HOW TO DECREASE EROSION BY NATURAL TERRAIN SCULPTURING

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There is a natural tendency for all of us to think of "ideal" landscaping as a flat, smooth, or uniform terrain surface. A close look at any natural terrain surface, however, will not support such a perfect concept of the land.

It is assumed such smooth uniform surfaces are in harmony with nature. Subdivisions, parks and other constructed landscapes are often made as free of irregularities as possible.

We suggest that attempts to construct landscapes that are smooth, uniform and perhaps visually pleasing actually contribute greatly to increased erosion and subsequent sedimentation.

Rather than trying to hold the soil in place, it may be more realistic and cost effective to sculpture the terrain into a form and shape that would approximate a natural surface at equilibrium. Application of such a sculpturing technique might range from large scale surface mine reclamation or subdivision design to small half acre units feeding into an existing watershed.

Take a look at any natural terrain surface and the drainage system which evolved to carry away runoff water. It will include rills and gullies near the tops of slopes integrating downslope into permanent channels and trunk systems. Side slopes will be concave in shape with steep gradients near ridge crests and flatter slopes in the tributary bottoms. Although relief within a watershed may vary from a few feet to hundreds of feet, natural landscapes are seldom smooth and uniform or without irregularities.

Slope geometry

Numerous studies involving field and theoretical laboratory work indicate that natural terrain slopes most often can be classified as concave, convex, uniform or complex in shape.

It is accepted by observation and theory that the concave shape is most stable and in near equilibrium with precipitation runoff that would tend to produce sheet erosion. In fact, a convex slope shape will ultimately erode to a concave shape and the complex and uniform shapes probably represent traditional profiles. As figure 1 shows, a great volume of material has the potential to erode.

Attempts to construct landscapes that are smooth and uniform actually contribute to increased erosion.

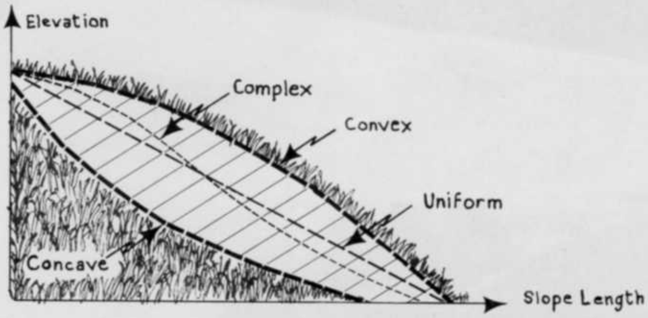

Figure 1 illustrates (top) quantities of erodable material with various slope shapes.
Severe initial erosion on a smooth graded slope prepared for a development.

Studies indicate that the concave shape yields the least amount of sediment through erosion to a stream. The steepness of the toe of the slope (that portion at the lowest elevation) is most significant in affecting the rate of erosion and sediment yield. Most man-made landscapes are created with convex or complex slope shapes thus creating a natural tendency for sedimentation and erosion.

Drainage design

Any land surface which has been altered by man will, with time, develop a drainage network sufficient to carry the discharge from the area. The network will be characterized by its drainage density, which is the cumulative length of channel segments in a unit of area, usually per square mile. These channels are distributed in a random veinlike pattern unless manmade controls are exerted upon the system.

An inspection of an area prior to disturbance will give some indication of tendency to erode. For large areas this may be most practical by aerial observation. The higher the density of channels the more likely the surface will erode. Factors which

Aerial view of site developed for building shows erosion beginning on smooth slopes. Note rills forming.

may play a part in erosion are the shear strength of the soil, the slope of the hillside, the rate of flow of runoff, and shape.

Naturally occuring drainage densities vary across the United States. The Coastal Plain of Virginia has a drainage density of 6 mi./sq.mi., while the Badlands of New Jersey (Perth Amboy) have a drainage density of 650 mi./sq.mi. Other examples are the Appalachian Plateau of Kentucky with a drainage density of 56 mi./sq.mi. and the Coastal Range of California with a drainage density of 35 mi./sq.mi. The glaciated areas of north Wisconsin have a drainage density of just 1.5 mi./sq. mi.

Concave slopes yield the least amount of sediment through erosion to a stream.

These densities were taken from areas where the forces giving rise to channel development are in dynamic equilibrium with those forces resisting initial channel development. It is generally accepted that the drainage density remains relatively constant throughout a watershed.

Some basic characteristics of drainage densities are:

— as soil shear strength decreases, drainage density increases.

— as average slope increases, drainage density increases.

— as runoff rate increases, drainage density increases.

Applications

Although none of the concepts presented have been evaluated for economic practicality, there is strong evidence that reclamation and landscaping could be improved by making reclaimed surfaces more nearly the shapes of natural surfaces. Initial grading for creation of concave slope profiles and well-defined, randomly oriented channels could reduce the potential for natural erosion to carve these shapes.

Also, the drainage on previously reclaimed mine areas or landscapes could be modified to induce more randomness in drainage as well as concave slopes and thus reduce natural erosion. Further study might lead to tested values for desired terrain characteristics, but at present a sculptured terrain could be designed using a combination of theoretical and artistic interpretation and inference.

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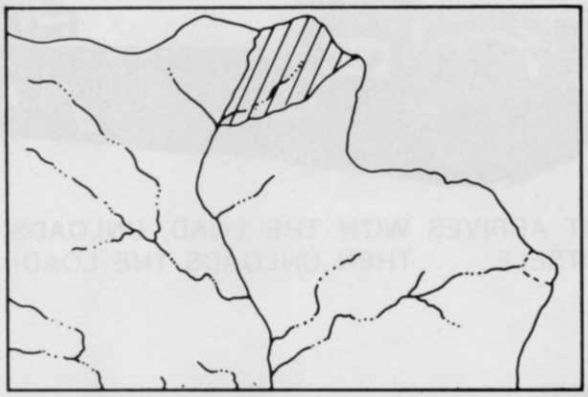
Erosion *from page 32*

The following steps, if undertaken, would tend to cause land to be more natural in shape and consequently less prone to severe initial erosion:

Runoff area design — The smallest area which supports the creation of a channel high in the drainage network can be estimated. This area should be approximately the same before disruption and afterward in a manmade drainage network.

Drainage density — Design of drainage density should include the appropriate drainage density for the site. The drainage layout could best be sketched in a naturally appearing random (veinlike) branching pattern. A first approximation to the required drainage density could be measured from pre-disturbance maps and photos and then increased slightly for effects of disruption.

Drainage channels should be constructed to resemble natural channels. All channels should grade from shallow (0.5 ft.) at the head end to several feet deep for trunk collector channels. Top bank widths should range from perhaps 12 ft. wide for small tributaries to broader channels in the trunk stream. The gradient of the channels should be steepest at the head end with flattening toward the mouth of the primary trunk stream.



Random drainage pattern common to undisturbed land.

Slope profiles — In the process of creating drainage channels some effort should be taken to sculpture the land into concave shapes where possible. Similar shapes within watershed areas would tend to reduce severe initial erosion. Exacting mathematical formulas using the above criteria are available for those interested from the authors, 125 Mining Building, Rolla, MO 65401. **WTT**