Civil Engineering

Prepared by the Standards Committee on Fitting of Hydraulic Conductivity Using Statistical Spatial Estimation of the Standards Development Council of the Environmental and Water Resources Institute of ASCE

Standard Guideline for Infiltration-based Stormwater Control Measures for Permeable Soils, ASCE/EWRI 79-26, provides comprehensive guidance for infiltration-based stormwater control measures (SCMs) for permeable soils and addresses their design, installation, and operation and maintenance. This standard focuses on three types of widely used SCMs: dry wells, vegetated (grassy) swales, and infiltration trenches. These structural practices capture urban stormwater runoff, promote infiltration into permeable soils, support groundwater recharge, and help remove or degrade pollutants within the unsaturated zone.

This standard outlines key design considerations essential to effective SCM performance, including soil properties, infiltration rate estimation, climatic influences, groundwater protection, and selection of an appropriate design basis. It presents detailed methodologies for estimating capacities and typical configurations for dry wells, vegetated (grassy) swales, and infiltration trenches, along with approaches for evaluating system capacity and optimizing SCM sizing. Additional chapters address installation procedures, operation and maintenance requirements of these SCMs, documentation, and performance assessment strategies.

Standard ASCE/EWRI 79-26 is a vital resource on the design, construction, and maintenance of SCMs for environmental engineers, stormwater professionals, and regulatory officials involved in sustainable stormwater management, infrastructure development, and water quality protection.

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EWRI ENVIRONMENTAL & WATER RESOURCES INSTITUTE

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Principles of Design, Installation, and Operation and Maintenance

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PREFACE

Urban waterfronts formed by inland and coastal waters often serve as focal points for residential, commercial, and recreational development and make living in or visiting a city an enjoyable experience. Many urban areas have legal mandates, through discharge permits, to maintain or improve the water quality of the rivers, lakes, or oceans within their jurisdictions. Historically, efforts have focused on regulating the effluent discharged from wastewater treatment plants. However, it is now recognized that urban stormwater runoff also plays an important role. Urban stormwater runoff may contain a variety of pollutants that are discharged to the receiving water body without any form of treatment. Therefore, the management of urban stormwater runoff must be considered in urban planning, development, and redevelopment using an integrated approach that improves and protects the quality of the receiving waters. This involves controlling sources of pollutants that are mobilized during storm events, reducing urban stormwater runoff volumes, and treating urban stormwater runoff.

This standard is a guideline for infiltration-based stormwater control measures (SCMs) for permeable soils and addresses their design, installation, and operation and maintenance. SCMs are structural controls that capture stormwater runoff that would otherwise discharge to surface water bodies, along with suspended and dissolved constituents, and infiltrate the runoff to the subsurface, which recharges the groundwater while sequestering/degrading any pollutants in the unsaturated zone. Three types of widely used SCMs are addressed in this standard: dry wells, vegetated (grassy) swales, and infiltration trenches. Typical designs are presented for each along with methodologies for estimating their capacities. Optimization approaches for sizing are also described. The standard also provides guidance on the installation and operation and maintenance of these SCMs.

US customary units and Système International (SI) units are used throughout this standard. The formulas in this standard require that all their values be expressed in consistent units, whether they are US customary units or SI units.

ASCE does not endorse commercial spreadsheets, numerical software, or testing methods produced by other organizations cited in this standard. Any such products are cited to illustrate possible ways of carrying out calculations and conducting experimental tests that are cited in this standard guideline. It is left to the user's discretion to choose and verify the accuracy of whichever computational technique or testing method they apply to implement this standard's methodology.

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CHAPTER 1
INTRODUCTION

1.1 SCOPE

This standard guideline addresses the design, installation, and operation and maintenance of three widely used stormwater control measures (SCMs), which include dry wells, vegetated swales, and infiltration trenches. SCMs are structural controls that capture stormwater runoff that would otherwise discharge to surface water bodies, along with suspended and dissolved constituents, and infiltrate the runoff to the subsurface, which recharges the groundwater while sequestering/degrading any pollutants in the unsaturated zone.

Use of such SCMs support low impact development (LID) objectives. LID refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration, and management of stormwater to protect water quality and associated aquatic habitat.

The three SCMs addressed in this standard guideline, while widely used, do not represent the full suite of practices that support LID. There are a range of measures that use plant or soil systems; permeable pavement or other permeable surfaces or substrates; stormwater harvest and reuse; or landscaping elements to store, infiltrate, or evaporate stormwater and reduce flows to sewer systems or to surface waters (USEPA 2023). Such measures can be used alone or in combination with one another to meet LID objectives. Additional infiltration-based practices may be considered in future revisions of this standard or as a separate stand-alone standard.

1.2 DEFINITIONS

Aquifer (Confined): Soil or rock below the land surface that is saturated with water. There are layers of impermeable material both above and below it, and it is under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer.

Aquifer (Unconfined): Aquifer whose upper water surface (phreatic surface or water table) is at atmospheric pressure and thus is able to rise and fall.

Artificial Recharge: Practice of increasing the amount of water that enters an aquifer through human-controlled means. For example, groundwater can be artificially recharged by redirecting water across the land surface through canals, infiltration basins, or ponds; adding irrigation furrows or sprinkler systems; or simply injecting water directly into the subsurface through injection wells.

Combined Sewer Overflow (CSO): Combined sewer overflow carries both wastewater and stormwater runoff. CSOs discharging to receiving waters can result in contamination problems that may prevent the attainment of water quality standards.

Costs: Capital and operating expenses of constructing and operating a project. They usually consist of (1) capital costs, the initial expenditures to design and construct project facilities; and (2) operating costs, the ongoing annual expenses associated with operating the project, including labor, material, and energy costs.

Dry Well: Bored, drilled, or driven shaft lined with gravel or other porous materials to infiltrate stormwater.

Effluent: Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.

First Flush: Delivery of a highly concentrated pollutant loading during the early stages of a storm due to the washing effect of runoff on pollutants that have accumulated on the land prior to the storm.

Flood: Overflow of water onto lands that are used or usable by humans and not normally covered by water. Floods have two essential characteristics: the inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river, stream, lake, or ocean.

Grassy Swale: Vegetated, shallow, landscaped depressions designed to capture, treat, and infiltrate stormwater runoff.

Greenway: Policy or land use designation in land-use planning to retain areas of largely undeveloped, wild, or agricultural land surrounding or neighboring urban areas.

Groundwater Recharge: Inflow of water to a groundwater reservoir from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge. Also, the volume of water added by this process.

Hydraulic Conductivity: Capacity of a material to allow fluids to pass through it, expressed as the volume flow rate of water through a cross-sectional area of a porous medium under the influence of a hydraulic gradient of unity at a specified temperature. This depends on properties of the porous medium (intrinsic permeability) and the fluid (specific weight and viscosity).

Infiltration Rate: Rate of water absorption into the ground. The infiltration rate is expressed in terms of depth per unit time, such as in./h. For a given soil, the infiltration rate is time dependent.

Infiltration Trench: Gravel-filled trench that allows stormwater to soak into the ground.

Low Impact Development (LID): Sustainable landscaping approach that can be used to replicate or restore natural watershed functions and/or address targeted watershed goals and objectives.

Percolation: Movement and filtering of fluids through porous materials. Sometimes used synonymously with deep infiltration.

Permeable: Ability of a material to allow the passage of a liquid, such as water through sedimentary deposits or rocks. Permeable materials, such as gravel and sand, allow water to

move quickly through them, whereas impermeable materials, such as clay, do not allow water to flow freely or quickly through them.

Phreatic Surface: Upper surface of the zone of saturation on which the water pressure in the porous medium equals atmospheric pressure. Synonymous with water table.

Porosity: Measure of the water-bearing capacity of subsurface earth materials such as soil, unconsolidated sediments, and rock.

Porous Pavement: Special type of pavement that allows rain to pass through it and infiltrate into the underlying soil, thereby reducing runoff from the site and surrounding areas.

Receiving Waters: Creeks, streams, rivers, lakes, estuaries, and other bodies of water into which urban runoff flows.

Recharge: Process of adding water to the saturated zone.

Runoff: Term used to describe the flow of water, from rain, snowmelt, or other sources, over the land surface, and is a major component of the water cycle.

Sediment: Product of erosion processes, usually small organic and inorganic particles that are transported by flowing water and subject to deposition.

Seepage: (1) Slow movement of water through small cracks, pores, interstices, and so forth, of a material into or out of a body of surface or subsurface water. (2) Loss of water by infiltration into the soil from a canal, ditches, laterals, watercourse, reservoir, storage facilities, or other body of water, or from a field.

Storm Runoff: Rainfall that does not evaporate or infiltrate into the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity but instead flows onto adjacent land or water bodies or is routed into a drain or sewer system.

Storm Sewer: Sewer that carries only surface runoff, street wash, and snow from the land. In a separate sewer system, storm sewers are completely separate from those that carry domestic and industrial wastewater (sanitary sewers).

Stormwater: Urban runoff generated by rainfall that does not seep into the earth and flows overland to flowing or open bodies of water.

Surface Waters: Water that is present above the substrate or soil surface. Usually refers to natural water bodies such as streams, rivers, lakes and impoundments, and estuaries and coastal ocean.

Urban Drainage: Water derived from surface runoff or shallow groundwater discharge from urban land use areas.

Urban Runoff: Water from city streets and adjacent residential or commercial properties that can transport a range of pollutants. In the dry season, the bulk of the flow is from anthropogenic sources. During wet weather, the flow includes storm-generated runoff (stormwater), which can be at much higher volumetric rates.

Vadose Zone: Layer of unsaturated soil above the groundwater table.

Wastewater: Usually refers to effluent from an industrial or municipal sewage treatment plant.

Water Quality Standards: Standards that set the goals, pollution limits, and protection requirements for each water body. These standards are composed of designated (beneficial) uses, numeric and narrative criteria, and anti-degradation policies and procedures.

Watershed: All the land that drains downslope to a common lowest point.

Withdrawals: Water withdrawn from surface water or groundwater by public or private water suppliers for use within a community. Water is used for domestic, commercial, industrial, and public water uses such as firefighting.

1.3 ABBREVIATIONS

BOD	Biological oxygen demand
CSO	Combined sewer overflow
HSG	Hydrologic soil group
IPCC	Intergovernmental Panel on Climate Change
LID	Low impact development
LP	Linear programming
MS4	Municipal separate storm sewer systems
NPDES	National Pollutant Discharge Elimination System
SCM	Stormwater control measure
SWMM	Storm Water Management Model
TMDL	Total maximum daily load
USACE	US Army Corps of Engineers
USDA	US Department of Agriculture
USDOT	US Department of Transportation
USEPA	Environmental Protection Agency

1.4 SYMBOLS AND NOTATION

A = Infiltration area, equal to $\pi D^2/4$ for a dry well and $L_1 L_2$ for a grassy swale or infiltration trench (L^2)
A_Q = Impervious drainage area (L^2)
A_S = Grassy swale planter box area (L^2)
B = Vertical distance between the bottom of SCM and phreatic surface (L)
D = Diameter of infiltration borehole (L)
ET = Cumulative evapotranspiration (L)
f = Infiltration rate (L/T)
F = Cumulative infiltration (L)
h_f = Soil-water tension across the wetting front (L)
i = Rainfall intensity (L/T)
I = Volume of water that would infiltrate if there is sufficient fillable pore space in the soil and sufficient runoff volume to infiltrate (L^3)
K_s = Saturated hydraulic conductivity (L/T)
L_1 = Length of grassy swale planter box or infiltration trench (L)
L_2 = Width of grassy swale planter box or infiltration trench (L)
n = Porosity (dimensionless)
n_0 = Antecedent volumetric water content (dimensionless)
Q = Cumulative runoff depth (L)
R = Runoff volume (L^3)
r = Runoff rate (L^3/T)
t_p = Time to ponding (T)
t_R = Storm duration (T)
V = Fillable pore space in soil (L^3)
V_I = Volume of water infiltrated by dry well (L^3)
z_f = Depth of infiltration below the bottom of SCM (L)

1.5 CONSENSUS STANDARDS AND OTHER REFERENCED DOCUMENTS

ANSI/ASCE/EWRI 12-13, 13-13, 14-13, *Standard Guidelines for the Design, Installation, and Operation and Maintenance of Urban Subsurface Drainage*, ASCE, 2013.

ANSI/ASCE/EWRI 45-16, 46-16, 47-16, *Standard Guidelines for the Design, Installation, and Operation and Maintenance of Urban Stormwater Systems*, ASCE, 2017.

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