# 2.0 Introduction to Stormwater

## 2.1 Definition of Stormwater

Stormwater is produced immediately following a rainfall event or as a result of snowmelt. When a rainfall event occurs, there are four potential fates for the precipitation: (1) infiltration into the soil, (2) plant uptake and transpiration, (3) evaporation (4) runoff from pervious and impervious areas. This final fraction is stormwater.

## 2.2 Effects of Urbanization – Impervious Surfaces

North Carolina's communities are considered among the best places to live in America; as a result, the state's growth rate is consistently one of the highest in the country. The resulting urban influx affects many facets of the state's infrastructure–more cars drive on our roads, more children enroll in our schools, increased population creates higher wastewater discharges, and more development necessitates stormwater runoff controls. How does urbanization affect stormwater runoff? Impermeable surfaces, such as roads, parking lots, sidewalks, homes, and offices replace the natural, and permeable, landscape. Rainfall that once soaked into vegetated areas is now transported as stormwater runoff. As more surfaces become impermeable, water simply runs off of them. Impermeable surfaces and storm sewers efficiently convey water to streams at greater rates and in larger volumes (Figure 2.1).

**Figure 2.1 Stormwater runoff in a highly urbanized watershed.**

There are many effects of this increase in impermeable area: (1) more stormwater reaches streams because there is less opportunity for it to infiltrate into the ground or evapotranspire; (2) peak flows increase because the impermeable surfaces rapidly transport runoff from large areas; (3) velocities in the stream increase, causing a larger erosion potential; and (4) baseflow is lower during dry weather due to a lack of infiltration into the underlying groundwater. Open areas with natural ground cover transfer approximately 50% of the annual rainfall to evapotranspiration, 25% of the annual rainfall goes into the shallow groundwater, 20% goes into deep infiltration, and 5% runs off. When urbanization occurs, about 35% of the annual rainfall is lost to evapotranspiration, 10% of the annual rainfall goes into the shallow groundwater, 5% goes into deep infiltration, and 15% runs off (Leopold, 1968; Swank and Crossley, 1988). Figure 2.2 illustrates the impact of urbanization.

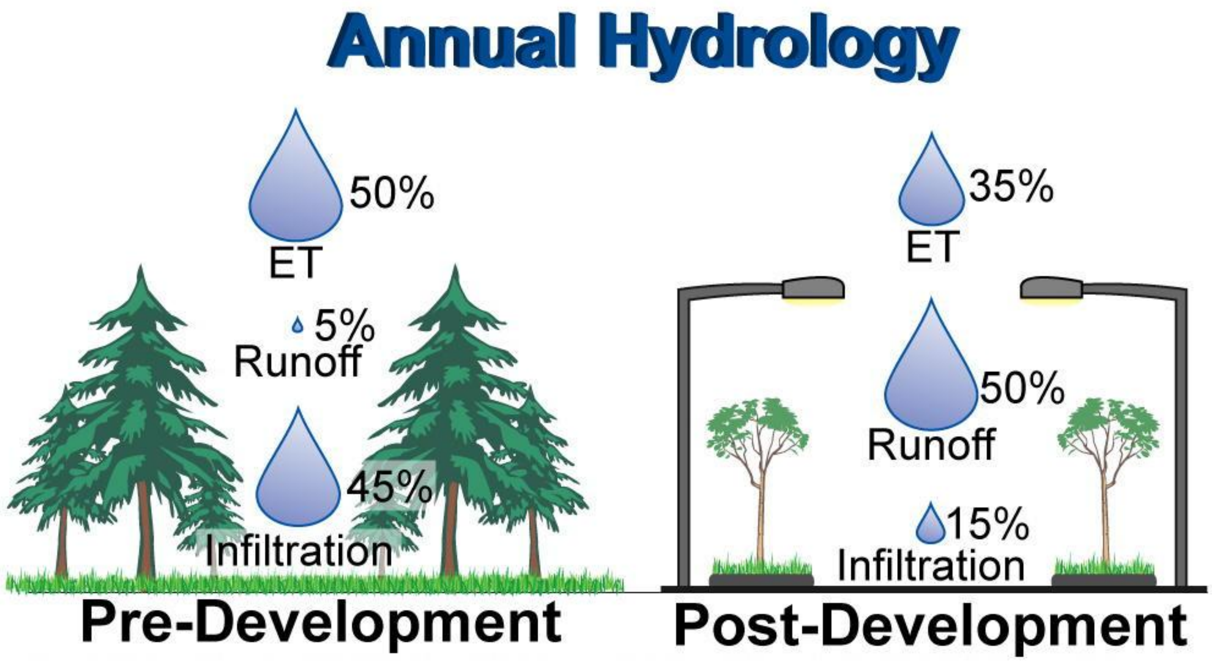


**Figure 2.2 Watershed hydrology pre- and post-development (Swank and Crossley, 1988).**

Using traditional analyses such as the Natural Resources Conservation Services' stormwater model, TR-55, or the U.S. Army Corps of Engineers' HEC model, the model shows that peak flows alone can increase by up to five-fold from pre- to post-development conditions. The public knows this effect of urbanization as flooding. While an increase in stormwater runoff is a conspicuous result of urbanization, there are many less visible water quality impacts associated with development. Erosion and sedimentation have long been recognized as water quality concerns. Although the North Carolina legislature passed laws to curb sediment pollution in 1973, sediment remains the number one pollutant of N.C. waters (Sutherland, 2002). In addition to sediment, metals and chemicals from vehicles and industries pollute stormwater runoff. Under forested conditions, these pollutants would only be found in trace amounts.

Nutrients are found in the urban environment in a variety of forms, one such form being fertilizer. Fertilizer contains nutrients for plants to grow, but excess fertilizer or fertilizer that is inadvertently applied to pavement harms water quality. Even if proper amounts of fertilizer are applied, nutrients can enter our streams in other ways, including atmospheric deposition, wildlife and pet waste, and septic system malfunction. There are numerous ways to reduce pollutant loadings, including source reduction–such as proper application of fertilizer and correctly maintaining septic systems. Structural devices can also help curb this problem. This manual will provide design guidance for several structural best management practices (BMPs) that can be constructed to treat runoff and thereby reduce the amount of pollution entering streams.

## *2.3 Connected Imperviousness*

Impervious areas were discussed above in section 2.2; however, not all impervious areas substantially contribute to stormwater runoff in a given watershed. Impervious areas that immediately drain to a drainage system (such as a pipe or storm sewer) are considered to be “connected impervious” areas and more readily produce runoff within urban environments. For example, a rooftop that drains to a gutter which drains directly into a nearby street and into the street drainage would be considered “connected impervious.” Conversely, if a rooftop drained onto a lawn where runoff would sheet flow across the grass, the rooftop would not be considered connected impervious. Runoff from disconnected impervious areas is routed to a pervious area where it has a chance to infiltrate. As a rule of thumb, if a rooftop or pavement is allowed to sheet flow for at least 30 feet before it re-concentrates (e.g. forming a swale or spilling into a drop inlet), it may be considered a disconnected impermeable surface.

Please note this is generalized guidance and the 30 foot area does not take into account soil type or treatment of lawn, etc. This determination will be site specific and need to incorporate the individual project site and landscape characteristics.

For the purposes of this manual’s guidance, the differentiation between connected and disconnected impervious coverage is for informational and project prioritization purposes only. Connected impervious areas should receive priority project funding over disconnected impervious. Please note, sizing of BMPs with the Simple Method (Section 3.2) does not differentiate between connected and disconnected impervious coverage. The total impervious area is utilized.

## *2.4 Best Management Practices (BMPs)*

An urban BMP is a method of treating or limiting pollutants in stormwater runoff. It can be as simple as applying the proper amount of fertilizer to a home lawn or as complex as building an engineered structure such as a stormwater wetland. Each BMP has certain conditions under which it will function properly. The pollutants to be treated, size of watershed, imperviousness of the watershed, local water table, and amount of available land for the practice all influence the selection of a BMP. Some of the BMPs are relatively well known and researched, while others are in their infancy. This document will focus on BMPs that can be installed in small-scale settings, such as individual residences and small businesses. The best management practices that will be discussed in this document are backyard rain gardens, backyard wetlands, cisterns, vegetated swales, impervious surface removal, and permeable pavements. Each of these BMPs can be valuable in treating the stormwater leaving a catchment. Guidance on BMP selection (based on site conditions) will be discussed in detail in the next two sections.