The Erosion and Sedimentation Process

Erosion and sedimentation are naturally occurring processes. However, human activities have accelerated these processes well beyond the rate desired by nature. The removal of large volumes of soil from the land, and their deposition in waterways, has destroyed ecosystems and degraded the environment.

In order to minimize and control erosion and sedimentation, it is important to understand the process and cause of each.

A. The Erosion Process

1. **Water:** Erosion from water typically occurs in the following ways:

   a. **Raindrop Splash and Sheet Erosion:** The first step in the erosion process begins as raindrops impact the soil surface. Raindrops typically fall with a velocity of 20 to 30 feet per second. The energy of these impacts is sufficient to displace soil particles as high as two feet vertically. In addition, the impact of rainfall on bare soil can compact the upper layer of soil, creating a hard crust that inhibits plant establishment and infiltration.

      Sheet erosion occurs as runoff travels over the ground, picking up and transporting the particles dislodged by raindrop impacts. The process of sheet erosion is uniform, gradual, and difficult to detect until it develops into rill erosion. If runoff is maintained as sheet flow, the velocity remains low and there is little potential that the flow will remove particles that have not been dislodged by other means (i.e. raindrop splash).

      The method used to prevent erosion from raindrop splash and sheet erosion is stabilization. Stabilizing techniques such as temporary and permanent vegetation, sodding, mulching, compost blankets, and rolled erosion control products absorb the impact of raindrops and protect the ground surface. By protecting the surface, soil particles are not dislodged and transported by sheet flow. Typically, sheet flow does not have sufficient volume or velocity to dislodge soil particles from a bare surface by itself. It is dependent on raindrop impacts to disturb the surface. Therefore, stabilizing a surface protects the ground from both raindrop and sheet erosion.

   b. **Rill Erosion:** Rill erosion occurs as runoff begins to form small concentrated channels. As rill erosion begins, erosion rates increase dramatically due to the resulting higher velocity concentrated flows. Construction sites that show signs of rill erosion need to be re-evaluated and additional erosion control techniques employed. Rilling can be repaired by tilling or disking (filling in the rills and discouraging concentrated flows) and should be repaired as soon as possible in order to prevent gullies from forming.

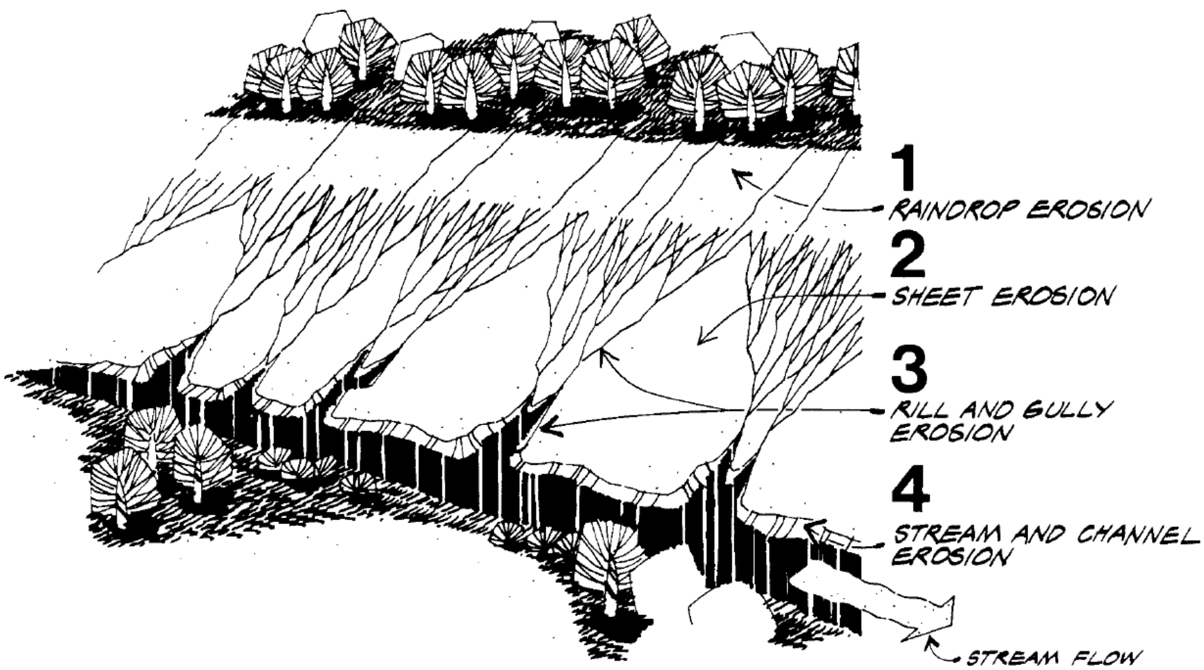
   c. **Gully Erosion:** Gully erosion results from water moving in rills, which concentrates to form larger channels. When rill erosion can no longer be repaired by merely tilling or disking, it is defined as gully erosion. Gullies must typically be repaired with earthmoving equipment. Gully erosion can be prevented by quickly repairing rill erosion and addressing the cause of the rill erosion.

d. **Stream Channel Erosion:** Stream channel erosion consists of both streambed and streambank erosion. Streambed erosion occurs as flows cut into the bottom of the channel, making it deeper. This erosion process will continue until the channel reaches a stable slope. The resulting slope is dependent on the channel materials and flow properties.

As the streambed erodes and the channel deepens, the sides of the channel become unstable and slough off, resulting in streambank erosion. Streambank erosion can also occur as soft materials are eroded from the streambank or at bends in the channel. This type of streambank erosion results in meandering waterways.

One significant cause of both streambed and streambank erosion is the increased frequency, volume, and duration of runoff events that are a result of urban development.

Figure 7C-1.01: Types of Soil Erosion by Water



Source: USDA NRCS, 2002

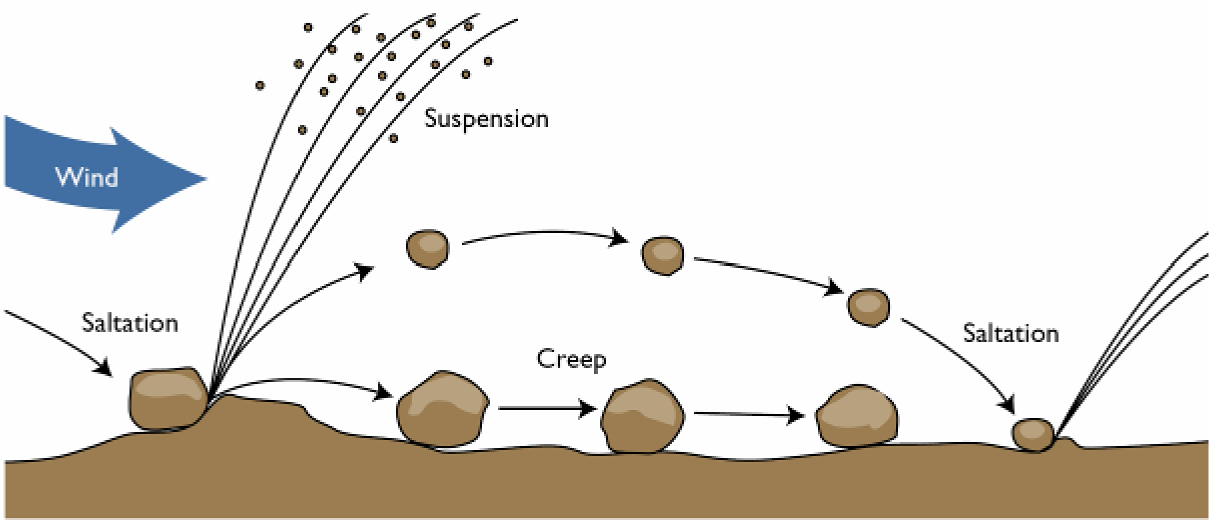
2. **Wind:** Wind can also detach soil particles. Detached soil is moved by wind in one of three ways:

   a. **Suspension:** Very fine silt and clay particles (smaller than 0.002 inches in diameter) may be picked up by the wind and carried in suspension. Suspended dust may be moved great distances, but does not drop out of the air unless rain washes it out or the velocity of the wind is dramatically reduced.

   b. **Saltation:** Fine silts up to medium sand particles (0.002 to 0.02 inches in diameter) move in the wind in a series of steps, rising into the air and falling after a short flight. This movement is called saltation. A vast majority of wind erosion is a result of the saltation process.

   c. **Creep:** Soil particles larger than medium sands (greater than 0.02 inches) cannot be lifted into the wind, but particles up to 0.04 inches (coarse sand) may be pushed along the soil surface by saltating grains or direct wind action. This action is called creep.

Figure 7C-1.02: Movement of Soil Particles by Wind Erosion



Source: McCauley & Jones, 2005

B. Factors Affecting Erosion

The extent of erosion that occurs is dependent on a number of factors including soil erodibility, climate, vegetative cover, topography, and season.

1. **Soil Erodibility:** The erodibility of a soil depends on its texture and physical properties. The characteristics that influence the potential for erosion are those related to the infiltration capacity of the soil and its ability to resist detachment. Soil properties that affect erodibility include texture, organic matter content, soil structure, and permeability.

   In general, soils with a high percentage of fine sand and silt are the most erodible. These particles are easily detached and carried away by rainfall and runoff. As the clay and organic content of a soil increases, the erodibility of the soil tends to decrease.

   Clay particles have the ability to bind together, reducing the potential for detachment by raindrop splash. However, they are also more impermeable, resulting in increased runoff. The increase in runoff increases the erosion potential (especially rill and gully), offsetting some of the benefit that the binding effect has against resisting erosion. The problem with clay particles is that once they have eroded, they are easily transported by water and are very difficult to remove.

   Soils that are high in organic matter content have a more stable texture and increased permeability. This allows the soil to resist detachment and infiltrate more precipitation. Well-draining sands and gravels are the least erodible soils. Soils with high infiltration rates such as these significantly reduce the amount of runoff, thereby reducing the potential for erosion.

   The USDA county soil surveys provide an indication of soil erodibility. This value (K) ranges from 0 to approximately 0.7. Higher values indicate a greater potential for erosion.

2. **Precipitation:** The rate of erosion is directly related to the amount and type of precipitation that occurs. High intensity storms increase particle detachment. In addition, frequent or lengthy storms can saturate the soil, reducing infiltration and increasing runoff. Increased detachment and runoff both contribute to erosion. Erosion risks are high where precipitation is frequent,

intense, or lengthy. In Iowa, the wettest months occur between May and August, when construction activities are at their peak.

3. **Ground Cover:** Ground cover can significantly reduce erosion potential. Vegetative residue, mulch, and compost, as well as the leaves and branches of vegetation, intercept precipitation and shield the ground from raindrop impacts. The roots of vegetation help hold soil particles together and prevent them from becoming detached. Ground cover slows runoff velocity, increases infiltration, and can even filter sediment out of runoff.

4. **Topography:** Areas with long and/or steep slopes increase the potential for erosion. Long slopes increase the potential for runoff to accumulate and develop into erosive concentrated flow near the bottom of the slope. On steep slopes, high-velocity flows can develop quickly and cause significant erosion.

5. **Season:** The potential for erosion varies throughout the year. In winter months when the ground surface is frozen, there is little chance of water erosion. As spring approaches, the surface soils begin to thaw, but the ground below remains frozen. This creates a high potential for erosion. An early spring rain at this time cannot infiltrate into the frozen subsoils. However, the newly thawed surface can be easily washed away, even by a light rain. Erosion potential is also high in the summer months, due to the high-intensity thunderstorms that occur during this period.

C. Sediment Transportation

Once soil particles are detached from the surface and suspended in runoff waters, they will remain there until the velocity of the water is reduced. Flowing waters create turbulence that constantly churns and mixes the flow, holding the particle in suspension. In order for the particles to be removed, the velocity of the flow must be reduced sufficiently to allow the particle to settle out by gravity. This process is discussed in further detail in Section 7D-1 - Design Criteria.

Once sediment reaches a natural waterway or stream, it is nearly impossible to remove. As discussed above, the flowing nature of the stream holds the particles in suspension until the flow velocity is reduced. For natural waterways, this reduction in flow velocity does not normally occur until the waterway empties into a water body. At this point, the sediment settles out and is deposited on the bottom of the pond or lake. Over time, this sediment accumulates, forming large deposits and can eventually fill in a water body completely. Sediment is the largest pollutant (by volume) in stormwater runoff. The resulting deposits can destroy ecosystems and are difficult and expensive to remove.