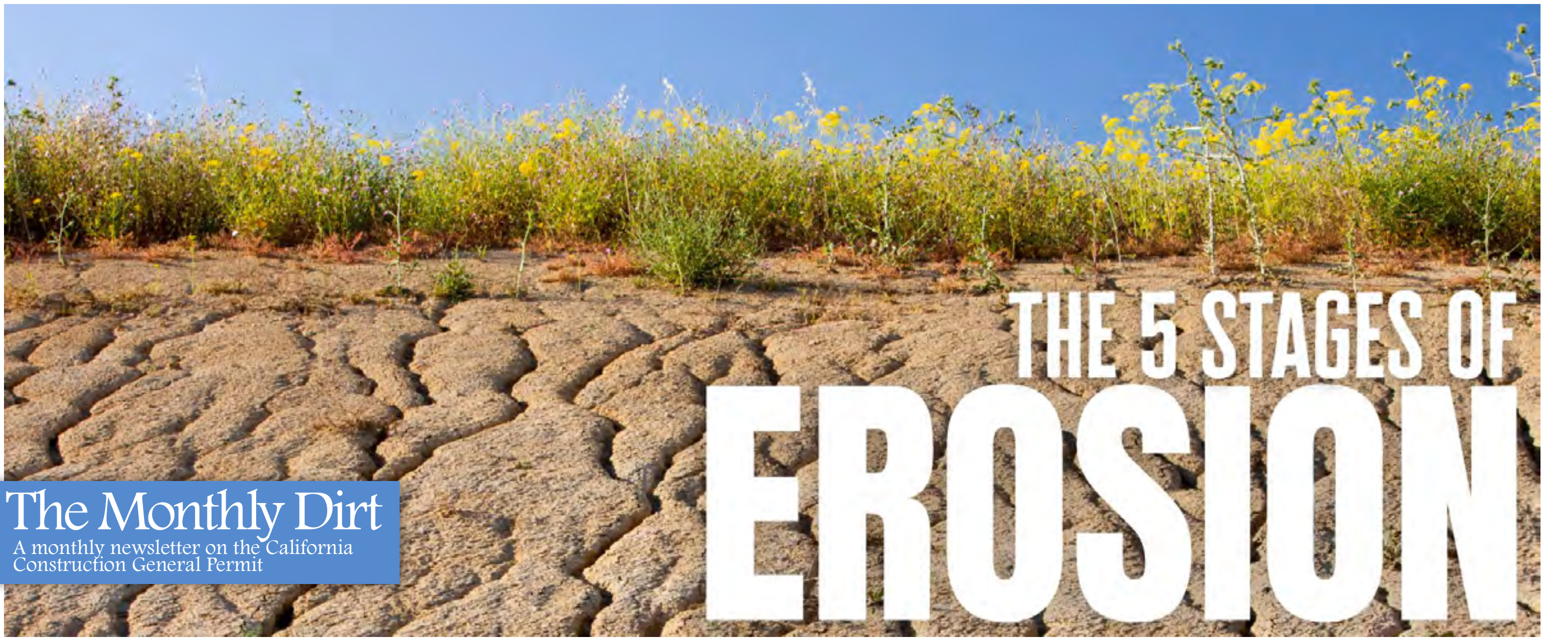


The Monthly Dirt

A monthly newsletter on the California Construction General Permit

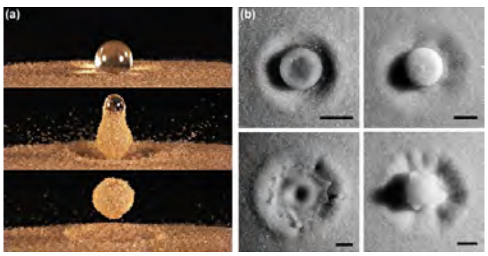
THE 5 STAGES OF EROSION

e·ro·sion: the process by which soil particles are detached and transported by the actions of wind, water, or gravity

The term "erosion" is often thrown around at a construction site or referenced in the SWPPP, but did you know that there are different forms of erosion? Erosion isn't just one process of dirt being eroded off site, it's actually a broad term which covers various stages and types *(wind, water, human created, and etc.)* of soil removal. Since it's still in the middle of the rainy season, in this month's edition of **The Monthly Dirt**, we're going to focus on the 5 different stages of erosion that are due to water.

As mentioned above, erosion is "the process by which soil particles are detached and transported by the actions of wind, water, or gravity." When a soil particle becomes detached it has been eroded. In the natural world, erosion is constantly occurring all around us. Even the most durable things like granite, concrete, and asphalt erode over time; albeit perhaps slowly, but they are still losing particles due to external and internal forces. Erosion is directly proportional to the velocity of runoff. The faster water is moving, the more erosion there will be. But, when we slow water down, eroded particles being transported by the water can settle out when the forces of gravity supersede the forces exerted by water movement. The particles (sediment) are then deposited in these areas of slow flow. Fast water will usually occur where there are slopes. Slower water is found on flatter surfaces. The enemy of erosion control is fast water. So, slow the flow! But in order to control erosion, we first need to identify and understand the 5 stages of uncontrolled erosion (wind erosion is a different form of erosion we will have to address another time).

Raindrop/Splash Erosion: Erosion starts with the raindrop. Every raindrop that hits the earth is like a miniature bomb. After all, raindrops fall from the sky at a relatively high velocity. Applying physics to a raindrop (assuming a raindrop radius of 0.3 mm), we get a terminal velocity of 10.9 m/s (24.4 mph). What happens when a raindrop hits the dirt at this speed? It creates a crater—well, a very small one.



The University of Minnesota studied the impact of a raindrop and found that the crater it produces is, in fact, similar to craters produced by massive asteroid strikes on planetary bodies. The researchers took high resolution rapid photographs of a drop of water falling onto a bed of fine glass beads. The above photo shows the results of the impact. The black bars shown in the gray colored photos (b) represent 3 mm. The displaced volume within the raindrop crater in this laboratory demonstration was 880 mm, which equates to 0.05 cubic inches. Not much you say? Well, that is only one raindrop. But how many raindrops fall on a one-acre project during a storm that produces 0.5 inches of rain? Approximately 1.2 trillion! If each one displaces only a third of the volume of the above photographed laboratory example, approximately 11,458 ft^3 (424 cubic yards) of soil would be displaced just from a passing shower!

Sheet Erosion: As we see each time it rains, all the individual rain drops come together and cause the next form of erosion by flowing downgradient in a laminar or sheet flow condition. In proportion to the slope inclination, this film of water can "push along" or "carry on its back" those particles of sediment displaced by the raindrop bombs. This second process of erosion is called Sheet Erosion. This is the sneakiest form of erosion, because it's difficult for our eyes to see the sediment in the laminar flow against the backdrop of the surface from whence they were detached. Only further downgradient will you realize your project has been robbed blind of tons of sediment, oftentimes valuable topsoil! This condition is more visible to the eye as the water becomes increasingly turbid when viewed against different backgrounds. If you ever had the opportunity to observe a soil-exposed slope over the course of the wet season, you might have noticed that it almost appears like someone was dumping aggregate on the surface. Throughout the winter months you start to see more and more coarse sands and gravel on the surface of the slope. Well, guess what? You were robbed and didn't even know it! What you were actually observing was sheet erosion. With this form of erosion there are not the telltale signs like we will see in the next processes. Sheet Erosion removes the fine particles and leaves the coarse ones in place. So, from a distance, it looks like everything is holding up and that you dodged the erosion bullet. You have to get close to the surface to see what is actually happening or go to downgradient sediment control measures and see what has deposited behind them. This form of erosion can account for many tons of soil loss, because while the raindrop detaches the sediments, sheet flow moves them!

Rill Erosion: Water likes to take the easy road; it tends to move to paths of preferential flow. This is where the next form of erosion occurs: Rill Erosion. At these locations of preferential flow, soil loss occurs at a higher rate than the surrounding areas. Therefore, as particles are detached and transported away, a depression in the soil occurs and a rill is formed. The working definition of a rill is something that you can easily step over. We will see bigger forms of erosion later. But it is important to note where the rills are forming, because they will tell you what is happening at the site. A misunderstanding of rills may result in a significant waste of money, time, and effort for a project that is trying to control erosion. Years ago, we had a project along a stretch of the California Delta levees that was wrapping up its construction activities. The contractor wanted to finish their portion of the work and decided to apply a hydraulic mulch / hydroseed mix to the landside surface of the levee slope. Noting the compacted roadway at the top of the levee, we commented that run-off controls should be installed along the levee road to dissipate and spread out the flow from the roadway onto the slope or to provide slope drains to provide a controlled flow from the roadway to the base of the slope. The contractor did not want to extend the project any longer and chose to, instead, apply a durable hydraulic mulch blend at a greater application rate (not a cheap proposition!). In spite of our warning that it may be a waste of money, the mix was applied. After

the next series of storms, our predictions proved to be accurate. Rills extended from the top of the slope to the bottom, much like what is shown in this picture. We knew that would be the result because we had been watching rills form at the top of the slope throughout the life of the project. But sometimes rills do not form at the top of the slope and instead begin to take shape ten to thirty feet down the slope. This is a different problem and therefore needs a different solution. Sometimes, after landing on the surface of the slope and traveling ten-plus

feet down the slope, all the converged rain drops find a path of preferential flow, which is where the rill begins. This is why the California Construction General Permit requires Risk Level 2 and 3 projects to install linear sediment controls along the face of the slope and at the grade breaks of exposed slopes. The linear sediment controls (typically fiber rolls) are required by the permit to be spaced between ten and thirty-five feet apart

depending upon the slope ratio. Essentially, these linear sediment controls stop the sheet flow and "reset the clock" (so to speak) for rills. A properly installed horizontal line of fiber roll will, at least in theory, "buy" another ten to thirty-five feet of sheet flow travel before rills once again become likely to occur. Now make no mistake about it, raindrop and sheet erosion are still occurring, but these linear sediment controls will hopefully keep the erosion processes from progressing beyond them and help capture any particles that became detached.

Gully Erosion: When rills start to intersect and runoff flows become greater, far more sediment will be removed from the—now combined—paths of preferential flow. More water with greater velocities means greater soil

loss, which leads to the next erosion process—Gully Erosion. The working definition of a gully is something that you can stand in. The picture to the right shows a gully we could easily put the whole construction crew in. There are many factors which can lead to the formation of gullies, such as the nine back-to-back atmospheric rivers that occurred from late December 2022 through mid-January 2023 in California. They can also result from poor site management and planning. Directing too many drainage management areas into a single flow path will cause gullies to form in erodible soils. The combined flows will result in greater volumes of runoff and higher flow rates and will overwhelm the undersized conveyance. But, to get to this stage of erosion, a project usually fails to regard the three earlier forms of erosion elsewhere on the project and is not applying adequate controls to slow and manage the flow. Gullies are typically a symptom of a bigger problem.

Channel Erosion: The last of the five erosion processes is Channel Erosion. Now, as we mentioned before, erosion is natural and is constantly occurring even in the hardest of rock or most stabilized channel. In a stream or a river, channel erosion, sometimes referred to as stream bank erosion, is part of the healthy

balance of that waterbody. But it is the erosion accelerators that typically lead to channel erosion that are detrimental to water quality. Channel erosion will typically not occur on a construction site or would even be attributed to a single construction project. Rather, it is the result of changes in a watershed. When erosion accelerators (de-vegetation, soil disturbance, removal of top soils or vegetation, concentrated flow, impervious surfaces, etc.) are occurring at a significant level in a watershed, channel erosion may and probably will occur in a downgradient waterbody or conveyance. With new development comes more impervious surfaces. Increased imperviousness results in more frequent discharges, higher peak flow rates, and greater volumes. When this increase of discharge from a watershed flows through a downgradient concrete-lined channel we might not see much change other than higher and more frequent flows. But when the water reaches a portion of the channel that is erodible, guess what gives! The erodible channel is the weak link, and it is where we observe channel erosion. This not only results in significant increases of sediment in the waterbody but will also threaten habitat along and in the channel; cause downstream dams, reservoirs, or lakes to fill up with sediment; threaten properties along the eroding banks of the channel; and potentially cause flooding at the point where the eroded sediment settles out.

Please contact us if you have any questions …

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