NebGuide

University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources

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Stormwater Management: What Stormwater Management Is and Why It Is Important

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This NebGuide provides an overview of what stormwater is; what it means to manage stormwater; why it is important to do so; and the changing practice of stormwater management.

Stormwater is water from rain and melting snow and ice. Stormwater can soak into the soil (infiltrate), be held on the surface and evaporate, or run off and end up in a nearby stream, river, or other water body. Before land is developed with buildings, roadways, and agriculture, the majority of stormwater soaks into the soil or evaporates. In a natural area such as a prairie or forest, the soil absorbs considerable amounts of stormwater, and plants help hold stormwater close to where it falls so very little runs off.

When the Great Plains was covered with prairie grass and occasional woodlands, rainfall drained slowly into streams and rivers. Plant leaves and stems intercepted and slowed rainfall, allowing it to seep through decaying plant material on the soil surface and soak into the ground. Some of this water would slowly flow through the soil to nearby water bodies. Water that percolated down to groundwater might be released to the surface by springs. During heavy rains, runoff would flow over the ground, but was slowed and filtered by plants before reaching surface water.

In contrast, as populations grow, cities expand, and more development takes place, large amounts of runoff are produced from rooftops, concrete, asphalt, and other impervious surfaces that are built to shed water. Rather than soaking into the soil and slowly seeping to surface water, runoff is quickly funneled through storm drainage systems directly to streams, rivers, and lakes (*Figure 1*). The natural processes of infiltration, evaporation, and filtering are greatly reduced, and the amount and speed of stormwater runoff is greatly increased.

Figure 1. Stormwater runoff flowing into a storm drain. From here it flows directly to a nearby stream, river, or other surface water body.

Stormwater Management

Stormwater management is the control and use of stormwater runoff. It includes planning for runoff, maintaining stormwater systems, and regulating the collection, storage, and movement of stormwater. Stormwater management also considers drainage in the design of cities and housing developments.

The goals of stormwater management include protecting our environment; reducing flooding to protect people and property; reducing demand on public stormwater drainage systems; supporting healthy streams and rivers; and creating healthier, more sustainable communities. Effective stormwater management provides environmental, social, and economic benefits to local communities. When stormwater management is done well, streams, rivers, and lakes are cleaner; flood risks are reduced; costs due to flood damage decrease; and community quality of life increases.

Examples of Green Infrastructure

Conserving green space — allowing natural areas to remain during development to continue providing benefits (sometimes called ecosystem services) such as stormwater retention, air filtering, diversity of plants and wildlife, summer cooling, and recreation.

Rain gardens — decorative gardens that catch stormwater; they have plants and soil that filter runoff water and encourage infiltration; excessive runoff typically flows out of the garden through a designed overflow.

Bioretention gardens — much like rain gardens but larger and have a pipe underdrain system with a valve to manage water levels and enhance filtration and plant growing conditions (*Figure 2*).

Green roofs — special roofs with plants and soil-like growing media that capture and use stormwater, and slow and filter the water that flows off.

Stormwater swales — shallow, planted ditches that carry runoff; they slow and filter the water and increase infiltration.

Figure 2. A bioretention garden after a rainstorm. Bioretention gardens capture and filter runoff and let it soak into the soil, usually within 24 to 48 hours.

Rain barrels and cisterns — containers that capture and store runoff for later use, most often to water plants.

Constructed wetlands — built to act like natural wetlands to slow, filter, and soak in stormwater.

Permeable pavements — paving systems that allow stormwater to pass through and into gravel layers that store water until it soaks into the soil; a pipe system may be included in the gravel layer to drain excessive runoff.

Stream restoration — returns channelized, damaged streams to a meandering flow path with healthy plant cover to hold more stormwater, reduce erosion, and improve floodplain function; also includes stream "daylighting" where a previously buried stream is restored to a more natural, open channel.

Traditional Stormwater Management

As development occurs, buildings, roads, parking lots, and other impermeable surfaces increase the amount of runoff. This runoff traditionally has been considered a nuisance because it could cause flooding. Gutters, storm drains, pipes, and other structures were used to collect and carry stormwater away and release it into local streams as quickly as possible. Many urban streams were straightened or channelized to remove runoff even faster. While this can reduce local flooding, flooding is more likely to happen downstream, especially if high flows from two or more streams converge. Because water moves faster in a channelized stream, increased erosion of the stream bed and bank can occur.

Channelization also disconnects a stream from its natural floodplain. The floodplain is an area of low-lying land along a stream or river that holds and then slowly releases floodwaters, reducing downstream flooding. Channelized streams have artificially deep and steep-sided channels to contain floodwaters. Levees are also built to keep floodwaters out of the floodplain. But floods still occur that overtop stream banks, breech levees, and cause damage. If left undeveloped to function naturally, the floodplain could protect people and property from flooding, but few urban streams or rivers retain that protection. Unfortunately, traditional stormwater management often results in the unintended consequences of increased flood risk because of fast-moving, high water levels, altered stream channels, and loss of the floodplain.

A New Way of Thinking

Stormwater management is changing. Current techniques imitate natural systems by capturing and using rainwater close to where it falls. New practices, often referred to as green infrastructure, treat runoff as an asset, not a waste product or nuisance. Green infrastructure relies on plants, soils, and the microbial action of soil organisms to encourage stormwater infiltration, evaporation, and filtering. It lessens the negative impacts of stormwater runoff by mimicking the functions of natural ecosystems.

Stormwater management functions best when it works together with the existing landscape. This is frequently called low impact development. Low impact site design can greatly reduce runoff problems by preserving natural areas and natural vegetation; reducing the amount of impervious surfaces that produce runoff; and integrating stormwater management into the landscape. This decreases the amount of runoff, reduces erosion, and helps keep polluted runoff out of streams, rivers, and lakes.

New stormwater management techniques like green infrastructure and low impact development won't make our cities act like the prairies or forests they once were. But they can ease the effects of increasing amounts of impervious surfaces that shed runoff. Keeping stormwater close to where it falls, slowing it down, and soaking it in are important benefits of the new approach to stormwater management.

Stormwater Management to Reduce Pollution

As runoff amounts have increased because of increased amounts of impervious surfaces, the likelihood of runoff picking up pollutants also has increased. The U.S. Environmental Protection Agency (EPA) identifies stormwater runoff as a significant cause of water pollution. Sources of pollution include:

- Soil, chemicals, fertilizer, animal waste, leaves, oil and grease, trash, and other pollutants that are carried by stormwater runoff to surface water.

Some Things You Can Do to Reduce Stormwater Pollution

- Pick up pet waste and throw it in the trash (*Figure 3*).
- Sweep or blow fertilizer and pesticide granules from driveways, sidewalks, patios, and other impervious surfaces to ensure they end up in lawn and landscape areas. Don't spray liquid fertilizer or pesticide on these surfaces.
- Sweep or blow grass clippings from paved surfaces and put them back on the lawn or use in compost.
- Rake leaves and add to compost or properly dispose of them.
- Never dump anything into a storm drain or street gutters.
- Reduce soil erosion by planting bare areas and keeping plants healthy.
- Don't apply lawn chemicals or fertilizer when rainfall greater than about ½ inch is predicted within the next 24 hours.
- Carefully read fertilizer and pesticide labels, apply the correct amount, and properly store containers.
- Use commercial car washes or use environmentally friendly soap and the least amount of water practical when washing cars at home.
- Pick up litter and keep street gutters free of leaves and twigs.
- Adopt a storm drain and remove litter, leaves, twigs, etc., from the opening.

Figure 3. Picking up and properly disposing of pet waste in the garbage is one way to help keep stormwater runoff clean.

- Eroded soil in runoff leads to sediment deposits that can destroy aquatic habitat.
- Runoff containing chemicals, metals, or oil can harm or kill fish and other wildlife.
- Nutrients in fertilizer, grass clippings, leaves, and animal waste can cause excessive growth of algae and aquatic plants.
- Trash and debris are ugly and can injure or kill aquatic wildlife and spoil outdoor recreation.
- Thermal pollution, or increased water temperature, is also an issue. In warm weather, surfaces such as roofs and pavement become hot and runoff flowing over them is warmed. Thermal pollution reduces the oxygen-holding capacity of water and harms fish and other organisms living in the water.

Effective stormwater management reduces the amount of runoff and runoff pollution by slowing runoff and allowing it to soak in. When stormwater stays close to where it falls, less soil erosion occurs and fewer pollutants are carried to surface water. Green infrastructure encourages water infiltration into the soil, which filters runoff to remove and neutralize many kinds of pollutants.

Modern stormwater management also focuses on public education to help reduce runoff pollution. The entire community can help keep runoff clean.

Reducing the pollution carried in stormwater runoff is an important part of stormwater management because most stormwater is not treated to remove pollutants. Unlike sewage from homes and businesses that flows in sanitary sewers to a wastewater treatment plant, stormwater generally moves through separate pipes and empties directly into a stream or river without being cleaned. The exception to this is a combined sewer system that handles both sewage and stormwater.

Older cities, including Omaha and many cities in the eastern and northwestern United States, have combined sewer systems. Many years ago when these systems were built, the effects of stormwater were not as pronounced; populations were smaller and less concentrated; and a combined system was cheaper than building two separate systems.

In dry weather, or when there is very little stormwater, all flow (sewage and stormwater) in a combined sewer is treated at a wastewater treatment plant. When it rains, a combined sewer system is often overwhelmed by large volumes of stormwater, and the combined sewage and stormwater overflows into a stream or river at designed points. In this case, not only does stormwater enter the stream untreated, but untreated sewage is discharged to the stream as well.

Water Pollution Regulations

Good stormwater management is the responsible thing to do for the environment. It is also the law as a result of the Clean Water Act and the National Pollutant Discharge Elimination System (NPDES) permit program.

NPDES permits help control water pollution by regulating point sources, which are identifiable points such as pipes, channels, or manmade ditches that could discharge pollutants. Initially, the NPDES program focused on things such as wastewater released from sewage treatment and manufacturing facilities; in other words, pollution sources other than stormwater. The program limits the amount of pollution these facilities can discharge into U.S. waters.

These regulations made good progress in improving water quality. However, in many places surface water was still significantly polluted. Because stormwater runoff is a major source of water pollution, municipal and industrial stormwater discharges were added to the NPDES permitting program in 1990. The program does not, however, regulate agricultural runoff or irrigation return flows. These sources of water pollution are exempted from NPDES permitting requirements.

The Clean Water Act Regulates Stormwater

The Clean Water Act (CWA) is the primary United States federal law governing water pollution. It was first passed by Congress in 1972 and has since been amended and refined. The goal of the CWA is to restore and maintain the quality of the nation's waters. The CWA established the basic structure for limiting discharges of pollutants into waters of the United States, which is the National Pollutant Discharge Elimination System (NPDES) permit program. This program's objective is to prevent harmful pollutants from entering streams, rivers, lakes, or coastal waters. The provisions of the CWA are enforced by the EPA and state environmental agencies.

Stormwater Permits

The NPDES stormwater permitting program regulates stormwater discharges from municipal separate storm sewer systems (MS4s) and specific types of industries. An MS4 is a storm sewer system that is operated or owned by a public body, is separate from sanitary sewers, and carries only stormwater, which is discharged untreated into local surface waters. Not all MS4s are included in the program. Many smaller communities, typically those with populations less than 10,000, are not presently required to have an NPDES stormwater permit. MS4s that must have a permit are referred to as regulated MS4s.

The construction industry is one example of an industry regulated by the NPDES stormwater permitting program *(Figure 4)*. Construction activities have a unique potential to cause water pollution because of soil disturbance such as digging and earthmoving. Construction site operators doing land clearing, grading, and excavating that disturbs one acre or more must have a permit for their stormwater discharges. Smaller construction sites also may need a permit if they are part of a larger development.

Figure 4. A construction site with a National Pollutant Discharge Elimination System permit, which in Nebraska is administered through the Nebraska Department of Environmental Quality.

Regulated MS4, industrial, and construction site operators must apply for and obtain an NPDES stormwater permit. However, this does not prevent them from discharging pollutants. In reality, totally prohibiting pollution in stormwater runoff is not practical or economical, and certainly not enforceable. In effect, a permit allows the discharge of stormwater that is somewhat polluted but requires that certain things be done to reduce the amount of pollution released.

The permitting process makes these operators aware of their responsibilities to reduce stormwater pollution. It requires them to have a stormwater management plan, keep records, and submit periodic reports. The permitting process also gives guidance on how to prevent pollution. When permitting requirements are not followed, hefty fines can be imposed.

National Pollution Discharge Elimination System

The NPDES stormwater permitting system was introduced in two phases. Phase I, which began in 1990, required MS4s serving populations of 100,000 or more to obtain permits for their stormwater discharges. It also required permits for stormwater discharges from industries and construction sites greater than five acres in size.

Phase II, issued in 1999, brought all MS4s located in urbanized areas into the permitting program. MS4s outside urbanized areas that serve populations greater than 10,000 are also typically included. Facilities with their own separate storm sewer systems, such as universities and military bases, also may be required to have an NPDES stormwater permit. Under the Phase II rules, construction sites of one or more acres also are required to have a permit.

Summary — The Big Picture

The need for stormwater management has evolved with the growth of cities and their populations. Large percentages of developed areas are covered with impervious surfaces that do not allow water to soak into the soil. These surfaces cause large increases in the amount of runoff and the speed with which it is fed into urban streams, rivers, and lakes. Surface waters are also at risk because of the pollution that this runoff collects.

The realization of the negative effects of increased runoff and runoff pollution led to the development of new ways to handle stormwater, many of which imitate natural processes. Modern stormwater management, including proper planning, the use of green infrastructure, and public education, reduces runoff and runoff pollution to protect and improve water quality.

Stormwater: Keep It Clean! Slow It Down! Soak It In!

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