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Stormwater BMP Design Guide

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Section 1 Introduction

This course provides guidance on the design of best management practices (BMPs) for mitigation of the environmental impacts to receiving waters associated with urban runoff. Volume 1 presents general design considerations associated with the selection and use of BMPs. Volume 2 provides design guidelines for a group of stormwater management (SWM) best management practices (BMPs) broadly referred to as vegetative biofilters. Volume 3 presents design considerations related to the use of Pond BMPs.

Volume 1 provides guidance on the following elements:

- wet weather flow impacts on receiving waters
- regulations
- BMP design concepts and guidance
- BMP types and selection.

Wet Weather Flow Impacts on Receiving Waters

The goals and objectives of implementing BMP control practices vary by municipality, State, or watershed. Stormwater management technology and the use of BMPs have changed considerably since their introduction in the 1960's. Many stormwater controls were initially employed for flood control, i.e., to capture peak flows, provide local drainage and manage the quantity of runoff produced during wet weather flow (WWF). In response to the provisions of the Clean Water Act (CWA), a number of activities were initiated to characterize and quantify the water quality impacts of WWF such as the National Urban Runoff Program (NURP), and BMPs were adapted for pollutant removal. More recently, in response to a growing national awareness and understanding of the wide range of environmental impacts associated with land use changes, particularly urbanization, BMPs have begun to be designed for stream channel protection and restoration, groundwater infiltration, and protection of riparian habitat and biota. Collected runoff has also been used for irrigation and other non-potable purposes, such as for ponds and wetlands that also enhance urban aesthetics.

It can be observed that changes and improvements in stormwater management technology and BMPs have followed closely our increasing awareness and quantification of the impacts of land use changes on receiving waters. Section 2 of this volume provides a summary or our current knowledge of these impacts.

Regulations

Laws and regulation relating to management of WWF have also paralleled our increasing awareness of the impacts of WWF on receiving waters. These laws and regulations continue to have a significant influence in the development of stormwater management technology. Section 3 provides a brief summary of the major federal, State and local regulations that influence the design of BMPs.

The number of sources that require BMPs is expected to increase dramatically with the implementation of Phase II of the National Pollution Elimination Discharge Program (NPDES) stormwater permitting regulations. U.S. Environmental Protection Agency (EPA) promulgated Phase II in January 1998 and the Final Rule was published in the Federal Register on December 8, 1999. Phase II requires NPDES permits for stormwater discharges from regulated small municipal separate storm sewer systems (MS4s) (primarily all those in urbanized areas) and construction activity that disturbs between one and five acres of land. The Phase I rule applies to large municipal sources (> 100,000 population), industrial sources and construction activity on areas larger than five acres.

BMP Design Concepts and Guidance

BMPs can be designed for a wide range of goals and objectives that can range from a single parameter approach such as flood control or pollutant removal – typical in older developed watersheds – to multi-parameter ecological sustainability of receiving systems, which is more common in watersheds only recently being developed. These management goals will determine the requirement for proper design and the mix of ecological and engineering principles that must be considered. These will typically include hydrology and inflow hydraulics, soil characteristics/infiltration rates, site-specific water quality and location, as well as the condition of the receiving waters.

Section 4 provides a brief review of currently available design goals and objectives. These levels of control have been identified as:

- flood and peak discharge control
- flood and peak discharge control and specified pollutant guidelines
- flood, peak discharge and water quality control
- multi-parameter (Unified Sizing Criteria) and ecologically sustainable control.

The guidance provided in these manuals focused primarily on pollutant removal and water quality control. Providing guidance for multi-parameter and ecologically sustainable control is an emerging issue beyond the scope of This course and is only addressed in these documents as a future direction of research and implementation.

Section 4 also addresses hydrologic concepts and control strategies, criteria and standards. The hydrologic concepts that are presented include:

- rainfall frequency spectrum
- large storm hydrology
- small storm hydrology
- ground water recharge hydrology.

Control strategies for peak discharge control and water quality control are also summarized.

Section 5 identifies currently used BMP types and provides guidance on their selection and suitability for the various goals and objectives. BMPs can be classified in a number of ways. These include as pollution prevention, runoff control, end-of-pipe treatment control, source control, micro management control, regional control, and structural or non-structural control.

A brief summary of the suitability of the various BMP types to address the impact areas identified in Section 1 is provided. Section 5 also provides BMP selection guidance with respect to the following design factors:

- watershed factors
- terrain factors
- physical site factors
- community and environmental factors
- location and permitting factors.

The appendices provide greater detail on some of the topics introduced in this volume. Appendix A Large Storm Hydrology covers the larger modeling schemes. Appendix B Small Storm Hydrology presents three approaches to small storm hydrology. Appendix C Ground Water Recharge Hydrology for BMP Design and Appendix F Geotechnical Methods for Karst Feasibility Testing provide methods as the titles imply. Appendix D discusses and presents pollutant loading estimates while Appendix E provides information on the difficulties of quantifying BMP performance. A glossary is provided in Appendix G

Section 2 Wet Weather Flow Impacts on Receiving Waters

Introduction

Historically, Best Management Practices (BMPs) were first incorporated into the urban landscape as flood and drainage controls, but increasingly BMPs are being relied on to serve multiple tasks that also include treatment of stormwater and protection of receiving waters. The purpose of this three-volume manual is to guide the selection and implementation of BMPs that will be effective in preventing or mitigating the adverse impacts to stormwater by urbanization either through retrofitting of existing BMPs or application of new BMPs to new growth. This will be done by reviewing and building upon traditional BMP design concepts that did not address quality at first, and by presenting more recent concepts like “small storm hydrology” and the treatment train approach, which intend to improve stormwater quality.

Background

For the past three decades, municipalities in the U.S. have successfully addressed pollution in the watershed by collecting and treating their wastewater. Currently, all municipalities provide secondary level treatment and in some cases tertiary treatment, while industries provide best available/best practicable treatment. This has had great benefits. More rivers are meeting water quality standards and the public health is being protected from waterborne disease. The challenge now facing us is to address pollution associated with stormwater runoff, which is now the last major threat to water quality.

It is less costly to prevent runoff than to treat it. Today, many municipalities are looking at low-cost BMPs that do so. The lowest cost BMPs, termed nonstructural or source control BMPs, include such practices as limiting pesticide use in agricultural areas or retaining rainwater on residential lots (currently termed "low impact development [LID]"). There are higher-cost BMPs that involve building a structure to store stormwater and enable sedimentation. These can be more costly, especially in areas where land costs are high. BMPs have been classified a number of different ways, including by stormwater runoff source, pollutant, land use and BMP type. For example, the Rouge River Restoration Project has six classifications in a matrix of BMPs (http://www.rougeriver.com/pdfs/apmatrix.pdf): public information and participation, urban source control, treatment control, construction erosion and sediment control, channel restoration/stabilization and agricultural. The American Society of Civil Engineers has nine categories (ASCE, 1998) and the State of Texas has three classes.

For the past ten years, the EPA has encouraged municipalities to approach water pollution controls on a watershed basis. A watershed approach allows tradeoffs between pollution sources, point source treatment and pollution prevention, and optimal balances between these. It requires community-level involvement and often includes the use of both hard (structural) and soft (nonstructural) engineering approaches to protect or restore watersheds from chemical, physical, or biological stressors. The watershed approach allows simultaneous pollution, flood and erosion- sedimentation control by properly siting BMPs within the watershed to maximize pollutant removals and reduce stormwater-associated stressors.

Historically, BMPs were employed to capture peak flows, provide local drainage and manage the quantity of runoff produced during WWF, i.e., flood control. While these objectives will probably remain a goal of watershed management planners, BMPs are now also considered for pollutant removal, stream restoration and groundwater recharge infiltration. Some source control and pollution prevention are considered "good housekeeping" practices, i.e., practices that keep pollutants out of runoff such as street cleaning, product substitution and controlled application of pesticides herbicides. Runoff source controls are used to reduce runoff generated at the source of specific activities and are divided into two types: those used on a temporary basis (e.g., runoff control at construction activities) and those used on a permanent basis (e.g., hot spot treatment at vehicle repair sites). End-of-pipe or treatment controls are used to remove pollutants from contaminated runoff.

The three most commonly used treatment BMPs are basins or ponds (retention/detention), vegetative biofilters (swales, filter/buffer strips and bioretention cells) and constructed wetlands. Two other categories of structural treatment BMPs are filters (notably sand filters) and innovative technology options (catchbasin inserts, filters, etc). These documents concentrate on the first two most commonly used treatment BMPs: basins and vegetative biofilters. BMPs that can be applied to agricultural lands will not be covered. Constructed wetlands are covered but only as a sub-category to retention ponds. The key aquatic stressors of concern in the U.S. are nutrients, suspended solids (SS) and sediments, pathogens, toxic substances and flow. These stressors have worldwide significance.

Overview

This section presents a brief summary of the impacts that result from the interaction of WWF and land use changes on receiving waters. The summary is provided from a CWA, 33 U.S.C. 1251 et. seq.) reference point since the CWA is the legal and technical foundation for defining water quality standards. The objective of the CWA is to restore and maintain the chemical, physical and biological integrity (or ecological integrity) of the Nation's water bodies as illustrated in Figure 2-1 (CWA Section 101(a)) (EPA 1990). Consequently the impacts have been grouped into these three major impact area categories: physical, chemical and biological. Table 2-1 presents a summary of these impact areas.

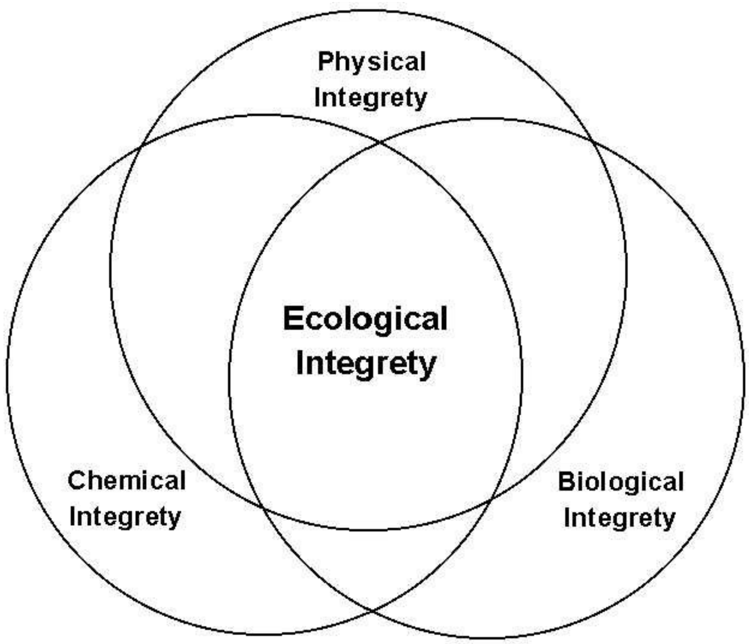

Figure 2-1 Goal of Ecological Integrity Under the Clean Water Act

Physical Impacts

The physical impacts resulting from land use changes, particularly construction and land development, can be grouped into four major categories: 1) hydrologic regime (including groundwater impacts), 2) geomorphology and channel stability, 3) flooding and 4) thermal impacts.

Purchase this course to see the remainder of the technical materials.