EROSION PREDICTION

Revised Universal Soil Loss Equation (RUSLE)

GENERAL

The Revised Universal Soil Loss Equation (RUSLE) is an erosion model predicting longtime average annual soil loss (A) resulting from raindrop splash and runoff from specific field slopes in specified cropping and management systems and from pastureland. Widespread use has substantiated the RUSLE's usefulness and validity. RUSLE retains the six factors of Agriculture Handbook No. 537 to calculate A from a hillslope. Technology for evaluating these factor values has been changed and new data added. The technology has been computerized to assist calculation.

BACKGROUND

Scientific planning for soil conservation and water management requires knowledge of the relations among those factors that cause loss of soil and water and those that help to reduce such losses. Controlled studies on field plots and small watersheds have supplied much valuable information on these complex interrelations of factors. But the maximum benefits from such research can be realized only when the findings are applied as sound practices on the farms, ranches, and other erosion-prone areas throughout the United States. Specific guidelines are needed for the selection of the control practices best suited to the particular needs of each site.

Such guidelines are provided by the procedure for soil-loss prediction using RUSLE. The procedure methodically combines research information from many sources to develop design data for each conservation plan. Widespread field experience for more than four decades has proved that this technology is valuable as a conservation-planning guide. The procedure is founded on the empirical Universal Soil Loss Equation (USLE) that is believed to be applicable wherever numerical values of its factors are available. Research has supplied information from which at least approximate values of the equation's factors can be obtained for specific farm or ranch fields or other small land areas throughout most of the United States. The personal-computer program makes information readily available for field use.

The Revised Universal Soil Loss Equation (RUSLE) includes analyses of data not available when the previous handbooks were prepared. The analyses are documented so that users can review, evaluate, and repeat them in the process of making local analyses.

Furthermore, the technology was revised to permit the addressing of problems not included or inadequately addressed in earlier versions of USLE. The current revision is intended to provide the most accurate estimates of soil loss without regard to how the new values compare with the old values.

SOIL-LOSS EQUATION

The erosion rate for a given site results from the combination of many physical and management variables. Actual measurements of soil loss would not be feasible for each level of these factors that occurs under field conditions. Soil-loss equations were developed to enable conservation planners, environmental scientists, and others concerned with soil erosion to extrapolate limited erosion data to the many localities and conditions that have not been directly represented in the research.

Erosion and sedimentation by water involve the processes of detachment, transport, and deposition of soil particles. The major forces are from the impact of raindrops and from water flowing over the land surface. Erosion may be unnoticed on exposed soil surfaces even though raindrops are eroding large quantities of sediment, but erosion can be dramatic where concentrated flow creates extensive rill and gully systems.

Sediment yield should not be confused with erosion; the terms are not interchangeable. Sediment yield is the amount of eroded soil that is delivered to a point in the watershed that is remote from the origin of the detached soil particles. RUSLE does not estimate sediment yield.

RUSLE computes the average annual erosion expected on field slopes as **A = R • K •L • S • C • P**

Where:
A = average soil loss expressed in ton/acre/yr.
R = rainfall-runoff erosivity factor — the rainfall erosion index plus a factor for any significant runoff from snowmelt.
K = soil erodibility factor — the soil loss rate per erosion index unit for a specified soil as measured on a standard plot, which is defined as a 72.6-ft (22.1-m) length of uniform 9% slope in continuous clean-tilled fallow.
L = slope length factor — the ratio of soil loss from the field slope length to soil loss from a 72.6-ft length under identical conditions.
S = slope steepness factor — the ratio of soil loss from the field slope gradient to soil loss from a 9% slope under otherwise identical conditions.
C = cover-management factor — the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow. (See Appendix 1)
P = support practice factor — the ratio of soil loss with a support practice like contouring, stripcropping, or terracing to soil loss with straight-row farming up and down the slope.

Field worksheets are to be used to document field conditions (Appendix 2) when estimating soil loss.

While not part of the equation, soil loss tolerance **(T)** denotes the maximum rate of erosion that can occur and still permit crop productivity to be sustained economically.

RUSLE users need to be aware that "A" (in addition to being a longtime average annual soil loss) is the average soil loss over a field slope and that the losses at various points on the slope may differ greatly from one another. On a long uniform slope, the loss from the top part of the slope is much lower than the slope average, and the loss near the bottom of the slope is considerably higher. This suggests that even if a field soil loss is held to "T," soil loss on some portion of the slope may exceed T, even when the ephemeral gully and other types of erosion that are not estimated by RUSLE are ignored. These higher-than-average rates generally occur at the same locations year after year, so excessive erosion on any part of the field may be damaging the soil resource.

With appropriate selection of its factor values, RUSLE will compute the average soil loss for a multicrop system, for a particular crop year in a rotation, or for a particular crop stage period within a crop year. Erosion variables change considerably from storm to storm about their means. But the effects of the random fluctuations such as those associated with annual or storm variability in R and the seasonal variability of the C tend to average out over extended periods. Because of the unpredictable short-time fluctuations in the levels of influential variables, however, present soil-loss equations are substantially less accurate for the prediction of specific events than for the prediction of longtime averages.

RUSLE does not estimate soil loss from disturbed forested conditions. Users of such technology are referred to A Guide for Predicting Sheet and Rill Erosion on Forest Land, USDA-Forest Service.

Some recent research addresses the application of USLE technology to mine spoils reconstructed topsoil and land disturbed by construction. The effects of compaction on erosion are significant in such instances and are treated as an integral part of the subfactor for calculating C. Soil consolidation also influences the L/S factor for construction and mining sites. (Appendix 2-Table LS-3). Other RUSLE values are not affected by these land disturbance activities.

For most conditions in the United States, the approximate values of the six factors for any particular site may be obtained by use of the computer program developed to assist with the RUSLE evaluation. Further description of these factors, their use and affects on soil loss is provided in Appendix I.

REFERENCES

Dissmeyer, George E. and Foster, George R., 1980. A Guide for Predicting Sheet and Rill Erosion on Forest Land. USDA-US Forest Service. Atlanta, GA.

Renard, K.G. (et.al.) 1997. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation – Agricultural Handbook 703. USDA. Washington, DC.

APPENDIX I

RAINFALL AND RUNOFF FACTOR (R)

The rainfall and runoff factor (R) of the Universal Soil Loss Equation (USLE) was derived from research data from many sources. The data indicate that when factors other than rainfall are held constant, soil losses from cultivated fields are directly proportional to a rainstorm parameter: the total storm energy (E) times the maximum 30-min intensity (I_{30}).

Rills and sediment deposits observed after an unusually intense storm have sometimes led to the conclusion that significant erosion is associated with only a few severe storms—that significant erosion is solely a function of peak intensities. However, more than 30 years of measurements in many states have shown that this is not the case. The data shows that a rainfall factor used to estimate average annual soil loss must include the cumulative effects of the many moderate-sized storms as well as the effects of the occasional severe ones.

The numerical value used for R in RUSLE must quantify the effect of raindrop impact and must also reflect the amount and rate of runoff likely to be associated with the rain. The erosion index (R) meets these requirements better than any of the many other rainfall parameters and groups of parameters tested against the plot data.

The energy of a rainstorm is a function of the amount of rain and of all the storm's component intensities. The median raindrop size generally increases with greater rain intensity, and the terminal velocities of free-falling waterdrops increase with larger drop size. Since the energy of a given mass in motion is proportional to velocity squared, rainfall energy is directly related to rain intensity.

R VALUES LOCATION

Local values of the rainfall erosion index are taken directly from the CITY database in the RUSLE computer program.

R VALUES FOR FLAT SLOPES

Although the R factor is assumed to be independent of slope in the structure of RUSLE, splash erosion is less on low slopes. On flat surfaces, raindrops tend to be more buffered by water ponded on the soil surface than on steep slopes. Higher rainfall intensities that are correlated with higher R factors also tend to increase the depth of ponded surface water, which in turn protects the soil from rainfall impact. To account for this soil protection by a ponded water layer on low slopes under high rainfall rates, the R factor should be adjusted using the RUSLE computer program.

SOIL ERODIBILITY FACTOR (K)

Soil erodibility is a complex property and is thought of as the ease with which soil is detached by splash during rainfall or by surface flow or both. From a fundamental standpoint, however, soil erodibility should be viewed as the change in the soil per unit of applied external force or energy. RUSLE uses a restrictive and applied definition of soil erodibility. Soil erodibility is related to the integrated effect of rainfall, runoff, and infiltration on soil loss and is commonly called the soil-erodibility factor (K). The soil-erodibility factor (K) in RUSLE accounts for the influence of soil properties on soil loss during storm events on upland areas.

In practical terms, the soil-erodibility factor is the average long-term soil and soil-profile response to the erosive powers of rainstorms; that is, the soil-erodibility factor is a lumped parameter that represents an integrated average annual value of the total soil and soil profile reaction to a large number of erosion and hydrologic processes. These processes consist of soil detachment and transport by raindrop impact and surface flow, localized deposition due to topography and tillage-induced roughness, and rainwater infiltration into the soil profile.

The soil-erodibility factor (K) represents the effect of soil properties and soil profile characteristics on soil loss. Some interdependency exists between the K factor and other RUSLE factors. For instance, the traditional topographic relationships for slope length and steepness factors derived from soil-loss measurements on mostly medium-textured, poorly aggregated surface soils. Interactions with the cover-management factor (C) are primarily due to the effect of organic matter or organic carbon on soil loss. The organic-carbon content of soils depends on the annual additions of surface and subsurface crop residue and manure and on their decomposition rate. No sharp delineation can be made where the effects of crop residue cease to be part of a C factor and instead become part of the K factor.

SOILS WITH ROCK FRAGMENTS

Rock fragments, when present on the soil surface, significantly reduce soil detachment by rainfall. When present in a coarse-textured-soil profile (having sand and loamy sand textures), the fragments can appreciably reduce infiltration.

Surface cover by rock fragments varies from site to site on otherwise identical soils. The fragments act as a surface mulch by protecting the soil surface from raindrop impact in a manner similar to that of surface mulches of straw and chopped stalks. Rock fragments are usually not moved by water from interrill areas but remain behind on the soil surface and act as an “armor”.

Subsurface rock fragments affect infiltration and thus runoff in a manner similar to that of subsurface residue by reducing the soil void space and soil hydraulic conductivity in coarse-textured soils. Moreover, because soil-mechanical-analysis procedures are based on particle-size fractions smaller than 2mm, rock fragments larger than 2 mm are usually excluded when estimating K-factor values. However, rock fragments are part of a continuum of particle sizes in the mineral phase of the soil and therefore can be considered as part of the soil-erodibility factor. (See Appendix 2)

TOPOGRAPHIC FACTOR (LS)

The effect of topography on erosion in RUSLE is accounted for by the LS factor. Erosion increases as slope length increases, and is considered by the slope length factor (L). Slope length is defined as the horizontal distance from the origin of overland flow to the point where either (1) the slope gradient decreases enough that deposition begins or (2) runoff becomes concentrated in a defined channel. It is important to remember that change of vegetative cover type does not affect length of slope. Surface runoff will usually concentrate in less than 250 feet in West Virginia under natural conditions. As the slope gets steeper, the length of slope is shorter. For most cropland, slope of 125-150 ft. are common unless the surface has been carefully graded into ridges and furrows that maintain flow for long distances. Few slope lengths as long as 250 ft. should be used in RUSLE. Slope length is best determined by pacing or measuring in the field. For steep slopes, these lengths should be converted to horizontal distance for use in RUSLE. Slope lengths estimated from contour maps are usually too long because most maps do not have the detail to indicate all concentrated flow areas that end RUSLE slope lengths. (Figure 1, Appendix 2) illustrates some typical slope lengths.

The slope steepness factor (S) reflect the influence of slope gradient on erosion. Slope is estimated in the field by use of an inclinometer, Abney level or similar device. Slope may be estimated from contour maps having 2-ft. contour intervals if considerable care is used.

Both slope length and steepness substantially affect sheet and rill erosion estimated by RUSLE. The effects of these factors have been evaluated separately in research using uniform-gradient plots. However, in erosion prediction, the factors L and S are usually evaluated together.

Consolidation of soils affect the LS values. Pasture soil have a low rate of rill to interrill erosion; cropland has a medium ratio; and construction and mining sites has a high ratio (Appendix 2-Tables LS 1 thru 3). The effect is that a high ratio will result in higher erosion levels.

UNIFORM SLOPES

The combined LS factor in RUSLE represents the ratio of soil loss on a given slope length and steepness to soil loss from a slope that has a length of 72.6 ft. and a steepness of 9%, where all other conditions are the same. LS values are not absolute values but are referenced to a value of 1.0 at a 72.6-ft. slope length and 9% steepness.

Procedures are developed in the RUSLE computer program for predicting soil loss on uniform slopes, where steepness is the same over their entire length.

IRREGULAR AND SEGMENTED SLOPES

The shape of a slope affects the average soil loss and the soil loss along the slope. For example, the average soil loss from a convex slope can easily be 30% greater than that for a uniform slope with the same steepness as the average steepness of the convex slopes. The average erosion on a concave slope that does not flatten enough to cause deposition is less than that on a uniform slope that is equivalent to the average concave-slope steepness. Maximum erosion along a concave slope, which occurs about one-third of the way along the slope, may nearly equal the maximum erosion on a uniform slope. Therefore, when the slope shape is significantly curved, use of the procedure for an irregularly shaped slope should be used by breaking a non-uniform slope into a number.

The procedure for irregular slopes can include the evaluation of changes in soil type along a slope. The RUSLE computer program allows a planner the ability to evaluate a combination of slope segments.

GUIDES FOR CHOOSING SLOPE LENGTHS

In training sessions, more questions are asked about slope length than about any other RUSLE factor. Slope length is the factor that involves the most judgement, and length determinations made by users vary greatly. Figure 1 illustrates the major slope-length situations that are found in the field.

Actually, an infinite number of slope lengths exist in the field. To apply RUSLE, erosion can be calculated for several of them and the results averaged according to the area represented by each slope length. Sometimes a particular position on the landscape is chosen as the location for a slope length. To establish the ends of the slope length, the user walks upslope from that position, moving perpendicular to the contour, until the origin of overland flow is reached. Often this point is not at the top of the hill but at a divide down the nose of a ridge.

The lower end of the slope length is located by walking downslope perpendicular to the contour until a broad area of deposition or a natural or constructed waterway is reached. These waterways are not necessarily eroded or incised channels and this lack of channels can make it difficult to determine the end of slope. One aid is to visualize the locations on the landscape where eroded channels or gullies would naturally form.

If a slope flattens enough near its end, deposition may occur. When erosion and deposition rates are low and erosion has not recently occurred, deposition begins at the point where slope has decreased to about 5%. Deposition does not necessarily occur everywhere a slope flattens. The best time to train yourself on slope lengths is during early spring runoff when you can visually track runoff, find the contour, and locate point of deposition or concentrated flow (See Figures 1 & 2 for illustration to determine slope length).

COVER-MANAGEMENT FACTOR (C)

The C factor is used in the Revised USLE (RUSLE) to reflect the effect of cropping and management practices on erosion rates, and is the factor used most often to compare the relative impacts of management options on conservation plans.
The C factor indicates how the conservation plan will affect the average annual soil loss and how that soil-loss potential will be distributed in time during construction activities,

crop rotations, or other management schemes.

As with most other factors within RUSLE, the C factor is based on the concept of deviation from a standard, in this case an area under clean-tilled continuous-fallow conditions. The soil loss ratio (SLR) is then an estimate of the ratio of soil loss under actual conditions to losses experienced under the reference conditions. Studies indicate that the general impact of cropping and management on soil losses can be divided into a series of subfactors. In this approach the important parameters are the impacts of previous cropping and management, the protection offered the soil surface by the vegetative canopy, the reduction in erosion due to surface cover and surface roughness, and in some cases the impact of low soil moisture on reduction of runoff from low-intensity rainfall. As used in RUSLE, each of these parameters is assigned a subfactor value, and these values are multiplied together to yield a SLR.

An individual SLR value is thus calculated for each time period over which the important parameters can be assumed to remain constant. Each of these SLR values is then weighted by the fraction of rainfall and runoff erosivity (EI) associated with the corresponding time period, and these weighted values are combined into an overall C factor value. (See Appendix 2)

USE OF TIME-VARYING OR AVERAGE ANNUAL VALUES

For areas such as pasture that have reached a relative equilibrium, the parameters used in computing SLR values may change very slowly with time, so calculated SLR values will also change little. It is adequate to calculate a C factor based on a single average SLR representing the entire year.

In almost all cropland scenarios and in many cases where pasture is being managed, the crop and soil parameters change with time due to either specific management practices or natural cyclic effects such as winter knockdown and spring growth. This demands that the SLR values be calculated frequently enough over the course of a year or a crop rotation to provide an adequate measure of how they change. This is especially important because the erosion potential is also changing with time. The calculated average annual soil loss should be high if a cropping or management scheme happens to leave the soil susceptible to erosion at a time of high rainfall erosivity. RUSLE incorporated this effect into calculations of SLR values based on crop-growth stages. These values were based on tillage type, elapsed time since a tillage operation, canopy development, and date of harvest. RUSLE calculations are based on a 15-day time step. This means that SLR values are calculated every 15 days throughout the year, and that the important parameters are assumed to remain constant during those 15 days.

If a management operation occurs within the period, the parameters can no longer be assumed constant; the half-month period is then broken into two segments and two SLR values are calculated.

Calculations of the SLR for the average annual and time-varying approaches are the same and require the same input parameters; the difference lies in how often the calculation is performed. In the time-varying approach (cropland), the SLR value is then weighted by the percentage of EI associated with that segment. In the average annual approach, everything is assumed constant (pasture), so the calculation is made once.

COMPUTATION OF SOIL-LOSS RATIOS

Based on new descriptions of cropping and management practices and their influence on soil loss, soil-loss ratios are computed as

$$SLR = PLU \bullet CC \bullet SC \bullet SR \bullet SM$$

Where SLR is the soil-loss ratio for the given conditions, PLU is the prior-land-use subfactor, CC is the canopy-cover subfactor, SC is the surface-cover subfactor, SR is the surface-roughness subfactor, and SM is the soil-moisture subfactor.

Each subfactor contains cropping and management variables that affect soil erosion. Individual subfactors are expressed as functions of one or more variables, including residue cover, canopy cover, canopy height, surface roughness, below-ground biomass (root mass plus incorporated residue), prior cropping coil moisture, and time.

RUSLE uses a CROP database to store the values required to calculate the impact on soil loss of any vegetation within the management plan. These user-defined sets of values specify the growth characteristics of the vegetation, the amount of residue the vegetation will produce, and the characteristics of that residue. The program uses that information to calculate the change with time of the variables listed above and their impact on the subfactors.

RUSLE contains another database to store user-supplied information defining the impacts of management operations on the soil, vegetation, and residues, and uses that information to modify the variables accordingly.

The RUSLE program contains a third database that represents the climate for the area of interest. This is important to the C-factor calculations in two ways: first, the EI distribution within the database set is used to weight each SLR value in calculating the overall C-factor value. Second, the set also contains temperature and rainfall data, which are needed to calculate the rate of residue decomposition.

SUPPORT PRACTICE FACTOR (P)

By definition, the support practice factor (P) in RUSLE is the ratio of soil loss with a specific support practice to the corresponding loss with upslope and downslope tillage. These practices principally affect erosion by modifying the flow pattern, grade, or direction of surface runoff and by reducing the amount and rate of runoff. For cultivated land, the support practices considered include contouring (tillage and planting on or near the contour), stripcropping, terracing, and subsurface drainage.

P does not consider improved tillage practices such as no-till and other conservation tillage systems, sod-based crop rotations, fertility treatments, and crop-residue management. Such erosion-control practices are considered in the C factor.

An overall P-factor value is computed as a product of P subfactors for individual support practices, which are typically used in combination.

CONTOUR TILLAGE

The effect of contour tillage on soil erosion by water is described by the countour P factor in the Revised Universal Soil Loss Equation (RUSLE). If erosion by flow occurs, a network of small-eroded channels or rills develops in the areas of deepest flow. On relatively smooth soil surfaces, the flow pattern is determined by random natural microtopography. When tillage leaves high ridges, runoff stays within the furrows between the ridges, and the flow pattern is completely determined by the tillage marks. High ridges from tillage on the contour cause runoff to flow around the slope, significantly reducing the grade along the flow path and reducing the flow’s detachment and transport capacity compared to runoff directly downslope.

When grade is sufficiently flat along the tillage marks, much of the sediment eroded from the ridges separating the furrows is deposited in the furrows. However, tillage is seldom exactly on the contour. Runoff collects in the low areas on the landscape and if accumulated water overtops the ridges, then rill and concentrated flow erosion usually occur, especially in recently tilled fields. Runoff from contoured fields is often less that that from fields tilled upslope-downslope. Contour tillage reduces erosion by reducing both the runoff and the grade along the flow path.

EFFECT OF RIDGE HEIGHT

Table 2 Appendix 1 represents the effectiveness of contouring where ridge heights are very low, low, moderate, high, and very high and where the ridges follow the contour so closely that runoff spills over the ridges uniformly along their length. Data showing the greatest effectiveness of contouring were generally from plots having high ridges.

EFFECT OF STORM SEVERITY

Data from field studies indicate that contouring is less effective for large storms than for small storms. The reduced effectiveness depends on both amount of runoff and peak rate runoff. These runoff variables are directly related to rainfall amount and intensity, which are the principal variables that determine EI (storm energy times maximum 30-min intensity), the erosivity factor in RUSLE. Therefore, values for the contouring subfactor should be near 1 (little effectiveness) when EI is high and infiltration into the soil is low, and should be small (greater effectiveness) when EI is low and infiltration is high. Loss of contouring effectiveness is likely to occur from a few major storms.

EFFECT OF OFF-GRADE CONTOURING

Contouring alone is often inadequate for effective erosion control. Runoff frequently flows along the furrows to low areas on the landscape, where breakovers occur. Grassed waterways are needed in conjunction with contouring to safely dispose of the runoff that collects in natural waterways at the breakovers.

SUPPORT PRACTICE FACTOR (P) FOR CROSS-SLOPE STRIPCROPPING, BUFFER STRIPS, AND FILTER STRIPS

Stripcropping is a support practice where strips of clean-tilled or nearly clean-tilled crops are alternated with strips of closely growing vegetation such as grasses and legumes. Stripcropping for the control of water erosion is variously described as contour stripcropping, cross-slope stripcropping, and field stripcropping. Each of these practices has the common characteristic of crops in rotation forming strips of nearly equal width. The difference between the practices is the degree of deviation from the contour. All of them, including contour stripcropping, involve some degree of off-grade contouring. The effectiveness of all of them can be determined with the same equations in the RUSLE computer model.

Buffer strips, located at intervals up the slope, are resident strips of perennial vegetation laid out across the slope. Like the strips in cross-slope stripcropping, they may or may not be on the contour. These strips, predominantly composed of grass species, are not in the crop rotation, are usually much narrower than the adjacent strips of clean-tilled crops, and may be left in place for several years or permanently. The effectiveness of buffer strips in trapping sediment and reducing erosion can also be evaluated by the RUSLE model.

Vegetated filter strips are bands of vegetation at the base of a slope. Riparian filter strips are located along stream channels or bodies of water. These conservation practices are designed to reduce the amount of sediment reaching offsite water bodies. Neither practice traps eroded sediment on the hillslope and therefore has minimal benefit as a P factor.

Densely vegetated strips that induce deposition of eroded sediment are assigned a P-factor value. Deposition must occur on the hillslope in areas where crops are routinely grown to deserve a low P factor indicative of greatest value to soil conservation. Therefore, P-factor values for maintenance of soil productivity are lowest for cross-slope stripcropping, moderate for buffer strips, and highest for filter strips. A P value of 1.0 is assigned to filter strips because they provide little protection to the majority of the field where crops are grown.

A major advantage of stripcropping is the rotation of crops amoung the strips. By rotating crops among strips, each clean-tilled crop receives benefit from the sediment deposited in a previous year by the closely growing crop or the rough strip. Stripcropping significantly reduces the rate of sediment moving down the slope. Because filter strips are located at the base of slopes, the strips do not greatly affect this rate. In general, the benefit of deposition depends on the amount of deposition and its location. Sediment deposited far down the slope provides less benefit than does sediment deposited on the upper parts of the slope. With buffer strips, the sediment is trapped and remains on small areas of the slope, such as terraces; thus the entire slope does not benefit as much as it does in stripcropping.

SOIL LOSS TOLERANCE (T)

A major purpose of the soil-loss equation is to guide the making of methodical decisions in conservation planning. The equation enables the planner to predict the average rate of soil erosion for each of various alternative combinations of cropping systems, management techniques, and erosion-control practices on any particular site. The term “soil-loss tolerance” (T) denotes the maximum rate of soil erosion that can occur and still permit crop productivity to be sustained economically. The term considers the loss of productivity due to erosion but also considers rate of soil formation from parent material, role of topsoil formation, loss of nutrients and the cost to replace them, erosion rate at which gully erosion might be expected to begin, and erosion-control practices that farmers might reasonably be able to implement. When predicted soil losses are compared with the value for soil-loss tolerance at that site, RUSLE provides specific guidelines for bringing about erosion control within the specified limits. Any combination of cropping, grazing and management for which the predicted erosion rate is less than the rate for soil-loss tolerance may be expected to provide satisfactory control of erosion. Of the satisfactory alternatives offered by this procedure, the alternative(s) best suited to a particular farm or other enterprise may then be selected.

Values of soil-loss tolerance ranging from 2 to 5 ton acre yr. for the soils in West Virginia. Factors considered in defining these limits include soil depth, physical properties and other characteristics affecting root development, gully prevention, on-field sediment problems, seeding losses, reduction of soil organic matter, and loss of plant nutrients.

A deep, medium-textured, moderately permeable soil that has subsoil characteristics favorable for plant growth has a greater tolerable soil-loss rate than do soils with shallow root zones or high percentages of shale at the surface. Widespread experience has shown that the concept of soil-loss tolerance may be feasible and generally adequate for indefinitely sustaining productivity levels.

Soil-loss limits are sometimes established to prevent or reduce damage to offsite water quality. The criteria for defining the tolerance limits of field soil-loss tolerance limits for this purpose are ***not*** the same as those for tolerances designed to preserve cropland productivity. Soil depth is not relevant for offsite sediment control, and uniform limits on erosion rates still allow a range in the amount of sediment per unit area that is delivered to a stream. Soil material eroded from a field slope may be deposited along field boundaries, in terrace channels, in depression areas, or on flat or vegetated areas traversed by overland flow before it reaches a watercourse. Erosion damages the cropland on which it occurs, but sediment deposited near its place of origin does not directly affect water quality.

APPENDIX 2

Erosion Prediction

Single Year "C" Factors for Cropland {January 1997}

Table 1 Cover/Management Condition and Code

Table 2 Guidelines for Selecting Ridge Heights for Contouring with RUSLE Single Year "C" Factors for Cropland

Soil Cover Modification Using Rock Fragments

Ten-Year Frequency Single-Storm Erosion Index Values for West Virginia

Grassland RUSLE Field Worksheet

Cropland RUSLE Field Worksheet

Table LS-1 Pasture, Hayland and Continuous No-Till

Table LS-2 Cropland with Tillage

Table LS-3 Construction and Mining Sites

Figure 1 Examples of Principles Used in Determining Slope Length

Figure 2 Slope Lengths on Row Crop Fields