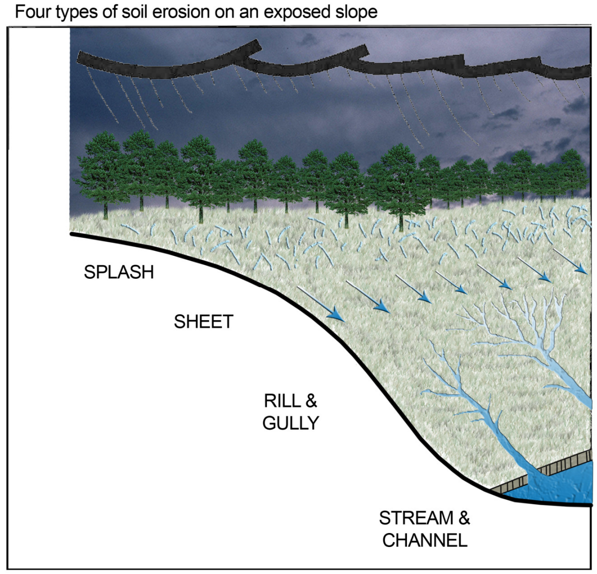
Chapter 1
Introduction to Erosion and Sediment Processes

This chapter is intended to be an introduction to the processes referred to as erosion, sedimentation and stormwater management. If in-depth information is needed on these subjects, other references should be used.

Erosion and Sedimentation Processes

Erosion

Four types of soil erosion on an exposed slope



Erosion is the process by which the land surface is worn away by the action of water, wind, ice or gravity. Water-related erosion is the primary problem in the developing areas of Mississippi and is the primary type of erosion that this handbook addresses.

The slow sedimentation and deposition of products from millions of years of geological erosion of upland sources has created the Mississippi we know today. With the exception of shorelines and stream channels where erosion may be rapid and catastrophic, geologic erosion occurs at very slow rates. This natural erosion process, which has taken place over millions of years, has probably occurred at rates comparable to erosion on our current forests.

In contrast to geologic erosion, the erosion accelerated by the disturbances of humans, through agriculture and non-agricultural uses of the land, has caused several inches of erosion over the last 100 to 150 years, a comparatively short period. Thus, "accelerated erosion" can be very significant and can potentially create related adverse impacts. Accelerated erosion occurs in developed or developing areas where developing sites are either poorly planned or the plans that appear adequate are not installed and maintained properly.

To understand erosion caused by water, it is helpful to think of the erosive action of water as the effects of the energy developed by rain as it falls or as the energy derived from water's motion as it flows across the land surface. Both falling rain and flowing water, typically referred to as stormwater, perform work in detaching and moving soil particles, but their actions are different. The force of falling rain is applied vertically. The force of flowing water is applied mostly horizontally.

The energy of raindrops falling on bare soil detaches soil particles. Water flowing over exposed soil picks up detached soil particles. As the velocity of flowing water increases, additional soil particles are detached and transported. Flowing water concentrates because of surface irregularities. If not prevented, these flows will create small channels, or rills, and eventually larger channels, or gullies of varying widths and depths. If the volume and velocity of storm runoff leaving a disturbed site increases because of the activities on the site, it is likely to cause additional erosion of streambanks and within floodplains beyond the rate of geologic erosion.

Although not as prominent in the Southeast as erosion caused by water, wind erosion can cause on-site health and safety problems and is a source of fugitive dust.

Sedimentation and Turbidity

Sedimentation is the process that describes soil particles settling out of suspension as the velocity of water decreases. The larger and heavier particles, gravel and sand, settle out more rapidly than silt and clay particles. Silt and clay particles are easily transported and settle out very slowly. It is difficult, and perhaps impossible in some instances, to totally eliminate the transport of clay and silt particles, even with the most effective erosion control programs.

Turbidity occurs in conjunction with sedimentation. Turbidity—a cloudy, muddy condition in the water—occurs when eroded soil is suspended in the water (i.e. before it settles out). Turbid water can stress or kill fish by clogging their gills and making it difficult for them to identify food sources.

Factors Influencing Erosion

The erosion process is influenced primarily by climate, topography, soils, and vegetative cover. The following description of the factors is an overview adequate for this handbook; however, it is recognized that this is a very complex subject and many details are not included here.

Climate

Climate includes rainfall, temperature and wind. The frequency, intensity and duration of rainfall are the principal aspects of rainfall influencing the volume of runoff, erosion, and sediment (potential) from a given area. As the volume and intensity of rainfall increase, the ability of water to detach and transport soil particles increases. When storms are frequent, intense, and of long duration, the potential for erosion of bare soils is high. Temperature has a major influence on soil erosion. Frozen soils are relatively erosion resistant. However, bare soils with high moisture content are subject to uplift or “spew” by freezing action and are usually easily eroded upon thawing. Wind contributes to the drying of soil and increases the need for irrigation for new plantings and for applying wind erosion control practices during periods of bare soils.

Topography

Topography includes the shape and slope characteristics of an area or watershed and influences the amount and duration of runoff. The greater the slope length and slope gradient, the greater the potential for runoff, erosion and sediment delivery.

Soils

Soil characteristics include texture, structure, organic matter content and permeability. In addition, in many situations, compaction is significant. These characteristics greatly determine the erodibility of soil.

Soils containing high percentages of sand and silt are the most susceptible to detachment because they lack inherent cohesive characteristics. However, the high infiltration rates of sands either prevent or delay runoff except where overland flow is concentrated. Clearly, well-graded and well-drained sands are usually the least erodible soils in the context of sheet and rill erosion.

Clay and organic matter act as a binder to soil particles, thus reducing erodibility. As the clay and organic matter content of soils increase, the erodibility decreases. However, while clays have a tendency to resist erosion, they are easily transported by water once detached.

Soils high in organic matter resist raindrop impact, and the organic matter also increases the binding characteristics of the soil.

Sandy and silty soils on slopes are highly susceptible to gully erosion where flows concentrate because they lack inherent cohesiveness.

Small clay particles, referred to as colloids, resist the action of gravity and remain in suspension for long periods of time. Colloids are potentially a major contributor to turbidity where they exist.

Vegetative Cover

Vegetative cover is an extremely important factor in reducing erosion at a site. It will:

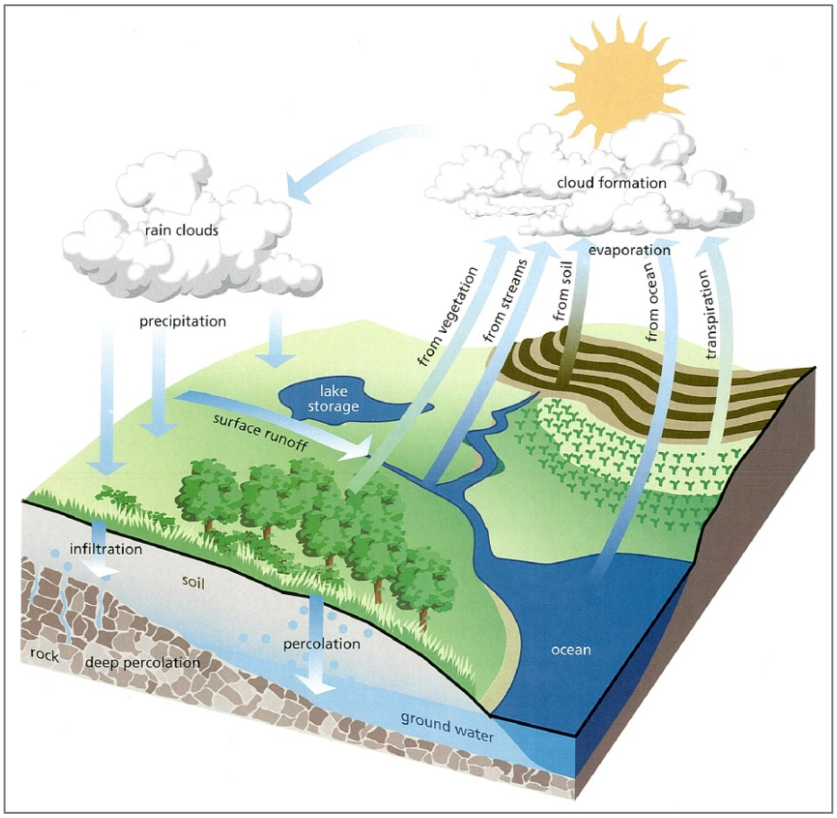
a. Absorb energy of raindrops.
b. Bind soil particles.
c. Slow velocity of runoff water.
d. Increase the ability of a soil to absorb water.
e. Remove subsurface water between rainfall events through the process of evapotranspiration.
f. Reduce off-site fugitive dust.

By limiting the amount of vegetation disturbed and the exposure of soils to erosive elements, soil erosion can be greatly reduced.

Stormwater

Water flowing over the land during and immediately following a rainstorm is called stormwater runoff. The runoff passing a particular point is equal to the total amount of rainfall upstream of that point less the amounts of infiltration, transpiration, evaporation, surface storage and other losses. The amount of these losses is a function of climate, soils, geology, topography, vegetative cover and, most importantly, land use.

In an undeveloped area, stormwater runoff is managed by nature through the hydrologic cycle. The cycle begins with rainfall. Rain either stands where it falls and evaporates or is absorbed into the ground near the surface, to feed trees and vegetation, ultimately to be returned to the atmosphere by transpiration; or it percolates deeply into the ground replenishing the groundwater supply. The remainder of the rainfall collects into rivulets. This collected runoff increases in quantity as it moves down the watershed, through drainageways, streams, reservoirs and to its ultimate destination, the river and then the sea. Evaporation from the sea surface begins the cycle again.



The Hydrological Cycle
(Source: NRCS "Stream Corridor Restoration: Principles, Processes, and Practices")

This simple explanation of the hydrologic cycle belies its complexity. Nature's inability to accommodate severe rainfalls without significant damage, even in undeveloped areas, is very apparent. Nature's stormwater management systems are not static but are constantly changing. Streams meander, banks erode, vegetation changes with the seasons, lakes fill in with sediment and eventually disappear. The stripping of ground and tree cover by fire can change an entire system, forcing new natural accommodations throughout the system.

The volume of stormwater runoff is governed primarily by infiltration characteristics and is related to the land use, soil type, topography and vegetative cover. Thus, runoff is directly related to the percentage of the area covered by roofs, streets and other impervious surfaces. Water intercepted by vegetation and evaporated or transpired is lost from runoff. A small portion of the water that infiltrates into the soil and groundwater is delivered to the stream as delayed flow and does not contribute directly to peak stormwater runoff. Impervious surfaces normally contribute almost all of the total rain immediately to stormwater runoff.

There are four distinct yet interrelated effects of land use changes on the hydrology of an area:

1) Changes in peak flow characteristics; 2) changes in total runoff; 3) changes in water quality; and 4) changes in the hydrologic amenities (Leopold, 1968). The hydrologic amenities are what might be called the appearance or the impression that the river, and its channel and valleys, leaves with the observer.

Of all land use changes affecting the hydrology of an area, urbanization is the most impactful. As an area becomes urbanized, the peak rate of runoff and volume of runoff increase. These effects are caused by: 1) a reduction in the opportunity for infiltration, evaporation, transpiration and depression storage; 2) an increase in the amount of imperviousness; and 3) modification of the surface drainage patterns, including the associated development of stormwater management facilities.

Summary of Hazards Associated with Land Development

Land development clearly increases potential erosion and sediment hazards on-site by removing cover, developing cuts and fills that are more susceptible to erosion than the previously undisturbed soils and changing water conveyance routes. More subtle changes related to erosion and sediment include soil compaction (both planned and unplanned), longer slopes, and more and faster stormwater runoff.

Land development, in most instances, has the following potential effects off-site both during and following the development phase and reflect the impacts of changed use of the land on stormwater:

- Increased volumes of storm runoff.
- Higher peak flows of storm runoff if not modified by planned measures.
- Increased loads of sediment and other pollutants associated with the site unless prevented or minimized by planned measures.

The potential off-site effects include increased flooding, accelerated erosion of stream systems, increased sediment deposition in both streams and floodplains, and adverse impacts to the biological communities associated with the streams and floodplains.

Each progression toward more intensive land use tends to disrupt the ongoing natural processes that protect and preserve water quantity and water quality. Therefore, to ensure future protection of water resources, it is imperative that land uses be managed in a responsible way.

As we reflect on the processes and the potential impact, we should recognize the importance of sound site planning, timely and proper installation of the measures planned, and the need for long-term maintenance of measures that sustain site stabilization. If the best available technology is used for planning, design, installation and maintenance of erosion and sediment control and stormwater management, the impacts of land development will be minimized. Other chapters of this handbook present relevant planning considerations, design criteria, and installation and maintenance information.

To address the hazards associated with land disturbance, The National Pollutant Discharge Elimination System (NPDES) Stormwater Program regulates stormwater discharges from construction activities. (Two other sources are also regulated, MS4s and industrial activities.) Most stormwater discharges are considered point sources, and operators of these sources may be required to receive an NPDES permit before they can discharge. This permitting mechanism is designed to prevent stormwater runoff from washing harmful pollutants into local surface waters such as streams, rivers, lakes or coastal waters.

Most states are authorized to implement the NPDES Stormwater Program and administer their own stormwater permitting programs. Mississippi is such a delegated state (see **Appendix B**). EPA remains the permitting authority in a few states, in territories, and on most tribal lands. For these areas, EPA provides oversight and issues stormwater permits.