Best Management Practice Definitions Document for Pollutant Load Estimation Tool

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Introduction

This document provides definitions for best management practice (BMPs) used in the Pollutant Load Estimation Tool (PLET). Definitions provided in this document are also applicable to the BMPs used in the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). BMP definitions that follow are categorized based on land use type (cropland, pastureland, forest, feedlots, and urban).

Combined BMPs–Calculated

Combined BMPs – Calculated

When multiple BMPs are applied to the same area, a *combined BMP* represents those BMPs. There is no default combination of BMPs that make up the *combined BMPs*. They are user defined, based on individual model scenarios. The aggregate pollutant reduction efficiencies are calculated based on the efficiencies of the individual practices. *Combined BMPs* can be applied to any land use.

Cropland

Bioreactor

A *bioreactor* is an edge-of-field treatment process used to reduce nitrate (a form of nitrogen) in runoff typically coming from a tile line (see Figure 1). Tile drains from the field carry excess water from the plant root zone and divert a portion of the drainage water into the bioreactor, which is a buried trench filled with a carbon source—usually wood chips (Christianson and Helmers 2011). The presence of wood chips and low dissolved oxygen promote denitrification, a process in which microorganisms on the wood chips consume the nitrates in the water and expel nitrogen gas. Although performance varies based on site conditions, such as geometry and location, the residence time of water in a bioreactor is the most critical factor in performance. Longer residence times correspond to higher nitrate removal efficiencies.

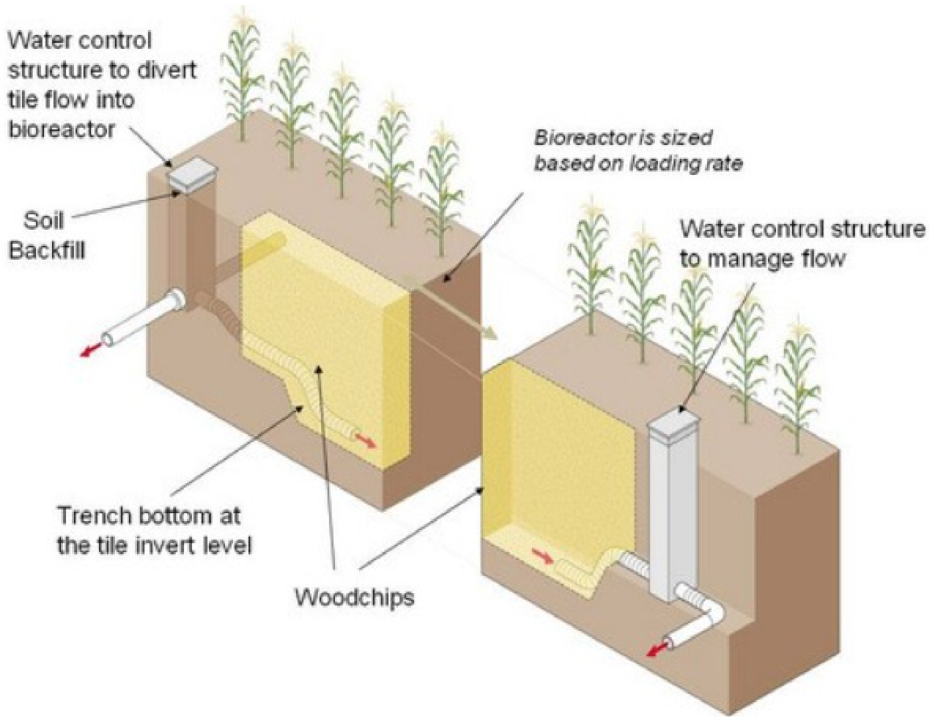

Figure 1. Bioreactor. (*Source*: Cohen 2016)

Buffer–Forest (100ft wide)

This buffer refers specifically to riparian *forest buffers*, which are areas of trees and shrubs lining the edges of waterbodies, including streams, rivers, and lakes (see Figure 2). The riparian buffer area filters excess sediment, organic material, nutrients, and pesticides from surface runoff and shallow groundwater. Other benefits buffers offer include increased shade to lower or maintain water temperatures to improve habitat for aquatic organisms, improved riparian habitat, and increased carbon storage in plant biomass and soils (NRCS 2020a). To achieve PLET nutrient and sediment pollutant reduction efficiencies, the riparian buffer should be at least 100 feet (ft) wide measured perpendicularly from the edge of the waterbody.

Figure 2. Buffer – Forest between cropland and a river. (*Source*: USDA National Agroforestry Center 2021)

Buffer–Grass (35ft wide)

A *grass buffer* is newly established area along a waterbody that intercepts overland flow (see Figure 3). It is used to maintain bank stabilization and reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals to supply food, cover, and shade (thermal protection) to fish and other wildlife. To achieve these results, the recommended minimum width is 35 ft and should include native grasses.

Figure 3. Buffer–Grass. (*Source*: USDA 2020)

Conservation Tillage 1 (30-59% Residue)

This practice manages the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while limiting soil-disturbing activities used to grow and harvest crops in systems where the field surface is tilled prior to planting. *Conservation tillage 1* leaves 30–59 percent of crop residue in place after planting. This crop residue will reduce sheet, rill, and wind erosion and excessive sediment in surface waters (soil erosion); reduce tillage-induced particulate emissions (air quality impact); improve soil health and maintain or increase organic matter content (soil quality degradation); and reduce energy use (inefficient energy use).

Conservation Tillage 2 (equal or more than 60% Residue)

This practice limits soil disturbance to manage the amount, orientation, and distribution of crop and plant residue on the soil surface year-round. *Conservation tillage 2* leaves more than 60 percent of crop residue in place. This crop residue will reduce sheet, rill, and wind erosion and excessive sediment in surface waters; reduce tillage-induced particulate emissions; maintain or increase soil health and organic matter content; increase plant-available moisture; reduce energy use; and provide food and escape cover for wildlife.

Contour Farming

This practice aligns ridges, furrows, and roughness formed by tillage, planting, and other operations to alter velocity and/or direction of water flow to move around the hillslope (see Figure 4). This practice is applied to achieve one or more of the following: reduce sheet and rill erosion; reduce transport of sediment, other solids, and the contaminants attached to them; reduce transport of contaminants found in solution runoff; or increase water infiltration.

Figure 4. Contour Farming. (*Source*: NRCS, Montana, 1974)

Controlled Drainage

Water control structures are installed in drainage tile lines to allow the water table in a field to be raised or lowered as needed (see Figure 5). This practice enables the manager to control the drainage volume and water table elevation by regulating the flow from a surface or subsurface agricultural drainage system. It can reduce nutrient, pathogen, and pesticide loading from drainage systems into downstream receiving waters; improve productivity, health, and vigor of plants; and reduce oxidation of organic matter in soils.

Figure 5. Controlled Drainage–Example of a flashboard riser. (*Source*: NRCS 2017a)

Cover Crops

Cover crops are crops grown to provide soil cover and prevent erosion (see Figure 6). *Cover crops* are used to fill in bare soil when a main crop has been harvested, when there is a niche in a season's crop rotation, or when there is a need to interplant a cover crop with a cash crop. They provide ground cover, reduce erosion, suppress weeds, reduce insect pests and diseases, absorb excess fertilizer, reduce nutrient leaching, and enrich soil with organic matter. Important elements of the practice and its effectiveness include selecting the cover crop species, the previous crop, the planting time, and the seeding method. The two basic categories of *cover crops* are (1) a ***traditional*** cover crop that might be neither fertilized nor harvested, and (2) a ***commodity*** cover crop that might receive nutrient applications in late winter or spring of the following year after establishment. In PLET, cover crops fall into three groups:

Cover Crop 1 (Group A Commodity) (High Till only for Sediment)

- *Commodity cover crops* include a legume/grass mixture with at least 50 percent of the full rate of the grass component, rye, triticale, barley, and/or wheat that is planted for harvest.

Cover Crop 2 (Group A Traditional Normal Planting Time) (High Till only for TP and Sediment)

- *Traditional crops* include a legume/grass mixture with at least 50 percent of the full rate of the grass component, rye, triticale, barley, and/or wheat that is not harvested.
- *Normal planting time* is the average between the frost date and 2 weeks before the frost date.

Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)

- *Traditional crops* include a legume/grass mixture with at least 50 percent of the full rate of the grass component, rye, triticale, barley, and/or wheat that is not harvested.
- *Early planting time* is more than 2 weeks before the average frost date.

Figure 6. Cover Crops–Example of a cover crop seeded into corn residue. (*Source*: USDA 2019b)

Land Retirement

This process takes land out of production and replaces it with permanent vegetative cover, such as shrubs, grasses, and/or trees.

Nutrient Management 1 (Determined Rate)

This practice involves managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments to (1) budget, supply, and conserve nutrients for plant production; (2) minimize agricultural nonpoint source pollution of surface and groundwater resources; (3) properly use manure or organic byproducts as a plant nutrient source; (4) protect air quality by reducing odors, nitrogen emissions (ammonia and oxides of nitrogen), and the formation of atmospheric particulates; and/or (5) maintain or improve the physical, chemical, and biological condition of soil.

Nutrient Management 2 (Determined Rate Plus Additional Considerations)

This practice involves managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments to (1) budget, supply, and conserve nutrients for plant production; (2) minimize agricultural nonpoint source pollution of surface and groundwater resources; (3) properly use manure or organic byproducts as a plant nutrient source; (4) protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates; and/or (5) maintain or improve the physical, chemical, and biological condition of soil.

Additional considerations include, but are not limited to, the following: (1) nitrogen management; (2) nitrification inhibitors; and (3) ensuring adequate holding capacity, especially in cases in which manure is used as a nutrient source and cannot be applied to frozen soil.

Streambank Stabilization and Fencing

Streambank stabilization is used to minimize the erosion of streambanks and channels to reduce the amount of sediment and nutrients from eroding banks that enter the stream and maintain the flow capacity of the stream (NRCS 2020b). It can also help to protect land and structures from eventual erosion. Potential causes of streambank erosion include livestock access, upland activities causing a change in stream flow volume or runoff with additional sediment, and head cuts. Practices can include vegetative or structural protection measures. Stabilization methods include modifying the channel capacity, armoring the channel (riprap lining) (see Figure 7), providing channel crossings for livestock, adding vegetated buffers, and seeding (vegetating or planting the banks to prevent erosion). *Streambank fencing* is used to restrict livestock access to streambanks because animal traffic erodes streambanks, increases sediment load, and contributes animal waste in and near the stream, which impairs water quality.

Figure 7. Streambank Stabilization–Example of riprap banks and channel modifications for channel stabilization and reduced erosion on Big Spring Creek, Montana. (*Source:* NRCS, Montana 2017)

Terrace

A *terrace* is an earth embankment or a combination ridge and channel that is constructed across a field slope to enable water to be stored temporarily to promote sediment deposition and water infiltration (see Figure 8). This practice is applied as part of a management system to either reduce erosion and trap sediment or retain runoff for moisture conservation.

Figure 8. Example of terraced cropland. (*Source*: NRCS 2021)

Two-Stage Ditch

A *two-stage ditch* is a type of open channel ditch designed with vegetated benches, a design that creates both a low-flow channel and a flooded bench that is inundated during higher flows. The bench is vegetated to reduce the velocity of water through the channel and to encourage sediment deposition and particle-bound nutrients (see Figure 9). These ditches should be limited to low grade areas (unless grade-control structures are provided) and relatively flat fields with subsurface tile drainage. Two-stage ditches can be used in channels that are prone to bank erosion (OSUE 2022).

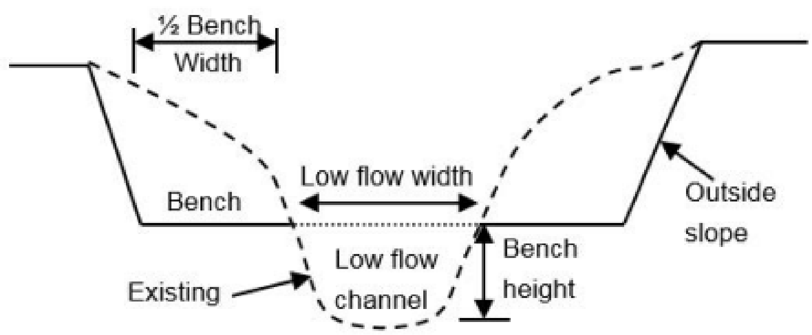

Figure 9. Illustration comparing a conventional ditch (*dotted line*) and a two-stage ditch (*solid line*). (*Source*: NRCS, Indiana 2018)

Pastureland

30m Buffer with Optimal Grazing

This combination of practices includes a grass or forested buffer of at least 30 meters, which provides a grazing area set back from a stream or other environmentally sensitive area, with pastureland next to it with an optimized grazing management system in place. Optimal grazing management is achieved by aligning grazing time and approach to ensure competitive regrowth of desired forage (Oregon State University 2022). This system accounts for growth mechanisms of grass recovery and the identification of growing points that provide for continued leaf blade growth or new shoot production.

Alternative Water Supply

An *alternative water supply* provides drinking water access for livestock at an off-stream location, which prevents degradation and erosion of stream, river, and lake banks and minimizes the time livestock spend in surface water. Adopting this BMP reduces the sediment, nutrients, and bacteria contributions from livestock watering. Troughs and tanks are typically used (see Figure 10). Strategically locating the water supply also can improve animal distribution and forage health (NRCS 2020c). *Alternative water supply* can be used in conjunction with riparian buffer restoration.

Figure 10. Alternative Water Supply–Example of livestock drinking from a watering facility in Washington. (*Source*: WSCC, Adams Conservation District 2019)

Critical Area Planting

Critical area planting is the planting of grasses, legumes, or other vegetation to stabilize slopes in small, severely eroding areas. The permanent vegetation stabilizes areas such as gullies, over-grazed hillsides, and terraced backslopes. Although the primary goal is erosion control, the vegetation also can provide nesting cover for birds and small animals.

Forest Buffer (minimum 35 ft wide)

This buffer refers specifically to riparian *forest buffers*, which are areas of trees and shrubs lining the edge of waterbodies, including streams, rivers, and lakes (see Figure 2). The riparian buffer area filters excess sediment, organic material, nutrients, and pesticides from surface runoff and shallow groundwater. Buffers offer other benefits such as increased shade to lower or maintain water temperatures to improve habitat for aquatic organisms; improved riparian habitat, and increased carbon storage in plant biomass and soils (NRCS 2020a).

Grass Buffer (minimum 35 ft wide)

A *grass buffer* is a newly established area along a waterbody that intercepts overland flow (see Figure 3). It is used to maintain bank stabilization and reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals to supply food, cover, and shade (thermal protection) to fish and other wildlife. To achieve these results, the recommended minimum width is 35 ft and should include native grass(es).

Grazing Land Management (Rotational Grazing with Fenced Areas)

Grazing land management also can be referred to as *rotational grazing with fenced areas* for management. Livestock are rotated through different forage pastures in a strategic way that maximizes production and reduces sediment and nutrient runoff by maintaining healthy vegetative cover in non-grazed areas of the pasture (USDA 2019a). Fencing restricts livestock to the desired pasture for a short grazing period before the livestock are rotated to the next pasture to allow a longer period of rest and regrowth in the grazed paddock.

Heavy Use Area Protection

Heavy use area protection provides ground surface stability and erosion prevention in areas with frequent animal or human usage, including driving vehicles in the areas. Common surface treatments include concrete and gravel; in some cases, a roof might be needed to provide adequate protection (NRCS 2015). This practice is common in areas of concentrated livestock, such as feeding areas, hay rings, watering facilities, feeding troughs, and mineral areas; in these locations, manure and contaminated runoff also must be collected and treated (see Figure 11).

Figure 11. Heavy Use Protection Area–Cement pad to protect the soil around the cattle drinking water trough. (*Source*: NRCS 2020d)

Litter Storage and Management

Litter storage and management addresses excess nutrients from poultry operations. Litter must be held and stored in a manner that does not allow rainfall to reach the litter stockpiles, which creates nutrient laden runoff. Appropriate short-term storage can include stockpiles covered by plastic sheeting anchored to the ground with berms or ditches to prevent runoff from entering the pile. More permanent storage structures include manure stacking sheds, which have a concrete floor and roof, and roofless stacking facilities, which have bunker walls and a concrete pad. In some cases, walls also might be necessary to prevent rain from reaching the stockpile (Cunningham et al. 2003; CUCE 1997). Proper litter management includes adopting a litter management plan or nutrient management plan that describes the facility and waste handling and storage methods, estimates of litter production, the number of acres required to apply the litter at appropriate agronomic rates, soil test reports, application records, and nutrient analysis (NCAGR 1997).

Livestock Exclusion Fencing

Livestock exclusion fencing is used to restrict livestock's access to streambanks to improve water quality. Animal traffic erodes streambanks, increases sediment loads, and contributes animal waste in and near the stream, which impairs water quality. The fencing should be permanent and may consist of several types of fencing including, board, barbed wire, high-tensile wire, and electric wire (NCAGR 2019).

Multiple Practices

This is a placeholder efficiency value intended to represent a generic suite of agricultural BMPs. The preferred approach is to calculate the combined efficiency of the specific practices used in a scenario.

Pasture and Hayland Planting (also called Forage Planting)

Pasture and hayland planting (*forage planting*) is the planting of herbaceous annual, biannual, or perennial vegetation to help improve soil and water quality, reduce erosion, and improve livestock health and nutrition. Vegetation also might be planted for energy production. Species selection should account for climate, soil condition, landscape position, and resistance to disease or pests (NRCS 2012).

Prescribed Grazing

Prescribed grazing is the controlled harvest of vegetation with grazing or browsing animals, managed with the intent to maintain or improve water quality and quantity. For example, on grazed forest, native pasture, or rangeland, grazing is limited so that the grazing animals will consume no more than 50 percent (by weight) of the annual growth of high or medium preferred grazing species.

Streambank Protection without Fencing

Streambank protection helps prevent streambank erosion. Streambank protection methods are essentially the same as stream stabilization methods; however, fencing approaches are not included. Specific streambank protection approaches include modifying the channel capacity, armoring the channel (with riprap lining) (see Figure 7), adding vegetative buffers, providing channel crossings for livestock, and seeding (vegetating or planting the banks to prevent erosion).

Streambank Stabilization and Fencing

Streambank stabilization is used to minimize the erosion of streambanks and channels to reduce the amount of sediment and nutrients from eroding banks that enter the stream and maintain the flow capacity of the stream (NRCS 2020b). It also can help to protect land and structures from eventual erosion. Potential causes of streambank erosion include livestock access, upland activities causing a change in stream flow volume or runoff with additional sediment, and head cuts. Practices can include vegetative or structural protection measures. Stabilization methods include modifying the channel capacity, armoring the channel (with riprap lining) (see Figure 7), providing channel crossings for livestock, adding vegetative buffers, and seeding (vegetating or planting the banks to prevent erosion). Streambank fencing is used to restrict livestock access to streambanks because animal traffic erodes streambanks, increases sediment load, and contributes animal waste in and near the stream, which impairs water quality.

Use Exclusion

Use exclusion also is known as *access control* and relies on construction of barriers to prevent or limit access to certain areas for the protection, maintenance, or improvement of natural resources (NRCS 2017b). Livestock, people, vehicles, and equipment may all be limited, depending on the desired land type, sensitivity, and protection goals. Access may be limited to the area using fencing, signs, gates, or natural structures, such as vegetation, logs, or boulders.

Winter Feeding Facility

A dedicated *winter feeding facility* is designed to reduce damage to pastures, increase forage health, improve herd health, and avoid concentrating nutrients in sensitive areas by controlling heavy livestock traffic and avoiding ground cover degradation (TJSWCD 2022). *Winter feeding facilities* can incorporate animal waste control facilities to store manure, a seasonal feeding pad (generally concrete or gravel), and loafing lot management. A *winter feeding facility* can improve water quality by helping to prevent overgrazing of pastures when vegetation is dormant and soils are vulnerable to erosion. It also provides an opportunity for manure collection and application at a controlled rate/quantity, rather than allowing for deposition by livestock in concentrated areas in the pastures, such as near streams.

Forest

Road Dry Seeding

Dry seeding is used to revegetate inactive roads to provide long-term erosion control. In *dry seeding*, seeds are broadcast or planted without mixing them with water or other liquid. *Dry seeding* and fertilizing along roads are usually done with cyclone-type rotary seeders.

Road Grass and Legume Seeding

Grass and legume seeding is a form of revegetation of bare soils used to prevent erosion. Native plants, domesticated native plants, and introduced agronomic species all are useful for rehabilitation and revegetation.

Road Hydro Mulch

Hydromulching, or hydraulic mulching, is a process by which wood fiber mulch, processed grass, and hay or straw mulch is applied with a tacking agent in a slurry with water to provide temporary stabilization of bare slopes or other bare areas. This mulching method provides uniform, economical slope protection. It might be combined with hydroseeding as a revegetation method.

Road Straw Mulch

Straw mulch is applied on slopes to hold the soil and prevent loss of grass seed. *Straw mulch* provides erosion control and moisture conservation, and it prevents soil crusting.

Road Tree Planting

Tree planting is used for erosion control on permanently closed or decommissioned forest roads to return the site to forest and timber production. Where necessary, compacted or rock-surfaced roads are loosened to reduce surface runoff and promote seedling survival.

Site Preparation (Soil Stabilization Measures)

The following table lists measures that can be used to stabilize soils for forest site preparation and road construction.

Site Preparation Measure	Description
Crimp	Placed straw rolled with a sheepfoot roller
Fertilizer	Nitrogen, phosphorus, and potassium applied by hand spreader or water mix
Hydromulch	Mix of cellulose fiber and water sprayed on slope
Net	Jute netting hand-placed on slope and pinned in place
Seed	Grasses, alfalfa, or other legumes spread using a hand spreader or water mix
Straw	Straw hand-placed evenly on slope
Transplant	Hand transplantation of locally grown plant species

Feedlots

Diversion

Diversion is the redirection of a storm drain line or outfall channel, so it can temporarily discharge into a sediment-trapping device. Its purpose is to prevent sediment-laden water from entering a watercourse or flowing across public or private property through a storm drain system. It also can temporarily provide underground conveyance of sediment-laden water to a sediment-trapping device. A diversion channel is constructed across a slope and has a supporting earthen ridge on the lower side.

Filter Strip

A *filter strip* is a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach waterbodies or water sources, including wells.

Runoff Management System

A *runoff management system* controls excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances. A settling basin (see *Settling Basin*) is a type of runoff management system.

Solids Separation Basin

A *solids separation basin* is a basin used for gravity settling of solids from liquid manure. A typical design for a *solids separation basin* is a 2- to 3-ft-deep basin with a concrete floor and walls and a porous dam or perforated pipe outlet that allows access by a front-end loader to remove solids every 1–2 months. Alternative earthen settling basins that allow for 6–12 months' storage of solids are also common. The basin contents should be thoroughly agitated and removed for land spreading by either a liquid manure spreader or slurry irrigation.

Solids Separation Basin w/Infiltration Bed

A *solids separation basin* also can be paired with an *infiltration bed*. An *infiltration bed* is constructed in highly permeable soil that provides temporary storage of runoff during rain events. Over a period of several hours or days, the *infiltration bed* allows the water to discharge primarily by infiltration through the surrounding soil. It might have an outlet for overflow discharge to surface water.

Terrace

A *terrace* is an earth embankment or a combination ridge and channel that is constructed across the field slope to enable water to be stored temporarily, allowing sediment deposition and water infiltration (see Figure 8). This practice is applied as part of a management system to either reduce erosion and trap sediment or retain runoff for moisture conservation.

Waste Management System

Animal *waste management systems* comprise a variety of BMPs or combination of BMPs used at concentrated animal feeding operations and farms to manage animal waste and related animal byproducts. These systems include engineered facilities and management practices for the efficient collection, proper storage, necessary treatment, transportation, and distribution of waste. The BMPs are designed to reduce the discharge of nitrogen, phosphorus, pathogens, organic matter, heavy metals (e.g., zinc, copper, and occasionally arsenic present in many animal rations), and odors. Examples of facilities and management methods are holding ponds, waste treatment ponds, composting, manure management, and land application.

Waste Storage Facility

A *waste storage facility* is an impoundment made by constructing an embankment, excavating a pit or dugout, or fabricating a structure (see Figure 12).

Figure 12. Waste Storage Facility–An example of a waste storage shed at a farm in Washington. (*Source*: WSCC, Snohomish Conservation District 2016)

Urban

The majority of urban practices are credited using pollutant reduction efficiencies. A subset of practices uses both pollutant reduction and flow volume reduction, and another subset provides only flow volume reduction and no pollutant reduction. Refer to the table at the end of this section for a description of the crediting method for each practice.

Alum Treatment

Alum is a compound that is added to stormwater to remove phosphorus. Alum is aluminum sulfate that forms an aluminum hydroxide precipitate (floc) when added to water, which binds with phosphorus to form an insoluble aluminum phosphate compound. Alum can be added to stormwater within a stormwater sewer system before it is discharged downstream, or it can be added to lakes to address internal cycling of phosphorus from lakebed sediments (USEPA 2021a). In lake applications, sediment also is collected by the floc as it sinks to the bottom, providing additional water clarity improvements (WDNR 2003).

Bioretention Facility and Bioretention (Low Impact Development [LID])

A *bioretention facility* consists of a shallow depression or basin to control stormwater runoff via a flow regulating structure or infiltration. The design also includes vegetation and specially engineered soil media to remove pollutants via biological, physical, and chemical processes (USEPA 2021b).

Cisterns and Rain Barrels (LID)

Cisterns and rain barrels are a group of stormwater harvesting devices designed to capture and store rooftop runoff for later use. Cisterns are large storage devices often installed in commercial settings where the larger rooftop footprint can generate several thousand gallons of runoff. Runoff from cisterns can be used for activities where large quantities of water are needed, such as landscape irrigation, toilet flushing, and commercial vehicle washing. *Rain barrels* are smaller storage devices, usually less than 100 gallons, that are typically designed for a residential setting and smaller rainwater reuse opportunities, such as watering gardens or lawns.

Concrete Grid Pavement

Concrete grid pavement is a pavement surface that consists of strong structural materials having regularly interspersed void areas filled with pervious materials like sod, gravel, or sand (see Figure 13). The pervious materials enhance rainfall infiltration, which reduces runoff.

Figure 13. Concrete Grid Pavement–An example of a parking lot application. (*Source*: MPCA 2012)

Dry Detention

A *dry detention* basin is a stormwater retention basin that remains dry except for short periods following large rainstorms or snowmelt events. Its main benefit is its moderating influence on peak flows, which helps to control streambank erosion.

Dry Well (LID)

Dry wells are subsurface stormwater infiltration devices designed with a pretreatment facility designed to remove sediment and debris. This leads to an infiltration facility that is typically 20–50 ft below the surface but above the water table. Runoff enters the dry well and slowly discharges water through perforations along the length of the pipe, allowing infiltration into the native soils and providing filtration before the collected stormwater reaches deeper soil layers or groundwater (CASQA, n.d.)

Extended Wet Detention

An *extended wet detention* basin is a detention basin designed to increase the length of time that stormwater is retained. This type of basin is typically configured in sections, with a shallow forebay and a deeper permanent pool of water where sedimentation occurs. During large storm events, stormwater temporarily fills the additional storage volume and is slowly released over several hours, reducing peak flow rates. Detention basins often are heavily vegetated to filter pollutants.

Filter / Buffer Strip (LID)

A *filter* or *buffer strip* is a longitudinal strip or area of vegetation that treats sheet flow from impervious surfaces by filtering sediment, organic matter, and other pollutants from runoff and allowing some of the stormwater to infiltrate into the soil. *Filter / buffer strips* also work to slow the velocity of runoff. They are generally used to treat small drainage areas, such as parking lots, sidewalks, and roadways. It is important to maintain sheet flow through the *filter / buffer strip* to avoid concentrated flows that will reduce their effectiveness (USEPA 2021f).

Filter Strip -Agricultural

A *filter strip* is a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach waterbodies or water sources, including wells.

Grass Swales

Grass swales are elongated depressions in the land surface that are at least seasonally wet, usually heavily vegetated, and normally without flowing water (see Figure 14). Swales direct stormwater flows into primary drainage channels and allow some of the stormwater to infiltrate into the ground surface. Swales are vegetated with erosion-resistant, flood-tolerant grasses. Sometimes check dams are strategically placed in swales to moderate flow. Additionally, an engineered soil mixture can be included under the swales.

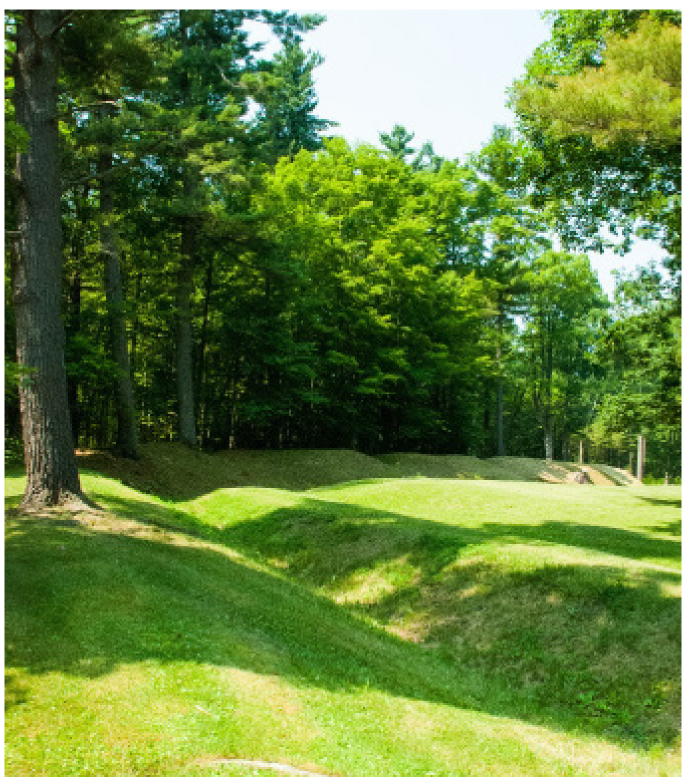

Figure 14. Grass Swale. (*Source:* USEPA 2021c)

Infiltration Basin

An *infiltration basin* is a facility constructed in highly permeable soil that provides temporary storage of runoff during rain events. Over a period of several hours or days, the basin allows the water to discharge primarily by infiltration through the surrounding soil. It also might have an outlet for overflow discharge to surface water.

Infiltration Devices

Infiltration devices include a suite of practices that capture a portion of runoff and retain it on-site, allowing it to infiltrate into the soil. If these devices are properly sited, designed, and constructed and regularly maintained, they can be very effective in reducing peak discharge rates and stormwater volumes and removing pollutants from the first flush of runoff. Infiltration trenches, infiltration basins, dry wells, leaching catch basins, porous pavement/ blocks, and infiltration islands within parking areas are examples of *infiltration devices*.

Infiltration Swale (LID)

An *infiltration swale* is a grass swale designed to retain additional stormwater. It is typically designed with check dams to reduce runoff flow velocities, increase storage capacity, and temporarily retain stormwater runoff to promote infiltration and evapotranspiration (Ekka and Hunt 2020).

Infiltration Trench and Infiltration Trench (LID)

An *infiltration trench* is an excavated ditch that has been backfilled with stone or gravel to allow stormwater runoff to soak into the underlying soils. Runoff is diverted into the trench through a grassed area or pretreatment device. *Infiltration trenches* are typically designed for drainage areas of less than 5 acres. For the *infiltration trench* to function properly, the on-site soils should have infiltration rates that range between 0.5 and 3 inches per hour (USEPA 2021d).

Oil/Grit Separator

An *oil/grit separator* consists of a series of three or four concrete chambers connected to a storm drain system (see Figure 15). Runoff passes through the chambers, settling sediment and particulate matter, screening debris, and separating free surface oils from stormwater runoff before the water passes to a storm drain. An *oil/grit separator* is used primarily to treat water to remove contaminants from small areas where activities contribute large loads of grease, oil, mud, sand, and trash to stormwater runoff. Oil/grit separators are often used in areas such as automotive work areas, loading areas, gas stations, parking areas, and roads that experience a heavy amount of motor vehicle traffic.

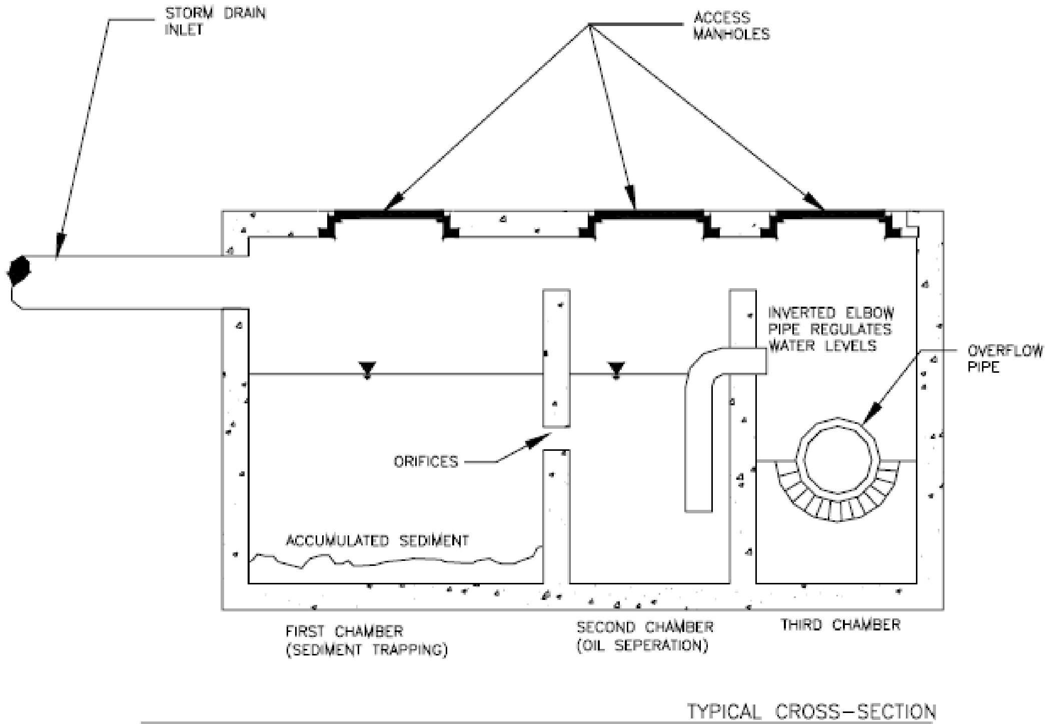

Figure 15. Oil/Grit Separator schematic. (*Source*: adapted from Schueler 1987, cited in MassHighway 2004)

Porous Pavement

An alternative to conventional asphalt, *porous pavements* use a variety of porous media, often supported by a structural matrix, concrete grid, or modular pavement. The media allows water to percolate through the pavement to a subbase for gradual infiltration into the underlying soil.

Sand Filters

Sand filters are self-contained, compartmented treatment systems designed to catch runoff from highly impervious areas, such as roads, driveways, drive-up lanes, parking lots, and urban areas, which have relatively high loads of total suspended solids, heavy metals, and hydrocarbons (see Figure 16). The compartments consist of a forebay that removes trash, debris, and coarse sediment, followed by a sand bed that allows solids to settle out while also using filtering and adsorption processes to reduce pollutant concentrations in the stormwater. The sand filter compartments are usually constructed of concrete, and they may be set above or below ground.

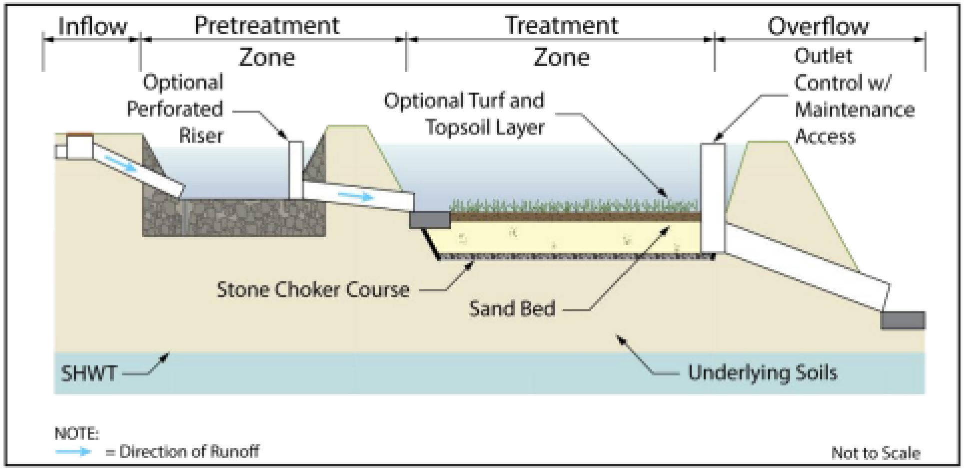

Figure 16. Sand Filter schematic. (*Source*: NJDEP 2021)

Settling Basin

A *settling basin* is a temporary basin with a controlled stormwater release structure that releases flow at a very slow velocity, allowing the solids to settle out. *Settling basins* are used to collect and store sediment from sites that are cleared or graded during construction or for extended periods of time before permanent vegetation is established or structures are built. They are intended to help prevent the release of silt-laden runoff.

Vegetated Filter Strips

A *vegetated filter strip* is a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach waterbodies or water sources, including wells.

Vegetated Swale (LID)

A vegetated swale is a vegetated, open-channel, elongated depression that receives stormwater runoff from upland areas. The vegetation slows the velocity of runoff and promotes the settling of sediment. Runoff also is filtered through the soils, and some infiltration might occur if underlying soils are suitable. These swales allow for both treatment and conveyance of stormwater (USEPA 2021f).

Weekly Street Sweeping

Weekly street sweeping is performed to remove contaminants, sediment, and debris from roadways before they can be carried away in stormwater runoff.

Wet Pond

A *wet pond* is a constructed basin that has a permanent pool of water throughout the year (or at least throughout the wet season). The primary removal mechanism is the gradual settling out of pollutants, while the stormwater runoff is held in the pool. Nutrient uptake also occurs through biological activity in the pond. *Wet ponds* are among the most cost-effective and widely used stormwater treatment practices. Although there are several different versions of the wet pond design, the most common is the extended detention *wet pond* (see *Extended Wet Detention*).

Wet Swale (LID)

A *wet swale* is similar to a grass swale in that it is a linear stormwater management practice; however, it functions like stormwater wetlands and should include wetland soils, hydrology, and vegetation. Stormwater is stored in small pools and shallow depressions along the length of the swale. Often a high-water table is present that maintains seasonal water in the *wet swale*. It can provide added benefits over grass and vegetated swales through enhanced filtration with thicker vegetation, additional sediment removal resulting from the flatter slopes, and higher nutrient removal (Ekka and Hunt 2020).

Wetland Detention

Wetland detention uses a detention basin planted with wetland vegetation. The wetland vegetation can improve the quality of stormwater released from the basin more effectively than dry detention and typical wet detention because the wetland vegetation takes up nutrients; settling and mechanical filtration by wetland plants also reduce suspended solids and turbidity. Wetland detention basins have a permanent pool of water and microtopography that encourages a longer residence time in the wetland to allow for more treatment. *Wetland detention* involves routing stormwater runoff to a constructed wetland, not a natural wetland, which should be avoided to prevent disruption to the hydrology of the natural wetland (USEPA 2021e).

Water Quality (WQ) Inlets

Inlet devices are various types of inserts placed in water intakes to trap pollutants and floating trash. Some inlet devices, such as silt fences, culvert inlet sediment traps, and oil-skimming booms, are intended for temporary use to prevent sediment from entering storm drainage systems prior to permanent stabilization of a disturbed area, such as during construction. Other inlet devices, such as strainer baskets, are installed in stormwater inlets permanently. The baskets sometimes incorporate an oil-skimming boom to collect hydrocarbons. These baskets must be cleaned out, and the oil-absorbent material must be replaced periodically.

Summary of Urban Practice Crediting

BMP	Pollutant Reduction Efficiency	Flow Volume Reduction
Alum Treatment	Yes	No
Bioretention facility	Yes	No
Combined BMPs-Calculated	Yes	No
Concrete Grid Pavement	Yes	No
Dry Detention	Yes	No
Extended Wet Detention	Yes	No
Filter Strip-Agricultural	Yes	No

BMP	Pollutant Reduction Efficiency	Flow Volume Reduction
Grass Swales	Yes	No
Infiltration Basin	Yes	Yes
Infiltration Devices	Yes	Yes
Infiltration Trench	Yes	Yes
LID*/Cistern	No	Yes
LID*/Cistern+Rain Barrel	No	Yes
LID*/Rain Barrel	No	Yes
LID/Bioretention	Yes	Yes
LID/Dry Well	Yes	Yes
LID/Filter/Buffer Strip	Yes	No
LID/Infiltration Swale	Yes	Yes
LID/Infiltration Trench	Yes	Yes
LID/Vegetated Swale	Yes	No
LID/Wet Swale	Yes	No
Oil/Grit Separator	Yes	No
Porous Pavement	Yes	Yes
Sand Filter/Infiltration Basin	Yes	Yes
Sand Filters	Yes	No
Settling Basin	Yes	No
Vegetated Filter Strips	Yes	No
Weekly Street Sweeping	Yes	No
Wet Pond	Yes	No
Wetland Detention	Yes	No
WQ Inlet w/Sand Filter	Yes	No
WQ Inlets	Yes	No

References

CASQA (California Stormwater Quality Association). n.d. *Dry Well Factsheet*. https://www.casqa.org/sites/default/files/downloads/dry_wells.pdf.

Christianson, L., and M. Helmers. 2011. *Woodchip Bioreactors for Nitrate in Agricultural Drainage*. PMR 1008. Iowa State University Extension, Ames.

Cohen, K. 2016. *Bioreactors Form a Last Line of Defense against Nitrate Runoff*. U.S. Department of Agriculture, Natural Resources Conservation Service. Accessed October 14, 2022. https://www.usda.gov/media/blog/2016/02/26/bioreactors-form-last-line-defense-against-nitrate-runoff.

CUCE (Clemson University Cooperative Extension). 1997. Management, Handling, Transfer, Storage, and Treatment of Manure and Litter from Poultry Production Facilities. Chapter 4 in *Confined Animal Manure Managers Poultry Training Manual.* C:\Datafiles\CAMM\CAMMP\CAMM-P Manual\Chapt 4\pch4_01.wpd (clemson.edu).

Cunningham, D.L., C.W. Ritz, and W.C. Merka. 2003. *Best Management Practices for Storing and Applying Poultry Litter*. Accessed August 1, 2022. https://www.thepoultrysite.com/articles/best-management-practices-for-storing-and-applying-poultry-litter.

Ekka, S., and B. Hunt. 2020. *Swale Terminology for Urban Stormwater Treatment*. North Carolina State University Extension Publications. AG-588-26. Accessed June 17, 2022. https://content.ces.ncsu.edu/swale-terminology-for-urban-stormwater-treatment.

MassHighway (Massachusetts Highway Department). 2004. *The MassHighway Storm Water Handbook for Highways and Bridges*. Massachusetts Highway Department, Boston.

MPCA (Minnesota Pollution Control Agency). 2012. Permeable interlocking concrete pavement photograph on *Minnesota Stormwater Manual* web page. Accessed October 19, 2022. https://stormwater.pca.state.mn.us/index.php?title=File:Picture_of_permeable_interlocking_concrete_pavement_1.jpg.

NCAGR (North Carolina Department of Agriculture and Consumer Services). 1997. *Poultry Dry Litter Management Plan*. https://www.ncagr.gov/SWC/tech/documents/AppenxPoultryDryLitterDPLMP.pdf.

NCAGR (North Carolina Department of Agriculture and Consumer Services). 2019. Agriculture Cost Share Program – Livestock Exclusion Fencing. Accessed October 19, 2022. 2019_07_livestock_exclusion_fencingwithtable.pdf (ncagr.gov).

NJDEP (New Jersey Department of Environmental Protection). 2021. Small-Scale Sand Filters. Chapter 9.9 in *New Jersey Stormwater Best Management Practices Manual.* New Jersey Department of Environmental Protection, Division of Watershed Management, Trenton.

NRCS (Natural Resources Conservation Service). 2012. *Conservation Practice Standard Overview – Forage and Biomass Planting (512)*. Accessed March 9, 2023. https://efotg.sc.egov.usda.gov/api/CPSFile/23090/512_NC_CPS_Forage_and_Biomass_Planting_2012.

NRCS (Natural Resources Conservation Service). 2015. *Conservation Practice Standard – Heavy Use Area Protection (Code 561).* Accessed March 9, 2023. https://efotg.sc.egov.usda.gov/api/CPSFile/26771/561_NC_CPS_Heavy_Use_Area_Protection_2015.

NRCS (Natural Resources Conservation Service). 2017a. *Conservation Practice Overview – CPS Structure for Water Control (Code 587).* https://www.nrcs.usda.gov/sites/default/files/2022-10/Structure_for_Water_Control_587_Overview_Sheet_Oct_2017.pdf.

NRCS (Natural Resources Conservation Service). 2017b. *Conservation Practice Standard – Access Control (Code 472)*. https://www.nrcs.usda.gov/sites/default/files/2022-08/Access_Control_472_CPS_Oct_2017.pdf.

NRCS (Natural Resources Conservation Service). 2020a. *Conservation Practice Standard – Riparian Forest Buffer (Code 391).* https://www.nrcs.usda.gov/sites/default/files/2022-09/Riparian_Forest_Buffer_391_CPS_10_2020.pdf.

NRCS (Natural Resources Conservation Service). 2020b. *Conservation Practice Standard – Streambank and Shoreline Protection (Code 580).* https://www.nrcs.usda.gov/sites/default/files/2022-10/Streambank_Shoreline_Protection_580_CPS_10_2020.pdf.

NRCS (Natural Resources Conservation Service). 2020c. *Conservation Practice Standard – Watering Facility (Code 614).* https://www.nrcs.usda.gov/sites/default/files/2022-10/Watering_Facility_614_NHCP_CPS_2020.pdf.

NRCS (Natural Resources Conservation Service). 2020d. Spring Steel Farm keep Cattle High and Dry (CPS Code 561). 20201117-NRCS-LSC-0281. Photo on Flickr. Accessed March 9, 2023. https://www.flickr.com/photos/usdagov/50720009843/in/album-72157717325376368/

NRCS (Natural Resources Conservation Service). 2021. Warren County Terraces Before/After – BrommelTerrace_0731. Photo on Flickr. Accessed March 9, 2023. https://www.flickr.com/photos/iowanrcs/51261928743/in/album-72157711644752413/

NRCS (Natural Resources Conservation Service), Indiana. 2018. *Conservation Practice Standard – Open Channel (Code 582).* Accessed March 9, 2023. https://efotg.sc.egov.usda.gov/api/CPSFile/9503/582_IN_CPS_Open_Channel_2018

NRCS (Natural Resources Conservation Service), Montana. 1974. Contour Farming01, Whitehall, MT. Photo stream on Flickr. Accessed March 9, 2023. https://www.flickr.com/photos/160831427@N06/23972931847/in/album-72157690532642945/

NRCS (Natural Resources Conservation Service), Montana. 2017. Big Spring Creek Restoration Project, Lewistown, MT. Photo stream on Flickr. Accessed October 12, 2022. https://www.flickr.com/photos/160831427@N06/39740199513/.

OSUE (Ohio State University Extension). 2022. *Open Channel/Two-Stage Ditch (NRCS 582)*. Accessed June 29, 2022. https://agbmps.osu.edu/bmp/open-channeltwo-stage-ditch-nrcs-582.

Oregon State University. 2022. *Optimizing Grazing*. Forage System–Grass Growth and Regrowth for Improved Management web page. Accessed October 4, 2022. https://forages.oregonstate.edu/regrowth/how-does-grass-grow/introduction/optimizing-grazing.

TJSWCD (Thomas Jefferson Soil and Water Conservation District). 2022. *Winter Feeding and Manure Management*. Accessed October 4, 2022. https://www.tjswcd.org/winter-feeding/.

USDA (U.S. Department of Agriculture). 2019a. Conservation Enhancement Activity E528R Management Intensive Rotational Grazing. https://www.nrcs.usda.gov/sites/default/files/2022-11/E528R%20August%202019.pdf

USDA (U.S. Department of Agriculture). 2019b. Deerfield Farm Cover Crop Project 20191018-NRCS-LSC-0919 in Deerfield, MA. Photo on Flickr. Accessed October 4, 2022. https://www.flickr.com/photos/usdagov/49445102503/in/album-72157712846548431/.

USDA (U.S. Department of Agriculture). 2020. Streamside buffer photo in 10,000 Pennsylvania landowners sought to buffer their streams. Accessed March 9, 2023. https://www.pennlive.com/life/2020/08/10000-pennsylvania-landowners-sought-to-buffer-their-streams.html.

USDA (U.S. Department of Agriculture) National Agroforestry Center. 2021. Riparian Forest Buffer 3101-0015. Photo on Flickr. Accessed October 4, 2022. https://www.flickr.com/photos/139938511@N02/26472805943/.

USEPA (U.S. Environmental Protection Agency). 2021a. *Alum Injection*. Stormwater Best Management Practice. EPA-832-F-21-031K. https://www.epa.gov/system/files/documents/2021-11/bmp-alum-injection.pdf.

USEPA (U.S. Environmental Protection Agency). 2021b. *Bioretention (Rain Gardens)*. Stormwater Best Management Practice. EPA-832-F-21-031L. https://www.epa.gov/system/files/documents/2021-11/bmp-bioretention-rain-gardens.pdf.

USEPA (U.S. Environmental Protection Agency). 2021c. *Grassed Swales*. Stormwater Best Management Practice. EPA-832-F-21-031P. https://www.epa.gov/system/files/documents/2021-11/bmp-grassed-swales.pdf.

USEPA (U.S. Environmental Protection Agency). 2021d. *Infiltration Trench*. Stormwater Best Management Practice. EPA-832-F-21-031C. https://www.epa.gov/system/files/documents/2021-11/bmp-infiltration-trench.pdf.

USEPA (U.S. Environmental Protection Agency). 2021e. *Stormwater Wetland*. Stormwater Best Management Practice. EPA-832-F-21031AA. https://www.epa.gov/system/files/documents/2021-11/bmp-stormwater-wetland.pdf.

USEPA (U.S. Environmental Protection Agency). 2021f. *Vegetated Filter Strip*. Stormwater Best Management Practice. EPA-832-F-21-031EE. https://www.epa.gov/system/files/documents/2021-11/bmp-vegetated-filter-strip.pdf.

WDNR (Wisconsin Department of Natural Resources). 2003. *Alum Treatments to Control Phosphorus in Lakes*. https://dnr.wi.gov/lakes/publications/documents/alum_brochure.pdf.

WSCC (Washington State Conservation Commission). Adams Conservation District. 2019. Livestock Watering Facility. Photo on Flicker. Accessed October 14, 2022. https://www.flickr.com/photos/sccgallery/51728024627/in/album-72157715839462223/.

WSCC (Washington State Conservation Commission). Snohomish Conservation District. 2016. Waste Storage Shed. Photo on Flicker. Accessed October 14, 2022. https://www.flickr.com/photos/sccgallery/50304560383/in/album-72157715839462223/.