Chapter 2
EROSION AND SEDIMENT CONTROL

2.1 Erosion Process

Short-term stormwater quality management predominately focuses on erosion and sediment control for construction sites. However, erosion may occur on any site, even fully developed properties.

Soil erosion is the process by which wind, water, or gravity removes soil particles from land surfaces. Natural erosion generally occurs at slow rates; however, the rate of erosion increases whenever the land is cleared or disturbed. Clearing and grubbing activities during construction remove vegetation and disrupt the structure of the soil surface, leaving soil susceptible to overland erosion, stream and channel erosion, and wind erosion. Ultimately, the material suspended by erosion settles during the sedimentation process in downstream reaches. This can lead to an increase in maintenance needs, flooding problems, and water quality concerns.

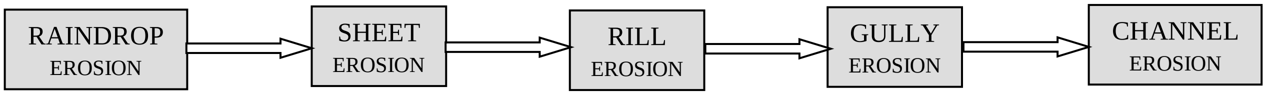
2.2 Overland Erosion

The overland erosion process begins when raindrops impact the soil surface and dislodge minute soil particles, which then become suspended in the water droplet. The sediment-laden water droplets accumulate on the soil surface until a sufficient quantity has developed to begin flowing under the natural forces of gravity.

The initial flow of sediment-laden water generally consists of a thin, slow-moving sheet, known as sheet flow. While sheet flow is generally not highly erosive on its own, it does begin to transport previously suspended sediment particles. Due to irregularities in the soil surface and uneven topography, sheet flow will usually begin to concentrate into small grooves, or rills, where the flow picks up velocity and erosive energy because of gravitational forces.

Rill erosion of the soil surface tends to concentrate more flows, which then flow faster and gain erosive energy. Typically, rills are oriented downslope parallel to other rills, and rills are generally small enough to be easily stepped across. The combination of several adjacent rills, or sufficient enlargement of a single rill, begins gully erosion. Gully erosion of the soil surface tends to further concentrate more flows.

Gullies have four principal methods of increasing erosion. First, gullies often have a “head cut” at the upstream end, which progresses its way upstream as water flowing into the gully erodes away the lip of the head. This process is similar to a waterfall working its way upstream. Second, the flow in a gully tends to undercut the banks. Once sufficiently under cut, the banks collapse into the gully where the collapsed soil is then washed away. Third, when banks collapse into the gully, flowing water is diverted around the temporary blockage of soil, which then increases velocities along one or both banks. Fourth, the concentration of flows in the gully can result in scour of the gully floor until a stable slope is obtained.



2.3 Stream and Channel Erosion

Streams and channels are subject to the same types of erosion as gullies, with slightly different terminology. A stream develops naturally to handle the stormwater and groundwater drainage of a particular watershed. The location, length, width, slope, sediment composition and size, amount of meandering, etc, are all determined by the characteristics of the precipitation and the landforms. The stream adjusts naturally to changes in rainfall, land cover, geology, and many other factors.

One or more of the following factors may disrupt the delicate balance required for stable streams and channels and could generally precipitate erosion within streams and channels:

- Disturbing the banks of streams and channels is often required during construction. Once vegetation or other bank protection measures are disturbed, flows may begin to erode the unprotected soil.

- Disturbing the flow within a stream or channel is often necessary to facilitate construction activities. However, this should only be allowed when traversing banks such as temporary stream crossing, culvert installation, bridge construction, etc. By diverting flows within the channel, velocities are generally increased in some areas to compensate for decreases in other areas. The increases in velocity may exceed those normally experienced by the channel, resulting in bank erosion and bottom scour.

- Increasing the quantity and rate of flow to streams and channels often results from construction activities and construction of facilities that increase the quantity and rate of runoff, as well as how runoff is conveyed to the discharge point. The increased quantity and rate of flow can cause bank erosion and bottom scour.

Soil characteristics play a key role in determining stream and channel flow. The tractive force or shear stress developed by flowing water over the channel banks and bottom can cause the soil particles to move and become suspended into the runoff. The permissible shear stress indicates the maximum stress that the channel banks and bottom can sustain without compromising stability. Determining the shear stress for a manmade channel is relatively easy, when compared to a stream, which is constantly changing shape, direction, material, etc.

Disturbing a stream or other natural channel should only be done as a last resort. The Tennessee Department of Environment and Conservation (TDEC) requires permits for the disturbance of any blue-line stream. The Tennessee Valley Authority and the Army Corps of Engineers may also require a permit for the disturbance of any blue-line stream. A blue-line stream is defined according to the 7.5-minute quadrangle maps published by the United States Geological Survey (USGS).

2.4 Dust Control

Wind erosion contributes to the degradation of stormwater runoff by depositing dust over the land surfaces. This dust will generally be washed into the stormwater drainage system during the first portion of a rainfall event. Dust is defined as solid particles or particulate matter small enough to remain suspended in the air for a period of time and large enough to eventually settle out of the air. Dust from a construction site originates as inorganic particulate matter from rock and soil surfaces and material storage piles. The majority of dust generated and emitted into the air at a construction site is related to earth moving, demolition, construction traffic on unpaved surfaces, and wind over disturbed soil surfaces.

Consult AM-11, Dust Control, for various methods of reducing dust and air pollution; however, many of the BMPs that reduce overland erosion also greatly reduce the generation of dust. Dust control for disturbed surfaces generally is accomplished by applying water or a chemical mixture to the surface. BMPs that capture the sediment from the disturbed areas should also take into account the dust control chemicals.

2.5 Factors Influencing Erosion

There are five primary factors that influence erosion: soil characteristics, vegetative cover, topography, climate, and rainfall. The five factors are also components in the Revised Universal Soil Loss Equation (RUSLE), which was originally developed for the United States Department of Agriculture with regard to soil losses on farming land. For more information on RUSLE, see the official website listed in Chapter 8. The RUSLE formula is:

$$A = R\ K\ L\ S\ C\ P$$

where
A = predicted soil loss (tons per acre per year)
R = rainfall erosion index
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = vegetative cover factor
P = erosion control practice factor

- Rainfall frequency, intensity, and duration are fundamental factors in determining the amounts of erosion produced. When storms are frequent, intense, or of long duration, erosion risks are high. In the City of Knoxville, the months with highest rainfall are December through May, which also coincides with the period of minimal vegetative cover. However, the most intense storms occur during the spring and summer months. This leads to the conclusion that the spring is potentially the most erosive season. Site grading and excavation occurs at the beginning of a construction project, which is also often during spring.
- Climate is a key factor that influences erosion. Factors such as humidity, temperature extremes, freeze/thaw cycles, and average wind speeds can have significant effects on soil stability and structure. In addition, these factors affect the permeability of the soil.

- Soil characteristics that determine the erodibility of the soil include particle size and shape, particle gradation, organic content, soil structure, and permeability. Less permeable soils have a higher likelihood for increased runoff and erosion, particularly soils with a high percentage of silt and clay. Fill soil and placed embankments are more likely to erode than cut areas and excavations, so fill areas are generally required to have a flatter slope than cut areas.

- Vegetative cover plays an important role in controlling erosion by shielding the soil surface from the impacts of falling rain and by slowing the velocity of runoff. This permits greater infiltration, maintains the soil’s capacity to absorb water, and holds soil particles in place. Vegetative root structures create a favorable soil structure, improving its stability and permeability.

- Topography such as slope length and steepness are key elements in determining the volume and velocity of runoff. As slope length and steepness increases, so does the rate of runoff and the erosion potential. Steep slopes should be limited to short lengths whenever possible.

Application of a soil erosion equation such as RUSLE is generally not necessary on small construction projects, but may be required by the Engineering Director in situations involving very large areas or in extremely sensitive areas. However, the basic concepts such as limiting the gradient and length of steep slopes should be practiced whenever possible.

2.6 Sedimentation Process

The settling of soil particles is known as the process of sedimentation. Once soil particles are eroded by and suspended in water or wind, they can be carried a distance, from a few inches to many miles, before conditions allow the forces of gravity to cause the soil particles to settle. In other words, the sedimentation process usually occurs when the flow of water slows.

Larger particles, such as gravel and sand, will settle more rapidly than fine particles, such as silt and clay. Particles may be re-suspended when the flow of water increases. The pattern of the sedimentation process is often a good indication of the stormwater flow that carried it. Excessive levels of sediment can plug storm drains, block streams and channels, reduce floodwater storage, damage habitats, and occasionally result in formation of habitats in undesirable locations. Sediment removal is an expensive task that must be performed regularly.

Generally, the sedimentation process can be forced to occur by creating conditions that slow the flow of water or air, thus allowing particles to settle. Conversely, creating conditions of rapid and turbulent flow will prevent particles from settling. Sediment traps and sediment basins are examples where sedimentation occurs at a designed location.