activities; one WLA for all permitted industrial facilities)
3. Individual by each stormwater source
4. Individual by each outfall

It is important to note that the four categories listed above are just basic options for presenting allocations within the TMDL. They do not represent all possibilities. TMDL writers can consider using one or more of these options in concert within a TMDL for various types of stormwater sources. In addition, TMDL writers can further refine these basic options using spatial and temporal considerations to make the allocations more meaningful to stormwater sources. For example, a TMDL writer could present individual or aggregated WLAs for sources by subwatershed or by land cover category. If the WLA has temporal variations, a TMDL writer could further refine the WLAs by flow conditions (i.e., wet versus dry), months, or seasons.

> ***Tip: Refining allocations using spatial and temporal considerations***
>
> TMDL writers can consider further refining any of the four basic categories of stormwater source WLAs using spatial and temporal considerations. Spatial considerations can include jurisdictional boundary, subwatershed boundary, or land cover. Temporal considerations can include wet seasons versus dry condition (based on flow), seasonally, or monthly.

WLAs that reflect the way that stormwater sources implement their respective SWMPs and SWPPPs are likely to be more *user-friendly* than WLAs that do not closely align with how stormwater sources manage their programs and plans. The more detailed and refined the allocation, the easier it will be for permit writers to translate through the permit and for stormwater sources to implement through by complying with permit requirements. The goal is to ultimately develop WLAs that are accurate, equitable, and implementable.

The details of each basic categorization option are discussed below. Table 11 summarizes advantages and disadvantages associated with the four basic options for categorizing and assigning WLAs to stormwater sources. Where available, examples illustrate how states and EPA have used each categorization approach. The Appendix of this Handbook contains additional examples of categorization approaches for WLAs.

Table 11. Options for assigning WLAs to stormwater sources

Option	Advantages	Disadvantages
Single Aggregated WLA for All Permitted Stormwater Sources *Example: Lake Champlain (Vermont) Phosphorus TMDL (2002)*	▪ Requires fewer permitted stormwater source characterization data to calculate ▪ Requires fewer resources to calculate ▪ Allows use of less complex WLA development approaches ▪ Allows permitted stormwater sources to determine at the local level how to further subdivide the overall allocation without specific commitments that could translate into permit requirements ▪	▪ More difficult to implement in permits ▪ Requires permit writers or sources to conduct further analyses to disaggregate the overall WLA to individual sources ▪ Potentially overlooks pollutant load contributions from all types of permitted stormwater sources throughout the watershed ▪ Does not promote individual permitted stormwater source accountability for pollutant load reductions to implement the WLA ▪ More potential to capture unpermitted stormwater sources (i.e., urban nonpoint source runoff) in the aggregated WLA
Separate Aggregated WLA for Types of Permitted Stormwater Sources *Examples:* ▪ *Potomac Direct Drain (West Virginia) Sediment TMDL* ▪ *Charles River (Massachusetts) Pathogen TMDL* ▪ *Shingle Creek (Minnesota) Chloride TMDL* ▪ *Columbia Slough (Oregon) TMDLs*	▪ Requires less permitted stormwater source characterization data to calculate but allows for specificity within each category of permitted stormwater sources ▪ Requires fewer resources to calculate ▪ Allows use of less complex WLA development approaches ▪ Allows permitted stormwater sources within a specific category to determine at the local level how to further subdivide the overall allocation without specific commitments that could translate into stormwater permit requirements ▪	▪ Does not result in equitable and easy-to-understand (i.e., implementable) WLAs for permit writers or stormwater sources ▪ Requires permit writers or stormwater sources to conduct further analyses to identify sources that will implement the WLA ▪ Does not promote individual permitted stormwater source accountability for pollutant load reductions to implement the overall WLA ▪ Potential for double-counting pollutant load reductions where categories of stormwater sources might overlap (e.g., MS4s with permitted construction activities that a TMDL writer could assign under the aggregated MS4 WLA or under the aggregated construction WLA

Option	Advantages	Disadvantages
WLAs to Each Individual Stormwater Source *Examples:* ▪ *Columbia Slough (Oregon) Lead TMDLs* ▪ *Wissahickon Creek (Pennsylvania) Siltation TMDL* ▪ *Swamp Creek (Washington) Pathogen TMDL* ▪ *Potomac Direct Drain (West Virginia) Sediment TMDL*	▪ Promotes transparency and accountability in TMDL implementation ▪ Provides permit writers enough information to include reasonable provisions in relevant permit(s) ▪ Allows permitted stormwater source to understand specific pollutant load reduction responsibility and take steps to analyze overall SWMP or SWPPP to achieve reduction ▪ Promotes following regulatory boundaries (e.g., regulated MS4 boundary) that are familiar to permitted stormwater sources and used to develop and implement SWMPs and SWPPPs	▪ Has the potential to add time to the overall TMDL development process if each permitted stormwater source has concerns related to the separate WLA assigned to its respective regulated MS4, industrial facility, or construction site ▪ Requires data and information specific to each permitted stormwater source, depending on the WLA development approach selected by TMDL writers (e.g., specific regulatory boundaries for each permitted stormwater source)
Individual WLAs on an Outfall Basis *Example: Middle Rio Grande (New Mexico) Fecal Coliform TMDL (2002)*	▪ Provides permit writers with detailed information to develop tailored permit provisions, particularly for individual permits ▪ Allows stormwater sources to target implementation efforts to address a specific area represented by a stormwater discharge from a specific outfall	▪ Requires data and information pertinent to each outfall addressed by the TMDL analysis ▪ Requires comprehensive spatial understanding of a permitted stormwater source area, including a detailed system map with location of all outfalls, and surrounding land uses ▪ Might not be feasible in watersheds with a large number of permitted stormwater sources, particularly permitted MS4s that might have a large number of outfalls draining the system ▪ Does not align with how many permitted stormwater sources approach SWMP and SWPPP implementation (i.e., focus on systemwide approach as opposed to an outfall-by-outfall approach)

4.4.1. Single Aggregated WLA for All Stormwater Sources

When data and resources to develop a refined characterization of sources are extremely limited, the ability of TMDL writers to analyze and identify the pollutant load contributions from each type of source is also limited. As a result, the TMDL writer might opt to group all stormwater sources into one category and assign one all allocation to all stormwater sources in this generalized category.

Although this approach alleviates some technical complexities for TMDL writers, the lack of specificity associated with this approach can result in a lack of transparency and accountability that can create implementation challenges for permit writers and sources. TMDL writers can mitigate some of the challenges by considering and addressing them at the outset of WLA development. To ensure that the single aggregated WLA promotes transparency and accountability, it is essential to generate a comprehensive inventory of all permitted stormwater sources represented under the single WLA as a means to help (1) stakeholders and EPA reviewers ensure that the WLA considers all relevant stormwater sources in the watershed boundary (2) permit writers to incorporate reasonable and clear provisons into the relevant permit(s), and (3) stormwater sources understand who has a responsibility to help conduct implementation activities to implement the WLA. As discussed in Chapter 3, Characterizing Impairments and Stormwater Sources, it is important that the TMDL writer has a comprehensive understanding of the type, number, and location of stormwater sources within the watershed boundary. The TMDL document should clearly identify all stormwater sources addressed by

the single aggregated WLA. As with all WLAs, the TMDL writer should also document other assumptions used to generate the single aggregated WLA. Assumptions might include the following:

- The analysis used municipal jurisdictional boundary versus the actual MS4 boundary that defines the permitted area
- The analysis assumes that all construction sites within the boundary selected to represent the MS4 (i.e., jurisdictional boundary or actual MS4 boundary) are the responsibility of regulated MS4s and fall under the MS4 allocation, not a separate construction allocation

Tips for Using a Single Aggregated WLA for All Permitted Stormwater Sources

- Create a comprehensive inventory of all permitted stormwater sources within the watershed boundary and document this inventory in the WLA assumptions
- Indicate which permitted stormwater sources are part of the single aggregated WLA and provide rationale
- Consider providing guidance to permitted stormwater sources on ways to further sub-allocate the single aggregated WLA to promote equity and accountability in implementation strategies and approaches
- Provide rationale for using this approach versus other approaches that assign WLAs to more narrowly defined categories (e.g., limited available data, limited TMDL development resources, desire to promote flexibility)
- Highlight any plans to revisit and revise the single aggregated WLA based on future data availability

Under this approach, permit writers or stormwater sources captured in the single aggregated WLA likely will need to conduct further analyses to make sub-allocations to each source; therefore, it is important that the TMDL document clearly identifies which stormwater sources are included in the single aggregated WLA. While it is possible to use single aggregated WLAs for stormwater sources in TMDLs, this approach is not preferred because of the associated implementation challenges. To avoid using this approach, TMDL writers can work with permit writers and stormwater sources to collect the additional data necessary to disaggregate allocations and assign to specific types of stormwater sources or, ideally, individual sources.

4.4.2. Separate Aggregated WLA for Each Type of Permitted Stormwater Source

This approach is an option for the TMDL writer to consider when the data are available to identify and separate the general pollutant load contributions from each type of permitted stormwater source, but source-specific information is not available to support accurate individual source allocations. For example, the TMDL writer might have a complete inventory of industrial facilities within the watershed boundary compiled from data obtained from a Phase I MS4 required to maintain an inventory of regulated industrial facilities (for permitted industrial facilities within the regulated MS4 boundary) and from a state or EPA Regional Office database of industrial facilities covered by individual or general industrial stormwater permits (for permitted industrial facilities outside the regulated MS4 boundary but within the watershed boundary). Although the TMDL writer has compiled a comprehensive inventory of the location and number of permitted industrial facilities, more information would be necessary on facility-specific processes and practices to estimate the pollutant load contribution from each facility. In such a case, the TMDL writer can use a general set of assumptions about the inventory of industrial facilities, such as the aggregate land area occupied by all industrial facilities and the location of these facilities within the watershed boundary (to determine soil type, perviousness, proximity to receiving waterbody) to calculate an aggregated.

Tips for Using Separate Aggregated WLA for Each Type of Permitted Stormwater Source

- Create a comprehensive inventory of all permitted stormwater sources within the watershed boundary under each category of stormwater sources and document this inventory by category in the WLA assumptions
- Indicate which permitted stormwater sources are included under each permitted stormwater source category of the separate aggregated WLA for each category and provide decision criteria to ensure consistency and clarity (e.g., all separately permitted construction sites in and outside regulated MS4 boundaries should be represented in the aggregated construction WLA; all separately permitted industrial facilities in and outside of regulated MS4 boundaries should be represented in the aggregated industrial WLA; only stormwater discharges from within the regulated MS4 boundary should be represented in the aggregated MS4 WLA)
- Provide guidance to permitted stormwater sources on ways to further sub-allocate the separate aggregated WLA for each stormwater source category to promote equity and accountability in implementation strategies and approaches
- Provide rationale for using this approach versus other approaches that assign WLAs to more narrowly defined categories (e.g., limited available data, limited TMDL development resources, desire to promote flexibility for purposes of implementation)
- Highlight any plans to revisit and revise the separate aggregated WLAs for each stormwater source category and under what circumstances (e.g., availability of better data or additional resources)

In Practice: Approaches and Rationale for Developing and Assigning Separate Aggregated WLAs for Specific Types of Stormwater Sources in West Virginia, Massachusetts, Minnesota, and Oregon

TMDL writers might decide to develop and assign separate aggregated WLAs for specific categories of stormwater sources based on a variety of factors, such as data availability, links to other TMDLs, or implementation considerations. Three TMDLs that assign separate aggregated WLAs for categories of stormwater sources include the Potomac Direct Drain (West Virginia) Sediment TMDL, the Charles River (Massachusetts) Pathogen TMDL, and Shingle Creek (Minnesota) Chloride TMDL. A brief description of the approach and rationale for developing and assigning stormwater source WLAs under each TMDL is provided below.

Potomac Direct Drain (West Virginia) Sediment TMDL (www.wvdep.org/alt.cfm?asid=140)

This TMDL addresses construction activities in tributaries of the Potomac River in Berkeley and Jefferson counties, West Virginia. The TMDL provides allocations for 297 active and pending construction sites registered under the West Virginia CGP. The main TMDL report provides an aggregated WLA for construction activities by subwatershed. In addition, the TMDL's appendices provide individual WLAs for each impending and active construction site.

Charles River (Massachusetts) Pathogen TMDL (www.mass.gov/dep/water/resources/tmdls.htm#charles)

According to the final TMDL, all 35 communities in the Charles River watershed have stormwater permit coverage under the Phase I and Phase II MS4 Stormwater program (34 are covered under Phase II, and one is covered under Phase I). The TMDL addresses stormwater runoff from Phase I and Phase II as a pathogen source and assigns two WLAs toall MS4s—one for each type of surface water classification—as daily concentration targets. In addition, the TMDL expresses WLAs for stormwater as a daily load (i.e., colonies/day) using flow data from the fraction of the watershed that has IC; areas with pervious cover are considered nonpoint source runoff and accounted for under the LA. WLAs expressed as daily loads for stormwater runoff from Phase I and Phase II also includes contributions from combined sewer overflows and are presented on a segment-by-segment basis.

Shingle Creek (Minnesota) Chloride TMDL (www.pca.state.mn.us/water/tmdl/project-shinglecreek-chloride.html)

The Shingle Creek Chloride TMDL addresses chloride contributions from road deicing activities by nine municipalities, one county, and the Minnesota Department of Transportation that have road maintenance

responsibilities within the Shingle Creek watershed. All these entities are MS4s. Under this TMDL, the MS4s received one aggregated WLA in the form of a percent reduction. (It is important to note that the WLA also addressed road salt storage facilities, private application, and residential chloride sources.) These permitted stormwater sources worked together through the Shingle Creek Watershed Commission to develop an implementation plan to meet the overall percent reduction target. The approach of assigning a single aggregated WLA for permitted stormwater sources in the regulated MS4 category allowed for a more flexible approach to implementation. Per the Shingle Creek Chloride Implementation Plan, working collectively to achieve the overall percent chloride load reduction allowed the entities with permitted MS4s to allocate load reductions to meet the percent reduction target on the basis of unique factors such as financial constraints, feasibility limitations, and public concerns and perceptions.

Columbia Slough (Oregon) TMDLs
(www.deq.state.or.us/wq/TMDLs/docs/willamettebasin/columbiaslough/tmdl.pdf)

The TMDLs developed for the Columbia Slough include WLAs for industrial facilities and MS4s to address numerous parameters including dissolved oxygen, phosphorus, bacteria, and lead. To address the pollutant load reductions needed from stormwater sources, the TMDLs for 5-day biochemical oxygen demand (BOD_5) and lead group together the two MS4s in the Columbia Slough basin into an MS4 category and the industrial facilities with permitted stormwater discharges into an industrial category.

4.4.3. Individual WLAs for Each Permitted Stormwater Source

TMDL writers can develop and assign WLAs for each stormwater source within the impaired waterbody's watershed boundary. Although this approach might require additional data, it can facilitiate the implementation of permits and is ideal for permitted stormwater sources that want to know their specific pollutant load reduction responsibility without the need for negotiating with other permitted stormwater sources to further allocate pollutant load reductions. In some instances, depending on data availability, TMDL writers might have the ability to assign individual WLAs to specific permitted stormwater sources under a category of permitted stormwater sources (e.g., each MS4, each industrial facility), but might find that data limitations require the use of aggregated WLAs for other permitted stormwater sources (e.g., all active construction sites). This approach has the potential to allow each permitted stormwater source, and other interested stakeholders, to more closely review and analyze the technical approach for WLA development, including the specific assumptions used to generate the individual WLA. It also provides more of a direct nexus between the WLA and stormwater permit requirements that must contain conditions consistent with the requirements and assumptions of the WLA, thus promoting more accountability and a more clearly defined expectation with regards to implementation. Individual WLAs also provide a foundation for transparent and accountable watershed-based trading because each permittee has its own WLA (which is enforceable through a permit), and the WLAs are available to all potential trading partners to review.

Tips for Using WLAs Assigned to Each Permitted Stormwater Source

- Provide clear description of assumptions and information used to calculate the WLA for each permitted stormwater source
- Ensure that permitted stormwater sources listed in the TMDL source characterization links to the list of permitted stormwater sources assigned a WLA to ensure transparency and equity
- Provide information on estimated baseline pollutant load contributions from each permitted stormwater source to help sources understand the required pollutant load reduction
- Consider additional methods for presenting the WLA that will support implementation based on understanding of existing SWMP and SWPPP approaches (e.g., breaking down total WLA for each permitted stormwater source on a subwatershed basis)

In Practice: Approaches and Rationale for Developing and Assigning Separate WLAs for Individual Stormwater Sources in Oregon, Pennsylvania, Washington, and West Virginia

Columbia Slough (Oregon) TMDLs
(www.deq.state.or.us/wq/TMDLs/docs/willamettebasin/columbiaslough/tmdl.pdf)

The lead TMDL developed for the Columbia Slough includes an aggregated WLA for the industrial permitted area and provides an approach for these industrial facilities to calculate their individual allocation. The approach involves calculating individual industrial facility allocations on a unit-area basis for each flow condition. While the TMDL does not contain specific individual WLAs for each industrial facility, the TMDL provides the equation necessary for each facility to calculate the load specific to its site.

Wissahickon Creek (Pennsylvania) Siltation TMDL
(www.epa.gov/reg3wapd/tmdl/pa_tmdl/wissahickon/index.htm)

This TMDL calculated WLAs for 16 permitted MS4s (defined by municipal boundaries, as opposed to regulated MS4 boundaries, for purposes of this TMDL) using land-use-specific, unit-area loads determined in modeling analysis for specific regions of the Wissahickon Creek basin, as well as the streambank erosion within each municipality. TMDL writers divided the Wissahickon Creek watershed into five main subwatersheds to match the impaired watershed with the smaller reference watershed used in the analysis. Sediment loads were estimated for each of the five subwatersheds and then distributed among municipalities as MS4 stormwater WLAs for each individual 303(d)-listed watershed. The WLA assigned to each of the 16 permitted MS4s accounted for both overland flow and streambank erosion. The final TMDL report presented a summary table that presented the existing load, the WLA, and the associated percent reduction to implement the WLA for both overland flow and streambank erosion, as well as the total WLA, for each permitted MS4. Appendix G of the final TMDL report also presents this information for each permitted MS4 on a subwatershed basis, allowing permitted MS4s to see and understand WLA information in both formats.

Swamp Creek (Washington) Pathogen TMDL (www.ecy.wa.gov/biblio/0610021.html)

This TMDL estimated the relative bacteria loading from each MS4 permit holder (i.e., the permit holder's jurisdictional boundary, not necessarily the loading from the actual MS4 boundary) using the Simple Method and assigned WLAs to MS4s at each water quality monitoring station on the basis of their proportional contribution at that station and the bacteria criterion needing the greatest reduction. Each MS4 is required to achieve a percent reduction of the loading capacity at each TMDL compliance point according to the estimated contribution from the MS4 permit holder.

Potomac Direct Drain (West Virginia) Sediment TMDL (www.wvdep.org/alt.cfm?asid=140)

Although the main body of the TMDL report provides an aggregated WLA for construction sites, the TMDL's appendices provide individual WLAs for each impending and active construction site. The individual WLAs are provided on a subwatershed basis. This TMDL covers approximately 297 active and pending construction sites registered under the West Virginia CGP in tributaries of the Potomac River within Berkeley and Jefferson counties, West Virginia.

4.4.4. Individual WLAs on an Outfall Basis

Stormwater permits require permitted stormwater sources to develop maps of regulated MS4s, industrial facilities, and construction sites that include locations of stormwater outfalls. Permitted stormwater sources are required to map the location of stormwater outfalls, and with increasing frequency, this information is available. It is still possible that some stormwater sources might not have the information necessary to develop and assign WLAs on an outfall-by-outfall basis. However, for those stormwater sources that do have adequate data, TMDL writers can consider the feasibility and benefits of assigning individual WLAs to specific outfalls. For example, if a TMDL addresses pathogens during dry-weather flow from a high-priority area within the boundary of a regulated MS4 (i.e., the system boundary), an individual WLA for specific outfalls within the high-priority area could be more useful in terms of supporting implementation than a WLA assigned to the entire MS4.

Tips for Using Individual WLAs on an Outfall Basis

- Use where information about the permitted stormwater source and watershed conditions indicate that an outfall approach is not only feasible, but would be supported through SWMP and SWPPP implementation (e.g., few known outfalls that allow permitted stormwater sources to isolate and track implementation activities associated with changes in discharge pollutant loads at each outfall)
- Ensure that permitted stormwater source has up-to-date information about outfall locations
- Ensure that an outfall-by-outfall approach is feasible for the TMDL development process
- Ensure that effectiveness monitoring is required in relevant permits, as appropriate, on an outfall-by-outfall basis

In Practice: Developing and Assigning WLAs to Individual Outfalls Under the Middle Rio Grande, New Mexico, Fecal Coliform TMDL (2002)

The Middle Rio Grande fecal coliform TMDL established that stormwater conveyances are the primary sources of fecal coliform loading to the Middle Rio Grande. Specifically, the TMDL report identifies four discrete concrete transports of stormwater contributing to fecal coliform loads and assigns a WLA to these four conveyances. The city of Albuquerque is responsible for implementing the WLAs assigned to these four stormwater conveyances through its MS4 SWMP. The TMDL is at www.nmenv.state.nm.us/SWQB/Middle_Rio_Grande-Fecal_Coliform_TMDL-May2002.pdf

In Practice: Using Multiple Approaches to Categorize Stormwater Source WLAs in the Los Angeles River Metals TMDL (2007)

The Los Angeles River Metals TMDL categorizes stormwater source WLAs using a variety of options to help permitted stormwater sources meet both dry-weather and wet-weather targets for cadmium, copper, lead, zinc, and selenium in impaired reaches of and tributaries to the Los Angeles River.

For dry weather, the TMDL provides single aggregated WLAs for all permitted stormwater sources on a subwatershed basis for three pollutants—copper, lead, and zinc. The permitted stormwater sources included in the single aggregated dry-weather WLAs include Los Angeles County MS4, Long Beach MS4, Caltrans, industrial facilities subject to the general industrial stormwater permit, and construction activities subject to the CGP. However, per the TMDL, industrial facilities and construction activities received a WLA of zero for dry weather, so only those entities subject to MS4 permit requirements share the single aggregated dry-weather WLAs for copper, lead, and zinc in the six reaches of the Los Angeles River and the seven tributaries.

For wet weather, the TMDL presents single aggregated WLAs for cadmium, copper, lead, and zinc that apply to all reaches and tributaries. In addition to providing single aggregated WLAs for each of these pollutants, the TMDL breaks down the overall WLAs into different stormwater source categories "by their percent area of the portion of the watershed served by storm drains." Under this approach, the TMDL assigns separate aggregated WLAs to MS4s (i.e., Los Angeles County and Long Beach MS4s), Caltrans, industrial facilities covered by the industrial general permit, and construction sites covered by the CGP. In addition to separate aggregated WLAs, the TMDL states that each permitted industrial facility and construction site will receive individual WLAs per acre on the basis of the total acres of their facility.

The TMDL is available at www.swrcb.ca.gov/rwqcb4/water_issues/programs/tmdl/tmdl_list.shtml.

4.4.5. Other Elements in a TMDL

> ***Resources:*** For more information on the required elements of a TMDL, refer to the Resources list at the end of this chapter in Section 4.5.7.

Regulation and guidance require that all TMDLs include minimum elements. In addition to the elements already discussed in previous chapters (water quality standards, loading capacity, WLAs, LAs), a TMDL must also include a MOS, seasonal variation, and daily loads, In addition EPA recommends that TMDLs include allocations for future growth and reasonable assurance. The process or decisions related to including these elements in a TMDL might not vary when stormwater sources are involved. However, TMDL writers should consider how these other minimum elements might change when addressing stormwater sources in the analysis. Summarized below is each additional minimum element and, where appropriate, the stormwater-specific considerations related to the minimum element.

- **MOS.** MOS must be included in a TMDL to account for any lack of knowledge concerning the relationship between allocations and water quality. The MOS may be implicit, incorporated into the TMDL through conservative assumptions in the analysis, or explicit, expressed in the TMDL as loadings set aside for the MOS.
- **Seasonal Variation.** TMDLs must be developed with a consideration of seasonal variation in the analysis. As discussed in Section 4.3, TMDLs addressing stormwater sources are likely to have seasonal variations related to wet and dry seasons included in the analysis.
- **Reasonable Assurance.** For TMDLs developed for waters affected by a mix of point sources and nonpoint sources, the TMDL should include reasonable assurance that nonpoint source control measures can achieve expected load reductions. TMDLs addressing stormwater sources often use this element to describe the NPDES permit requirements that apply to MS4s, industrial facilities, and construction activities included in the analysis.
- **Future Growth.** TMDLs can also include allocations for future nonpoint and point sources, acting as a reserve for future sources. This minimum element is particularly important to stormwater sources that are intermittent. For example, construction activities might obtain permit coverage and commence after developing a TMDL or an industrial facility might no longer certify to a condition of no exposure and require permit coverage. These types of stormwater sources would need to implement WLAs from the future growth allocation.
- **Daily Load.** TMDLs should include allocations expressed in terms of daily time increments. In addition, TMDL submissions can include alternative, non-daily pollutant load expressions (e.g., monthly, annual) to facilitate implementation of the applicable water quality standards.

TMDL writers should consider how to include these minimum elements early in the TMDL development process and evaluate them in context of the major sources, critical conditions, and the chosen TMDL development approach.

4.5. Resources

4.5.1. General TMDL Development

1. USEPA (U.S. Environmental Protection Agency). 1991. *Guidance for Water-Quality-based Decisions: The TMDL Process*. EPA 440/4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/OWOW/tmdl/decisions/

   This guidance document explains the programmatic elements and requirements of the TMDL process as established by CWA section 303(d) and by EPA's Water Quality Planning and Management Regulations (40 CFR Part 130). It discusses the process for developing a TMDL, roles of EPA and the states in the process, and supporting or related water programs.

2. USEPA (U.S. Environmental Protection Agency). 1999. *Protocol for Developing Sediment TMDLs*. EPA 841-B-99-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/owow/tmdl/sediment/pdf/sediment.pdf

   This technical guidance document provides information to support TMDL writers in developing TMDLs for sediment. The document includes information on how to complete each step of the TMDL process, including problem identification, source assessment, linkage of water quality targets and sources, allocation analysis, and monitoring.

3. USEPA (U.S. Environmental Protection Agency). 2000. *Protocol for Developing Pathogen TMDLs*. EPA 841-R-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/owow/tmdl/pathogen_all.pdf

   This technical guidance document provides information to support TMDL writers in developing TMDLs for pathogens. The document includes information on how to complete each step of the TMDL process, including problem identification, source assessment, linkage of water quality targets and sources, allocation analysis, and monitoring.

4. USEPA (U.S. Environmental Protection Agency). 2000. *Protocol for Developing Nutrient TMDLs*. EPA 841-B-99-007. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/owow/tmdl/nutrient/pdf/nutrient.pdf

   This technical guidance document provides information to support TMDL writers in developing TMDLs for nutrients. The document includes information on how to complete each step of the TMDL process, including problem identification, source assessment, linkage of water quality targets and sources, allocation analysis, and monitoring.

4.5.2. Watershed Models

1. USEPA. 2005. *TMDL Model Evaluation and Research Needs*. EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk

Management Research Laboratory, Cincinnati, OH. www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm

This report documents the review of more than 60 available watershed and receiving water models for their applicability to TMDL development and implementation. It discusses model selection on the basis of model capabilities and provides a series of tables rating the capabilities or applicability the models using the categories of TMDL endpoints, general land and water features, special land processes, special water processes, and application considerations. The document also provides individual fact sheets for each reviewed model.

2. USEPA. 1997. *Compendium of Tools for Watershed Assessment and TMDL Development.* EPA 841-B-97-006. U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC. www.epa.gov/owow/tmdl/comptool.html

This document reviews more than 50 watershed, receiving water and ecological assessment models. The document provides factsheets for each model that describes model components, methods, applications, pollutants addressed, limitations, input data requirements, and type of output. The document also contains information on model selection for specific applications, model calibration, and model verification.

4.5.3. Simple Method

1. Center for Watershed Protection's Web site on the Simple Method: www.stormwatercenter.net. Click "By Category." Information on the Simple Method is included in the *Impacts of Urbanization* category.

4.5.4. Receiving Water Models

1. USEPA. 2005. *TMDL Model Evaluation and Research Needs.* EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH. www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm

This report documents the review of more than 60 available watershed and receiving water models for their applicability to TMDL development and implementation. It discusses model selection on the basis of model capabilities and provides a series of tables rating the capabilities or applicability the models using the categories of TMDL endpoints, general land and water features, special land processes, special water processes, and application considerations. The document also provides individual fact sheets for each reviewed model.

2. USEPA. 1997. *Compendium of Tools for Watershed Assessment and TMDL Development.* EPA 841-B-97-006. U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC. www.epa.gov/owow/tmdl/comptool.html

This document reviews more than 50 watershed, receiving water and ecological assessment models. The document provides factsheets for each model that describes model components, methods, applications, pollutants addressed, limitations, input data requirements, and type of

output. The document also contains information on model selection for specific applications, model calibration, and model verification.

4.5.5. Load Duration Curves

1. USEPA (U.S. Environmental Protection Agency). 2007. *An Approach for Using Load Duration Curves in the Development of TMDLs*. EPA 841-B-07-006. U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC. www.epa.gov/OWOW/tmdl/duration_curve_guide_aug2007.pdf

   This document provides an overview on the use of duration curves for TMDLs, describing the basic steps needed to develop duration curves and subsequently identify loading capacities, LAs, WLAs, MOS, and seasonal variations. The guide also discusses some considerations and limitations in using the approach and includes several case examples.

4.5.6. WLA Expression Options

1. Wayland, R.H., and J.A. Hanlon. 2002. *Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs*. Memorandum from Robert H. Wayland, III, Director, Office of Wetlands, Oceans and Watersheds, and James A. Hanlon, Director, Office of Wastewater Management, U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/npdes/pubs/final-wwtmdl.pdf

   This memo clarifies existing EPA regulatory requirements for, and provides guidance on, establishing WLAs for stormwater discharges in TMDLs approved or established by EPA.

4.5.7. Required Elements of a TMDL

1. USEPA (U.S. Environmental Protection Agency). 1991. *Guidance for Water-Quality-based Decisions: The TMDL Process*. EPA 440/4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.epa.gov/OWOW/tmdl/decisions/

   This guidance document explains the programmatic elements and requirements of the TMDL process as established by CWA section 303(d) and by EPA's Water Quality Planning and Management Regulations (40 CFR Part 130).

2. Grumbles, B.H. 2006. *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits*. Memorandum from Benjamin H. Grumbles, Assistant Administrator. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. www.epa.gov/owow/tmdl/dailyloadsguidance.html

   This memo clarifies EPA's expectations concerning the appropriate tirne increment used to express TMDLs in light of the recent decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015 (D.C. Cir. 2006), which held that two TMDLs for the Anacostia River did not comply with the CWA because they were not expressed as *daily* loads.

3. USEPA (U.S. Environmental Protection Agency). 2007. *Options for Expressing Daily Loads in TMDLs (Draft)*. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, D.C. www.epa.gov/owow/tmdl/draft_daily_loads_tech.pdf

   This document provides technically sound options for developing daily load expressions for TMDLs calculated using allocation time frames greater than daily (e.g., annual, monthly, seasonal).

4. Perciasepe, R. 1997. *New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs)*. Memorandum from Robert Perciasepe, Assistant Administrator, to Regional Administrators Regional Water Division Directors. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

   The memo supplements existing regulations and guidance by documenting two policies to establish a nationally consistent approach for establishing and implementing TMDLs. These policies, and will remain in effect unless they are specifically changed by the Office of Water.

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1. Understanding the Connections Between TMDLs and Stormwater Permits
2. Identifying Opportunities to Coordinate TMDLs and Stormwater Permits
3. Characterizing Impairments and Stormwater Sources
4. Developing TMDLs with Stormwater Sources
5. **Promoting Effective Stormwater Management**
6. Coordinating TMDLs and Stormwater Permits

Chapter Five
Promoting Effective Stormwater Management

What's included in this chapter

- ✓ Description of possible stormwater management strategies and techniques for evaluating and selecting appropriate strategies for implementing WLAs.

What you should know after reading this chapter

- ✓ Potential criteria for evaluating and selecting stormwater BMPs most suitable for implementing WLAs.
- ✓ Types of resources, tools, and models available to assist in the selection of appropriate BMPs.

Potential roles and responsibilities under this activity

If you are a TMDL writer

1. Determine if the TMDL can include BMP recommendations for implementing stormwater WLAs.
2. Work with stormwater permit staff and others involved with implementation activities to identify BMPs and associated pollutant load reduction estimates to recommend through the TMDL.
3. Provide technical assistance to stormwater staff in reviewing stormwater management plans and pollution prevention plans that contain BMPs selected to implement WLAs.

If you are a stormwater permit writer

1. Determine if the stormwater permit will include prescriptive BMP implementation requirements in permit(s) based on recommendations in TMDL and work with TMDL staff to develop those BMP recommendations.
2. Determine if the stormwater permit will require stormwater dischargers to identify and implement BMPs necessary to achieve WLAs, but will provide assistance by recommending BMPs to consider or a process for quantifying potential pollutant load reductions.
3. Review stormwater management plans and pollution prevention programs to ensure selected BMPs and associated rationale are technically appropriate for achieving pollutant load reductions.

5. PROMOTING EFFECTIVE STORMWATER MANAGEMENT

TMDLs identify and quantify the loading reductions needed to meet water quality standards and, to the extent possible, facilitate implementation of management measures to implement targeted loading reductions. For stormwater discharges, permittees will reduce loadings in most cases by implementing a suite of structural and nonstructural stormwater BMPs over a certain period of time. Permittees then need to evaluate the effectiveness of BMPs implemented to implement loading reductions, make adjustments where performance was less than expected, and incorporate lessons learned in future BMP implementation activities. In many cases TMDL writers can anticipate an iterative process for making progress toward implementing WLAs and reflect this type of process in the TMDL report. This type of iterative, information-based approach to continuous improvement is often referred to as adaptive management. Through TMDL recommendations and permit requirements, TMDL and permit writers can direct permittees to create SWMPs and SWPPPs that achieve progress toward implementing WLAs over time and demonstrating such progress.

As shown in Figure 20, the step of TMDL implementation involves identifying management options to implement LAs and WLAs. This chapter discusses the activities related to TMDL implementation for stormwater sources. The goal of this chapter is to provide TMDL and permit writers with an understanding of (1) their potential role in developing implementation and adaptive management recommendations and requirements; (2) technical considerations for analyzing and selecting structural and nonstructural BMPs that are suitable for making progress toward implementing a WLA; and (3) technical considerations for monitoring and assessing implementation strategies to implement the WLA.

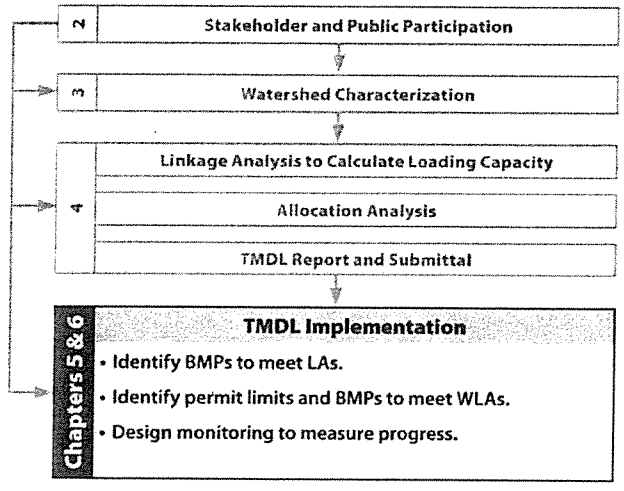


Figure 20. Illustration of the steps in the TMDL process, including activities related to TMDL implementation.

5.1. Implementation Roles and Responsibilities

Implementing TMDLs through stormwater permits will involve planning and coordination. Implementation planning activities might involve TMDL and permit writers or draw on the skills of other agency staff dedicated to implementation related activities. In some instances, implementation planning activities might only involve permittees. As a result, this chapter refers to those engaged in implementation planning activities as *stormwater planners*.

The role of stormwater planners in implementation planning will vary. Potential roles and activities for stormwater planners can include the following:

- **Evaluating and interpreting the WLAs assigned to stormwater sources.** As discussed in Chapter 4, TMDL writers can use a variety of approaches for categorizing and calculating stormwater WLAs in TMDLs. Individual WLAs assigned to each stormwater source or a specific source's stormwater outfall(s) are the most straightforward type of WLAs to interpret and implement. Permit writers can

most directly use individual WLAs and translate them into permit requirements. Stormwater planners should have the ability to conduct implementation planning activities using these refined WLAs. Where TMDL writers use aggregated approaches to categorize WLAs, stormwater sources might need to implement disaggregated WLAs for the purpose of SWMP or SWPPP implementation. Who disaggregates an aggregated WLA might vary—in some instances, it could be the TMDL writer, the permit writer, or even the actual stormwater sources. Stormwater planners can play a role in conducting the activities necessary to refine aggregated WLAs.

- **Developing a recommended list of structural and nonstructural BMPs to include in TMDLs or permits.** If the approach entails providing sources with a narrow suite of BMPs to promote implementation, TMDL and permit writers can play the role of stormwater planners and have the responsibility for analyzing and identifying a suite of BMPs that is most appropriate for addressing the impairment(s) for use by one or more types of sources. Under this option, TMDL and permit writers acting as stormwater planners can coordinate to determine where to list the suite of BMPs—either in the TMDL as recommended BMPs or in the permit as part of the permit requirements. Chapter 6 of this Handbook provides a detailed discussion on options for language to connect BMP implementation recommendations and requirements through TMDLs and permits.
- **Identifying specific structural and nonstructural BMPs when no BMP recommendations or requirements are provided in the TMDL or permits.** If the approach requires sources to analyze and select BMPs on their own, permittees can then act as the primary stormwater planners. Under this option, TMDL and permit writers might focus on providing permittees with technical assistance to assist in BMP selection. As mentioned throughout this Handbook, federal law does not require the development of TMDL implementation plans. Where state regulations require the development of TMDL implementation plans, or states voluntarily attempt to develop these plans as part of the TMDL development process, TMDL writers might consider providing technical assistance type information in the implementation plan. TMDL writers can also consider incorporating recommendations on BMPs to implement the load reductions as part of the TMDL report. Permit writers can consider providing TMDL implementation technical assistance to permittees through the permit fact sheet or compliance assistance documents.
- **Developing BMP performance standards to include in the TMDL or permit.** In some instances, the TMDL or permit might focus on BMP performance standards, rather than actual BMP recommendations or requirements. TMDL and permit writers in the role of stormwater planners can develop BMP performance standards to implement WLAs. Performance standards provide sources with the flexibility to select structural and nonstructural BMPs that are locally suitable while achieving the required or recommended performance standard. For example, New Jersey's Stormwater Management Rules (N.J.A.C. 7:8) requires *major development* projects that create at least 0.25 acres of new or additional impervious surface to include stormwater management measures that reduce the average annual TSS load in the development site's post-construction runoff by 80 percent. This type of performance standard allows sources in the role of stormwater planners to identify, select, and implement the most effective structural and nonstructural BMPs for a site or facility.

Regardless of who plays the role of stormwater planner and to what degree, it is important for TMDL and permit writers to understand the range of potential BMPs, technical information related to BMP performance, processes for BMP selection, and adaptive management techniques to ensure that implementation recommendations and requirements translate into effective, on-the-ground implementation actions by sources. It is also important that permit writers and other agency staff

involved in permitting activities (e.g., enforcement and compliance staff) have an understanding of BMP implementation and adaptive management for purposes of reviewing and approving (where applicable) permit information and documentation (e.g., SWMPs, annual reports, monitoring data).

The focus of this chapter is on the technical considerations necessary for selecting appropriate BMPs, evaluating BMP effectiveness over time, and making modifications to BMP implementation to ensure continuous water quality improvements. The goal of this chapter is to present these technical considerations to help stormwater planners as they develop implementation recommendations and requirements for use in TMDLs and permits to form the basis for demonstrating that TMDLs are adequately addressed in permits and associated SWPPPs and SWMPs. Although the focus of this chapter is on TMDL and permit writers serving as stormwater planners, the information presented in this chapter might also benefit permittees playing the role of stormwater planners.

5.2. Key Questions for Promoting Effective BMP Implementation

Stormwater planners can ask a series of six key questions to promote effective BMP implementation through an adaptive management framework. The adaptive management framework consists of planning, implementing, evaluating and learning, and adjusting. The six key questions are as follows:

1. What is the current pollutant loading from the stormwater source's discharge to the impaired waterbody accounting for existing BMPs?
2. What additional loading reduction is necessary to implement the WLA?
3. What additional BMPs might provide the remaining pollutant load reductions necessary to implement the assigned WLA on the basis of the expected performance of these BMPs?
4. How should permittees measure BMP performance as implementation proceeds?
5. Are measured pollutant load reductions adequate to make progress toward the assigned WLA over time?
6. What modifications to the overall implementation strategy are necessary to make further progress toward implementing the WLA?

Stormwater planners can use these key questions to guide implementation and adaptive management activities to achieve progress toward implementing WLAs. Although the discussion of the key questions highlights potential roles for TMDL and permit writers, sources might find these key questions helpful in conducting their implementation planning activities to comply with permit requirements.

5.2.1. Establishing the Baseline Load and Accounting for Existing Load Reductions (Key Questions 1 and 2)

The planning phase of adaptive management focuses on selecting BMPs to achieve the WLA and associated performance indicators to aid in tracking progress. Because the goal is to make iterative progress toward implementing a WLA, it is first necessary to quantify the starting point from which a source should measure progress. This is often referred to as the baseline. The baseline for a source might vary, depending on the context of the TMDL analysis. Sometimes the baseline pollutant loads for a

source's discharge might take into account existing BMPs, and sometimes it might not. Stormwater planners involved in implementation planning should address the issue of a source's baseline by asking the first two key questions as follows:

1. What is the current pollutant loading from the stormwater source's discharge to the impaired waterbody accounting for existing BMPs?
2. What additional load reduction is necessary to implement the WLA?

5.2.1.1. Answering Key Question 1: Determining Current Pollutant Loading from Stormwater Source Discharge

Stormwater planners can first review the TMDL to determine how the analysis defined a source's pollutant baseline load. During the development of the TMDL, the TMDL writer characterizes the pollutant loads from existing stormwater discharges. It is important for stormwater planners to review the TMDL analysis to determine the approach used to characterize pollutant loads from stormwater discharges. For example, the TMDL report should indicate if the TMDL writer made this determination on the basis of modeling using literature values for land use types and other generalized assumptions related to the stormwater source or if the analysis included real-world data and information, such as monitoring data to calibrate the model to actual conditions.

After identifying the stormwater discharge pollutant loading used in the TMDL analysis, stormwater planners can then determine if the analysis accounted for any existing BMPs and, if so, the assumed or measured pollutant load reductions from those BMPs. If the TMDL analysis does account for existing BMPs, stormwater planners can use the pollutant loading information contained in the TMDL analysis as the starting point for gauging progress toward the WLA. Stormwater planners should attempt to verify that the existing BMPs used in the TMDL analysis represent a comprehensive and accurate listing.

It is important for TMDL writers to remember that the information provided in the TMDL, as well as the assumptions used in the analysis, can influence the BMP selection process. The information contained in the TMDL serves as the basis for identifying the pollutants of concern and their source, which broadly indicates the type(s) and locations of BMPs needed to implement the pollutant load reductions from the sources with assigned WLAs. Greater specificity in the characterization of existing stormwater loads can likely promote more effective implementation.

If the TMDL analysis does not provide comprehensive information on existing BMPs, answering key question 1 requires conducting two activities: (a) accounting for existing BMPs and (b) quantifying the associated pollutant load reductions. The first activity involves developing an inventory of existing BMPs that would affect loads of the pollutant of concern. The second activity involves measuring or estimating the pollutant load reductions from the BMPs identified in the inventory.

5.2.1.1.1 Key Question 1, Activity A: Inventorying Existing BMPs

A BMP inventory is a comprehensive listing or database of existing structural and, if applicable, nonstructural BMPs that directly or indirectly address the impairment(s). For structural BMPs, the inventory should include information on the type of BMP, location, date of installation, area treated by the BMP, and design and maintenance issues. For nonstructural BMPs, the inventory should include information on type of activity, implementation schedule, area addressed, and performance related data.

Stormwater planners involved in implementation activities for sources covered by individual stormwater permits might feasibly engage in developing BMP inventories by working with sources. For sources covered by general permits, it is unlikely that stormwater planners will conduct this activity. Instead, permit writers might opt to include in general permits a requirement for developing a BMP inventory. Through this option, stormwater planners could provide criteria to assist sources in the development of a BMP inventory, such as defining the type or location of BMPs that are most appropriate to address the impairment(s). The TMDL writer could include these BMP inventory criteria in the TMDL or the permit writer could include the criteria in the permit with the BMP inventorying requirement.

Sources can also develop an accurate and comprehensive BMP inventory without the aid of criteria in the TMDL or permit. Permit writers can include BMP inventory requirements in permits that instruct sources to review existing SWPPPs or SWMPs—depending on the type of permittee—and identify BMPs that are likely to address the impairment(s). Sources would develop BMP inventories in compliance with this requirement through inspections or *desktop auditing*, depending on the type and number of BMPs in place.

Technical issues related to compiling a BMP inventory can vary depending on the type of stormwater source—industrial facility, construction site, or MS4. Therefore, stormwater planners—particularly permit writers—should keep these technical issues in mind when developing permit requirements related to compiling BMP inventories. For industrial facilities and construction sites, compiling a BMP inventory might involve a review of SWPPPs or a thorough facility inspection or monitoring of influent and effluent of BMP structures. This approach would obviously be very complex within some MS4s, however, because of the sheer numbers of BMPs and the difficulty in locating and characterizing them. The level of detail, therefore, for the BMP audit at an MS4 might be less, and many assumptions might need to be made. For example, an MS4 responsible for conducting a BMP inventory as part of the implementation process to implement a TSS WLA might determine that it is necessary to include all erosion and sediment control BMPs on active construction projects. Because of the large number and dynamic nature of construction projects, however, the MS4 might determine that it is not feasible to do an actual count of the numbers of various types of BMPs. Therefore, the MS4 uses the assumption that all active construction sites implement certain standard BMPs (i.e., silt fence, construction entrances, sediment traps) due to local ordinance and state permit requirements. The MS4 could then assume a certain *noncompliance factor* after reviewing enforcement actions against existing sites to attempt to correct for improper implementation of BMPs in the field when modeling actual contribution. Using municipal planning tools, municipalities with permitted MS4s can also project the number and location of future construction sites on the basis of growth projections, comprehensive planning, and land use zoning.

Resources: For more information on compiling a BMP inventory, refer to the Resources list at the end of this chapter in Section 5.3.1.

In Practice: Promoting the Development of an Existing BMP Inventory in Washington

The draft Phase II MS4 General Permit for Western Washington (Appendix 2) contains the list of all TMDLs in western Washington that include specific implementation activities that go beyond the general permit requirements. The general permit requires permittees with WLAs under these TMDLs to implement the activities specified in Appendix 2. Some of these additional requirements include developing an inventory of existing BMPs. For example, the Snohomish River Tributaries fecal coliform TMDL (2001) in Washington requires (via the permit) permittees to implement *baseline* source control BMPs for (1) commercial animal handling areas and (2) commercial composting facilities. The TMDL requires (via the permit) that the permittees compile a list of the existing facilities and conduct inspections of them to ensure implementation of

source control BMPs. After meeting these baseline conditions, permittees must develop and implement a Bacterial Pollution Control Plan.

In addition to the type of stormwater source, the effort of compiling a BMP inventory can have an additional set of technical issues if the inventory is to include nonstructural BMPs. Nonstructural BMPs are typically programmatic in nature, such as good housekeeping practices at a transportation facility. While it might prove easy to account for these activities, it is not always easy to determine the pollutant load reduction associated with these activities. In the case of programmatic BMPs, stormwater planners should consider the need to make assumptions about defining what it means to implement nonstructural BMPs according to plan and justifying associated assumptions.

5.2.1.1.2 Key Question 1, Activity B: Quantifying Load Reductions from Existing BMPs

After the BMP inventory is complete, stormwater planners can either undertake the second activity of key question 2 or develop recommendations or requirements for sources related to this activity. The second component of key question 2 focuses on measuring or estimating the pollutant load reductions associated with the existing BMPs. Quantifying existing pollutant load reductions can help to determine if sources have made any progress toward implementing the WLA if the TMDL had assumed no BMP implementation.

It is important that planners consider how best to evaluate and quantify the effectiveness of BMPs and provide guidance to sources either through the TMDL or the permitting process. Evaluation techniques might vary by the type of BMP, pollutant type, and other factors. It is particularly important to provide this type of guidance in instances where multiple sources addressed under the same TMDL will participate in BMP evaluations to determine progress toward the same or related WLAs. Ensuring that sources are using similar evaluation techniques for similar BMPs can not only provide a more defensible pool of BMP performance data, but also provide a level of equity among sources as they determine progress toward implementing WLAs.

Quantifying pollutant load reductions associated with existing BMPs can vary in complexity for sources, depending on the size of the source's permitted boundary, the number and types of BMPs, and whether they are structural versus nonstructural. For example, it might be relatively easy to determine the effectiveness of BMPs at an industrial facility with a single defined outfall and four oil/water separators which treat the runoff from the processing facility and parking lots than it would be to quantify the effects of multiple, individual BMPs or an entire MS4 SWMP.

For a source with many BMPs, such as a large MS4 or a large construction site, the most viable option might be a suite of evaluation techniques that include monitoring, researching applicable literature values, and modeling using justifiable assumptions. For example, a large construction site with several types of erosion and sediment control BMPs could choose to either monitor representative BMPs or use existing literature to determine optimum sediment removal efficiency. Using the values for representative pollutant removal, the source could then estimate erosion and sediment control BMPs throughout the entire construction site.

The complexities only increase when trying to quantify the effects of more programmatic BMPs, including employee training on good housekeeping techniques, public outreach, and inspections of industrial/commercial facilities. Many of these activities focus on source reduction and pollution prevention or behavioral changes that are difficult to translate into pollutant load reductions.

BMPs are likely to vary among the types of sources; therefore, appropriate evaluation techniques and approaches are likely to also vary. Evaluation techniques might also vary depending on the specific pollutant of concern or impairment that a source is trying to address through BMP implementation.

The evaluation of stormwater management BMPs and plans can be very complex because many of these BMPs and plans focus on nonstructural, source reduction activities that prevent pollutants from entering the storm sewer system to begin with. As a result, there might not be any easy means to quantify the associated pollutant load reductions. Stormwater planners attempting to quantify pollutant load reductions from BMPs can likely have to generate estimates using a wide range of information sources ranging from state and local studies, national BMP performance data, monitoring data, modeling, and assumptions based on best professional judgment. It is critical that TMDL and permit writers keep these challenges in mind when developing WLAs and recommendations or requirements for assessing progress toward WLAs. The TMDL itself needs to account for the complexities of quantifying the effects of BMPs on stormwater runoff and the permit writer needs to allow for flexibility in the development of assessment strategies.

Regardless of the difficulty level, it is in the source's best interest that stormwater planners conduct the inventory of existing BMPs thoroughly and justifiably. If the source is the primary stormwater planner and is conducting the BMP inventory, the permit writer might want to review the BMP inventory procedure before initiation to confirm that the pollutant load reductions attributed to existing BMPs are appropriate. If a review of the BMP inventory procedure is a permit requirement, the permit writer should consider explicitly stating what the source must submit for review and approval. Information in the final inventory can assist sources with future implementation efforts, including scheduling and tracking maintenance activities and compiling records and reports.

In Practice: Conducting a BMP Effectiveness Evaluation in Portland, Oregon

Portland conducted an evaluation to determine the effectiveness of existing stormwater BMPs. According to the summary document, *Effectiveness Evaluation of Best Management Practices for Stormwater Management in Portland, Oregon* (www.portlandonline.com/shared/cfm/image.cfm?id=133994), the purpose of the effectiveness evaluation was to "develop and document the effectiveness ranges and preferred values for all BMPs either currently in use or anticipated for use in the management of stormwater quality and quantity in the City of Portland." The evaluation methodology focused on analyzing a list of BMPs that met specific criteria, including BMPs required to implement TMDLs. The methodology also focused on surrogate pollutants selected to represent whole classes of pollutants. Surrogates included TSS, dissolved zinc, *E. coli*, and total phosphorus. In addition to water quality parameters, the evaluation addressed flow rates and volume, temperature, and habitat issues. Through the evaluation, Portland derived values for BMP performance using a wide variety of information sources as well as best professional judgment. The evaluation provides a range of effectiveness values for each BMP to account for uncertainty and location-specific or application-specific conditions that result in various points in the range of values. The evaluation serves as the necessary documentation of methods and assumptions to facilitate future review of BMP effectiveness and to evaluate the applicability of a particular value to a specific BMP.

5.2.1.2. Answering Key Question 2: Determining Additional Load Reductions Necessary to Implement the WLA

After quantifying the measured or estimated pollutant load reductions associated with existing BMPs, stormwater planners can calculate the remaining pollutant load reductions necessary to implement the WLA. This value can serve as the driver for addressing key question 3: selection of additional BMPs.

By comparing the information generated to answer key question with the overall pollutant load reduction necessary to implement the WLA, stormwater planners can estimate the magnitude of the pollutant load not addressed by BMPs. The difference between the source's actual contribution (defined as the baseline pollutant load minus the pollutant load reductions addressed through existing BMPs) and the assigned WLA is the additional amount of pollutant removal that the source can implement through additional BMPs.

5.2.2. Selection of Additional BMPs to Implement WLAs (Key Question 3)

The information generated under key question 2 can serve as a starting point for stormwater planners to answer key question 3:

What additional BMPs might provide the remaining pollutant load reductions necessary to implement the assigned WLA on the basis of the expected performance of these BMPs?

> ***Tip: Ensure proper O&M to maximize BMP performance and resource investment***
>
> State planners can remind sources that O&M are extremely important factors in maximizing BMP effectiveness. Sources might maximize pollutant load reductions by improving the O&M of existing BMPs rather than investing in additional BMPs. TMDL and permit writers can develop recommendations and requirements that ensure sources focus on proper O&M of BMPs intended to achieve progress toward WLAs.

Answering key question 3 also entails two activities: (a) identifying the list of possible BMPs to address the pollutant of concern or impairment and (b) quantifing the expected performance of each BMP under consideration. The role of stormwater planners in the BMP identification and selection process can vary depending on the approaches discussed at the beginning of this chapter. In addition, factors such as the type of source and the type of permit under which the source has coverage can also affect the role of stormwater planners at this phase of implementation planning. For example, TMDL and permit writers playing the role of stormwater planners can work closely with sources covered under an individual permit (e.g., large and medium MS4s) to conduct an analysis of possible BMPs and select a final suite of prescribed BMPs to include in the permit. Where general permits are available to sources, TMDL and permit writers playing the role of stormwater planners might rely on the use of performance standards in TMDLs and permits, while providing broad technical assistance through guidance documents. For example, TMDL and permit writers could research a range of possible BMPs and provide some of the information (e.g., expected performance information, cost, maintenance requirements) that sources would need to evaluate and identify the most suitable additional BMPs to address the remaining pollutant load reductions necessary to implement the WLA. Stormwater planners should keep in mind the range of other factors that can ultimately influence a source's decision to implement a BMP, such as location, cost, and maintenance.

The topics of identifying possible management strategies and selecting final management strategies to implement pollutant load reduction targets are discussed extensively in Chapters 10 and 11 of EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA 2008a). While

the information provided in this extensive EPA resource is geared toward sources with implementation responsibilities, the process for screening and selecting BMPs described in these chapters have applicability to planners involved in TMDL implementation planning activities considering developing a suite of recommended or required BMPs to include in the TMDL or the permit. This section provides an overview of BMP identification and selection information that would benefit stormwater planners playing a more active role in this step of the process.

5.2.2.1. Key Question 3, Activity A: Identifying List of Possible BMPs

Identifying and selecting BMPs to implement the remaining pollutant load reductions involves compiling a list of candidate BMPs appropriate for the pollutant of concern or the impairment and determining a BMP performance rating (i.e., expected pollutant load removal or flow rate and volume reduction). It is possible that much of this work might already be done by addressing key question 1 focused on inventorying and estimating the pollutant load reductions from existing BMPs. However, the suite of BMPs available to implement a WLA might encompass BMPs beyond those already implemented by a source. Therefore, the list of candidate BMPs is likely to include both existing and new practices for consideration.

> ***Resources:*** For more information on BMP selection, refer to the Resources list at the end of this chapter in Section 5.3.2.

Stormwater planners should consider providing a suite of BMPs that encompasses every possible category of controls: source controls, treatment controls, structural controls, and nonstructural controls. Source controls are BMPs that seek to reduce the presence, use, or exposure of pollutants to the weather; volume controls promote infiltration, evapotranspiration and reuse of water, detention, or retention of stormwater and its constituents. Treatment controls are BMPs that attempt to remove or inactivate pollutants through physical, chemical, or biological processes. Structural controls are built structures or facilities that capture runoff, treat it through chemical, physical, or biological means, and discharge the treated effluent to the soil, the stormwater conveyance system, or directly to surface waters. Nonstructural controls usually involve management practices that focus on changes in activities or behaviors, as well as focus on controlling pollutants at their source. Examples include developing and implementing erosion and sediment control plans, organizing public education campaigns, and practicing good housekeeping at municipal, commercial, and industrial facilities. Regulatory and policy tools, such as ordinances, operating procedures, and maintenance schedules, are also examples of nonstructural controls.

> ***Tip: Addressing peak flows to reduce channel impacts***
>
> To prevent downstream degradation and maintain stream channel stability, planners should promote maintenance of predevelopment runoff volumes and rates for new development and redevelopment. Recent research shows that simply requiring site designs not to exceed pre-development runoff rates for a specified storm size (e.g., a detention basin designed to limit release rates) will not adequately protect the hydrology and habitat of the receiving water. Management practices that slow, detain or infiltrate the runoff and release it slowly via baseflow to the receiving stream systems can replicate predevelopment site conditions and ensure both adequate aquifer recharge and stream base flow.

It is important to note that for certain types of impairments in certain areas nonstructural controls and source reduction practices might be less expensive and more effective than structural controls. For example, implementing new policies for sweeping streets and addressing illicit discharges is often less costly and more protective of water quality than constructing ponds or other stormwater treatment facilities at down-gradient locations. For example, stormwater planners addressing areas with seasonal chloride impairments associated with deicing activities can consider nonstructural practices

such as alternatives to salt or salt reduction management activities (e.g., calibrating salt trucks) rather than structural BMPs.

Many BMPs do and should target volume reductions (i.e., flow) to reduce total pollutant load. In addition to pollutant load reductions, BMPs that provide volume reductions also reduce channel erosion, alleviating impacts related to increased runoff. Streambank erosion, channel deformation and down-cutting, and loss of natural habitat are among the more common effects of increased runoff from impervious surfaces. Stormwater planners can promote BMPs that reduce volumes through infiltration and evapotranspiration to ensure that BMPs are most effective in protecting or restoring impaired waterbodies. Volume reduction can also play a significant role in overall pollutant load reduction, which might not be immediately apparent if a BMPs ability to reduce incoming effluent concentrations is the primary metric by which it is measured. When a BMP, such as a rain garden or bioretention practice, captures a portion of incoming runoff and infiltrates it into the soil, the pollutants in that portion are prevented from entering a nearby river, lake, wetland, or coastal water. Simply comparing the concentration in and the concentration out of a BMP does not account for this pollutant load reduction due to infiltration.

Because flow is a critical factor to consider during BMP selection and implementation, stormwater planners can promote that sources first consider source controls and volume reduction controls before considering more traditional treatment controls. One option for doing so is to include only these types of BMPs on a list of prescribed BMPs (e.g., sources must implement all BMPs on the list) or on a required menu of options (e.g., sources must select one or more BMPs from the list). Another option could involve stormwater planners developing recommendations or requirements that indicate that sources must first examine source and volume reduction controls to implement remaining pollutant load reductions and provide associated assumptions that indicate treatment controls are more appropriate or effective at reducing remaining loads.

> ***Resources:*** For more information on volume control, refer to the Resources list at the end of this chapter in Section 5.3.3.

In Practice: Promoting Maintenance of Predevelopment Runoff Volumes and Rate in New Jersey

New Jersey's Stormwater Management Rules (N.J.A.C. 7:8) recognize that predevelopment site hydrology is essential to maintain to protect downstream hydrology. The New Jersey Model Stormwater Control Ordinance for Municipalities, included in the *New Jersey Stormwater Best Management Practices Manual* (www.state.nj.us/dep/stormwater/tier_A/bmp_manual.htm) as Appendix D, contains requirements pertaining to controlling stormwater runoff quantity impacts. The ordinance requires developers to select and comply with one of the requirements. Two requirements focus on conducting a hydrologic and hydraulic analysis that compares pre-construction runoff volume and rates with post-construction conditions. A third requirement focuses on performance standards for stormwater management measure design to control post-construction peak runoff rates.

In Practice: Promoting Consideration of Nonstructural Controls First in New Jersey

The New Jersey Model Stormwater Control Ordinance for Municipalities (referenced above) encourages MS4s to require developers to first consider nonstructural controls into new development designs. The model ordinance provides a list of nonstructural controls that includes protecting natural vegetation and drainage; protecting areas susceptible to erosion; minimizing impervious surfaces and breaking up or disconnecting flow over impervious surfaces; providing low maintenance landscaping; and incorporating source controls to minimize use and exposure of pollutants into site designs. The ordinance language states that if the developer contends it is not feasible to include these nonstructural controls into a project, the developer must provide the engineering, environmental, or safety reasons that render use of the nonstructural controls unfeasible.

In many cases, functions of the various BMPs can overlap and can reduce a pollutant in more than one way. For example, green infrastructure (GI) and low impact development (LID) practices control the volume of stormwater being delivered downstream, which can help reduce streambank erosion and sediment loading, while also retaining sediment. GI and LID are stormwater management approaches and practices intended to eliminate or reduce urban runoff and pollutant loadings by managing the runoff as close to its sources as possible. As a collection of small-scale practices, linked together on a site, GI/LID have the potential to reduce the effects of development and redevelopment activities on water resources by maintaining or replicating the predevelopment hydrology of the site. Through practices such as rain gardens, vegetated swales, pervious pavements, and green roofs, GI/LID promote on-site infiltration, evapotranspiration, or reuse of rainwater.

Resources: For more information on GI and LID, refer to the Resources list at the end of this chapter in Section 5.3.4.

The final mix of structural and nonstructural management practices selected can, most importantly, be determined by which pollutants each BMP can effectively address and, more importantly, what specific level of performance each can provide. This can depend upon several highly variable factors, including the concentration and total load of the pollutant in the runoff, the volume and various rates of the runoff, antecedent rainfall and runoff conditions, and even the season or time of year. The variability of both applicable pollutants and levels of treatment can be seen by reviewing the sampling results of actual structural facilities taken over a number of storm events. Depending on the pollutant, the reduction in pollutant load or mean concentration achieved by selected structural facilities can vary considerably from event to event, with even negative reductions achieved at times, particularly for nutrients. Such variability makes it extremely difficult to determine a structural facility's exact pollutant removal rate and illustrates why pollutant removal criteria are typically based on average annual conditions.

Tip: Calculating the savings associated with GI

The Green Values® Stormwater Calculator (http://greenvalues.cnt.org/calculator), developed by the Center for Neighborhood Technology, helps users see how GI can help save money and increase hydrologic benefits. It can be used to estimate the benefits of LID and conservation practices and allows users to input site development characteristics and green practices and returns financial and hydrologic outcomes for different scenarios.

5.2.2.2. Key Question 3, Activity B: Determining Expected BMP Performance

Evaluating the potential performance of a BMP is a potentially challenging activity, but the information generated through this activity is essential to selecting BMPs with the most potential for making progress toward WLAs and attainment of water quality standards. Although this activity is discussed as

a separate activity after compiling the list of possible BMPs, planners can make assumptions and determinations about BMP performance *while* generating the list.

There are three important factors to consider when evaluating the potential performance of BMPs: concentration, volume, and total load. Estimating the total pollutant load reduction associated with a BMP is probably the best way to evaluate overall BMP performance. To calculate the total load, multiply the volume of water discharged by the BMP over a given period by the mean or average concentration of the pollutant. EPA's Urban BMP Performance Tool Web site, at http://cfpub.epa.gov/npdes/stormwater/urbanbmp/bmptopic.cfm, provides an in-depth discussion of these factors and other considerations for evaluating potential BMP performance.

Stormwater planners can estimate load reductions from BMPs in a number of ways. The most desirable method would be to monitor a BMP for every rain event over the course of several years to determine the volume of water coming into and leaving the BMP and the associated changes in pollutant concentrations. Rarely, however, is this level of monitoring possible because of resource constraints or because the type of BMP does not lend itself to this kind of *water in—water out* type of monitoring. This is important for planners to keep in mind when considering options related to monitoring and assessing implementation progress as part of the overall adaptive management framework.

Other options for evaluating potential BMP performance include using existing information from past BMP studies and evaluations or computer-based predictive tools. Stormwater planners can consider the strengths and challenges associated with each option for evaluating potential BMP performance to determine which approach to use for supporting internal implementation planning activities, or to promote through recommendations and requirements for sources. Planners should consider several factors when examining each potential approach, including water quality parameters, source types, local conditions, available data, and user experience. Approaches range from simple to complex. Simple approaches include the use of published literature values for typical BMP performance or simple, spreadsheet-based models that calculate loads delivered to and removed by management measures. Complexity increases with the use of watershed models, which require substantial data inputs on multiple management techniques and can evaluate the optimum placement of BMPs as well as their performance. Simpler models are often sufficient to meet the needs of an analysis and are advantageous when time and budget resources are limited. Considerations for the use of literature values versus computer-based predictive tools are provided below.

> ***Tip: Understanding "Percent Removal"***
>
> Percent removal is a common metric for gauging BMP effectiveness. The pollutant concentration of stormwater flowing into a BMP is compared to the pollutant concentration of stormwater discharged after treatment by the BMP. Stormwater planners should understand the advantages and challenges associated with using percent removal as a way to determine BMP performance. One advantage of using percent removal is that it is a relatively available estimation of BMP performance. The challenge, however, is that percent removal can be a misleading statistic. For example, percent removal depends primarily on the influent quality. A BMP treating very *dirty* runoff will have a higher percent removal than the same BMP treating *cleaner* runoff. Also does not take into account volume reductions achieved through the BMP. For more detail describing why percent removal is a poor measure of BMP performance, see the fact sheet developed for the international stormwater BMP database at www.bmpdatabase.org/Docs/FAQPercentRemoval.pdf.

5.2.2.2.1 BMP Literature Values

One method used for predicting load reductions from BMPs is to use literature values of performance typically associated with type

> ***Resources:*** For more information on BMP performance literature values, refer to the Resources list at the end of this chapter in Section 5.3.5.

of management practice and pollutant (e.g., detention pond, sediment). The percent reductions commonly documented in the literature are normally estimated from one or more monitoring studies where performance of BMPs was measured using flow and chemical monitoring. For example, the effectiveness of management practice systems could be calculated using the relative effectiveness of individual practices. Stormwater planners using this approach should verify that the study carefully estimated inflow pollutant concentrations and should also take volume reductions into consideration. This approach can help with initial BMP scoping and screening. However, planners using this approach to estimate pollutant load removals should be aware that this approach might oversimplify and overestimate cumulative removal rates for BMP treatment trains.

5.2.2.2.2 Modeling Tools

Stormwater planners can select or refine a list of potential BMPs using computer-based predictive tools, or modeling. Modeling stormwater pollutant load reductions from BMPs commonly involves three primary measures—pollutant concentrations in the stormwater at some point in time, the total pollutant load conveyed over a time period, and the event mean concentration. Stormwater planners can refer to the TMDL analysis to determine what modeling approach the TMDL writer used and if it is possible to use the same model to narrow the range of BMP options and aid in siting and sizing them. Performance standards for management practices often include controls on the stormwater peak discharge rate, the total runoff volume, and the total pollution load, which often is the focus of the WLA. Load reductions for individual and multiple BMPs—functioning as groups of practices or consecutive facilities arranged in a treatment train—can be modeled in some cases by using BMP calculators built into watershed models. For example, planners can use SWMM to evaluate urban area management practices and has the capabilities to emulate the major management practice processes (i.e., storage, infiltration, first-order decay, and sediment settling). The recently added overland flow rerouting (land-to-land routing) options block can be used to mimic the parcel (individual lot) level sites.

> ***Resources:*** For more information on model applicability, refer to the Resources list at the end of this chapter in Section 5.3.6.

A variety of more BMP-specific modeling options exist to simulate specific BMPs or unique situations. In some cases, specialized watershed models and management practice models are used to perform small-scale analysis of BMPs. Table 12 provides a brief description of several specialized models that can aid planners in selecting and siting BMPs to implement progress toward WLAs.

Those selecting BMPs can take into account the unique set of conditions associated with each stormwater source. In addition to performance, sources will undoubtedly need to consider other selection factors that have little to do with water quality improvement. If the planning is being conducted by someone other than the permittee, consultations with industrial, construction site, and MS4 permittees during this process can help to create a bridge for discussions regarding BMPs selected, sites, designs, size, and cost.

> ***Tip: Determining if models used in TMDL development are appropriate for implementation planning.***
>
> If the TMDL development process involved watershed modeling, planners might have an opportunity to use this type of model for selecting and siting BMPs. Planners can work with TMDL writers to determine if the watershed model contains the necessary data for BMP implementation analysis. TMDL writers can also keep in mind the potential a watershed model might have for implementation planning purposes early in the TMDL development process.

Table 12. Description of modeling tools available for BMP selection, sizing, and siting decision making

Model/tool	Description
The Site Evaluation Tool (SET)	The model was developed to assess the effects of development, including sediment and nutrient loading, on a site scale. The tool allows definition of pre- and post-treated land use, allowing for multiple drainage areas and various combinations of practices. Structural and nonstructural practices can be represented, giving the user a suite of options for evaluation. www.unrba.org/set/index.shtml
Prince George's County BMP-Decision Support System (PG BMP-DSS)	The PG BMP-DSS evaluates the effect of management practices or combinations of management practices on flow and pollutant loading. This module uses simplified process-based algorithms to simulate management practice control of modeled flow and water-quality time series generated from runoff models such as HSPF. These simple algorithms include weir and orifice control structures; storm swale characteristics; flow and pollutant transport; flow routing and networking; infiltration and saturation; and a general loss/decay representation for a pollutant. The module offers the user the flexibility to design retention-style or open-channel management practices; define flow routing through a management practice or management practice network; simulate Integrated Management Practices such as reduced or discontinued imperviousness through flow networking; and compare management practice controls against a defined benchmark such as a simulated predevelopment condition.
Model for Urban Stormwater Improvement Conceptualization (MUSIC)	MUSIC was developed to evaluate small and large-scale (100 square kilometer) urban stormwater systems using modeling time steps that range from 6 minutes to 24 hours. MUSIC provides an interface to help set up complex stormwater management scenarios. The stormwater control devices evaluated by MUSIC include ponds, bioretention, infiltration buffer strips, sedimentation basins, pollutant traps, wetlands, and swales. Major techniques used to evaluate management practices including settling in ponds and decay of pollutants. www.toolkit.net.au/cgi-bin/WebObjects/toolkit.woa/wa/productDetails?productID=1000000
Integrated Design and Evaluation Assessment of Loadings (IDEAL)	IDEAL provides a spreadsheet-based technique for assessing the benefits of urban management practices on flow, sediment, nutrients and bacteria. The model predicts watershed runoff, concentrations, and loads, using the user's selection of vegetative filter strips, dry detention ponds, and wet detention ponds. Urban areas are defined as pervious, impervious connected, and impervious unconnected areas. Flow and loads can be directed to a pond that can be either dry (no permanent pool) or wet (permanent pool). The model then calculates the pollutant removal efficiencies of the practices using empirical equations. The model predicts single storm values and converts them to average annual storm values using a statistical process. The IDEAL model is designed to help managers estimate long-term management practice pollutant removal efficiencies and is not designed for looking at individual storms. www.greenvillecounty.org/land_development/Planning.asp
Soil and Water Assessment Tool (SWAT)	SWAT is a river basin-scale model developed to quantify the effect of land management practices in large, complex (primarily agricultural) watersheds. SWAT was developed to predict the effect of land management practices on water, sediment, and agricultural chemical yields in watersheds with varying soils, land use, and management conditions over long periods of time. www.brc.tamus.edu/swat/
Storm Water Management Model (SWMM)	SWMM is a dynamic rainfall-runoff simulation model applied primarily to urban areas and for single-event or long-term (continuous) simulation using various time steps. It was developed for analyzing surface runoff and flow routing through complex urban sewer systems. In SWMM, flow routing is performed for surface and subsurface conveyance and groundwater systems, including the options of nonlinear reservoir channel routing and fully dynamic hydraulic flow routing. SWMM has a variety of options for quality simulation, including traditional buildup and washoff formulation as well as rating curves and regression techniques. SWMM can simulate storage, treatment, and other BMPs. www.epa.gov/ednnrmrl/models/swmm/index.htm
Vegetative Filter Strip Model (VFSMOD)	VFSMOD provides specialized modeling of field-scale processes associated with filter trips or buffers. This model provides routing of storms runoff from an adjacent field through a vegetative filter strip and calculates outflow, infiltration, and sediment trapping efficiency. The model is sensitive to characteristics of the filter including: vegetation roughness or density, slope, infiltration characteristics, and the incoming runoff volume and sediment particle sizes. http://carpena.ifas.ufl.edu/vfsmod/

Model/tool	Description
Wetland water balance and nutrient dynamics model (WETLAND)	WETLAND is a dynamic compartmental model to simulate hydrologic, water quality and biological processes and to assist the design and evaluation of wetlands. The model can simulate both free-water surface and subsurface flow wetlands. WETLAND is modular and includes hydrologic, nitrogen, carbon, dissolved oxygen, bacteria, sediment, vegetation, and phosphorous submodels.
Virginia Field Scale Wetland Model (VAFSWM)	VAFSWM is a field-scale model for quantifying the pollutant removal in a wetland system. It includes a hydrologic subroutine to route flow through the treatment system; precipitation, evapotranspiration, and exchange with subsurface groundwater.
Delaware Urban Runoff Management Model (DURMM)	The Delaware Department of Natural Resources (DNREC) created DURMM to provide a more rigorous hydrological design tool for Green Technology BMPs. Green Technology BMPs are designed to "intercept runoff from rooftops, parking lots and roads as close as possible to its source, and direct it into vegetative recharge/filtration facilities incorporated into the overall site design and runoff conveyance system." They include conservation site design, impervious area disconnection, conveyance of runoff through swales and biofiltration swales, filtration through filter strips, terraces, bioretention facilities, and recharge through infiltration facilities. www.swc.dnrec.delaware.gov/Pages/SedimentStormwater.aspx
Basin Sizer	The Basin Sizer program allows users to find information useful for sizing stormwater basins in California. It is built from the STORM model and performs continuous simulation. Elements sized include infiltration basins, detention basins, and flow-based BMPs. http://stormwater.water-programs.com/BasinSizer/Basinsizer.htm
City of Emeryville Stormwater Sizing Worksheet	This spreadsheet allows the user to size metered detention, bioretention, planter strip, flow-through planter box, and biofiltration BMPs. www.ci.emeryville.ca.us/planning/stormwater.html

In Practice: Predicting BMP performance using a BMP Decision Support System in Vermont

The Vermont Department of Environmental Conservation has developed a BMP Decision Support System (BMP-DSS) to facilitate stormwater permit issuance and compliance under the state's stormwater regulation. The BMP-DSS is an innovative decision-making tool for evaluating placement and selection of BMPs and LID techniques at strategic locations in urban watersheds. It uses GIS technology, integrates BMP process simulation models, and applies system optimization techniques for BMP placement and selection to address the cost/benefit issues associated with stormwater management. The model provides the continuous simulation of hydrographs and pollutant loads and concentrations so that the effectiveness of LID approaches can be simulated within large-scale watersheds models such as HSPF and SWMM. It offers the user the flexibility to design stormwater structural practices such as bioretention cells, rain barrels, roof gardens, vegetated swales, infiltration chambers, wetlands and off-line regional stormwater retention and detention ponds. It also includes the simulation of site design characteristics such as storm drains, building density, road and sidewalk dimensions, disconnection of impervious surfaces, and compares BMP controls against some defined benchmark such as a simulated predevelopment condition.

In Practice: Predicting BMP performance using a Site Evaluation Tool in the Upper Neuse River Basin, North Carolina

The Upper Neuse River Basin Association (UNRBA), made up of 13 city and county governments in the Triangle region of North Carolina, works to protect water resources within the 770-square-mile watershed above Falls Lake dam. Critical issues in the watershed are risk of nutrient enrichment in water supply reservoirs and effects on stream aquatic life from sediment loading and stream channel erosion. The Upper Neuse Site Evaluation Tool (SET) was developed under the guidance of many of the participating governments that were interested in a tool that could be used for both UNRBA goals and for local stormwater programs. This version of the SET included the ability to predict storm event peak flows and hydrographs, with scoping-level assessment of BMP influence on the storm event hydrographs. Model output was also tailored to assess site performance against variable nutrient loading rate goals on the basis of the user's selection of the whether the site was residential or nonresidential and whether it was in a predefined urban versus rural zone.

5.2.2.2.3 Additional Screening Criteria

After researching candidate BMPs with regard to the effect on the pollutant of concern, planners should have enough information to analyze each management opportunity using appropriate and locally applicable screening criteria (see example in Table 13). Screening criteria are typically based on pollutant type, source area(s), performance/effectiveness, capital and O&M costs, and so on.

Table 13. Example of screening criteria for stormwater management practices

Screening criteria	Description
Volume reduction/source controls	Consider the role volume plays in contributing to elevated pollutant loads. Determine the extent to which rate and volume of flow can be retained or reduced on-site.
Location of the management practice within the critical area/watershed landscape	Check to see if the candidate management practice can help implement the load reductions that were identified in one of the critical areas of the watershed.
Estimated load reductions	Using the information you collected during desktop and field scoping, document whether the anticipated load reduction is low, medium, or high.
Legal and regulatory requirements	Identify legal or regulatory requirements for projects, and determine whether any pose significant constraints.
Property ownership	Determine the numbers of property owners that need to agree to installation or implementation of the management practice(s). It is often easier to obtain easements on lands in public ownership.
Site access	Consider whether you will be able to physically access the site and identify a contact to obtain permission if private property must be traversed to access the site. Consider whether maintenance equipment (e.g., front-end loaders, vacuum trucks) will be able to reach the site safely. Designs and cost estimates might require adjustment if a structural control requires hand-cleaning because of maintenance access constraints.
Added benefits	In addition to their intended design, management practices can also provide secondary benefits by controlling other pollutants, depending on how the pollutants are generated or transported. For example, practices that reduce erosion and sediment delivery often reduce phosphorus losses because phosphorus is strongly adsorbed to silt and clay particles.
Unintended effects	In some cases, management practices that are used to control one pollutant could inadvertently increase the generation, transport, or delivery of another pollutant.

Screening criteria	Description
Physical factors	There are many physical factors that can determine whether you will be able to install management practices. Look for constraints such as steep slopes, wetlands, high water tables, and poorly drained areas. Also look for opportunities such as open space, existing management practices that can be upgraded, outfalls where management practices could be added, and well-drained areas.
Infrastructure	Look for sites that have few utilities, road crossings, buried cables, pipelines, parking areas, or other significant physical constraints that could preclude installation or cause safety hazards.
Costs	The appropriateness of a management practice for a site can be affected by economic feasibility considerations that encompass short- and long-term costs. Short-term costs include installation costs, while long-term costs include continued O&M.
Social acceptance	Consider how nearby landowners will perceive the management practice. Will it cause nuisances such as localized ponding of water or vector control problems? Can these issues be addressed in the siting and design of the practice? How can nearby residents be involved in selecting and designing the practice to address their concerns? The optimal method for evaluating site feasibility for both riparian and upland management practices is through a site visit.

5.2.2.2.4 BMP Site Selection

In most instances, it is likely that sources acting as stormwater planners, rather than TMDL and permit writers or other entities at the state or EPA Regional level, will focus on identifying the most appropriate geographic location for siting and installing structural BMPs or conducting nonstructural BMPs. Factors affecting BMP siting decisions might include local conditions such as slopes, soils, and critical areas; historical, current, and future land uses; property ownership; cost; site access; infrastructure considerations; and social acceptance. Therefore, state or EPA Regional stormwater planners should either work closely with sources if the strategy includes making siting recommendations or consider leaving siting decisions to sources altogether.

Stormwater planners can use, recommend, or require desktop and field reconnaissance to scope the possible additional BMPs appropriate for addressing the pollutants of concern and the potential geographic locations for implementing these additional BMPs. This information can be gathered during the initial phase of determining the location of existing BMPs. The reconnaissance usually involves locating and mapping the likely source areas for the TMDL listed pollutants, identifying candidate BMPs that might be used to address them, and screening possible BMP installation sites—or, in the case of nonstructural BMPs (e.g., erosion control, pavement sweeping, IDDE, materials management)—scoping potential policy practices to address the problems identified.

After identifying pollutant sources cited in the TMDL, stormwater planners might consider recommending areas where appropriate management measures can likely implement the greatest pollutant load reductions, or requiring sources to identify these areas. These so-called *critical areas* are at or near pollutant source areas, and could include places with severe upland or channel erosion, sites generating oil and grease or other toxics, extensively paved subwatersheds or small catchments requiring runoff volume controls, areas with a high density of illicit connections, parks that generate significant bacteria loads from pets, industrial facilities generating high pollutant loads, and similar locations.

Stormwater treatment via multiple, consecutive BMPs can significantly improve the quality of water discharged to urban rivers, lakes, streams, wetlands, and coastal waters. In general, stormwater treatment

trains should seek to address source controls and infiltration, evapotranspiration and reuse first, then large particles, and, finally, small particles. The specific pollutant removal role of the second or third facility in a treatment train often assumes that significant settling or removal of solids has already occurred. For example, phosphorus removal using a two-facility treatment sequence relies on the second facility (e.g., sand filter) to remove a finer fraction of solids than those removed by the first facility. Oil control facilities must be upstream of treatment facilities and as close to the source of oil-generating activities as possible. They should also be upstream of detention facilities, if possible.

5.2.3. Monitoring and Assessing Implementation Progress (Key Questions 4-5)

After identifying the suite of BMPs appropriate for addressing the remaining pollutant load reduction to implement the WLA, stormwater planners will need to rely on the sources to undertake the necessary steps to implement the final set of BMPs. At this point, stormwater planners can provide recommendations and requirements that focus on assessing BMP performance to determine if the additional controls are producing the expected pollutant load reductions. To accomplish this, stormwater planners should consider what recommendations and requirements can promote iterative improvements using an adaptive management framework. The key questions that planners should help sources answer include the following:

4. How should permittees measure BMP performance as implementation proceeds?

5. Are measured pollutant load reductions adequate to make progress toward the assigned WLA?

5.2.3.1. Answering Key Question 4: Monitoring and Assessing Implementation of Additional BMPs

This set of questions summarizes the basic activities related to conducting an adaptive management approach. It is important to remember that the ultimate goal of stormwater management driven by implementing a WLA is to meet the water quality criteria associated with the designated use(s) of the relevant waterbody. The iterative approach of stormwater management implementation allows for sources to make progress toward that goal over time. Therefore, it is imperative that stormwater planners provide sources with recommendations and requirements related to assessing the performance of BMPs and overall SWMPs and SWPPPs and how to use assessment information to make meaningful changes to management strategies that can ensure further progress.

Stormwater planners can generate monitoring and assessment recommendations and requirements that can encourage sources to periodically evaluate BMP implementation and review monitoring and assessment information to track progress toward implementing WLAs. To comprehensively evaluate implementation activities, stormwater planners need to consider a combination of both process and

> ***Tip: Consider best placement of treatment trains***
>
> There is some uncertainty regarding whether treatment facilities should be placed upstream or downstream of detention facilities that are needed for flow control purposes. In general, all treatment facilities can be installed upstream of detention facilities, although presettling basins are needed for sand filters and infiltration basins. However, not all treatment facilities can function effectively if located downstream of detention facilities. Those facilities that treat unconcentrated sheet flows, such as filter strips and narrow biofilters, are usually not practical downstream of detention facilities because of a variety of factors, including the sheer volume that must be treated.

summative analyses. A process analysis is one that tracks progress, assesses the quality of data relative to measurement quality objectives (i.e., whether the data are of sufficient quality to answer the monitoring question), and provides early feedback on trends, changes, and problems in the watershed. The summative analysis is more intensive and determines the status, changes, trends, or other issues that measure the environmental response to BMP implementation, as well as overall SWMP and SWPPP implementation.

The California Stormwater Quality Association (CASQA) developed the *Municipal Stormwater Program Effectiveness Assessment Guidance* (CASQA 2007) to assist municipal stormwater program managers in designing and conducting program effectiveness assessments using a range of assessment methods. The document also describes how to use these methods on the basis of program-specific desired outcomes and goals. Figure 21 (labeled Figure 2 in the CASQA guidance document) shows the outcome levels described with associated effectiveness assessments. Levels 1 to 4 are evaluated through *Implementation Assessments* and Levels 5 to 6 are evaluated through *Water Quality Assessments*. An MS4 would typically use Levels 1-4 to determine if programmatic targets or goals are being met.

Evaluations like the ones described in the CASQA document or those typically conducted by permitting authorities to determine an MS4's compliance with permit requirements and SWMP obligations typically do not *quantify* the level of effectiveness. They typically assess whether the MS4 is meeting the goals of the permit to the MEP. (For a discussion of MEP, see Chapter 2) This quantification or characterization in a manner that can be compared to the goals in a TMDL is the greatest challenge when trying to determine if an MS4 program is making progress toward a WLA. The best, most appropriate method to accomplish this can vary greatly among MS4s according to the types of BMPs and pollutant being limited by the TMDL.

> ***Resources:*** For more information on stormwater program evaluation, refer to the Resources list at the end of this chapter in Section 5.3.7.

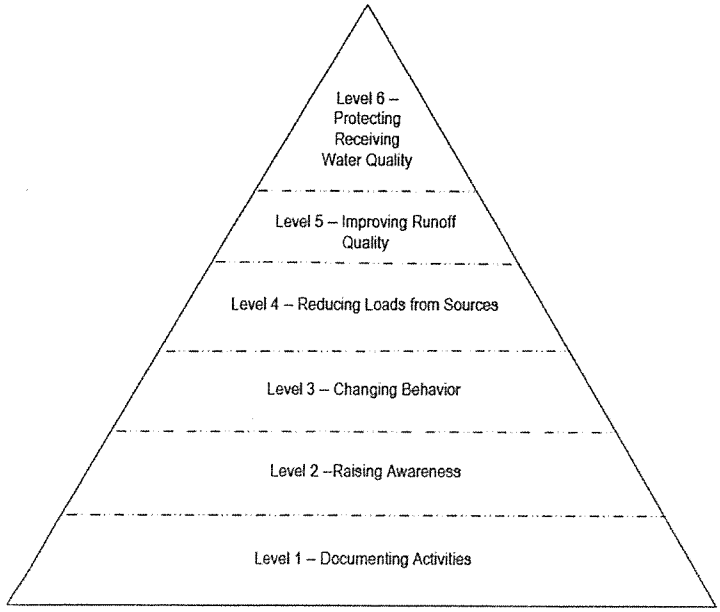


Figure 21. Approaches to evaluating storm water program effectiveness. (Source: CASQA 2007)

In Practice: Developing a Monitoring Program to Assess BMP Effectiveness in Addressing Pathogens in the Middle Rio Grande, New Mexico (2002)

Middle Rio Grande TMDL for fecal coliform recommends that MS4s, "[d]evelop and implement a monitoring program to assess BMP effectiveness and to compare loadings to the targets." The Albuquerque MS4 permit, based on this recommendation in the TMDL, requires the city to develop a monitoring program to track trends in fecal coliform and BMP effectiveness to track compliance with the TMDL WLA; to use an adaptive management approach by implementing revisions to the required programs if deemed necessary on the basis of monitoring data; and to develop and submit BMP evaluations and assessments, as well as an Annual TMDL Progress Report that summarizes monitoring results and includes computations of annual percent reduction achieved from the baseline loads and comparisons with the target loads.

In Practice: Working with Stakeholders on Adaptive Management for Swamp Creek, Washington

The Swamp Creek TMDL (2006) includes language that requires the Washington Department of Ecology to annually meet with municipal stakeholders to, "share information on the state of water quality in the watershed and status of implementation activities. Water quality data, trends (where applicable), regulatory changes, new and innovative concepts, and funding sources will be discussed to evaluate the overall status of the TMDL. Ecology will solicit input from the workgroup at this time to help direct the adaptive management of this TMDL. Ecology will track implementation no less than annually using the tracking table in Appendix E and through municipal stormwater permit program audits."

In Practice: Permit Requirements for Establishing Pollutant Load Reduction Benchmarks for Columbia Slough, Oregon

The Columbia Slough TMDL (1998) states that monitoring and implementation of BMPs will be done by MS4s to comply with the BOD_5 WLA. The Phase I MS4 permit for the city of Gresham, city of Fairview, and Multnomah County specifies BMP requirements to implement the WLA to the MEP. The Oregon Department of Environmental Quality created an MS4 permit benchmarking approach that applies to all TMDL parameters for which stormwater WLAs were established. Benchmarks are estimates of future pollutant load reductions. The permit requires that the benchmarks and necessary BMPs be included in the MS4 SMWP. The permit defines a benchmark as follows:

> A benchmark is a total pollutant load reduction estimate for each parameter or surrogate, where applicable, for which a WLA is established at the time of permit issuance. A benchmark is used to measure the overall effectiveness of the stormwater management plan in making progress toward the WLA (this estimate will be related to the statistical variability of the underlying data and may be stated as a range), and is intended to be a tool for guiding adaptive management activities. A benchmark is not a numeric effluent limit; rather it is a goal that is subject to the maximum extent practicable standard. The co-permittee must provide the rationale for the proposed benchmark, which includes an explanation of the relationship between the benchmarks and the TMDL wasteload allocations. Any limiting factors related to the development of a benchmark, such as data availability and data quality, must also be included in this rationale.

The Phase I permit requires that a monitoring plan be designed to track the long-term progress of the SWMP toward achieving improvements in receiving water quality, including progress toward implementing pollutant load reduction benchmarks associated with TMDL constituents. This requirement is addressed with the ambient and outfall monitoring that is conducted, and assessed as part of the data evaluation and reporting components of the program that occur during each permit renewal application. The permit also requires that results of the monitoring be used to support the adaptive management process and lead to refinements of the SWMP.

To ensure a successful adaptive management process, both water quality and BMP performance monitoring data should be assessed fairly frequently (e.g., as part of the SWPPP/SWMP evaluation process). Progress reports and regular team meetings are two effective ways to accomplish this. Even though frequent evaluations of BMP performance and water quality data might seem demanding, early indications of trends or problems can prevent major future problems.

The best use of monitoring data can depend on a variety of factors, including the type of permittee, geographic size of the permittee and the impairment(s). However, there are three basic types of monitoring that could be used—BMP monitoring, outfall monitoring, and receiving water monitoring.

- **BMP Monitoring.** There are several options for assessing BMP performance, including BMP monitoring. The University of Minnesota's *Assessment of Stormwater Best Management Practices* provides a process for developing and implementing a BMP assessment program that includes four levels of assessment: (1) visual inspections, (2) capacity testing, (3) synthetic runoff testing, and (4) monitoring. Monitoring is considered the most accurate method for assessing BMP volume reduction, peak flow reduction, and pollutant removal efficiency. Procedures for each level of BMP assessment can vary by the type of BMP. As previously stated, certain types of structural BMPs lend themselves well to direct monitoring (e.g., discharge from a stormwater pond). Data from these types of BMPs should be collected to the extent possible and used to determine if the BMPs are performing as expected and if this is adequate. If there is a large number of BMPs, it will likely be more appropriate to sample a representative number and extrapolate the results to the rest.

  Resources: For more information on BMP monitoring, refer to the Resources list at the end of this chapter in Section 5.3.8.

- **Outfall Monitoring.** Permittees of small geographic size (i.e., construction project or industrial facility) with few outfalls might be able to monitor the effluent and directly measure whether the facilities' contribution has been reduced adequately to implement the applicable WLA. Monitoring outfalls of large permittees (i.e., MS4s) might not provide any useful data for adaptive management of specific BMPs but could help to determine geographic areas or isolated land use types that might need further attention if the monitoring reveals inadequate progress toward TMDL goals. Data from outfall monitoring can also serve as an indicator to determine if more structural or nonstructural BMPs are needed in the area contributing flow to the outfall (e.g., data from one outfall demonstrates inferior BMP performance versus other outfalls).

  Resources: For more information on stormwater outfall monitoring, refer to the Resources list at the end of this chapter in Section 5.3.9.

- **Receiving Water Monitoring.** Because the ultimate purpose of the TMDL and subsequent implementation efforts is to improve receiving water quality, it might be in the best interests of permittees to conduct their own ambient monitoring. For example, larger permittees with adequate resources could regularly monitor receiving water to evaluate trends, confirm significant sources, and potentially update and improve existing models. As previously described, the CASQA *Municipal Stormwater Program Effectiveness Assessment Guidance* provides information on water quality assessments to help determine what effect BMPs are having on receiving water quality. A list of other monitoring-related resources is also provided at the end of this section.

  Resources: For more information on receiving water monitoring, refer to the Resources list at the end of this chapter in Section 5.3.10.

In Practice: Using Receiving Water Monitoring to Demonstrate Progress in the Los Angeles River, California

Receiving water monitoring is required to demonstrate a permittee is implementing the WLAs in the Los Angeles River and Tributaries Metals TMDL. This TMDL includes an implementation plan which states the following:

> Each municipality and permittee will be required to meet the storm water waste load allocations shared by the two MS4s and Caltrans permittees at the designated TMDL effectiveness monitoring points. [...] The MS4 and Caltrans stormwater NPDES permittees will be found to be effectively meeting dry-weather waste load allocations if the in-stream pollutant concentration or load at the first downstream monitoring location is equal to or less than the corresponding concentration- or load-based waste load allocation. Alternatively, effectiveness of the TMDL may be assessed at the storm drain outlet based on the waste load allocation for the receiving water. For storm drains that discharge to other storm drains, the waste load allocation will be based on the waste load allocation for the ultimate receiving water for that storm drain system. The MS4 and Caltrans stormwater NPDES permittees will be found to be effectively meeting wet-weather waste load allocations if the loading at the downstream monitoring location is equal to or less than the wet-weather waste load allocation.

5.2.3.2. Answering Key Question 5: Determining Whether Implementation Progress is Adequate

After quantifying the pollutant load reduction gains made through implementing existing and additional BMPs, stormwater planners should assist sources in determining if the current SWMP and SWPPP are adequate to implement the WLA over time. To answer this question, however, both stormwater planners and sources need guidance or criteria for judging progress, information that ideally should be first presented in the TMDL and permit. Therefore, TMDL and permit writers should consider how to define progress, which is likely to vary by pollutant, permittee type, and other potential factors such as compliance determination methods by the permitting authority.

Options for defining progress toward implementing the WLA are as follows:

- Demonstrating pollutant load reductions by an agreed on date
- Demonstrating pollutant concentration reductions by a particular date
- Implementing a set of prescribed BMPs with specific performance standards by a particular date
- Complying with the permit SWMP or SWPPP requirements during the permit term

Stormwater planners should be aware that current TMDLs and permits use a variety of these approaches to define progress, while still other TMDLs and permits remain silent on the issue of progress. If the TMDL and the permit do not provide a definition of how to determine progress, stormwater planners can consider developing recommendations and requirements to help sources create and justify their own progress milestones or benchmarks. Stormwater planners can specify the nature of the benchmarks (e.g., quantifiable) and determine supporting information sources should submit to justify and verify the validity and accuracy of the selected benchmarks. Most importantly, TMDL and permit writers need to remember the iterative, dynamic nature of SWMP and SWPPP implementation when crafting TMDL and permit requirements. Where possible, defining a framework approach, including goals, for assessing progress and allowing the sources to determine the details (with adequate evaluation through the SWMP and SWPPP) is going to be more useful than trying to identify a detailed approach at the state level.

(Chapter 6 provides a brief discussion on compliance schedules—an important factor to consider when evaluating overall progress.)

In Practice: Including Specific Criteria for Assessing Progress in the Los Angeles MS4 Permit

The Santa Monica Bay Beaches dry weather bacteria TMDL is expressed in terms that are directly applicable to MS4s and the associated WLA is included in the Los Angeles MS4 permit. This provides the permittees a clear understanding of what must be accomplished to implement the WLA. The permit language (Provision 29 of Order 01-182) is as follows:

> The Waste Load Allocations (WLAs) in the Dry Weather Bacteria TMDL are expressed as the number of allowable days that the Santa Monica Bay beaches may exceed the Basin Plan water quality objectives for protection of Water Contact Recreation (REC-1) in marine waters, specifically the water quality objectives for bacteria.... Tables 7-4.1, 7-4.2a, and 7-4.3 of the [Los Angeles River] Basin Plan set forth the pertinent provisions of the Dry Weather Bacteria TMDL. They require that during Summer Dry Weather there shall be no exceedances in the Wave Wash of the single sample or the geometric mean bacteria objectives set to protect the Water Contact Recreation (REC-1) beneficial use in marine waters. Accordingly, a prohibition is included in this Order barring discharges from a MS4 to Santa Monica Bay that result in exceedance of these objectives. Since the TMDL and the WLAs contained therein are expressed as receiving water conditions, Receiving Water Limitations have been included in this Order that are consistent with and implement the zero exceedance day WLAs.
>
> [Provision 32] These Receiving Water Limitations apply at the compliance monitoring sites identified in the Santa Monica Bay Beaches Bacterial TMDLs Coordinated Shoreline Monitoring Plan dated April 7, 2004.1 Compliance with the Receiving Water Limitations shall be determined using shoreline monitoring data obtained in conformance with the Santa Monica Bay Beaches Bacterial TMDLs Coordinated Shoreline Monitoring Plan dated April 7, 2004.

In Practice: Allowing Sources to Establish Benchmark Values for Pollutants in the City of Gresham, Oregon

The MS4 permit for the City of Gresham requires that the permittees develop benchmark values for applicable TMDLs. The permit language is as follows:

> Schedule D.2.(d)
>
> i) Progress toward reducing TMDL pollutant loads must be evaluated by the co-permittee through the use of performance measures and pollutant load reduction benchmarks developed and listed in the SWMP.
>
> (1) ...
>
> (2) A benchmark is a total pollutant load reduction estimate for each parameter or surrogate, where applicable, for which a [Waste Load Allocation] WLA is established at the time of permit issuance. A benchmark is used to measure the overall effectiveness of the storm water management plan in making progress toward the wasteload allocation (this estimate will be related to the statistical variability of the underlying data and may be stated as a range), and is intended to be a tool for guiding adaptive management activities. A benchmark is not a numeric effluent limit; rather it is a goal that is subject to the maximum extent practicable standard. The co-permittee must provide the rationale for the proposed benchmark, which includes an explanation of the relationship between the benchmarks and the TMDL wasteload allocations. Any limiting factors related to the development of a benchmark, such as data availability and data quality, must also be included in this rationale. The Interim Evaluation Report City of Gresham & Co-permittees (May 1, 2006, 4.0 Benchmark Evaluation for Gresham) summarizes the benchmarking process developed by the City of Gresham for TMDLs within the Columbia Slough.

In Practice: Specifying Pollutant Concentrations and BMPs Necessary to Make Adequate Progress in Oregon

The state of Oregon includes two options in the general permit for construction activities (www.deq.state.or.us/wq/stormwater/constappl.htm) that must be implemented to meet the goals of any turbidity or sediment TMDL—either meeting a benchmark concentration in the runoff established by the permitting authority or implementing a set of BMPs specific to the pollutant of concern. The exact permit language follows:

> 2. Water Quality Requirements for TMDL and 303(d) Listed Waterbodies
>
> In addition to other applicable requirements of this permit, if sediment or turbid water from a permit registrant's construction project has the potential to discharge into waterbodies that are listed for turbidity or sedimentation on the most recently EPA-approved Oregon 303(d) list or that have an established Total Maximum Daily Load (TMDL) for sedimentation or turbidity, the permit registrant must implement one of the two following sets of actions, in accordance with Schedule C.
>
> a. Option #1: Collect and analyze samples for turbidity in stormwater runoff from the construction site as required by Condition B.2. (p. 12) and compare the results to the benchmark value of 160 Nephelometric Turbidity Units (NTUs). The benchmark is used to determine if best management practices are effective; it is not an effluent limit. If any stormwater sample exceeds the benchmark, then the permit registrant must evaluate the best management practices (BMPs) and the adequacy of the ESCP and take corrective actions. If after such actions have been implemented and sample results still exceed the 160 NTU benchmark, the requirements of Option #2 below must be followed, and the permit registrant must submit an Action Plan to the department identifying the selected BMP(s) that will be implemented and the rationale for choosing the selected BMP(s).
>
> b. Option #2: In addition to the applicable BMPs required by Condition A.7., implement one or more of the following BMPs to control and treat sediment and turbidity:
>
> i. Compost berms, compost blankets, or compost socks;
>
> ii. Erosion control mats (rolled or blown);
>
> iii. Tackifiers used in combination with perimeter sediment control BMPs;
>
> iv. Established vegetated buffers sized at 50 feet plus 25 feet per 5 degrees of slope;
>
> v. Water treatment by electro-coagulation, chemical flocculation, or filtration; or
>
> vi. Other substantially equivalent sediment or turbidity BMP approved by the department.
>
> The selected BMP(s) must be specifically identified in the ESCP [erosion and sediment control plan] as addressing this condition of the permit, and the rationale for choosing the selected BMP(s) must also be provided.

In this example, the permittee has two choices for demonstrating that the construction project is implementing the goals of the TMDL. The permittee would either need to apply Option A and monitor the effluent per the requirements of the permit to show that the benchmark turbidity value is being met at the construction project. Or the permittee would need to demonstrate through inspection reports, that the BMPs required in a basic SWPPP as well as the additional BMPs defined by Option B are implemented and operating as designed on the site.

5.2.4. Adjusting Implementation for Continuous Improvements (Key Question 6)

Adaptive management focuses on learning from the information gathered through monitoring and assessment and making changes to implementation strategies on the basis of the information collected. Sources can continue to implement BMPs, as well as overall SWMPs and SWPPPs, if the information gathered through the process and summative analyses show the necessary progress toward implementing the WLA. If progress is not adequate, planners should develop recommendations and requirements that will allow sources to answer key question 6:

5.2.4.1. Answer Key Question 6: Identifying Modifications to Implementation Strategy

Because the adaptive management approach is not linear but iterative, TMDL and permit writers can develop recommendations and requirements for sources that focus on taking the information from key questions 4 and 5 to adjust the current implementation strategy. This could entail conducting an efficiency audit of existing BMPs to determine if they are properly installed, operated, and maintained, or recommend that sources identify the most effective BMPs after a set number of years of operation (so that these most effective BMPs are used in the future). In addition, modifications could involve revisiting key question 3 to determine if additional BMPs are necessary to make continuous improvements. Adaptive management actions might include retrofitting or adjusting previously installed BMPs that are not performing as expected or compiling lessons learned from implementation activities to help in future implementation planning.

It is important to note that permit writers include requirements that can facilitate adaptive management activities in existing individual and general stormwater permits, such as recording keeping and reporting requirements associated with inspections and, where applicable, monitoring activities. For example, construction stormwater permits might include requirements to conduct weekly stormwater monitoring and visual BMP inspections; where information from these activities show BMPs are not performing adequately, stormwater sources must modify the SWPPP accordingly. MS4 stormwater permits contain requirements for developing annual SWMP reports that assess the performance of BMPs and include detailed information on planned modifications. While these permit requirements might not have an explicit link to WLAs, sources should already have experience in collecting and analyzing performance information and applying that information to improve the effectiveness of SWPPPs and SWMPs.

5.3. Resources

5.3.1. BMP Inventory

1. USEPA (U.S. Environmental Protection Agency). 2007. *Municipal Separate Storm Sewer System (MS4) Program Evaluation Guidance*. U.S. Environmental Protection Agency, Office of Wastewater Management. EPA-833-R-07-003 (field test version) www.epa.gov/npdes/pubs/ms4guide_withappendixa.pdf and www.epa.gov/npdes/pubs/ms4guide_appendicesb-d.pdf

This document is available to assist in assessing the compliance and effectiveness of Phase I and Phase II MS4 stormwater programs, including compiling a comprehensive BMP inventory. Sources can also use this document to conduct self-audits of SWMPs.

5.3.2. BMP Selection

1. ASCE (American Society of Civil Engineers). 2001. *Guide for Best Management Practice Selection in Urban Developed Areas*. American Society of Civil Engineers, Reston, VA. www.asce.org/bookstore/book.cfm?book=4058

   This guide examines permanent structural techniques which can be used for retrofitting the stormwater management systems in existing developed areas.

2. Washington Department of Ecology. 2005. *Stormwater Management Manual for Western Washington*. Washington Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/wq/stormwater/manual.html

   This manual focuses on the applicability, technical design, construction, and maintenance of a range of stormwater management practices for use in western Washington to achieve water quantity and water quality control.

3. Maryland Department of the Environment. 2000. *Maryland Stormwater Design Manual*. Maryland Department of the Environment, Baltimore, MD. www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

   This manual focuses on the applicability, technical design, construction, and maintenance of a range of stormwater management practices for use in Maryland to achieve water quantity and water quality control.

4. New Jersey Department of Environmental Protection. 2004. *New Jersey Stormwater Best Management Practices Manual*. New Jersey Department of Environmental Protection, Trenton, NJ. www.njstormwater.org/bmp_manual2.htm

   This manual focuses on the applicability, technical design, construction, and maintenance of a range of stormwater management practices for use in New Jersey to achieve water quantity and water quality control.

5. University of Wisconsin – Extension. 2000. *Wisconsin Stormwater Manual: Technical Design Guidelines for Stormwater Management Practices*. University of Wisconsin Extension, Madison, WI. http://learningstore.uwex.edu/Wisconsin-Storm-Water-Manual-P603C123.aspx.

   This manual focuses on the applicability, technical design, construction, and maintenance of a range of stormwater management practices for use in Wisconsin to achieve water quantity and water quality control.

6. Center for Watershed Protection. 2003-2008. Urban Subwatershed Restoration Manual Series. Center for Watershed Protection, Ellicott City, MD. www.cwp.org/Store/usrm.htm.

This 11 manual series covers the seven major practices used to restore urban watersheds: stormwater retrofits, stream repair, riparian management, discharge prevention, pollution source controls, watershed forestry and municipal operations. In addition, the series outlines new methods for desktop and field assessment and stakeholder management to develop effective small watershed restoration plans, and presents an integrated framework for urban watershed restoration.

5.3.3. Volume Control

1. Zomodi, K. 2007. *Effectiveness of Time of Concentration Elongation on Peak Flow Reduction.* 2nd National Low Impact Development Conference, March 12–14, 2007. www.bae.ncsu.edu/topic/lidconference07/A6/A6.4.Effectiveness%20of%20Time%20of%20Concentration%20Elongationon%20on%20Peak%20Flow%20Reduction.pdf

   This presentation discusses the findings of a study intended to theoretically evaluate the relative impact of time of concentration elongation on peak flow reduction under typical conditions of LID use.

2. Stein, Eric D. 2005. *Effect of Increases in Peak Flows and Imperviousness on Stream Morphology of Ephemeral Streams in Southern California.* Technical Report 450. Southern California Coastal Water Research Project, Westminster, CA. www.environmental-expert.com/files/19961/articles/4562/4562.pdf.

   This technical report investigates the effects of urbanization on ephemeral or intermittent streams in Southern California. The study seeks to (from the document) establish a stream channel classification system for Southern California streams, assess stream channel response to watershed change, develop deterministic/predictive relationship between changes in IC and stream channel enlargement and provide a conceptual model of stream channel behavior that may be used as the basis for a future numeric model. Eight watersheds and eleven sites were selected for study.

5.3.4. Green Infrastructure and Low Impact Development

1. Horner, R., C. May, E. Livingston, D. Blaha, M. Scoggins, and J. Tims. (n.d.). *Structural and Non-Structural BMPs for Protecting Streams.* Watershed Management Institute, Crawfordsville, FL. www.chesterfield.gov/CommunityDevelopment/Engineering/LIDGrant/Studies/HornerMay2001Paper.pdf

   This paper presents findings from a study of the effects of non-structural BMPs, including riparian buffers and retention of natural wetlands, on three stream ecosystems to help guide application of these practices in low-impact urban design.

2. Kloss, C, and C. Calarusse. 2006. *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows.* Natural Resources Defense Council, New York City, NY. www.nrdc.org/water/pollution/rooftops/contents.asp

This policy guide provides decisionmakers with ideas on how to incorporate green strategies into urban landscapes to address the effects of wet weather on water quality. Includes nine case studies.

3. USEPA (U.S. Environmental Protection Agency). 2008. *Incorporating Green Infrastructure Concepts into Total Maximum Daily Loads.* U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/owow/tmdl/stormwater/

   This 11 page fact sheet provides recommendations for incorporating GI and LID concepts into various elements of a TMDL and provides two TMDL case studies.

5.3.5. BMP Performance Literature Values

1. American Society of Civil Engineers' (ASCE) and EPA's International Stormwater BMP Database: www.bmpdatabase.org/

   The database contains more than 300 BMP studies, performance analysis results, tools for use in BMP performance studies, monitoring guidance and other study-related publications. The overall purpose of the project is to provide scientifically sound information to improve the design, selection, and performance of BMPs. Continued population of the database and assessment of its data will ultimately lead to a better understanding of factors influencing BMP performance and help to promote improvements in BMP design, selection and implementation.

2. FHWA (Federal Highway Administration). 2002. *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring.* Federal Highway Administration, Landover, MD. www.fhwa.dot.gov/environment/ultraurb/

   The purpose of this document is to provide a planning-level review of the applicability and use of new and more traditional BMPs in ultra-urban areas. The document presents data, design criteria, and monitoring study results on BMPs implemented in ultra-urban areas

3. Pitt, R.E., A. Maestre, and R. Morquecho. 2004. The National Stormwater Quality Database (NSQD, version 1.1). University of Alabama, Tuscaloosa, AL. http://unix.eng.ua.edu/~rpitt/Research/ms4/mainms4.shtml and http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm

   These stormwater quality data and site descriptions are to describe the characteristics of national stormwater quality, provide guidance for future sampling needs, and enhance local stormwater management activities in areas having limited data. The monitoring data was collected over nearly a 10-year period from more than 200 municipalities throughout the country. This project is creating a national database of stormwater monitoring data collected as part of the existing stormwater permit program, providing a scientific analysis of the data, and providing recommendations for improving the quality and management value of future NPDES monitoring efforts.

4. University of Massachusetts Amherst's Massachusetts Stormwater Technology Evaluation Project (MASTEP), Stormwater Technologies Clearinghouse: www.mastep.net/

   This searchable database contains validated performance data and technical information on innovative stormwater treatment technologies. The Technology Acceptance and Reciprocity

Partnership (TARP) protocol is the basis for evaluating treatment efficiencies for various pollutants and the Web site is designed to help stakeholders interpret information such as site and environmental considerations as well as whether performance studies meet the minimum TARP requirements. It also serves as a repository for test reports and performance data from a variety of sources.

5. Fraley-McNeal, F., T. Schueler, and R. Winer. 2008. National Pollutant Removal Performance Database Technical Brief (Version 3.0). Center for Watershed Protection, Ellicott City, MD. www.cwp.org/Resource_Library/Center_Docs/SW/bmpwriteup_092007_v3.pdf

   The updated database was statistically analyzed to derive the median and quartile removal values for each major group of stormwater BMPs. The data are presented as box and whisker plots for the various pollutants found in stormwater runoff.

6. EPA's Urban BMP Performance Tool: http://cfpub.epa.gov/npdes/stormwater/urbanbmp/bmpeffectiveness.cfm

   Based largely on data from the International Stormwater BMP Database, this tool allows users to search BMP study summaries based on the pollutants measured, BMPs examined, or total volume of stormwater runoff reduced. Search results are displayed in a tabular format sorted by effluent concentration, and additional details on each study can be accessed by clicking on the study title. The Urban BMP Performance Tool also includes background information about BMP performance, including basic information on understanding how BMP affect concentration, volume and total load.

7. University of New Hampshire Stormwater Center, Nonpoint Education for Municipal Officials (NEMO), Innovative Stormwater Management Inventory Database: www.erg.unh.edu/stormwater/index.asp

   This searchable and amendable database highlights innovative stormwater management techniques such as low impact design, used in New England. The database contains information on bioretention areas, green roofs, rain gardens, detention pond retrofits, tree filters, and constructed wetlands.

5.3.6. Model Applicability

1. USEPA. 2005. *TMDL Model Evaluation and Research Needs*. EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH. www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm

   This report documents the review of more than 60 available watershed and receiving water models for their applicability to TMDL development and implementation. It discusses model selection on the basis of model capabilities and provides a series of tables rating the capabilities or applicability the models using the categories of TMDL endpoints, general land and water features, special land processes, special water processes, and application considerations. The document also provides individual fact sheets for each reviewed model.

2. USEPA. 1997. *Compendium of Tools for Watershed Assessment and TMDL Development*. EPA 841-

B-97-006. U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC. www.epa.gov/owow/tmdl/comptool.html

This document reviews more than 50 watershed, receiving water and ecological assessment models. The document provides factsheets for each model that describes model components, methods, applications, pollutants addressed, limitations, input data requirements, and type of output. The document also contains information on model selection for specific applications, model calibration, and model verification.

3. USEPA (U.S. Environmental Protection Agency).2008. *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/nps/watershed_handbook/

Chapter 8 of this document focuses on methods for estimating pollutant loads, including the use of watershed models. This chapter provides assistance in selecting and applying watershed models to estimate pollutant loads from existing conditions.

5.3.7. Stormwater Program Evaluation

1. CASQA (California Stormwater Quality Association). 2007. *Municipal Stormwater Program Effectiveness Assessment Guidance*. California Stormwater Quality Association, Menlo Park, CA. www.casqa.org

This document provides stormwater managers with a variety of stormwater program assessment strategies and methods appropriate for different stormwater program elements and outcome levels.

2. USEPA (U.S. Environmental Protection Agency). 2007. *Municipal Separate Storm Sewer System (MS4) Program Evaluation Guidance*. U.S. Environmental Protection Agency, Office of Wastewater Management. EPA-833-R-07-003 (field test version) www.epa.gov/npdes/pubs/ms4guide_withappendixa.pdf and www.epa.gov/npdes/pubs/ms4guide_appendicesb-d.pdf

This document is available to assist in assessing the compliance and effectiveness of Phase I and Phase II MS4 stormwater programs, including compiling a comprehensive BMP inventory. Sources can also use this document to conduct self-audits of SWMPs.

5.3.8. BMP Monitoring

1. Washington Department of Ecology. 2008. *Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol* (revised). Publication # 02-10-037. Washington Department of Ecology, Olympia, WA. www.ecy.wa.gov/biblio/0210037.html

This document's primary purpose is to establish a testing protocol and process for evaluating and reporting on the performance and appropriate uses of emerging stormwater treatment technologies. This document is also intended for use in evaluating public domain practices possibly resulting in changes to the design standards for these practices in the state's *Stormwater Management Manual*.

2. University of Minnesota. 2008. *Assessment of Stormwater Best Management Practices*. University of Minnesota, St. Paul, MN. http://wrc.umn.edu/outreach/stormwater/bmpassessment/assessmentmanual/

   This manual provides information on four levels of a BMP assessment program and provides assessment procedures for source reduction BMPs, filtration practices, infiltration practices, sedimentation practices, and biologically enhanced practices.

3. TARP (Technology Acceptance and Reciprocity Partnership). 2003. *TARP Protocol for Stormwater Best Management Practice Demonstrations*. Final August 2001. Updated July 2003. www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/pdffiles/Tier2protocol.pdf

   This protocol describes a set of uniform criteria on evaluating stormwater BMP performance that is acceptable to the endorsing states (California, Massachusetts, Maryland, New Jersey, Pennsylvania, Virginia). The protocol primarily deals with the demonstration of BMPs that are designed for one or more of the following: (1) directing and distributing flows; (2) reducing erosive velocities; and (3) removing contaminants such as suspended or dissolved pollutants from collected stormwater through physical and chemical processes such as settling, media-filtering, ion-exchange, carbon adsorption, and precipitation.

4. Stricker, E., and M. Quigley (URS Greiner Woodward Clyde), ASCE (American Society of Civil Engineers), and USEPA (U.S. Environmental Protection Agency). 1999. *Determining Urban Stormwater Best Management Practice (BMP) Removal Efficiencies*. American Society of Civil Engineers, Urban Water Resources Research Council, City, ST, and U.S. Environmental Protection Agency, Office of Water, Washington, DC. www.bmpdatabase.org/docs/task3_1.pdf

   This technical memorandum provides an overview of methods for evaluating the efficiency, performance, and effectiveness of BMPs through analysis of water quality, flow, and precipitation data for monitored storm events as well as BMP design attributes collected and stored in the National Stormwater Best Management Practices Database.

5.3.9. Outfall Monitoring

1. USEPA (U.S. Environmental Protection Agency). 1992. *NPDES Stormwater Sampling Guidance Document*. EPA 833-B-92-001. U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/npdes/pubs/owm0093.pdf

5.3.10. Receiving Water Monitoring

1. Stormwater Monitoring Coalition's Model Monitoring Technical Committee. 2004. *Model Monitoring Program for Municipal Separate Storm Sewer Systems in Southern California. August 2004*. Technical Report #419. ftp://ftp.sccwrp.org/pub/download/PDFs/419_smc_mm.pdf

   This report describes a model monitoring program for receiving waters affected by urban runoff in both wet and dry weather.

2. USGS (U.S. Geological Survey). Variously dated. *National Field Manual for the Collection of Water-Quality Data*. U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9. U.S. Geological Survey, Reston, VA. http://pubs.water.usgs.gov/twri9A

This manual includes information and detailed descriptions of water quality sampling methods.

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1 Understanding the Connections Between TMDLs and Stormwater Permits
2 Identifying Opportunities to Coordinate TMDLs and Stormwater Permits
3 Characterizing Impairments and Stormwater Sources
4 Developing TMDLs with Stormwater Sources
5 Promoting Effective Stormwater Management
6 **Coordinating TMDLs and Stormwater Permits**

Chapter Six
Coordinating TMDLs and Stormwater Permits

What's included in this chapter

- ✓ Discussion of the type of permit requirements (e.g., water quality controls and effluent limitations, monitoring and adaptive management, reporting) that permit writers can develop with input from TMDL writers.
- ✓ Options for connecting TMDLs and stormwater permit language.

What you should know after reading this chapter

- ✓ Possible approaches for conveying TMDL-specific recommendations through a general permit without reopening the permit.
- ✓ Options for incorporating TMDL recommendations by reference into stormwater permits to create enforceable permit requirements.

Potential roles and responsibilities under this activity

If you are a TMDL writer

1. Work with permit writers to determine if stormwater permits will reference recommendations in TMDL reports and, where applicable, implementation plans.
2. Develop recommendations and other language for TMDL reports and, where applicable, implementation plans that stormwater permits can incorporate by reference.

If you are a stormwater permit writer

1. Work with TMDL writers to determine what recommendations TMDL reports and, where applicable, implementation plans will contain that stormwater permits can incorporate by reference.
2. Develop appropriate stormwater permit language that implements approved WLAs and are consistent with WLA assumptions.

6. COORDINATING TMDLS AND STORMWATER PERMITS

Improving the communication between TMDLs and permit writers can result in more effective implementation of TMDLs into stormwater permits. Considerations for developing a connection between the TMDL and the stormwater permit can include the following:

- What type of permit requirements (e.g., water quality controls and effluent limitations, monitoring, reporting) can permit writers consider to facilitate implementation of stormwater WLAs?
- How can permit writers, with information provided by TMDL writers, describe these elements?
- What can each programmatic document (e.g., TMDL reports or stormwater permits) say in relation to the other to facilitiate TMDL implementation?

As discussed in Chapter 1 of this Handbook, TMDLs include technical analyses that are not self-implementing. For point sources, permit limits that are consistent with the WLA are enforceable through NPDES permits. It is the permit writer's responsibility to interpret and incorporate information from the TMDL into permits, thereby turning them into enforceable requirements. Stormwater permit writers therefore can incorporate data and information provided in the TMDL directly into the permit, or can include information indirectly (e.g., reference sections of the TMDL. As a result, TMDLs and permitscan work in tandem to identify effective implementation methods and make progress toward restoring impaired waters.

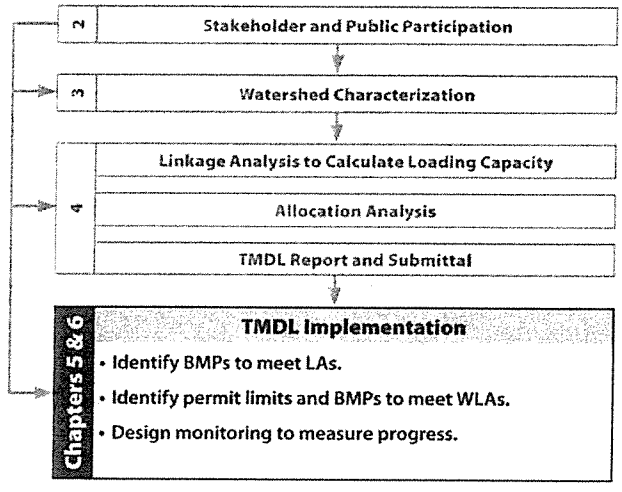


Figure 22. Illustration of the steps in the TMDL process, including activities related to TMDL implementation.

As shown in Figure 22, the step of TMDL implementation involves identifying and implementing management options to implement the LAs and WLAs. This chapter discusses ways to coordinate development of permit language with the information and data provided in the TMDL report to promote effective implementation of TMDLs through permits.

6.1. Options for Implementing TMDLs in Permits

Stormwater permit writers often consider TMDL-related information as they develop permit requirements such as applicability, implementing water quality controls through SWMPs and SWPPPs, developing a monitoring plan, reporting, and assessing progress. Under each of these permit elements, permit writers can consider a variety of options for expressing requirements related to TMDL implementation. The two primary types of stormwater permits—individual and general permits—can affect options and approaches for coordinating TMDL language with the permit.

Regulatory Requirements and EPA Guidance on Establishing Stormwater Permit Requirements to Implement WLAs

In the 2002 memorandum, *Establishing TMDL WLAs for Stormwater Sources and NPDES Permit Requirements Based on Those WLAs*, EPA provides regulatory requirements and guidance on how stormwater permit requirements should link to stormwater source WLAs under approved TMDLs. With regard to stormwater permit requirements, such as effluent limitations and monitoring, the 2002 memorandum states the following:

- NPDES permit conditions must be consistent with the assumptions and requirements of available WLAs. See 40 CFR 122.44(d)(1)(vii)(B).
- WQBELs for NPDES-regulated storm water discharges that implement WLAs in TMDLs may be expressed in the form of BMPs under specified circumstances. See 33 U.S.C. 1342(p)(3)(B)(iii); 40 CFR 122.44(k)(2)&(3). If BMPs alone adequately implement the WLAs, then additional controls are not necessary.
- EPA expects that most WQBELs for NPDES-regulated municipal and small construction storm water discharges will be in the form of BMPs, and that numeric limits will be used only in rare instances.
- When a non-numeric WQBEL is imposed, the permit's administrative record, including the fact sheet when one is required, needs to support that the BMPs are expected to be sufficient to implement the WLA in the TMDL. See 40 CFR 124.8, 124.9, and 124.18.
- The NPDES permit must also specify the monitoring necessary to determine compliance with effluent limitations. See 40 CFR 122.44(i). Where effluent limits are specified as BMPs, the permit should also specify the monitoring necessary to assess if the expected load reductions attributed to BMP implementation are achieved (e.g., BMP performance data).
- The permit should also provide a mechanism to make adjustments to the required BMPs as necessary to ensure their adequate performance.

Individual permits provide the permit writer with an opportunity to develop specific permit requirements because the permit focuses on one source, or a primary source and its co-permittees. As a result, permit writers can feasibly work with the TMDL writer in developing a permit that directly reflect elements of the TMDL analyses and, where available, implementation plans. This could include incorporating information provided in the TMDL directly into the permit. General permits apply to a broad category of sources in a geographic area. In most cases, general permits are statewide, but in some cases, permit writers can develop and issue general permits on a watershed-scale. While general permits provide permit writers with a degree of permitting efficiency, this type of permit may not provide the same opportunities for tailoring requirements and adding a level of specificity. To implement TMDLs through statewide general stormwater permits, permit writers can use broad requirements that direct sources to identify applicable TMDLs and modify their SWMPs or SWPPPs accordingly. Implementing TMDLs through watershed-scale general permits can provide permit writers with more flexibility to incorporate specific elements, such as BMP performance standards, that broadly apply to a group of sources. Permit writers could also add specificity into general permits to promote TMDL implementation, such as developing technical appendices that include TMDL-specific elements applicable to stormwater sources.

Categories of permits elements discussed in this section include determining applicability, water quality controls, and monitoring. These categories apply to both individual and general permits, although the approaches used in each category will vary depending on the type of permit. Each category contains a description of options based on real-world examples, and are available in the Appendix.

6.1.1. Requirements Related to Determining Applicability

Stormwater permits often require permittees to first determine if an existing TMDL is applicable to its discharge. The key questions for making this determination are:

1. Is there a discharge to an impaired waterbody with an approved TMDL?
2. Does the discharge include the pollutant of concern addressed in the approved TMDL?

One option for determining applicability requirements could be for a state that the source should make a determination on the basis of the knowledge of their location and discharges, and provide infomration on how to determine if a discharge goes to an impaired waterbody, such as a link to a Web site that provides lists of impaired waterbodies. Another option could be to provide more detailed information to sources to help them determine if they contribute to one or more impairments, where to go for more information on a specific TMDL, or to even include the applicable TMDL data and information in an appendix to the permit.

Applicability can go beyond whether the source is discharging to an impaired waterbody to determine if the discharge contributes to the impairment(s). A source might have a discharge to an impaired waterbody, but if the discharge does not contribute to the impairment(s) (e.g., does not contain the pollutant of concern) the additional controls related to the impaired waterbody might not apply. If permit writers want to use pollutant-specific considerations as a factor in determining applicability, there are various options to consider. One option could be for permit writers to limit permit coverage for sources that discharge to impaired waterbodies with impairments caused by pollutants commonly associated with that source. For example, permit writers could state that industrial facilities are not eligible for coverage under an industrial general permit if the facility discharges to an impaired waterbody with an approved TMDL for metals. Another option for permit writers could be to require sources to conduct discharge monitoring for a pollutant of concern or flow monitoring (or both) over a specified period of time to determine applicability. If the source can demonstrate that the discharge does not contribute to the impairment(s), the permit could then exempt the source from some or all additional TMDL implementation requirements.

In Practice: Requiring Sources to Determine Applicability in Tennessee

Tennessee's Phase II MS4 General Permit simply states that a permitted stormwater source must determine if any discharges go to an impaired waterbody. The permit states the following:

> Determine whether stormwater discharge from any part of the MS4 significantly contributes directly or indirectly to a 303(d) listed (i.e., impaired) waterbody. Water quality impaired waters means any segment of surface waters that has been identified by the division as failing to support classified uses.... If you have 303(d) discharges described above, you must also determine whether a Total Maximum Daily Load (TMDL) has been developed by the division and approved by EPA for the listed waterbody.

In Practice: Providing Applicable TMDL Requirements as a Permit Appendix in Washington

The state of Washington's final Phase II MS4 general permits for regulated small MS4s in eastern and western portions of the state compile the information permitted stormwater sources need to determine TMDL requirement applicability. Each permit contains a separate appendix that lists all the applicable TMDLs, the specific requirements, and a list of the potential permittees to which each of the TMDLs applies.

In Practice: Using Geographic Location to Determine Applicability for Georgia's Industrial General Permit

Georgia's Industrial General Permit contains applicability requirements that are based on a permitted stormwater source's geographic location, relative to an impaired stream segment. Permit language follows:

Any operator who intends to obtain coverage under this permit for storm water discharges associated with industrial activity into an Impaired Stream Segment, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment, identified as partially supporting or not supporting designated uses on Georgia's most current 303(d) list, must satisfy the requirements of Part III.C of this permit if the pollutant(s) of concern for which the Impaired Stream Segment has been listed may be exposed to storm water as a result of current or previous industrial activity at the facility. Those discharges that are within one (1) linear mile of an Impaired Stream Segment, but are not within the watershed of any portion of that stream segment are excluded from this requirement.

Georgia's 303(d) list is at www.gaepd.org.

In Practice: Identifying Pollutants of Concern in Permit Eligibility Requirements

Minnesota's CGP lays out what are the pollutants of concern for construction sites that discharge to impaired waterbodies. Construction site operators that want coverage under Minnesota's CGP must implement the applicable BMPs listed in the permit and any other specific implementation measures specified in the approved TMDL to which they are subject. The draft Minnesota CGP states the following:

> Discharges to waters identified as impaired pursuant to section 303 (d) of the federal Clean Water Act (33 U.S.C. § 303(d)) where the identified pollutant(s) or stressor(s) are phosphorus (nutrient eutrophication biological indicators), turbidity, dissolved oxygen, or biotic impairment (fish bioassessment, aquatic plant bioassessment and aquatic macroinvertebrate bioassessment), and with or without a U.S. Environmental Protection Agency (USEPA) approved Total Maximum Daily Load (TMDL) for any of these identified pollutant(s) or stressor(s)" must meet the applicable requirements of Part III.A.9, which include specific BMPs to limit these stressors.

6.1.2. Requirements Related to Identifying and Implementing Water Quality Controls

After EPA has approved a TMDL, permit writers must develop effluent limitations and permit conditions that are consistent with the assumptions and requirements of the approved WLA. In the context of stormwater permits, effluent limitations are most often expressed as BMPs, but permit writers can also use numeric limits (e.g., loads, concentrations, or performance standards). Effective TMDL implementation often relies on selecting the right mix of control measures to achieve progress toward addressing the WLA. Chapter 5 of this Handbook focuses on the technical resources and approaches for evaluating and selecting BMPs to implement the WLA.

Permit writers, in conjunction with information provided by TMDL writers, can consider a variety of approaches that involve either recommending BMPs or relying on sources to do the evaluation and selection on their own. Approaches for permit writers to consider are described below.

- **Requiring implementation of specific BMPs in the permit.** Under this option, permit writers could develop a proposed list of BMPs that a source could implement to reduce pollutant loadings to

implement the WLA. Permit writers could consider this approach when stormwater planners have conducted an internal analysis of possible BMPs. Given the resource-intensive nature of this option, this approach might be suitable for geographic areas that need certain types of BMPs (e.g., developing areas versus built-out areas of an MS4), or discreet sources (e.g., the only MS4 or construction site discharging to the impaired waterbody).

- **Providing a recommended menu of potential BMPs in the TMDL, implementation plan, or the permit for sources to evaluate and select.** This option is similar to the option described above in that TMDL and permit writers could develop a recommended list of BMPs. The difference between these options, however, is that this BMP list serves more as a menu of potential BMPs. Under this option, permit writers could provide some technical information related to each BMP to help sources evaluate and select appropriate BMPs. Sources would need to conduct a thorough analysis to select the appropriate suite of BMPs from the list to achieve progress toward implementing the WLA.
- **Referencing BMP performance standards in the TMDL, implementation plan, or the permit.** Under this option, TMDL and permit writers could recommend or reference performance standards for specific pollutants and allow sources to determine which BMPs will best meet the performance standard. One example might be a construction site must achieve a specific percent reduction in TSS, giving the source flexibility in the types of BMPs used to meet the standard. The TMDL and permit writer could provide recommendations on how sources could demonstrate that the selected BMPs can meet the required performance standards (e.g., using a combination of modeling and monitoring).
- **Recommending the selection of BMPs and developing benchmark values or performance measures.** This option has similarities to the option described above in that it focuses on the use of performance standards. However, under this option, permit writers could develop permit requirements that give sources the responsibility for developing the performance standards, often referred to in this context as benchmark values or performance measures. Permit requirements can focus on selecting BMPs to achieve progress toward implementing the WLA and developing performance measures that indicate the expected level of BMP performance. Beyond BMP performance, requirements can focus on developing quantifiable benchmarks that track the overall success of SWMPs and SWPPPs in reducing pollutant loads. If permit writers choose this option, it is important to note that sources might have concerns about compliance implications associated with benchmark values and performance measures. As a result, permit writers might want to consider developing permit language that specifies the intended use of performance measures and benchmark values—not as numeric effluent limits but as guideline values to facilitate adaptive management.
- **Requiring the review of existing BMPs and selecting additional BMPs to achieve progress toward addressing the WLA.** Under this option, permit writers could require sources to conduct an analysis of existing BMPs to determine the need for additional pollutant load reductions through improved BMP implementation or additional BMPs. Sources receive little technical guidance through the requirements, allowing them flexibility in conducting the analysis and justifying the selection of specific BMPs. Permit writers could consider including in the requirements a list of supporting documentation (e.g., calculations, assumptions, studies) that would provide the rationale for the proposed strategy to achieve progress toward addressing the WLA. This option is particularly effective when the the TMDL writer develops a WLA that permit writers can use as the basis for developing a performance standard. This approach provides permittees with flexibility in finding the optimal combination of existing and new BMPs to implement the WLA.

- **Consider numeric effluent limitations.** Permit writers might determine that BMPs are not an appropriate way to express effluent limitations and might choose to develop numeric effluent limitations as a feasible and appropriate way to incorporate the TMDL provisions into the permit.

There are no guidelines for determining which approach is most appropriate to use. It is likely that a variety of factors, including type of source, type of permit, and availability of resources, will influence which approach makes the most sense.

In Practice: Options for Water Quality Control Requirements

Existing stormwater permits use different types of requirements to ensure SWMPs and SWPPPs integrate effective BMPs for addressing stormwater source WLAs under approved TMDLs and, in some cases, impaired waterbodies without approved TMDLs. Provided below are examples of differing SWMP and SWPPP requirements for developing and implementing BMPs to addressWLAs under various types of stormwater permits.

Broad Requirements for Permitted Stormwater Sources to Develop SWMPs and SWPPPs to Address Impairments and Stormwater Source WLAs

Tennessee Phase II MS4 General Permit
The general permit developed for use by regulated small MS4s in Tennessee contains a broad set of requirements for developing and implementing SWMPs. The requirements focus on evaluating whether the implementation of existing stormwater control measures is meeting the TMDL provisions, or if additional control measures are necessary. Permittees must document all control measures being implemented or planned to be implemented and provide a schedule of implementation for all planned controls. To demonstrate that control measures will meet TMDL requirements and assumptions, permittees must also provide associated calculations, assessments, reports, and other evidence that provided the rationale for selecting specific control measures.

Wisconsin Phase II MS4 General Permit
Under Wisconsin's Phase II MS4 general permit, permittees that discharge to an impaired waterbody must take steps to develop and implement an SWMP to reduce—and potentially eliminate—the pollutant of concern contributing to a waterbody impairment. Because the permit is a general permit and the requirements could apply to a wide range of pollutants, the permit uses broadly defined requirements to ensure permittees discharging to impaired waterbodies develop and implement SWMPs that will reduce the pollutant of concern. Specifically, the general permit language requires permittees to, "include a written section in its storm water management program that discusses the management practices and control measures it will implement as part of its program to reduce, with the goal of eliminating, the discharge of pollutant(s) of concern that contribute to the impairment of the waterbody. This section of the permittee's program shall specifically identify control measures and practices that will collectively be used to try to eliminate the MS4's discharge of pollutant(s) of concern that contribute to the impairment of the waterbody and explain why these control measures and practices were chosen as opposed to other alternatives."

Watershed-specific BMP and Performance Standard Requirements

Big Darby Creek Watershed (Ohio) Construction General Permit
To implement the Big Darby Creek Watershed TMDL, Ohio EPA developed and issued the Big Darby Creek Watershed CGP. The overall permit is intended to implement the pollutant load reduction targets established under the TMDL; therefore, the permit states that the "general permit requires control measures/BMPs for construction sites that reflect recommendations set forth in the U.S. EPA approved Big Darby Creek TMDL." The water quality control measures specified under the SWPPP requirements include a combination of management practices, effluent targets, and infiltration requirements necessary to support stream base flows and stream setbacks necessary to protect the stream channel. The permit also states that "the erosion, sediment, and stormwater management practices used to satisfy the conditions of this permit, should meet the standards and specifications in the most current edition of Ohio's Rainwater and Land Development manual or other standards acceptable to Ohio EPA unless otherwise specified as a condition of this permit."

Specific BMP Requirements for SWMPs and SWPPPs to Address Impaired Waterbodies and Implement Stormwater Source WLAs

Oregon Construction General Permit (1200-C)
If a permitted construction site has the potential to discharge sediment or turbid water to a waterbody with an approved TMDL for sedimentation or turbidity, or is listed on the state's 303(d) for impairment due to sedimentation or turbidity, Oregon's CGP requires the permittee to implement one of two sets of options. Under Option 2, the CGP requires permittees to implement one or more of six BMPs identified to control and treat sedimentation and turbidity, in addition to implementing the standard set of BMPs required of all erosion and sediment control plans (ESCP). The BMPs identified in the permit are as follows:

- Compost berms, compost blankets, or compost socks;
- Erosion control mats (rolled or blown);
- Tackifiers used in combination with perimeter sediment control BMPs;
- Established vegetated buffers sized at 50 feet plus 25 feet per 5 degrees of slope;
- Water treatment by electro-coagulation, chemical flocculation, or filtration; or
- Other substantially equivalent sediment or turbidity BMP approved by the department.

Permittees selecting Option 2 must indicate in the ESCP which of the six supplemental BMPs have been selected to address discharges to waterbodies impaired for sedimentation and turbidity.

Georgia Industrial Stormwater Permit (GAR000000)
Georgia's industrial stormwater permit contains requirements related to discharges into, or within 1 linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment impaired for fecal coliform, as well as substances other than fecal coliform. Under the requirements for facilities discharging fecal coliform, the permit references an appendix that contains a list of BMPs specifically for animal processing plants that might be potential sources of fecal coliform. Permittees that do not meet the TSS benchmark value (used as a surrogate indicator for fecal coliform under this permit) in the first 12-month sampling period have one year to select, design, and implement supplemental BMPs from the list of BMPs provided in the appendix, or other appropriate BMPs.

Quantifiable Performance Targets to Determine the Need for Additional BMPs

City of Portland, Multnomah County, and Port of Portland (Oregon) Phase I MS4 Individual Permit No. 101314
Portland and its co-permittees are subject to an individual Phase I MS4 permit that contains a variety of requirements for developing and implementing an effective SWMP to address approved WLAs for the permitted MS4s. Permit conditions do not include recommended or required BMPs; instead, the permit requires co-permittees to select BMPs to implement the approved WLAs and develop quantifiable performance measures for assessing BMP effectiveness. Performance measures are pollutant load reduction estimates to facilitate an adaptive management approach to SWMP implementation—the quantifiable performance measures for BMPs are not numeric effluent limitations.

Washington Construction General Permit
The Washington Department of Ecology issued a CGP that contains requirements for three categories of permitted construction sites: (1) less than 1 acre; (2) between 1 and 5 acres; and (3) greater than 5 acres. Under this permit, permittees that discharge turbidity, fine sediment, high pH, or phosphorus to impaired waterbodies listed for one of these parameters is required to conduct regular sampling. If discharge sampling indicates that the permittee's discharge exceeds the water quality standard for turbidity, all future discharges are subject to a numeric effluent limitation equal to the water quality standard for turbidity. Exceedances of the numeric effluent limitation then triggers requirements for evaluating and modifying the SWPPP to include BMPs that will allow the permittee to meet the numeric effluent limitation for turbidity.

Numeric Effluent Limitations

Draft Ventura County Phase I MS4 Individual Permit No. CAS004002
The draft version (dated 08/28/07) of the Ventura County Phase I MS4 Individual permit addresses requirements under multiple TMDLs for multiple watersheds for a variety of pollutants of concern, including nitrogen compounds, bacteria, sediments, and toxicity. Rather than express effluent limitations in the form of BMPs, this version of the Ventura County Phase I MS4 individual permit addresses the TMDL WLAs as numeric WQBELs for dry weather and wet weather.

6.1.3. Monitoring Requirements

As discussed in Chapter 5, monitoring and assessment are essential to help sources to make progress toward implementing WLAs. Information generated through monitoring and assessment activities are also key to promoting adaptive management and continuous improvement in implementation activities. In addition, monitoring and assessment activities are key to quantifying pollutant load reductions achieved through SWMP and SWPPP implementation—first to establish a baseline of pollutant load reductions expected or achieved through BMPs implemented under existing SWMPs and SWPPPs and then to determine pollutant load reductions from any additional BMPs deemed necessary to address WLAs. Requirements related to quantifying pollutant load reductions focus on developing and implementing monitoring plans.

Many SWMP and SWPPP requirements related to meeting stormwater source WLAs include some type of monitoring requirements to gauge BMP effectiveness, overall SWMP and SWPPP effectiveness, and to facilitate adaptive management activities. Options for monitoring requirements include BMP performance monitoring, stormwater discharge outfall monitoring, and ambient in-stream water quality monitoring. Per EPA's 2002 memorandum, where stormwater permits contain effluent limitations expressed as BMPs, these permits should specify the monitoring necessary to determine if BMPs are achieving the expected pollutant load reductions. Therefore, stormwater permits that implement TMDLs often contain monitoring requirements that focus on BMP performance, such as benchmark monitoring to determine progress toward a pollutant reduction goal, and support adaptive management activities related to modifying SWMPs and SWPPPs to improve overall effectiveness. Where stormwater permits do contain numeric effluent limitations, monitoring requirements are likely to focus on determining compliance with applicable numeric effluent limitations.

It is important to note that many existing permits do not specifically require monitoring; however, monitoring might be warranted for these permits to assess TMDL implementation. Chapter 5 of this Handbook discusses monitoring and assessment issues and provides resources that can aid in the development of monitoring and assessment requirements.

In Practice: Options for Monitoring Requirements

General Monitoring Plan Development

Tennessee Phase II MS4 General Permit
Under the general permit, regulated small MS4s must describe a method for evaluating whether stormwater controls are adequate for meeting the requirements of the TMDL.

Performance and Benchmark Monitoring

City of Portland, Multnomah County, and Port of Portland (Oregon) Phase I MS4 Individual Permit No. 101314
To gauge the effectiveness of the SWMP in reducing TMDL pollutant loads to the MEP, the Portland and its co-permittees must include a specific strategy for implementing monitoring in the SWMP. Under this permit, co-permittees measure effectiveness according to the quantifiable performance measures and benchmarks that the permit requires them to establish to support SWMP adaptive management. According to the permit, performance measures are estimates of the effectiveness of BMPs expressed as pollutant load reduction estimates and benchmarks are total pollutant load reduction estimates for each parameter or surrogate, where applicable, for which a WLA is established at the time of permit issuance. Neither performance measures nor benchmarks are numeric effluent limits, but rather tools for guiding adaptive management activities.

Oregon Construction General Permit (1200-C)

If a permitted construction site has the potential to discharge sediment or turbid water to a waterbody with an approved TMDL for sedimentation or turbidity, or is listed on the state's 303(d) for impairment due to sedimentation or turbidity, Oregon's CGP requires the permittee to implement one of two sets of options. Under Option 1, the permittee must conduct stormwater monitoring to determine if discharges meet or exceed a benchmark value for turbidity (i.e., 160 NTUs) that indicates the effectiveness of BMPs. If any samples exceed the benchmark value, the permittee must evaluate existing BMPs and take corrective action. If stormwater discharge samples continue to exceed the benchmark value, the permittee must implement Option 2 (see description of Option 2 under the In Practice discussion related to water quality controls above) and submit an Action Plan that identifies additional BMPs to be implemented and the rationale for selecting the identified BMPs.

Washington Construction General Permit
Permittees covered under Washington's CGP must conduct turbidity sampling to determine compliance with the water quality standard for turbidity. The permit requires permittees to measure background turbidity in the 303(d)-listed receiving water immediately upstream (upgradient) or outside the area of influence of the discharge. For monitoring discharge turbidity, the permit requires permittees to measure at the point of discharge into the 303(d) listed receiving waterbody, inside the area of influence of the discharge or at the point where the discharge leaves the construction site, rather than in the receiving waterbody. Although the permit states that monitoring is used to determine compliance with the turbidity water quality standard, it appears that it functions more as a performance benchmark. If discharge turbidity exceeds the water quality standard for turbidity, all future discharges must comply with a numeric effluent limitation (equal to the water quality standard for turbidity). Future discharges exceeding the numeric effluent limitation triggers SWPPP modification requirements.

Compliance Monitoring

Draft Ventura County Phase I MS4 Individual Permit No. CAS004002
Compliance with the dry-weather and wet-weather numeric WQBELs under the draft version of the Ventura County Phase I MS4 Individual permit is determined through end-of-pipe monitoring at major outfalls. The draft version of the permit requires co-permittees to develop a wet-weather and dry-weather monitoring workplan for review and approval by the Regional Water Board.

6.1.4. Compliance Considerations

[This section still under internal review – do not quote or cite]

When developing permit requirements, permit writers will likely face issues and questions related to determining compliance. One key issue relates to establishing an appropriate compliance schedule for sources to implement a WLA (e.g., within a 5-year permit term or beyond). Permit writers can consider using interim limits or a phased implementation approach. Interim limits are a way for permit writers to schedule incremental progress toward implementing the WLA over time. One option is for the TMDL to reference, or for the permit to specify, the interim limits by providing a schedule with the required interim numeric targets in a specific timeframe. Another option to consider relates to the benchmarking approach (discussed earlier in this chapter) in which a source determines how much progress is feasible, over a specified time frame, to implement the WLA. The source could then submit the proposed benchmarks and associated schedule to the permit writer for review and approval.

Resources: The Appendix of this Handbook contains the actual stormwater permit language referenced in this section, as well as relevant requirements from other stormwater permits, for TMDL and permit writers to review and consider when discussing and developing requirements to implement TMDLs.

In Practice: Incorporating Interim TMDL Numeric Targets into Permits in San Diego, California

The San Diego Phase I MS4 permit (Order No. R9-2007-0001/NPDES No. CAS0108758) contains requirements to implement the Chollas Creek Diazinon TMDL. The permit includes a table that presents the WLA, interim TMDL numeric target, and percent reduction required over the permit duration. Permit language reads as follows:

a. The Copermittees in the Chollas Creek watershed shall implement BMPs capable of achieving the interim and final diazinon Waste Load Allocation (WLA) concentration in the storm water discharge in Chollas Creek listed in Table 5.

b. The Copermittees in the Chollas Creek watershed shall not cause or contribute to the violation of the Interim TMDL Numeric Targets in Chollas Creek as listed in Table 5. If the Interim TMDL Numeric Target is violated in Chollas Creek in more than one sample in any three consecutive years, the Copermittees shall submit a report that either 1) documents compliance with the WLA through additional sampling of the urban runoff discharge or 2) demonstrates, using modeling or other technical or scientific basis, the effectiveness of additional BMPs that will be implemented to achieve the WLA. The report may be incorporated into the Watershed Urban Runoff Management Program Annual Report unless the Regional Board directs an earlier submittal. The report shall include an implementation schedule.

6.2. Options for Connecting Programmatic Documents

TMDL and permit writers can not only work together to consider the appropriate types of conditions that could be developed to implement stormwater source TMDLs, but also can collaborate to decide how the associated programmatic documents, such as the TMDL report and the stormwater permit, can help articulate this information. The goal is to help ensure that no matter what document a permitted stormwater source refers to—the TMDL or the stormwater permit—each document has a clear and consistent connection to the information contained in the other. This section discusses options for TMDL and permit writers to consider when deciding how to develop a connection between the TMDL report and stormwater permits, as well as other related programmatic documents including implementation plans.

Within the TMDL report and stormwater permit, TMDL and permit writers have several possible options for developing a connection between the information contained in the document. In the TMDL report, the TMDL writer might develop a connection to the permit through the WLA or the implementation plan (if included as part of the TMDL report) or other components that could be included in the TMDL report or implementation plan (e.g. optional monitoring section). In stormwater permits, the connection to TMDLs can also vary. Permit requirements might appear as a comprehensive set of detailed special conditions related to stormwater discharges to impaired waterbodies with approved TMDLs (or listed waterbodies without an approved TMDL), or the requirements ccould appear throughout the permit under existing permit conditions related to SWMP and SWPPPs, monitoring, reporting, and other categories of requirements.

TMDL and permit writers can work together to develop the most appropriate section of each programmatic document to place stormwater-source-TMDL-related information. From there, TMDL and permit writers can decide the best approach for developing the connection, such as referencing elements contained in one programmatic document or directly including and referenceing them in each. A brief discussion these approaches related to each type of programmatic document and its associated components is provided below.

6.2.1. Using the WLA to Connect to Permits

Per EPA's 2002 memorandum, regulations state that when a TMDL has been approved, NPDES permits should contain effluent limits and conditions consistent with the requirements and the assumptions of the WLA. One option is to describe and reference all relevant permit requirements for implementing the WLA within the the TMDL report. Under this approach, stormwater permits could state that sources should comply with the numeric WLA and the associated elements included in the TMDL document. This approach basically incorporates the WLA and associated implementation information into the permit by reference. It is important to note, that although this type of approach could facilitate connections between WLAs and general permits, it may result in permits that are more challenging to tailor with specific permit requirements.

Another option is to have stormwater permits directly incorporate the TMDL WLA information so that each programmatic document contains the same element using identical language, as opposed to just referencing the other document as is suggested above. While this more specific approach could be easier to apply when using individual or watershed-based stormwater permits, permit writers could also use this type of approach with general permits in conjunction with a regularly updated TMDL appendix that contains specific information for permittees.

In Practice: Referencing and Integrating TMDL Provisions in Permits in Washington

The Western Washington Phase II MS4 General Permit contains broad language to convey the requirements related to MS4s addressed by an approved TMDL. The body of the permit requires MS4s to comply with the specific actions described in applicable TMDLs. To aid permittees, the Washington Department of Ecology compiled all relevant, existing implementation actions from applicable TMDLs into a comprehensive appendix to the permit. By referencing the appendix in the permit, permit writers were able to ensure that the compilation of TMDL-specific activities would become enforceable permit requirements. The general permit language states the following:

> The following requirements apply if an applicable Total Maximum Daily Load (TMDL) is approved for stormwater discharges from MS4s owned or operated by the Permittee. Applicable TMDLs are TMDLs which have been approved by EPA on or before the date permit coverage is granted. All Permittees shall be in compliance with the requirements of applicable TMDLs.
>
> A. For applicable TMDLs listed in Appendix 2, affected permittees shall comply with the specific requirements identified in Appendix 2. Each Permittee shall keep records of all actions required by this Permit that are relevant to applicable TMDLs within their jurisdiction. The status of the TMDL implementation shall be included as part of the annual report submitted to Ecology.
>
> Where monitoring is required in Appendix 2, the Permittee shall conduct the monitoring according to a Quality Assurance Project Plan (QAPP) approved by Ecology.
>
> B. For applicable TMDLs not listed in Appendix 2, compliance with this Permit shall constitute compliance with those TMDLs.
>
> C. For TMDLs that are approved by EPA after this Permit is issued, Ecology may establish TMDL related permit requirements through future permit modification if Ecology determines implementation of actions, monitoring or reporting necessary to demonstrate reasonable further progress toward achieving TMDL waste load allocations, and other targets, are not occurring and shall be implemented during the term of this Permit or when this Permit is reissued. Permittees are encouraged to participate in development of TMDLs within their jurisdiction and to begin implementation.

6.2.2. Using Implementation Plans to Connect to WLAs and Permits

While implementation plans are not a required component of a TMDL, many states do develop and include some form of an implementation plan in their TMDL document either to satisfy state regulatory requirements or to facilitiate TMDL implementation. If TMDL and permit writers intend to engage in implementation planning activities and develop an implementation plan for stormwater source TMDLs, there are a few ways to consider developing a stronger connection between WLAs and permits through the use of implementation plans. One option for using implementation plans to connect stormwater source WLAs with stormwater permits is to have the implementation plan serve as the primary vehicle for referencing and conveying information relating to implementation of the stormwater source WLAs (e.g., supplemental BMPs, SWMP and SWPPP assessment and modification, monitoring plan development and implementation, adaptive management measures). The TMDL could include these elements by reference and the associated stormwater permits could then incorporate the implementation plan information by reference.

In Practice: Using Implementation Plans to Connect WLAs and Stormwater Permits

Implementation plans with recommendations to guide stormwater permit requirements:

Swamp Creek Fecal Coliform Bacteria TMDL (Washington) Water Quality Improvement Report and Implementation Plan
The Water Quality Improvement Report and Implementation Plan includes recommendations for each MS4 as well as "anticipated actions" or requirements that the permitting authority intends to include in associated NPDES permits (Appendix D). The recommendations are those measures and practices that are intended to reduce bacterial pollution to Swamp Creek.

Big Darby Creek (Ohio) Watershed TMDLs
The implementation portion of the TMDL develops a tiered approach to monitoring progress and validating the TMDL:

1. Confirmation of completion of implementation plan activities
2. Evaluation of attainment of chemical water quality criteria
3. Evaluation of biological attainment.

A TMDL revision will be triggered if any one of the validation steps is not being completed or if the water quality standards are not being attained after an appropriate time interval. Once the majority of or the major implementation plan items have been carried out or the water quality monitoring shows consistent and stable improvements then a watershed assessment would be completed to evaluate attainment of the use designations. If water quality monitoring does not show improvement or waterbodies are still not attaining water quality standards after the implementation plan has been carried out, a TMDL revision would be initiated.

Implementation plans with specific BMPs using adaptive management and phased implementation:

Chloride TMDL Report: Shingle Creek, Minnesota
The implementation portion of the TMDL report calls for the use of adaptive management principles. According to the report, adaptive management is appropriate because it is difficult to predict the chloride reduction that will occur from implementing strategies with limited amount of data available to predict expected reductions. The report requires continued monitoring and *course corrections* based on monitoring results.

Another possible option is for the stormwater permit, not the implementation plan, to include all additional requirements developed to implement the stormwater source WLAs. Under this approach, the implementation plan serves as a mechanism to link the TMDL and the stormwater permit without providing a significant amount of detail in the TMDL. This approach could be ideal for situations in which TMDL writers do not have the time or resources to engage in detailed implementation planning.

Resources: The Appendix of this Handbook contains excerpts of TMDLs, implementation plans, and stormwater permit requirements from the real-world examples provided in this section, as well as other TMDLs and stormwater permits that illustrate how states connect permitted stormwater source requirements among programmatic documents.

6.3. Other Information to Consider

Permit writers, watershed organizations, or municipalities could encounter situations where previously developed TMDLs and implementation plans are more difficult to implement in permits, including the following situations.

6.3.1. No separate WLA for NDPES Stormwater source

Permit writers might be working with older TMDLs that were approved prior to EPA's guidance, *Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs* (Wayland, R.H., and J.A. Hanlon, 2002), or that include allocations for stormwater discharges that were considered to be nopoint sources at the time the TMDL was approved, but that currently are subject to NPDES permitting. For example, an older TMDL could group both urban nonpoint source and point source runoff into one overall category under an aggregated load allocation, or the older TMDL could include runoff from MS4's under the load allocation that are now covered under the Phase II NDPES requirments. Because permit effluent limits have to meet water quality standards under 122.44(d)(1)(vii)(A), the permit writer will need to account for the current regulated stormwater discharges identified in the TMDL regarldless of how they were labeled in the older TMDL document, and should explain how they are being accounted for in the permit. The permit writer might be able to get additional information from TMDL writers to help implement these wasteload allocations into permits.

6.3.2. Impaired Waterbody with No Approved TMDL

Another scenario that TMDL and permit writers might encounter is an impaired waterbody that does not yet have an approved TMDL. Clearly, it is important to ensure that stormwater discharges do not further cause or contribute to exceedances of water quality standards. However, without a specific WLA, TMDL and permit writers might have questions about the appropriate implementation activities to recommend or, in the case of a permit, require until a TMDL is developed and approved. To provide some level of control on pollutants of concern associated with the impairment, TMDL and permit writers could work together to identify interim early action BMPs or performance standards that sources could implement until an approved TMDL becomes available. In such cases, it might be valuable to identify monitoring programs to evaluate contributions from stormwater sources to the impairment for use in future TMDL development.

In Practice: Addressing Impaired Waterbodies with No Approved TMDL in Permits in Wisconsin

The Wisconsin Phase II MS4 General Permit contains requirements that address MS4 discharges to impaired waterbodies with no approved TMDL. The permit requires permittees to address the pollutant of concern contributing to the impairment in the SWMP and limits permittees' ability to have a new or increased discharge of a pollutant of concern unless there is an approved TMDL. The general permit language states the following:

> 1.5.2 If the permittee's MS4 discharges to an impaired waterbody, the permittee shall include a written section in its storm water management program that discusses the management practices and control measures it will implement as part of its program to reduce, with the goal of eliminating, the discharge of pollutant(s) of concern that contribute to the impairment of the water body. This section of the permittee's program shall specifically identify control measures and practices that will collectively be used to try to eliminate the MS4's discharge of pollutant(s) of concern that contribute to the impairment of the waterbody and explain why these control measures and practices were chosen as opposed to other alternatives. Pollutant(s) of concern means a pollutant that is causing impairment of a waterbody.
>
> 1.5.3 After the permittee's start date of coverage under this permit, the permittee may not establish a new MS4 discharge of a pollutant of concern to an impaired waterbody or increase the discharge of a pollutant of concern to an impaired waterbody unless the new or increased discharge causes the receiving water to meet applicable water quality standards, or the Department has approved a total maximum daily load (TMDL) for the impaired waterbody.

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Appendix: TMDL and NPDES Stormwater Permit Language Excerpts

California

Los Angeles County MS4 NPDES Permit

10. On May 18, 2000, the USEPA established numeric criteria for priority toxic pollutants for the State of California (California Toxics Rule (CTR)) 65 Fed. Reg. *31682 (40 CFR 131.38), for the protection of human health and aquatic life. These apply as ambient water quality criteria for inland surface waters, enclosed bays, and estuaries. The State Board adopted the* Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP) – 2000, *on March 2, 2000, for implementation of the CTR (State Board Resolution No. 2000-15 as amended by Board Resolution No. 2000-030). This policy requires that discharges comply with TMDL-derived load allocations as soon as possible but no later than 20 years from the effective date of the policy.*

28. The Regional Board adopted the Santa Monica Bay Beaches Dry Weather TMDL for Bacteria (hereinafter "Dry Weather Bacteria TMDL") on January 24, 2002. The TMDL was subsequently approved by the State Board, the Office of Administrative Law (OAL), and the USEPA and became effective on July 15, 2003.

29. The Waste Load Allocations (WLAs) in the Dry Weather Bacteria TMDL are expressed as the number of allowable days that the Santa Monica Bay beaches may exceed the Basin Plan water quality objectives for protection of Water Contact Recreation (REC-1) in marine waters, specifically the water quality objectives for bacteria. Appropriate modifications to this order are therefore included in Parts 1 (Discharge Prohibitions) and 2 (Receiving Water Limitations), pursuant to 40 CFR 122.41(f) and 122.62, and Part 6.I.1 of this Order. Additionally, 40 CFR 122.44(d)(1)(vii)(B) requires that NPDES permits be consistent with the assumptions and requirements of any available waste load allocation. Tables 7-4.1, 7-4.2a, and 7-4.3 of the Basin Plan set forth the pertinent provisions of the Dry Weather Bacteria TMDL. They require that during Summer Dry Weather there shall be no exceedances in the Wave Wash of the single sample or the geometric mean bacteria objectives set to protect the Water Contact Recreation (REC-1) beneficial use in marine waters. Accordingly, a prohibition is included in this Order barring discharges from a MS4 to Santa Monica Bay that result in exceedance of these objectives. Since the TMDL and the WLAs contained therein are expressed as receiving water conditions, Receiving Water Limitations have been included in this Order that are consistent with and implement the zero exceedance day WLAs.

30. Pursuant to federal regulations at 40 CFR 124.8, and 125.56, a Fact Sheet was prepared to provide the basis for incorporating the Dry Weather Bacteria TMDL into this Order. The Fact Sheet is hereby incorporated by reference into these findings.

31. The iterative approach to regulating municipal stormwater is not an appropriate means of implementing the Santa Monica Bay beaches Summer Dry Weather WLAs for any and all of the following reasons: (a) The WLAs do not regulate the discharge of stormwater; (b) The harm to

the public from violating the WLAs is dramatic both in terms of health impacts to exposed beachgoers, and the economic cost to the region associated with related illnesses; (c) Despite the fact that more than a decade and a half has passed since MS4 permittees were required to eliminate illicit connections/discharges (IC/ID) into their MS4s, their programs have not eliminated standards violations at the beaches; and (d) Few permittees have ever documented revisions to their SQMP to address chronic exceedances of water quality standards.

Georgia

Phase II MS4 General Permit

D. Stormwater Management Modifications

1. The SWMP may be modified by the permittee at any time. Written notification of substantial SWMP modifications must be submitted 30 days prior to implementation of the SWMP modification.

2. EPD may require the permittee to modify the SWMP as needed to:

a. Include more stringent requirements as necessary to comply with new State or Federal statutory or regulatory requirements;

b. Include other conditions deemed necessary by the Director to comply with the goals and requirements of the CWA and the State Act. The Director's request for modifications shall be made in writing and set forth a time schedule for the permittee to develop the modification(s), and offer the permittee the opportunity to propose alternative SWMP modifications to meet the objective of the requested modification.

General Permit for Stormwater Discharges Associated with Industrial Activity

C. Discharges Into, Or Within One Mile Upstream Of And Within The Same Watershed As, Any Portion Of An Impaired Stream Segment.

An operator is not eligible for coverage under this permit for discharges of stormwater associated with industrial activity to waters of the State for which a Total Maximum Daily Load (TMDL) is approved prior to or during the term of this permit, unless the facility develops, implements, and maintains a SWP3 that is consistent with the TMDL. The SWP3 must specifically address any conditions or requirements included in the TMDL that are applicable to the operator's discharge within the timeframe specified in the TMDL. If the TMDL establishes a specific numeric wasteload allocation that applies to an operator's discharge, or to stormwater discharges associated with industrial activity in general, then the operator must incorporate that allocation into the facility's SWP3 and implement all necessary measures to meet that allocation.

Any operator who intends to obtain coverage under this permit for stormwater discharges associated with industrial activity into an Impaired Stream Segment, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment, identified as "partially supporting" or "not supporting" designated uses on Georgia's most current 303(d) list, must satisfy the requirements of Part III.C of this permit if the pollutant(s) of concern for which the Impaired Stream Segment has been listed may be exposed to stormwater

as a result of current or previous industrial activity at the facility. Those discharges that are within one (1) linear mile of an Impaired Stream Segment, but are not located within the watershed of any portion of that stream segment are excluded from this requirement. Georgia's 303(d) list can be viewed on EPD's website at www.gaepd.org.

1. Discharges into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment Impaired by substances other than fecal coliform.

a. Sampling schedule.

Regulated industrial facilities that are subject to the requirements in Part III.C.1. of this permit must conduct stormwater discharge sampling for the pollutant(s) of concern two times per quarter for a period of twelve (12) months. The pollutant(s) of concern for each impaired stream segment are identified on Georgia's 303(d) list. The sampling will only be required for those outfalls at the facility that have the potential to discharge the pollutant(s) of concern. The sampling must be conducted in accordance with Parts VI.A.3, 4, and 5 of this permit, except that composite samples may be collected in lieu of grab samples at the permittee's discretion. The Director may require composite or grab sampling where deemed appropriate in order to ensure that representative samples are collected.

Except as provided below, the sampling must begin no later than ninety (90) days after the later of the effective date of the permit or the date the facility becomes subject to the sampling requirements in Part III.C. However, if a facility with an existing stormwater discharge associated with industrial activity determines that additional time is needed to design and implement new or improved BMPs specifically for the pollutant(s) of concern, then that facility may delay commencement of the sampling program under this section of the permit for no more than twelve (12) months after the effective date of the permit in order to design and implement those BMPs. Facilities choosing this option must, no later than the date on which the Part III.C sampling would otherwise begin, provide a written notification, signed in accordance with Part VII.G of this permit, to EPD that they have elected to delay sampling and provide a schedule for BMP implementation. The Part III.C sampling program must begin immediately after the BMPs are required to have been implemented according to the schedule provided to EPD.

A summary of the sampling results must be submitted to EPD's Watershed Protection Branch with the Annual Report (see Appendix B of this permit). The report must also identify the applicable benchmark value(s) and state whether the facility has passed or failed the benchmark requirement for the twelve (12) month sampling period.

If a facility is unable to conduct one or both of the Part III.C sampling event(s) during a certain quarter due to adverse climatic conditions (i.e. no qualifying rainfall event occurs), then the facility shall include a written explanation for the absence of the sampling event in the next Annual Report submitted to EPD.

b. Applicable Benchmark Values.

The applicable benchmark values for discharges into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment shall be the same numeric value as the Instream Water Quality Criterion for the pollutant(s) of concern as specified in Georgia's Rules and Regulations for Water Quality Control (Georgia Rule 39136.

03) unless otherwise established in Part III.C of this permit. The benchmark values are designed to assist permittees in determining if the BMPs established in a facility's SWP3 are effective in minimizing the concentration of the pollutant(s) of concern in stormwater discharge(s) from their facility. These benchmark values are intended to be guideline concentrations rather than numeric effluent limitations or permit conditions. The exceedance of a benchmark value established in Part III.C of this permit is not a permit violation and does not of itself indicate a violation of instream water quality standards. However, an exceedance of a benchmark value may be used in conjunction with other information to demonstrate a violation of this permit or a violation of water quality standards.

(1). Specific requirements for discharges into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment impaired for DO (Dissolved Oxygen).

Facilities discharging into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment for which the listing criterion is identified as DO (Dissolved Oxygen) will only be required to conduct sampling under Part III.C if industrial materials that may contribute Five Day Carbonaceous Biochemical Oxygen Demand (CBOD5) or ammonia (NH3) may be exposed to stormwater as a result of current or previous industrial activity at the facility. These facilities must sample for Five Day Carbonaceous Biochemical Oxygen Demand (CBOD5) and NH3. The applicable benchmark value for these discharges shall be an Ultimate Oxygen Demand (UOD) of 125 mg/l. The UOD shall be calculated as [(CBOD5 x 1.5) + (NH3 x 4.57)].

(2). Specific requirements for discharges into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment impaired by nonpollutant specific criteria.

(i). Facilities discharging into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment for which the listing criterion is identified as "Biota or Sediment" are required to conduct sampling for Total Suspended Solids (TSS) unless a TMDL has identified a different pollutant from nonpoint sources as causing the impairment, in which case sampling should be conducted for the pollutant(s) identified in the TMDL. The applicable TSS benchmark value for these discharges shall be 100 mg/l.

(ii). Facilities discharging into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment for which the listing criterion is toxicity, FCG (fish consumption guidelines), SB (shellfishing ban), CFB (commercial fishing ban) or TWR (trophic weighted residue value of mercury in fish tissue)" will only be required to conduct sampling under Part III.C if a TMDL identifying a specific water quality parameter has been approved for the stream segment.

c. Evaluation of Part III.C sampling data

The Part III.C stormwater discharge sampling is intended to measure the effectiveness of the Best Management Practices (BMPs) implemented at those facilities. If benchmark values are exceeded using the pass/fail determination provided below, then improved or additional BMPs are required at the facility.

The sampling data for the twelve (12) month period must be evaluated using one of the following criteria. This shall constitute the pass/fail determination for evaluating BMP effectiveness:

(1). At least seventy-five (75) percent of the samples collected during the twelve (12) month period do not exceed the applicable benchmark value(s); or

(2). The average of the samples collected during the twelve (12) month period does not exceed the applicable benchmark value(s).

If a facility meets at least one of the above criteria then that facility has passed the benchmark requirement and may discontinue the Part III.C sampling but must thereafter properly maintain all of the BMPs that enabled the facility to meet the benchmark requirement.

If a facility does not meet at least one of the above criteria, then that facility has failed the benchmark requirement. Those facilities that do not pass the benchmark requirement for the first twelve (12) month sampling period may take up to one year to budget, select, design and construct/implement additional supplemental BMPs at the facility. Once the supplemental BMPs have been implemented, an additional twelve (12) month (two samples per quarter) period of sampling must be conducted as described in Part III.C.1.a above. Those facilities that pass the benchmark requirement, using the above pass/fail determination, after implementing supplemental BMPs may discontinue the Part III.C sampling but must thereafter properly maintain all of the BMPs that enabled the facility to meet the benchmark requirement.

Facilities that are not able to pass the benchmark requirement, using the above pass/fail determination, after implementing supplemental BMPs must continue the process of implementing additional supplemental BMPs at the facility and conducting a subsequent twelve month (two samples per quarter) period of sampling until the facility meets the benchmark requirement using the pass/fail determination provided above. If a facility is unable to pass the benchmark requirement after the twelve (12) month sampling period following a second round of implementing supplemental BMPs, then EPD will determine what further action is required, which may include, but is not limited to, applying for an individual NPDES permit.

d. Written justification to cease Part III.C sampling.

If a facility provides a written justification after the first twelve (12) month period of sampling (or after any subsequent twelve (12) month period of sampling) and EPD concurs that the facility's stormwater discharges associated with industrial activity do not have a reasonable potential to cause or contribute to a violation of an instream water quality standard, then EPD may conclude that additional sampling under Part III.C is not required. Facilities that have passed the benchmark requirement are not required to submit a written justification in order to cease Part III.C sampling.

2. Discharges into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment impaired for fecal coliform.

Facilities discharging into, or within one (1) linear mile upstream of and within the same watershed as, any portion of an Impaired Stream Segment for which the listing criterion is identified as fecal coliform must adhere to the following conditions if industrial materials or

activities that are potential sources of fecal coliform (as defined in Part IV.D.9 of this permit) are, or may be, exposed to stormwater at the facility during the term of this permit.

a. List of BMPs for animal processing plants that may be potential sources of fecal coliform.

A list of BMPs designed to reduce fecal coliform levels in stormwater runoff has been developed for animal processing plants that may be potential sources of fecal coliform. Other facilities may find this list to be useful as well. The list is provided in Appendix C of this permit.

b. Sampling schedule.

Regulated industrial facilities that are subject to the requirements in Part III.C.2 of this permit must conduct stormwater discharge sampling for TSS two times per quarter for a period of twelve (12) months. Two of the sampling events must include simultaneous testing of TSS and fecal coliform. The sampling will only be required for those outfalls at the facility that have the potential to discharge stormwater associated with industrial activity where industrial materials or activities that are potential sources of fecal coliform (as defined in Part IV.D.9 of this permit) are, or may be, exposed to stormwater at the facility during the term of this permit. The sampling must be conducted in accordance with Parts VI.A.3, 4, and 5 of this permit.

Except as provided below, the sampling must begin no later than ninety (90) days after the later of the effective date of the permit or the date the facility becomes subject to the sampling requirements in Part III.C. However, if a facility with an existing stormwater discharge associated with industrial activity determines that additional time is needed to design and implement new or improved BMPs specifically for the pollutant(s) of concern, then that facility may delay commencement of the sampling program under this section of the permit for no more than twelve (12) months after the effective date of the permit in order to design and implement those BMPs. Facilities choosing this option must, no later than the date on which the Part III.C sampling would otherwise begin, provide a written notification, signed in accordance with Part VII.G of this permit, to EPD that they have elected to delay sampling and provide a schedule for BMP implementation. The Part III.C sampling program must begin immediately after the BMPs are required to have been implemented according to the schedule provided to EPD.

A summary of the sampling results for TSS and fecal coliform must be submitted to EPD's Watershed Protection Branch with the Annual Report (see Appendix B of this permit). The report must also identify the applicable benchmark value(s) and state whether the facility has passed or failed the benchmark requirement for the twelve (12) month sampling period.

If a facility is unable to conduct one or both of the Part III.C sampling event(s) during a certain quarter due to adverse climatic conditions (i.e. no qualifying rainfall event occurs), then the facility shall include a written explanation for the absence of the sampling event in the next Annual Report submitted to EPD.

c. Applicable Benchmark Value

A Total Suspended Solids (TSS) benchmark value of 100 mg/l will be used as a surrogate for evaluating fecal coliform levels in stormwater discharges associated with industrial activity. Fecal coliform sampling data collected simultaneously with TSS sampling data (as required in

Part III.C.2.b) is not subject to the pass/fail determination for benchmark sampling as established in Part III.C.2.d below.

The TSS benchmark value is designed to assist permittees in determining if the implementation of the BMPs (as established in a facility's SWP3) is minimizing the concentration of the pollutant(s) of concern in stormwater discharge(s) from their facility. These benchmark values are intended to be guideline concentrations rather than numeric effluent limitations or permit conditions. The exceedance of a benchmark value established in Part III.C of this permit is not a permit violation and does not of itself indicate a violation of instream water quality standards. However, an exceedance of a benchmark value may be used in conjunction with other information to demonstrate a violation of this permit or a violation of water quality standards.

d. Evaluation of Part III.C sampling data.

The Part III.C stormwater discharge sampling is intended to measure the effectiveness of the Best Management Practices (BMPs) implemented at those facilities. If benchmark values are exceeded using the pass/fail determination provided below, then improved or additional BMPs are required at the facility.

The TSS sampling data for the twelve (12) month period must be evaluated using one of the following criteria. This shall constitute the pass/fail determination for evaluating BMP effectiveness.

(1). At least seventy-five (75) percent of the samples collected during the twelve (12) month period do not exceed the TSS benchmark value; or

(2). The average of the samples collected during the twelve (12) month period does not exceed the TSS benchmark value.

If a facility meets at least one of the above criteria then that facility has passed the TSS benchmark requirement and may discontinue the Part III.C sampling but must thereafter properly maintain all of the BMPs that enabled the facility to pass the TSS benchmark requirement.

If a facility does not meet at least one of the above criteria, then that facility has failed the TSS benchmark requirement. If a facility does not pass the TSS benchmark requirement for the first twelve (12) month sampling period then the facility may take up to one year to budget, select, design and construct/implement additional supplemental BMPs from the list provided in Appendix C, or other appropriate BMPs. Once the supplemental BMPs have been implemented at the facility, an additional twelve (12) month (two samples per quarter) period of sampling must be conducted as described in Part III.C.2.b above. Those facilities that pass the benchmark requirement, using the above pass/fail determination, after implementing supplemental BMPs may discontinue the Part III.C sampling but must thereafter properly maintain all of the BMPs that enabled the facility to pass the TSS benchmark requirement.

Facilities that are not able to pass the TSS benchmark requirement after implementing supplemental BMPs must continue the process of implementing additional supplemental BMPs from the Appendix C list, or other appropriate BMPs, (within twelve (12) months after the end of the previous twelve (12) month sampling period) and conducting a subsequent twelve month (two

samples per quarter) period of sampling until the facility passes the benchmark requirement using the pass/fail criteria provided above.

e. Written justification to cease Part III.C monitoring.

If a facility provides a written justification, after the first twelve (12) month period of sampling (or after any subsequent twelve (12) month period of sampling), and EPD concurs that the facility's stormwater discharges associated with industrial activity do not have a reasonable potential to cause or contribute to a violation of an instream water quality standard, then EPD may conclude that additional sampling under Part III.C is not required. Facilities that have passed the benchmark requirement are not required to submit a written justification in order to cease Part III.C sampling.

f. Demonstration of appropriate BMPs.

If a facility with a stormwater discharge associated with industrial activity that may be a potential source of fecal coliform has implemented all technologically and economically feasible BMPs in the Appendix C list (for animal processing facilities), or other appropriate BMPs (for other facilities), and is still unable to pass the TSS benchmark requirement, the owner or operator of that facility may submit a demonstration to EPD that the facility has properly designed, installed and maintained all of the BMPs that are technologically and economically feasible for the facility and still cannot meet the benchmark. If, after reviewing the demonstration and conducting a site inspection, EPD concurs with the facility's determination, then the facility will not be required to implement additional supplemental BMPs in order to comply with the permit. However, if new BMPs become technologically and economically feasible for the facility at a later date, then EPD may require the implementation of such BMPs at that time. EPD may also require an individual NPDES permit for a facility if that facility does not properly design, install and maintain technologically and economically feasible BMPs in a timely manner.

New Mexico

Phase I MS4 Permit for the City of Albuquerque

B. Area-specific Stormwater Management Program Requirements. Permittees are required to develop and implement measures necessary to bring the discharge into compliance with the Middle Rio Grande Total Maximum Daily Load (TMDL) for Fecal Coliform. Specific permit requirements to implement the TMDL are included in Part III, Table III.B. [Note: Table III.B. includes the implementation activities required, the co-permittees responsible and the schedule of compliance. The implementation activities in the table have been incorporated as text as follows:]

1.0 Source Categories. Develop and submit a list of potential categories of fecal coliform sources by watershed and watershed density (undeveloped, low, moderate, high), covering the entire permit area.

1.1 Legal Authority Evaluate adequacy of existing legal authority to implement the conditions included in this T able. Where existing ordinances are lacking, provide a schedule for obtaining the necessary legal authority. Ordinances shall be in place prior to the implementation of the programs.

2.0 Dry Weather Investigation. Develop and submit a dry weather field investigation program, by watershed, to identify and isolate fecal coliform sources that occur during dry weather so that they can be reduced/eliminated. The program shall address the sources identified in item 1.0 above. The program shall address the suitability of each of the following measures and shall include detailed description of activities and frequencies.

2.1 Low Density Watersheds:

2.1.1 Conduct dry weather channel survey

2.1.2 Conduct survey of septic systems (e.g. aerial, ground, etc.)

2.1.3 Conduct visual or tracer tests on suspected failing systems

2.1.4 Investigate recreational and seasonal sewage dischargers

2.1.5 Conduct ARA and study to determine whether fecal coliform s are of human or nonhuman origin

2.1.6 Test ditch or channel sediments to see if they are a bacteria source or reservoir

2.2 Moderate/High Density Watersheds:

2.2.1 Conduct dry weather channel survey

2.2.2 Test for Illicit connections

2.2.3 Check integrity of major trunk lines for cracks and leaks

2.2.4 Check for historic and unconnected septic systems

2.2.5 Conduct ARA and study to determine whether fecal coliform s are of human or nonhuman origin

2.2.6 Check ponds, lakes and impoundments for waterfowl concentrations

3.0 Wet Weather Investigation Develop and submit a wet weather field investigation program, by watershed, to identify and isolate fecal coliform sources that occur during wet weather so that they can be reduced/eliminated. The program shall address the sources identified in item 1.0 above. The program shall address the suitability of each of the following measures and shall include detailed description of activities and frequencies.

3.1 Low Density Watersheds

3.1.1 Inspect septic systems for wet-weather failure

3.1.2 Conduct comprehensive wet weather monitoring to isolate subwatershed hot spots

3.1.3 Submit results of the Antibiotic Resistance Analysis and the study to determine whether fecal coliforms are of human or nonhuman origin

3.1.4 Sample runoff from suspected source areas (e.g. hobby farms and livestock areas)

3.1.5 Test storm drain or channel sediments to see if they are a bacteria sink or source

3.2 Moderate/High Density Watersheds:

3.2.1 Check for chronic sanitary sewer overflows at specific manholes and /or pumping stations

3.2.2 Submit results of the Antibiotic Resistance Analysis and the study to determine whether fecal coliforms are of human or nonhuman origin

3.2.3 Conduct comprehensive wet weather monitoring to identify key source areas or subwatersheds

4.0 Submit certification of the full implementation of the dry and wet weather field investigation programs.

5. 0 Fecal Coliform Reduction and Treatment Develop and submit a program for reducing or treating existing fecal coliform sources, by watershed and watershed density. The program shall address the sources identified in items 3.0 and 4.0 above. The program shall address the suitability of each of the following measures and shall include detailed description of activities and frequencies. Where activities are to be performed by entities other than the permittee, describe enforcement mechanism to be used to ensure compliance.

5.1 Low Density Watersheds

5.1.2 Rehabilitate failing septic systems
5.1.3 Connect failing septic systems to sewer
5.1.4 Increase sep tic system clean outs
5.1.5 Retrofit stormwater ponds
5.1.6 Retrofit ditches as dry swales
5.1.7 Waterfowl management
5.1.8 Install recreational vehicle sewage pumpouts
5.1.9 Implement conservation plans at hobby farms

5.2 Moderate/High Density Watersheds:

5.2.2 Eliminate illicit connections to storm sewer
5.2.2 Rehabilitate existing sewer system to eliminate sanitary sewer overflows
5.2.3 Relocate storm outfalls
5.2.4 Disinfect at the end of pipe
5.2.5 Retrofit stormwater ponds
5.2.6 Retrofit ditches as dry swales
5.2.7 Waterfowl harassment
5.2.8 Enforce pet waste disposal
5.2.9 Implement conservation plans at hobby farms

6.0 Submit certification of the full implementation of fecal coliform reduction and treatment program.

7.0. Prevention of Future Fecal Discharges Develop and submit a program for preventing future fecal coliform discharges, by watershed. The program shall address at a minimum, the measures included below, with detailed description of activities and frequencies. Where activities are to be performed by entities other than the permittee, describe enforcement mechanism to be used to ensure compliance.

7.1 Low Density Watersheds

7.1.1 Land use management
7.1.2 Stringent septic system requirements:
7.1.2.1 Feasibility criteria
7.1.2.2 Setbacks
7.1.2.3 Reserve field requirements
7.1.2.4 Minimum lot size
7.1.2.5 Technology criteria
7.1.2.6 Inspections
7.1.2.7 Maintenance requirements
7.1.3 Stream/ ditches buffers and access restrictions
7.1.4 Livestock fencing
7.1.5 Wildlife control
7.1.6 Land application criteria for biosolids

7.1.7 Stormwater treatment for new development
7.1.8 Public education
7.1.9 Recreational vehicle and park sewage pump-out facilities
7.2 Moderate/High Density Watersheds:
7.2.1 New Sewer Testing
7.2.2 Inspection of new sewer hookups
7.2.3 SSO monitoring and prevention
7.2.4 Stormwater treatment for new development
7.2.5 Optimal stormwater outfall location
7.2.6 Engineered stream buffers
7.2.7 Pet Exclusion
7.2.8 Waterfowl control /management
7.2.9 Public education on pet waste
7.2.10 Transient sewage disposal
7.2.11 Septic system rehabilitation

8.0 Submit certification of the implementation of the program to prevent future fecal coliform sources.

9.0 Monitoring Program Develop a monitoring program, in consultation with the State of New Mexico, to assess BMP effectiveness and compliance with Fecal Coliform TMDL at North Diversion Floodway Channel, San Jose Drain, South Diversion Channel and Tijeras Arroyo. Target values and equation for comparison of loadings are included in Table III.B.2 below. While developing this monitoring program, the permittees should take into account the frequency of storm events, and the variation in Fecal Coliform levels, within individual storm event. Collection and analysis of samples shall be conducted in accordance with Part V requirements. Results shall be submitted in Discharge Monitoring Report (DMR) forms.

10.0 Submit certification of the full implementation of the monitoring program to assess BMP effectiveness.

11.0 BMP Assessment Submit BMP evaluations and assessment, and revisions to the programs above if deemed necessary, based on monitoring data obtained.

12. 0 Annual TMDL Progress Reports The permittees shall submit annual reports describing progress on the activities required in Table III.B. to comply with the Fecal Coliform TMDL. The reports shall follow the requirements included in Part V.C, items 1, 4, 6 and 7, but shall be submitted separately from the Annual Report covering all other items of the permit. Results of the monitoring program shall be summarized in the Annual TMDL Progress Report and shall include graphic representation of fecal coliform trends. The Annual TMDL Progress Report shall also include computations of annual percent reduction achieved from the baseline loads and comparisons with the target loads.

Ohio

Big Darby Creek Watershed Construction General Permit

F. Total Maximum Daily Load (TMDL) allocations

This general permit requires control measures/BMPs for construction sites that reflect recommendations set forth in the U.S. EPA approved Big Darby Creek TMDL.

G. SWP3 Requirements

G2. Controls.

*2b. **Riparian Setback Requirements**. The SWP3 shall clearly delineate the boundary of required stream setback distances. No construction activity shall occur within the delineated setback boundary except activities associated with restoration or recovery of natural floodplain and channel form characteristics as described in Attachment B and storm water conveyances from permanent treatment practices. Such conveyances must be designed to minimize the width of disturbance. If intrusion within the delineated setback boundary is necessary to accomplish the purposes of a project then mitigation shall be required in accordance with Part III.G.2.c of this permit. Streams requiring protection under this section are defined as perennial, ephemeral or intermittent streams with a defined bed, bank or channel. National Resources Conservation Service (NRCS) soil survey maps should be used as one reference and the presence of a stream requiring protection should also be confirmed in the field. Any required setback distances shall be clearly displayed in the field prior to any construction related activity.*

Riparian setbacks shall be delineated based upon one of the following three methods:

i. The setback distance from the centerline of the stream shall be sized as the greater of the following:

1. The regulatory 100 year floodplain based on FEMA mapping;

2. A minimum of 100 feet on each side; or

3. Distance calculated using the following equation:

$W = 133DA^{0.43}$
where:
DA = drainage area (mi^2)
W = total width of riparian setback (ft)

W should be divided by two (2) in order to calculate the setback for one side of the stream. If the DA remains relatively constant throughout the stretch of interest, then the DA of the downstream edge of the stretch should be used. Where there is a significant increase in the DA from the upstream edge to the downstream edge of the area of interest, the setback width shall increase accordingly.

ii. Site Specific Riparian Setback Delineation. The total setback width shall be the streamway width centered over the meander pattern of the stream plus an additional 100 feet from the edge of the streamway per side.

The streamway width shall be calculated as described in Part III.G.2.b.i.3 or as ten times the bankfull width determined from sufficient site specific information adequate to characterize the channel through the site by a professional experienced in stream morphology. The average site specific bankfull width may be used if the bankfull width does not vary significantly throughout the reach of interest. Otherwise the streamway width should vary with bankfull width. Centering about the meander pattern can be thought of as determining where a line representing the streamway width would evenly intersect equal elevation lines on either side of the stream.

iii. Stream Restoration with 100 feet (each side) Riparian Setback. Each stream segment within the proposed site boundaries can be assessed in accordance with Attachment B. In the event the stream segment is classified as a "Previously Modified Low Gradient Headwater Stream", the permittee has the option to restore the stream segment in accordance with Attachment B and include a 100 feet water quality setback distance from the centerline of the stream on each side. In the event the stream segment exceeds the minimum criteria in Attachment B to be classified as a "Previously Modified Low Gradient Headwater Stream", Part III.G.2.b.iii may be considered on a case-by-case basis. No structural sediment controls (e.g., the installation of silt fence or a sediment settling pond) or structural post-construction controls shall be used in a stream or the delineated setback.

2i. ***Post-Construction Storm Water Management Requirements****. So that receiving stream's physical, chemical, and biological characteristics are protected and stream functions are maintained, post-construction storm water practices shall provide perpetual management of runoff quality and quantity. To meet the post-construction requirements of this permit, the SWP3 must contain a description of the post-construction BMPs that will be installed during construction for the site and the rationale for their selection. The rationale must address the anticipated impacts on the channel and floodplain morphology, hydrology, and water quality.*

Detail drawings and maintenance plans shall be provided for all postconstruction BMPs. Maintenance plans shall be provided by the permittee to the post-construction operator of the site (including homeowner associations) upon completion of construction activities (prior to termination of permit coverage). A description of maintenance operations must be included in the maintenance agreement to ensure all Post Construction BMP's will be maintained in perpetuity. For sites located within a community with a regulated municipal separate storm sewer system (MS4), the permittee, land owner, or other entity with legal control of the property may be required to develop and implement a maintenance plan to comply with the requirements of the MS4. Maintenance plans must ensure that pollutants collected within structural post-construction practices, be disposed of in accordance with local, state, and federal regulations. Permittees, except for those regulated under the small MS4 program, are not responsible under this permit for operation and maintenance of post-construction practices once coverage under this permit is terminated.

This permit does not preclude the use of innovation or experimental postconstruction storm water management technologies. However, the director may require discharges from such structures to be monitored to ensure compliance with Part III.G.2.i of this permit. The installation of structural controls in certain scenarios may also require a separate permit under section 404 of the CWA. Permittees are only responsible for the installation and maintenance of storm water management measures prior to final stabilization of the site and are not responsible for maintenance after storm water discharges associated with construction activity have been

eliminated from the site. However, post-construction storm water BMPs that discharge pollutants from point sources once construction is completed, may in themselves, need authorization under a separate NPDES permit.

Linear construction projects, (e.g., pipeline or utility line installation), which do not result in the installation of impervious surface, are not required to comply with the conditions of Part III.G.2.i of this permit. However, linear construction projects must be designed to minimize the number of stream crossings and the width of disturbance.

Large Construction Activities. For all large construction activities (involving the disturbance of five or more acres of land or will disturb less than five acres, but is a part of a larger common plan of development or sale which will disturb five or more acres of land), the post construction BMP(s) chosen must be able to detain storm water runoff for protection of the stream channels, stream erosion control, and improved water quality. Structural (designed) post-construction storm water treatment practices shall be incorporated into the permanent drainage system for the site. The BMP(s) chosen must be sized to treat the water quality volume (WQ_v) and ensure compliance with Ohio's Water Quality Standards in OAC Chapter 3745-1. The WQ_v shall be equivalent to the volume of runoff from a 0.75-inch rainfall and shall be determined according to one of the two following methods:

i. Through a site hydrologic study approved by the local municipal permitting authority that uses continuous hydrologic simulation and local long-term hourly precipitation records or ii. Using the following equation:

$WQv = C * P * A / 12$
where:
WQ_v = *water quality volume in acre-feet*
C = *runoff coefficient appropriate for storms less than 1 inch (see Table 5)*
P = *0.75 inch precipitation depth*
A = *area draining into the BMP in acres*

An additional volume equal to 20 percent of the WQ_v shall be incorporated into the BMP for sediment storage and/or reduced infiltration capacity. Ohio EPA recommends that BMPs be designed according to the methodology included in the most current edition of the Rainwater and Land Development manual or in another design manual acceptable for use by Ohio EPA.

BMPs shall be designed such that the drain time is long enough to provide treatment, but short enough to provide storage available for successive rainfall events as described in Table 6 below.

The permittee may request approval from Ohio EPA to use alternative structural post-construction BMPs if the permittee can demonstrate that the alternative BMPs are equivalent in effectiveness to those listed in Table 6 above. Construction activities shall be exempt from this condition if it can be demonstrated that the WQ_v is provided within an existing structural post-construction BMP that is part of a larger common plan of development or if structural post-construction BMPs are addressed in a regional or local storm water management plan.

For redevelopment projects (i.e., developments on previously developed property), post-construction practices shall either ensure a 20 percent net reduction of the site impervious area, provide for treatment of at least 20 percent of the WQ_v, or a combination of the two.

Small Construction Activities. For all small land disturbance activities (which disturb one or more, but less than five acres of land and is not a part of a larger common plan of development or sale which will disturb five or more acres of land), a description of measures that will be installed during the construction process to control pollutants in storm water discharges that will occur after construction operations have been completed must be included in the SWP3. Structural measures should be placed on upland soils to the degree attainable.

i. Such practices may include, but are not limited to: storm water detention structures (including wet basins); storm water retention structures; flow attenuation by use of open vegetated swales and natural depressions; infiltration of runoff onsite; and sequential systems (which combine several practices). The SWP3 shall include an explanation of the technical basis used to select the practices to control pollution where flows exceed pre-development levels.

ii. Velocity dissipation devices shall be placed at discharge locations and along the length of any outfall channel to provide non-erosive flow velocity from the structure to a water course so that the natural physical and biological characteristics and functions are maintained and protected (e.g., no significant changes in the hydrological regime of the receiving water).

Big Darby Creek Watershed TMDL

5.0 Implementation of the Big Darby Creek TMDL

A key objective for preserving or restoring the high quality aquatic communities in the Big Darby Creek watershed is to determine ways for human activities to proceed without disrupting the existing natural system. Human intervention usually happens on a local scale. A small swale or ditch is often viewed locally as a conduit for exporting water so that the products of human pursuits can be maximized. But the system as a whole has a finite capacity. The cumulative impact of local interventions in the system has grown to the point that the system can no longer assimilate the changes, particularly in the upper Big Darby Creek watershed, Treacle Creek, Robinson Run and Hellbranch Run. These local interventions are happening from all aspects of our society, as such, solutions will need to come from all aspects of our society. This chapter of the TMDL report outlines the ways to implement the guidelines and loading reductions provided in Chapter 4. Achievement of these are necessary to maintain the Big Darby Creek watershed as a high quality aquatic system.

5.1 Implementation Mechanisms

Stream integrity concepts are discussed in Chapters 3 and 4, as well as the establishment of allowable loads for pollutants, and effluent limitations for point source dischargers. A variety of mechanisms will be evaluated and used to achieve these loading reductions. These mechanisms are discussed in more detail below.

5.1.1 Storm Water Control

Storm water control is largely achieved through the issuance of general permits under the NPDES program. These permits are issued for construction activities, and for industrial activities, and are issued to control storm water that is discharged from a discrete conveyance, such as pipes or confined conduits. NPDES individual and general permits are issued to

individuals, private entities, and local government entities. These permits function together to form a web of state and local authority under which storm water is controlled.

General Permits For Construction Storm Water

Ohio EPA has issued a draft general permit for runoff associated with construction activity that is specific to the Big Darby Creek watershed. Ohio EPA has used existing permit terms and conditions and has included new types of permit terms and conditions to ensure, to the extent authorized by law, that loading targets developed in Chapters 3 and 4 are achieved for storm water. These permit terms and conditions include management practices, effluent targets, infiltration requirements necessary to support stream base flows and stream setbacks necessary to protect the stream channel. The goal is to issue a permit that is protective of the aquatic life uses in the Big Darby Creek watershed.

As is the case with the existing construction storm water general permit, construction companies will be expected to be co-permittees along with developers. This condition of the permit will be an area of emphasis by Ohio EPA in evaluating compliance with the general permit for storm water from construction activity.

Phase I and Phase II MS4 Permits For Local Jurisdictions

Federal storm water regulations call for the issuance of Phase I NPDES storm water permits to large municipalities, and the issuance of Phase II NPDES storm water permits to smaller municipalities. As with the general permits for construction storm water, Ohio EPA intends to revise the MS4 permits, to the extent authorized by law, so as to achieve the loading limitations established in Chapter 4 of this TMDL for storm water. Ohio EPA expects to exercise its authority to designate additional Phase II communities within the Big Darby Creek watershed and to ensure that the permits issued to those jurisdictions are protective of the aquatic life uses.

Oregon

Columbia Slough TMDL

The DMAs will conduct monitoring of stormwater BOD5 loads and the instream response to those loads. Previous monitoring under the MS4 permits has measured BOD5 levels from urban runoff that do not correlate with the few instream BOD5 samples taken during storm events. The discrepancy between loads and instream concentration is likely due to processes such as deposition and decay during the transport to the receiving water. The monitoring data will be used to calibrate a dynamic water quality model to simulate the Slough's response to stormwater and deicing fluid. The DMA WLA will not be included as an effluent limit. Achievement of the WLA will be through implementation of BMPs. Municipal discharges will be required to implement BMPs and demonstrate that the BMPs achieve the WLAs established. The DMAs will be required, through MOAs, to:

1. Provide DEQ with a description of the program designed to reduce BOD5 loads to the Slough.

2. Implement a program of BMPs that will reduce overall BOD5 load to achieve the DMA WLAs.

3. Implement coordinated monitoring to define stormwater loads to the Slough and the influence of stormwater BOD5 on receiving water quality.

4. Implement monitoring to demonstrate compliance with BOD5 WLA targets. Instream monitoring will include grab samples of BOD5 and DO and continuous hydrolab monitoring.

5. Implement water quality management plans as developed as part of the Lower Willamette Subbasin plan (projected completion spring 1999).

Phase I MS4 Permit for City of Gresham, City of Fairview, and Multnomah County

The requirements of this section [p. 17] apply to co-permittee's MS4 discharges to receiving waters with established TMDLs and associated allocations as noted on page 1 of this permit. It is the intent of this section to ensure that pollutant discharges for those parameters listed in the TMDL are reduced to the maximum extent practicable. Adequate progress toward achieving assigned wasteload allocations (WLAs) will be demonstrated through the implementation of best management practices that are targeted at TMDL related pollutants.

i) Progress towards reducing TMDL pollutant loads must be evaluated by the co-permittee through the use of performance measures and pollutant load reduction benchmarks developed and listed in the SWMP.

(1) Performance measures are estimates of the effectiveness of various best management practices (BMPs) implemented by the co-permittees as per the SWMP; and they are not numeric effluent limits. Performance measures must, where appropriate, be pollutant reduction estimates. The performance measures for the BMPs addressing TMDL pollutants may be based on the same metrics developed in accordance with the program effectiveness monitoring requirements in Schedule B(1)(c)(i).

(2) A benchmark is a total pollutant load reduction estimate for each parameter or surrogate, where applicable, for which a WLA is established at the time of permit issuance. A benchmark is used to measure the overall effectiveness of the stormwater management plan in making progress toward the wasteload allocation (this estimate will be related to the statistical variability of the underlying data and may be stated as a range), and is intended to be a tool for guiding adaptive management activities. A benchmark is not a numeric effluent limit; rather it is a goal that is subject to the maximum extent practicable standard. The co-permittee must provide the rationale for the proposed benchmark, which includes an explanation of the relationship between the benchmarks and the TMDL wasteload allocations. Any limiting factors related to the development of a benchmark, such as data availability and data quality, must also be included in this rationale.

ii) The SWMP must describe a program that includes BMPs, monitoring triggers, narrative conditions, or other elements, designed to achieve reductions in the TMDL pollutants. The SWMP must include a specific strategy for implementing monitoring designed to enable the co-permittee to gauge the effectiveness of the SWMP in reducing TMDL pollutant loads to the maximum extent practicable.

iii) When the co-permittee applies for permit renewal, the co-permittee must include an evaluation of the effectiveness of the stormwater management plan with respect to all pollutant

parameters addressed in an applicable TMDL. This evaluation must assess progress towards meeting the pollutant load reductions (benchmarks) using the reporting and monitoring programs and other methods described in Schedules B(1), B(2) and D(2)(d)(v) of this permit. If the co-permittee has failed to meet the estimated pollutant load reductions during the permit term, they must use the adaptive management process described in Schedule D(2)(a)of this permit to reassess the SWMP and determine what additional or alternative BMPs are practicable. The co-permittee must update the SWMP to include these BMPs. The co-permittee must submit the evaluation and any SWMP revisions to the Department as specified in Schedule D(2)(d)(v).

iv) If within three (3) years following permit issuance a TMDL is approved by the Environmental Protection Agency (EPA) and the TMDL has wasteload allocations assigned to stormwater within the geographic area covered by this permit, the co-permittee must, at the time of the next permit renewal application, complete a review and strategy development, and propose changes, if appropriate, to the SWMP to address the urban stormwater discharges.

v) If, at the time of permit issuance, TMDL wasteload allocations have been established for pollutant parameters associated with the MS4's discharges, each co-permittee must, as appropriate, review their SWMP to determine its adequacy in reducing TMDL pollutant discharges to the maximum extent practicable and develop pollutant load reduction benchmark(s) and performance measures in the SWMP as defined in Schedule D(2)(d)(i)(1) and (2). As part of the SWMP review and benchmark and performance measure development process, the co-permittee must document, and subsequently report in accordance with Schedule B(2)(b), the following information:

(1) A description of the methodology and rationale used to develop and select pollutant reduction benchmarks and performance measures. The methodology must address current estimated discharge loadings and TMDL wasteload allocations.

(2) Any proposed modifications to the SWMP resulting from the adaptive management process [Schedule D(2)(a)] necessary to give reasonable assurance that the SWMP is designed to reduce TMDL pollutants to the maximum extent practicable. This must include selection of BMPs and any assumptions related to the proposed BMPs.

(3) Any proposed modifications to the monitoring component of the SWMP that are necessary to ensure adequate data and information are collected to assess SWMP implementation, BMP effectiveness, progress towards the pollutant load reduction (4) A description of the public participation process, including a summary of material public comments and the responses to those comments.

The requirements of this section apply to receiving waters without established TMDL wasteload allocations. The co-permittee must qualitatively review the pollutants that are on the 2002 303(d) list that are relevant to the co-permittee's MS4 discharges. This review and corresponding summary of proposed actions must be incorporated into the interim evaluation report. The review and summary must accomplish the following:

i) Determine whether there is a reasonable likelihood for stormwater from the MS4 to cause or contribute to water quality degradation of receiving waters through the discharge of pollutants

on the 2002 303(d) list. Provide the rationale for the conclusion, including the results of an evaluation.

ii) If the discharges from the MS4 is a contributor to specific listed pollutants, determine and describe the relationship between the 303(d) listed pollutant and the MS4 discharges.

iii) Determine whether the BMPs in the existing SWMP are effective to address the 303(d) pollutants. If not, describe how the plan could be adapted to more appropriately address these pollutants. A summary of the rationale for this determination must also be included in the report. If sufficient information is not available to make the determinations required above, the co-permittee must compile pertinent information necessary to adequately complete these determinations.

The Interim Evaluation Report is to include: i) An evaluation of, and proposed revisions to, the SWMP that addresses the requirements of Schedules D(2)(b) and B(1)(b), including the rationale supporting the proposed revisions. ii) A description of the current source identification components of the SWMP and the rationale regarding the adequacy of these components. iii) For each of the listed non-stormwater discharges [Schedule A(3)] expected to occur in a copermittee's area, the co-permittee must identify the appropriate control measures and the rationale for the selection of these BMPs (or the rationale for why BMPs are deemed not necessary). iv) The required information regarding TMDL pollutants as described in Schedule D(2)(d)(v) and the corresponding proposed revisions to the SWMP, and/or the required information regarding 303(d) listed pollutants as described in Schedule D(2)(e) and the corresponding proposed revisions to the SWMP. v) An executive summary of the SWMP, no more than 15 pages in length, that describes the main elements of the SWMP. vi) Maps providing updated information as described in 40 CFR §122.26(d)(1)(iii)(B), where applicable.

Draft Phase II MS4 Permit

The requirements of this section apply to MS4 discharges to receiving waters with established TMDLs and associated wasteload allocations as noted on page 1 of this permit or if the permittee becomes subject to an approved TMDL, and following notice of such by the Department. If the permittee reduces applicable pollutant discharges for the parameters listed in the TMDL to the maximum extent practicable, this reduction is deemed to be adequate progress toward achieving assigned TMDL wasteload allocations (WLAs).

a) Progress towards reducing TMDL pollutant loads will be evaluated, in subsequent permit terms, by the permittee through the use of performance measures and pollutant load reduction benchmarks developed and listed in the SWMP.

(1) Performance measures are estimates of the effectiveness of various best management practices (BMPs) implemented by the permittee as per the SWMP; and are not numeric effluent limits. Performance measures must, where appropriate, be pollutant reduction estimates. If appropriate, the performance measures for the BMPs addressing TMDL pollutants may be based on the same metrics developed to determine progress towards measurable goals, as described in the SWMP.

(2) A pollutant load reduction benchmark is an estimate for each parameter or surrogate, where applicable, for which a WLA is established. A benchmark is used to measure the overall

effectiveness of the stormwater management program in making progress toward the WLA (this estimate will be related to the statistical variability of the underlying data and may be stated as a range), and is intended to be a tool for guiding adaptive management activities. A benchmark is not a numeric effluent limit; rather it is a goal. The permittee must provide the rationale for the proposed benchmark, which includes an explanation of the relationship between the benchmarks and the TMDL wasteload allocations. Any limiting factors related to the development of a benchmark, such as data availability and data quality, must also be included in this rationale.

b) The permittee must use adaptive management, as described in Schedule A(3), to focus and refine SWMP elements to address TMDL wasteload allocation(s) over the course of this permit cycle.

c) If, at the time of permit issuance or within three (3) years of permit issuance, a TMDL establishes municipal stormwater wasteload allocations for pollutant parameters associated with the MS4's discharges, the permittee must develop and propose to the Department specific performance measures and pollutant load reduction benchmarks, as described in Schedule D(2)(a). Performance measures and pollutant load reduction benchmarks must be submitted to the Department as part of the permit renewal package described in Schedule B(3).

Pennsylvania

Wissahickon Creek TMDL

The reference watershed approach is based on determining the current loading rates for the pollutants of interest from a selected unimpaired watershed that has similar physical characteristics (i.e., landuse, soils, size, geology) to those of the impaired watershed. The objective of this process is to reduce the loading rate of sediment (or other pollutant) in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the unimpaired reference stream segment.

Tennessee

Harpeth River E. coli TMDL

SWMPs must include a section describing how discharges of pollutants of concern will be controlled to ensure that they do not cause or contribute to instream exceedances of water quality standards. Specific measures and BMPs to control pollutants of concern must also be identified. In addition, MS4s must implement the WLA provisions of an applicable TMDL and describe methods to evaluate whether stormwater controls are adequate to meet the WLA. In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. Instream monitoring, at locations selected to best represent the effectiveness of BMPs, must include analytical monitoring of pollutants of concern. A detailed plan describing the monitoring program must be submitted to the Division of Water Pollution Control Nashville Field Office within 12 months of the approval date of this TMDL. Implementation of the monitoring program must commence within 6 months of plan approval by the Field Office. The monitoring program shall comply with

the monitoring, recordkeeping, and reporting requirements of NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems.

Phase II MS4 General Permit

1. *Determine whether stormwater discharge from any part of the MS4 significantly contributes directly or indirectly to a 303(d) listed (i.e., impaired) waterbody. Water quality impaired waters means any segment of surface waters that has been identified by the division as failing to support classified uses. If you have discharges meeting these criteria, you must comply with Part 3.1.1.2 and 3.1.2; if you do not, the remainder of this Part 3.1 does not apply to you.*

2. *If you have "303(d)" discharges described above, you must also determine whether a Total Maximum Daily Load (TMDL) has been developed by the division and approved by EPA for the listed waterbody. If there is a TMDL, you must comply with both Parts 3.1.2 and 3.1.3; if no TMDL has been approved, Part 3.1.3 does not apply until a TMDL has been approved.*

3. *Water Quality Controls for Discharges to Impaired Waterbodies. The stormwater management program review submitted to the division must include a section describing how your program will control the discharge of the pollutants of concern. This section must identify the measures and BMPs that will collectively control the discharge of the pollutants of concern. The measures should be presented in order of priority with respect to controlling the pollutants of concern.*

4. *Consistency with Total Maximum Daily Load (TMDL). If a TMDL has been approved for any waterbody into which you discharge, you must follow the procedure below and report on these activities in annual reports to the division:*

5. *Determine whether the approved TMDL is for a pollutant likely to be found in stormwater discharges from your MS4.*

6. *Determine whether the TMDL includes a pollutant wasteload allocation (WLA), implementation recommendations, or other performance requirements specifically for stormwater discharges from your MS4.*

7. *Determine whether the TMDL addresses a flow regime likely to occur during periods of stormwater discharge.*

8. *After the determinations above have been made and if it is found that your MS4 must implement specific provisions of the TMDL, evaluate whether the implementation of existing stormwater control measures is meeting the TMDL provisions, or if additional control measures are necessary.*

9. *Document all control measures currently being implemented or planned to be implemented. Include a schedule of implementation for all planned controls. Provide your rationale (e.g., calculations, assessments, reports and/or other evidence) that shows that you will comply with the TMDL provisions. For control measures that are expected to be implemented and evaluated beyond the term of this permit, you should also include longer schedule of implementation as necessary to describe the control measure.*

10. Describe a method to evaluate whether the stormwater controls are adequate to meet the requirements of the TMDL.

11. If the evaluation shows that additional or modified controls are necessary, describe the type and schedule for the control additions/revisions.

Vermont

Phase II General MS4 Permit

Your SWMP, including your operation and maintenance program for preventing or reducing pollutant runoff from municipal operations prepared pursuant to section 4.2.6, must include a section describing how your program will control to the maximum extent practicable the discharge of the pollutants of concern. This discussion must specifically identify measures and BMPs that will collectively control the discharge of the pollutants of concern. Pollutant(s) of concern refer to the pollutant identified as causing the impairment.

As set forth in 1.3.7 in implementing the six minimum control measures set forth in 4.2 you must be consistent with recommendations applicable to your MS4 in the implementation section of the Lake Champlain TMDL and any future TMDLs for impaired waters affected by your MS4 established or approved by EPA pursuant to section 303(d) of the federal Clean Water Act. The Lake Champlain Phosphorus TMDL recommendations for municipalities include: adoption of erosion controls (page 65), improved construction and maintenance practices for gravel backroads (page 69), promotion of riparian buffers and setbacks (page 76) and impervious surface minimization (page 76). 3.1.4. Determination of Consistency. The assessment of whether your Stormwater Management Program is consistent with TMDL recommendations will be based on your implementation and maintenance of best management practices not on estimates or measurements of pollutant loading does not authorize a direct discharge that is inconsistent with any EPA approved TMDL waste load allocation and any implementation plan for the waterbody to which the direct discharge drains. This general permit does not authorize a discharge to an impaired waterbody for which the Department has issued a watershed-specific general permit.

Washington

Draft Phase II MS4 General Permit (Western Washington)

An example of TMDL specific requirements is as follows:

***Name of TMDL:** Snohomish River Tributaries*
Location of Original 303 (d) Listings – WA-07-1012, WA-07-015, WA-07-1052, WA-07-1163WA-07-1163, WA-07-1030 and WA-07-040
Area where TMDL Requirements Apply:
For each waterbody listed, TMDL coverage includes areas draining to the WASWIS segment number, and all the upstream tributaries contributing to it: Allen Creek, YT94RF: Quilceda Creek, TH58TS: French Creek, XZ24XU: Woods Creek, FZ74HO:

Pilchuck River, NF79WA: Marshland Watershed, XW79FQ
TMDL coverage includes the areas indicated in the Lower Snohomish River Tributaries Fecal Coliform Bacteria TMDL Detailed Implementation Plan dated June 2003, Figure 3, page 7. This TMDL can be found at http://www.ecy.wa.gov/programs/wq/tmdl/watershed/tmdl_info-nwro.html
***Parameter** – Fecal Coliform*
***Approval Date** – 9 – Aug. 2001*
***Potential MS4 Permittees** – Phase I permit: Snohomish County*
***Phase II permit**: Granite Falls, Lake Stevens, Monroe, Snohomish, Marysville, Arlington, Everett*
***WSDOT permit**: WSDOT.*
Action Required –
Baseline Requirements: *Within 12 months after the effective date of this permit, all municipal stormwater permittees must adopt and enforce an ordinance or ordinances requiring the application of source control BMPs for the following existing land uses if they occur within their jurisdiction: 1) commercial animal handling areas, and 2) commercial composting facilities.*

Where these activities are not occurring, no action is required. BMPs shall be equivalent to those found in Volume IV of the 2001 Ecology Stormwater Management Manual for Western Washington. Ordinances shall also address illicit connections to storm drains.

Where potential sources of bacterial pollution exist, operational source control BMPs shall be required for all pollutant generating sources. Only in those cases where a facility is demonstrated to be causing a violation of surface or ground water standards, or is discharging illegally, shall structural source control BMPs shall be required as related to this TMDL. The provision for structural source control BMPs is not intended to apply to individual municipal stormwater outfalls.

No later than 12 months after the effective date of this permit, affected municipal permittees shall compile a list of the existing composting and animal waste handling facilities. This list shall be updated no later than 180 days prior to the expiration of the permit and submitted with the permit renewal application. Starting no later than 24 months after the effective date of this permit, conduct an inspection program for all the listed sites, with adequate enforcement capability to ensure implementation of source control BMPs. All facilities must be inspected with 40 months of the effective date of this permit.

***Monitoring and Implementation Requirements:** Permittees shall choose one or both of the following monitoring strategies. Strategy A is the default implementation strategy unless the permittee chooses to implement Strategy B in all or part of the area subject to the TMDL:*

Strategy A, Targeted Implementation Approach
- *Within 90 days of permit issuance, prepare and submit to Ecology for review, a Quality Assurance Project Plan (QAPP) for the sampling of streams and/or discharges from stormwater conveyances within the jurisdictions boundaries in order to determine areas with highest bacteria concentrations (high priority areas). Provisions for additional monitoring in high priority areas shall be included in order to locate pollution sources were they are not obvious.*

- *The QAPP shall be prepared following Ecology's "Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies, Feb. 2001, Ecology Publication No. 01-03-003. Ecology will review and provide comments within 30 days the plan is received. The sampling plan shall include an adequate number of sampling points and adequate sampling frequency to reasonably characterize the receiving water or waste stream. Monitoring shall begin no later than 270 days after permit issuance.*

- *No later than 365 days prior to permit renewal application, a Bacterial Pollution Control Plan shall be developed. The Bacterial Pollution Control Plan shall, at a minimum, consider the use of the following approaches:*

  1) pet waste ordinance, 2) evaluation of water pollution control enforcement capabilities, 3) evaluation of CAO in relation to TMDL goals, 4) educational program directed at reducing bacterial pollution, 5) investigation and implementation of methods that prevent additional stormwater bacterial pollution through stormwater treatment, reducing stormwater volumes, and preventing additional sources of stormwater in association with new development, 6) implementation of activities in the Quilceda/Allen or French Creek Watershed Management Plans (as applicable), 7) ambient water quality and stormwater quality sampling to specifically identify bacterial pollution sources, and 8) livestock ordinance and compost ordinance (Phase I Permittees only.)

- *No later than 270 days prior to permit renewal application, conduct public review of the Bacterial Pollution Control Plan.*

- *Submit the final Bacterial Pollution Control Plan to Ecology at the time of permit renewal application.*

Strategy B: Early Action Approach.

- *Prepare Early Action BMP plan within 180 days of permit effective date. The Early Action Plan shall contain those BMPs that the permittee believes will be effective in reducing bacteria levels within the MS4 (or otherwise in local waters). The Early Action Plan must include implementation of the required baseline requirement for all municipal stormwater permittees including adoption and enforcement of ordinance(s) requiring the application of source control BMPs related to bacterial pollutants (equivalent to Volume IV of the 2001 Ecology Stormwater Management Manual for Western Washington).*

- *The Early Action BMP Plan shall, at a minimum, consider the use of the following approaches: 1) pet waste ordinance, 2) evaluation of water pollution control enforcement capabilities, 3) evaluation of CAO in relation to TMDL goals, 4) educational program directed at reducing bacterial pollution, 5) investigation and implementation of methods that prevent additional stormwater bacterial pollution through stormwater treatment, reducing stormwater volumes, and preventing additional sources of stormwater in association with new development, 6) implementation of activities in Quilceda/Allen or French Creek Watershed Management Plans (as applicable) Watershed Management Plan, 7) ambient water quality and stormwater quality sampling to specifically identify bacterial pollution sources, and 8) livestock and compost ordinances (Phase I permittees only)*

- *Conduct and complete public review of the Early Action BMP plan within 270 days of permit effective date.*

- *Begin implementation of Early Action BMPs as specified in the plan within 360 days of permit issuance. BMPs shall be place within 36 months of permit issuance unless otherwise approved by Ecology.*
- *Within 30 months of permit issuance, prepare and submit to Ecology for review, a Quality Assurance Project Plan (QAPP) for the sampling of streams and/or discharges from stormwater conveyances within the jurisdictions boundaries in order to assess whether or not affected water bodies and/or stormwater discharges, are meeting state water quality standards.*
- *The QAPP shall be prepared following Ecology's "Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies, Feb. 2001, Ecology Publication No. 01-03-003. Ecology will review and provide comments within 30 days the plan is received. The sampling plan shall include an adequate number of sampling points and adequate sampling frequency to reasonably characterize the receiving water or waste stream. Monitoring shall begin no later than 36 months after permit issuance.*
- *No later than 270 days prior to permit renewal, a Bacterial Pollution Control Plan shall be developed. The Plan shall consider all available monitoring data and the approaches noted for the Early Action BMP Plan above.*
- *No later than 270 days prior to permit renewal application, conduct public review of the Bacterial Pollution Control Plan.*
- *Submit the Bacterial Pollution Control Plan to Ecology at the time of permit renewal application for review.*

Construction General Permit (state-wide)

S8. DISCHARGES TO 303(D) OR TMDL WATERBODIES

A. Sampling and Numeric Effluent Limitations For Discharges to 303(d)-listed Waterbodies

1. Permittees that discharge to water bodies listed as impaired by the State of Washington under Section 303(d) of the Clean Water Act for turbidity, fine sediment, high pH, or phosphorus, shall conduct water quality sampling according to the requirements of this section.

2. All references and requirements associated with Section 303(d) of the Clean Water Act mean the most current listing by Ecology of impaired waters that exists on November 16, 2005, or the date when the operator's complete permit application is received by Ecology, whichever is later.

B. Discharges to 303(d)-Listed Waterbodies (Turbidity, Fine Sediment, or Phosphorus)

1. Permittees which discharge to waterbodies on the 303(d) list for turbidity, fine sediment, or phosphorus shall conduct turbidity sampling at the following locations to evaluate compliance with the water quality standard for turbidity: a. Background turbidity shall be measured in the 303(d)-listed receiving water immediately upstream (upgradient) or outside the area of influence of the discharge; and b. Discharge turbidity shall be measured at the point of discharge into the 303(d) listed receiving waterbody, inside the area of influence of the discharge; or Alternatively, discharge turbidity may be measured at the point where the discharge leaves the construction site, rather than in the receiving waterbody.

2. Based on sampling, if the discharge turbidity exceeds the water quality standard for turbidity (more than 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or more than a 10% increase in turbidity when the background turbidity is more than 50 NTU), all future discharges shall comply with a numeric effluent limit which is equal to the water quality standard for turbidity.

3. If a future discharge exceeds the water quality standard for turbidity, the Permittee shall:

a. Review the SWPPP for compliance with Condition S9 and make appropriate revisions within 7 days of the discharge that exceeded the standard;

b. Fully implement and maintain appropriate source control and/or treatment BMPs as soon as possible, but within 10 days of the discharge that exceeded the standard;

c. Document BMP implementation and maintenance in the site log book; d. Notify the appropriate Ecology Regional Office by phone within 24 hours of analysis;

e. Continue to sample daily until discharge turbidity meets the water quality standard for turbidity.

C. Discharges to waterbodies on the 303(d) list for High pH

1. Permittees which discharge to waterbodies on the 303(d) list for high pH shall conduct sampling at one of the following locations to evaluate compliance with the water quality standard for pH (in the range of 6.5 – 8.5): a. pH shall be measured at the point of discharge into the 303(d) listed waterbody, inside the area of influence of the discharge; or b. Alternatively, pH may be measured at the point where the discharge leaves the construction site, rather than in the receiving water.

2. Based on the sampling set forth above, if the pH exceeds the water quality standard for pH (in the range of 6.5 – 8.5), all future discharges shall comply with a numeric effluent limit which is equal to the water quality standard for pH.

3. If a future discharge exceeds the water quality standard for pH, the Permittee shall:

a. Review the SWPPP for compliance with Condition S9 and make appropriate revisions within 7 days of the discharge that exceeded the water quality standard;

b. Fully implement and maintain appropriate source control and/or treatment BMPs as soon as possible, but within 10 days of the discharge that exceeded the standards;

c. Document BMP implementation and maintenance in the site log book; d. Notify the appropriate Ecology Regional Office by phone within 24 hours of analysis; and

e. Continue to sample daily until discharge meets the water quality standard for pH (in the range of 6.5 – 8.5) or the discharge stops or is eliminated.

Parameter identified in 303(d) listing	Parameter/Units		Analytical Method	Sampling Frequency
Turbidity Fine Sediment	Phosphorus	Turbidity/NTU	SM2130 or EPA180.1	Weekly, if discharging If background is 50 NTU or less: 5 NTU over background; or If background is more than 50 NTU: 10% over background
High pH	pH/Standard Units		pH meter	Weekly, if discharging

D. Sampling and Limitations For Sites Discharging to Applicable TMDLs

1. Discharges to a waterbodies subject to an applicable Total Maximum Daily Load (TMDL) for turbidity, fine sediment, high pH, or phosphorus, shall be consistent with the assumptions and requirements of the TMDL.

a. Where an applicable TMDL sets specific waste load allocations or requirements for discharges covered by this permit, discharges shall be consistent with any specific waste load allocations or requirements established by the applicable TMDL. ii. The Permittee shall sample discharges weekly, or as otherwise specified by the TMDL, to evaluate compliance with the specific waste load allocations or requirements. iii. Analytical methods used to meet the monitoring requirements shall conform to the latest revision of the Guidelines Establishing Test Procedures for the Analysis of Pollutants contained in 40 CFR Part 136. Turbidity and pH methods need not be accredited or registered unless conducted at a laboratory which must otherwise be accredited or registered.

b. Where an applicable TMDL has established a general waste load allocation for construction stormwater discharges, but no specific requirements have been identified, compliance with Conditions S4 (Monitoring) and S9 (SWPPPs) will be assumed to be consistent with the approved TMDL.

c. Where an applicable TMDL has not specified a waste load allocation for construction stormwater discharges, but has not excluded these discharges, compliance with Conditions S4 (Monitoring) and S9 (SWPPPs) will be assumed to be consistent with the approved TMDL.

d. Where an applicable TMDL specifically precludes or prohibits discharges from construction activity, the operator is not eligible for coverage under this permit.

2. Applicable TMDL means a TMDL for turbidity, fine sediment, high pH, or phosphorus, which has been completed and approved by EPA prior to November 16, 2005, or prior to the date the operator's complete permit application is received by Ecology, whichever is later. TMDLs completed after the operator's complete permit application is received by Ecology become applicable to the Permittee only if they are imposed through an administrative order by Ecology, or through a modification of permit coverage.

Industrial General Permit (state-wide)

Facilities that discharge to a waterbody with a control plan unless this general permit is adequate to provide the level of protection required by the control plan. Excluded facilities need to obtain coverage under another NPDES permit for stormwater discharges associated with industrial activity. Control plans may be total maximum daily load (TMDL) determinations, restrictions for the protection of endangered species, ground water management plans, or other limitations that regulate or set limits on discharges to a specific waterbody or groundwater recharge area.

E. Stormwater Discharges to Impaired Waterbodies Except 303(d) Listings for Sediment and Tissue

The Permittee's discharge must not cause or contribute to an excursion of the State's water quality standards, including the State's narrative criteria for water quality. For 303(d) listings based on numeric water quality criteria, Permittees must comply with the State's water quality standard for each pollutant named as a pollutant causing a violation of water quality standards at the location named on the State's 303(d) list except for temperature which is not required and fecal coliform which is only required if there is a potential source from the industrial activity. Ecology will not require monitoring for fecal coliform if the Permittee can document that there is no potential source of fecal coliform from any of their industrial activities. A permittee's requirements to comply with this condition will be listed on the cover sheet. Ecology will maintain an electronic list of permittees subject to this permit condition. This list, titled Appendix 4, is available on Ecology's web site.

For waterbody segments listed as impaired by the State under Section 303(d) of the Clean Water Act, the applicable 303(d) list is the list which is in effect August 21, 2002, or the 303(d) list which is in effect at the date the first application for coverage is received by Ecology, whichever is later.

Permittees must be in compliance with applicable Total Maximum Daily Load (TMDL) determinations. Applicable TMDLs or TMDL determinations are TMDLs which have been completed by the issuance date of this permit, or which have been completed prior to the date that the permittees application is received by Ecology, which ever is later. A permittee's requirements to comply with this condition will be listed on their cover sheet. Ecology will maintain an electronic list of permittees subject to this permit condition. This list, titled Appendix 5, is available on Ecology's web site. Unless the first application for coverage is received after any updated 303(d) list is effective, changes associated with revised 303(d) lists completed after September 20, 2002 will only become effective if they are imposed through an administrative order issued by Ecology.

Unless the first application for coverage is received after the TMDL is completed TMDL requirements associated with TMDLs completed after the issuance date of this permit will only become effective if they are imposed through an administrative order issued by Ecology.

1. New Facilities and Significant Process Change New facilities that discharge either directly or indirectly via a stormwater conveyance system to waterbody segments listed as impaired by the State under Section 303(d) of the Clean Water Act must comply with the State's water quality standards for the named pollutant(s) at the point of discharge. Facilities with coverage under

this permit, that implement a significant process change (see S1.D.1.) must either comply with the State's water quality standards for the named pollutant(s) at the point of discharge or demonstrate no increase in loading from the entire facility as a result of the process change. All new discharges including new discharges associated with significant process changes must be in compliance with any applicable TMDL determination.

PARAMETER	***EFFLUENT LIMITATIONS: NEW FACILITIES TO IMPAIRED WATERS OR WATERS COVERED BY A TMDL***
Parameter(s) as identified for the 303(d) listed segment or if applicable, TMDL determination	*As listed on the coversheet, based on Chapter 173-201A or as identified in the TMDL or listing documentation*

2. Existing Facilities discharging to water bodies for which an applicable TMDL has been completed:

PARAMETER	***EFFLUENT LIMITATIONS: EXISTING FACILITIES TO WATERS COVERED BY A TMDL***
Parameter(s) as identified in the applicable TMDL	*As listed on the cover sheet to comply with the applicable TMDL*

Note: A current listing of permittees subject to this permit condition and the specific effluent limitations and monitoring requirements, Appendix 5, is available on Ecology's web site.

3. Existing facilities which discharge either directly or indirectly via a stormwater conveyance system to waterbody segments listed as impaired by the State under Section 303(d) of the Clean Water Act are subject to the general compliance with standards provisions in S7. Additional monitoring and benchmarks apply as described in S.4.G Note: A current listing of permittees subject to this permit condition, and the associated benchmarks and monitoring requirements, Appendix 4, is available on Ecology's web site.

G. Monitoring Requirements for Facilities Discharging to 303(d) Listed Waters or Subject to TMDL Determination Except 303(d) Listings for Sediment and Tissue

In addition to the requirements in S4.C. above, beginning January, 2005, all facilities that discharge to waterbody segments listed as impaired by the State under Section 303(d) of the Clean Water Act must conduct quarterly monitoring of authorized discharges of stormwater to surface water. Samples must be analyzed for the parameters named on the 303(d) as causing impairment of the listed waters except for temperature which is not required and fecal coliform which is only required if there is a potential source from the industrial activity. Note: A current Appendix 4 with a list of permittees subject to the monitoring requirements of this condition is available on Ecology's web site.

Discharges to a waterbody for which a TMDL has been completed must be consistent with the TMDL determination. Where the TMDL determination sets load allocations for new discharges or limits pollutant concentrations in the discharge, the Permittee must conduct quarterly monitoring for the named pollutant(s) and the monitoring must be consistent with TMDL

requirements, if any. Reporting as required by this permit begins with the first quarter of the year 2005. Note: A current Appendix 5 with a list of permittees subject to the monitoring requirements of this condition is available on Ecology's web site.

1. Permittees may suspend monitoring for a listed parameter if:

a. Eight consecutive samples fail to detect the presence of the listed parameter. Fail to detect does not apply to pH. For pH it is eight consecutive samples where the values are not outside of the water quality-based range of 6.5 to 8.5 (freshwater) or 7.0 to 8.5 (marine).

b. The Permittee can demonstrate to Ecology's satisfaction after eight or more consecutive quarterly samples that there is no reasonable potential to violate water quality standards. For the purposes of suspending monitoring required under S4.G only, no reasonable potential to violate water quality is defined as a single sample exceeding eighty percent of the benchmark, and the average of the last eight consecutive quarterly samples is less than sixty percent of the benchmark.

2. For existing permittees discharging to water bodies for which an applicable TMDL has been completed:

Parameter	***Units***	***Analytical Method***	***Minimum Sampling Frequency***
Parameter(s) as identified in the applicable TMDL. (See cover sheet)	*As Applicable (see cover sheet)*	*Appropriate EPA or Equivalent Method*	*Quarterly (See cover sheet for specifics)*

Note: A current Appendix 5 with a list of permittees subject to the monitoring requirements of this condition is available on Ecology's web site.

3. Existing permittees discharging to water bodies that discharge to waterbody segments listed as impaired by the State under Section 303(d) of the Clean Water Act:

Parameter	***Units***	***Analytical Method***	***303(d) Benchmark Value***	***Minimum Sampling Frequency***
Parameter(s) as identified for the 303(d) listed segment (See cover sheet)	*As Applicable (See cover sheet)*	*Appropriate EPA or Equivalent Method*	*Based on Chapter 173-201A (See cover sheet)*	*Quarterly (See cover sheet for specifics)*

Note: A current Appendix 4 with a list of permittees subject to the monitoring requirements of this condition is available on Ecology's web site.

H. Monitoring Requirements for Facilities Discharging to 303(d) Waterbody segments listed for Sediment

All facilities that discharge to waterbody segments listed for sediment must notify Ecology of any sediment data they may have collected. Upon request from Ecology they will submit the data.

In addition to the requirements in S4.A. above, beginning with the first quarter of the year 2005, all facilities that discharge to waterbody segments listed by the State for violations of sediment standards under Section 303(d) of the Clean Water Act must conduct quarterly monitoring of authorized discharges of stormwater to surface water for total suspended solids (TSS). Discharges that demonstrate TSS levels consistent with secondary treatment standards (30 mg/L monthly average not to exceed 45 mg/L) are considered unlikely to violate sediment quality standards. Permittees that can demonstrate consistent attainment TSS levels of secondary treatment standards may suspend monitoring for the duration of the permit term. Consistent attainment is defined as 8 consecutive quarterly samples (omitting any quarter where there is no discharge) with an average TSS of 30 mg/L and no sample exceeding 45 mg/L.

Wisconsin

Phase II MS4 general permit

1.5 Impaired Water Bodies and Total Maximum Daily Load Requirements

1.5.1 The permittee shall determine whether any part of its MS4 discharges to an impaired water body listed in accordance with section 303(d)(1) of the federal Clean Water Act, 33 USC §1313(d)(1)(C), and the implementing regulation of the US Environmental Protection Agency, 40 CFR §130.7(c)(1). Impaired waters are those that are not meeting applicable water quality standards. A list of Wisconsin impaired water bodies may be found on the Department's Internet site at: http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html.

1.5.2 If the permittee's MS4 discharges to an impaired water body, the permittee shall include a written section in its storm water management program that discusses the management practices and control measures it will implement as part of its program to reduce, with the goal of eliminating, the discharge of pollutant(s) of concern that contribute to the impairment of the water body. This section of the permittee's program shall specifically identify control measures and practices that will collectively be used to try to eliminate the MS4's discharge of pollutant(s) of concern that contribute to the impairment of the water body and explain why these control measures and practices were chosen as opposed to other alternatives. Pollutant(s) of concern means a pollutant that is causing impairment of a water body.

1.5.3 After the permittee's start date of coverage under this permit, the permittee may not establish a new MS4 discharge of a pollutant of concern to an impaired water body or increase the discharge of a pollutant of concern to an impaired water body unless the new or increased discharge causes the receiving water to meet applicable water quality standards, or the Department has approved a total maximum daily load (TMDL) for the impaired water body.

1.5.4 The permittee shall determine whether its MS4 discharges to an impaired water body for which the Department has approved a TMDL. If so, the permittee shall assess whether the TMDL wasteload allocation for the MS4 is being met through the existing storm water management controls or whether additional control measures are necessary. The permittee's assessment of whether the TMDL wasteload allocation is being met shall focus on the adequacy of the permittee's storm water controls (implementation and maintenance). Approved TMDLs

are listed on the Department Internet site at:
http://dnr.wi.gov/org/water/wm/wqs/303d/index.html.

1.5.5 The storm water management program developed under section 2 of this permit shall be revised as necessary to achieve and maintain compliance with any Department approved-TMDL wasteload allocation for an impaired water to which the MS4 discharges. The redesigned storm water management programs shall be implemented as soon as possible.

Federal Construction General Permit

Part 1.3.C.: Eligibility, Limitations on Coverage

5. Discharging into Receiving Waters With an Approved Total Maximum Daily Load Analysis

a. You are not eligible for coverage under this permit for discharges of pollutants of concern to waters for which there is a total maximum daily load (TMDL) established or approved by EPA unless you incorporate into your SWPPP measures or controls that are consistent with the assumptions and requirements of such TMDL. To be eligible for coverage under this general permit, you must incorporate into your SWPPP any conditions applicable to your discharges necessary for consistency with the assumptions and requirements of such TMDL. If a specific wasteload allocation has been established that would apply to your discharge, you must incorporate that allocation into your SWPPP and implement necessary steps to meet that allocation.

b. In a situation where an EPA-approved or established TMDL has specified a general wasteload allocation applicable to construction storm water discharges, but no specific requirements for construction sites have been identified in the TMDL, you should consult with the State or Federal TMDL authority to confirm that adherence to a SWPPP that meets the requirements of the CGP will be consistent with the approved TMDL. Where an EPA-approved or established TMDL has not specified a wasteload allocation applicable to construction storm water discharges, but has not specifically excluded these discharges, adherence to a SWPPP that meets the requirements of the CGP will generally be assumed to be consistent with the approved TMDL. If the EPA-approved or established TMDL specifically precludes such discharges, the operator is not eligible for coverage under the CGP.

3.14 Documentation of Permit Eligibility Related to Total Maximum Daily Loads

The SWPPP must include documentation supporting a determination of permit eligibility with regard to waters that have an EPA-established or approved TMDL, including:

A. Identification of whether your discharge is identified, either specifically or generally, in an EPA-established or approved TMDL and any associated allocations, requirements, and assumptions identified for your discharge;

B. Summaries of consultation with State or Federal TMDL authorities on consistency of SWPPP conditions with the approved TMDL, and

C. Measures taken by you to ensure that your discharge of pollutants from the site is consistent with the assumptions and requirements of the EPA-established or approved TMDL, including any specific wasteload allocation that has been established that would apply to your discharge.

See section 1.3.C.5 for further information on determining permit eligibility related to TMDLs.

Federal Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity

Impaired waters include both those with established TMDLs, and those for which TMDL development has been identified as necessary, but for which one has not yet been established. For a more detailed definition see Appendix A.

1.4.4.1 Discharge to an Impaired Water with an Established TMDL. If a wasteload allocation (WLA) has been established that applies to your discharge, you must develop the SWPPP accordingly (Part 2.1.3.2), and implement all necessary controls to meet that allocation. You must verify that your discharge complies with the WLA through the appropriate discharge monitoring (Part 3.2.4.2). Failure to comply with a relevant WLA is a violation of this permit.

If you have properly complied with the requirements of Part 2.1.3.2 and find that the applicable TMDL does not specify a wasteload allocation or other requirements either individually or categorically for your discharge (including disallowing such discharge), compliance with this permit will be deemed adequate to meet the requirements of the TMDL.

1.4.4.2 Discharge to an Impaired Water without an Established TMDL. If a TMDL has not been established that applies to your discharge you must comply with the requirements of this permit and any additional conditions stipulated by the Secretary (Part 2.1.3.2). If you have properly complied with all such requirements then compliance with this permit will be deemed adequate to meet the requirements for discharging to an impaired water. You are also subject to the monitoring requirement of Part 3.2.4.1. Failure to comply with applicable conditions is a violation of this permit.

3.2.4.1 Discharges to impaired waters with no applicable wasteload allocation. For discharges that are conveyed directly or indirectly to impaired waters, monitoring for the pollutant of concern must be conducted at a minimum of once each permit year throughout the term of the permit unless this permit already assigns your discharge an effluent limitation or a benchmark for the pollutant of concern. Your monitoring year begins on the day that your discharge is authorized.

This monitoring requirement is waived after one year if the pollutant of concern is not detected in an amount expected to cause and contribute to a violation of Vermont Water Quality Standards in your stormwater discharge, and you document in your SWPPP that there is no exposure of the pollutant of concern to stormwater at your site.

3.2.4.2 Discharges to impaired waters with an applicable wasteload allocation. For discharges that are conveyed directly or indirectly to waters for which a TMDL has been established with a wasteload allocation applicable to your discharge (either specifically or categorically), monitoring for the wasteload allocation pollutant of concern must be conducted, consistent with

any instructions in TMDL documentation. If the TMDL documentation does not specify specific monitoring requirements, monitoring for the pollutant of concern must be conducted at a minimum of once each permit year throughout the term of the permit, unless this permit already assigns your discharge an effluent limitation or a benchmark for the pollutant of concern, in which case you must follow the effluent limitation or benchmark monitoring schedule. Your monitoring year begins on the day your discharge is authorized. This monitoring must be conducted in addition to all other monitoring requirements prescribed in this permit. Monitoring of a pollutant of concern for which your discharge has been assigned a wasteload allocation cannot be waived unless the WLA is specified only in terms of BMPs, in which case the monitoring requirement is waived after one year if the pollutant of concern is not detected in your stormwater discharge and you document in your SWPPP that you have adopted the required BMPs.

If at any time your monitoring data exceed a relevant waste load allocation you are subject to the Corrective Action requirements of Part 3.3 and the Follow-up Monitoring and Reporting requirements of Part 3.4.

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Web Sites and Databases

American Society of Civil Engineers' (ASCE) and EPA's International Stormwater BMP Database: www.bmpdatabase.org/

Authorization Status for EPA's Stormwater Construction and Industrial Programs by State: http://cfpub.epa.gov/npdes/stormwater/authorizationstatus.cfm

Center for Watershed Protection's Stormwater Manager's Resource Center Web site: www.stormwatercenter.net/

Center for Watershed Protection's Web site on the Simple Method: www.stormwatercenter.net. Click "By Category." Information on the Simple Method is included in the *Impacts of Urbanization* category.

Conservation Technology and Information Center Web site, *Know Your Watershed: Building Local Partnerships*: www2.ctic.purdue.edu/KYW/Brochures/BuildingLocal.html

EPA's Biocriteria Web site: www.epa.gov/waterscience/biocriteria/

EPA's CADDIS Web site: http://cfpub.epa.gov/caddis/

EPA's eNOI system: http://cfpub.epa.gov/npdes/stormwater/enoi.cfm

EPA's Environmental Monitoring and Assessment Program (EMAP) database: www.epa.gov/emap/index.html

EPA's *Guidelines for Reviewing TMDLs Under Existing Regulations Issued in 1992*: www.epa.gov/owow/tmdl/guidance/final52002.html

EPA's list of bioassessment publications from EPA and other federal agencies (e.g., U.S. Geological Survey [USGS], U.S. Department of Agriculture [USDA]): www.epa.gov/bioindicators/html/publications.html

EPA's list of Regional stormwater contacts: http://cfpub.epa.gov/npdes/contacts.cfm?program_id=6&type=REGION

EPA's list of sectors of industrial activity that require permit coverage: http://cfpub.epa.gov/npdes/stormwater/swcats.cfm

EPA's list of state stormwater contacts: http://cfpub.epa.gov/npdes/contacts.cfm?program_id=6&type=STATE

EPA's NPDES Stormwater Discharges from Industrial Facilities Web site: http://cfpub.epa.gov/npdes/stormwater/indust.cfm

EPA's NPDES Stormwater Discharges from Municipal Separate Storm Sewer Systems Web site: http://cfpub.epa.gov/npdes/stormwater/munic.cfm

EPA's NPDES Stormwater Program Authorization Status: http://cfpub.epa.gov/npdes/stormwater/authorizationstatus.cfm

EPA's NPDES Stormwater program Web site: http://cfpub.epa.gov/npdes/home.cfm?program_id=6

EPA's NPDES Stormwater Discharges from Construction Activities Web site: http://cfpub.epa.gov/npdes/stormwater/const.cfm

EPA's PCS: www.epa.gov/enviro/html/pcs/index.html

EPA's Storage and Retrieval Database (STORET): www.epa.gov/storet/

EPA's TMDL and Stormwater Resources Web site: www.epa.gov/owow/tmdl/stormwater

EPA's TMDL Web site: www.epa.gov/owow/tmdl/

EPA's Urban BMP Performance Tool: http://cfpub.epa.gov/npdes/stormwater/urbanbmp/bmpeffectiveness.cfm

Google Earth: http://earth.google.com/

Multi-Resolution Land Characteristics (MRLC) Consortium's National Land Cover Database (NLCD): www.epa.gov/mrlc/

National Agriculture Imagery Program (NAIP) Aerial Photos: http://165.221.201.14/NAIP.html

University of Alabama's (Pitt, R.E., A. Maestre, and R. Morquecho) The National Stormwater Quality Database (NSQD, version 1.1): http://unix.eng.ua.edu/~rpitt/Research/ms4/mainms4.shtml

University of Massachusetts Amherst's Massachusetts Stormwater Technology Evaluation Project (MASTEP), Stormwater Technologies Clearinghouse: www.mastep.net/

University of New Hampshire Stormwater Center, Nonpoint Education for Municipal Officials (NEMO), Innovative Stormwater Management Inventory Database: www.erg.unh.edu/stormwater/index.asp

USDA's PACFISH/INFISH Biological Opinion Program: http://fsgeodata.fs.fed.us/pibo/

USGS's Earth Explorer: http://edcsns17.cr.usgs.gov/EarthExplorer/

USGS's National Water Information System Web site (NWISWeb): http://waterdata.usgs.gov/nwis

USGS's National Water-Quality Assessment (NAWQA) Program: http://water.usgs.gov/nawqa/

USGS's Land Cover Institute: http://landcover.usgs.gov/

GLOSSARY

Benchmark monitoring: The results of MSGP 2000 benchmark monitoring are primarily for the permittee's use to determine the overall effectiveness of an SWPPP in controlling the discharge of pollutants to receiving waters. Benchmark values are not viewed as effluent limitations. An exceedance of a benchmark value does not, in and of itself, constitute a violation of the MSGP. According to EPA, while exceedance of a benchmark value does not automatically indicate that violation of a water quality standard has occurred, it does signal that modifications to the SWPPP may be necessary. In addition, permitting authorities may use the exceedance of benchmark values to identify facilities that would be more appropriately covered under an individual, or alternative general permit where more specific pollution prevention controls could be required.

Best management practice (BMP): Policies or practices that prevent, reduce, or mitigate the effects of stormwater runoff. These methods can be structural (e.g., devices, ponds) or nonstructural (e.g., policies to reduce imperviousness). BMPs classified as *nonstructural* are those that rely predominantly on behavioral changes rather than construction to be effective. *Structural* BMPs are engineered or constructed to prevent or manage stormwater. BMPs are often further classified into (1) source-control BMPs to prevent pollution, (2) water quality BMPs to reduce or prevent pollutants in runoff, (3) flow-control BMPs to reduce the volume of stormwater and (4) infiltration BMPs to increase infiltration.

Combined sewer system: Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all their wastewater to a sewage treatment plant, where it is treated and then discharged to a waterbody. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other waterbodies.

Effluent limitation: Any restriction imposed on quantities, discharge rates, and concentrations of pollutants that are discharged from point sources into waters of the United States, the waters of the contiguous zone, or the ocean (40 CFR 122.2).

Flow duration curves: Calculations of limits that analyze the cumulative frequency of historic flow data over a specified period. Flow duration curve development typically uses daily average discharge rates, which are sorted from the highest value to the lowest. Using this convention, flow duration intervals are expressed as a percentage, with zero corresponding to the highest stream discharge in the record (i.e., flood conditions) and 100 to the lowest (i.e., drought conditions). Duration curve analysis identifies intervals that can be used as a general indicator of hydrologic condition (i.e., wet versus dry and to what degree). Flow duration curve intervals can be grouped into several broad categories or zones. For example, many duration curves categorize the flow intervals into the following five zones: high flows, moist conditions, mid-range flows, dry conditions, and low flows. When water quality concentrations or loads are plotted on the basis of these flow zones, the resulting graphs can provide additional insight about conditions, patterns associated with the impairment, and potential sources contributing to the problem. Duration curves add value to the TMDL process by characterizing water quality concerns in terms of flow conditions, linking these concerns to key watershed processes, prioritizing source assessment efforts, and identifying potential solutions.

General permit: An NPDES permit issued under 40 CFR 122.28 that authorizes a category of discharges under the CWA within a geographical area. A general permit is not specifically tailored for an individual discharger.

Illicit discharge: Any discharge to a municipal separate storm sewer that is not composed entirely of stormwater, except discharges pursuant to an NPDES permit and discharges resulting from fire fighting activities.

Individual permit: An NPDES permit specifically tailored for an individual discharger.

Integrated Design and Evaluation Assessment of Loadings (IDEAL; Barfield 2002) provides a spreadsheet-based technique for assessing the benefits of urban management practices on flow, sediment, nutrients, and bacteria. The model predicts watershed runoff, concentrations, and loads on the basis of the user's selection of vegetative filter strips, dry-detention ponds and wet-detention ponds. Urban areas are defined as pervious, impervious connected, and impervious unconnected areas. Flow and loads can be directed to a pond that can be either dry (no permanent pool) or wet (permanent pool). The model then calculates the pollutant removal efficiencies of the practices using empirical equations. The model predicts single storm values and converts them to average annual storm values using a statistical process. The IDEAL model is designed to help managers estimate long-term management practice pollutant removal efficiencies, and is not designed for looking at individual storms.

Load allocation (LA): The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. LAs are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished [40 CFR 130.2(g)].

Loading capacity: The greatest amount of loading that a waterbody can receive without violating water quality standards. Loading capacity is equal to the TMDL. Loading capacities calculated using data-driven approaches are typically based on *in-stream* or *delivered loads* (i.e., in-stream flow multiplied by target and conversion factor at a location in the waterbody). Loading capacities developed using land-based modeling approaches can also be based on *source loads* (i.e., land-based loads before they are delivered to the stream).

Margin of safety (MOS): The component of a TMDL that accounts for any lack of knowledge concerning the relationship between LAs, WLAs, and water quality [CWA section 303(d)(1)(C), 40 CFR 130.7(c)(1)]. EPA's *Guidance for Water Quality-based Decisions: The TMDL Process* (1991) explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

Maximum extent practicable (MEP): The pollutant reduction standard applied to stormwater management programs developed to address stormwater discharges from regulated MS4s.

Measurable goals: Quantifiable objectives for assessing program and best management practice effectiveness that regulated small municipal separate storm sewer systems must develop for the six minimum control measures to comply with Phase II MS4 permit requirements.

Model for Urban Stormwater Improvement Conceptualization (MUSIC; Wong et al. 2001): Software developed by the Cooperative Research Center (CRC) for Catchment Hydrology in Australia to evaluate small- and large-scale (100-square-mile) urban stormwater systems using modeling time steps that range from 6 minutes to 24 hours. MUSIC provides an interface to help set up complex stormwater management scenarios. It allows users to view results using a range of graphical and tabular formats. The stormwater control devices evaluated by MUSIC include ponds, bioretention, infiltration buffer strips, sedimentation basins, pollutant traps, wetlands, and swales. Major techniques used to evaluate management practices including settling in ponds and decay of pollutants (first order; see www.toolkit.net.au/music).

Multi-Sector General Permit (MSGP): Authorizes the discharge of stormwater from industrial facilities, consistent with the terms of the permit, in areas of the United States where EPA manages the NPDES permit program.

Municipal separate storm sewer system (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) Owned or operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law)...including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges into waters of the United States. (ii) Designed or used for collecting or conveying stormwater; (iii) Which is not a combined sewer; and (iv) Which is not part of a publicly owned treatment works (POTW) as defined at 40 CFR 122.2.

Notice of Intent (NOI): Submitting a completed NOI constitutes notice that the entity intends to be authorized to discharge pollutants to waters of the United States from the facility or site identified in the form under a state or EPA general permit such as the Phase II MS4 General Permit, the Multi-Sector General Permit (MSGP) for industrial stormwater, or the Construction General Permit (CGP).

Permitting authority: The U.S. Environmental Protection Agency (EPA), a Regional Administrator of EPA, or an authorized representative.

PGBMP-DSS: Evaluates the effect of management practices or combinations of management practices on flow and pollutant loading. This module uses simplified, process-based algorithms to simulate management practice control of modeled flow and water-quality time series generated from runoff models such as HSPF. These simple algorithms include weir and orifice control structures; storm swale characteristics; flow and pollutant transport; flow routing and networking; infiltration and saturation; and a general loss/decay representation for a pollutant. Users have the flexibility to design retention-style or open-channel management practices; can define flow routing through a management practice or management practice network; can simulate Integrated Management Practices (IMPs) such as reduced or discontinued imperviousness through flow networking; and can compare management practice controls against a defined benchmark such as a simulated predevelopment condition. Because the underlying algorithms are based on physical processes, management practice effectiveness can be evaluated and estimated over a wide range of storm conditions, management practice designs, and flow routing configurations.

Six minimum control measures: Categories of best management practices that regulated small MS4s must address under Phase II MS4 stormwater management programs.

Storm sewershed: Land area in which all stormwater flows are conveyed to a single point, or outlet.

Stormwater management program (SWMP): The program developed and implemented by EPA to minimize the discharge of pollutants from regulated MS4s to the maximum extent practicable using BMPs.

Stormwater pollution prevention plan (SWPPP): A plan developed to minimize the discharge of pollutants from an industrial site (including construction activities) using BMPs.

Subwatershed: Smaller division of a watershed, defined by the area draining to a tributary of the main waterbody.

The Site Evaluation Tool (SET): Software developed to assess the effects of development, including sediment and nutrient loading, on a site scale. The SET provides a more robust environment for testing multiple management practices and site configurations than do simple export calculations. The tool allows definition of pre- and post-treated land use/land cover, allowing for multiple drainage areas and various combinations of practices. An important benefit of the SET is testing management practices in combination with each other, in the context of a site or small catchment. Structural and nonstructural practices can be represented, giving the user a suite of options for evaluation.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL is the sum of individual wasteload allocations for point sources (WLA), load allocations for nonpoint sources and natural background (LA), and must consider seasonal variation and include a margin of safety. The TMDL comes in the form of a technical document or plan. (40 CFR 130.2 and 130.7)

Urbanized area (UA): A land area comprising one or more places—central place(s)—and the adjacent densely settled surrounding area—urban fringe—that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile used to identify regulated small MS4s under the Phase II MS4 Stormwater program.

Vegetative Filter Strip Model (VFSMOD; Muñoz-Carpena et al. 2003): A model that provides specialized modeling of field-scale processes associated with filter trips or buffers. It provides routing of storm runoff from an adjacent field through a vegetative filter strip and calculates outflow, infiltration, and sediment trapping efficiency. It is sensitive to characteristics of the filter including vegetation roughness or density, slope, infiltration characteristics, and the incoming runoff volume and sediment particle sizes. VFSMOD includes a series of modules Green-Ampt infiltration, kinematic wave overland flow, and sediment filtration. The model can also be used to describe transport at the edge of the field when flow and transport are mainly in the form of sheet flow and the path represents average conditions across the vegetative filter strip. VFSMOD uses a variable time step that helps to more accurately solve the overland water flow equation. The model inputs are specified on a storm basis, and the model summarizes all the information after each event to generate storm outputs.

Virginia Field Scale Wetland Model (VAFSWM; Yu, et al. 1998): A field-scale model for quantifying the pollutant removal in a wetland system. It includes a hydrologic subroutine to route flow through the treatment system; precipitation, evapotranspiration, and exchange with subsurface groundwater. The model adopted a Continuous Stirred Tank Reactor (CSTR) in series schema. VAFSWM models mechanisms of settling, diffusion, adsorption to plants and substrate, and vegetative uptake for a pollutant in dissolved and particulate forms in a two-segment (water column and substrate), two-state

(completely mixed and quiescent) reactor system by employing first-order kinetics. The governing equations for quiescent condition are identical to that of turbulent condition; however, far lower settling velocities are assumed to account for the greater percentage of finer particles during the quiescent state. VAFSWM is a relatively simple model that includes the most dominant processes in the wetland system. However, the users need to provide and calibrate the requisite kinetics parameters.

Wasteload allocation (WLA): The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation (40 CFR 130.2(h)).

Water Quality Based-Effluent Limitation (WQBEL): An effluent limitation determined by selecting the most stringent of the effluent limits calculated using all applicable water quality criteria (e.g., aquatic life, human health, wildlife, translation of narrative criteria) for a specific point source to a specific receiving water for a given pollutant or on the basis of the facility's WLA from a TMDL.

Watershed: A land area that drains to a common waterway, such as a stream, lake, estuary, wetland or ultimately the ocean.

WETLAND (Lee 1999; 2002): A dynamic, compartmental model to simulate hydrologic, water quality, and biological processes and help design and evaluate wetlands. WETLAND uses the continuously stirred tank reactor prototype, and it is assumed that all incoming nutrients are completely mixed throughout the entire volume. The model can simulate both free-water surface and subsurface flow wetlands. WETLAND is modular and includes hydrologic, nitrogen, carbon, dissolved oxygen, bacteria, sediment, vegetation, and phosphorous submodels. The strength of WETLAND lies on the linked kinetics for the water quality variables and considers seasonal variation (variable user-defined parameter by season/time period). The weaknesses of this model include the completely mixed assumption, which overlooks the effect of the system shape, and the needs for extensive kinetic parameters.